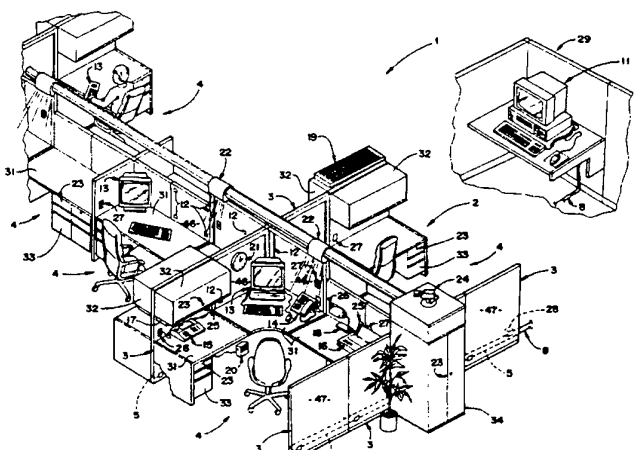


## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/US94/14031 <b>(22) International Filing Date:</b> 6 December 1994 (06.12.94)  <b>(30) Priority Data:</b> 08/165,029 9 December 1993 (09.12.93) US  <b>(71) Applicant:</b> STEELCASE INC. [US/US]; 901 44th Street, Southeast, P.O. Box 1967, Grand Rapids, MI 49501 (US).  <b>(72) Inventors:</b> TOMS, John, S.; 3782 Bushnell Road, University Heights, OH 44118-3110 (US). BROWN, Steven, M.; 599 Rookway, Southeast, Grand Rapids, MI 49546 (US). MILLER, William, L.; 7944 Whitburn Drive, Southeast, Ada, MI 49301 (US). WELLER, George, V.; 1144 Iroquois Drive, Southeast, Grand Rapids, MI 49506 (US). RUSSELL, Scott, H.; 6318 Eagle Ridge, Kalamazoo, MI 49004 (US). BRANC, Joseph, R.; 2705 Shadowbrook, Southeast, Grand Rapids, MI 49546 (US). SWEETON, David, C.; 3275 Beechwood Avenue, Cleveland Heights, OH 44118 (US). MIKOLAJCZAK, Matthew, M.; 21511 Ingram, Novi, MI 48375 (US).  <b>(74) Agent:</b> CARRIER, Robert, J.; Price, Heneveld, Cooper, DeWitt & Litton, 695 Kenmoor, Southeast, P.O. Box 2567, Grand Rapids, MI 49501 (US).		<b>(81) Designated States:</b> AU, BR, CA, JP, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> UTILITY DISTRIBUTION SYSTEM FOR MODULAR FURNITURE AND THE LIKE  <div style="text-align: center;">  </div> <b>(57) Abstract</b>  <p>A utility distribution system is provided for modular furniture of the type comprising individual furniture units (3) which are juxtaposed to form one or more workstations. A signal conductor (5) is positioned in each furniture unit, and extends generally between opposite sides thereof. Quick-disconnect connectors (7) are provided at the opposite ends of each of the signal conductors, and mate with like quickdisconnect connectors in adjacent furniture units to create a communications network through the workstations. Each furniture unit has a signaler (9) physically associated therewith, which is connected with an associated signal conductor at a coupler (10). A network controller (11) is operably connected to the network to evaluate the network and/or the associated furniture units. The furniture units may be equipped with one or more utility ports (12) which are connected with the coupler, and service utility appliances, such as personal computers (13), telephones (14), facsimile machines (15) switches (27), power outlets (25), data receptacles (26) and the like. The utility appliances preferably have memory capability to internally store operating instructions for the same, which are transmitted to the network controller when the utility appliance is initialized.</p>		

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UTILITY DISTRIBUTION SYSTEM FOR MODULAR  
FURNITURE AND THE LIKE

BACKGROUND OF THE INVENTION

5 The present invention relates to the distribution of utilities in modular furniture systems and the like, and a control arrangement therefor.

Modern offices are becoming increasingly complicated and sophisticated due largely to the ever increasing needs of the users for improved utilities support at each workstation. These "utilities," as the term is used herein, encompass all types of resources that may be used to support or service a worker, such as communications  
10 and data used with computers and other types of data processors, electronic displays, etc., electrical power, conditioned water, and physical accommodations, such as lighting, HVAC, security, sound masking, and the like.

One important consequence of the advent of sophisticated electronic offices is the increased need and desirability for distributing utilities throughout the various  
15 offices in a manner which can be readily controlled.

Another example of the increasing need to control the distribution of utilities in offices relates to energy management.

Signaling and/or communications is another essential utility in modern offices which must be effectively distributed and controlled. In addition to state-of-the-art  
20 telephone communications, interactive computers, electronic mail, facsimile messages, remote banking, computer stock trading, and many other similar activities, electronic information transfers are now becoming a part of everyday business practice. As these new forms of communications become well entrenched, our dependence upon them increases proportionately, such that even temporary signal overloads or  
25 interferences can result in significant reductions in worker productivity.

Other important utilities also need to be distributed and controlled in modern office settings. These utilities generally relate to physical ambient controls, such as building and local HVAC, ceiling lighting, task lighting, audio information such as music, alarms, sound masking, etc., video information, including cable TV, electronic  
30 display boards, and the like.

The efficient use of building floor space is also an ever-growing concern, particularly as building costs continue to escalate.

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In order to gain increased efficiency in the use of expensive office real estate, attempts are now being made to try to support highly paid knowledge workers with these types of modular furniture systems in open office settings, instead of conventional private offices. However, in order to insure peak efficiency of such knowledge workers, the workstations must be equipped with the various state-of-the-art utilities and facilities discussed above. Since such workstations must be readily reconfigurable to effectively meet the ever-changing needs of the user, the distribution and control of utilities throughout a comprehensive open office plan has emerged as a major challenge to the office furniture industry.

The inherent nature of modular furniture systems, which permits them to be readily reconfigured into different arrangements, makes it very difficult to achieve adequate utility distribution and control. To be effective, not only must the furniture units have built-in utility capabilities, but the distribution system should also be able to determine the location of each particular furniture unit within a system of multiple workstations, monitor its utility usage, and then control the same, all at a relatively low cost and readily adaptable fashion, which will function effectively, regardless of where the individual furniture unit is positioned or how it is configured.

#### SUMMARY OF THE INVENTION

One aspect of the present invention is a system for distributing utilities in modular furniture of the type wherein individual furniture units are juxtaposed in a preselected configuration to form one or more workstations. Each furniture unit includes a signal conductor positioned therein which extends through a portion thereof. First and second quick-disconnect connectors are connected with the opposite ends of the signal conductor, and are configured to mate with like quick-disconnect connectors associated with other similarly equipped furniture units to define a communications network for the workstations. A coupler is positioned in each of the furniture units, and is connected with the signal conductor at a location operably intermediate the first and second quick-disconnect connectors. A signaler is also physically associated with each furniture unit, and is connected with the signal conductor at the coupler to communicate through the signal conductor and the communications network, so as to facilitate the controlled distribution of utilities to the workstations.

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Another aspect of the present invention is a system for evaluating a modular furniture arrangement having a plurality of individual furniture units configured to form one or more workstations. At least one signal conductor extends along at least a portion of the furniture arrangement to define a communications network. A signaler is connected to the signal conductor, and is adapted for physical association with at least one of the furniture units. A network controller is coupled to the signal conductor for transmitting control signals to the signaler through the signal conductor, and receiving control signals from the signaler through the signal conductor, whereby the network controller evaluates the furniture arrangement to facilitate the distribution of utilities to the workstations.

Yet another aspect of the present invention is a utility distribution system for a modular furniture unit of the type having at least two portions thereof associated with different workstations. A first communication module is physically associated with one of the furniture portions, and includes a first signal conductor with quick-disconnect connectors at opposite ends thereof, and a coupler positioned therebetween. A second communications module is physically associated with the other furniture portion, and includes a second signal conductor extending between opposite sides thereof, with quick-disconnect connectors at opposite ends thereof, and a coupler positioned therebetween. The first and second communication modules each provide a respective communication path through both portions of the furniture unit to individually control the distribution of utilities to both of the different workstations.

Yet another aspect of the present invention is a communications network for a plurality of furniture units. A signal conductor is configured to extend along the furniture units. At least one signaler is associated with at least one of the furniture units, and is operably coupled to the signal conductor. A network controller is operably coupled to the signal conductor for communicating with the signaler, whereby the network controller and the signaler communicate information associated with the furniture units through the signal conductor.

Yet another aspect of the present invention is a communications network for a furniture arrangement, comprising at least one signal conductor extending along the furniture arrangement. A network controller is connected to the signal conductor, and includes control circuitry for the communications network. At least one utility appliance is coupled to the signal conductor for communicating with the network

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controller, and includes a memory unit storing operating instructions therefor, which are transmitted to the control circuitry of the network controller when the utility appliance is initialized, whereby the network controller controls the utility appliance according to the operating instructions received therefrom.

5 Yet another aspect of the present invention is a system for distributing utilities in a modular furniture unit of the type in which complementary furniture units are juxtaposed in a preselected configuration to form at least one workstation. A signal conductor is positioned in the furniture unit, and extends generally between opposite sides thereof. A coupler is positioned in the furniture unit, and is connected with the  
10 signal conductor at a location within the furniture unit. A utility appliance network is positioned within the furniture unit, and is coupled to the signal conductor through the coupler. At least one port is physically positioned on the furniture unit, and is operably connected with the utility appliance network, whereby the port is coupled to the signal conductor through the utility appliance network to facilitate the distribution  
15 of utilities to the workstation.

The principal objects of the present invention are to provide an efficient and effective system to distribute utilities in modular furniture arrangements and the like. Each furniture unit can be prewired with a signal conductor and a signaler connected with the signal conductor at a coupler. The signal conductors in adjacent furniture  
20 units are interconnected by quick-disconnect connectors, so as to form a communications network which is attached to a network controller capable of evaluating both the communications network and the furniture units. At least some of the furniture units include a plurality of ports which are capable of servicing a wide variety of utility appliances, such as computers, communication devices, switches,  
25 power outlets, data receptacles, etc., to meet the ever-changing needs of even the most advanced knowledge workers. The furniture units and the associated utility appliances preferably include identifiers and/or operating instructions which are communicated to the network controller through the communications network to evaluate and monitor utility distribution to the workstation, as well as control the  
30 same, such as by power shedding, communication line switching, and the like. The utility distribution system also is preferably capable of monitoring and controlling physical support equipment, such as lighting, HVAC, security, sound, and other similar environmental accommodations. Hence, the furniture units not only have

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built-in utility capabilities, but the distribution system for the same is able to determine the location of each particular furniture unit in the system, monitor its utility usage, and then control the same, all at a relatively low cost, and readily adaptable fashion, which will function effectively, regardless of where the individual furniture unit is positioned or configured in the system.

These and other advantages of the invention will be further understood and appreciated by those skilled in the art by reference to the following written specification, claims and appended drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view of a furniture arrangement including a utility distribution system embodying the present invention;

Fig. 2 is a front elevational view of two panels, which are furniture units included in the furniture arrangement according to Fig. 1, and including a utility distribution system according to the present invention;

Fig. 3 is a perspective view of a communication module used in the utility distribution system for the furniture arrangement according to Fig. 1;

Fig. 4 is a top plan view of a utility distribution system in the furniture arrangement according to Fig. 1;

Fig. 5 is a front elevational view of a panel according to Fig. 2 with the panel face cover removed;

Fig. 6 is a top plan view of a column of the panel according to Fig. 5;

Fig. 7 is a front elevational view of the panel face according to Fig. 5 with a utility appliance network;

Fig. 8 is a circuit schematic of the utility appliance network according to Fig. 7;

Fig. 8A is a partial circuit schematic of the utility appliance network;

Fig. 8B is a partial circuit schematic of an alternate embodiment of the utility appliance network;

Fig. 9 is a front elevational view of the panel according to Fig. 7 and further including power harnesses;

Fig. 10 is a circuit schematic of the power distribution circuit according to Fig. 9;

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Fig. 11 is a front elevational view of the portless panel face according to Fig. 2;

Fig. 12 is a front elevational view of a port in the ported panel face according to Fig. 2;

5 Fig. 13 is a top sectional view taken along plane XIII-XIII in Fig. 12;

Fig. 14 is a circuit schematic of a module according to Fig. 3 including couplers and signalers forming an identification module in the portless panel face according to Fig. 11;

10 Fig. 15 is a circuit schematic partially in block diagram form of a module according to Fig. 3 including couplers and signalers forming a bridge module for the ported panel face according to Fig. 2;

Fig. 16 is a circuit schematic in block diagram form of a bridge module according to Fig. 15;

15 Fig. 17 is a circuit schematic partially in block diagram form of a network controller for the utility distribution system according to Fig. 1;

Fig. 18 is a circuit schematic in block diagram form of the network controller according to Fig. 17;

Fig. 19 is a front perspective view of a switch which is one type of utility appliance in the furniture arrangement according to Fig. 1;

20 Fig. 20 is a back perspective view of the switch according to Fig. 19;

Fig. 21 is a circuit schematic in block diagram form of the switch according to Fig. 19;

Fig. 22 is a front perspective view of a triplex power outlet which is one type of utility appliance in the furniture arrangement according to Fig. 1;

25 Fig. 23 is a back perspective view of the power outlet according to Fig. 22;

Figs. 24A and 24B are a circuit schematic partially in block diagram form of the power outlet according to Fig. 22;

Fig. 25 is a circuit schematic in block diagram form of the outlet according to Fig. 22;

30 Fig. 26 is a circuit schematic partially in block diagram form of part of a power-in in the furniture arrangement according to Fig. 1;

Fig. 27 is a circuit schematic in block diagram form of the power-in according to Fig. 26;



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Fig. 28A is a top elevational view of a three-panel furniture arrangement including a utility distribution system according to the invention;

Fig. 28B is a circuit schematic of a utility distribution system for the furniture arrangement according to Fig. 28A;

5 Figs. 29-38 are flow diagrams for the program in the network controller according to Figs. 17 and 18;

Fig. 39 is a flow diagram of the program in the switch according to Figs. 19-21;

10 Figs. 40A, 40B and 40C are flow diagrams of the program in the outlet according to Figs. 22-25;

Figs. 41A, 41B and 41C are flow diagrams of the program of the power-in according to Figs. 26 and 27;

Figs. 42-46 are flow diagrams of the program in utility appliances according to Figs. 17-27;

15 Figs. 47, 48A, 48B, 49, 50, 51, 52, 53A, 53B, 53C, and 53D are flow diagrams of a program in the bridge module according to Figs. 15 and 16;

Fig. 54 is a perspective view of a system according to an alternate embodiment of the invention; and

20 Fig. 55 is a bottom plan view of a grid for the embodiment according to Fig. 54 with a panel system illustrated in phantom.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The reference numeral 1 (Fig. 1) generally designates a utility distribution system embodying the present invention, which is particularly adapted for use in conjunction with modular furniture arrangements 2 and the like of the type wherein individual furniture units 3 are juxtaposed to form one or more workstations 4. A signal conductor 5 is positioned in each furniture unit 3, and may extend generally between opposite sides thereof. Quick-disconnect connectors 6 and 7 (Figs. 2-4) are provided at the opposite ends of each signal conductor 5, and mate with like quick-disconnect connectors 6 and 7 in other similarly equipped furniture units 3 to define a communications network 8 through workstations 4. Each furniture unit 3 also has a signaler 9 physically associated therewith, which is connected with the associated signal conductor 5 at a coupler 10 positioned operably intermediate opposite quick-disconnect connectors 6 and 7. A network controller 11 is operably

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coupled to communications network 8 to evaluate the communications network and/or the associated furniture units 3. At least some of the furniture units 3 may also be equipped with one or more utility ports 12 (Fig. 2), which are connected with the associated coupler 10, and service utility appliances, such as those illustrated in Fig. 1, including personal computer 13, telephone 14, facsimile machine 15, printer 16, overhead mounted task light 17, freestanding task light 18, ambient light 19, personal heater 20, clock 21, ventilation system 22, electronic lock system 23, security system 24, power outlets 25, data receptacles 26, switches 27, and power-ins 28. Utility appliances 13-28 may be provided with internal memory to store operating instructions for the same, which are transmitted to network controller 11 when the particular utility appliance is initialized.

As described in greater detail below, network controller 11 (Fig. 1) is capable of interfacing with the various ports 12 in furniture system 2, so as to achieve nearly limitless flexibility in monitoring and controlling utility appliances 13-28 in a manner that can be easily rearranged and/or reconfigured without requiring any rewiring whatsoever.

The illustrated modular furniture arrangement 2 (Fig. 1) includes a portable partition system, wherein the furniture units 3 comprise a plurality of individual partition panels, which are interconnected in a side-by-side fashion to form multiple workstations 4. Partition panels 3 are adapted to mount thereon a plurality of conventional hang-on furniture articles, such as the illustrated worksurfaces 31, binder bins 32, etc., and are integrated with complementary pedestals 33, and wardrobes or closets 34.

The illustrated partition panel 3 (Fig. 2) is specially configured to accommodate utility distribution system 1, and includes a marginal frame 45, with two removable cover panels 46 and 47 enclosing the opposite sides or faces thereof. As best illustrated in Figs. 5 and 6, panel frame 45 includes a pair of vertical uprights 48 rigidly interconnected at their opposite ends by top and bottom cross members 49 and 50, respectively. A pair of feet 51 depend from bottom cross member 50, and include vertically adjustable glides 52 at their lower ends to facilitate leveling partition panel 3. Two plates 53 and 54 extend between opposite panel feet 51, and are attached thereto in a vertically spaced apart fashion to define a pair of back-to-back power raceways 55 and a pair of back-to-back cable raceways 56, which are vertically

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separated by center plate 53. Removable cover plates 57 and 58 are detachably mounted on the opposite sides of raceways 55 and 56 to selectively enclose the same.

The vertical uprights 48 (Figs. 5 and 6) of panel frame 45 are substantially identical in construction, wherein each includes a channel-shaped lateral cross-sectional configuration, comprising a flat outer web 60, and a U-shaped inner channel 61, having a central web 62 and opposite side flanges 63. An intermediate web 64 is positioned between webs 60 and 62, and is integrally connected therewith by flange members 65-68. The outer flange members 65 and 66 include a series of vertical slots 69 shaped to receive therein brackets for hang-on furniture articles, such as worksurfaces 31 and binder bins 32. Webs 62 and 64, in conjunction with flanges 67 and 68 define a vertical raceway 70 which communicates with power raceway 55 to route power conduits therethrough.

In the example shown in Fig. 2, cover panels 46 and 47 each have an upholstered construction, and are detachably connected with the opposite sides or faces of panel frame 45 to enclose the same. The illustrated cover panel 46 is provided with a plurality of ports 12 mounted thereon from which various utilities can be tapped in the fashion discussed below, whereas the illustrated cover panel 47 does not have any ports, and is simply aesthetic in nature.

The cover panel 46 illustrated on the left-hand side of Fig. 2 includes eight individual ports 12 connected to utility appliance network 37, which is in turn connected to the furniture arrangement network 36 at coupler 10. As previously noted, ports 12 may be arranged to provide service taps at the selected workstations 4 for a wide variety of different utilities, such as electrical power, communication, data, security, fiber optic transmissions, and possibly even HVAC, conditioned water, and other similar resources. Partition panels 3 can be either factory equipped, or even retro-fitted with those particular utility ports 12 which are desired, and in the specific configuration that will best serve the associated workstation 4.

In the illustrated example, and with reference to Fig. 1, each port 12 is configured so that it can be connected with either a power outlet 25, a data receptacle 26, a switch 27, or a power-in 28. In this configuration, the utility appliances 13-24 are connected to the communications network 8 indirectly through power outlets 25 and data receptacles 26. However, it is to be understood that utility appliances 13-24 can also be connected directly to ports 12. Preferably, each of the power outlets 25,

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data receptacles 26, switches 27 and power-ins 28 has a memory capability to store operating instructions therefor, which are transmitted to network controller 11 when the utility appliance is initialized, such that network controller 11 controls the utility appliances according to these programmed operating instructions. Utility appliances  
5 13-24 may also have memory capability to store operating instructions, which are transmitted to network controller 11 in a manner similar to power outlets 25, data receptacles 26, switches 27 and power-ins 28. In the panel 3 illustrated on the left-hand side of Fig. 2, those ports 12 located at the opposite corners of panel 3 are empty, the two ports 12 located immediately above the worksurface 31 have power  
10 outlets 25 connected therewith, and the two ports 12 positioned immediately below worksurface 31 have data receptacles 26 connected therewith.

With reference to Fig. 3, the illustrated signal conductor 5, quick-disconnect connectors 6 and 7, signaler 9 and coupler 10 are all incorporated into a one-piece assembly, which is designated herein as communication module 75, shaped to be  
15 received within the cable raceway 56 (Fig. 5) of partition panel 3. It is to be understood that communications module 75 might also be shaped to be positioned on a furniture unit 3 outside of raceway 55. Communication module 75 includes six signal conductors 5 (Fig. 3) which extend along the length of cable raceway 56, and have a connector block 76 mounted at one end, and a male quick-disconnect connector 7  
20 mounted at the opposite end. The illustrated connector block 76 includes at least one female quick-disconnect connector 6 positioned in the end wall thereof, which is shaped to receive one of the male connectors 7 therein. Connector block 76 also includes a female quick-disconnect connector 77 in the top wall thereof for connection with ports 12, as described below. Signaler 9 and coupler 10 are also integrally  
25 positioned within connector block 76.

In the embodiment illustrated in Figs. 2-4, each partition panel 3 includes a pair of communication modules 75 positioned on opposite sides thereof within back-to-back cable raceways 56. Each communication module 75 is physically associated with the adjacent side or face of partition panel 3, with switch 9 protruding  
30 therefrom. When partition panels 3 are positioned side-by-side, as shown in Fig. 2, the male quick-disconnect connector 7 associated with communication module 75 is inserted into the female quick-disconnect connector 6 in the communication module 75 of the next adjacent panel 3. All communication modules 75 in a particular furniture

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group or cluster 2 are similarly interconnected, so as to form the furniture arrangement network 36, which is in the shape of a loop, as shown in Fig. 4.

Each of the furniture units 2 may have two or more sections, which are designated herein as "portions," equipped with separate communication modules 75.

For example, each of the illustrated panels 3 has two opposite sides or faces, each of which has a communication module 75 associated therewith. Normally, the opposite faces of panels 3 will be associated with a different one of the various workstations 4. Hence, each of the illustrated panel faces 46 and 47 (Fig. 2) is a separate portion of furniture unit 3, and has a respective associated communication module 75. The ported panel faces 46 include a module 75A which communicates with the ports 12 thereon through a respective utility appliance network 37. The portless panel faces 46 will also have a communication module 75B associated therewith.

Network controller 11 (Fig. 4), may be located local to or remote from furniture group 2, and is connected with the furniture arrangement network 36. The furniture arrangement network 36 is in the form of a loop, so as to permit evaluation of the various partition panels 3 in the furniture system 2, as well as any and all utility appliances 13-28 (Fig. 1) connected with the same.

In operation, utility appliances 13-28 (Fig. 1) are plugged into panel ports 12 at their desired locations. The utility distribution system 1 is initialized, and the operating instructions for each of the utility appliances incorporated into communications network 8 are communicated to network controller 11. Additionally, information is communicated to network controller 11 from the communication modules 75 associated with each portion of furniture units 3. In this fashion, network controller 11 not only learns where each partition panel 3 is in the furniture group 2, but it also learns the identity of each of the utility appliances 13-28 mounted thereon, and its associated operating instructions. Network controller 11 can thereby monitor the flow of power, signals, and other utilities to each port 12 on each face of each partition panel 3 in furniture arrangement 2, and can also control the same, if necessary, by power shedding, communication line switching, or the like.

Furthermore, network controller 11 permits manipulation of utility appliances 13-28 on a system wide basis, such as by rerouting telephone calls to different locations, turning on and off lights 18-20, resetting clocks 21, locking and unlocking security system 24, and the like. Hence, partition panels 3 not only have built-in utility

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distribution capabilities, but the distribution system 1 for the same is able to determine the location of each particular partition panel 3 in the system 2, monitor its utility usage, and then control the same, all in a readily adaptable fashion, which will function effectively, regardless of where the individual partition panel 3 is positioned or configured in the furniture arrangement 2.

With reference to Figs. 7 and 8, a utility appliance network 37 is provided to establish a communication path between the ports 12 on cover panel 46 and an associated bridge module 75A. Bridge module 75A is a communication module 75 which includes a communication bridge 128 (Fig. 8) connected to coupler 10. Utility appliance network 37 includes data/power conductors 82 connected to all of the ports 12 and to the communication bridge 128. The data/power conductors 82 include two signal conductors 83 and 84 (Fig. 8) which transmit communication signals bi-directionally between ports 12 and the communication bridge 128 of bridge module 75A. Conductors 85 and 86 carry DC power from communication bridge 128 to ports 12. Utility appliance network 37 includes an address conductor 87 selectively connected uniquely to each of ports 12 on the panel face 46. Conductor 87 is connected to a logic level which is, for example, circuit ground. The three address pins AD0-AD2 of the eight ports 12 are connected to conductor 87, such that each address on a panel face 46 has a unique 3-bit value. The addresses AD0-AD2 range from 000 to 011 from bottom to top on the right side of Fig. 8, and range from 100 to 111 from bottom to top on the left side of Fig. 8. Thus, each port 12 associated with each panel face 46 has a unique address which identifies its location thereon. Conductors 83, 84, 85, 86 and 87 are preferably terminated at a male RJ-11 type connector adapted to be engaged in connector 77 of communication module 75 (Fig. 3).

With reference again to the bridge module 75 shown in Fig. 3, the opposite ends of the signal conductors 5 are terminated at quick-disconnect connectors 6 and 7. The illustrated male quick-disconnect connector 7 is a conventional RJ-11 male connector which includes at least six pins. The illustrated female connector 6 is a conventional female RJ-11 connector, having the same number of pins as male connector 7. Although female connector 6 is illustrated mounted in coupler block 76, it will be recognized that the female connector could be remote from connector block 76 and connected to block 76 by signal conductors 5. As will also be recognized by

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those skilled in the art, male connector 7 includes a resilient tongue 110, which is received in a keyway 111 of female connector 6, and releasably locks connector 7 in female connector 6 in a conventional manner. In general, tongue 110 is biased into keyway 111 when male connector 7 is inserted into female connector 6, and tongue  
5 110 is manually depressed inwardly to remove the male connector from the connector 6.

With reference to Fig. 9, the ports 12 on cover panel or face 46 are also connected to a powerway 92 by harnesses 94 and 95. Powerway 92 may be a conventional type of powerway, having quick-disconnect connectors 96 and 97 on  
10 opposite ends thereof. Connectors 96 and 97 are interconnected by power conductors 101 (Fig. 10, only some of which are numbered). Conductors 101 extend through power block 98. Power block 98 includes two power taps 99 and 100 on a top wall thereof through which the power conductors 101 (only some of which are numbered) are accessed. Harness 94 includes a connector 103 which mates with tap 99.  
15 Conductors 104 (only some of which are numbered) extend from connector 103 to each of the ports 12 on the left side of panel face 47. Harness 95 similarly includes a connector 105 which mates with connector 100 and signal conductors 106, which extend between ports 12 on the right side and connector 105.

Connector block 76 (Fig. 9) is also connected to powerway 92 by conductors  
20 109. The network bridge receives operating power from the powerway and generates a regulated DC voltage  $V+$  using the AC power received from the powerway.

In the example illustrated in Fig. 11, those cover panels or faces 47 which do not include ports 12 (i.e., "non-porting" or "portless" panel faces) do have a powerway 98 positioned in power raceway 55. These portless cover panels 47 also  
25 have an identification module 75B with associated signal conductors 5 and a coupler 10 positioned in cable raceway 56. Connectors 6 and 7 terminate the ends of the signal conductors 5. Identification module 75B also includes a signaler 9, along with a second signaler 127, which are both connected to coupler 10. The non-porting panel face 47 thus includes a signal conductor 5 and a powerway 98, similar to the ported  
30 panel faces 46.

As best shown in Figs. 12 and 13, each of the illustrated ports 12 includes a recessed housing 112, having an outer flange 113 on a face thereof which contacts cover panel face 46 and covers the perimeter of a hole which receives housing 112.

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Housing 112 may be attached to vertical frame uprights 48 by suitable conventional means, such as welding 111. The illustrated housing 112 includes a rectangular recess 110, which is closed on four sides and the back. A quick-disconnect connector 114 is positioned in housing 112 at the back of recess 110, and includes ten connector ports 115 (only some of which are numbered) housing respective male connectors 116 (only some of which are numbered). Male connectors 116 are connected to a respective conductor 104. A quick-disconnect signal connector 117 is positioned adjacent connector 114 in housing 112. Signal connector 117 includes seven female contacts 118 (only some of which are numbered). Contacts 118 are connected to conductors 83, 84, 85, 86, and are selectively connected to conductor 87 (Fig. 8).

In the illustrated embodiments, the six signal conductors 5 (Fig. 14) include three signal channels 130, 131 and 132, each having two of the signal conductors 5. Channel 130 is a data channel for communicating information, as described in greater detail hereinbelow. Channel 131 is an identifier channel for transmitting identification information, as is also described in greater detail hereinbelow. Channel 132 is a configuration channel for transmitting information pertaining to the workstations, as described hereinbelow.

The identification module 75B (Fig. 14) associated with the non-ported cover panels 47 includes junctions 125 for connecting signaler 9 to the signal conductors 5 of the workstation identification channel 132. The coupler 10 of module 75B also includes junctions 126 for connecting signaler 127 to signal conductors 5 of the identifier channel 131. Terminals 125 and 126 may be provided by an electrically conductive means, such as solder electrically connecting identifiers 9 and 127 to wires 5, or an electrically conductive trace deposited on a printed circuit board and connected to signal conductors 5, as well as signalers 9 and 127.

The bridge module 75A (Fig. 15) is associated with the ported panel face 46. Bridge module 75A functions as an interface between the furniture arrangement network 36, comprising interconnected signal conductors 5, and the utility appliance network 37. Bridge module 75A includes a coupler 10 (illustrated in phantom), and a communication bridge 128, which is coupled between signal conductors 5 and signal conductors 83, 84. Coupler 10 includes relay switches 136 and 137, which are connected in series in data channel 130. The switches 136, 137 are controlled by a relay coil 138. Switches 136 and 137 are normally closed, but are connected to an



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impedance when the switches are open. The impedance is preferably provided by a resistor 140 having an impedance of approximately 102 ohms. This resistor provides a suitable termination impedance for the data channel of furniture arrangement network 36 when switches 136, 137 are open. A transformer 144 is connected between terminals 145 and 146 of communication bridge 128 and data channel 130. Transformer 144 includes a winding 147 connected to terminals 145, 146, and a winding 148 connected to channel 130. Communication bridge 128 is connected to identifier channel 131 by an optical coupler 150 and one of the signal conductors 5. Optical coupler 150 includes a light emitting diode (LED) 151 connected to channel 131. A photodetector 152, implemented using a light responsive transistor, has an emitter and a collector connected to terminals 153, 154 of communication bridge 128. Coupler 10 also includes a conductor 156 connected to configuration channel 132 and to terminal 157, and a conductor 158 connecting one signal conductor of channel 132 to ground potential. A pull-up resistor 160 connects conductor 156 to a five volt power supply. Coupler 10 interrupts circuit 132. Accordingly, two signal conductors 5 are terminated at pins 161 and 162.

The identification units 127 (Figs. 7, 9 and 11) as noted above are provided for identification modules 75B and bridge modules 75A, and include a memory device having a unique identification code. These memory devices are interrogated as described in greater detail hereinbelow to identify: the number of panel faces between network controller 11 and the first ported panel face 46; between each subsequent ported panel face up to the last ported panel face; and between the last ported panel face and the network controller 11. In a particularly advantageous embodiment of the present invention, the identification unit 127 may also include a part identification number for the furniture unit 3 in which the identification module 127 is connected. Communication bridge 128 can interrogate the identification modules 127 to learn the identification code and the type of furniture unit 3 in which it is positioned, as well as the identification code and furniture unit type of adjacent portless furniture units 3. The network controller 11 can use this information to produce a centralized inventory of the furniture arrangement 1.

Network controller 11 (Fig. 18) includes a microcontroller 179, which may be implemented using any suitable commercial microprocessor. The network controller 11 may optionally include a keypad input 190, an alarm 191 and a display 192.

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Keypad 190 and display 192 may be provided by any suitable conventional keypad and display, such as those utilized for personal computers. The keypad 190 and display 192 are used as an interface with microcontroller 179, and may be provided in addition to a PC. Alarm 191 may be provided by any suitable conventional  
5 transducer. The 191 alarm may, for example, provide an audible signal when a maintenance message is generated on display 192.

The microcontroller 179 (Fig. 18) is connected to a network interface 195, which includes a male connector 198 provided by a conventional male RJ-11 six-pin quick-disconnect connector. A female quick-disconnect connector 196 is provided by  
10 a conventional female RJ-11 six-pin quick-disconnect connector. Furniture arrangement network 36 is connected to quick-disconnect connectors 196 and 198. As illustrated in Fig. 17, the workstation identification channel 132 is connected through network controller 11, such that the network controller is transparent to this channel. A transformer 205 includes windings 206 and 207, wherein winding 206 is  
15 connected to data channel 130, and winding 207 is connected to an interface circuit 210. Interface circuit 210 is also connected to one of the signal conductors 5 of identifier channel 131, and interface circuit 210 is connected to microcontroller 179 via communication bus 212.

Microcontroller 179 (Fig. 17) is connected to an interface circuit 213 through  
20 a communication bus 208. Interface circuit 213 is connected to channel 130 through connector 198 and transformer 214. One winding 215 of transformer 214 is connected to channel 130, and the other winding 216 is connected to interface circuit 213. An optical coupler 217 includes a diode 218 connected to identifier channel 131. A photodetector 219 of optical coupler 217 is connected to interface 213. The  
25 interface circuits 213 and 210 comprise suitable, conventional, impedance and protection circuitry for interfacing with microcontroller 179, and may include integrated circuit components, such as octal transceivers and RS485 drivers.

As described briefly above, the utility appliances 13-28 (Fig. 1) are connected to ports 12, and communicate through utility appliance network 37 (Fig. 2). One type  
30 of utility appliance is a switch 27 (Figs. 19-21), which includes a rectangular housing 235. According to the illustrated embodiment, the housing 235 has two switches 236 and 237 on a front face 238 thereof. Switches 236 and 237 are implemented using a three-position header to control the operation of utility appliances 13-26 and 28

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connected in the utility distribution system 1. Each of the switches 236 and 237 has a respective sixteen-position clock face association selector 239, 240 associated therewith, which are also mounted on a front face 238 of housing 235. Selectors 239 and 240 are used to select unit association numbers.

5 Another one of the utility appliances 13-28 which may be utilized with system 1 is power outlet 25 (Figs. 22-23), which includes a rectangular housing 270 having a front face 271. The illustrated power outlet 25 includes three receptacles 272, 273 and 274. However, it will be recognized that the power outlet 25 may contain any number of receptacles. Indicators 276, 277 and 278 are associated with receptacles 10 272, 273 and 274, respectively. Each indicator 276-278 emits red, green or yellow light according to the power level of the power source to which its associated receptacle is connected, as described in greater detail hereinbelow. The indicators 276-278 are particularly useful because users will want to plug appliances into a reliable power source. Thus, they will prefer a receptacle with a green indicator to 15 one with yellow indicator, and they will prefer a receptacle with a yellow indicator to one with a red indicator. Users will thus assist in balancing loads on different supplies by selecting the receptacle having the least load. An association selector 280, 281 and 282 is associated with each receptacle 272, 273, and 274, respectively. Selectors 280, 281 and 282 may be provided by a sixteen-position clock face selector 20 or other suitable switch means. These selectors are used to bind receptacles 272-274, as described in greater detail hereinbelow. Indicators 276-278, receptacles 272-274, and selectors 280-282 are positioned on the front face 271 of housing 270, so that they are readily accessible to a user for manual manipulation.

25 The back surface 285 (Fig. 23) of power outlet housing 270 has outwardly projecting connectors 286 and 287 positioned adjacent one another. Connector 286 includes female contacts 288 (only some of which are numbered) in protective silos 288' for connection with contacts 116 (Fig. 12). Connector 287 includes outwardly projecting male contacts 289 (Fig. 23, only some of which are numbered) for connection with contacts 118 in port 12 (Fig. 12).

30 As shown in Fig. 22, receptacles, 272-274 each include three conventional contacts for receipt of a conventional plug of the type used for typewriters, clocks, radios, computers, printers, televisions, and the like. It will be appreciated that

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receptacles 272-274 may be provided by any suitable, conventional power receptacle, such as a two contact receptacle.

With reference initially to Fig. 24A, the circuit in housing 270 will now be described. The power outlet 25 includes an identical circuit for each receptacle therein. Accordingly, only the circuit for receptacle 272 is described in greater detail herein. Receptacle 272 includes contacts 295, 296 and 297. Contacts 296 and 297 are connected to junctions 298 and 299, respectively. Junctions 298 and 299 are, in turn, connected to the neutral supply and safety ground of a power supply circuit through two contacts 288. Contact 295 is connected to a coil 301 of a transformer 302. Coil 301 is connected in series with a switch 303, which is connected to a junction 304. Junction 304 is connected with a live conductor of the power supply circuit through a contact 288. It will be appreciated that any two or more of the first, second and third receptacles 272, 273 and 274 may be attached to the power supply circuit of a single power source. Alternatively, each of the receptacles 272, 273, 274 may be connected to a power supply circuit of a different, respective, power source.

Power outlet 25 includes three voltage detectors 310 (Fig. 24B), 311 and 312 connected to receptacles 272-274, respectively. Voltage detectors 310-312 are identical, and accordingly, only voltage detector 310 is described in greater detail hereinbelow. Voltage detector 310 includes a transformer 314 having a first winding 315. Winding 315 has a terminal 316 connected through a fuse 317 to a junction 304, and a terminal 318 connected to a junction 299. A first overvoltage protection element 319 is connected between terminal 316 and an associated junction 298. A second overvoltage protection element 320 is connected between a terminal 299 and an associated junction 298. The overvoltage protection elements may be provided by any suitable conventional protection components, such as a 140-volt Metal Oxide Varister (MOV).

Transformer 314 (Fig. 24B) also has a secondary winding 322 with a terminal 323 connected to an output junction 324. Secondary winding 322 also has a terminal 325 connected to ground. Junction 324 is connected to the anode of a diode 326, and a cathode of a diode 327. The cathode of diode 326 is connected to voltage regulator 328. The anode of diode 327 is connected to a voltage regulator 329. Regulators 328 and 329 are conventional, and supply a positive output voltage and a negative output voltage, respectively. Each of the receptacles 272-274 associated with power

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outlet 25 includes a respective diode 326, 326'; 326" and diode 327, 327'; 327", which insures that the power supply circuit having a source with the largest magnitude of those connected to receptacles 272-274, supplies power to the regulators 328 and 329. The secondary winding 333 of transformer 314 has a terminal 335 connected to ground. A terminal 336 of winding 333 is connected to a terminal 337 through a resistor 338. A resistor 339 is connected between terminal 337 and ground. A diode 340 is connected between terminal 337 and +VREF. A diode 341 is connected between terminal 337 and -VREF. Diodes 340 and 341 insure that the voltage at terminal 337 is within the desired range of +VREF and -VREF.

Power outlet 25 also includes three current sensors 350, 351 and 352 (Fig. 24A). Each of the current sensors 350-352 is identical, and accordingly, only current sensor 350 is described in greater detail hereinbelow. Current sensor 350 includes a secondary winding 355 of transformer 302, with a terminal 356 connected to ground, and a terminal 357 connected to a junction 358. A resistor 359 is connected between junction 358 and ground. A non-inverting input of an amplifier 360 is connected to junction 358. The output 361 and inverting input 362 of amplifier 360 are connected by a resistor 363 and a capacitor 364, which are connected in parallel. The output 361 of amplifier 360 is also connected to a current sensor output 370 through a resistor 371. Four circuits 372, 373, 374 and 375 are connected in parallel between the inverting input of amplifier 360 and ground potential. These circuits are identical, and accordingly, only circuit 375 is described in greater detail hereinbelow. Circuit 375 includes a resistor 376 and a MOSFET element 378. The MOSFET element is an N-channel device having a source connected to ground potential, a drain connected to a respective resistor 376, and a gate connected to an interface circuit 379 to receive a control signal. A diode 380 is connected across each MOSFET element in a conventional manner to provide protection therefor.

The interface circuit 379 (Fig. 25) is connected to a microcontroller 385 through a communication bus 386. Interface circuit 379 has a respective output connected to the control input of each circuit 372-375 (Fig. 24A). Each control input is also connected to a respective pull-up resistor 387, only some of which are numbered. The interface circuit 379 selectively places circuits 372-375 in a conductive state to vary the net resistance of these circuits, which adjusts the gain of amplifier 360.

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Microcontroller 385 (Fig. 25) is coupled to connector 287 through a data bus 288. Connector 287 connects to the address conductor 87 and the signal conductors 83, 84 when the power outlet 25 is connected to a port 12. The microcontroller 385 is connected to a switch interface circuit 400 through a data bus 401. The association  
5 selectors 280-282 are connected to interface circuit 400. The association selectors for receptacles 272-274 are used to bind utility appliances 13-28, as is described in greater detail hereinbelow. The selected positions of the association selectors 280-282 are input to the microcontroller 385 from interface 400.

The microcontroller 385 (Fig. 25) is also connected to contacts 406 through a  
10 data bus 407 and an interface circuit 408. Contacts 406 are connected to a respective one of gates 410-412 (Fig. 24A) of MOSFET elements 413-415. The drain of each of the MOSFET elements 413-415 is connected to an associated one of three relay coils 417-419, respectively. Each of the MOSFET elements 413-415 is selectively energized to allow current to flow through its associated relay, and thus open switches  
15 303, 303' and 303" associated therewith. When switches 303, 303' and 303" are open, receptacles 272, 273 and 274, respectively, are disconnected from their associated power source. When relays 417-419 are not energized, switches 303, 303' and 303" are closed, such that the receptacles 272-274 are connected to their associated power source.

20 In addition to the utility appliances 13-27, a power-in 28 (Fig. 26) may be included in the utility distribution system. Power supplied to the modular furniture arrangement 2 is supplied through one or more power-ins 28. Power-in 28 is substantially similar to power outlet 25.

25 A general description of the operation of the illustrated utility distribution system 1 will now be made with reference to Figs. 28A and 28B. A more detailed description of the utility distribution system 1 follows this general description.

During normal operation, a network controller 11 (Fig. 28B) transmits a periodic message, referred to herein as the "heartbeat," every 50 msecs. Bridge modules 75A accept these heartbeats. If one of the bridge modules 75A does not  
30 detect a heartbeat for 500 msecs., the bridge module is reset. The network controller 11 resets when any one of the bridge modules 75A resets, as described herein below. A utility appliance 13-28 will also reset when the bridge module 75A to which it is connected through a utility appliance network 37 resets. Thus, when the network

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controller 11 suspends transmission of the heartbeat, every bridge module 75A, and thus every utility appliance 13-28 in the communications network 8 coupled to the network controller 11, resets.

During normal operation, utility appliances 13-28 (Fig. 28B) transmit state information to network controller 11. The network controller 11 is responsive to state information to transmit control information to utility appliances 13-28. The network controller 11 and utility appliances 13-28 communicate with one another through bridge modules 75A. The programs that derive the control information from the state information are loaded into the network controller 11 from the utility appliances 13-28 during initialization, as described in greater detail hereinbelow.

The network controller 11 (Fig. 1) has the ability to automatically determine the location of utility appliances 13-28 on a furniture unit 4. This is done by identifying the location of utility appliances 13-28 on a furniture unit portion, such as panel face 46. The location of utility appliances on the furniture unit 3 is determined from address information AD0-AD2 (Figs. 8, 8A, 8B) available at ports 12 on the furniture units 3. The locating of utility appliances 13-28 is also facilitated by the ability to evaluate furniture units 3 using communication modules 75 (Fig. 4), as described in greater detail hereinbelow.

Utility appliances 13-28 (Fig. 1) are also associated with one another using the network controller 11, as described in greater detail hereinbelow. For example, in the embodiment described herein, each utility appliance 25 (Fig. 22) includes association selectors 280-282, and each utility appliance 27 (Fig. 19) includes association selectors 239, 240. The network controller 11 (Fig. 1) associates all utility appliances 13-28 that are within a workstation 4, and have their association switch set at the same one of positions 0-9. The network controller 11 also associates all utility appliances 13-28 within the furniture system 2 having their association switch at the same one of positions A-F. Where a control utility appliance, such as a switch 236, 237, in utility appliance switch 27 and a controlled utility appliance, such as a receptacle 272, 274 in power outlet 25, are associated and functionally compatible, they are bound, and changing the state of the control utility appliance (e.g., flipping the switch 236, 237) will result in a change in the state of the associated controlled utility appliance (e.g., turning on or off the power supply to a receptacle 272-274).

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An important characteristic of the utility distribution system 1 (Fig. 1) described herein is that communication between utility appliances 13-28 and network controller 11 utilizes a request procedure. When the state of a utility appliance 13-28 changes, the utility appliance attempts to establish a virtual circuit with the network controller 11. A virtual circuit is a connection, through communications modules 75 and between a utility appliance and the network controller, which permits communication therebetween. Only when the network controller 11 is ready to process the state information does it accept the virtual circuit. The utility appliances 13-28 will then send the current state information to the network controller 11. Thus, the state information that is sent to the network controller 11 is always the most up to date information available. Similarly, when the network controller 11 program determines that some control information should be sent to one of the utility appliances 13-28, it first attempts to establish a virtual circuit with the utility appliance. Only when this virtual circuit is established does the network controller 11 program actually develop the control message that is to be sent to the utility appliances 13-28. Thus, the utility appliances 13-28 are always commanded to perform actions consistent with the most recently detected state of the communications network 8. This avoids having either state or control information enqueued, waiting to be processed.

The utility appliance networks 37 (Fig. 9) are designed as polled networks. Each bridge module 75A creates a poll list based on addresses AD0-AD2. Bridge module 75A polls each utility appliance 13-28 connected to a port 12 in its associated utility appliance network 37, and on its poll list, in address (AD0-AD2) order sequence. Periodically, the bridge module 75A acts to determine if any new utility appliances 13-28 have been added by connection to a port 12 in the utility appliance network 37. If new utility appliances 13-28 are detected, the poll list is updated to include the new utility appliance. Once a utility appliance 13-28 has been added to the poll list, the added utility appliance must respond to each poll (or one of its retries). If a utility appliance 13-28 fails to acknowledge a poll message (or any of its retries), the bridge module 75A will reset and restart operation with an empty poll list. If a utility appliance 13-28 having responded to a configuration message, and thereby having placed itself on the poll list, thereafter receives another configuration message, the utility appliance will reset. Thus a failure (or removal) of any



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configured utility appliance 13-28 will cause the bridge module 75A to reset, and the reset of the bridge module 75A will cause all configured utility appliances on that utility appliance network 80 to reset when an attempt is made to reconfigure them.

5 The network controller 11 (Fig. 28A) resets the utility distribution system 1 upon initialization of the communications network 8, a failure in the communications network 8, a change in the utility distribution system 1, or a power down. A failure in the communications network 8 will be detected when an activity sensor at the female connector 196 ("end of loop") of the network controller 11 does not detect network activity when a signal is transmitted on the furniture arrangement network 36  
10 or when the network controller 11 makes repeated transmission without receiving an acknowledgement. Whenever the network controller 11 resets, the network controller initiates a reset sequence to determine the relative location of utility appliances 13-28 and communication modules 75 in the system. The first action taken by network controller 11 upon reset is to suspend the heartbeat for about four seconds. This will  
15 insure that all bridge modules 75A (Fig. 28B) in network 8 are reset, and will also result in utility appliances 13-28 connected to bridge modules 75A resetting as described hereinbelow.

The network controller 11 (Fig. 28B) and bridge modules 75A each initiate a sequence on the identifier channel 131 to determine the number of downstream  
20 identification modules 75B between it and a next sequential bridge module 75A or controller 11. The bridge modules 75A also check the status of the configuration channel 132 to determine if any upstream first-portion-in-workstation switches 9, associated with it or a connected upstream identification module 75B, is closed, so as to ascertain if they are a first bridge module 75A in a workstation. Bridge modules  
25 75A will also attempt to reconstruct the utility appliances 13-28 attached to the utility appliance network 37 associated therewith as described briefly above, and in greater detail hereinbelow.

The utility appliances 13-28 upon being reset, attempt to establish a connection, which shall be referred to herein as a virtual circuit, communication  
30 connection with the network controller 11, for the purpose of sending their control programs to the network controller 11. In the preferred embodiment, the control programs are written in a dialect of the FORTH program language, which is an

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interpreted language, but any suitable programming language could be utilized, including a compiled language.

After reset, the data channel 130 (Fig. 28B) of the furniture arrangement network 36 is broken into respective segments by relay switches 136, 137 associated with each bridge module 75A. One bridge module 75A, and any number of sequential identification modules 75B, are included in each segment. After suspending the heartbeat for approximately four seconds, the network controller 11 re-enables the heartbeat, but disables any reset that might be caused by a network activity sensor on the female connector 196 failing to detect network activity. The network controller 11 then sends a configuration message addressed to any unconfigured bridge module 75A on the furniture arrangement network 36. At this stage, the data channel 130 of the furniture arrangement network 36 is segmented, so that there is only one unconfigured bridge module 75A on the furniture arrangement network that will receive this message. The message includes information that this unconfigured bridge module 75A is bridge module number one. Bridge module number one then closes its relay switches 136, 137, reconnecting the data channel of the furniture arrangement network 36 to the next segment. Bridge module number one also determines the number of identification modules 75B associated therewith, and responds to the configuration message with the number of identification modules 75B determined and the status of the first-portion-in-workstation channel 131.

Upon receiving this configuration response message from bridge number one, the network controller 11 then sends a configuration message addressed to any bridge module 75A on the furniture arrangement network 36. This message indicates that the unconfigured bridge module 75A is network bridge number two. At this stage, bridge module number one has joined the network controller segment with the next segment, so that there are two bridge modules 75A on the furniture arrangement network 36. Network bridge number one is already configured, so it does not respond to the new configuration message. The second network bridge module 75A is the only unconfigured bridge module 75A on the data channel, so it responds to the configuration message by closing its relay switches 136, 137, reconnecting the data channel of the next downstream segment, and responds to the network controller 11 with a configuration response message. The configuration response message includes the number of identification modules 75B that are associated with the second bridge

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module (between it and the next bridge module 75A or controller 11), and the status of the first-portion-in workstation switches 9 on channel 132. The network controller 11, upon receiving this configuration response message, will send a new configuration message identifying the next unconfigured bridge module 75A as bridge module  
5 number three. The procedure continues in a similar fashion as that described above with respect to bridge modules number one and two, until all bridge modules 75A on the furniture arrangement network 37 are configured.

After the network controller 11 has received the configuration response message from the last bridge module 75A, the network controller 11 sends a final  
10 configuration message addressed to any unconfigured bridge modules on the furniture arrangement network 36. Since all bridge modules 75A have been configured, the message will not generate any configuration response message. The software associated with network controller 11 then checks whether the configuration message has generated any activity at the female connector 196 of the network controller.

15 Normally, this will be the case, since all bridge modules 75A on the data channel 130 of the furniture arrangement network 36 will now form a single complete loop from the male connector 196 to the female connector 196 of the network controller 11. The network controller 11 then rearms the activity sensor on the female connector 196, so that any failure to detect activity while sending a message will cause a reset  
20 of the network controller 11, as described hereinbelow.

If activity is not detected at the female connector 196 when the final configuration message is sent, network controller 11 identifies a fault condition, and assumes that there is some problem either with one of the bridge modules 75A or with the conductivity of the furniture arrangement network 36. Since network  
25 controller 11 has ascertained the total number of bridge modules 75A up to the fault in the initialization procedure, as well as the total number of modules 75B coupled to the counted bridge modules 75A, and since each of these bridge modules 75A and identification modules 75B corresponds to a furniture portion (e.g., a panel face), the network controller 11 can present, as diagnostic information, the sequential order  
30 number of the furniture component that is the most likely location of the fault.

Once this configuration of furniture arrangement network 36 is completed, the network controller 11 begins accepting virtual circuits between utility appliances 13-28 (Fig. 1) and the network controller, and loading and initializing control programs

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from them. Once all the control programs have been loaded and initialized, and all the bridge modules 75A have been configured, the system start-up phase is complete.

It is noted that communication between bridge module 75A (Fig. 28B) and network controller 11 is coordinated according to the ability of the network controller 11 to process information. This is accomplished by a sender (one of bridge module 75A or network controller 11) having a request to communicate, but delaying information transmittal until the receiver (the other one of network controller 11 and a bridge module 75A) is ready to receive the message. The ability to receive is communicated by an acknowledgement being communicated to the sender with a non-zero credit. A credit is the amount of information (e.g. number of words) that the receiver will accept from the sender.

In the forgoing description, it will be readily perceived by those skilled in the art that modifications may be made without departing from the concepts disclosed herein. Such modifications are to be considered included in the following claims, unless these claims by their language expressly state otherwise.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows.

1. In a furniture unit for modular furniture arrangements of the type in which a plurality of individual furniture units are positioned in a preselected configuration to form at least one workstation, the improvement of a utility distribution system therefore, comprising:

5 at least one signal conductor positioned in said furniture unit, and extending along at least a portion thereof;

first and second quick-disconnect connectors connected with opposite ends of said signal conductor, and configured to mate with like quick-disconnect connectors associated with other similarly equipped furniture units to define a communications  
10 network for the workstation;

a coupler positioned in said furniture unit, and connected with said signal conductor at a location operably intermediate said first and second quick-disconnect connectors; and

a signaler physically associated with said furniture unit, and connected with  
15 said signal conductor at said coupler, and communicating through said signal conductor and the communications network to facilitate the controlled distribution of utilities to the workstation.

2. A utility distribution system as set forth in claim 1, including:

a network controller operably coupled to said signal conductor through said communications network, and transmitting control signals to said signaler through said communications network and receiving control signals from said signaler through said  
5 communications network to evaluate at least one of said communications network and said furniture unit to facilitate the distribution of utilities to the workstation.

3. A utility distribution system as set forth in claim 2, wherein:

said signal conductor, said coupler, and said signaler are integrally interconnected to define a communication module shaped to be received along an associated raceway portion of said furniture unit.

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4. A utility distribution system as set forth in claim 3, including:  
at least one utility appliance coupled to said signal conductor through said  
signaler, and storing operating instructions for said utility appliance which are  
transmitted to said network controller when said utility appliance is initialized, such  
5 that said network controller controls said utility appliance according to said operating  
instructions.
5. A utility distribution system as set forth in claim 4, wherein:  
said furniture unit includes at least one port, which is physically mounted  
thereon, and is operably connected with said coupler for distributing utilities  
therethrough to the workstation.
6. A utility distribution system as set forth in claim 5, wherein:  
said communications network defines a furniture arrangement network and a  
utility appliance network;  
said furniture unit includes a plurality of said ports which are connected with  
5 said coupler through said utility appliance network; and  
said signaler comprises a communication bridge between said furniture  
arrangement network and said utility appliance network.
7. A utility distribution system as set forth in claim 6, wherein:  
said furniture arrangement network comprises a plurality of said signal  
conductors interconnected to form an uninterrupted communication loop operably  
coupled to said network controller.
8. A utility distribution system as set forth in claim 7, wherein:  
each of said signal conductors has a length which is substantially equal to the  
width of its associated furniture unit, whereby said quick-disconnect connectors  
associated with adjacent furniture units are directly interconnected.
9. A utility distribution system as set forth in claim 8, wherein:  
said utility appliance network includes at least one conductor coupled to each  
of said ports on said furniture unit, and to said signaler.

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10. A utility distribution system as set forth in claim 9, wherein:  
said utility appliance is connected to the utility appliance network through one of said ports.
11. A utility distribution system as set forth in claim 10, wherein:  
said network controller includes means for implementing a communication protocol among said utility appliances.
12. A utility distribution system as set forth in claim 11, wherein:  
said furniture arrangement network includes an identification code corresponding to an associated portion of said furniture unit.
13. A utility distribution system as set forth in claim 12, wherein:  
said network controller supports a programming language which is used for controlling said utility appliances.
14. A utility distribution system as set forth in claim 13, wherein:  
each of said utility appliances includes a storage element storing control routines which are transmitted to said network controller when said utility distribution system is initialized.
15. A utility distribution system as set forth in claim 14, wherein:  
said signaler includes an identification mechanism to facilitate identifying a sequentially first signaler in the workstation.
16. A utility distribution system as set forth in claim 15, wherein:  
said signaler includes a first-portion-of-workstation identification mechanism to positionally associate a plurality of said furniture units within a given workstation.
17. A utility distribution system as set forth in claim 16, wherein:  
each of said utility appliances includes a utility appliance type identification embedded in its utility appliance memory which is transmitted to said network controller upon initialization.

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18. A system for evaluating a modular furniture arrangement having a plurality of individual furniture units configured to form at least one workstation, comprising:

at least one conductor extending along at least a portion of the furniture arrangement to define a communications network;

5 a signaler connected to said conductor, and adapted for physical association with at least one of the furniture units; and

a network controller coupled to said conductor for transmitting control signals to said signaler through said conductor and receiving control signals from said signaler through said conductor, whereby said network controller evaluates the  
10 furniture arrangement to facilitate the distribution of utilities to the workstation.

19. A utility distribution system for a modular furniture unit of the type having at least two portions thereof associated with different workstations, comprising:

a first communication module physically associated with one of said furniture portions, and including a first signal conductor extending at least partially along said  
5 one furniture portion; a first pair of quick-disconnect connectors connected with opposite ends of said first signal conductor, and configured to mate with like quick-disconnect connectors associated with other similarly equipped furniture portions; and a first coupler positioned adjacent said one furniture portion and connected with said first signal conductor at a location operably intermediate said first pair of quick-  
10 disconnect connectors; and

a second communication module physically associated with the other of said furniture portions, and including a second signal conductor extending at least partially along said other furniture portion; a second pair of quick-disconnect connectors connected with opposite ends of said second signal conductor, and configured to mate  
15 with like quick-disconnect connectors associated with other similarly equipped furniture portions; and a second coupler positioned adjacent said other furniture portion and electrically connected with said second signal conductor at a location operably intermediate said second pair of quick-disconnect connectors, whereby said  
20 first and second communication modules each provide a respective communication path through both portions of said furniture unit to individually control the distribution of utilities to both of the different workstations.



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20. A communications network for a plurality of furniture units, comprising:  
at least one signal conductor configured to extend along the furniture units;  
at least one signaler associated with at least one of the furniture units, and  
being operably coupled to said signal conductor; and

5 a network controller operably coupled to said signal conductor for  
communicating with said signaler, whereby said network controller and said signaler  
communicate information associated with the furniture units through said signal  
conductor.

21. A network for a furniture arrangement, comprising:  
at least one signal conductor extending along the furniture arrangement;  
a network controller connected to said signal conductor and including control  
circuitry; and

5 at least one utility appliance coupled to said signal conductor for  
communicating with said network controller, and including a memory unit storing  
operating instructions therefore which are transmitted to said control circuitry of said  
network controller when said utility appliance is initialized, whereby said network  
controller controls said utility appliance according to the operating instructions  
10 received therefrom.

22. In a furniture unit for modular furniture arrangements of the type in which a  
plurality of individual furniture units are positioned in a preselected configuration to  
form at least one workstation, the improvement of a utility distribution system  
therefore, comprising:

5 at least one signal conductor positioned in said furniture unit, and extending  
generally between opposite sides thereof;

a coupler positioned in said furniture unit, and connected with said signal  
conductor at a location within said furniture unit;

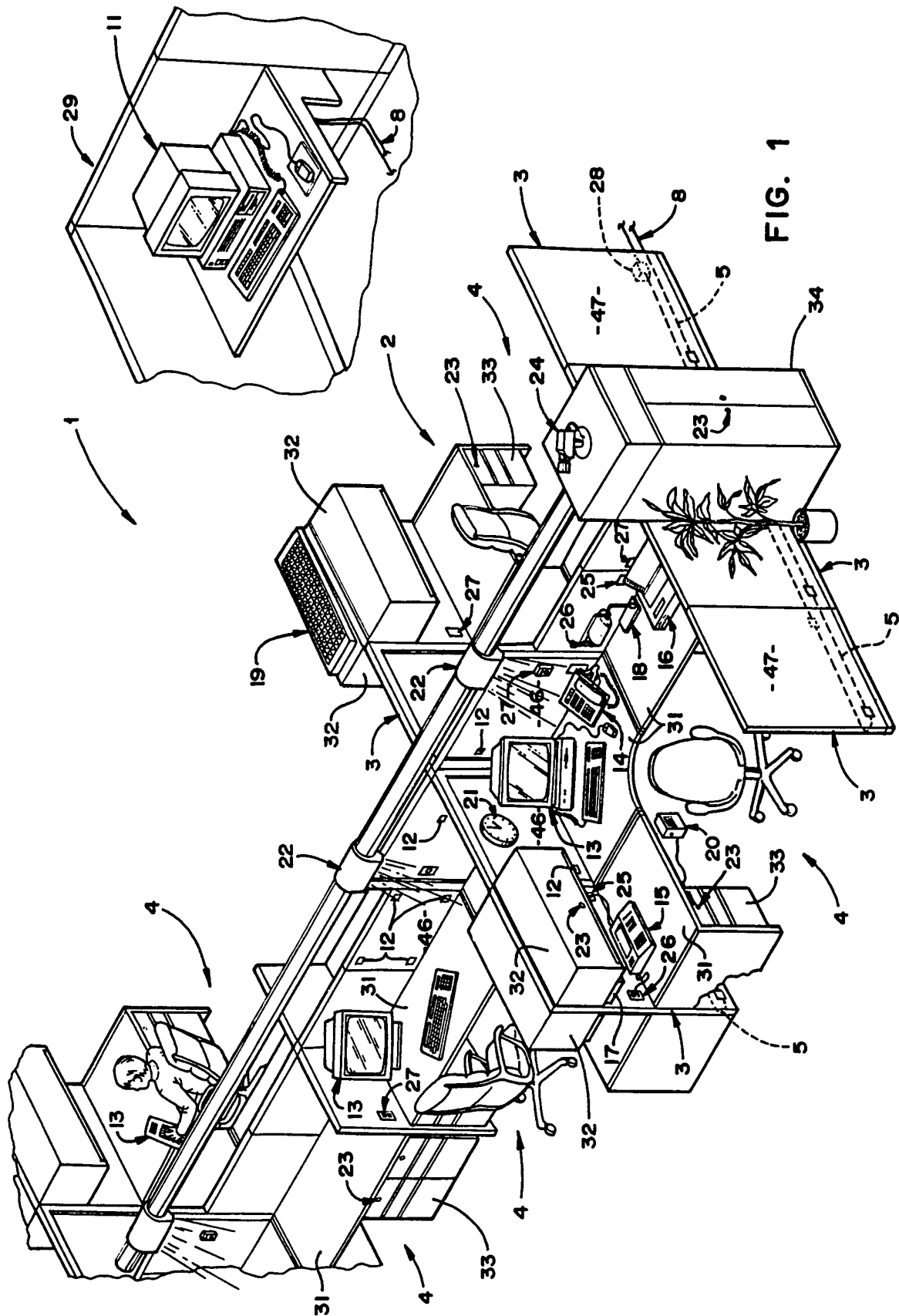
a utility appliance network positioned within said furniture unit and coupled to  
10 said signal conductor through said coupler; and

at least one port physically positioned on said furniture unit and operably  
connected with said utility appliance network, whereby said port is coupled to said

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signal conductor through said utility appliance network to facilitate the distribution of utilities to the workstation.

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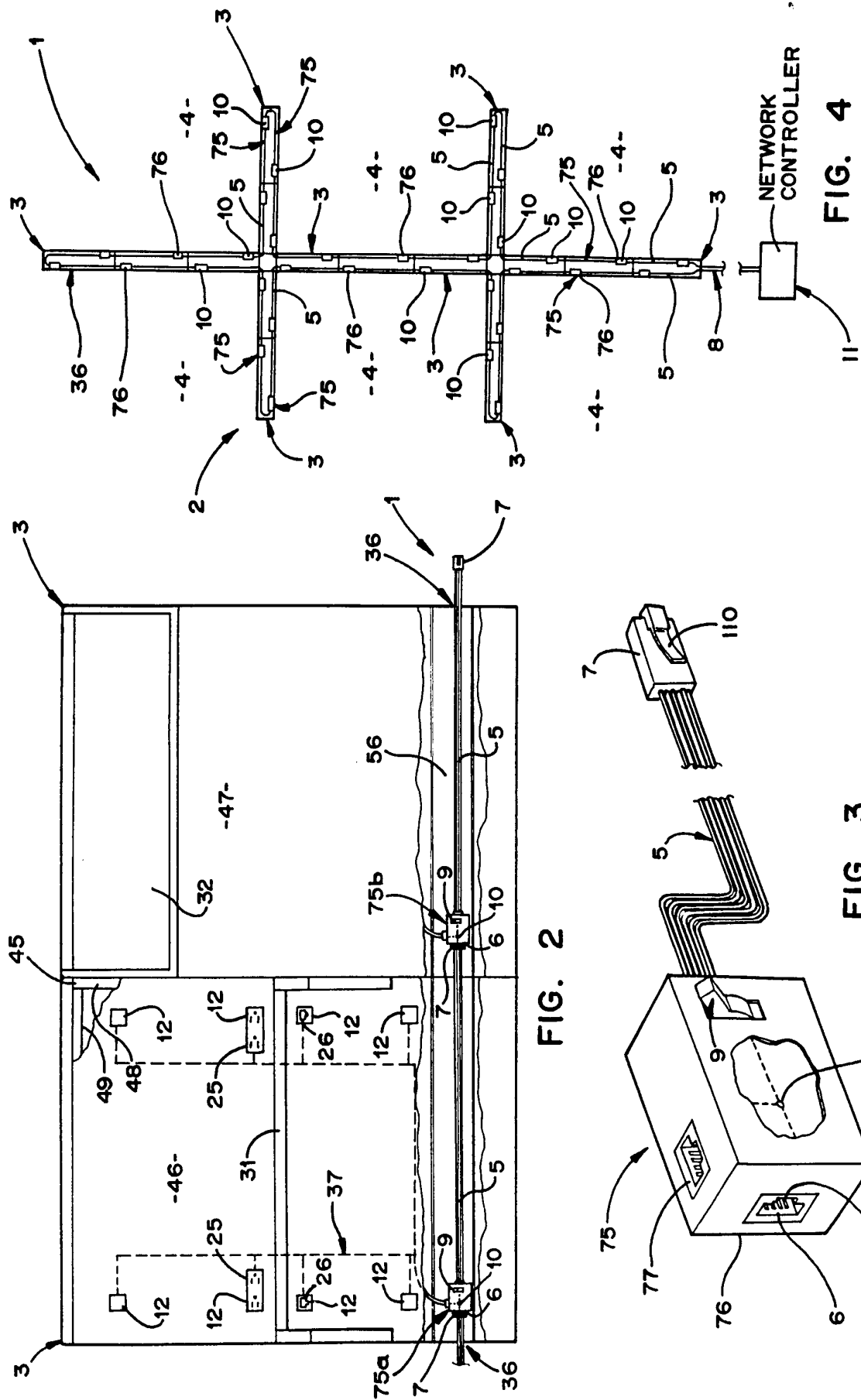
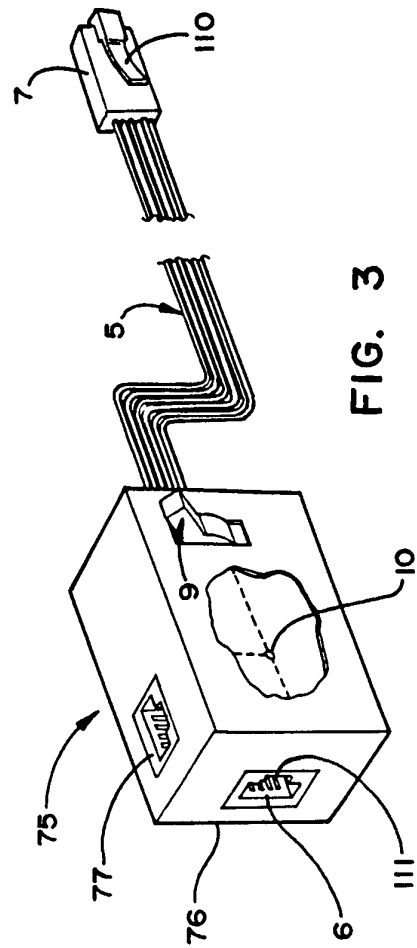
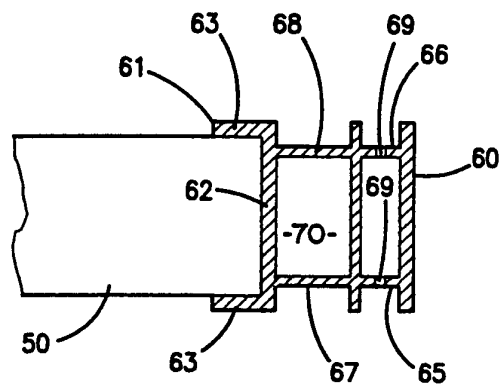
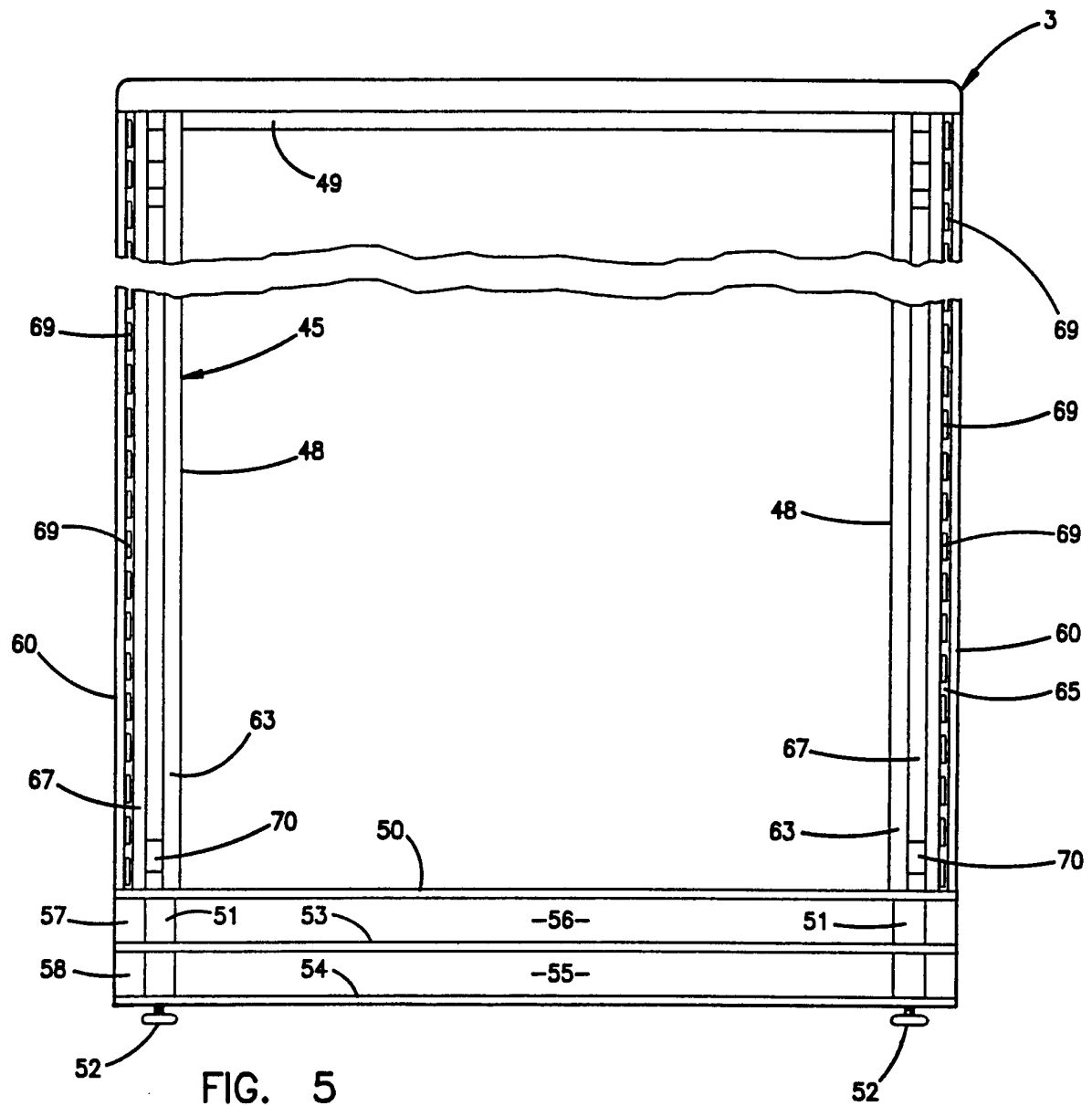


FIG. 2

FIG. 3

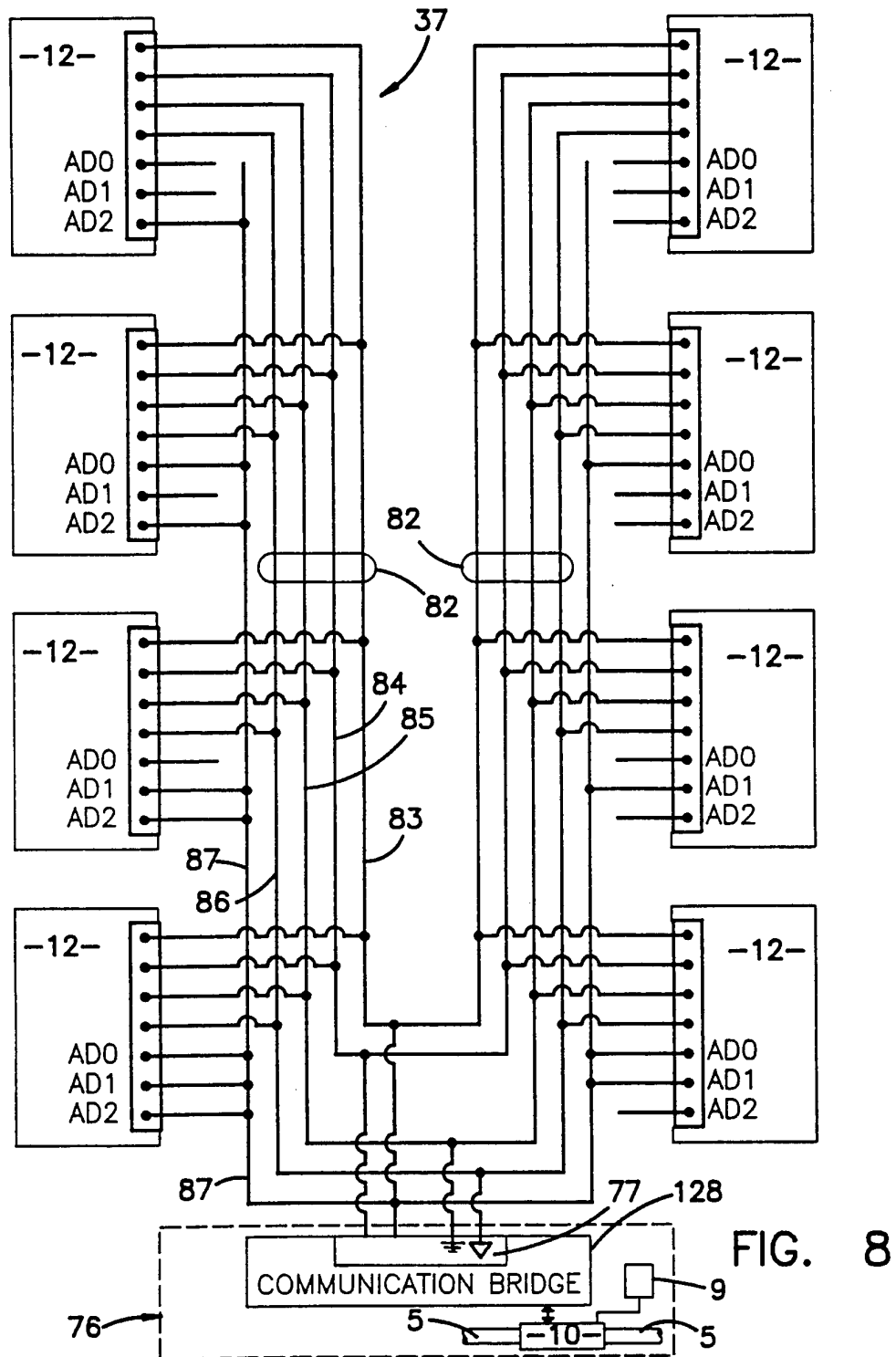


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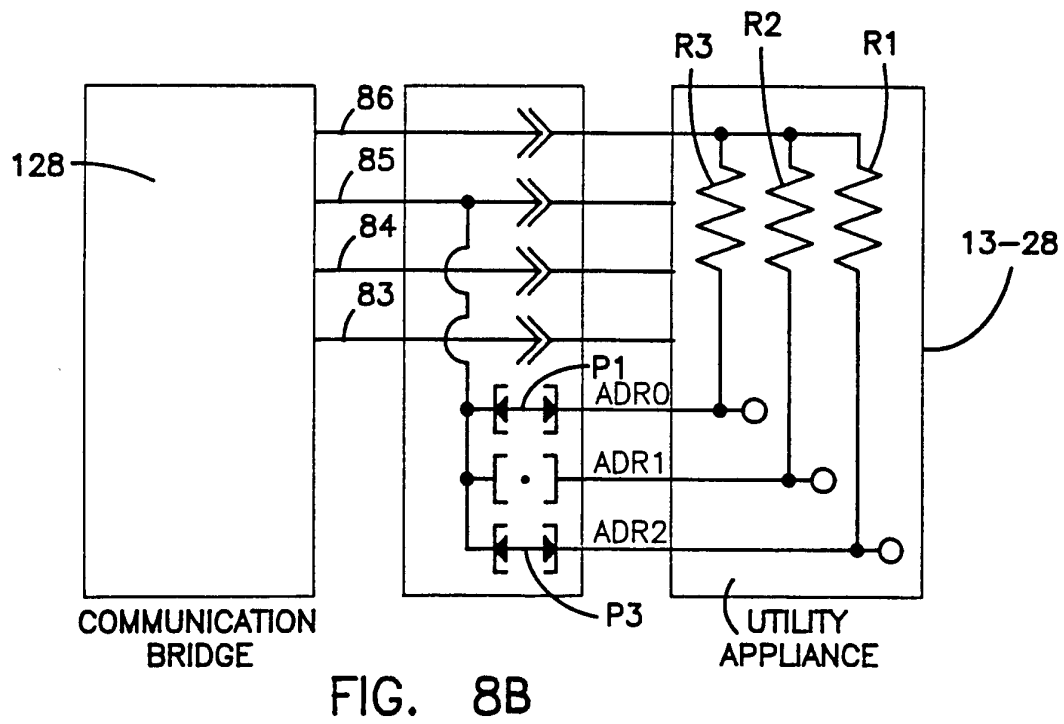
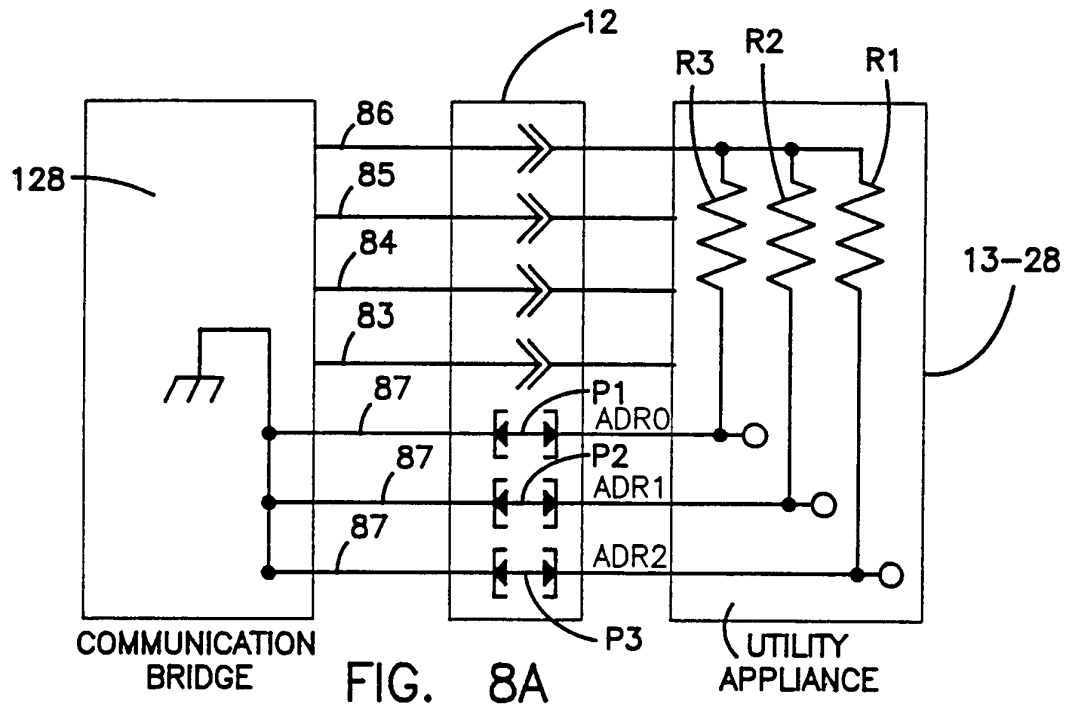




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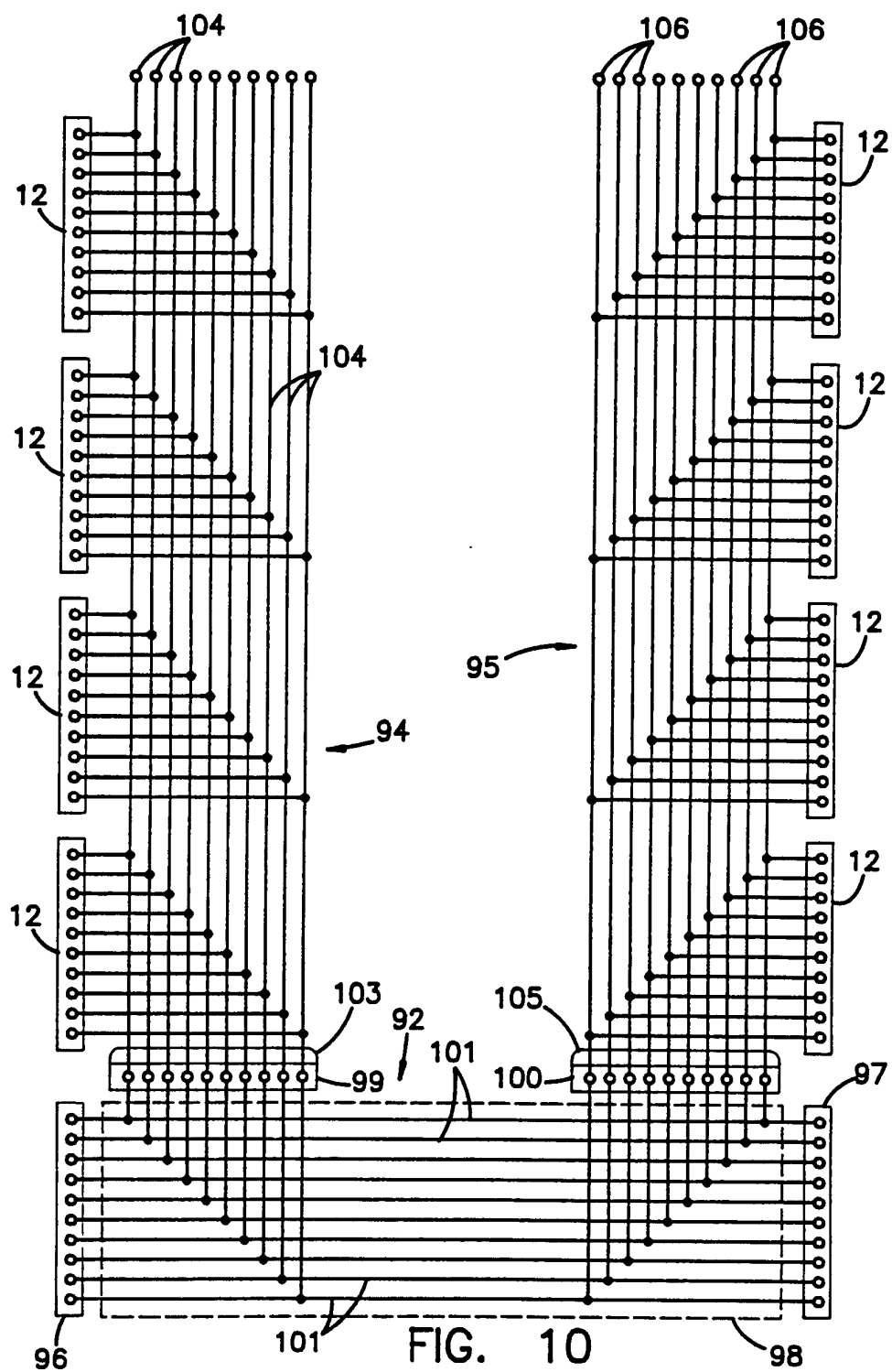
6/51







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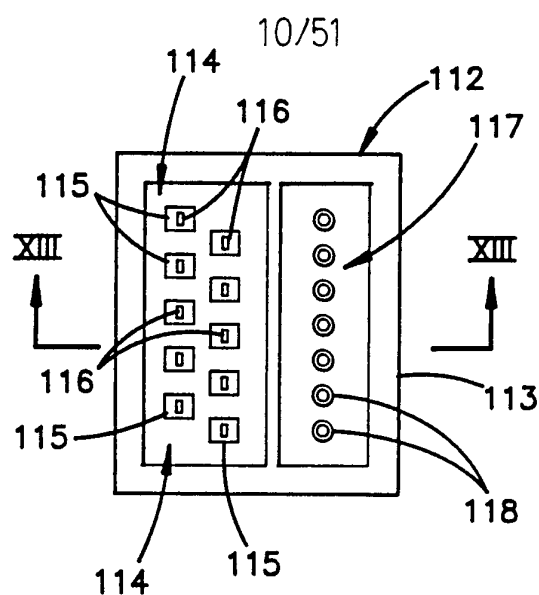


FIG. 12

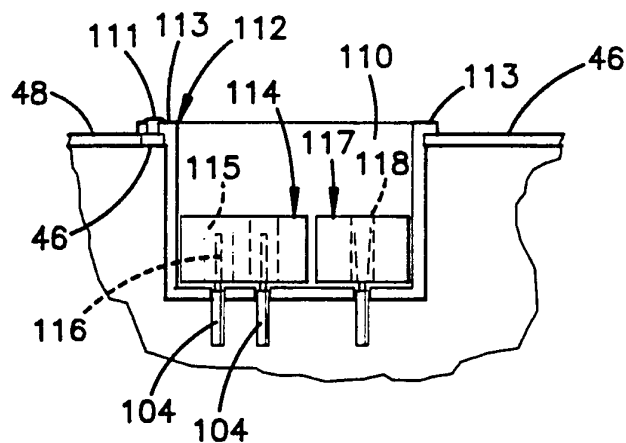


FIG. 13

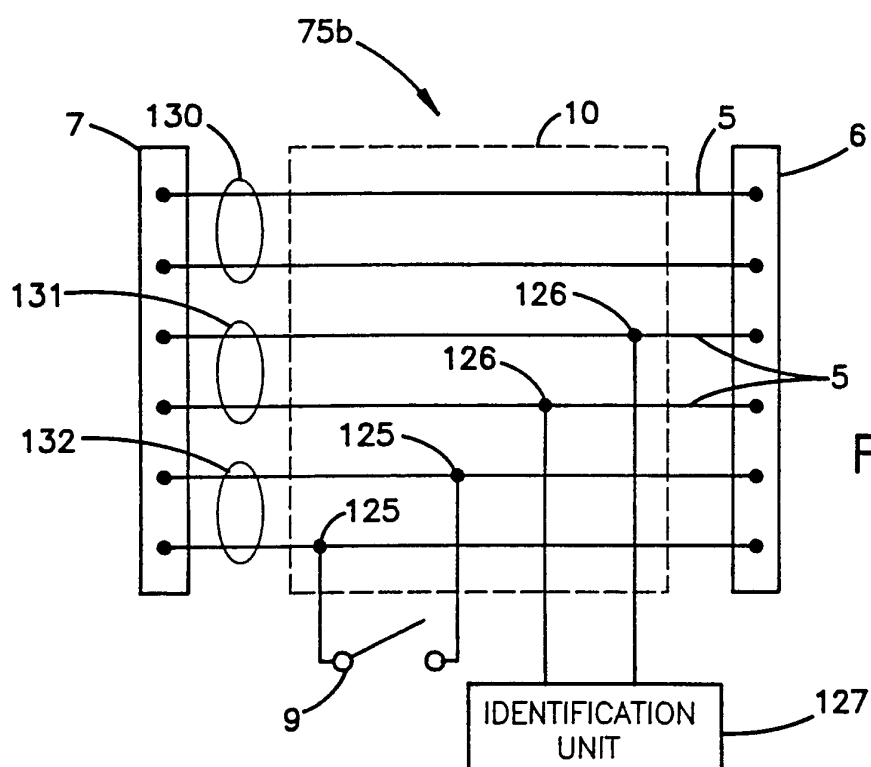
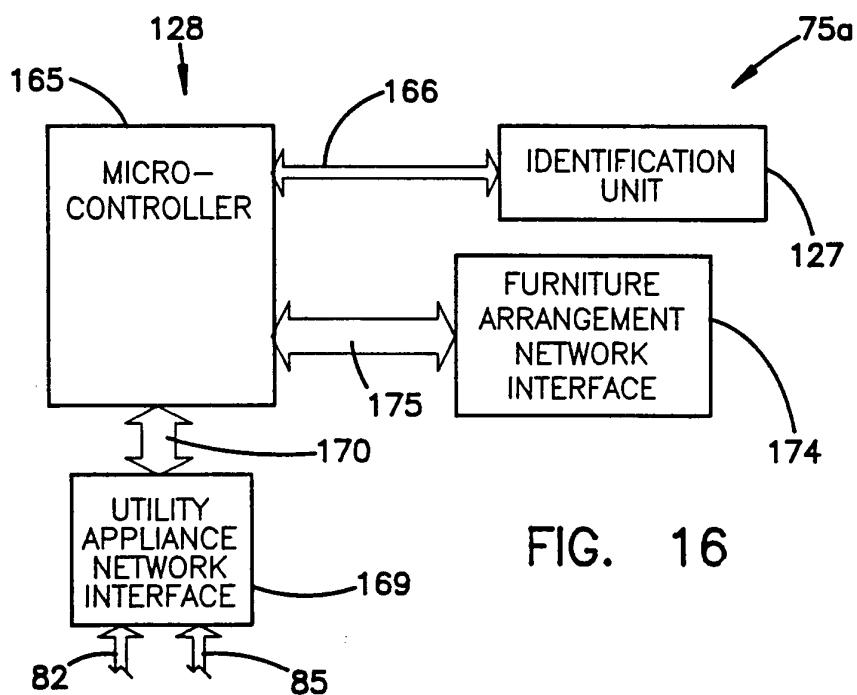
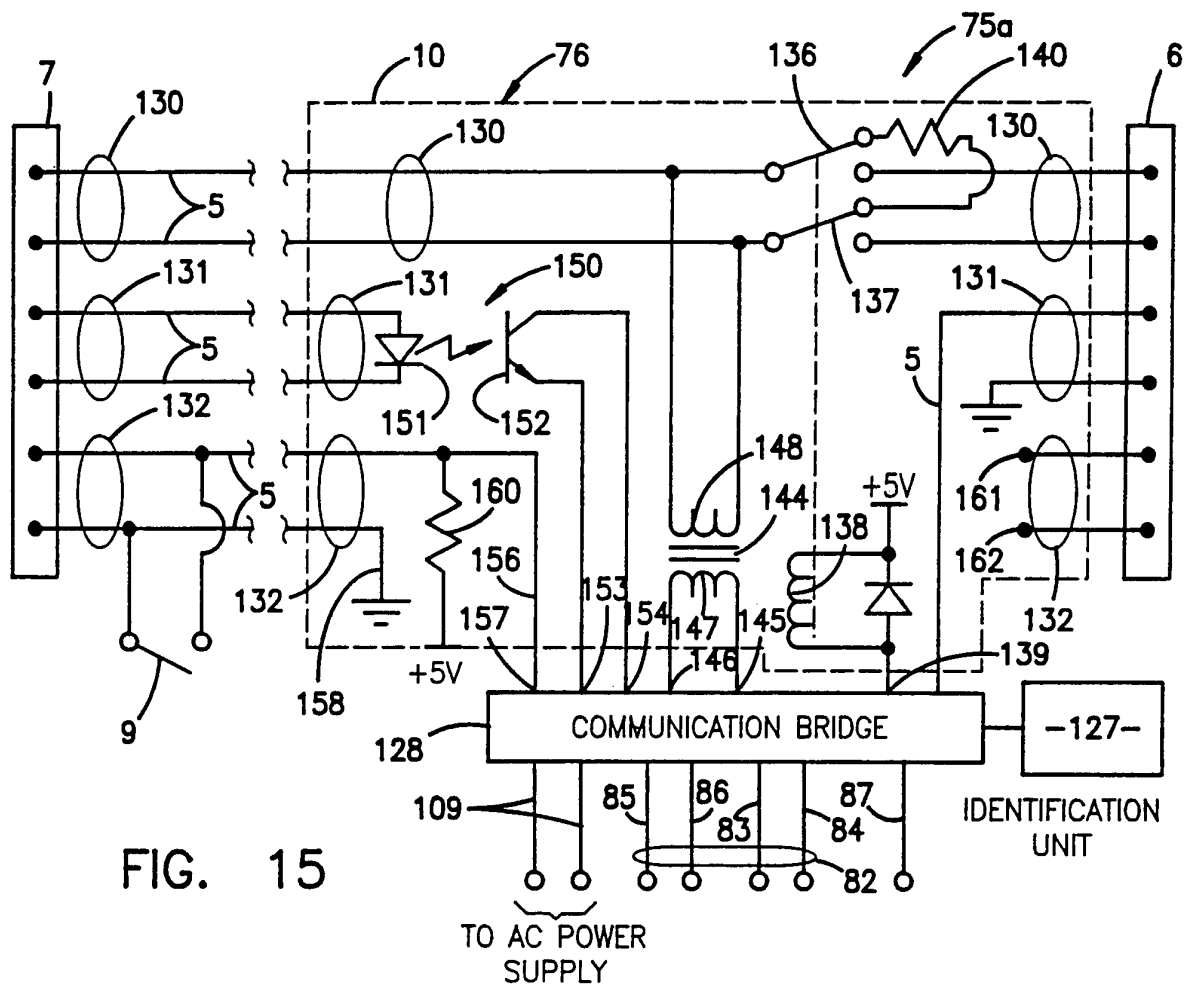
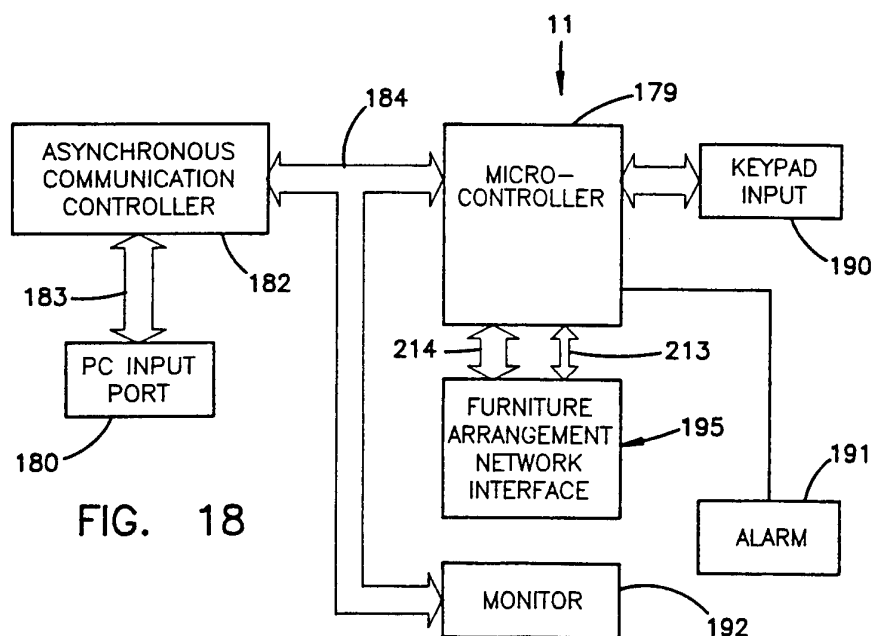
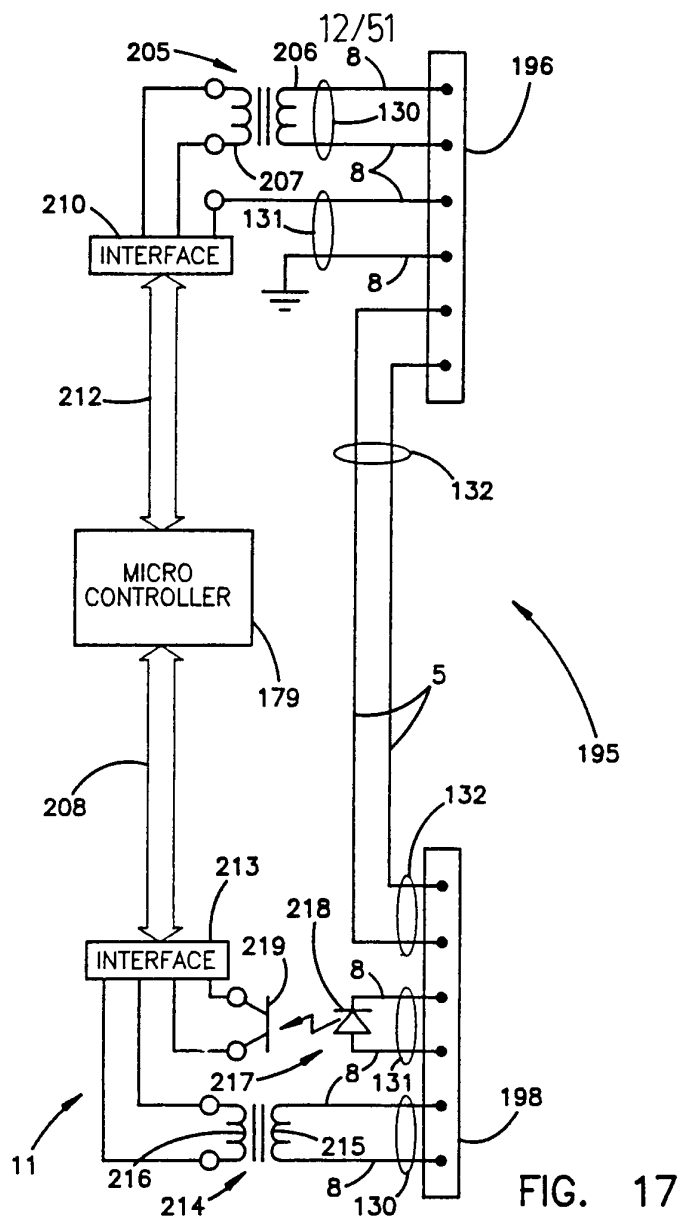


FIG. 14

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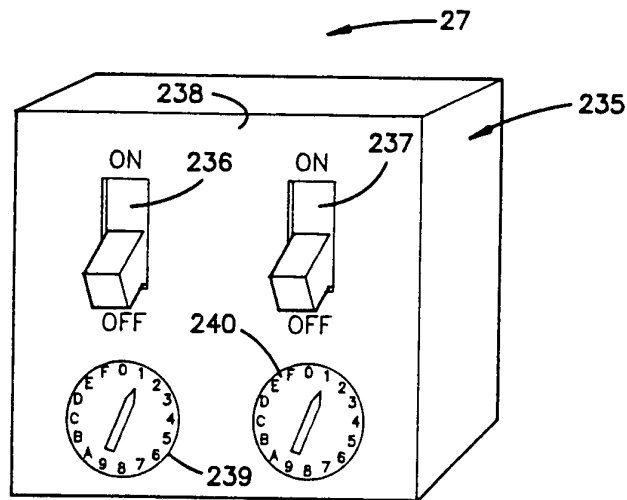


FIG. 19

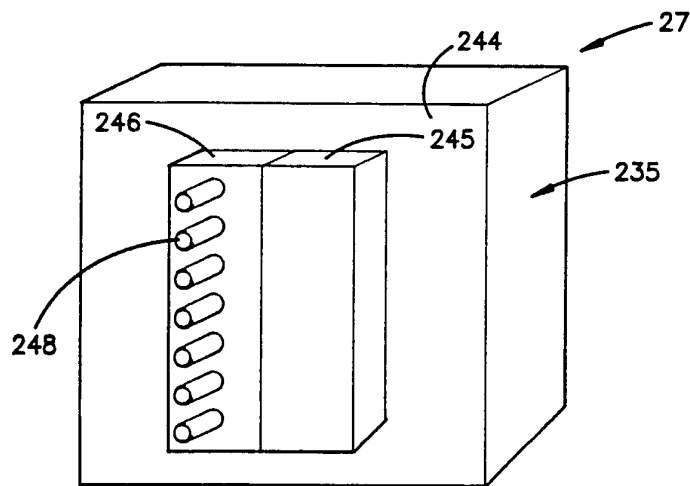


FIG. 20

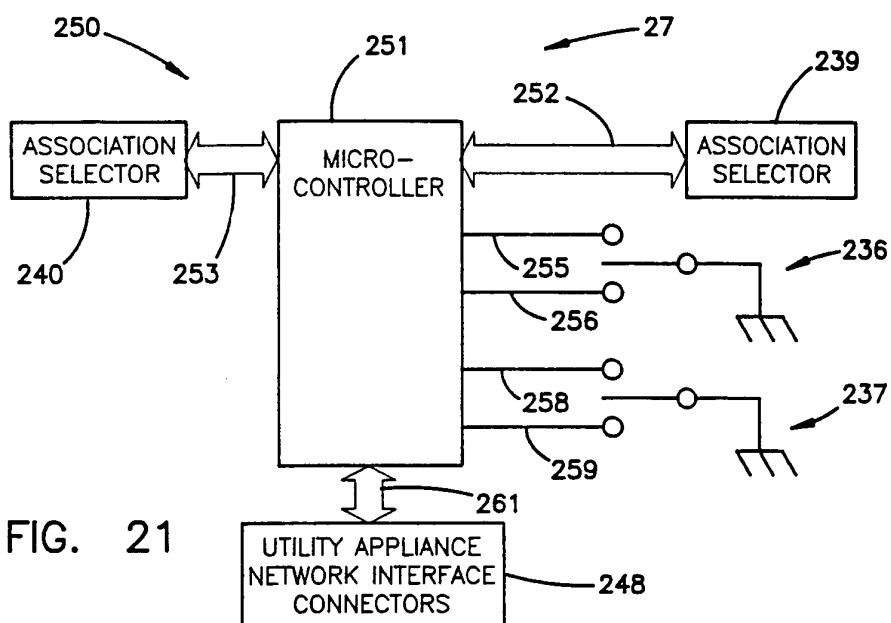
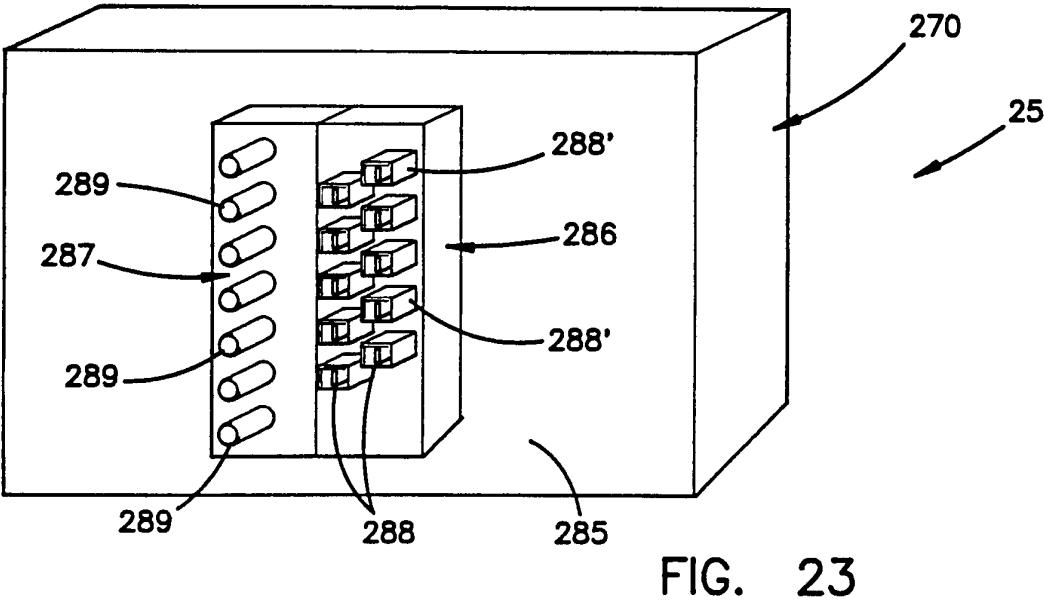
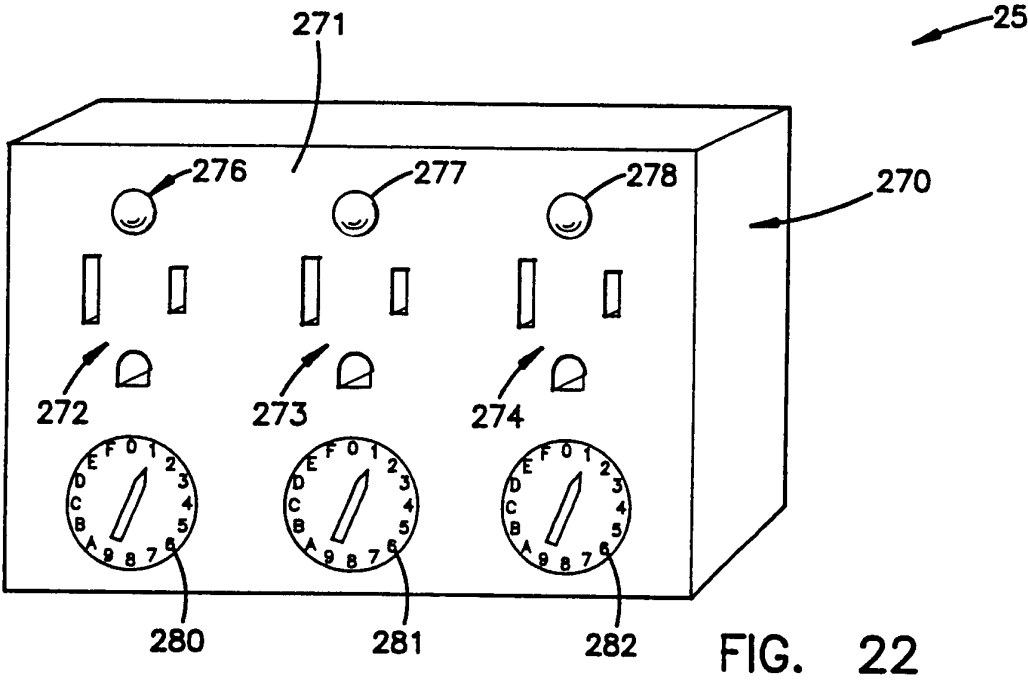


FIG. 21





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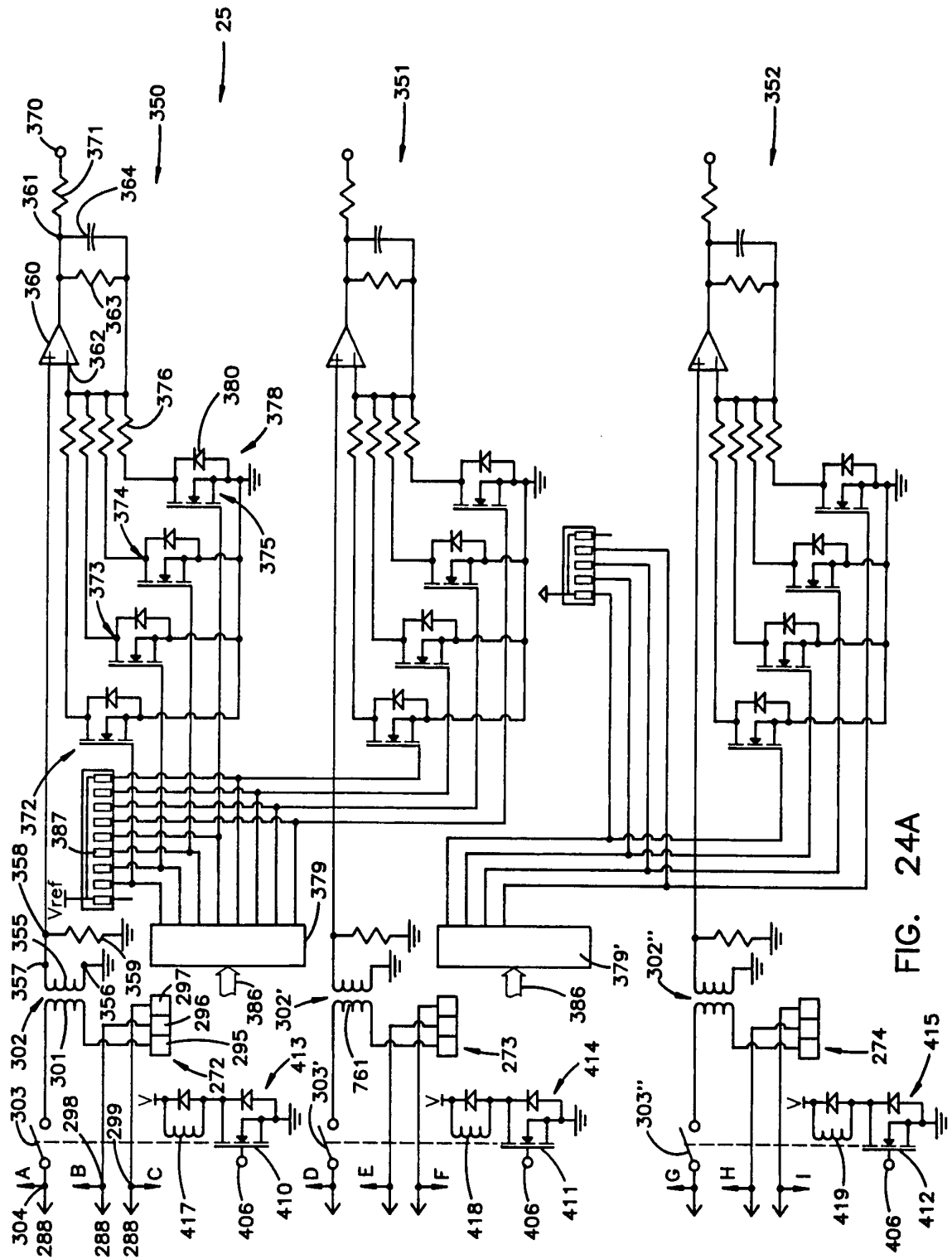


FIG. 24A

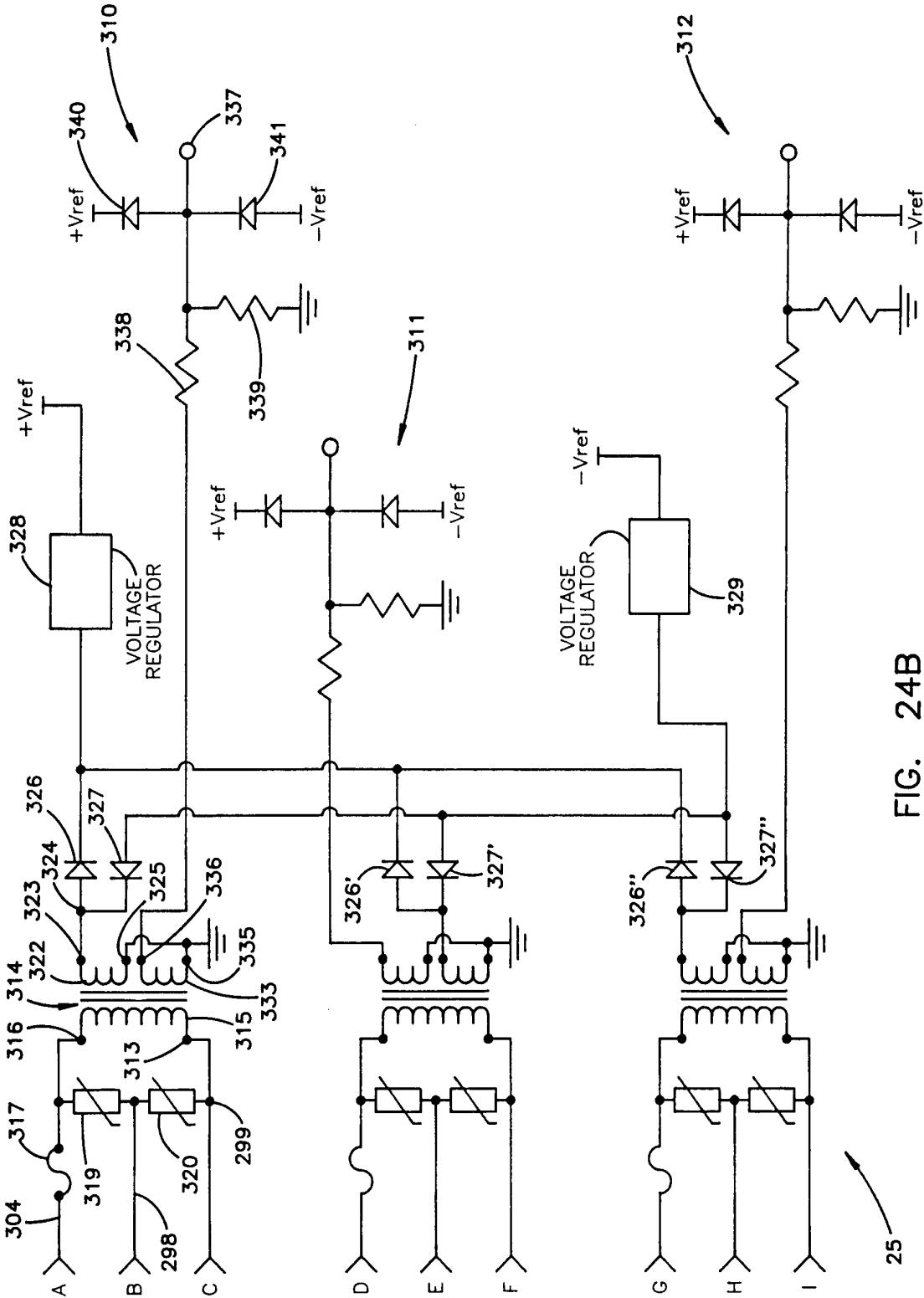
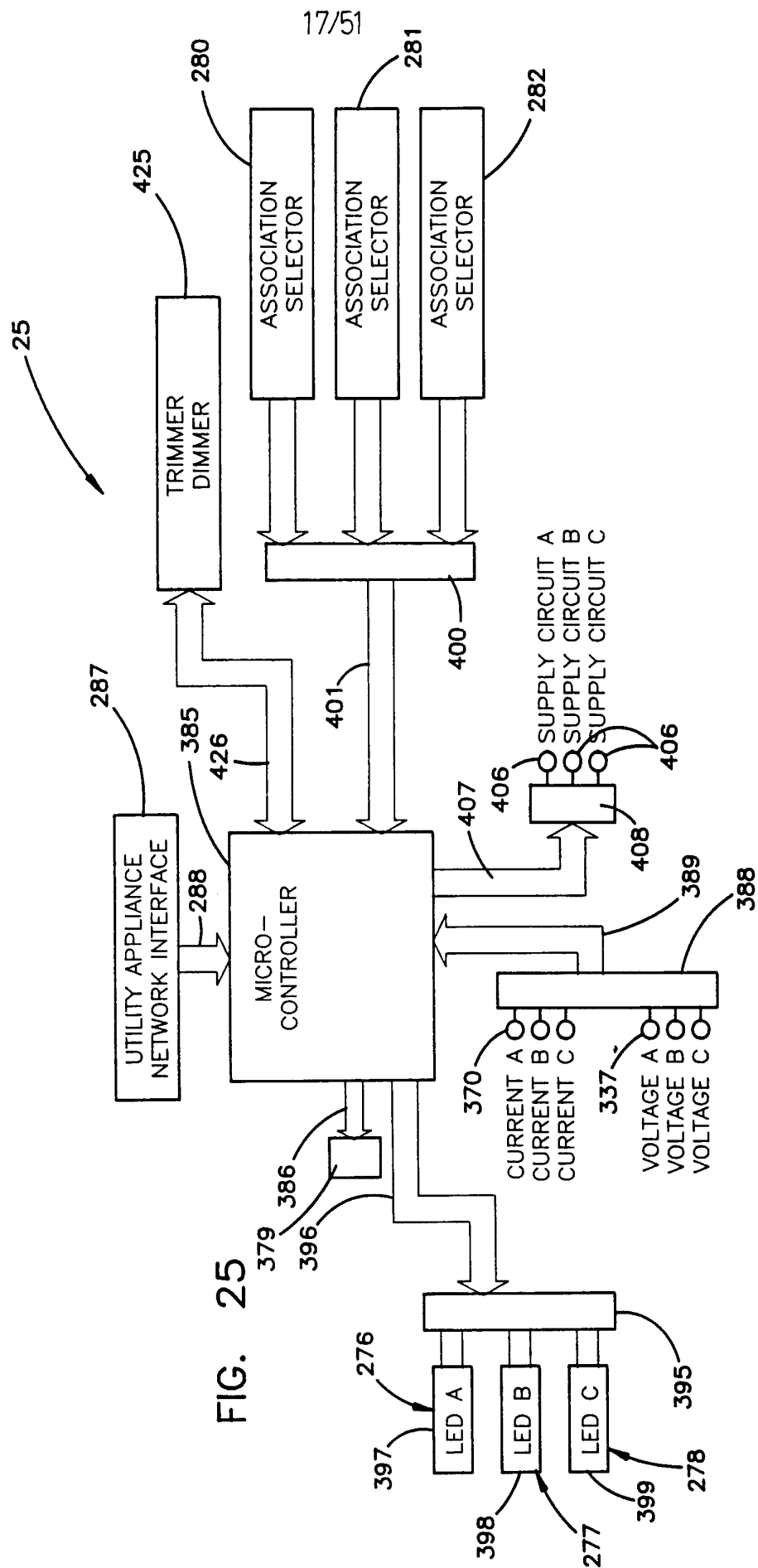


FIG. 24B



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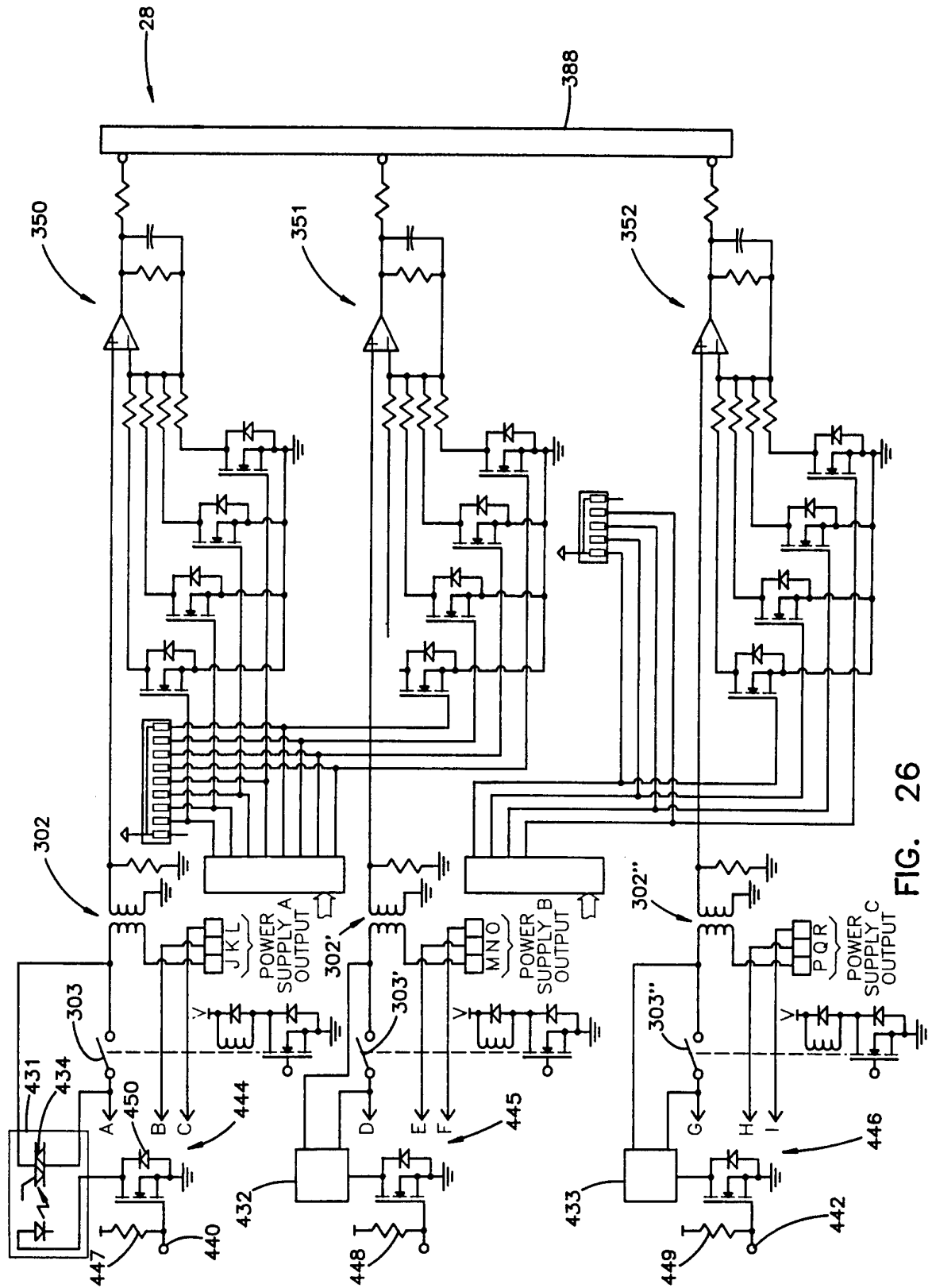


FIG. 26

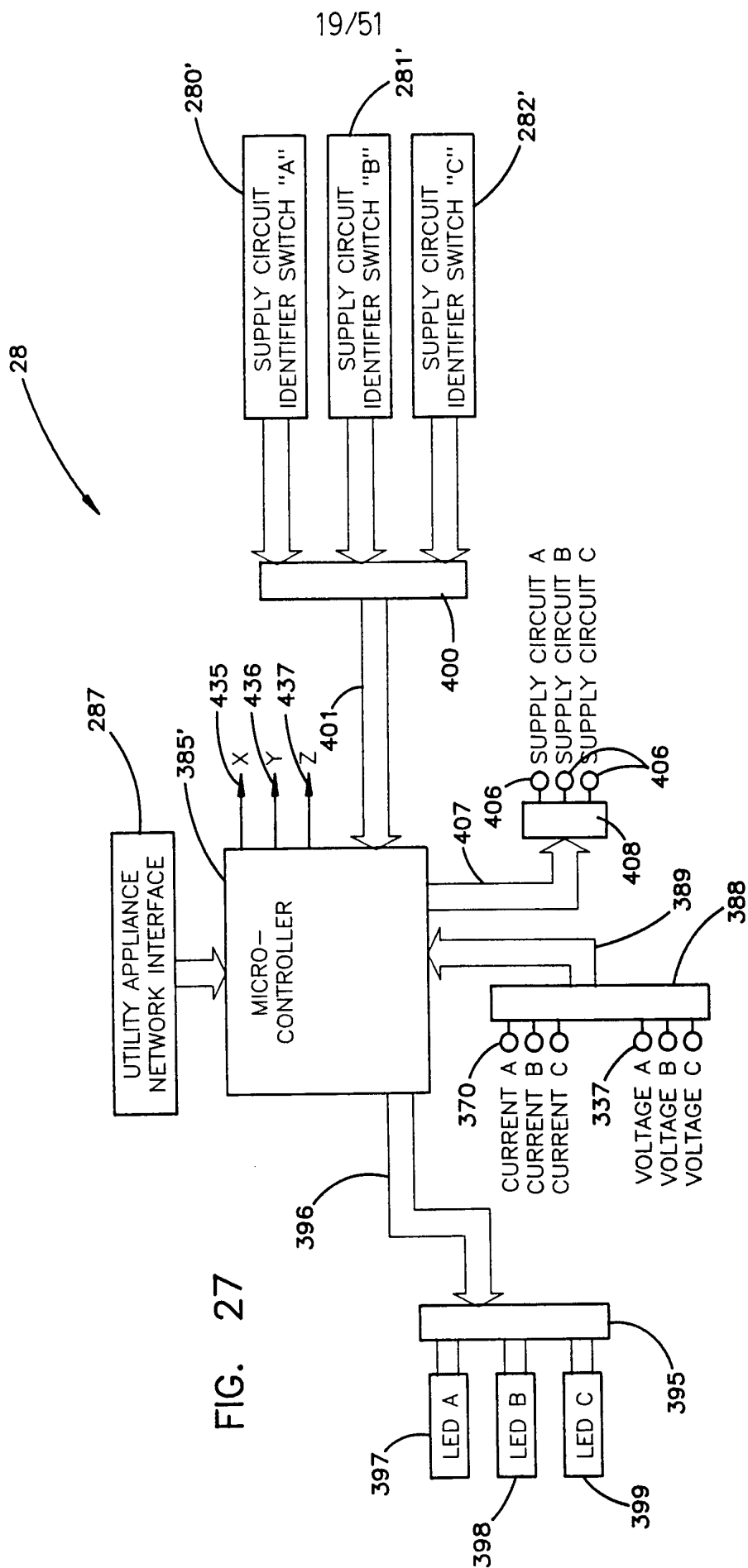


FIG. 27

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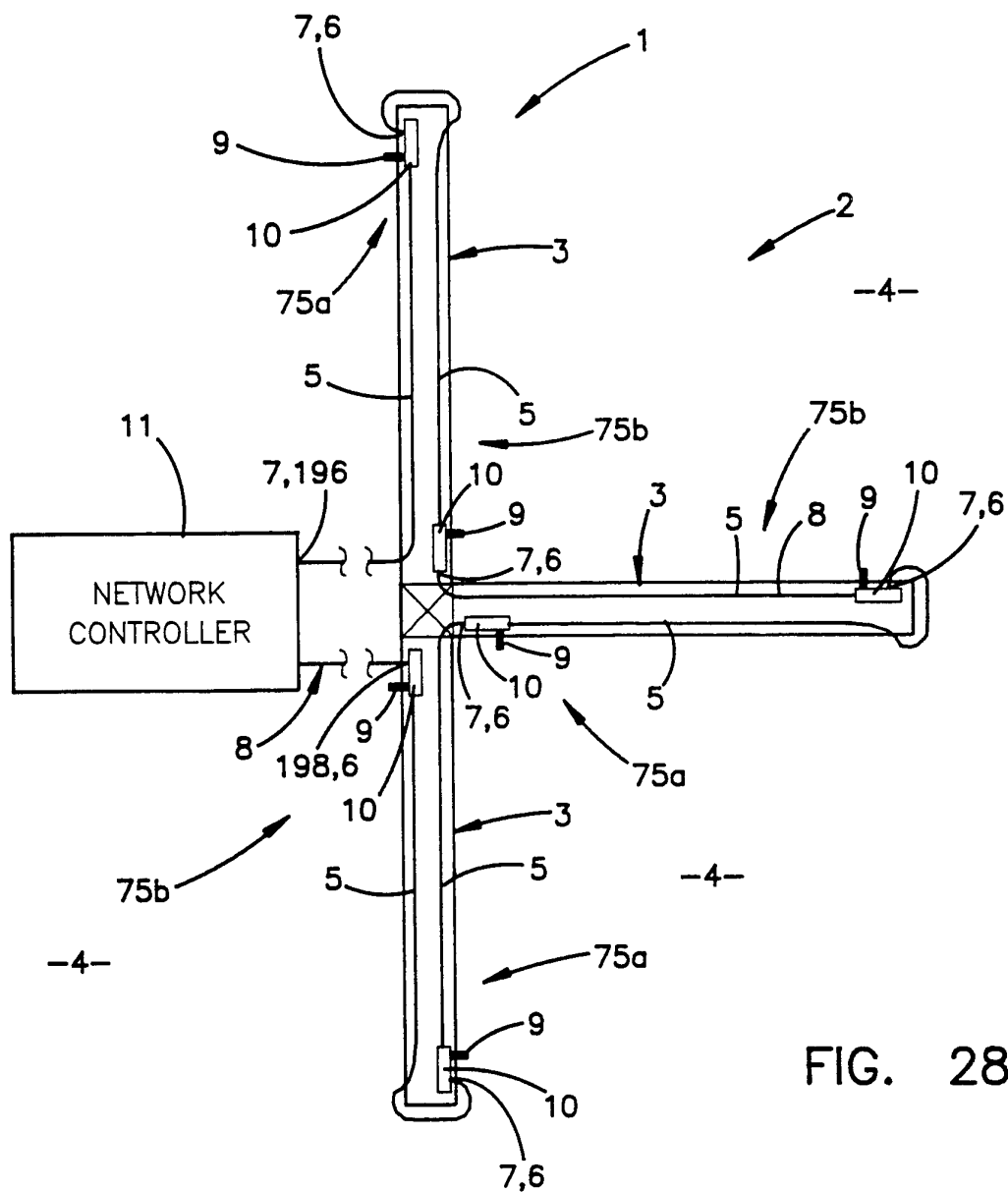


FIG. 28A

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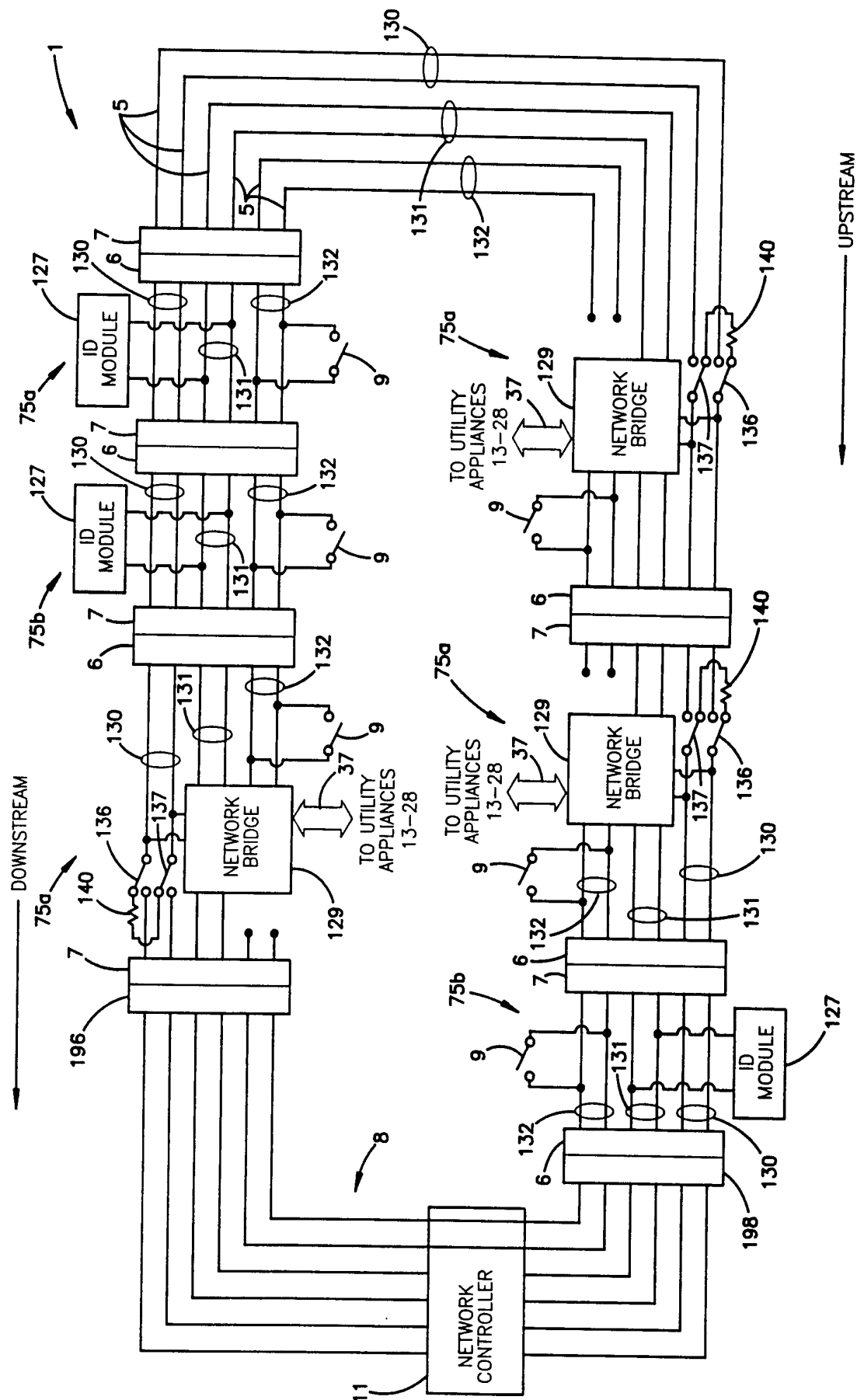


FIG. 28B

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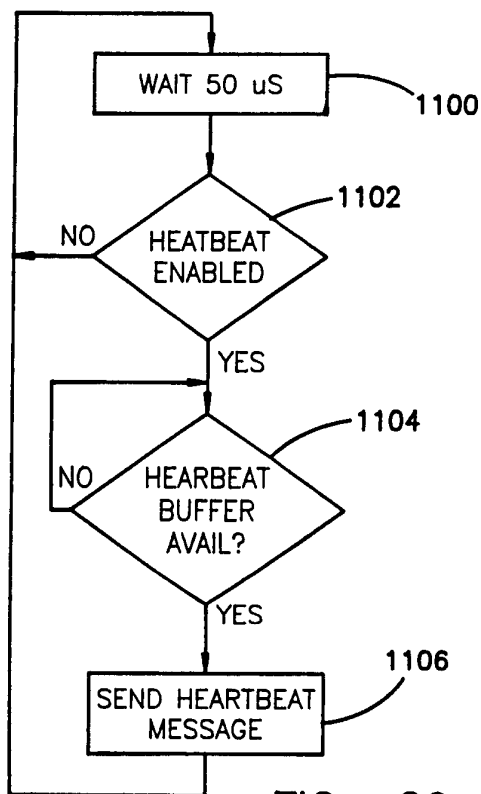


FIG. 29

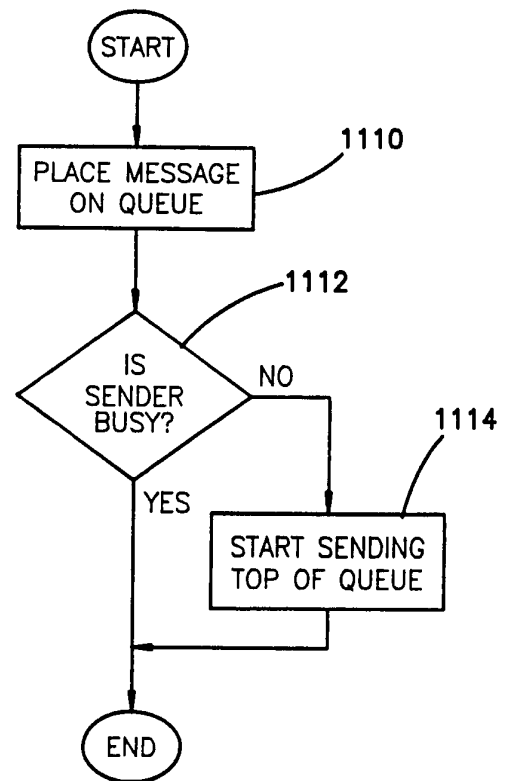


FIG. 30

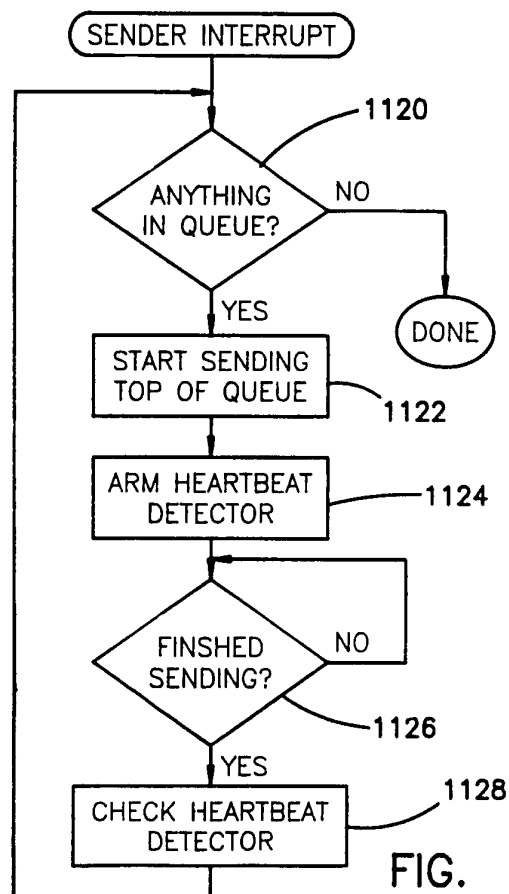


FIG. 31



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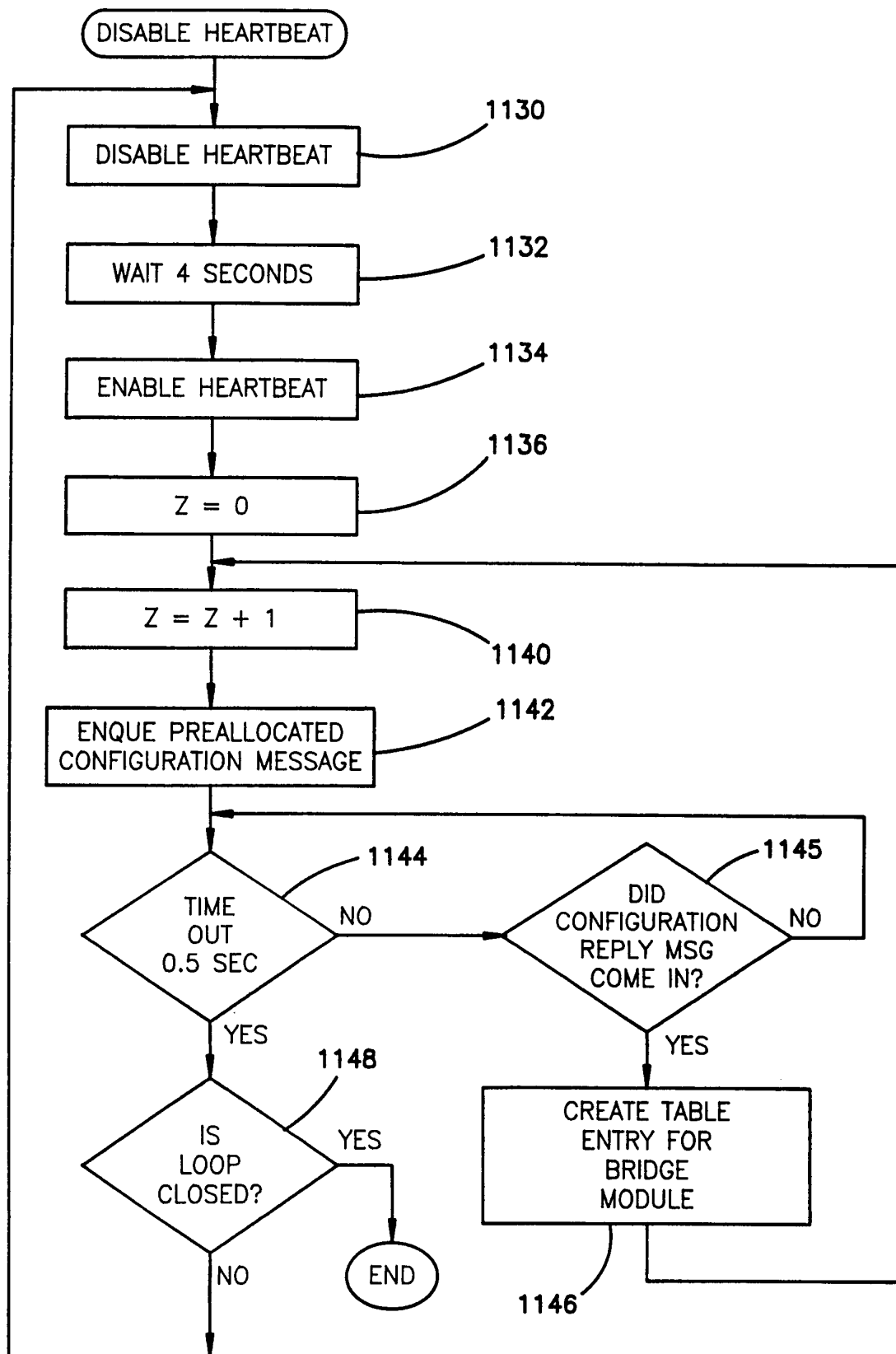


FIG. 32

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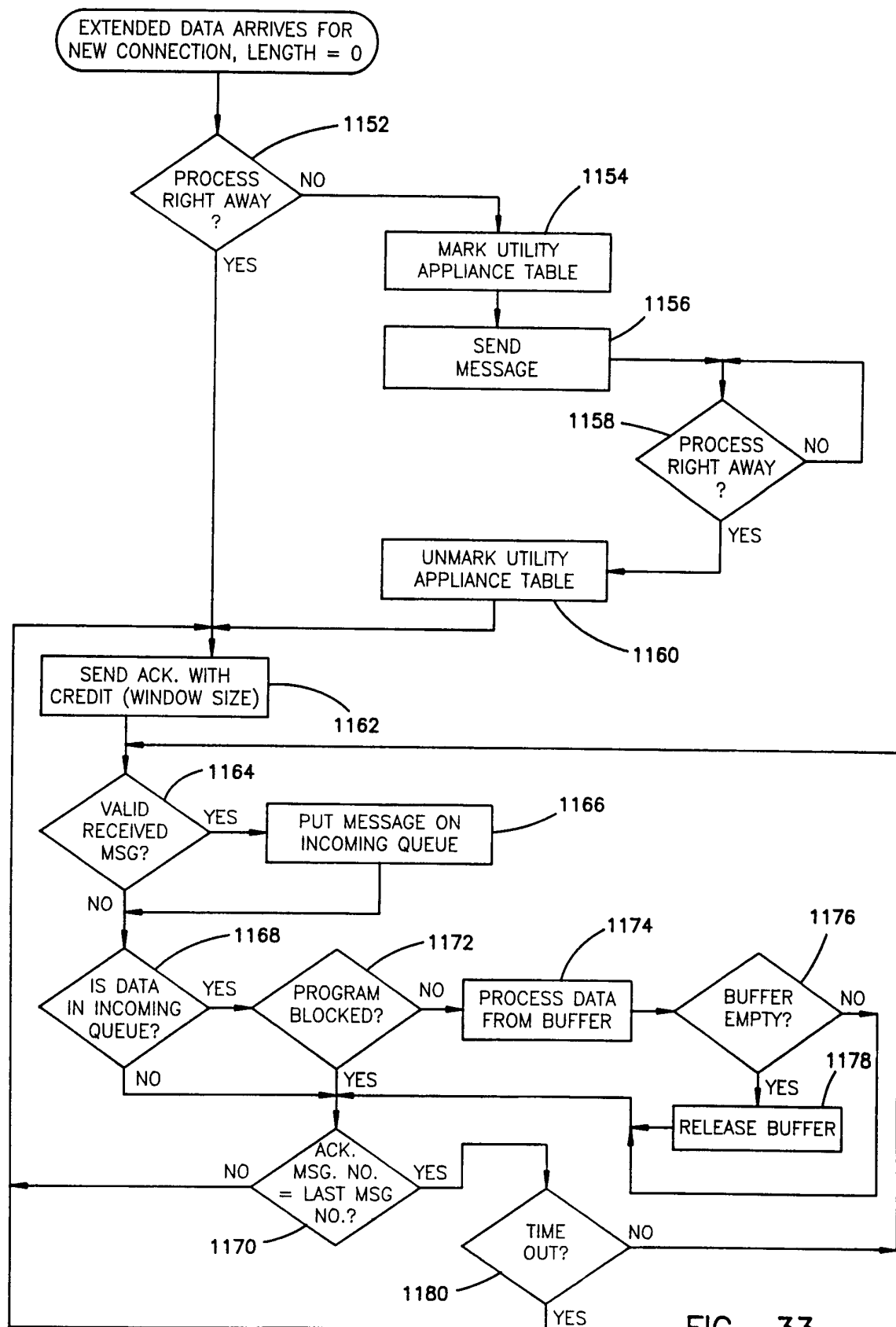


FIG. 33

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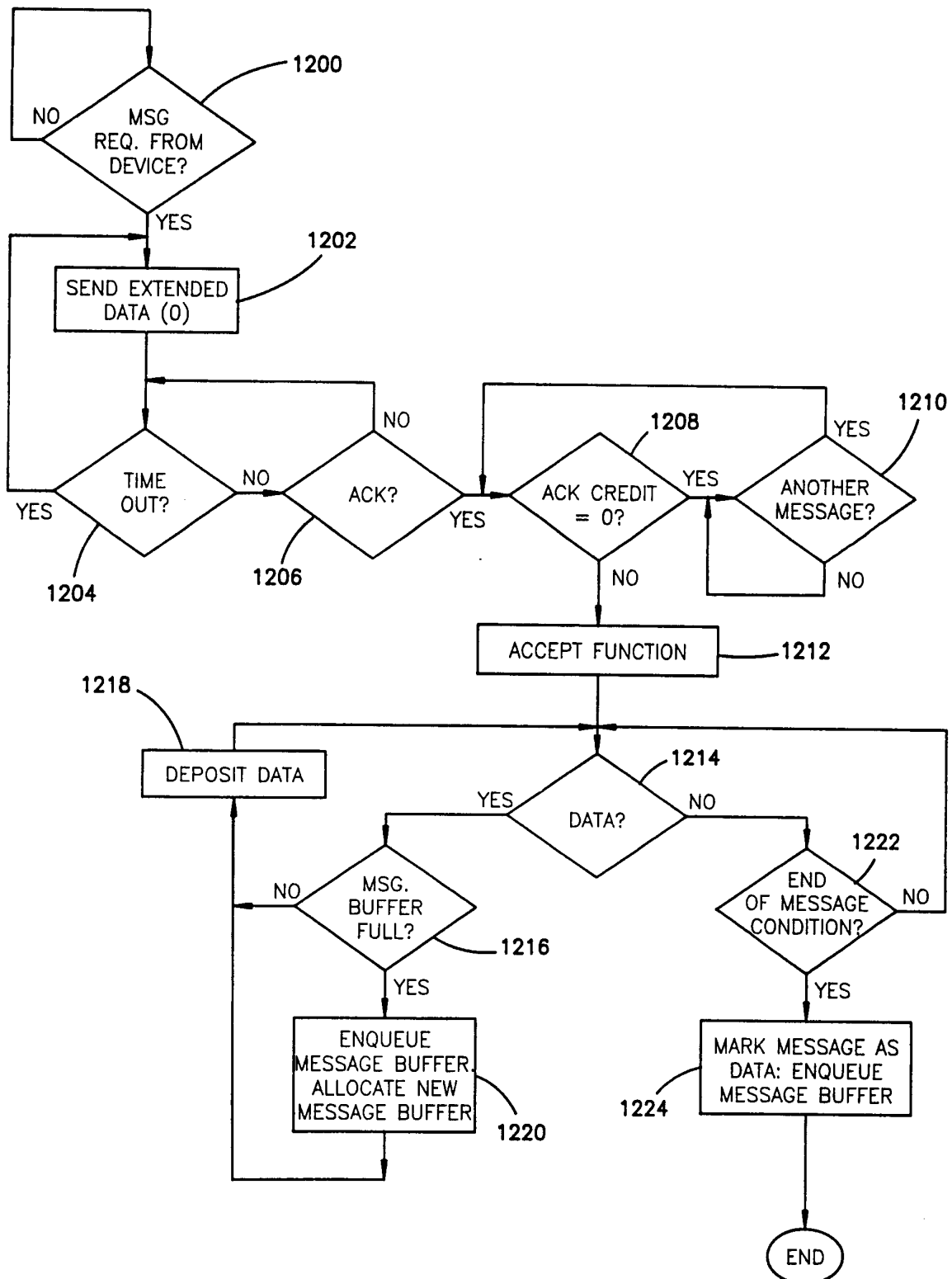


FIG. 34

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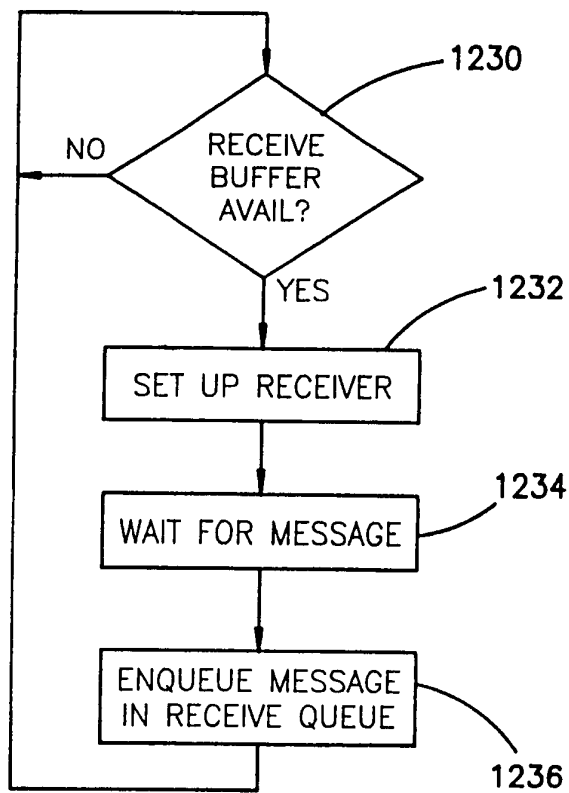


FIG. 35

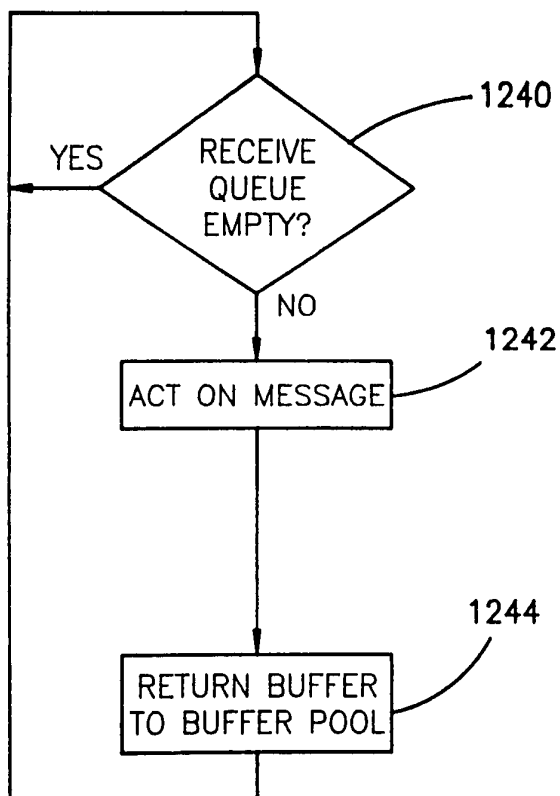
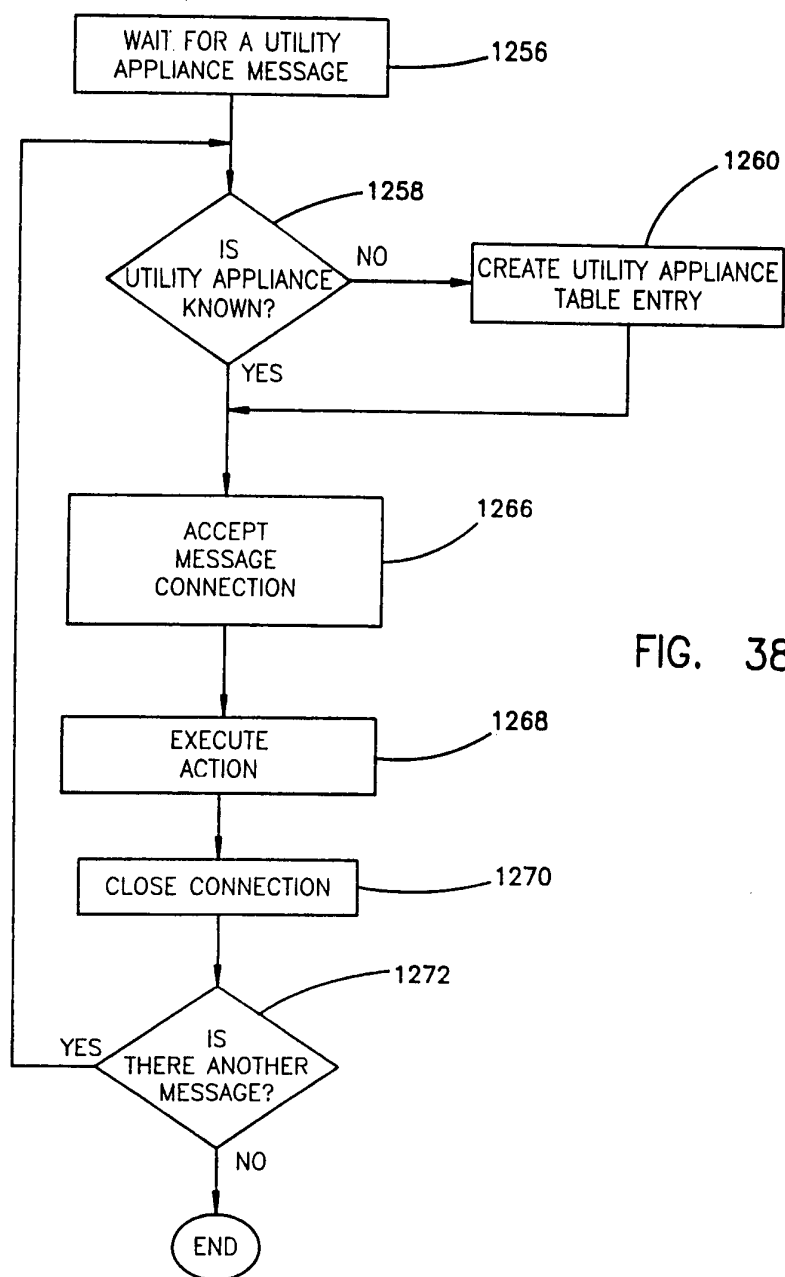
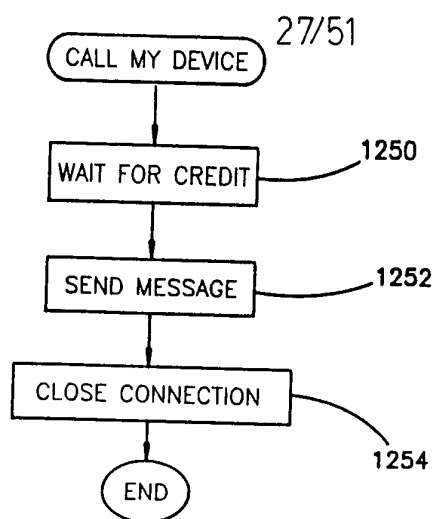


FIG. 36



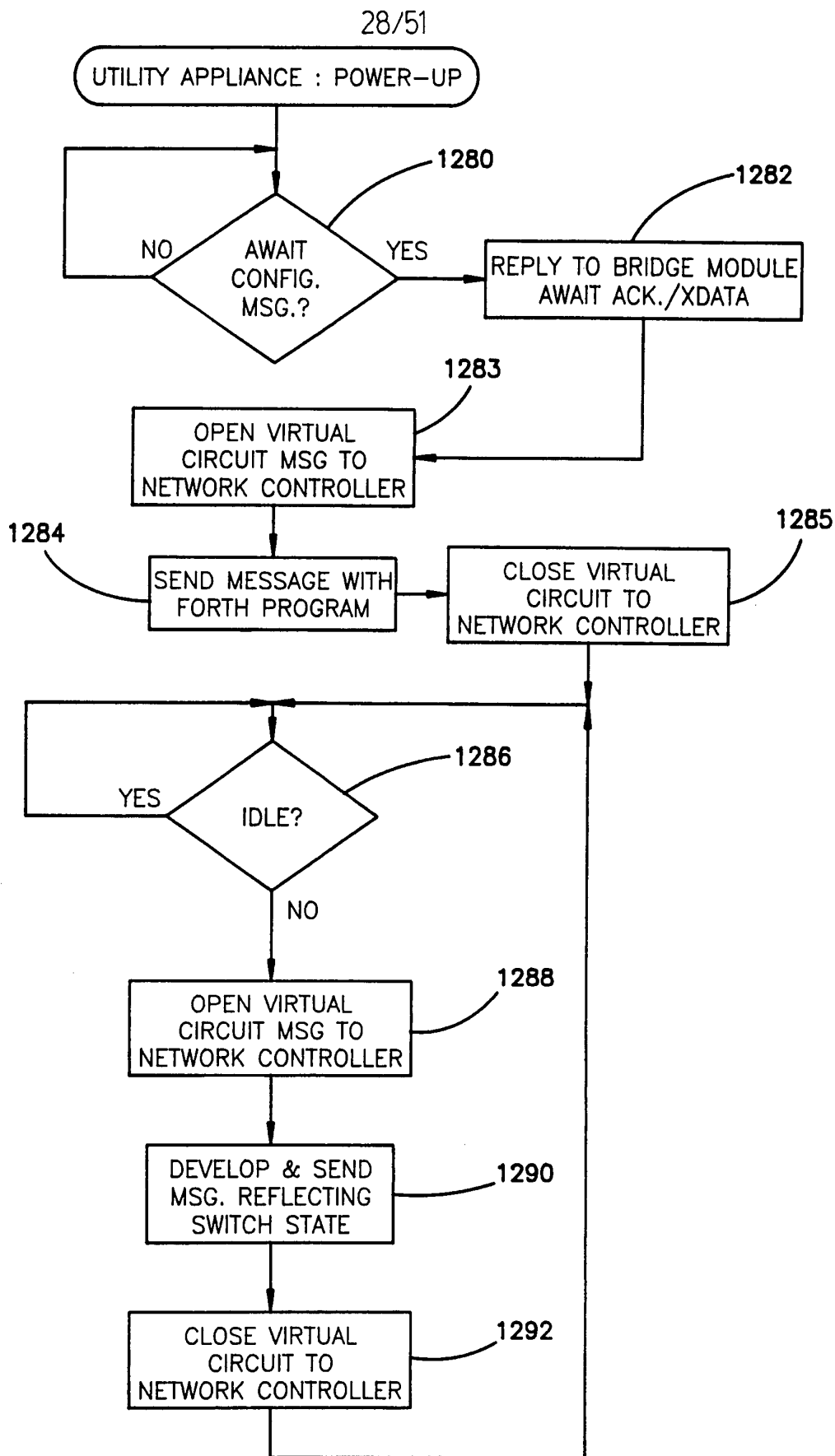


FIG. 39

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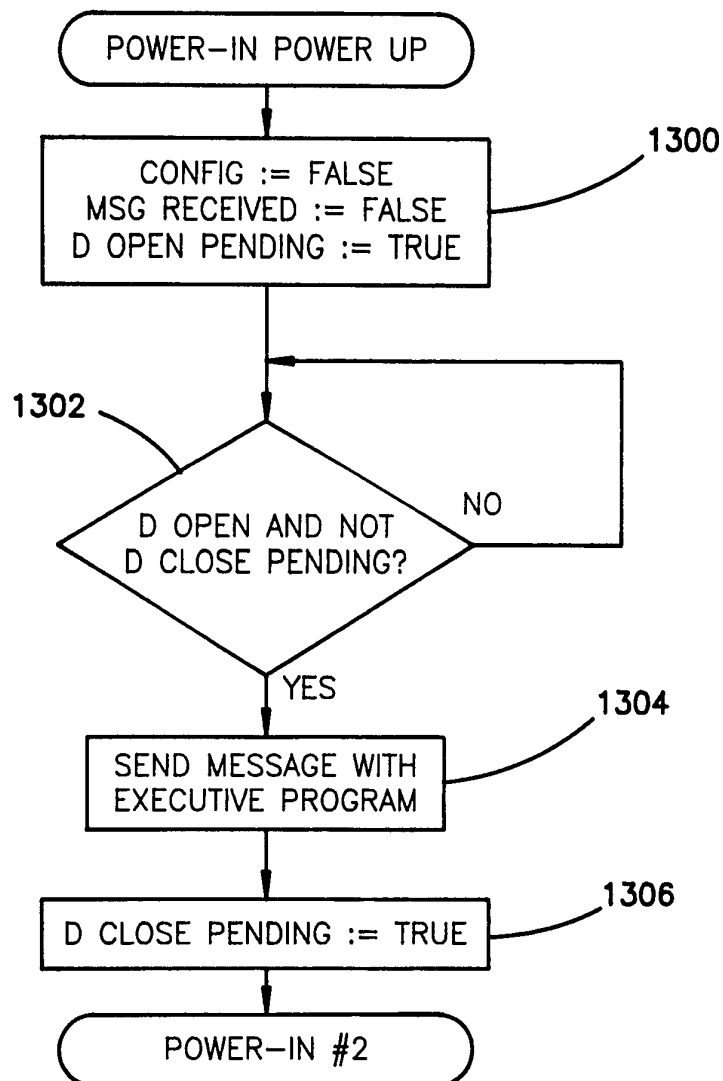


FIG. 40A

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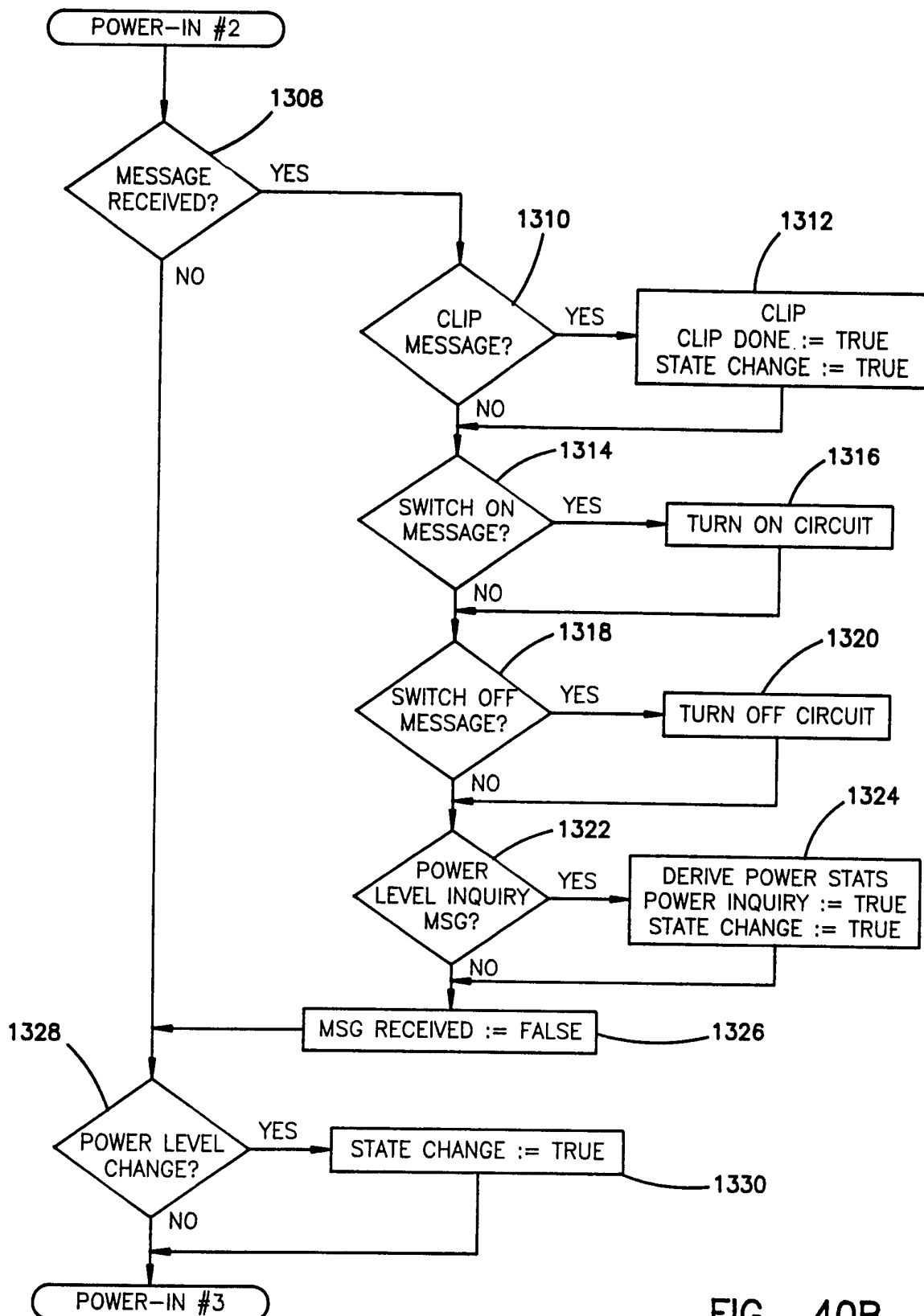
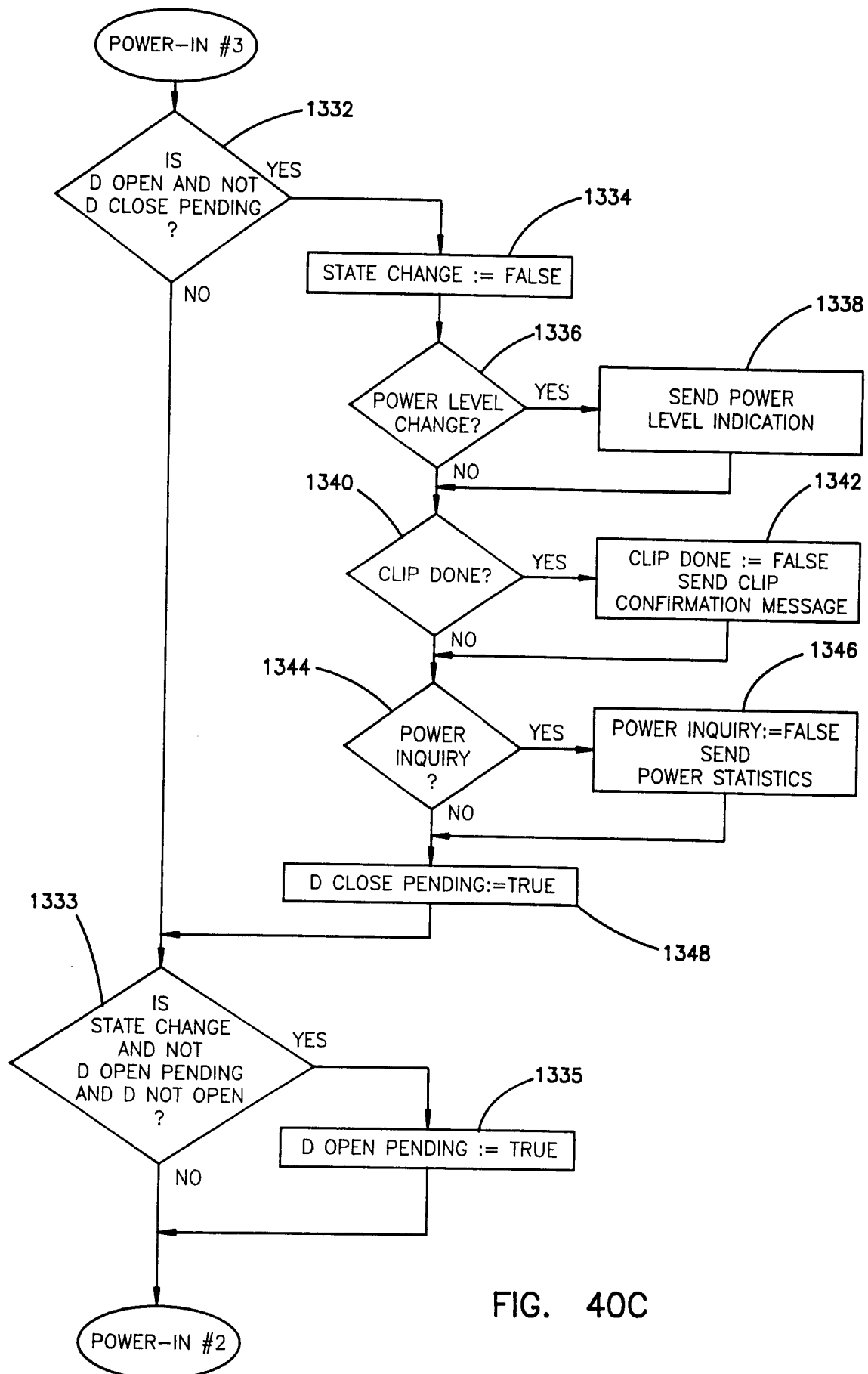


FIG. 40B



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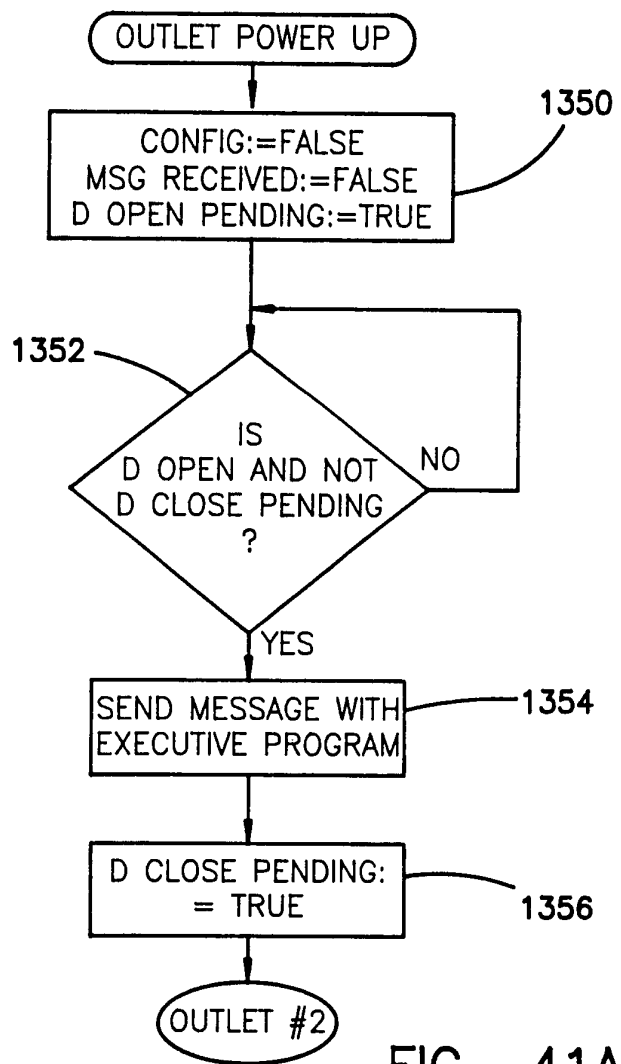


FIG. 41A

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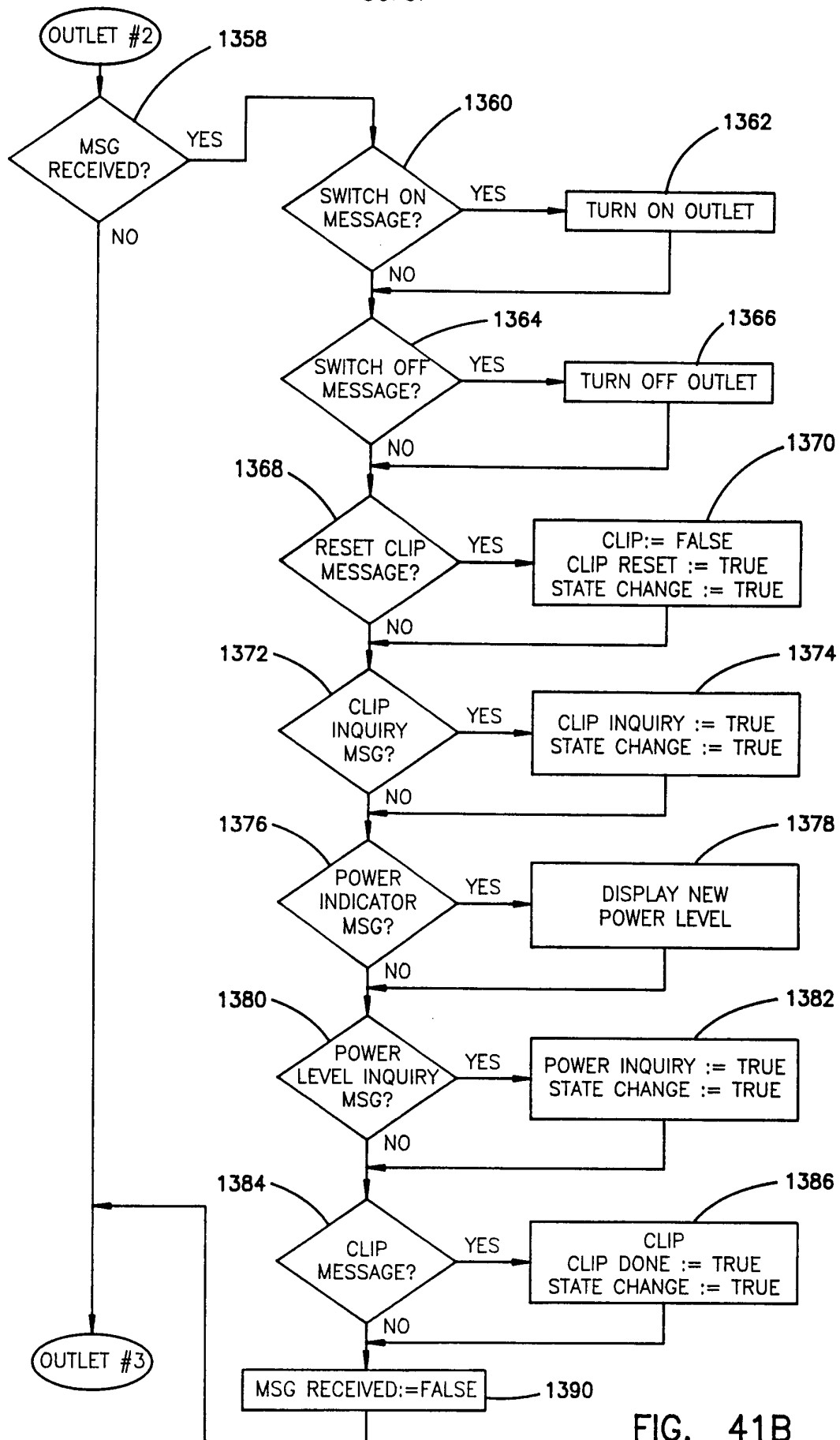


FIG. 41B

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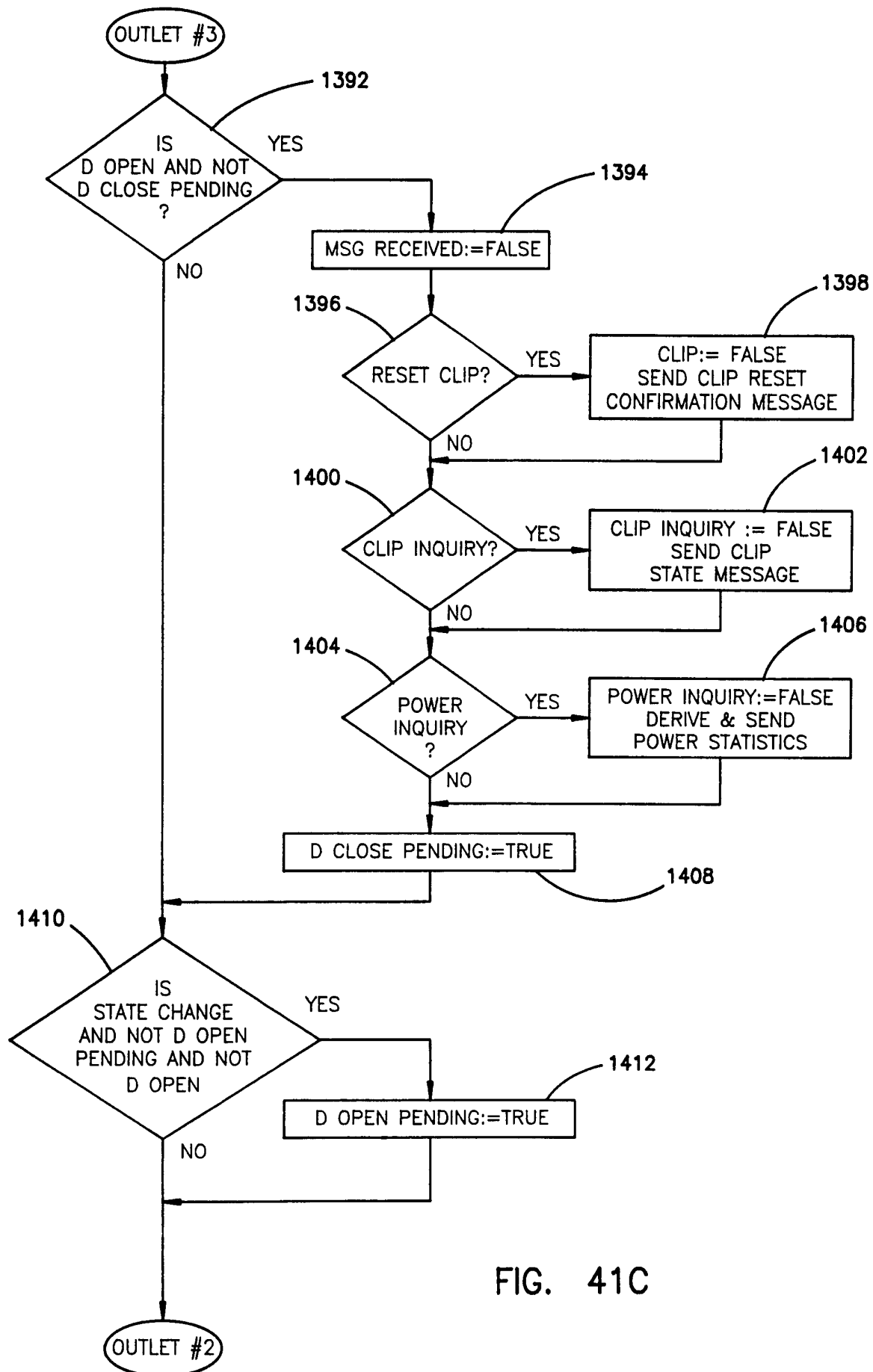


FIG. 41C

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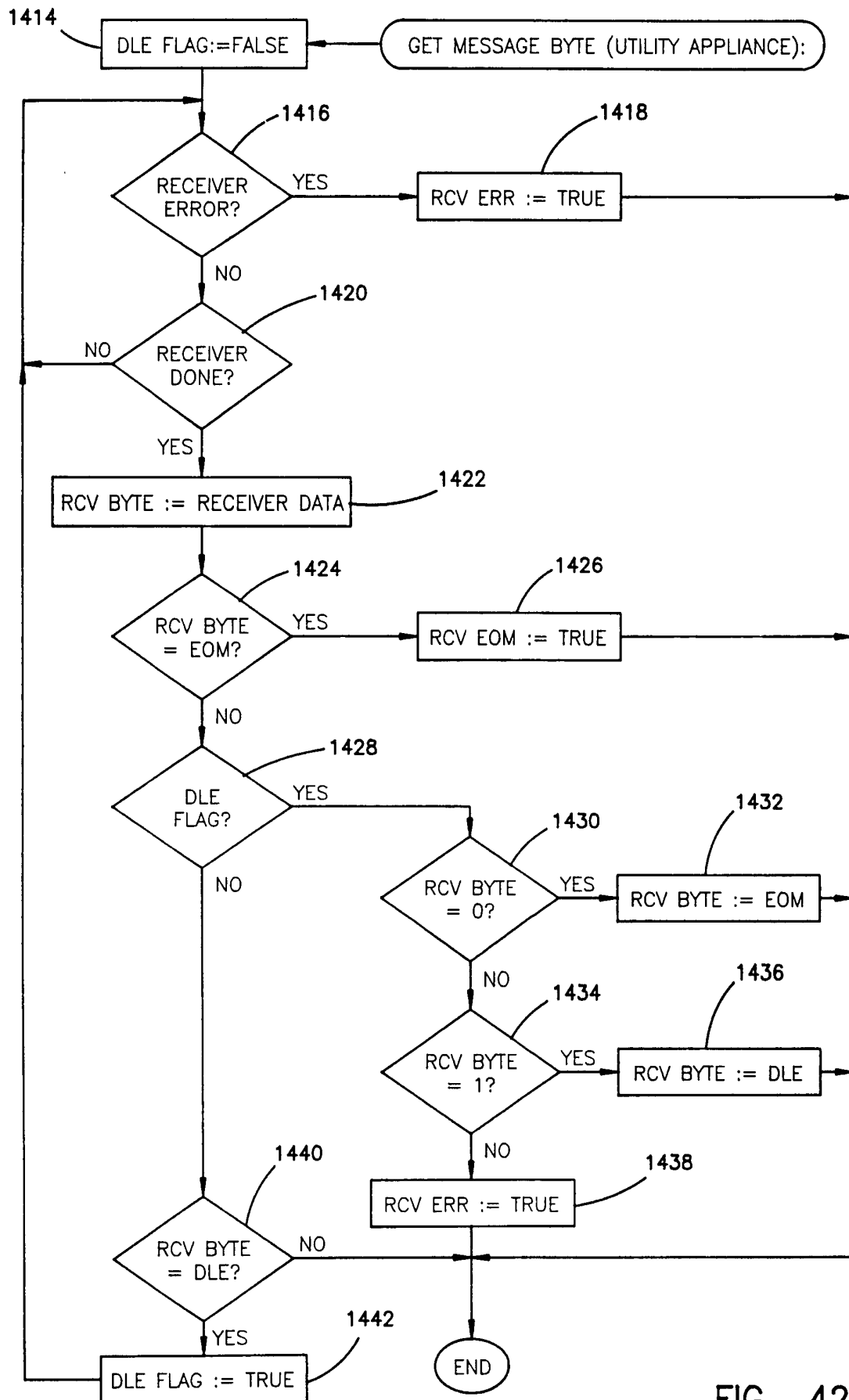


FIG. 42

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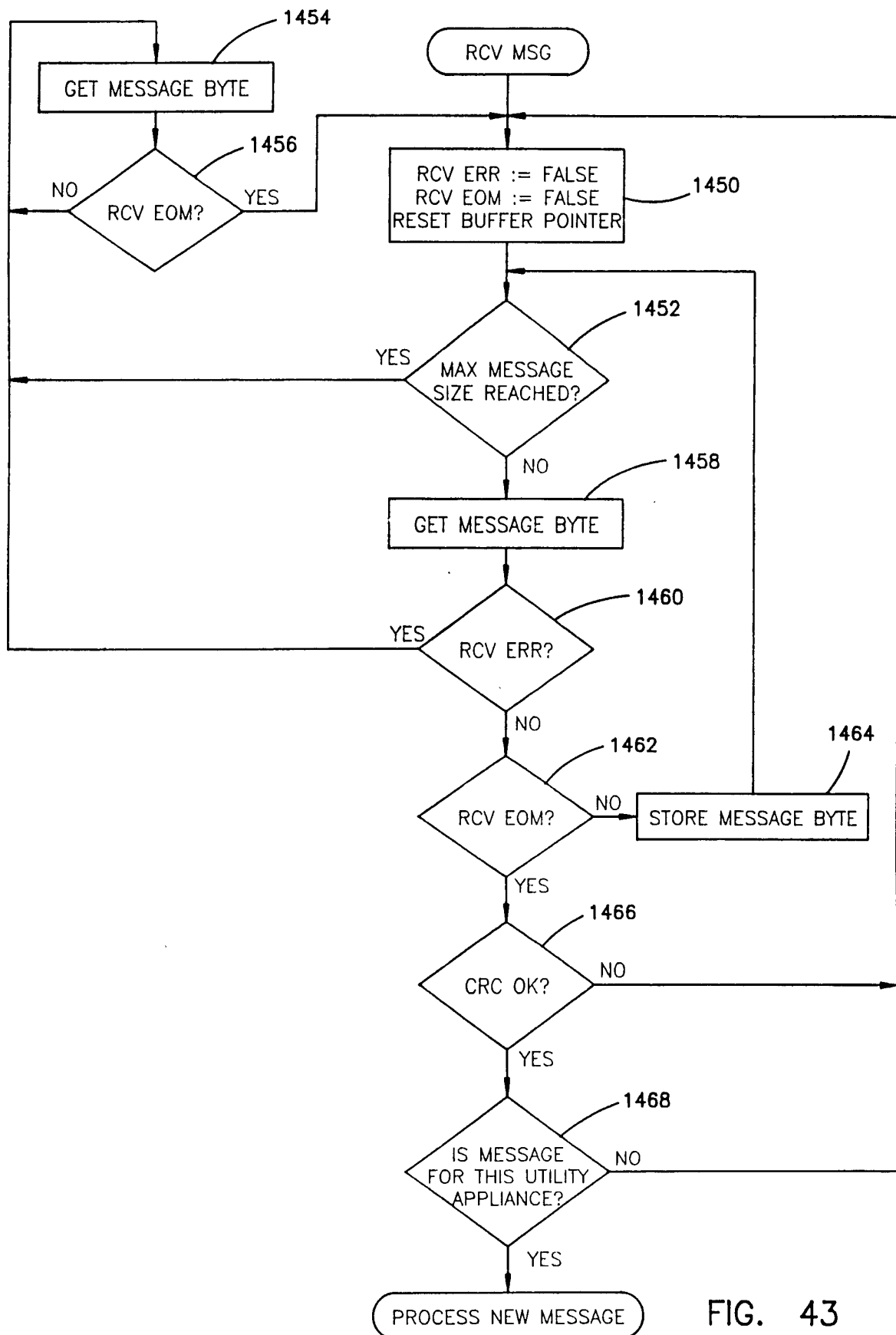
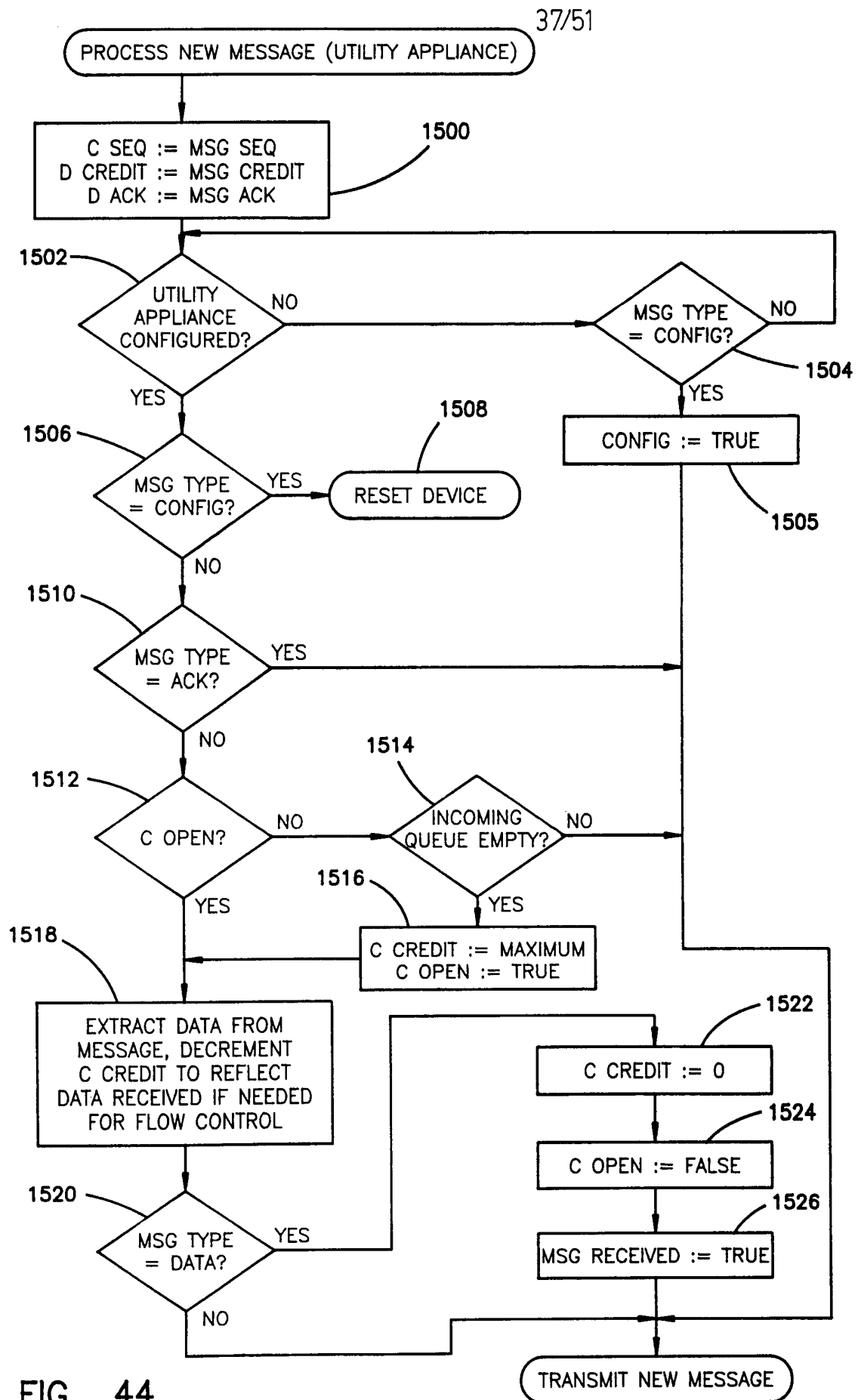


FIG. 43



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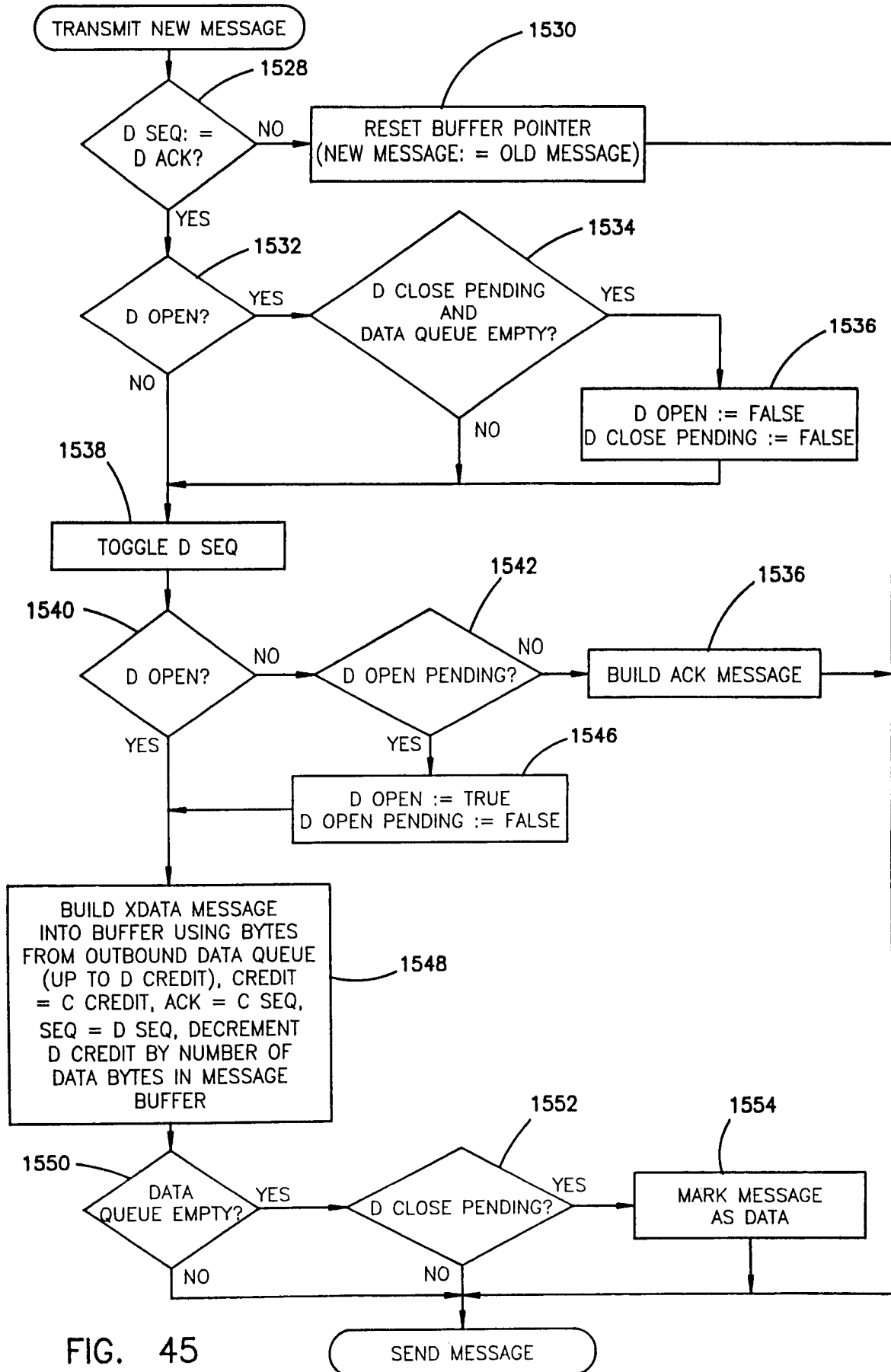


FIG. 45



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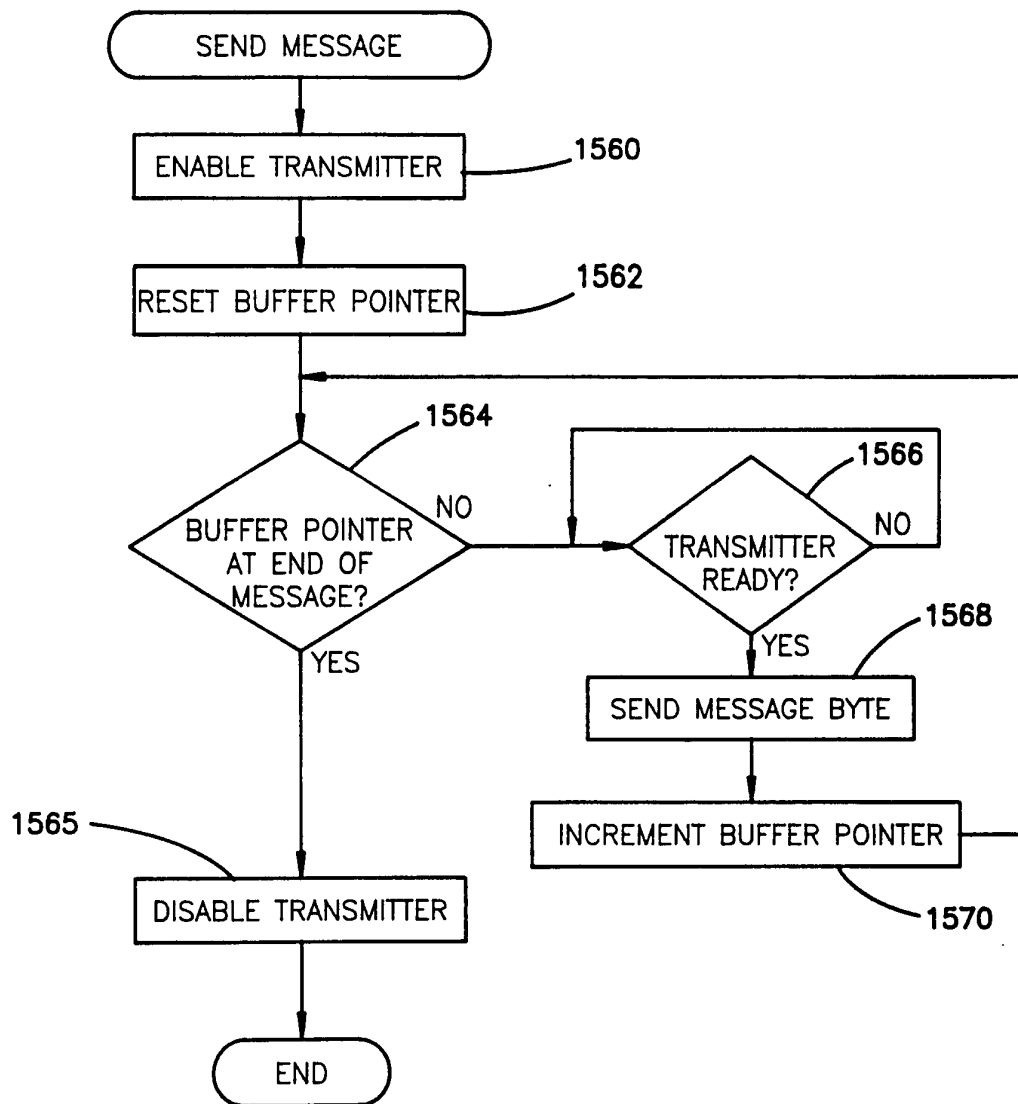


FIG. 46

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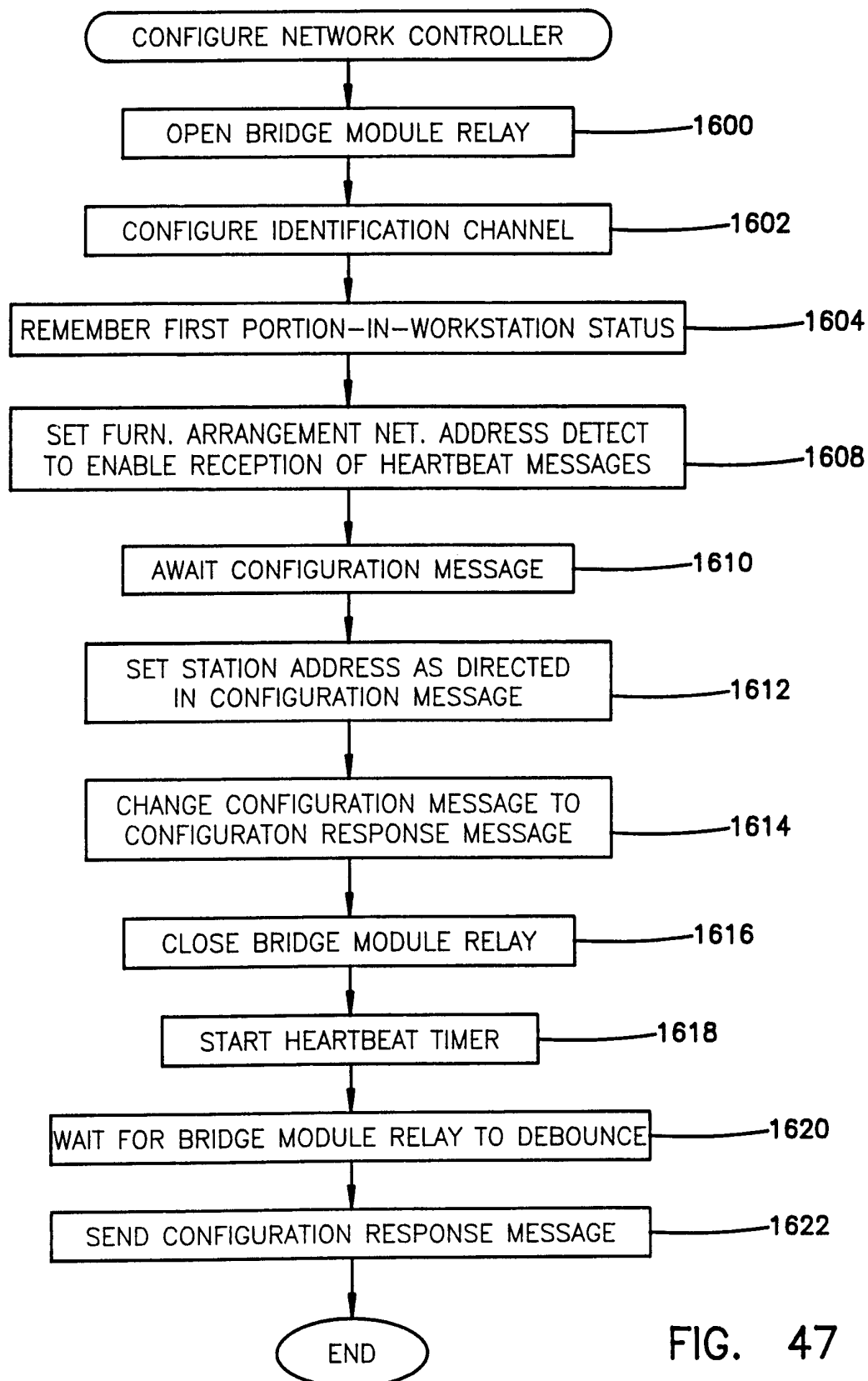
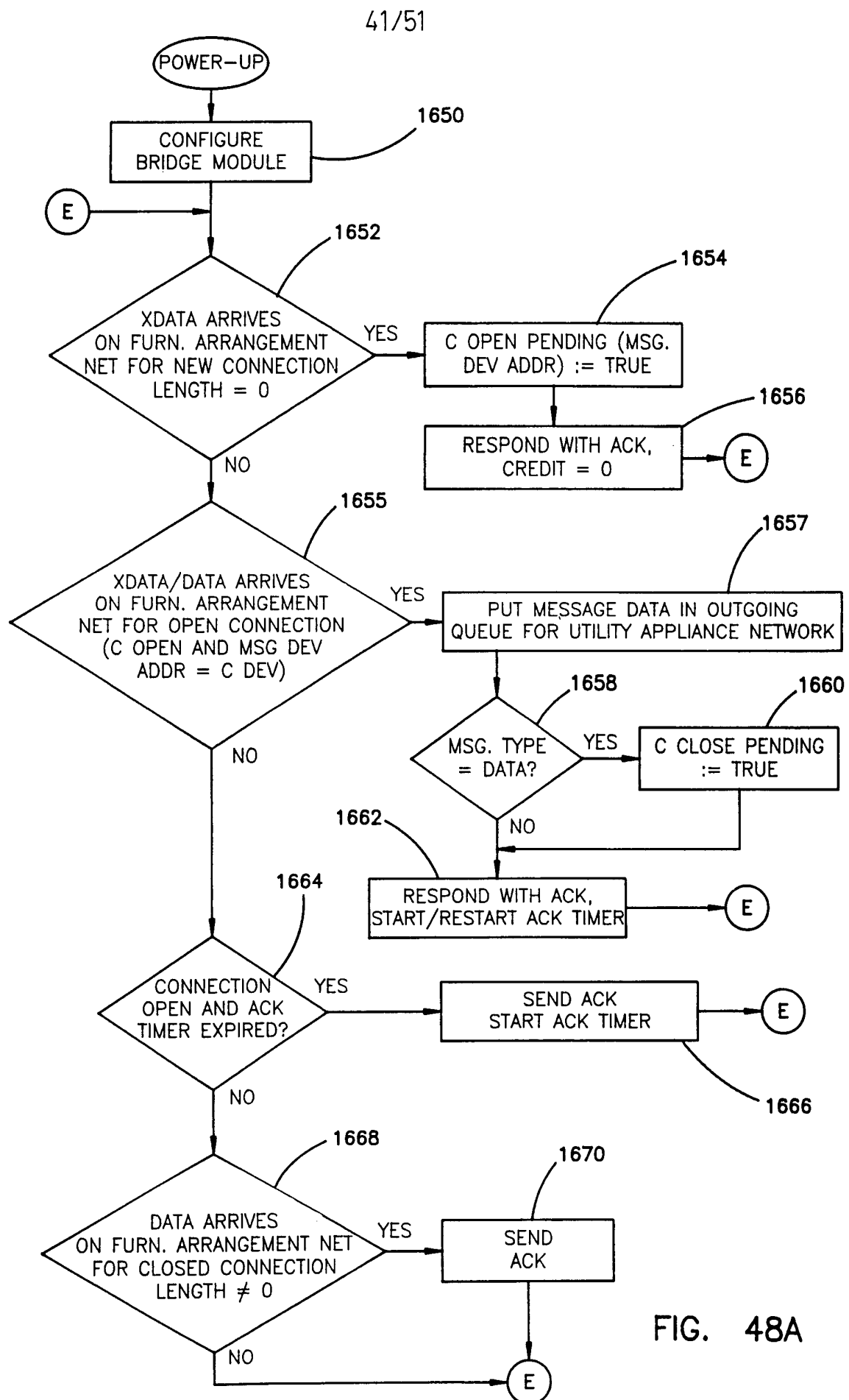


FIG. 47



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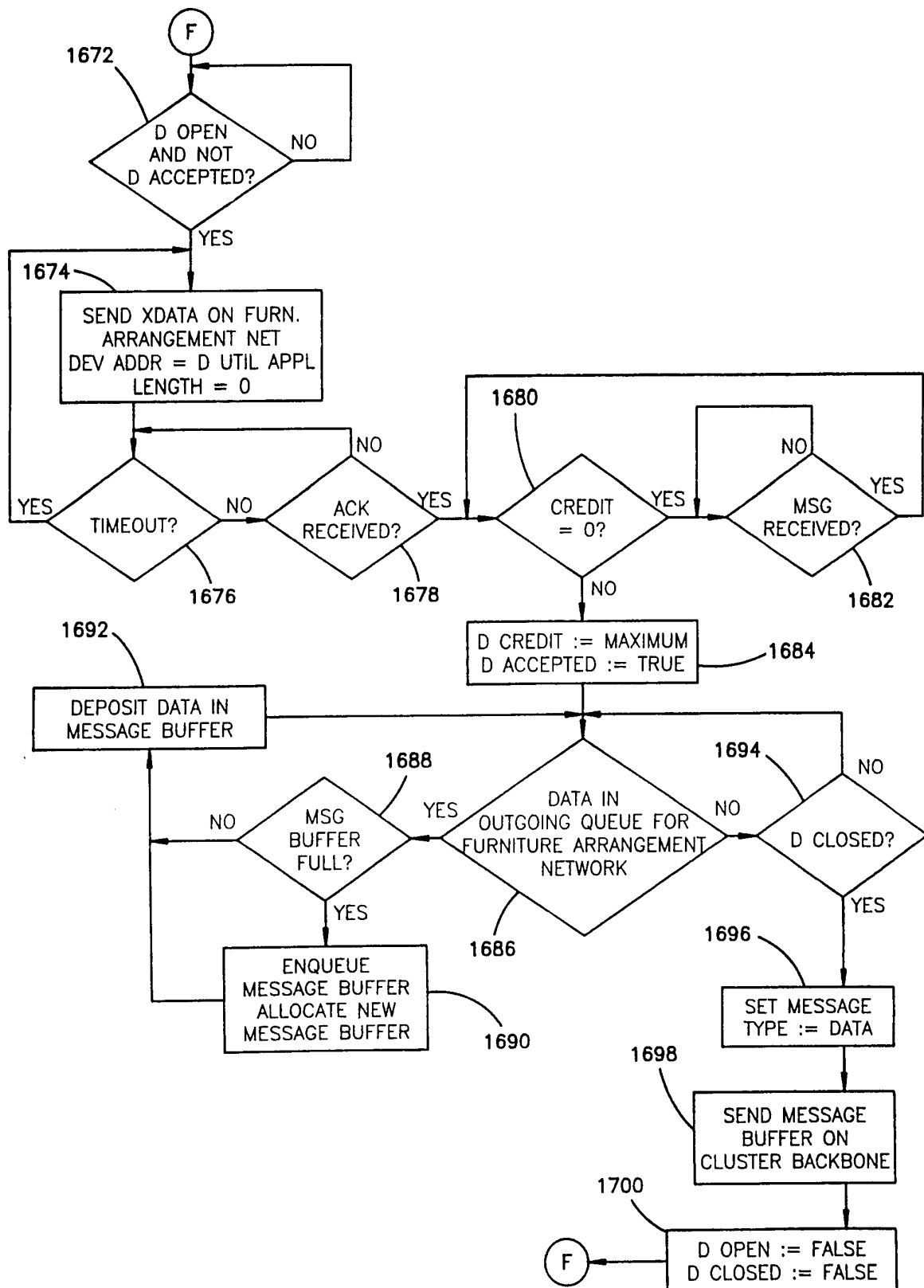


FIG. 48B

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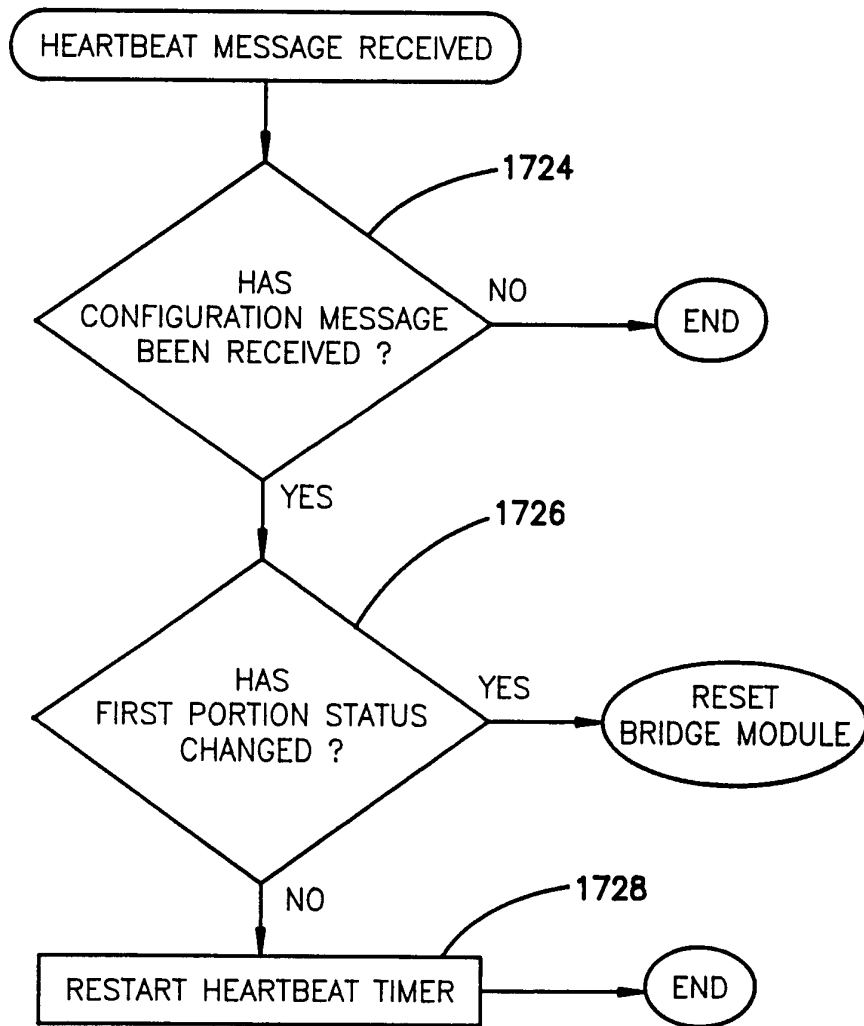


FIG. 49

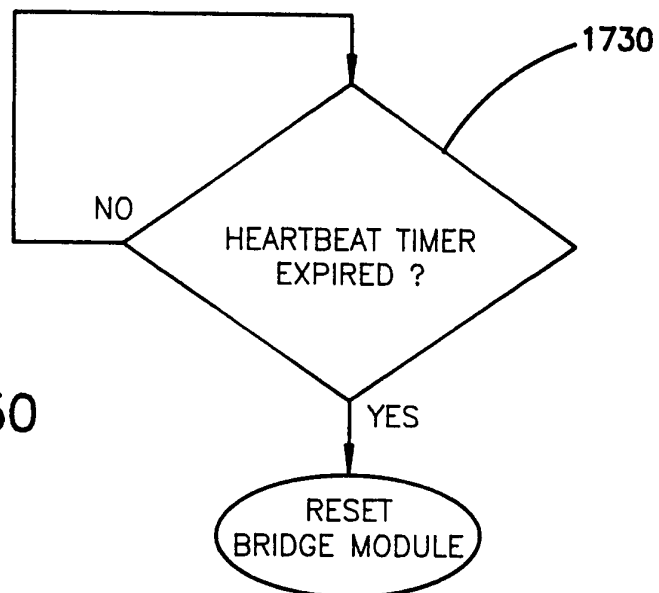
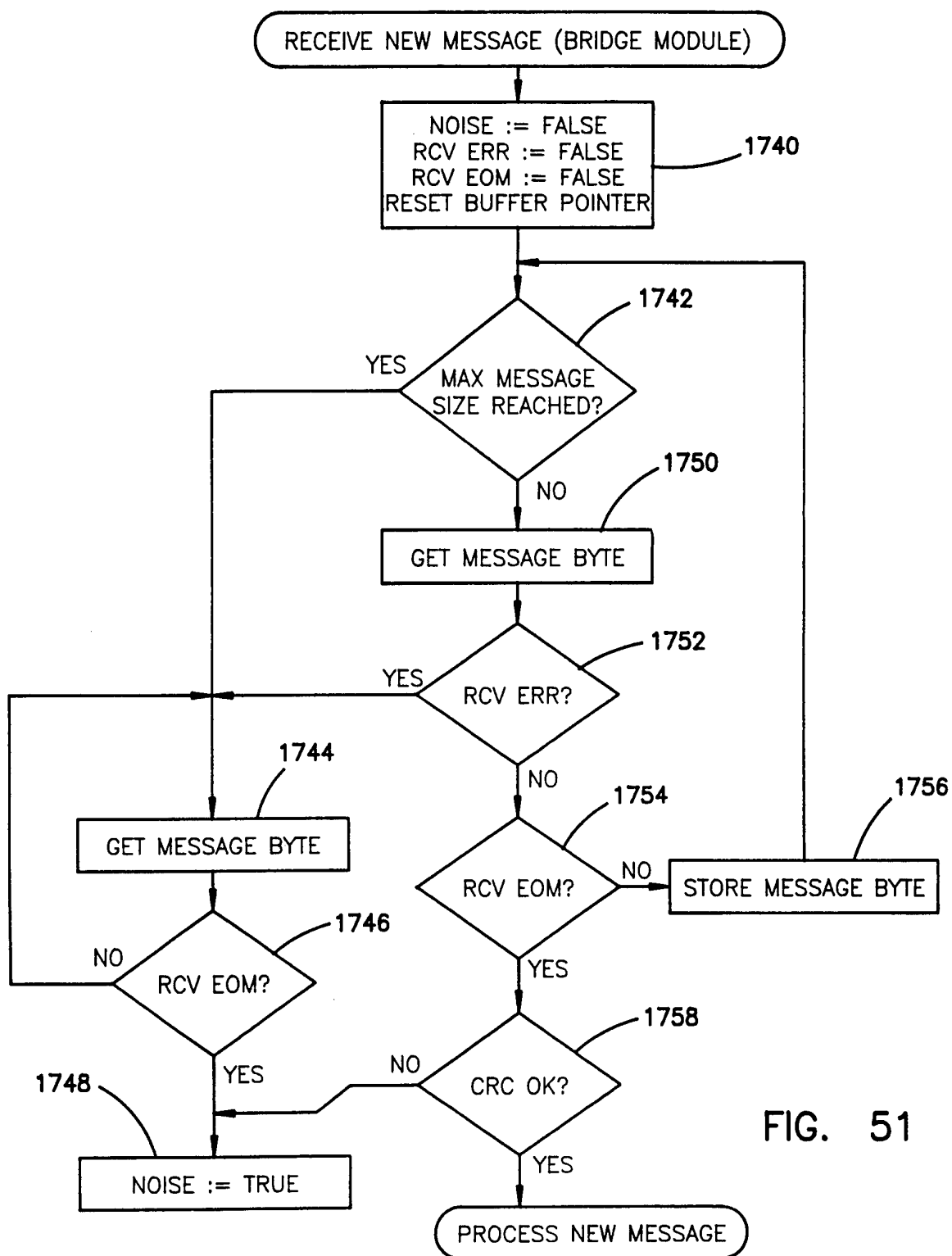


FIG. 50



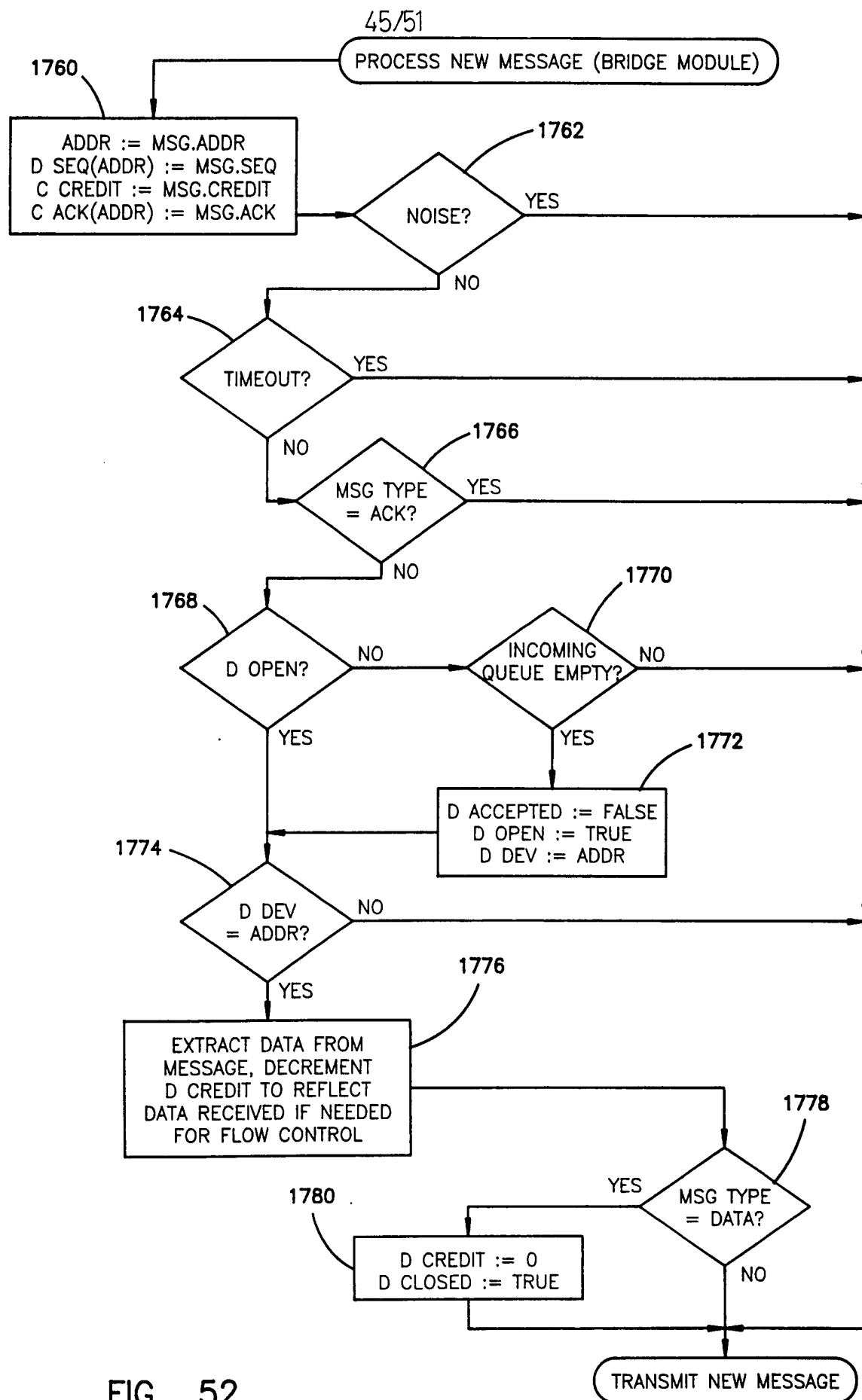
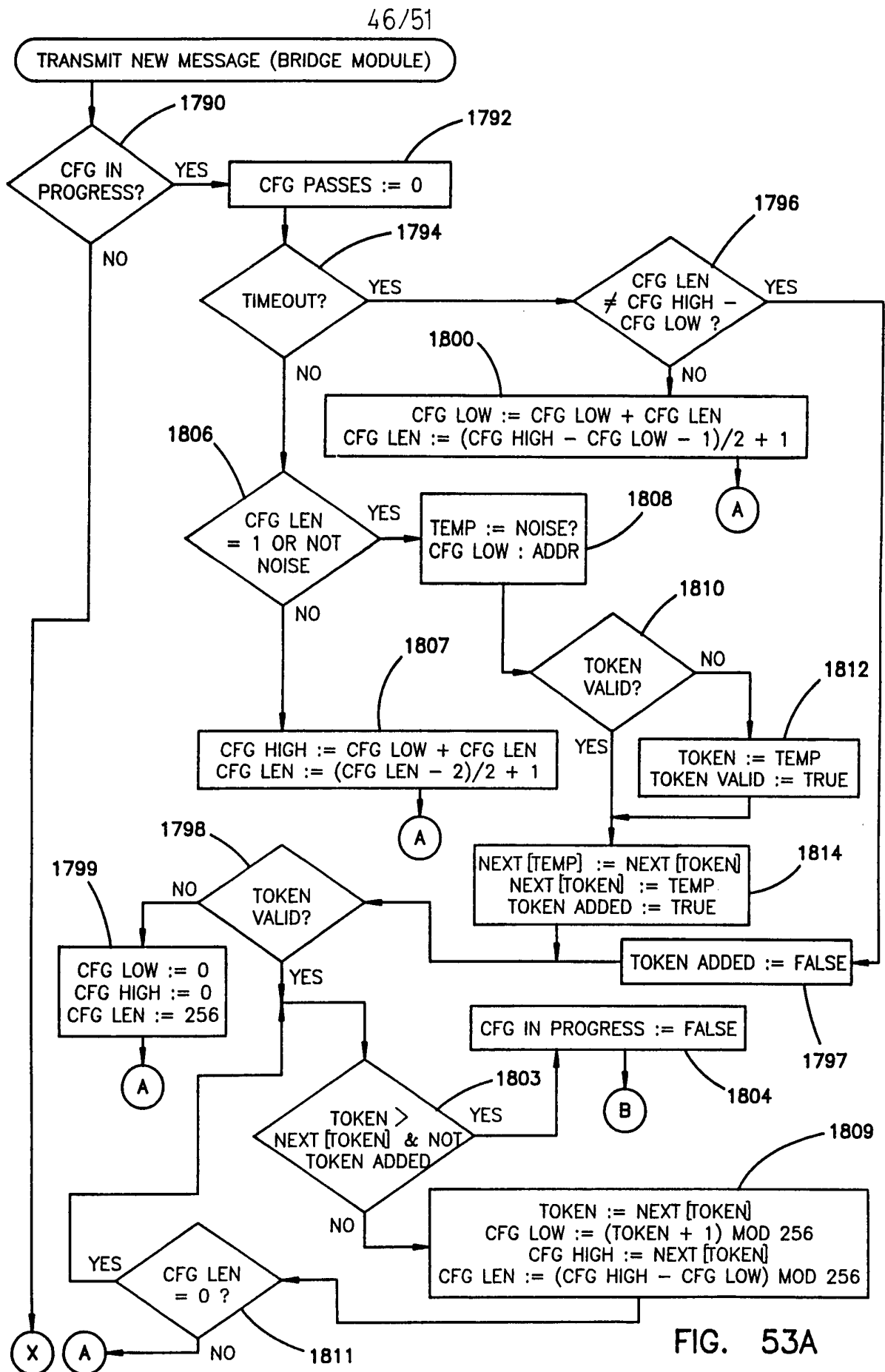


FIG. 52





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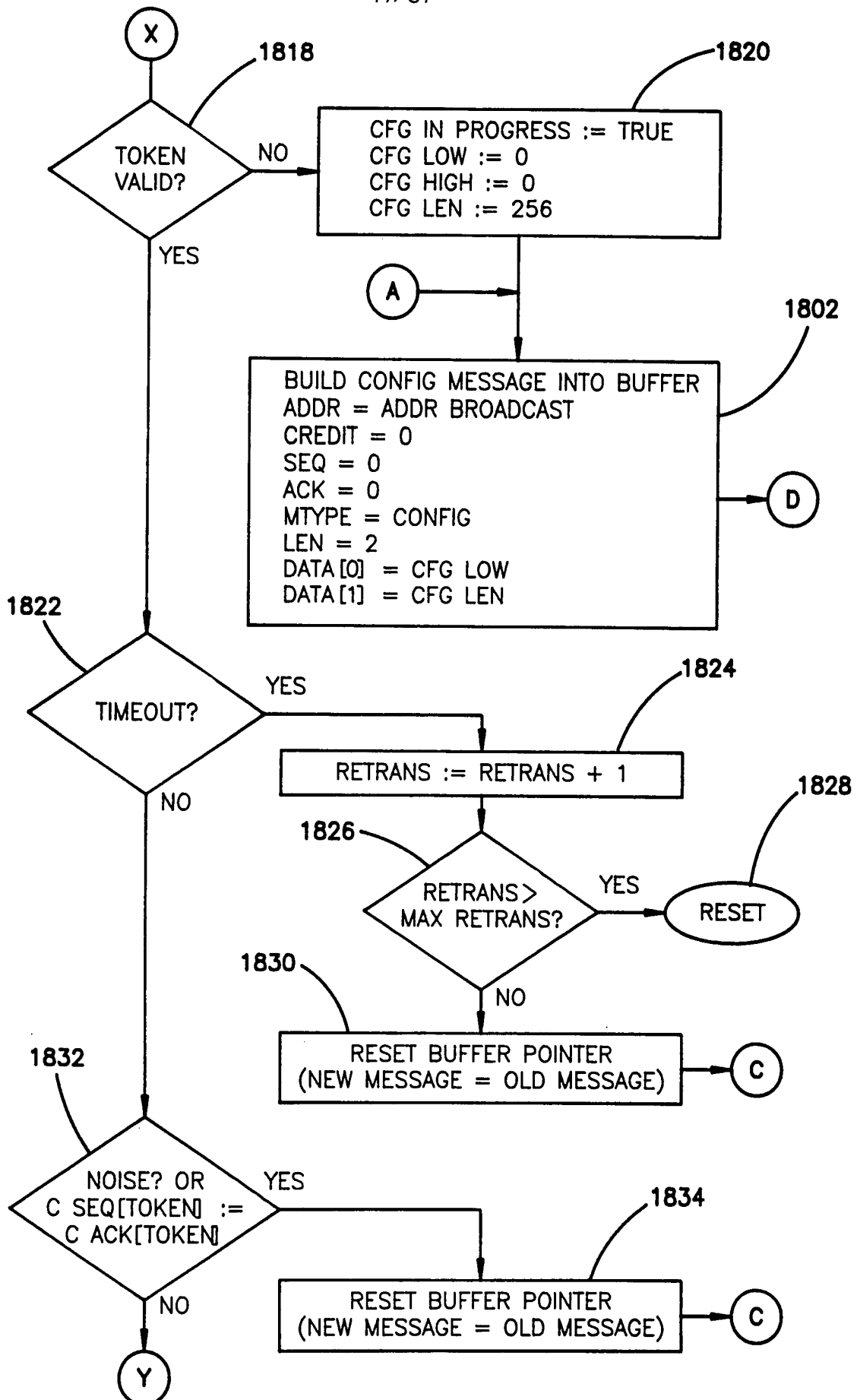


FIG. 53B

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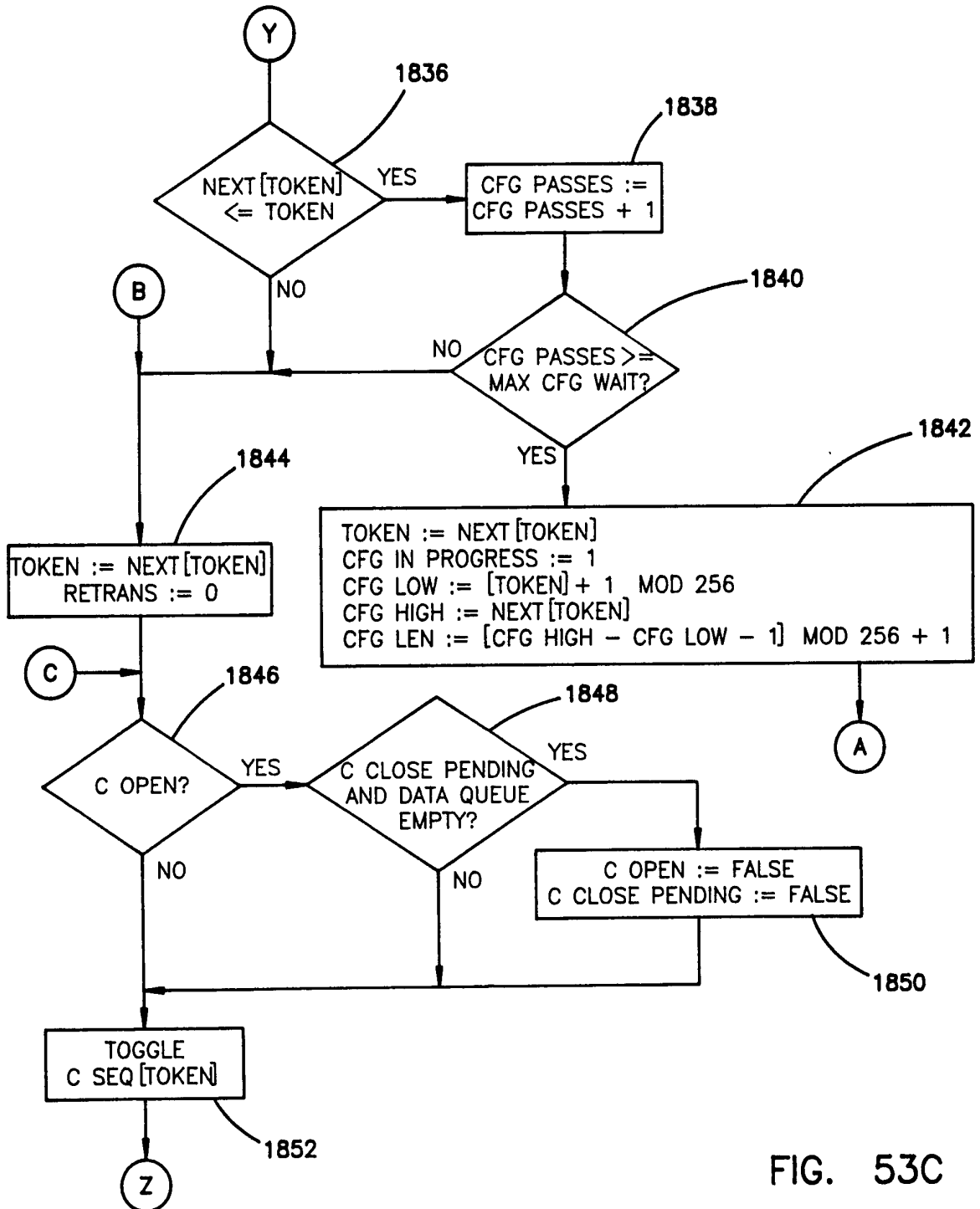
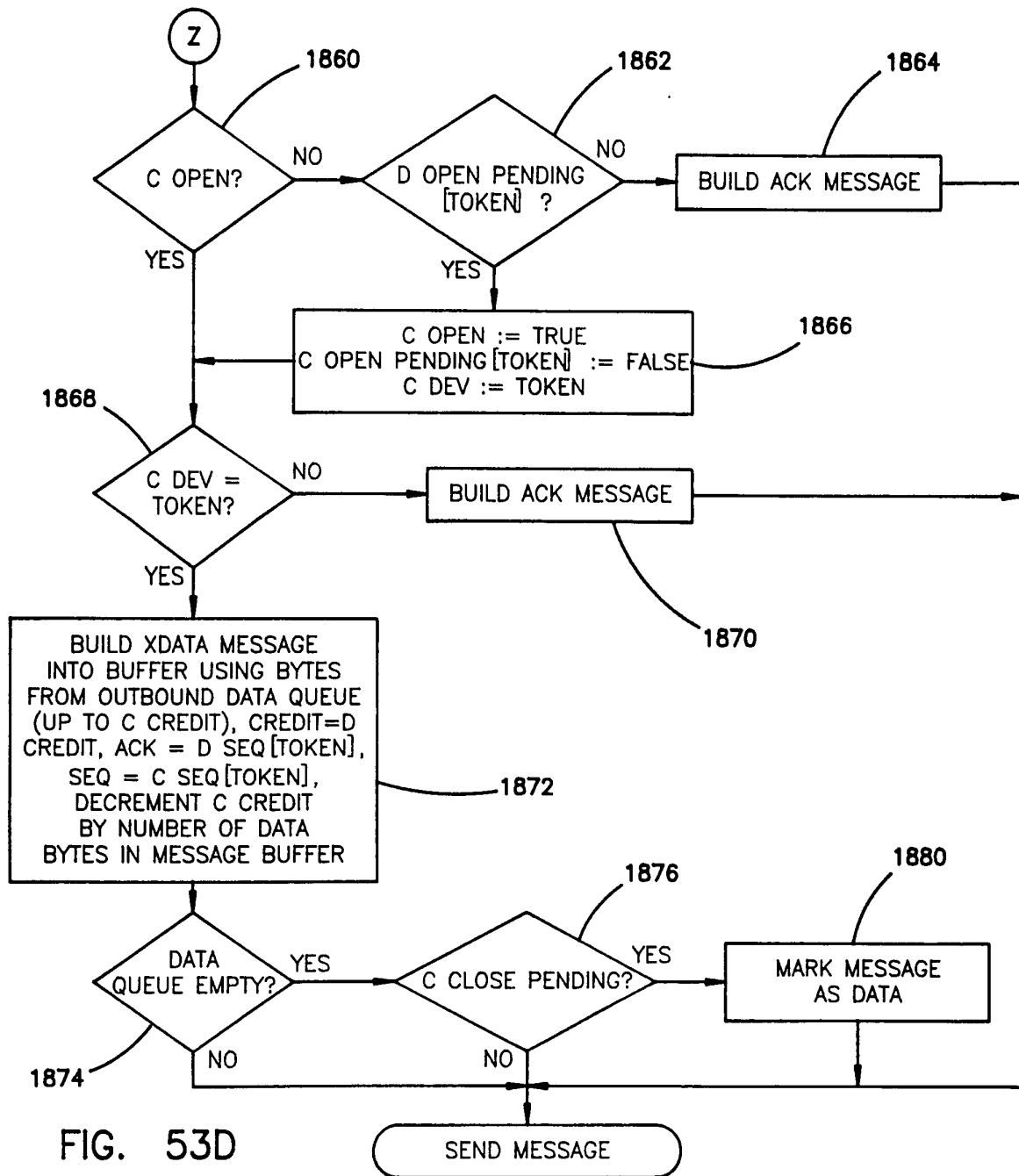


FIG. 53C

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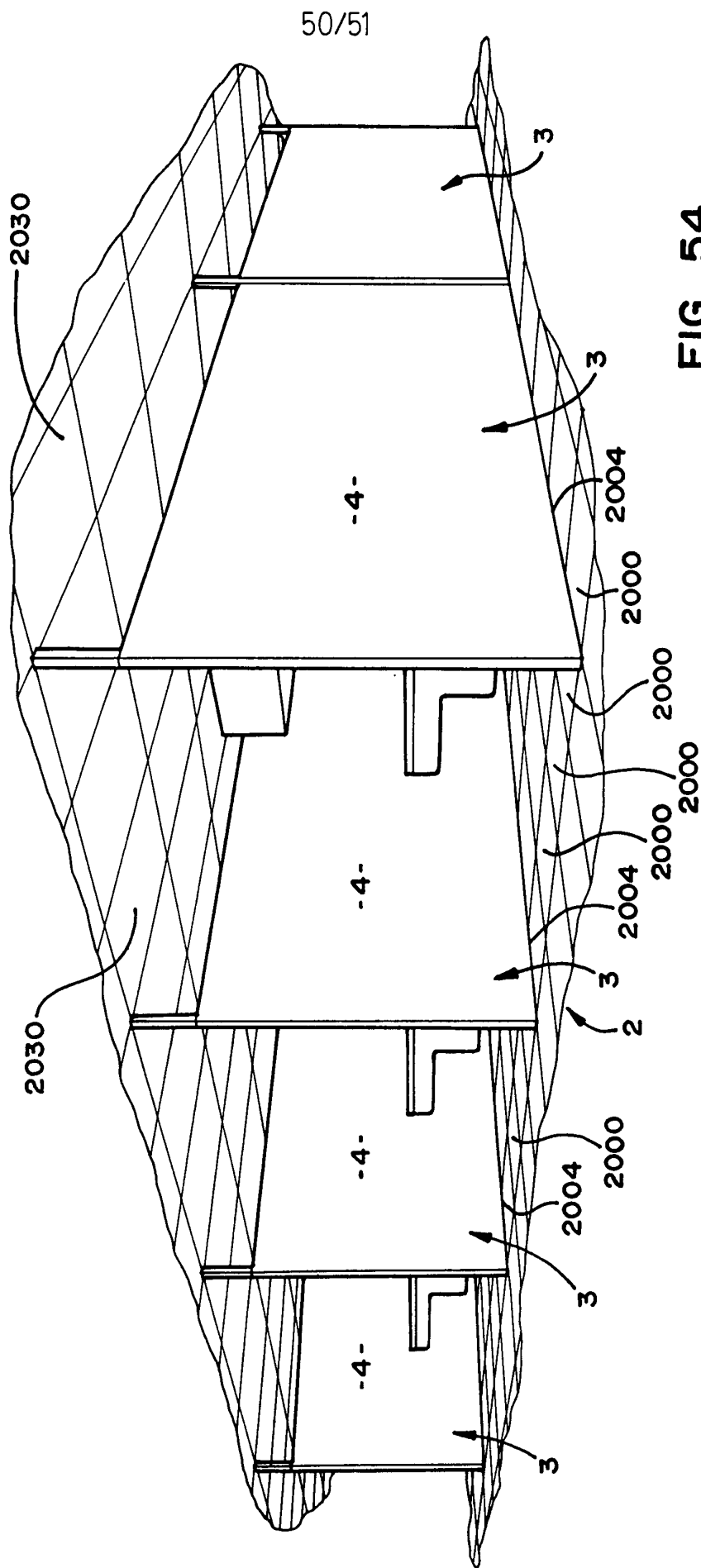
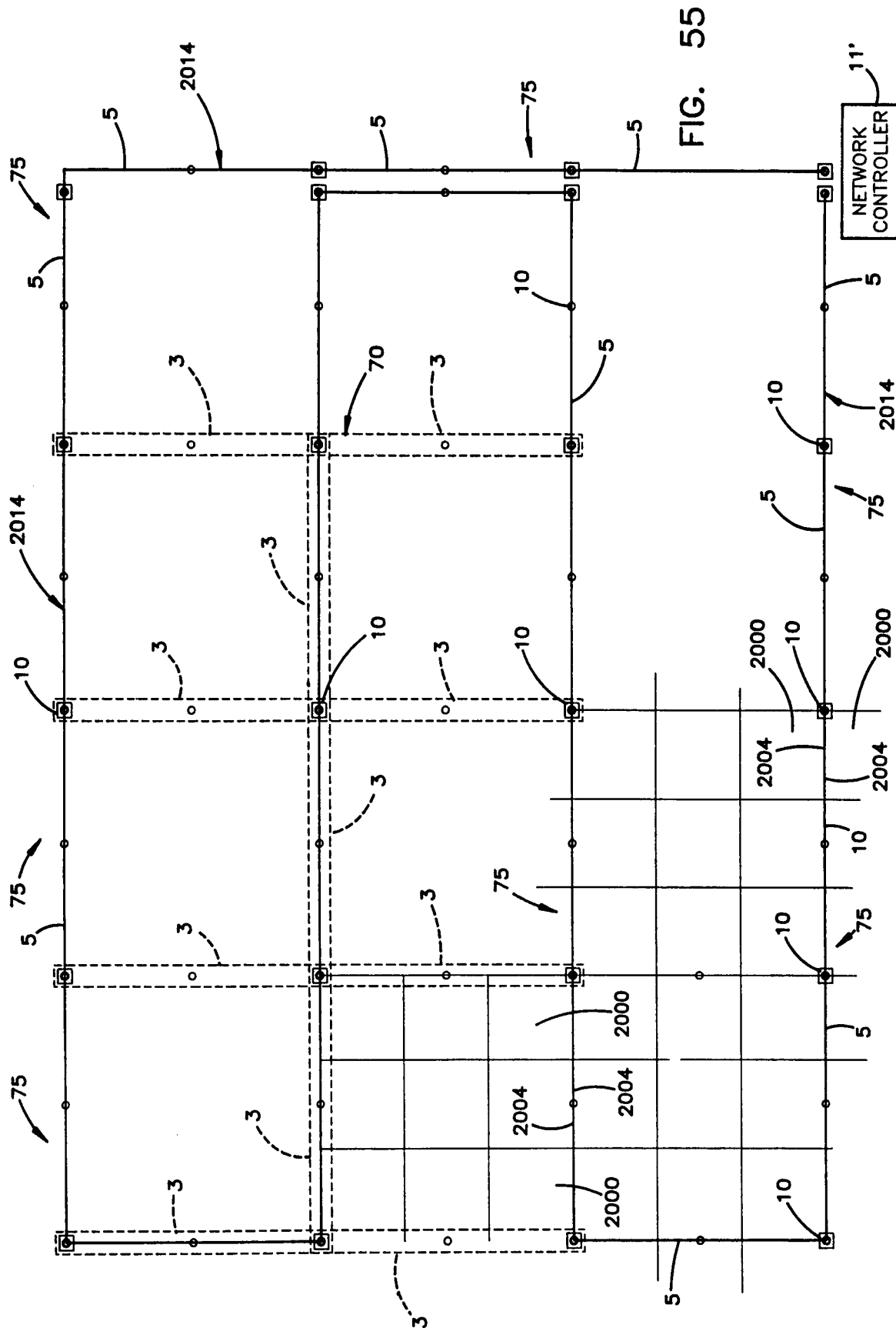


FIG. 54

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US94/14031

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) : H04Q 1/18

US CL : 340/825.07, 825.52, 310R; 52/239; 160/135

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 340/825.07, 825.51, 825.52, 825.53, 825.37, 310A, 310CP, 310R; 52/239, 221; 160/135, 351; 312/223.6

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5268666 [MICHEL] 07 DECEMBER 1993, FIGURE 2, COL. 11 LINES 45 +	1-22
Y	US, A, 4060294 [HAWORTH] 29 NOVEMBER 1977, ABSTRACT AND FIGURE 2.	1-22
Y	US, A, 5086385 [LAUNEY] 04 FEBRUARY 1992, DESCRIPTION OF FIGURE 1.	1-22
Y	IEEE PUBLICATION, OCTOBER 1989, G. HANOVER, "NETWORKING THE INTELLIGENT HOME" PAGES 48,49	1-22



Further documents are listed in the continuation of Box C.



See patent family annex.

•	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance		
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search

18 JANUARY 1995

Date of mailing of the international search report

06 APR 1995

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Washington, D.C. 20231

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