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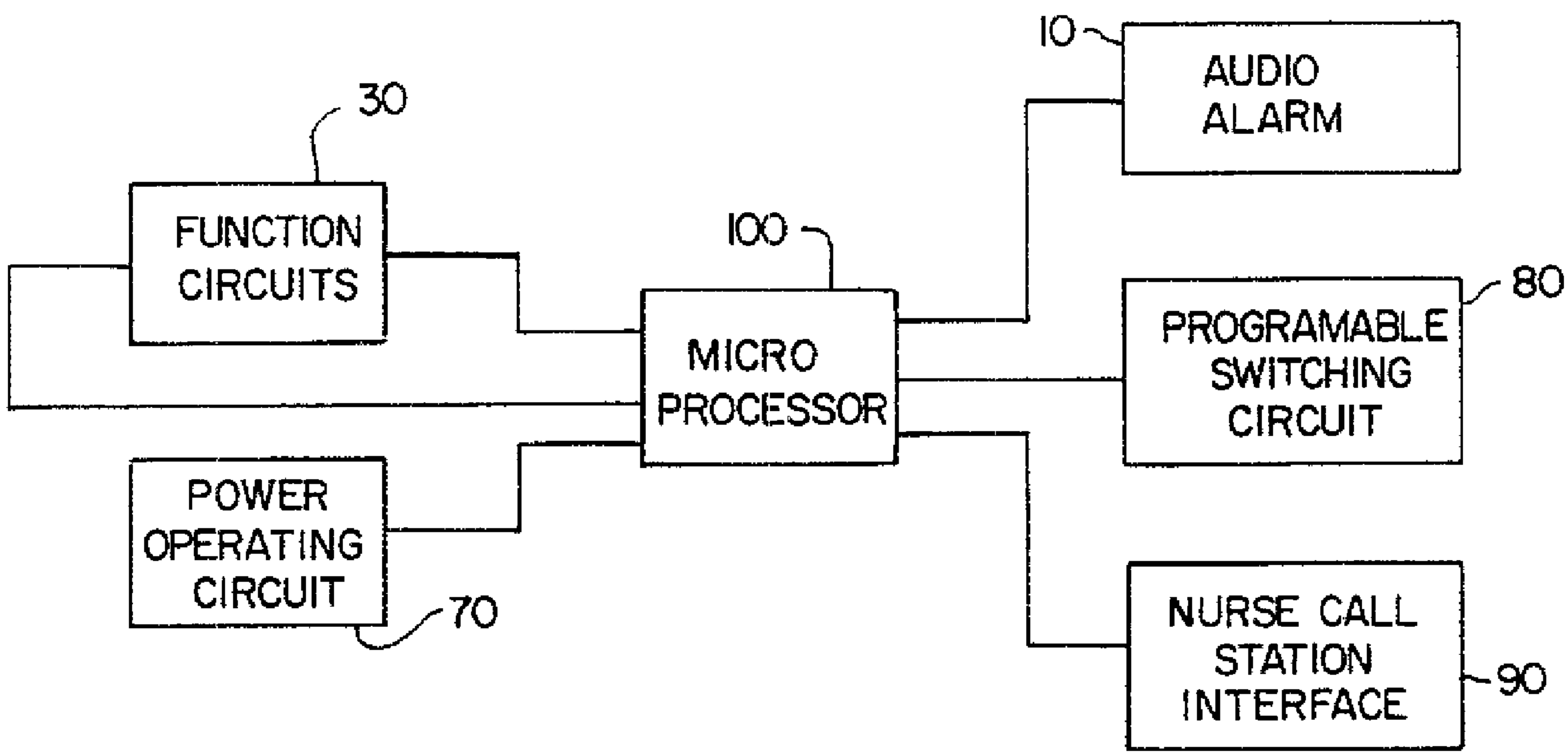


(57) Abrégé/Abstract:
An electric power driven system for monitoring a device or sensor for detecting the presence of a load, such as a patient, infirm person or infant, on a device or sensor. The system includes a microprocessor and a plurality of circuits connected to the microprocessor. A circuit connected to the microprocessor and to the sensor automatically initiates operation of the microprocessor upon detection by the sensor of the load's presence on the device or sensor. Another circuit connected to the microprocessor provides a signal or alarm upon demand by the microprocessor. A circuit connected to the microprocessor is adapted to be interfaced with a nurse call station for generating signals to the station upon demand by the microprocessor. A circuit connected to the microprocessor programs the system in response to commands manually applied to this circuit.

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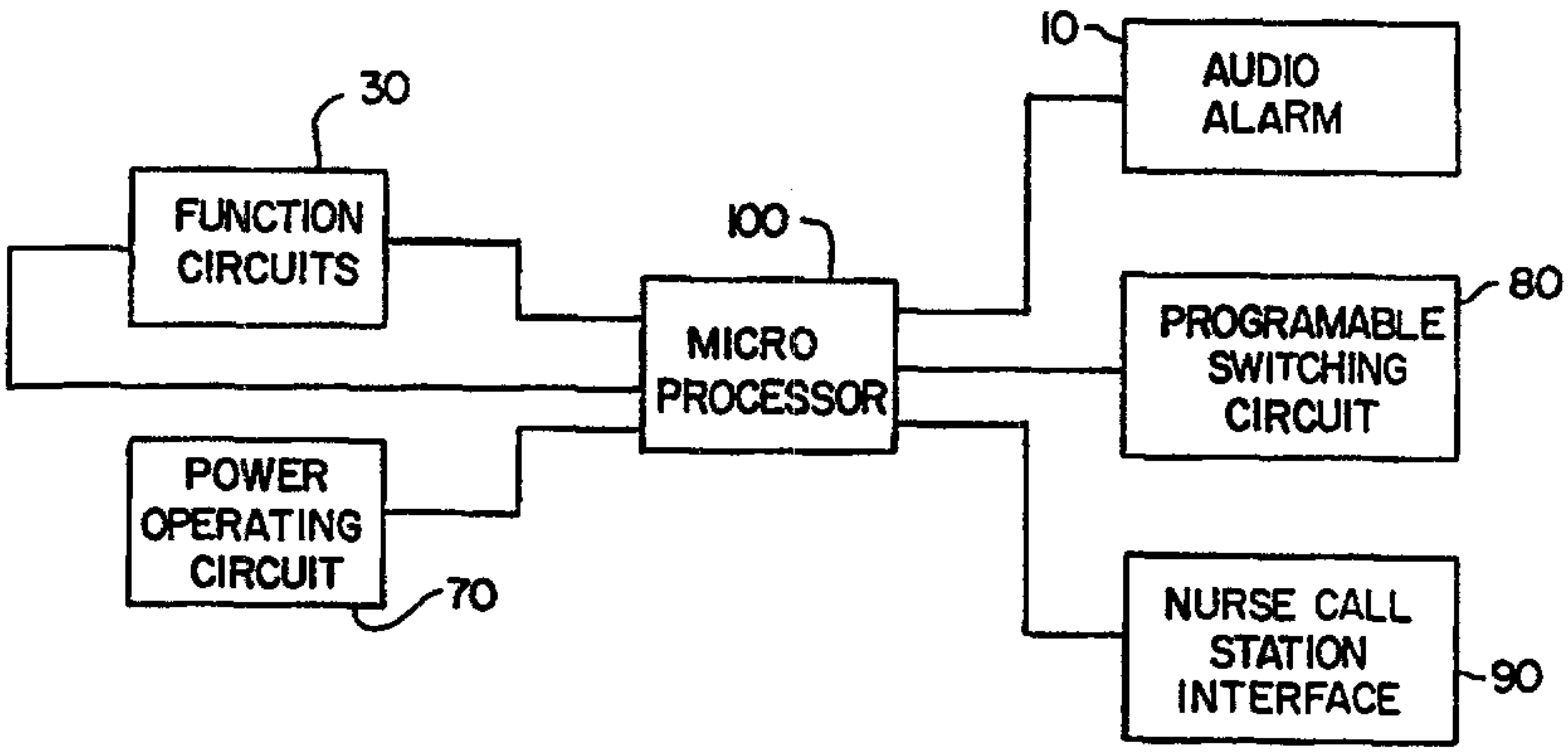


(57) Abstract

An electric power driven system for monitoring a device or sensor for detecting the presence of a load, such as a patient, infirm person or infant, on a device or sensor. The system includes a microprocessor and a plurality of circuits connected to the microprocessor. A circuit connected to the microprocessor and to the sensor automatically initiates operation of the microprocessor upon detection by the sensor of the load's presence on the device or sensor. Another circuit connected to the microprocessor provides a signal or alarm upon demand by the microprocessor. A circuit connected to the microprocessor is adapted to be interfaced with a nurse call station for generating signals to the station upon demand by the microprocessor. A circuit connected to the microprocessor programs the system in response to commands manually applied to this circuit.

# MONITOR FOR LOAD BEARING DEVICE

This invention relates generally to systems for monitoring the presence or absence of a load such as a patient, infirm person or a child in or from a location such as a bed, wheelchair, carriage, stroller, carseat, playpen, high chair and the like.

Presently known monitoring systems, such as those described in earlier U.S. Patents Nos. 4,484,043 and 4,565,910 have serious limitations of function and operating capability.

Where used for patients or the infirm they make no provision for ready interfacing with the variety of nurse call station configurations in different or even the same hospital facilities. They may require the manual operation of on/off switches to activate the monitoring process. Once activated they must then be shut down completely to enable a nurse to move a patient and then manually switched on to reactivate the device after return of the patient. They are not locally modifiable by the monitoring staff to accommodate the needs of a particular patient and/or environment. Furthermore, even in those systems which do permit some time delay adjustment, the system remains in the last time delay mode to which it was adjusted until an active readjustment of the selected delay is made. Consequently, failure to actively adjust the time delay from a previously selected increment could have an undesirable impact on a different patient or environment. A further problem encountered in present monitoring systems is that they employ their on/off switch controls in such a manner that loss of power or inadvertent disconnection from the nurse call station does not cause an alarm. Therefore, the monitoring staff has no assurance that a patient is actually being monitored without repetitive local inspection to assure that the system is properly connected and operable.

Such systems are also generally all hard-wired and therefore not useful in most mobile applications, especially in long term or home care situations. Hard-wired systems are generally intended for use in short term or hospital environment situations, their hard wiring typically provides a delay between switching and activation to permit multiple manipulations of a patient by the staff without triggering an alarm. Such systems require the manual operation of on/off switches to activate the monitoring process. Once activated they must be shut down completely to enable a nurse to move a patient and then manually operated to reactivate the device after return of the patient. But, once activated, patients can, intentionally or inadvertently, trigger the alarm by removing their weight from the system sensor device and then cancel the alarm by returning their weight to the system sensor device. This frequently results in tiresome "cry wolf" attempts by patients to get attention and can even result in disregard of a valid emergency situation by the monitoring staff. They are not locally modifiable by the monitoring staff to accommodate the needs of a particular patient and/or environment. They generally offer no selection of tonal variations in their audio alarm, no selection of time delay increments in their activate and/or alarm modes and no choices as to the operational steps required to disarm and re-arm the device.

None of the known devices, including the aforementioned devices, are suitable for reducing the risks of infant abduction from an infant bearing device or to enhance the opportunity to detect the situation and/or minister to the needs of an infant who has become unsatisfactorily positioned in or fallen from a high chair, carseat or the like.

Among other reasons, these known systems are not suitable for monitoring an infant's occupancy of an infant bearing device because they can be locally manipulated to disconnect or disarm the device. Many are hard-wired and do not permit mobility of the infant bearing device. They are generally not programmable and, whether programmable or not, are designed to operate in response to events likely to occur in the monitoring of an adult and not to meet the requirements imposed in monitoring an infant.

## SUMMARY OF THE INVENTION

A system has now been devised which is suitable to monitor short term and/or hospital care patients. This system may be readily interfaced with a variety of nurse call station configurations, may be programmable on-site by monitoring personnel to adapt the system to each specific patient and environment, may be activated by initial pressure on a sensor device for a predetermined continuous time period rather than by the use of on/off switches, may be made to be temporarily deactivated to a "hold" mode by use of a single hold/reset control on the unit and which will be automatically reactivated to a "monitor" mode when the patient is returned to the system for a predetermined continuous time period, may provide a patient monitoring system which can be immediately activated to override a predetermined delay so as to prevent a quick moving patient from defeating the system, may provide a patient monitoring system in which disconnection of the system from the sensor device, from power or from the nurse call station will result in a failsafe alarm, can be made to provide a patient monitoring system which, in its programmable functions, includes variations of type and volume of alarm tones, may provide a patient monitoring system which permits active selection of time delay increments required before triggering of an alarm and also automatically defaults to a "normal" preselected time delay if a different delay period is not actively selected and may provide a patient monitoring system which provides on-site ability to adapt the system to any of a variety of nurse call station configurations.

An embodiment of this system provides a patient monitoring system which is mobile rather than hard-wired. Such embodiment may provide a patient monitoring system which is suited to long term and/or home care of patients, may provide a patient monitoring system which is programmable on-site by monitoring personnel to adapt the system to each specific patient and environment, may provide a patient monitoring system which is activated by initial pressure on a sensor device rather than by the use of on/off switches, may provide a patient monitoring system which can be temporarily deactivated to a "hold" mode by use of a reset control on the unit and which will be automatically reactivated to a "monitor" mode when the patient is returned to the system, may provide a patient monitoring system in which disconnection of the sensor device from the system will result in a failsafe alarm, may provide a patient monitoring system which, in its programmable functions, includes variations of type and volume of alarm tones, variation in time delay characteristics and an election to cancel an alarm either by return to the monitored condition by the patient or by an independent disarming activity.

A further embodiment of the instant system provides a system for monitoring the occupancy of an infant in an infant-bearing device. Such further embodiment may provide a remotely controlled system for monitoring the occupancy of an infant in an infant-bearing device, may provide a system for monitoring the position of an infant in an infant bearing device, may provide a system which emits an audible alarm tending to discourage infant abduction, may provide a system which emits an alarm which is not unduly oppressive to an infant when the infant ceases occupancy of an infant bearing device and may provide a system not easily detectable by third parties for monitoring the occupancy of and infant-bearing device.

A system useful for the intended purposes is connectible to an electrical power source for monitoring a short term care device having a sensor thereon for detecting the presence of a patient on the device includes a microprocessor and a plurality of circuits connected to the microprocessor. A first circuit connected to the microprocessor and to the sensor automatically initiates operation of the microprocessor upon detection by the sensor of the patient's presence on the device. A second circuit connected to the microprocessor provides an alarm upon demand by the microprocessor. A third circuit connected to the microprocessor is adapted to be interfaced with a nurse call station for generating signals to the station upon demand by the microprocessor. A fourth circuit connected to the microprocessor programs the system in response to commands manually applied to the fourth circuit.

The microprocessor is responsive to a program resident therein to activate the system to a "monitor" mode after a predetermined time delay following detection by the sensor of the patient's presence on the device and is responsive to a first manually operable switch in the fourth circuit to deactivate the system to a "hold/reset" mode after the system has been activated to the "monitor" mode. The microprocessor is further responsive to the first manually operable switch in the fourth circuit to activate the system to the "monitor" mode immediately after detection by the sensor of the patient's presence on the device and manual operation of the first switch and to deactivate the system to the "hold/reset" mode for a predetermined period of time following activating of the system and manual operation of the first switch. The fourth also provides different visual indications when the system is in the "monitor" mode or in the "hold/reset" mode.

The microprocessor also is responsive to the first circuit to activate the system to the "monitor" mode after the system has been deactivated to the "hold/reset" mode with subsequent sequential detection by the sensor of the patient's presence on the device, termination of the patient's presence on the device and resumption of the patient's presence on the device. In addition, the microprocessor is responsive to the first circuit to activate the system to the "monitor" mode after the system has been deactivated to the "hold/reset" mode with subsequent continuous detection by the sensor of the patient's presence on the device for the necessary predetermined period of time.

The microprocessor is responsive to the first circuit to switch the system from the "monitor" mode to an "alarm" mode and trigger the second circuit to provide an alarm a predetermined time after detection by the sensor of termination of the patient's presence on the device. The fourth circuit provides a visual indication when the system is in the "alarm" mode. The microprocessor is sequentially responsive to a second manual switch in the fourth circuit to select the necessary predetermined time from a plurality of preselected different times and the fourth circuit provides a visual indication of which predetermined time has been selected. The microprocessor is further responsive to the fourth circuit to always default the second switch to the same predetermined time when the system has been disconnected from the electrical power source.

The microprocessor is responsive to the first manual switch in the fourth circuit to switch the system from the "alarm" mode to the "hold/reset" mode and disarm the second circuit to cease the alarm when the system is in the "alarm" move and the first manual switch is operated.

The second circuit includes a plurality of components switchably connectible between the microprocessor and the alarm device to provide different input signals to the alarm device while a fifth circuit has a plurality of switches connected to the microprocessor for manually programming the microprocessor. The microprocessor is responsive to the manual programming of the fifth circuit to connect corresponding ones of the signal providing components to the alarm device and thus permit selection of the alarm signal given.

The third circuit has components switchably connectible between the microprocessor and the nurse call station to adapt the system for electrical interfacing with a selected one of pulsed, continuous and one-shot nurse call station configurations while the fifth circuit means has another plurality of switches connected to the microprocessor for manually programming the microprocessor. The microprocessor is responsive to the manual programming of the fifth circuit to adapt the system for electrical interfacing with a selected on of the nurse call station configurations.

Finally, the microprocessor is responsive to disconnection of the first circuit from the microprocessor after the system is activated to the "monitor" mode to cause the second circuit to generate an alarm. Disconnection of the first circuit will occur if the system is disconnected from the electrical power source, the sensor is disconnected from the first circuit of the nurse call station or the sensor is disconnected from the third circuit.

In accordance with a mobile patient bed or chair occupancy monitoring system, a battery powered system is provided for monitoring a long term care device having a sensor thereon for detecting the presence of a load or patient on the device. A microprocessor is responsive to a resident program. A first circuit connected to the microprocessor and to the sensor automatically activates operation of the microprocessor to a "monitor" mode upon detection by the sensor of the patient's presence on the device, maintains operation of the microprocessor for a predetermined time period at least equal to a running time of the program and terminates operation of the microprocessor at the expiration of the predetermined time period after detection by the sensor of termination of the patient's presence on the device prior to expiration of the predetermined time period. A second circuit operates the system in response to commands manually applied to the second circuit. The microprocessor is responsive to a manually operable switch in the second circuit to deactivate the system to a "hold/reset" mode after activating of the system to the "monitor" mode. The microprocessor is further responsive to the first circuit to activate the system to the "monitor" mode after the system has been deactivated to the "hold/reset" mode together with subsequent detection by the sensor of termination of the patient's presence on the device and resumption of the patient's presence on the device. Alternatively, the microprocessor is responsive to the manually operable switch in the second circuit to activate the system to the "monitor" mode after the system has been deactivated to the "hold/reset" mode. A third circuit connected to the microprocessor provides an audio alarm upon demand by the microprocessor. The microprocessor is responsive to the first circuit to switch the system from the "monitor" mode to an "alarm" mode and trigger the third circuit to generate an alarm after the system has been activated to the "monitor" mode together with subsequent detection by the sensor of termination of the patient's presence on the device. The microprocessor is responsive to its program to delay switching to the "alarm" mode and generating of the alarm for a predetermined time after detection by the sensor of termination of the patient's presence on the device. The program affords a plurality of alternatives for the predetermined delay time and a fourth circuit having a plurality of switches connected to the microprocessor permits manual programming of the microprocessor to select the predetermined time from the plurality of alternatives. The microprocessor is also responsive to the first circuit to switch the system from the "alarm" mode to the "monitor" mode and disarm the third circuit to cease the alarm after the sensor detects resumption of the patient's presence on the device. Alternatively, the microprocessor is responsive to the switch of the second circuit to switch the system from the "alarm" mode to the "monitor" mode and disarm the third circuit to cease the alarm after manual operation of the switching. The fourth circuit connected to the microprocessor has a plurality of switches connected to the microprocessor for manually programming the microprocessor to select between the first circuit and second circuit for disarming the alarm. The third circuit may have a plurality of components switchably connectible between the microprocessor and an alarm device for, alone and in combination with others, providing different input signals to the alarm device. The fourth circuit would then include a plurality of switches connected to the microprocessor for manually programming the microprocessor to connect corresponding ones of the input signal providing components to the alarm device. A fifth circuit connected to the microprocessor may provide a visual indication upon demand by the microprocessor. The microprocessor will be responsive to the first circuit to cause the fifth circuit to provide an intermittent visual indication when the system is in the "monitor" mode and to cause the third circuit to generate a momentary audio alarm when the system is activated to the "monitor" mode.

The microprocessor is also responsive to disconnection of the first circuit from the microprocessor after the system is activated to the "monitor" mode to cause the third circuit to generate an alarm. Disconnection may occur by either the sensor being disconnected from the first circuit or by an insufficient voltage supply from a voltage source in the first circuit to operate the system.

In accordance with the remote controlled system for monitoring the occupancy of an infant bearing device, a system for monitoring an infant-bearing device having a sensor thereon for detecting the presence of an infant on the device includes a microprocessor responsive to a resident program. A first circuit connected to both the microprocessor and the sensor automatically activates operation of the microprocessor to a "monitor" mode upon detection by the sensor of the infant's presence on the device, maintains operation of the microprocessor for a predetermined time period at least equal to a running time of the program and terminates operation of the microprocessor at the expiration of the predetermined time period. A second circuit operates the system in response to signals received from a remote control device. The microprocessor is responsive to the signals received from the second circuit to deactivate the system from the "monitor" mode. The microprocessor is further responsive to the first circuit to activate the system to the "monitor" mode after the system has been deactivated from the "monitor" mode if the sensor subsequently detects termination of the infant's presence on the device and resumption of the infant's presence on the device. A third circuit to the microprocessor provides an audio alarm upon demand by the microprocessor. The microprocessor is responsive to the first circuit to switch the system from the "monitor" mode to an "alarm" mode and trigger the third circuit to generate an alarm if the sensor detects termination of the infants presence on the device after the system has been activated to the "monitor" mode. The microprocessor is responsive to the resident program for delay switching to the "alarm" mode and generating of the alarm for a predetermined time after detection by the sensor of termination of the infant's presence on the device.

In one preferred embodiment, the microprocessor is responsive to the first circuit to switch the system from the "alarm" mode to the "monitor" mode and disarm the third circuit to cease the alarm after the sensor detects resumption of the infant's presence on the device an also responsive to the signals received from the second circuit to switch the system from the "alarm" mode to the "monitor" mode and disarm the third circuit means to cease the alarm. In either embodiment, the microprocessor is responsive to the resident program to switch the system from the "alarm" mode to the "monitor" mode and disarm the third circuit to cease the alarm after a predetermined period of time. The system may also include a programmable device allowing the user to select either of the preferred alternative embodiments. Preferably, the microprocessor is responsive to the first circuit to cause the third circuit to generate a momentary audio alarm, perhaps two beeps, to indicate that the system is activated to the "monitor" mode.

As a failsafe, the microprocessor is further responsive to disconnection of the first circuit from the microprocessor after the system is activated to the "monitor" mode to cause the third circuit means to generate an alarm to indicate that the system is not operable. Disconnection of the first circuit occurs upon the sensor being electrically disconnected from the first circuit, the sensor being electrically disconnected from the microprocessor, or an insufficient voltage supply from a voltage source in the first circuit to operate the system.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram of a load bearing or patient hard-wired monitoring system;

Fig. 2 is a schematic diagram of an audio alarm circuit of a hard-wired load bearing or patient monitoring system;

Fig. 3 is a schematic diagram of a "function" alarm circuit of a patient monitoring system;

Fig. 4 is a schematic diagram of a sensor circuit of a patient monitoring system;

Fig. 5 is a schematic diagram of a programmable switching circuit of a patient monitoring system;

Fig. 6 is a schematic diagram of a monitoring station interface circuit of a patient monitoring system;

Fig. 7 is a flow chart of a digital monitoring system under the control of a microprocessor and its associated software;

Fig. 8 is a front elevation view of an enclosure of a patient monitoring system;

Fig. 9 is a top plan view of the enclosure of Fig. 8;

Fig. 10 is a bottom plan view of the enclosure of Fig. 8;

Fig. 11 is a flow chart illustrating the operation of a patient monitoring system from the viewpoint of the monitoring staff;

Fig. 12 is a block diagram of a of a mobile battery powered embodiment of a load monitoring system of the present invention;

Fig. 13 is a schematic diagram of an audio alarm circuit of the patient monitoring system of Fig. 12;

Fig. 14 is a schematic diagram of the visual alarm circuit of the patient monitoring system of Fig. 12;

Fig. 15 is a schematic diagram of the reset circuit of the patient monitoring system of Fig. 12;

Fig. 16 is a schematic diagram of the programmable switching circuit of the patient monitoring system of Fig. 12;

Fig. 17 is a schematic diagram of the power switching circuit of the patient monitoring system of Fig. 12;

Fig. 18 is a flow chart of the operation of the digital monitoring system under the control of the microprocessor and its associated software of the patient monitoring system of Fig. 12;

Fig. 19 is a front elevation view of the enclosure of the patient monitoring system of Fig. 12;

Fig. 20 is a top plan view of the enclosure of Fig. 19;

Fig. 21 is a bottom plan view of the enclosure of Fig. 19;

Fig. 22 is a rear elevational view of the enclosure of Fig. 19;

Fig. 23 is a flow chart illustrating the operation of the system of Fig. 12 from the viewpoint of the monitoring staff;

Fig. 24 is a block diagram of a remote controlled system for monitoring the occupancy of an infant bearing support of the present invention;

Fig. 25 is a schematic diagram of a sensor mat circuit for use with the system of Fig. 24;

Fig. 26 is a schematic diagram of an audio alarm circuit for use with the system of Fig. 24;

Fig. 27 is a schematic diagram of a voltage regulator circuit for use with the system of Fig. 24;

Fig. 28 is a flow chart illustrating the operation of the system of Fig. 24 under the control of a program resident in the microprocessor of the system;

Fig. 29 is a flow chart illustrating the operation of the system of Fig. 24 under the control of an alternative program resident in the microprocessor of the system; and

Fig. 30 is a process diagram illustrating the function of the system of Fig. 24 from the perspective of the care person operating the system.

Turning first to Fig. 1, a patient monitoring system includes and audio alarm circuit 10, a function circuit 30, a power operating circuit 70, a programmable switching circuit 80, a nurse call station interface 90 and a microprocessor 100 connected in a suitable configuration and for operation as hereinafter explained.

The audio alarm circuit 10 is shown in detail in Fig. 2 and includes an audio alarm 11 connected between a voltage source V and ground G. Three transistors 13, 15 and 17 have their bases connected through three resistors 19, 21 and 23 to output terminals on the microprocessor 100. The emitter of each of the transistors 13, 15 and 17 is connected to ground G. The collector of the first transistor 13 is connected directly to the audio alarm 11 to provide the highest level audio alarm. The collector of the second transistor 15 is connected through a resistor 25 to the audio alarm 11 to provide an intermediate level audio alarm. The collector of the third transistor 17 is connected through another resistor 27 having resistance greater than the resistance of the second transistor 25 to the audio alarm 11 to provide the lowest level of audio alarm. Thus, the audio alarm level is selectable under the control of the microprocessor 100.

Turning to Fig. 3, the function circuit 30 of the patient monitoring system is shown in detail. The voltage source V is connected to two terminals of the microprocessor 100. A hold/rest switch 31 is connected on one side to the voltage source V and on its other side through a resistor 33 to ground and to another terminal of the microprocessor 100 and also directly to another terminal of the microprocessor 100. Three LED's 35, 37 and 39 are also connected on one side to the voltage source V and from their other side through respective resistors 41, 43 and 45 to three separate terminals of the microprocessor 100. One LED 35 provides a visual indication, preferably green, that the system is in a "monitor" mode. The second LED 37 provides a visual indication, preferably amber, that the system is in a "hold/rest" mode and the third LED 39 provides a visual indication, preferably red, that the system is in an "alarm" mode. The function circuit 30 also includes a second switch 47 connected on one side to the voltage source V and on the other side to ground G through a resistor 49 and also to another terminal of the microprocessor 100. The second switch 47 permits selection of the delay time that will occur between a triggering event and triggering of the alarm. In conjunction with this second switch 47 three more LED's 51, 53 and 55 are connected on one side to the voltage source V and on their other side through resistors 57, 59 and 61, respectively, to three separate terminals of the microprocessor 100. Each LED 51, 53 and 55 is associated with a numerical indicator of the selected time delay. The LED circuit is sequentially scrolled through the possible time delays by repeated operation of the second switch 47. Preferably, there will also be a tone emitted each time the second switch 47 is pressed.

Fig. 4 illustrates the power operating circuit 70 of the patient monitoring system. A monitoring sensor device such as a pressure sensitive mat 190 is connected on one side to ground G and on its other side through a resistor 71 and a second resistor 73 to the voltage source V. Thus, the grounding of the circuit by application of pressure to mat 190 by the presence of the patient causes a signal to be delivered to the microprocessor 100 and activates the system after lapse of a predetermined built-in time delay, preferable approximately 10 seconds , or after manual override of the time delay, whichever first occurs. This terminal of the microprocessor 100 is connected via one diode 75 to the voltage source V and via a second diode 77 to ground to provide static protection to the microprocessor 100.

A programmable switching circuit 80 of the patient monitoring system illustrated in Fig. 5 is seen to include six two position switches 81, each connected on one side to ground G and on the other side each separately connected to a different terminal of the microprocessor 100. Thus, monitoring personnel can vary the functional operation of the system by reprogramming the microprocessor 100 via programmable switching circuit 80. Preferably, the switches 81 are internal to the system enclosure, but they may be externally accessible. In one preferred embodiment of the patient monitoring system, the switch configurations permit selection of pulsed, continuous or one shot relay nurse call closure as will be hereinafter discussed, as well as off, soft or loud audio levels and a pulsed or continuous alarm response.

Fig. 6, illustrates a nurse call station interface circuit 90. A 12 volt DC source 91 is connected to one side of the coil of a relay switch 93 which has its other side connected through a transistor 95 to ground G. The base of the transistor 95 is connected through a resistor 97 to a terminal of the microprocessor 100. The 12 volt source 91 is also connected through a diode 99 to ground G. The switching portion of the relay switch 93 has its common terminal C and both of its switching terminals S separately externally accessible for connection to the nurse call station (not shown).

Depending on the configuration of the nurse call station, the previously discussed setting of the programmable switching circuit 80 will appropriately connect the interface circuit 90 thus permitting the system to be readily used with all known possible nurse call station configurations, be they normally open, normally closed or one shot type systems.

Fig. 7 illustrates an operational sequence of the patient monitoring system under the control of the internal software of the microprocessor 100. With the system fully connected and before any pressure is applied to the mat 190, the program is initialized and a delay set to three second default 101. The routine then inquires as to whether the set delay switch 47 has been pressed 103. If the response to this inquiry is "YES" 105, the system proceeds to a set delay sub-routine 107 in which toggling of the set delay switch 47 scrolls the delay period from preferably one to three to five seconds and back to one. When the desired delay has been selected, the routine returns to continue the program from jump 109. The LED's 51, 53 and 55 of the set delay circuit indicate which time delay has been selected. If the response to the set delay pressed inquiry 103 is "NO" 111 then the routine continues to a mat pressed inquiry 113. If the response to this inquiry is "NO" 115, then the routine continues in a loop back to the set delay pressed inquiry 103. If the response to the mat pressed inquiry 113 is "YES" 117 then the routine proceeds to a hold mode 119 for the time delay built into the system to occur between application of pressure to the mat and activation of the system, preferably approximately ten seconds. In the hold mode 119, the routine next inquires whether the mat is still pressed 121. If the response to this inquiry is "NO" 123, the routine loops back to the set delay pressed inquiry 103. If the response to the mat still pressed inquiry 121 is "YES" 125, the routine next inquires at a time out for hold 127 as to whether the delay time has been exceeded. As long as the answer to this inquiry is "NO" 129, the routine continues to loop through the hold mode position 119. If, however, the answer to the inquiry is "YES" 131, the routine proceeds to the monitor mode 133 and turns on the monitor LED 51, preferably green, to indicate that the system is in the monitoring condition. Once in the monitor mode 133, the routine next inquires as to whether the hold/reset button 31 has been pressed 135. If the answer to this inquiry is "YES" 137, then the routine returns to the hold mode 119 to restart the cycle. If, however, the answer to this inquiry is "NO" 139, then the routine continues to inquire for a second time as to whether set delay is pressed 141. If the answer to this inquiry is "YES" 143, the system proceeds to the set delay subroutine 107. If the answer to this inquiry is "NO" 145, the routine proceeds to a mat released inquiry 147. If the answer to this inquiry is "NO" 149, the routine returns to the monitor mode 133. If the answer to this inquiry is "YES" 151, the routine proceeds to a time-out inquiry 153 to determine whether the set delay time has elapsed. If the delay time has not elapsed, the answer to this inquiry is "NO" 155 and the routine returns to the monitor mode 133. If the answer to this inquiry is "YES" 157, then the routine proceeds to an alarm on mode 159, where the alarm is given according to the configuration, level, type and location established by the system's programmable circuits. With the alarm on 159, the routine next inquires as to whether or not the hold/reset has been pressed 161. If the response to this inquiry is "NO" 163, the routine returns to the alarm on mode 159 and the alarm is continued. If the response to this inquiry is "YES" 165, then the alarm ceases and the routine returns to the set delay pressed inquiry 103. In the alarm on mode 159, the alarm LED 55, preferably red, will provide visual indication of this condition and in the hold/reset pressed conditions 135 and 161, if the response is "YES" 137 or 165, the hold/reset LED 53, preferably amber, will so indicate.

Figs. 8 through 10 illustrate the enclosure 200 containing the system and preferably approximates two inches in depth, 3 inches in width and 7 inches in height. Preferably, the reset/hold switch 31, the green amber and red LED's 35, 37 and 39, the delay switch 47 and the delay time LED's 51, 53 and 55 are mounted in the top face of the enclosure 200 under the protection of a clear plastic splashguard 201 which is open at the front to permit access to switches 31 and 47. A standard four by four phone jack 203 and power and control cables 205 and 207 are mounted in the bottom face of the enclosure 200, the jack 203 for connection to the sensor mat 190, the power cable 205 for connection to a power source of either 220 VAC 50Hz or 110-VAC 60 Hz (not shown) and the control cable 207 for connection to the nurse call station network (not shown). The front face of the unit is provided with apertures 209 for alignment with the audio alarm 11.

Looking at the operation of the system 300 from the viewpoint of the monitoring staff, after the switches 81 have been manipulated to provide the desired programmable features, the monitoring staff can connect the system for operation 301 by attaching it to the physical device to be monitored, such as a hospital bed, and inserting the sensor 190 into jack 203. Visual and audio indicia will confirm that the system is in operating condition. If, during the monitoring phase of the system operation, the sensor 190 becomes disconnected from the system, an alarm will be triggered to indicate the malfunction. The system is automatically activated when pressure is applied to the mat or sensor 190 either by lapse of the built in time delay 303, preferably approximately 10 seconds, or by pressing the hold/reset button 31 to vacate the delay time 305.

With the system so activated, if the patient moves independently 307, two possibilities result. If the patient's movement is transient and for a time less than the selected alarm time delay 309, the patient's movement will appear as a non-event 311 to the system If the patient's movement continues for a time greater than the selected time delay 313, then the alarm will be triggered 315 as soon as the time delay, if any, has elapsed. This will be indicated to the monitoring staff by both the audio and visual operation of the alarm. The alarm can be disarmed 311 only by pressing the hold/reset button 31 and the system will return to the activate mode by time delay 303 or override 305 condition.

Returning to the activate mode by time delay and by override conditions 303 and 305, if the staff desires to manipulate the system without triggering an alarm 319, it is necessary only to depress the hold/reset button to deactivate 321 the system. If the staff removes the patient within the delay time 323, no alarm will sound. Upon return of the patient 325, the process returns to the activate mode by time delay 303 or override 305 condition. If the staff does not remove the patient 327, the process automatically returns to the activate mode by time delay 303 or override 305 condition.

It should be noted that the above system is especially suited to patient short term or hospital care applications.

Many modifications can be made to the circuits hereinbefore illustrated in conjunction with a preferred embodiment of the system. Greater numbers of programmable switches can be employed to provide greater flexibility in the functional choices available to the monitoring personnel. Internally determined time delays can be established as may be best suitable for the particular application of the system. Many variations are possible with respect to the duration, volume, brightness and type of audio/visual alarm presented.

Turning to the embodiment of Fig. 12, the patient monitoring system includes an audio alarm system 410, a visual alarm system 430, a reset circuit 440, a programmable switching circuit 450, a power operating circuit 470, a sensor device 490 and a microprocessor 500 connected in suitable configuration and for operation as hereinafter explained.

The audio alarm system 410 is shown in detail in Fig. 13 and includes an audio alarm 411 connected between a voltage source V and ground G. Three transistors 413, 415 and 417 have their bases connected through three resistors 419, 421 and 423 to output terminals on the microprocessor 500. The emitter of each of the transistors 413, 415 and 417 is connected to ground G. The collector of the first transistor 413 is connected directly to the audio alarm 411 to provide the highest level audio alarm. The collector of the second transistor 415 is connected through a resistor 425 to the audio alarm 411 to provide an intermediate level audio alarm. The collector of the third transistor 417 is connected through another resistor 427 having resistance greater than the resistance of the second transistor resistor 425 to the audio alarm 411 to provide the lowest level of audio alarm. Thus, the audio alarm level is selectable under the control of the microprocessor 500.

Turning to Fig. 14, the visual alarm system 430 of the patient monitoring system includes an LED 431 connected between the voltage source V and ground G. A transistor 433 has its base connected through a resistor 435 to a terminal of the microprocessor 500. The emitter of the transistor 433 is connected to ground G and the collector of the transistor 433 is connected through another resistor 437 to the LED 431. Thus, the operation of the visual alarm 430 is controlled by the microprocessor 500.

Looking now at Fig. 15, the reset circuit 440 of the patient monitoring system includes a reset switch 441 connected at one side to ground G and at its other side to a terminal of the microprocessor 500 and through a resistor 443 to the voltage source V. Thus, the microprocessor 500 is responsive to operation of the reset circuit 440.

Turning now to Fig. 16, the programmable switching circuit 450 of the patient monitoring system is seen to include four two positioned switches 451, 453, 455 and 457, each connected on one side to ground G and on the other side each separately connected to the voltage source V through a resistor 461, 463, 465 and 467, respectively, and to a terminal of the microprocessor 500. Thus, monitoring personnel can vary the functional operation of the system by reprogramming the microprocessor 500 via the programmable switching circuit 450. In one preferred embodiment of the patent monitoring system, the first switch 451 permits selection of a one or three second time delay between arming of the system and alarm indication, the second switch 453 permits selection between first and second audio levels, the third switch 455 permits a choice of re-arming by either twice operating the reset button or alternatively re-arming by removal and replacement of pressure on the mat 490 and the fourth switch 457 permits election of a stepped or normal alarm response. The power operating circuit 470 of the patient monitoring system is illustrated in Fig. 17 and includes a voltage regulator 471 connected between a power source such as the battery 473 on the input side and the regulated voltage output terminal V (voltage source) to be connected to the other system components. Typically, the battery 473 will be 9 volts and the regulated voltage V will be 5 volts. The control voltage to the voltage regulator 471 is applied from the battery 473 through a resistor 475 to the voltage regulator control terminal 477. A transistor 479 has its collector connected to the control terminal 477 and its emitter connected to ground G. The base of the transistor 479 is connected through a resistor 481 to a terminal on the microprocessor 500. The control terminal 477 is also connected through a blocking diode 483 and resistors 85 and 87 to the sensor mat 490 and thence to ground G. A second blocking diode 491 is also connected between another terminal of the microprocessor 500 and a point between the resistors 485 and 487 in the path to the sensor mat 490, this microprocessor terminal being connected to the voltage source V through a resistor 493. If the mat 490 is plugged into the patient monitoring system without any pressure being applied to the mat 490, no power is delivered to the microprocessor 500. Upon application of pressure to the mat 490 the first blocking diode 483 is grounded, causing the voltage applied at the voltage regulator control terminal 477 to go low, thus energizing the voltage regulator 471 and causing power to be applied to the microprocessor 500. The microprocessor 500 then immediately causes the power operating circuit transistor 479 to be turned on for a predetermined time interval, perhaps 30 to 40 seconds, to maintain power to the microprocessor 500 as it proceeds through its program, even if the initiating pressure is removed from the mat 490. In addition, the presence of pressure on the mat 490 grounds the second blocking diode 491 and causes its associated terminal on the microprocessor 100 to go low, thus indicating to the microprocessor 500 that pressure has been applied to the mat 490. If the pressure on the mat 490 is released before the predetermined time delay, perhaps of 30 to 40 seconds, the power at transistor 479 will be turned off at the end of the delay period, thus shutting off the microprocessor 500 until the mat 490 again has pressure applied to it. It should also be noted that the first blocking diode 483 prevents the mat pressure detection terminal of the microprocessor 500 from going low under the influence of the power operating circuit transistor 479, thus assuring that the full power of the battery 473 will not be applied to the microprocessor 500.

Fig. 18 illustrates a function arrangement of the patient monitoring system under the control of the internal software of the microprocessor 500. With the system fully connected and before any pressure is applied to the mat 490, no power is available at the microprocessor 500. When the mat 490 is pressed 501, power to the microprocessor 500 is turned on 503 and latched 505 for the predetermined delay period by the power operating circuit transistor 479. The LED 431 lights momentarily preferably to a bright level, and the audio alarm 411 sounds once 507 to indicate that the patient monitoring system is armed. The system then proceeds to a monitor mode 509 in which the LED 431 flashes at intervals, preferably at a dimmer level than initially occurred, to indicate continued operation of the system. In this condition, the system proceeds to a monitoring loop and inquires as to whether the reset switch 441 has been pressed 511. If the response is "NO" 513, inquiry is made as to whether the mat 490 has been released 515. If the response to this inquiry is "NO" 517, the monitoring loop repeats itself many times per second 519. If, however, the response to the reset pressed inquiry 511 is "YES" 521, a check configuration step 523 occurs to determine the program status of the programmable switch 455 to choose re-arming by twice operating the reset switch 441. If the programmable switch 455 is in the off condition 525, power to the microprocessor will be turned off 527. If the response to the check configuration step 523 is that the programmable switch 455 is on 529, the system will further inquire as to whether the reset switch 441 has been pressed a second time 531. If the answer to this inquiry is "NO" 533, the reset pressed inquiry 531 will be repeated until such time as the response is "YES" 535, at which time the monitoring loop will be repeated 519 as before. If the response to the first reset pressed inquiry 511 was "NO" 513 and the response to the mat released inquiry 515 was "YES" 537, the system determines whether the first programmable switch 451 has been programmed for one or three second delay 539 and inquires as to whether the mat 490 remains in the pressed condition 541. If the response to this inquiry is "YES" 543, the system returns to the monitoring loop 519. If the answer to the mat pressed inquiry 541 is "NO" 544, the system inquires at a time-out step 545 as to whether the interval during which the mat 490 has not been pressed satisfies the interval determined at the time determining step 539. If the answer to the time-out inquiry 545 is "NO" 547, the routine returns to the mat pressed inquiry 541 where it is repeated until either the mat is pressed again and the routine continues through the mat pressed path 543 or the time established for the time-out step 545 is achieved and the response to the time-out inquiry 545 is "YES" 549. If a "YES" response 549 is received, the system is in the alarm mode and reads the second and fourth programmable switches 453 and 457 to determine the level and type of audio response to be given 551. The system then turns on the alarm to the appropriate configuration 553. At this point, the system again inquires as to whether the mat 490 is pressed 555. If the answer to this inquiry is "YES" 557, the system returns to the monitor loop 519. If the answer to this inquiry is "NO" 559, the system will again inquire as to whether the reset switch 441 has been pressed 561. If the answer to the reset pressed inquiry 561 is "YES" 563, the system turns power off 527 to the microprocessor 500. If, however, the answer to the reset pressed inquiry 561 is "NO" 565, the system inquires at a time-out step 567 as to whether or not a predetermined interval, typically 30 seconds, has occurred in which neither the mat nor the reset has been pressed. If the response to this inquiry is "YES" 569, power is turned off 527 to the microprocessor. If the answer to the time-out inquiry 567 is "NO" 571, the system returns to the second mat pressed inquiry 555 to continue the alarm signal for the time determined in the second time out step 567.

In normal operation as observed by monitoring personnel, the system is turned off until mat 490 is pressed. When pressure is applied to the mat 490, the system turns on and a short beep will be heard from the audio alarm 411 while visual indication from the LED 431 will be seen. When pressure is removed from the mat 490, the audio alarm 411 will sound after the selected time delay. Pressing the reset switch 441 will turn off the audio alarm 411. If it is desirable to move the patient without sounding the alarm 411, one press of the reset switch 441 will disarm the system until the reset switch 441 is pressed again or until pressure on the mat 490 is released and reapplied, depending on the position of the programmable switch 455 controlling the re-arming of the system.

Turning to Figs. 19-22, the enclosure 600 containing the entire system is quite small, approximating one inch in depth, 2 1/3 inches in width and 4 3/4 inches in height. Preferably enclosure 600 has a reset switch 441 containing a red LED 431 on the upper face thereof, a standard four by four phone jack 601 and a recharge jack 603 in the bottom face thereof, the former for connection to the sensor mat 490 and the latter for connection to a recharging power source (not shown). The front of the unit is provided with apertures 605 for alignment with the audio alarm 411 while the back of the unit has externally accessible programmable switches 451, 453, 455 and

457 thereon. A mounting stop 607 may also be attached to the rear face of the enclosure 600.

Looking at the operation of the system 700 from the viewpoint of the monitoring staff, after the switches 451, 453, 455 and 457 have been manipulated to provide the desired programmable features, the monitoring staff can connect the system for operation 701 by attaching it to the physical device to be monitored, such as a wheelchair, and inserting the sensor 490 into the jack 601. This will result in the hereinbefore discussed visual and audio indicia to confirm that the system is in operating condition. If the battery 473 is not sufficiently charged or if, during the monitoring phase of the system operation, the sensor 490 becomes disconnected from the system, an alarm will be triggered to indicate the malfunction. The system is automatically activated 703 when the patient takes a position in the monitored device which operates the sensor 490. Activation will occur immediately upon application of pressure or after a predetermined time delay of brief duration which may be built into the system. With the system so activated, if the patient moves independently 705, there are three possible results. If the patient's movement is transient and for a time less than the built in alarm time delay 707, the patient's movement will appear as a non-event 709 to the system. If the patient's movement is transient but continues for a time greater than the built in time delay 711, then the alarm will be triggered 713 as soon as the built in time delay, if any, has elapsed. This will be indicated to the monitoring staff by both the audio and visual operation of the alarm as hereinbefore described. Upon return of the patient to the system to again operate the sensor 490, the alarm is disarmed 715 and the system remains in its monitoring state. If the movement of the patient is permanent 717, the alarm will be triggered 719 immediately upon lapse of the built in delay time, if any, and will continue until it is disarmed by the affirmative action 721 of the monitoring staff to press the "hold" or "reset" button 441 to return the system to its initial condition prior to operation of the sensor 490 by the patient.

Returning to the condition 703 in which the system has been activated by the presence of the patient on the monitored device to operate the sensor 490, if the staff desires to move the patient without triggering an alarm 723, it is necessary only to depress the "hold" button 725 to deactivate the system which will then be automatically reactivated after removal from and return to the system of the patient 727. If the staff desires to deactivate the system without moving the patient 729, the staff need only press the "hold" button 441 to deactivate the system 731. In this condition, the system can be reactivated either by the subsequent removal and return of the patient to the monitored device 733 or, in the alternative, by depressing the "hold" button 441 once again 735, provided this option has been included by the setting of the programmable switch 455 assigned for this purpose.

It should be noted that the above system is especially suited to patient long term or home care application. The system is not hard wired so

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it is mobile with the device supporting the patient. The alarm is automatically immediately triggered unless a time delay is built into the system and is canceled automatically by return of the patient to the system. This encourages or "persuades" the patient to use the mobile support device that the caregiver desires the patient to use. On the other hand, it eliminates the "cry wolf" alarms that can be generated by a patient"s rapid transient movement in the device and unnecessarily inconvenience the care giver. On the other hand, the system gives the caregiver a great deal of flexibility in the control of the system when on-site manipulation of the patient is desirable.

Turning now to the embodiment of Figs. 24-30, the monitoring system S2 is connected to a sensor mat circuit 810 associated with a sensor mat 892 which is disposed on an infant-bearing device and includes an audio alarm circuit 830, a voltage regulator circuit 850, an RF receiver circuit 870, a remote control reader chip 880, a terminal block 890 and a microprocessor 900 connected in suitable configuration and for operation as hereinafter explained. A remote control device 882 contains a remote control encoder chip 884 which compliments the remote control decoder chip 880 of the system S2.

Fig. 25 illustrates the sensor mat circuit 810 of the monitoring system S2. A monitoring sensor device such as the pressure sensitive mat 892 has its switching circuit 811 connected on one side to ground G and on its other side through a first blocking diode 813 to a terminal of the microprocessor 900, through a second blocking diode 815 to the voltage regulator circuit 850 and through the resistor 871 and to the RF receiver circuit 870. Thus, the grounding of the circuit 810 by application of pressure to the mat 892 by the presence of an infant causes a signal to be delivered to the microprocessor 900 and automatically activates the system S2 after lapse of a time delay, preferably approximately 3 seconds, built into the program of the microprocessor 900.

The audio alarm circuit 830 is shown in detail in Fig. 26 and includes an audio alarm 831 connected between a voltage source V in the voltage regulator circuit 850 and ground G. Three transistors 833, 835 and 837 have their bases connected through three resistors 839, 841 and 843 to output terminals on the microprocessor 900. The emitter of each of the transistors 833, 835 and 837 is connected to ground G. The collector of the first transistor 833 is connected directly to the audio alarm 831 to provide the highest level audio alarm. The collector of the second transistor 835 is connected through a resistor 845 to the audio alarm 831 to provide an intermediate level audio alarm. The collector of the third transistor 837 is connected through another resistor 847 having resistance greater than the resistance of the second transistor resistor 845 to the audio alarm 831 to provide the lowest level of audio alarm. Thus, the audio alarm level and duration is determined by the resident program of the microprocessor 900. In one preferred embodiment, the alarm time will be stepped in volume increments to produce an initial continuous tone incrementally increasing in volume to a threshold at which the level continues to increase in intermittent increments to a maximum, at which time the alarm ceases, the entire alarm period normally extending for approximately 30 seconds from its lowest to its highest level.

The voltage regulator circuit 850 of the monitoring system S2 is illustrated in Fig. 27 and includes a voltage regulator 851 connected to a power source such as the battery 853 on the input side. Typically, the battery 853 will be 9 volts and the regulated voltage V will by 5 volts. The control voltage to the voltage regulator 851 is applied from the battery 853 through a resistor 855 to the voltage regulator control terminal 857. A transistor 859 has its collector connected to the control terminal 857 and its emitter connected to ground G. The base of the transistor 859 is connected through a resistor 861 to a terminal of the microprocessor 900. The control terminal 857 is also connected through the blocking diode 815 to the sensor mat circuit 810. The input terminal 861 of the voltage regulator 851 is also connected to the alarm circuit 830. If the mat circuit 810 is connected to the monitoring system S2 without any pressure being applied to the mat 892, no power is delivered to the microprocessor 900. Upon application of pressure to the mat 892, the second blocking diode 815 is grounded, causing the voltage applied at the voltage regulator control terminal 857 to go low, thus energizing the voltage regulator 851 and causing power to be applied to the microprocessor 900. The microprocessor 900 then immediately causes the transistor 859 to be turned on for a predetermined time interval, perhaps 30 to 40 seconds, to maintain power to the microprocessor 900 as it proceeds through its program, even if the initiating pressure is removed from the mat 892. In addition, the presence of pressure on the mat 892 grounds the first blocking diode 813 and causes its associated terminal on the microprocessor 900 to go low, thus indicating to the microprocessor 900 that pressure has been applied to the mat 892. If the pressure on the mat 892 is released before the predetermined time delay, perhaps of 30 to 40 seconds, the transistor 859 will be turned off at the end of the delay period, thus shutting off the microprocessor 900 until the mat 892 again has pressure applied to it. It should also be noted that the second blocking diode 815 prevents the mat pressure detection terminal of the microprocessor 900 from going low under the influence of the transistor 859, thus assuring that the full power of the battery 853 will not be applied to the microprocessor 900.

Returning to Fig. 24, parental control of the system S2 is accomplished by the combination of the RF receiver 870, the remote control decoder chip 880 and its associated remote control encoder chip 884 in the remote control unit 882 and the terminal block 890. The terminal block 890 is a standard address select device which can be set to establish the specific code that will remotely operate the system S2. With the remote control decoder chip 880 set to recognize a specific code, the microprocessor 900 is responsive to the chip 880 when the RF receiver 870 receives a signal from the encoder chip 884 of the remote control unit 882 which is recognized as the code set in the decoder chip 880. The remote control decoder chip 880 and encoder chip 884 might be MC145027 and MC145026 manufactured by Motorola. Preferably, the wire connecting the sensor mat circuit 810 to the RF receiver 870 serves as the antenna of the RF receiver 870. Preferably, the remote 882 will have a range of approximately fifty feet or more. A particularly preferred sensor mat 892 (Fig. 25) for use with the system S2 is disclosed in U.S. Patent No. 5,554,835, entitled "Pressure Sensitive Switch" filed by the Assignee herein on July 27, 1994. The length of the mat therein disclosed would be scaled to accommodate an infant-bearing device and will likely be approximately six inches long.

Turning now to Fig. 28, a preferred function arrangement of the monitoring system S2 under the control of the internal software of the microprocessor 900 is illustrated. With the system S2 fully connected as before any pressure is applied to the mat 892, no power is available at the microprocessor 900. When the mat 892 is pressed 901, power to the microprocessor 900 is turned on 903 and latched on 905 for the predetermined delay period by the transistor 859. The audio alarm 831 beeps twice 907 to indicate that the monitoring system is activated. The system S2 then proceeds to a monitor mode 909. In this condition, the system S2 proceeds to a monitoring loop and inquires as to whether the remote switch D(not shown) has been pressed 911. If the response is "NO" 913, inquiry is made as to whether the mat 892 has been released 915. If the response to this inquiry is "NO" 917, the monitoring loop repeats itself many times per second 919. If, however, the response to the reset pressed inquiry 911 is "YES" 921, power to the microprocessor 900 will be turned off 927. If the response to the remote pressed inquiry 911 was "NO" 913 and the response to the mat released inquiry 915 was "YES" 937, inquiry is made as to whether the mat 892 remains in the pressed condition 941. If the response to this inquiry is "YES" 943, the system S2 returns to the monitoring loop 919. If the answer to the mat pressed inquiry 941 is "NO" 944, the system inquires at a time-out step 945 as to whether the interval during which the mat 982 has not been pressed satisfies the interval set in the program. If the answer to the time-out inquiry 945 is "NO" 947, the routine returns to the mat pressed inquiry 941 where it is repeated until either the mat is pressed again and the routine continues through the mat pressed path 943 or the time established for the time-out step 945 is achieved and the response to the time-out inquiry 945 is "YES" 949. If a "YES" response 949 is received, the system turns on the alarm 953. At this point, the system S2 again inquires as to whether the mat 892 is pressed 955. If the answer to this inquiry is "YES" 957, the system S2 returns to the monitor loop 919. If the answer to this inquiry is "NO" 959, the system S2 will again inquire as to whether the remote switch has been pressed 961. If the answer to the remote switch pressed inquiry 961 is "YES" 963, the system S2 turns power off 927 to the microprocessor 900. If, however, the answer to the remote switch pressed inquiry 961 is "NO" 965, then the system S2 inquires at a time-out step 967 as to whether or not a predetermined interval, typically 30 seconds, has occurred in system neither the mat 892 nor the remote switch has been pressed. If the response to this inquiry is "YES" 969, power is turned off 927 to the microprocessor. If the answer to the time-out inquiry 967 is "NO" 971, the system returns to the second mat pressed inquiry 955 to continue the alarm signal for the time determined in the second time out step 967.

The function arrangement of the system S2 illustrated in Fig. 28 can be defeated if the infant is removed from the system and replaced within the initial time-out period by another weight sufficient to operate the sensor mat 892. Thus, that function arrangement to some extent relies on the assumption that third parties do not know that the system S2 is being employed. Looking at Fig. 29, and alternative function arrangement of the monitoring system S2 is illustrated to overcome this possibility. The system illustrated in Fig. 29 is in all respects the same as the system illustrated in Fig. 28 except that the third mat pressed inquiry 955 is eliminated and the first time-out inquiry 945 may have a shorter time-out period established in the program. Thus, the delay time between removal of the infant and initiation of the alarm may be set to make it more difficult to exchange a weight for an infant. Furthermore, once the alarm is triggered, it cannot be terminated by merely pressing the mat 892 but requires operation of the remote 882 by the parent or other caregiver.

In normal operation as observed by monitoring parents or care givers, the system S2 is connected for operation 1001 by plugging the mat 892 into the system S2. When pressure is applied to the mat 892, the system S2 is activated 1003 and two short beeps will be heard from the audio alarm 831. The beeps will confirm that the battery 853 is functioning and that the infant is in place on the mat 892. The system S2 is thus in the "monitoring" mode. The infant can be adjusted in place for the selected activate time delay, if any, without triggering the alarm 831. When pressure is removed 1005 from the mat 892 for more than the selected time delay 1005, the system S2 will switch to the "alarm" mode and trigger the alarm 1007. Pressing the remote switch or, depending on the function program selected, returning the infant to the sensor mat 892, or expiration of the alarm period will disarm the audio alarm 1009 and return the system S2 to the "monitor" mode. If it is desirable to remove the infant without sounding the alarm, deactivation can be accomplished by one press of the remote switch 1011. After the infant or pressure is removed 1013, the system S2 will be automatically reactivated by replacement of the infant or pressure 1015. Once the system S2 is activated 1003, if the sensor circuit 810 of the mat 892 becomes inoperable, because the mat 892 is disconnected from the system S2 or the battery 853 becomes inadequate to drive the system S2, then the alarm will be triggered 1019 and can be disarmed 1021 as earlier explained.

Thus, it is apparent that there has been provided, in accordance with the invention, a patient bed and chair occupancy monitoring system, a mobile battery powered patient bed and chair occupancy monitoring system and a remote controlled system for monitoring the occupancy of and infant bearing device that fully satisfies the objects, aims and advantages set forth above.

CLAIMS

1. A system for monitoring a device having a sensor (190; 490; 892) thereon for detecting the presence of a load on the device, the system comprising an alarm device (10; 410; 430; 830) capable of being activated by the system to generate an alarm signal when the sensor (190; 490; 892) indicates the absence of a load for a predetermined period of time, a microprocessor (100; 500; 900) responsive to a program resident therein, and circuit means (70; 470; 810) connected to the sensor (190; 490; 892) and to the microprocessor (100; 500; 900);

the system being characterized in that the microprocessor (100; 500; 900) has a non-monitoring mode in which it does not cause the activation of the alarm device (10; 410; 430; 830) even when the sensor (190; 490; 892) indicates the absence of a load for the predetermined period of time, and a monitoring mode in which it will cause the activation of the alarm device (10; 410; 430; 830) when the sensor (190; 490; 892) indicates the absence of a load for the predetermined period of time while the microprocessor (100; 500; 900) is in its monitoring mode, the microprocessor (100; 500; 900) being programmed to enter its monitoring mode when the sensor (190; 490; 892) detects the presence of a load.

2. A system according to claim 1 characterized by:

call station interface means (90) connected to the microprocessor (100) and adapted to be interfaced with a call station for generating signals to the station upon demand by the microprocessor (100); and

a manually operable delay device (47) connected to the microprocessor (100);

the microprocessor (100) being predetermined so that while the delay device (47) is pressed, the microprocessor (100) will not enter its monitoring mode.

3. A system according to claim 1 characterized in that, after the microprocessor has entered its monitoring mode, the circuit means (70; 470; 810) maintains operation of the microprocessor (100; 500; 900) for a predetermined time period, at least equal to a running

time of the program, and terminates operation of the microprocessor (100; 500; 900) at the expiration of a predetermined time period after detection by the sensor (190; 490; 892) of termination of the load's presence on the sensor (190; 490; 892) prior to expiration of the predetermined time period.

4. A system according to any one of claims 1 to 3 characterized in that the microprocessor (100; 500; 900) is responsive to a manually operable switching means (30; 440; 882) to deactivate the system from its monitoring mode to a hold/rest mode, the microprocessor (100; 500; 900), while in its hold/ rest mode, not monitoring the sensor (190; 490; 892).

5. A system according to claim 4 predetermined in that the microprocessor (100; 500; 900) is programmed, while in the hold/rest mode after deactivation from its monitoring mode, to resume its monitoring mode upon subsequent detection by the sensor (190; 490; 892) of the presence of a load on the device.

6. A system according to any of claims 1 to 5 characterized in that, after the microprocessor (100; 500; 900) has activated the alarm device (10; 410; 430; 830), if the sensor (190; 490; 892) detects resumption of the presence of a load on the device, the microprocessor (100; 500; 900) will disarm the alarm device (10; 410; 430; 830).

7. A system according to any one of claims 1 to 6 predetermined by a signal receiving circuit (880) arranged to operate the system in response to signals received from a remote control device.

8. A system according to any of claims 1 to 7 characterized in that, after the microprocessor (100; 500; 900) has been deactivated from its monitoring mode to its non-monitoring mode, if the sensor (190; 490; 892) subsequently detects termination of the

presence of a load on the device, followed by resumption of the presence of a load on the device, the circuit means (70; 470; 892) will cause the microprocessor to resume its monitoring mode.

9. A system according to any one of claims 1 to 8 characterized in that the microprocessor (100; 500; 900) is responsive to the circuit means (70; 470; 892) to delay at least one action of the circuit means (70; 470; 892) for a preselected period of time.

10. A system for monitoring an infant-bearing device having a sensor thereon for detecting the presence of an infant on the device comprising:

a microprocessor responsive to a program resident therein;

first circuit means connected to said microprocessor and to the sensor for automatically activating operation of said microprocessor to a "monitor" mode upon detection by the sensor of the infant's presence on the device, for maintaining operation of said microprocessor for a predetermined time period at least equal to a running time of said program and for terminating operation of said microprocessor at the expiration of said predetermined time period after detection by said sensor of termination of the infant's presence on the device prior to expiration of said predetermined time period; and second circuit means connected between said sensor and said microprocessor for operating said system in response to signals received from a remote control device.

11. A system for monitoring a long term care device having a sensor thereon for detecting the presence of a patient on the device comprising:

a microprocessor responsive to a program resident therein; and

first circuit means connected to said microprocessor and to the sensor for automatically activating operation of said microprocessor to a "monitor" mode upon detection by the sensor of the patient's presence on the device, for maintaining operation of said microprocessor for a predetermined time period at least equal to a running time of said program and for terminating operation of said microprocessor at the expiration of said predetermined time period if detection by said sensor of termination of the patient's presence on the device occurs prior to expiration of said predetermined time period.

12. A system connectible to an electrical power source for monitoring a short term care support device having a sensor thereon for detecting the presence of a patient on the device comprising:

a microprocessor;

first circuit means connected to said microprocessor and to the sensor for automatically initiating operation of said microprocessor upon detection by the sensor of the patient's presence on the device;

second circuit means connected to said microprocessor for providing an alarm upon demand by said microprocessor;

third circuit means connected to said microprocessor and adapted to be interfaced with a nurse call station for generating signals to the station upon demand by said microprocessor; and

fourth circuit means connected to said microprocessor for controlling said system in response to commands manually applied to said fourth circuit means;

said microprocessor being responsive to a program means resident therein for activating said system to a "monitor" mode after a predetermined time delay following detection by the sensor of the patient's presence on the device.

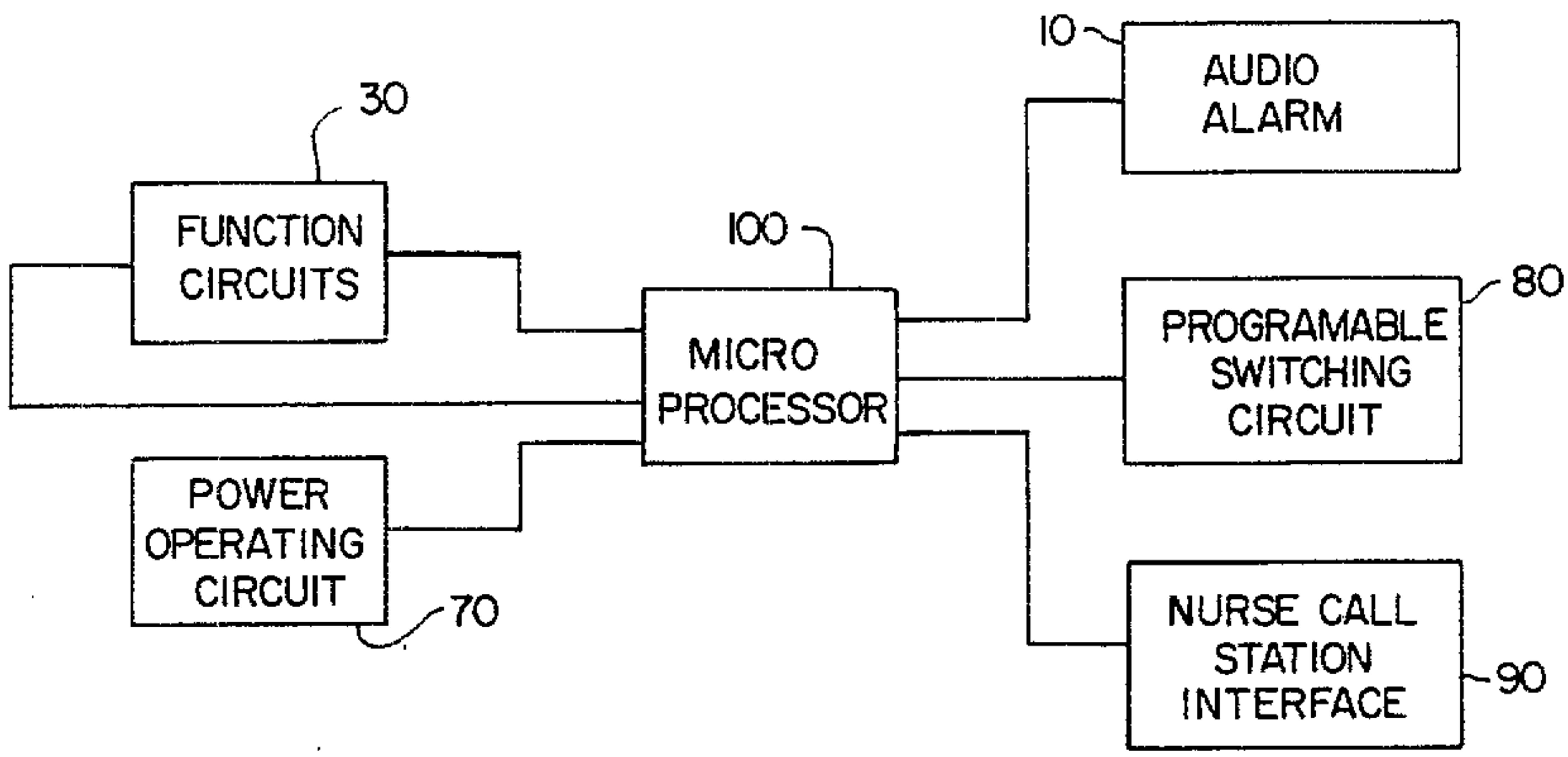

10
AUDIO ALARM
30
FUNCTION CIRCUITS
100
MICRO PROCESSOR
PROGRAMABLE SWITCHING CIRCUIT
80
POWER OPERATING CIRCUIT
70
NURSE CALL STATION INTERFACE
90

FIG. 1

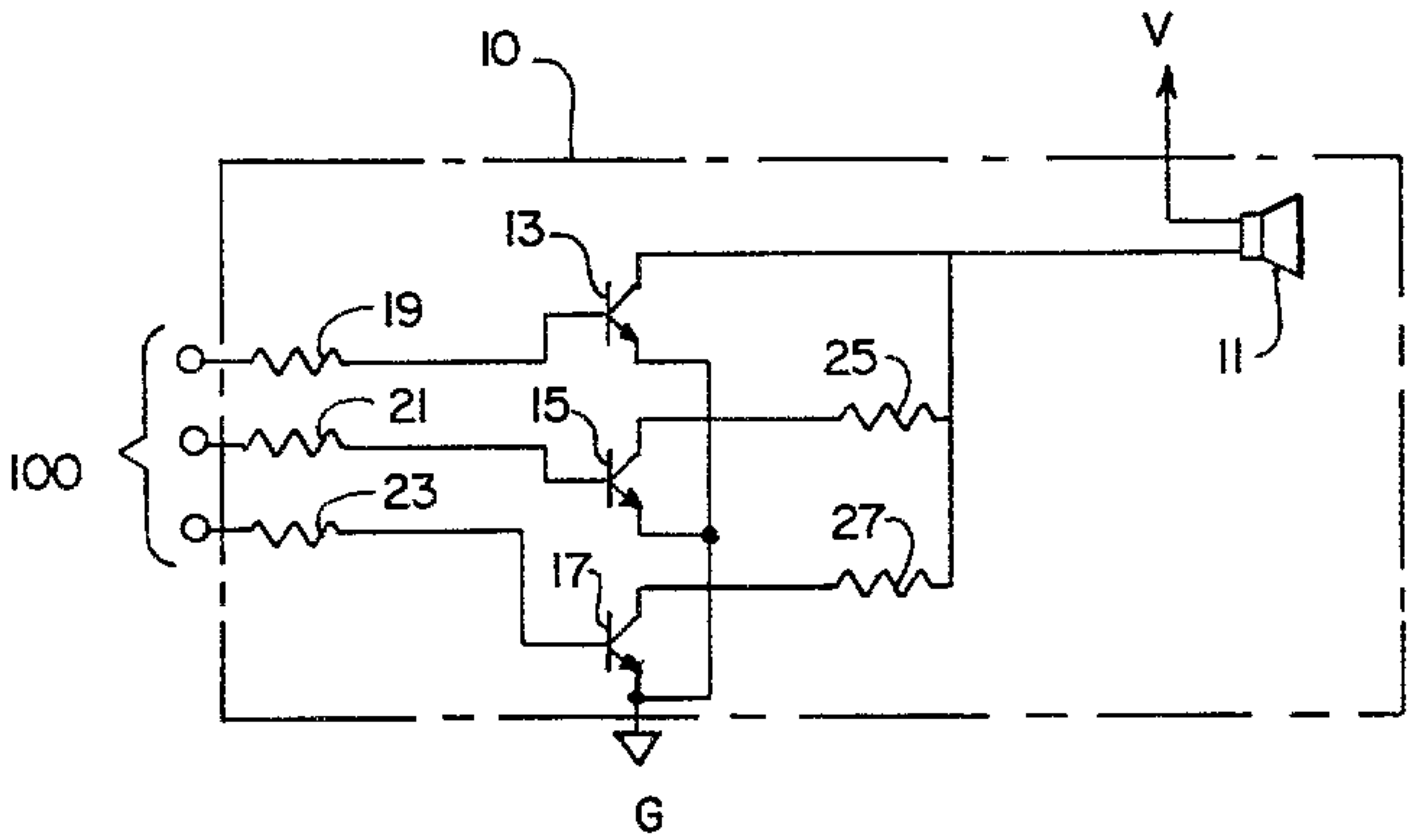

10
V
13
19
25
11
21
15
100
23
27
17
G

FIG. 2

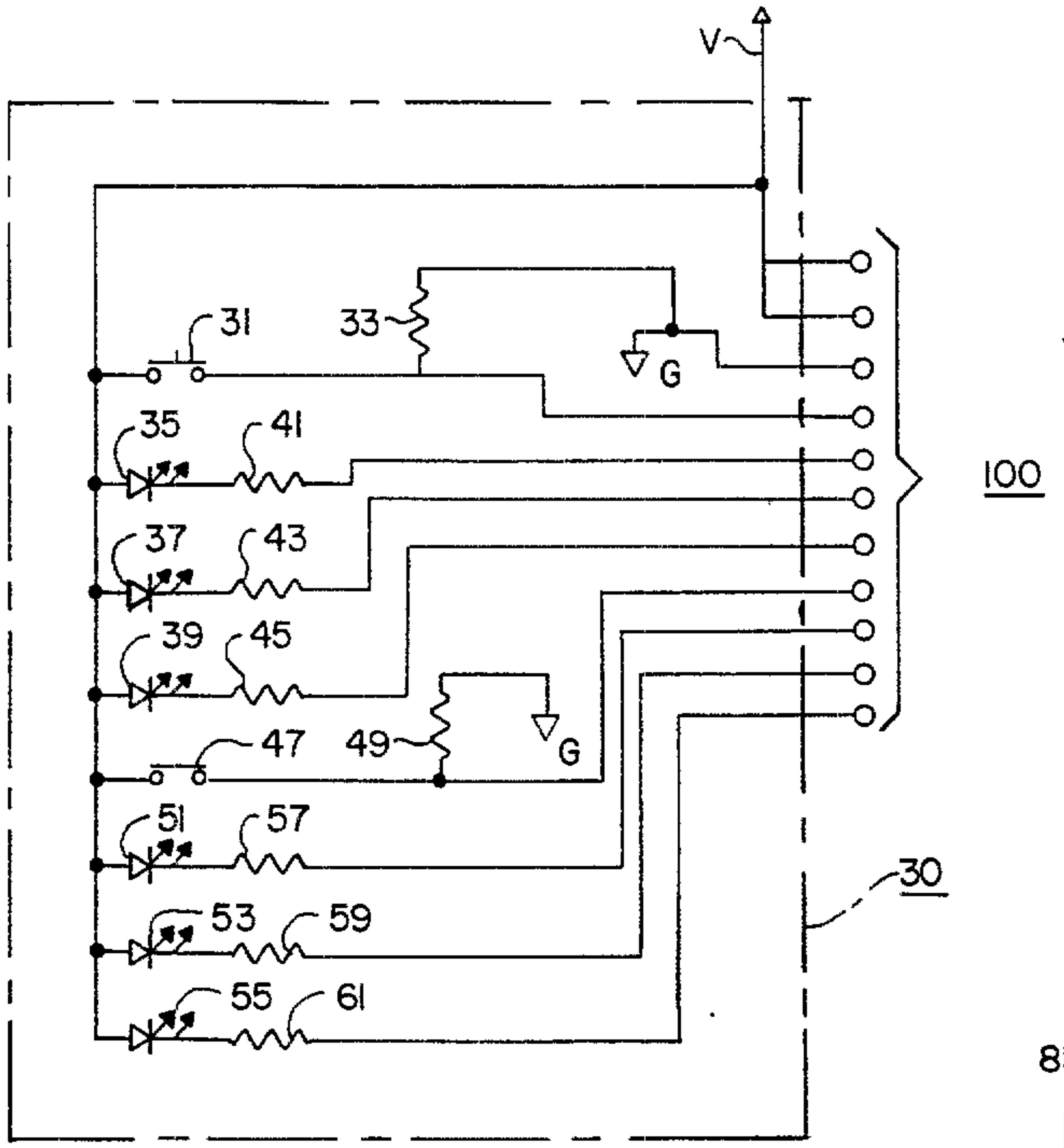



FIG. 3

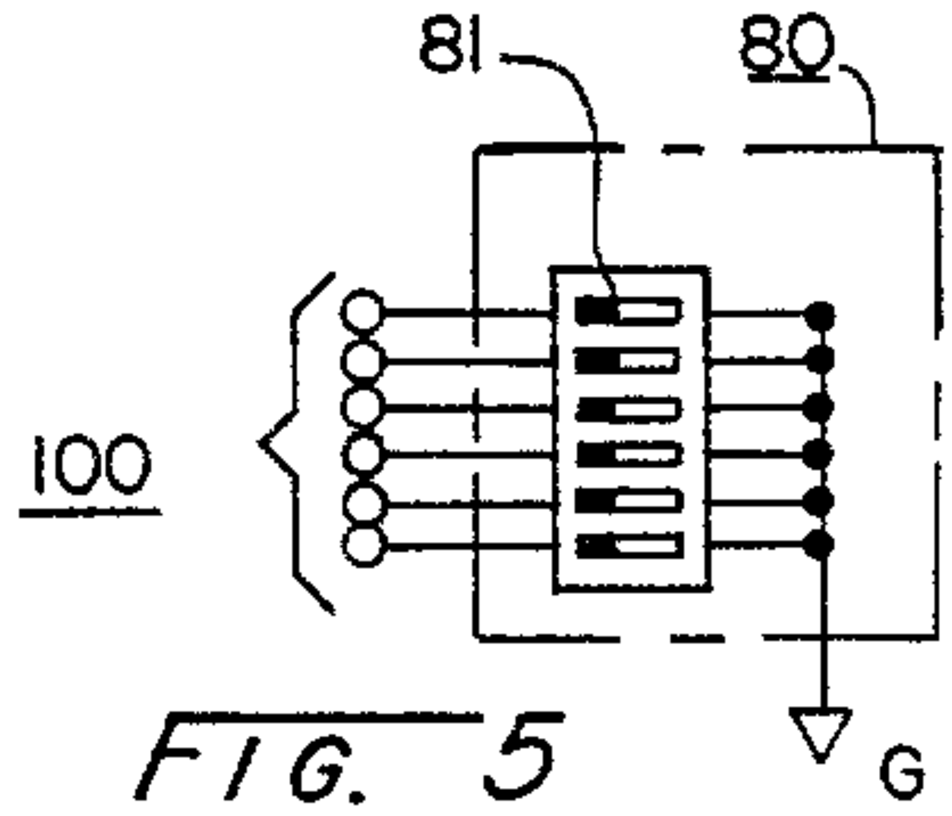



FIG. 5

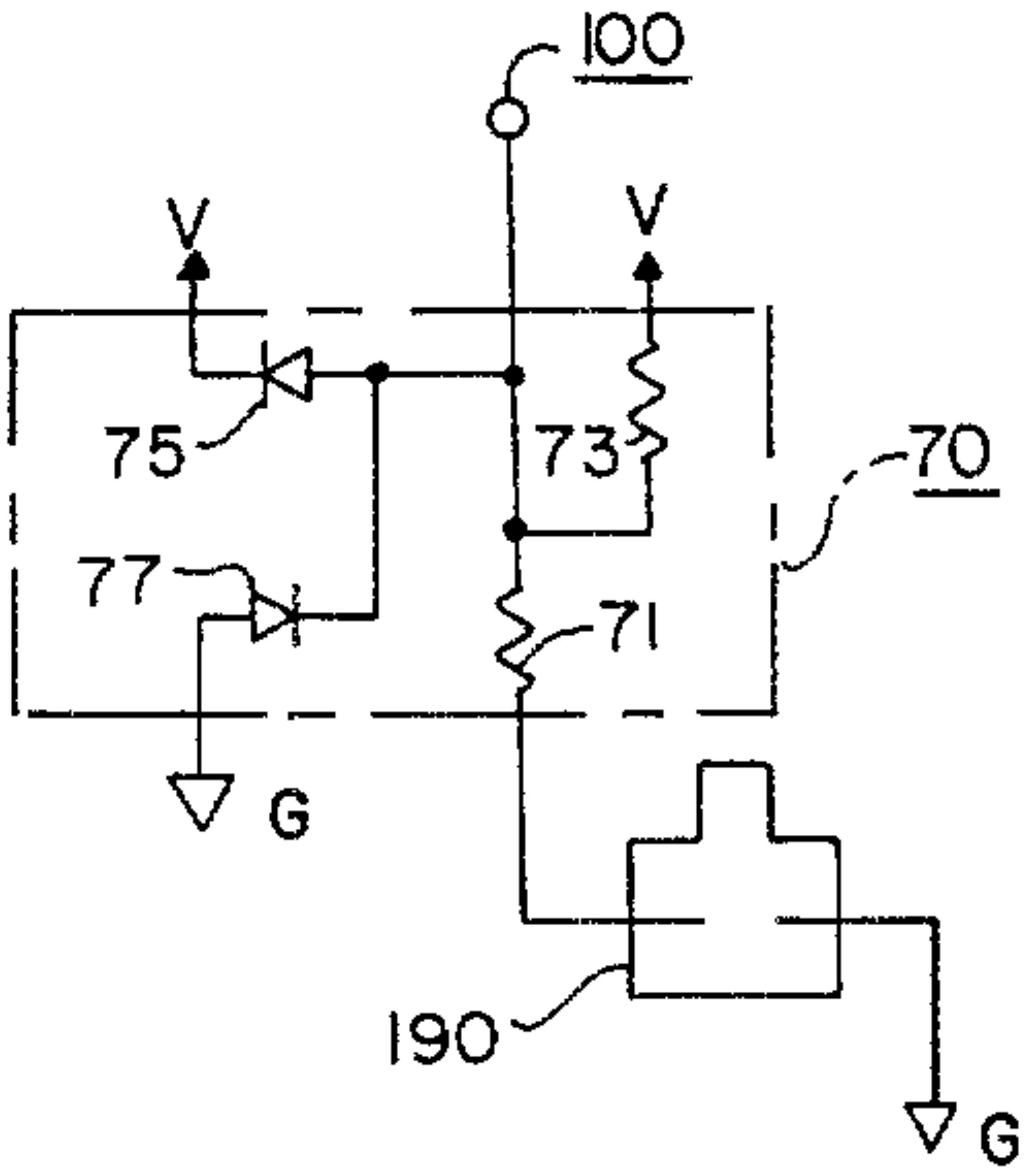



FIG. 4

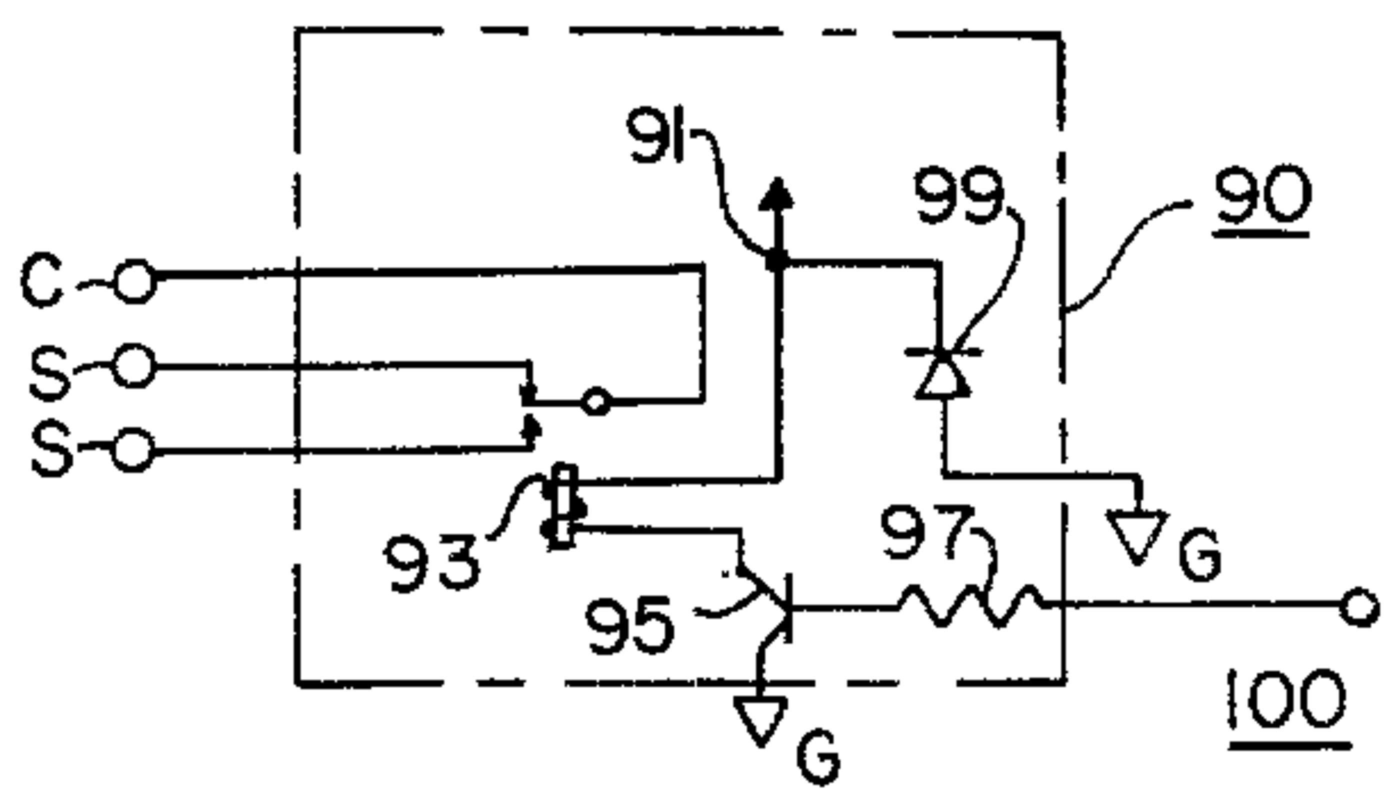
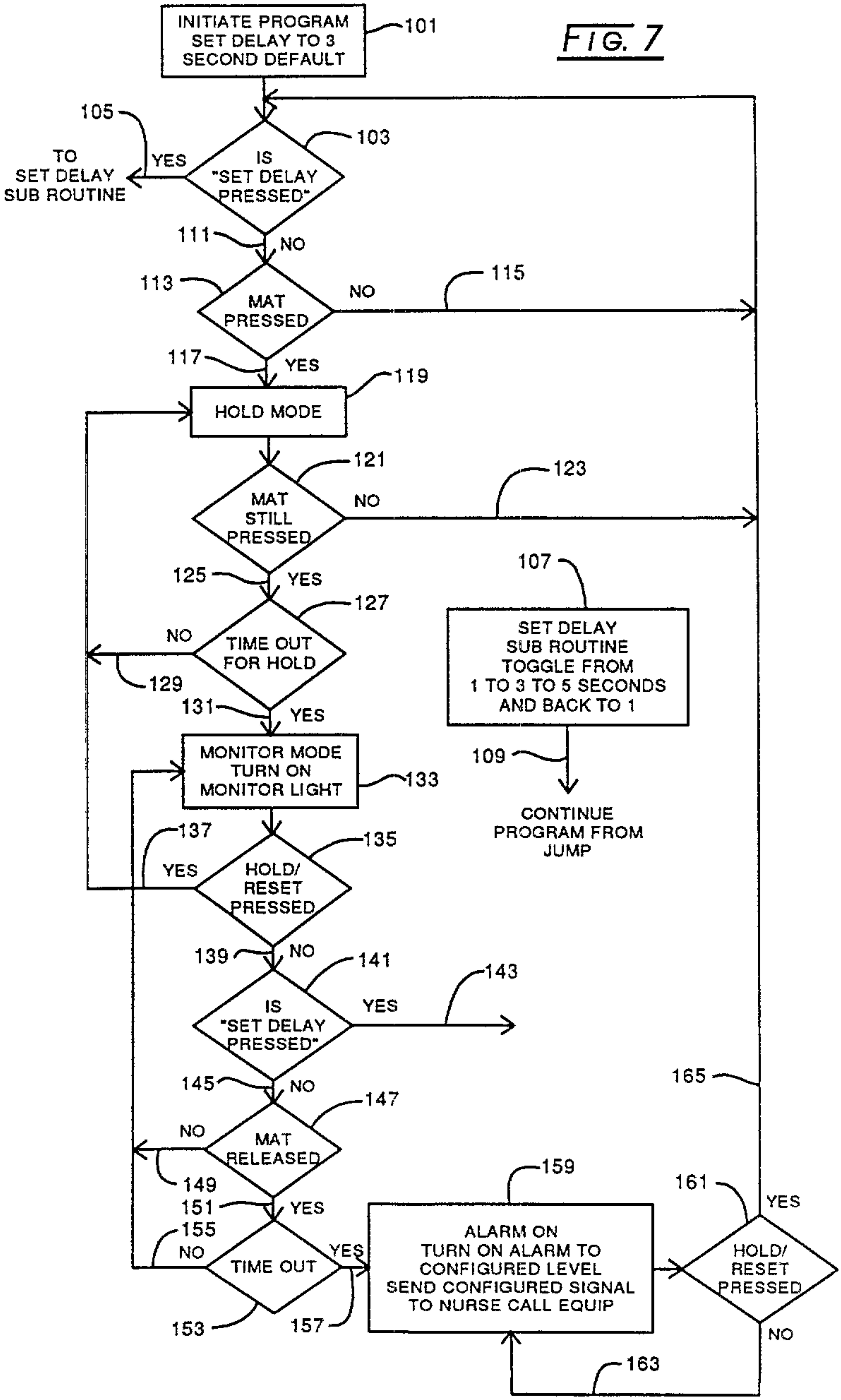



FIG. 6

FIG. 7


INITIATE PROGRAM SET DELAY TO 3 SECOND DEFAULT
101
105
TO SET DELAY SUB ROUTINE
YES
IS "SET DELAY PRESSED"
103
111
NO
113
MAT PRESSED
NO
115
117
YES
HOLD MODE
119
121
MAT STILL PRESSED
NO
123
125
YES
127
NO
TIME OUT FOR HOLD
129
131
YES
MONITOR MODE TURN ON MONITOR LIGHT
133
137
YES
HOLD/ RESET PRESSED
135
139
NO
141
IS "SET DELAY PRESSED"
YES
143
145
NO
147
NO
MAT RELEASED
149
151
YES
155
NO
TIME OUT
YES
153
157
107
SET DELAY SUB ROUTINE TOGGLE FROM 1 TO 3 TO 5 SECONDS AND BACK TO 1
109
CONTINUE PROGRAM FROM JUMP
165
159
ALARM ON TURN ON ALARM TO CONFIGURED LEVEL SEND CONFIGURED SIGNAL TO NURSE CALL EQUIP
161
YES
HOLD/ RESET PRESSED
NO
163

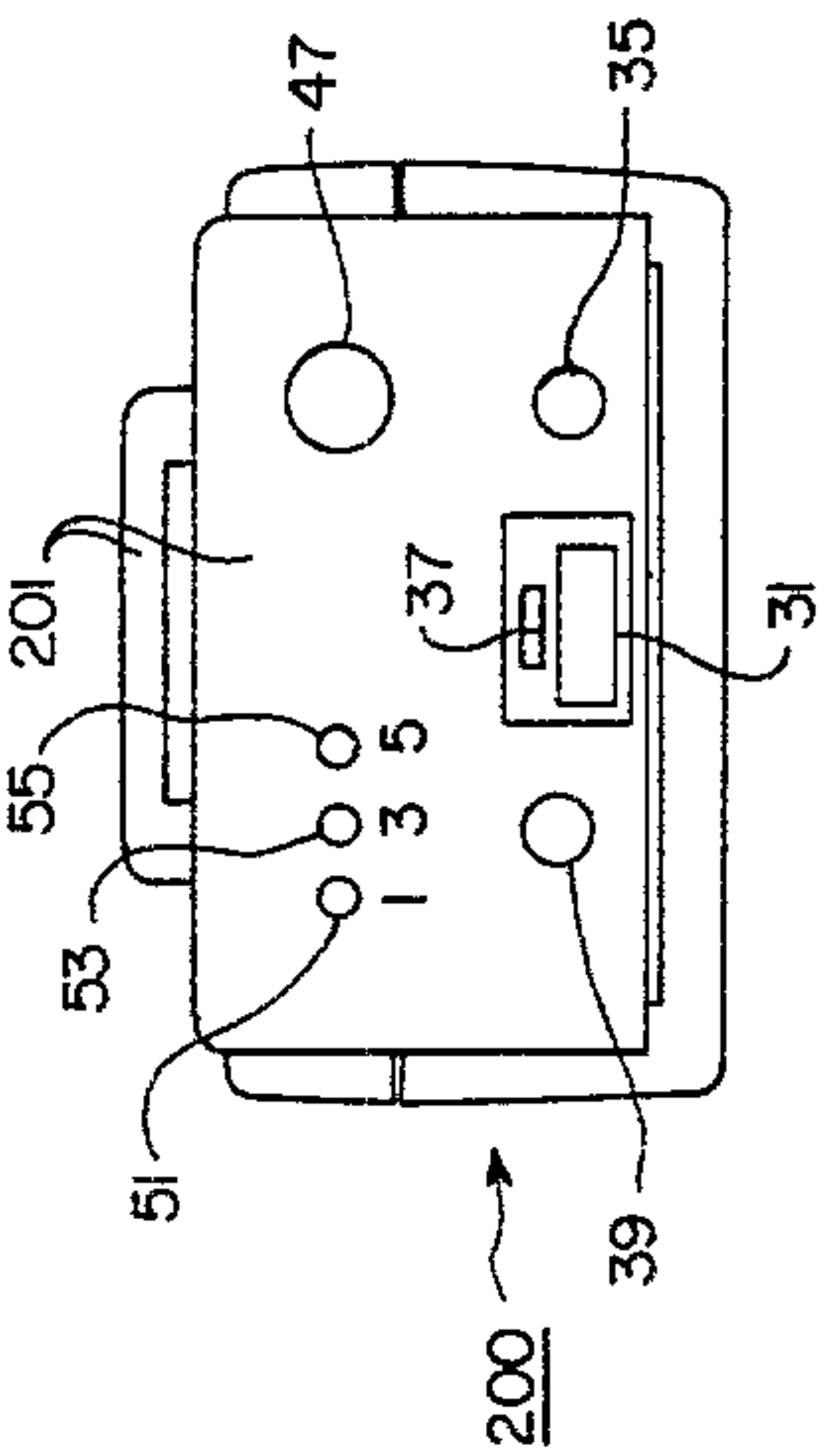



FIG. 9

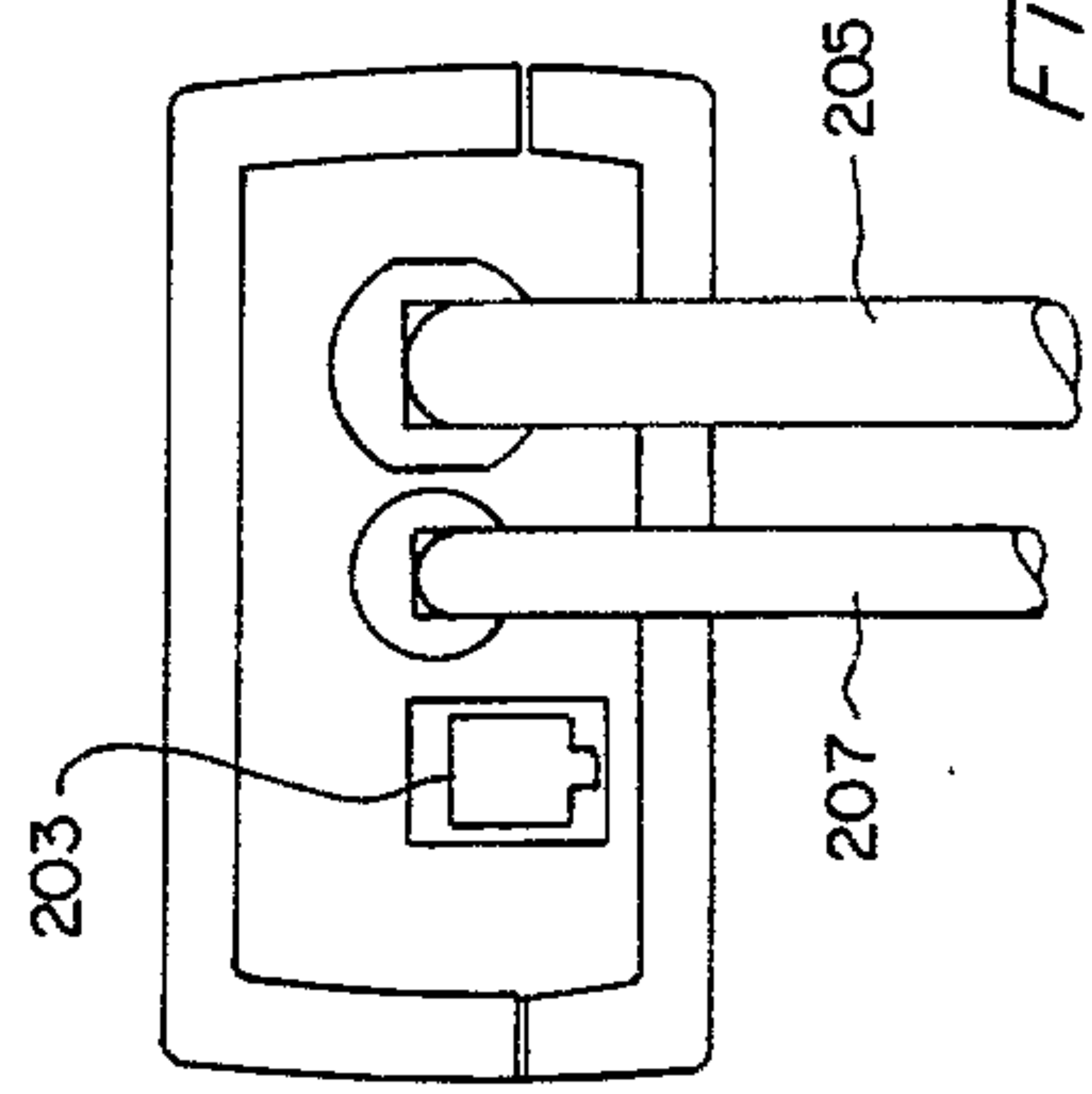



FIG. 10

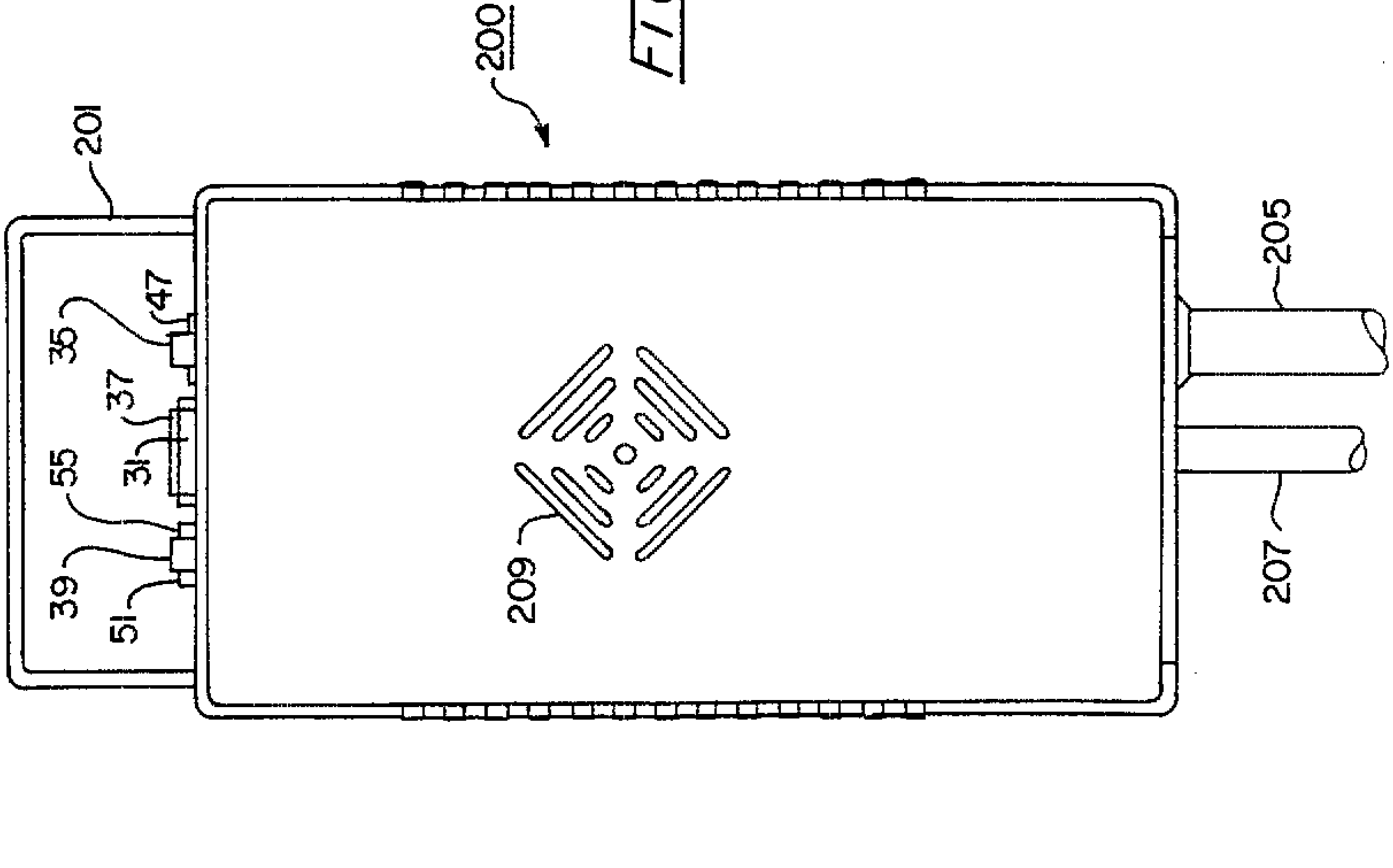



FIG. 8

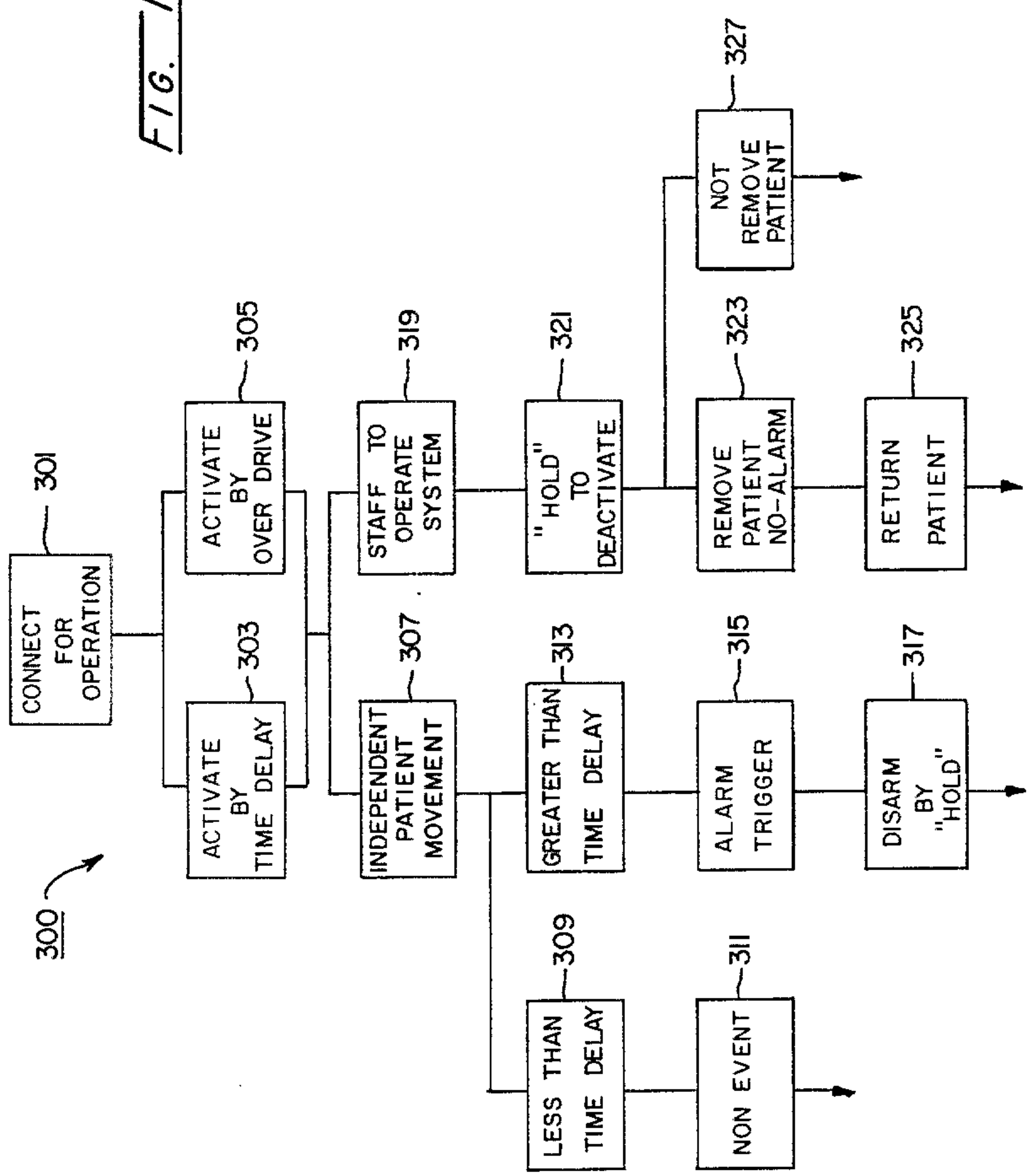

300
CONNECT FOR OPERATION
301
ACTIVATE BY TIME DELAY
303
ACTIVATE BY OVER DRIVE
305
INDEPENDENT PATIENT MOVEMENT
307
LESS THAN TIME DELAY
309
NON EVENT
311
GREATER THAN TIME DELAY
313
ALARM TRIGGER
315
DISARM BY "HOLD"
317
STAFF TO OPERATE SYSTEM
319
"HOLD" TO DEACTIVATE
321
REMOVE PATIENT NO-ALARM
323
RETURN PATIENT
325
NOT REMOVE PATIENT
327

FIG. 11

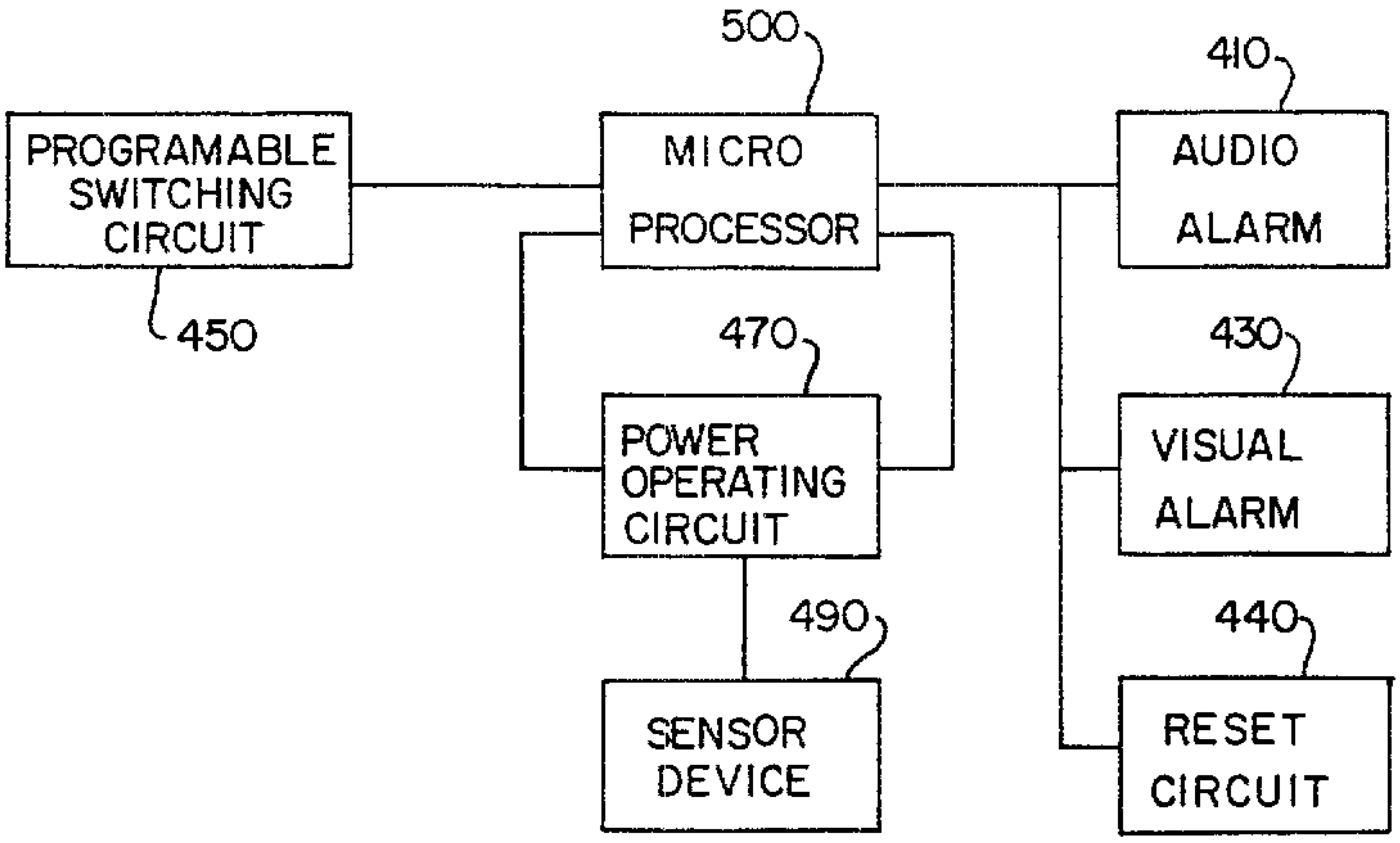
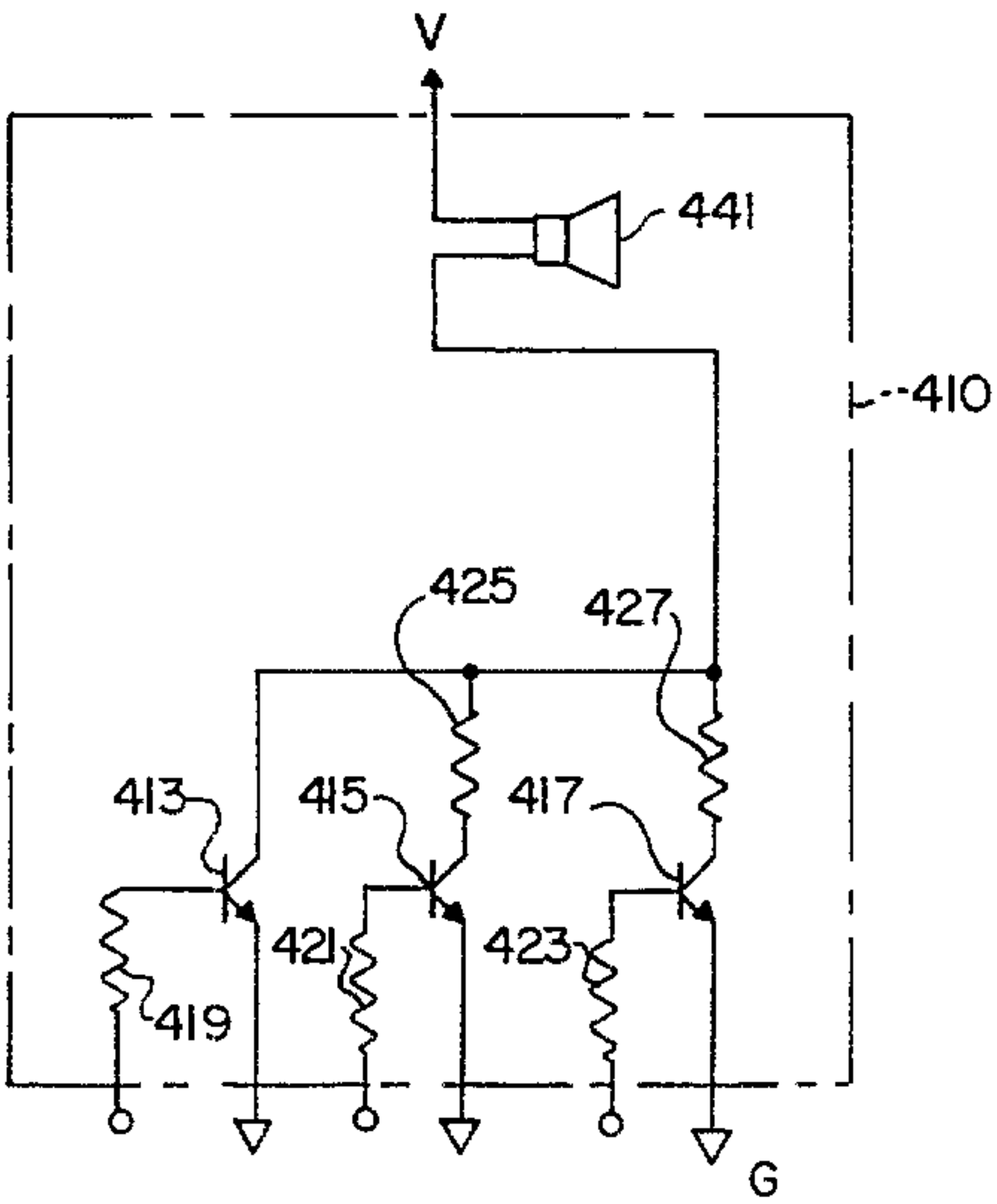



FIG. 12



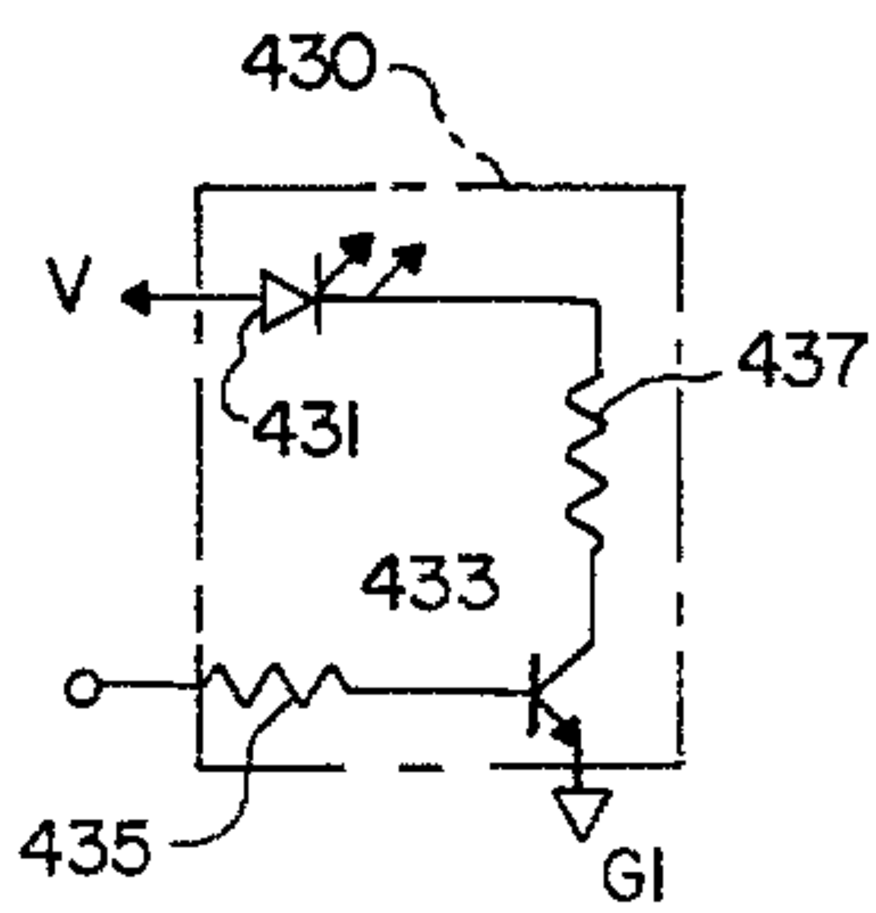




FIG. 14

FIG. 13

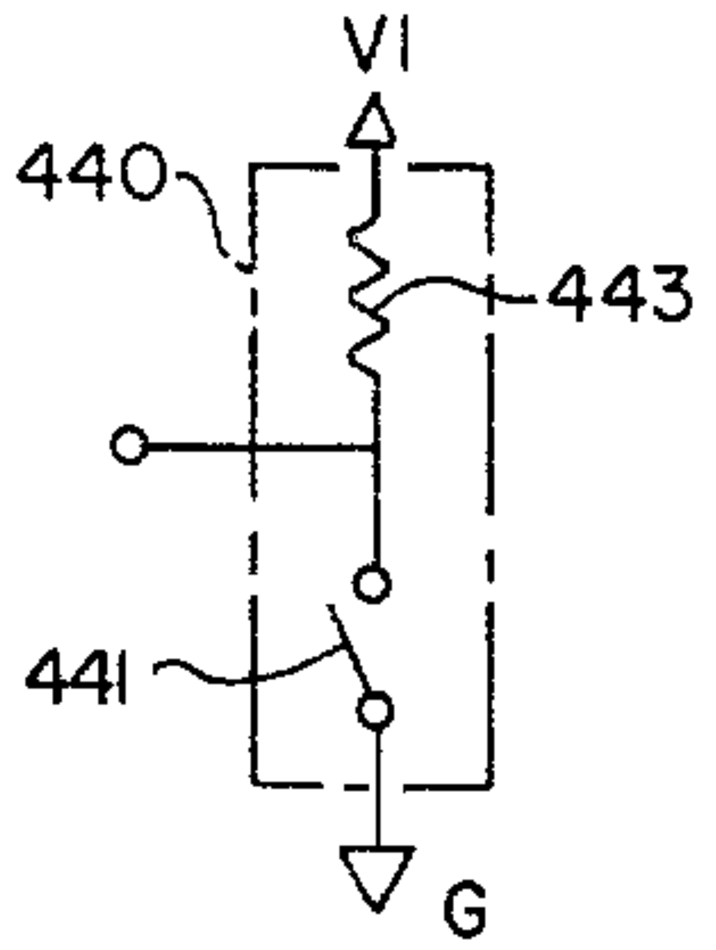



FIG. 15

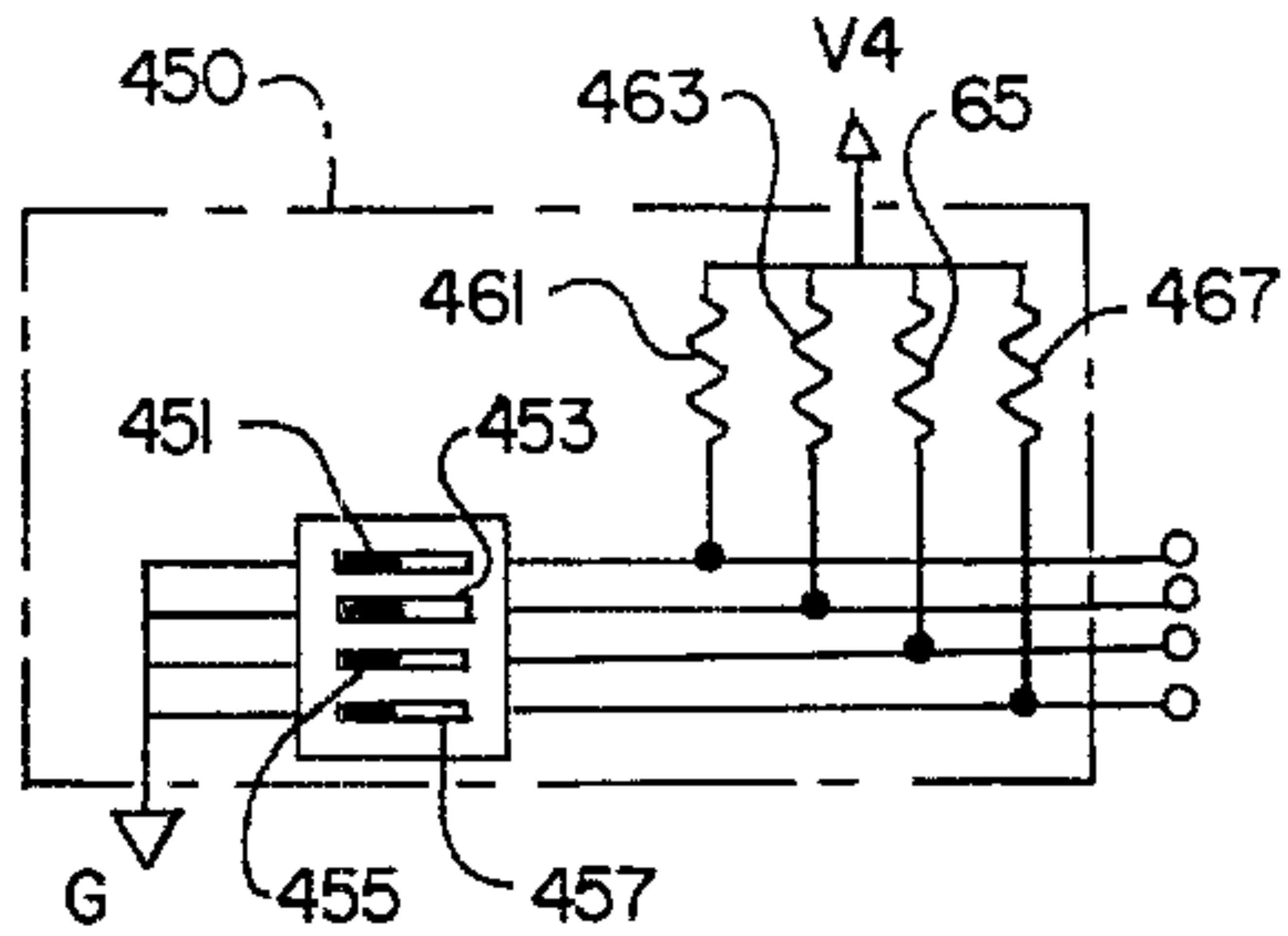



FIG. 16

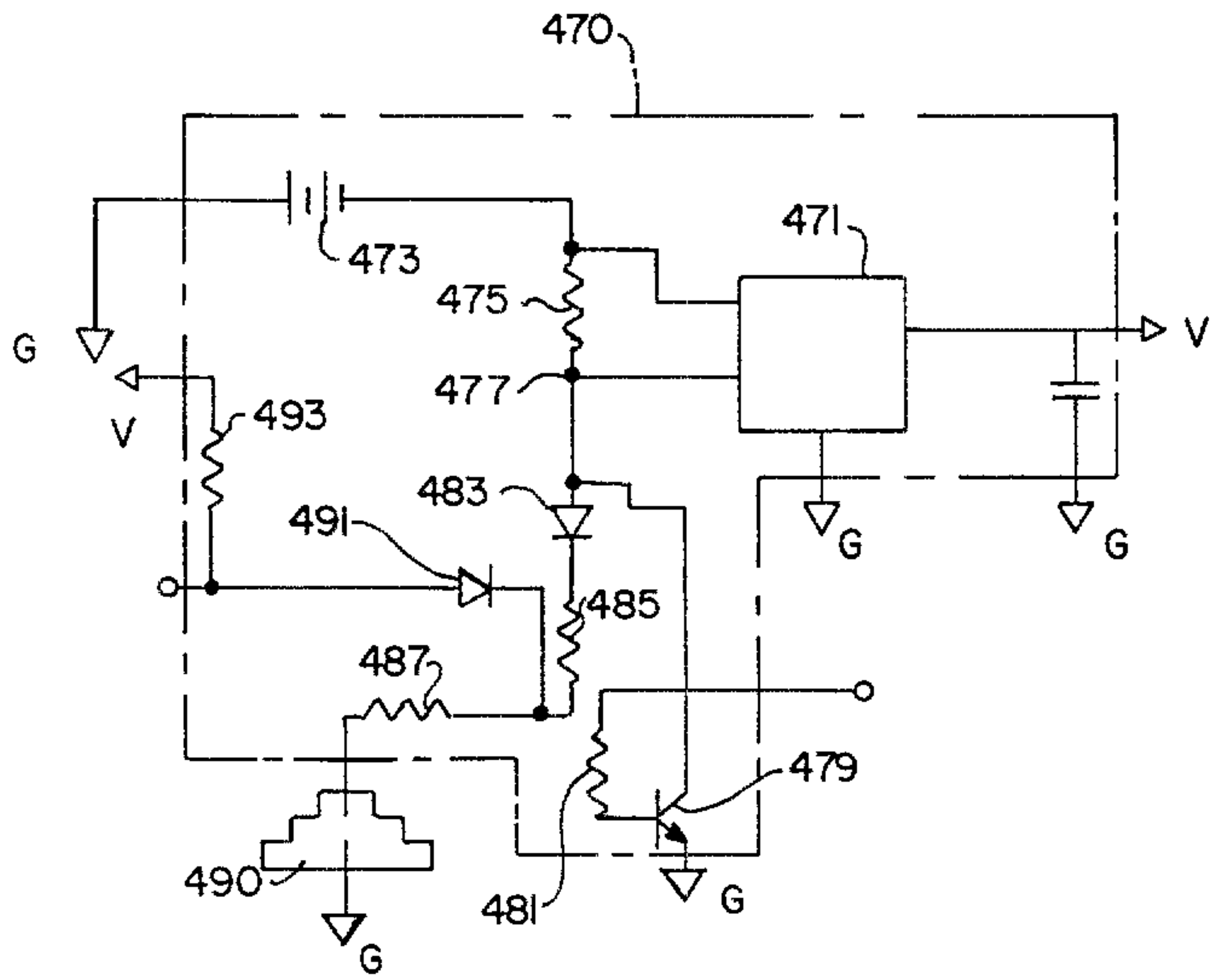



FIG. 17

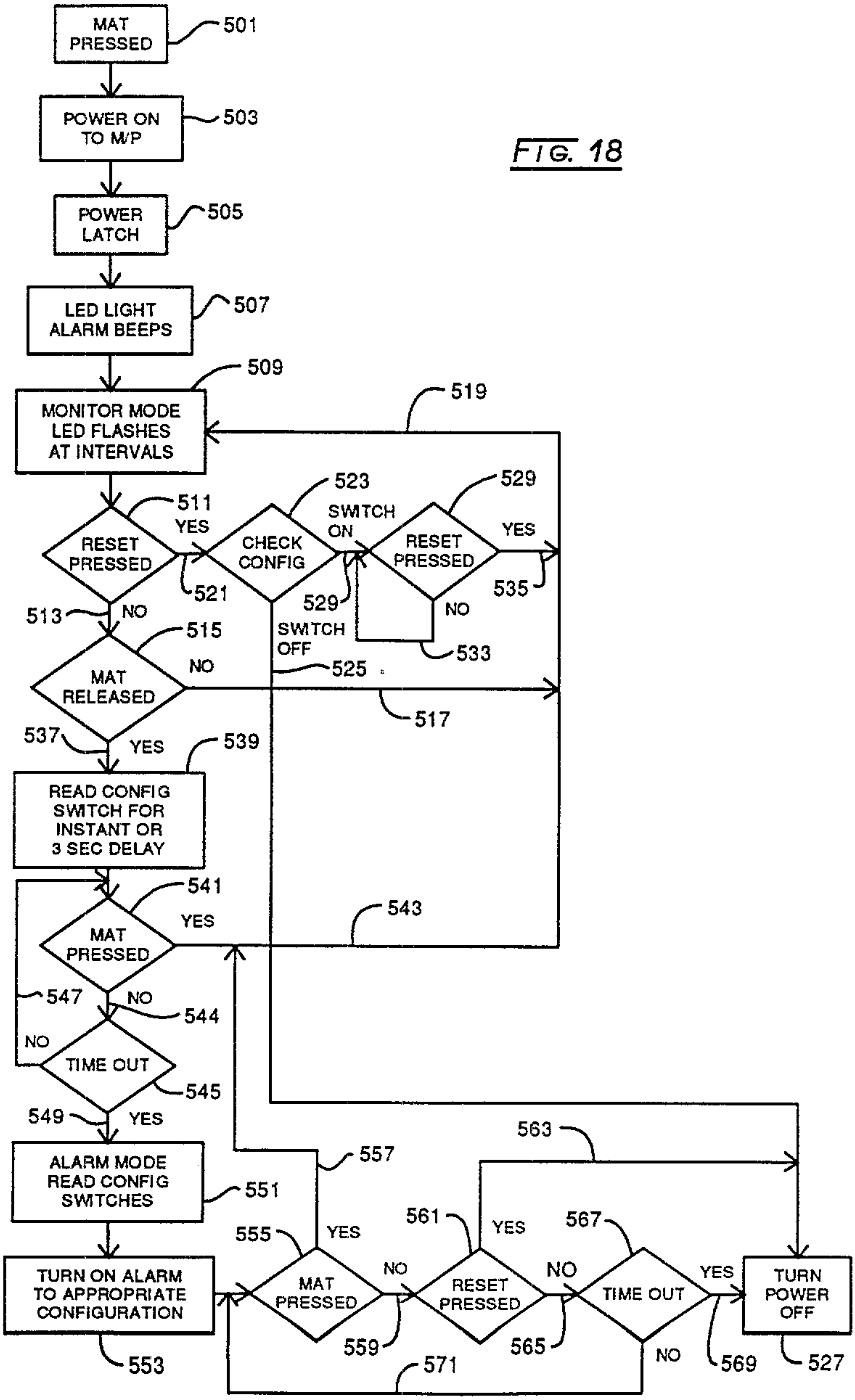

MAT PRESSED
501
POWER ON TO M/P
503
POWER LATCH
505
LED LIGHT ALARM BEEPS
507
509
MONITOR MODE LED FLASHES AT INTERVALS
519
511
YES
RESET PRESSED
523
CHECK CONFIG
SWITCH ON
529
RESET PRESSED
YES
535
521
529
NO
533
513
NO
515
MAT RELEASED
NO
SWITCH OFF
525
517
537
YES
539
READ CONFIG SWITCH FOR INSTANT OR 3 SEC DELAY
541
YES
543
MAT PRESSED
547
NO
544
NO
TIME OUT
545
549
YES
ALARM MODE READ CONFIG SWITCHES
551
557
563
TURN ON ALARM TO APPROPRIATE CONFIGURATION
553
555
YES
MAT PRESSED
NO
559
561
YES
RESET PRESSED
NO
565
567
TIME OUT
YES
NO
569
571
TURN POWER OFF
527

FIG. 18

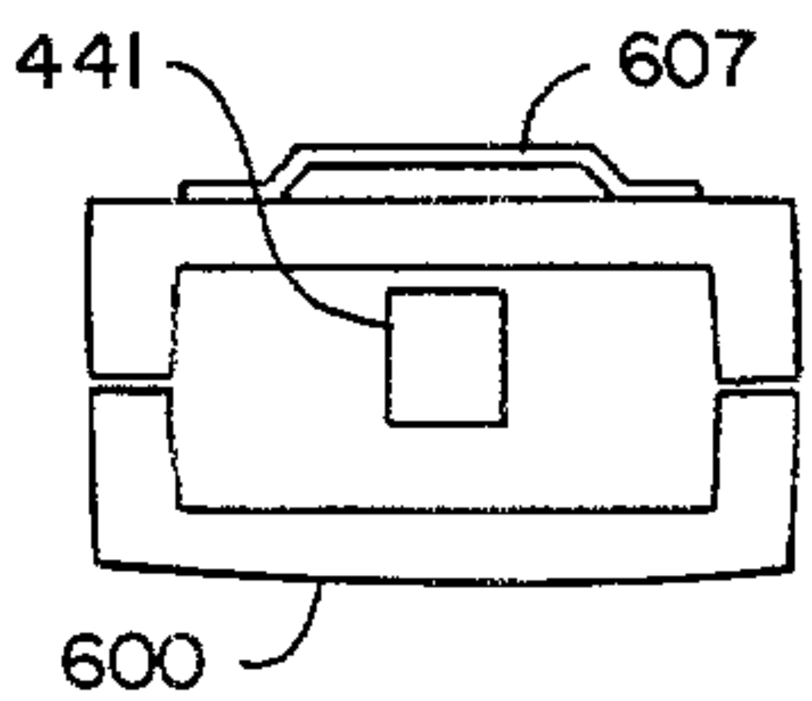



FIG. 20

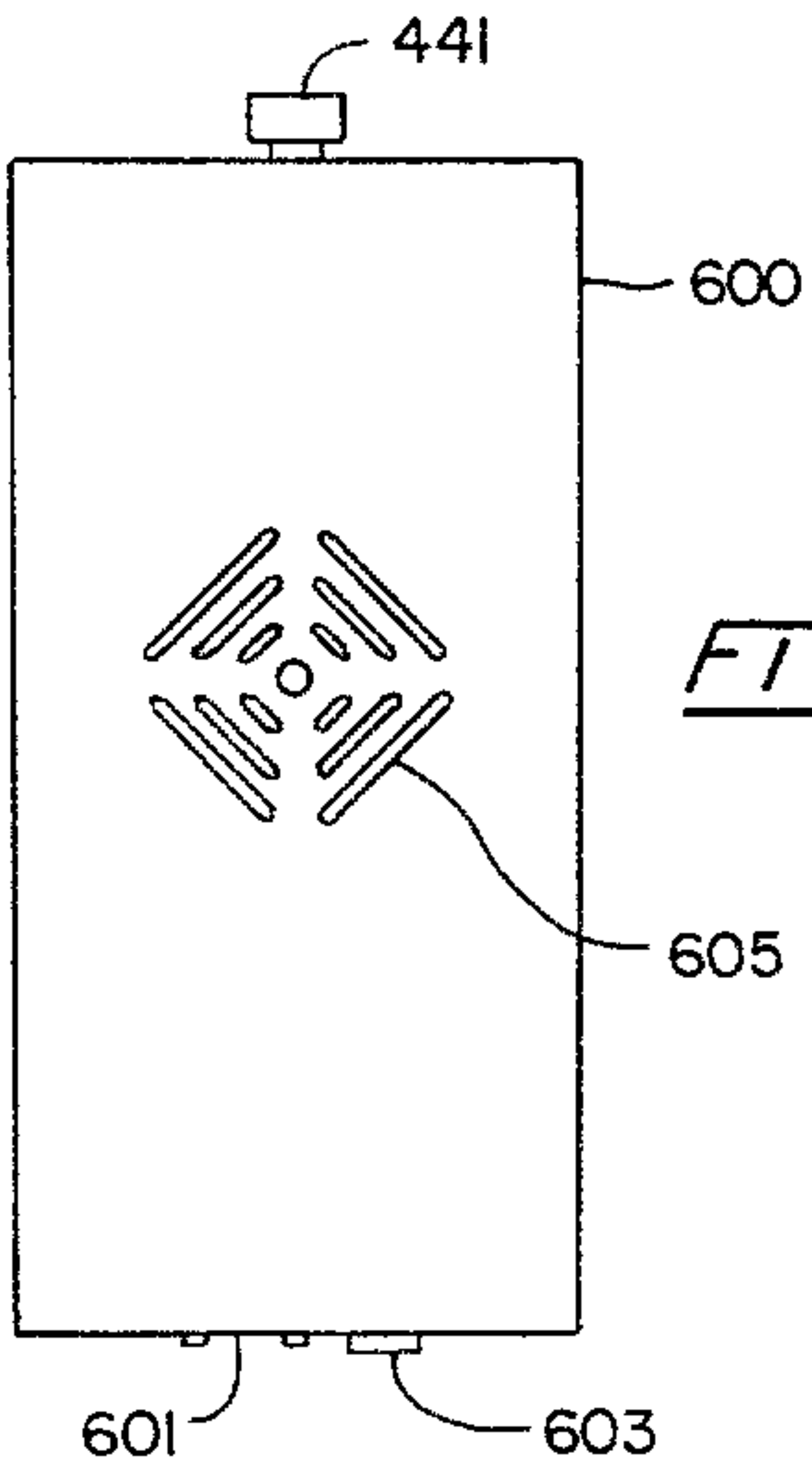



FIG. 19

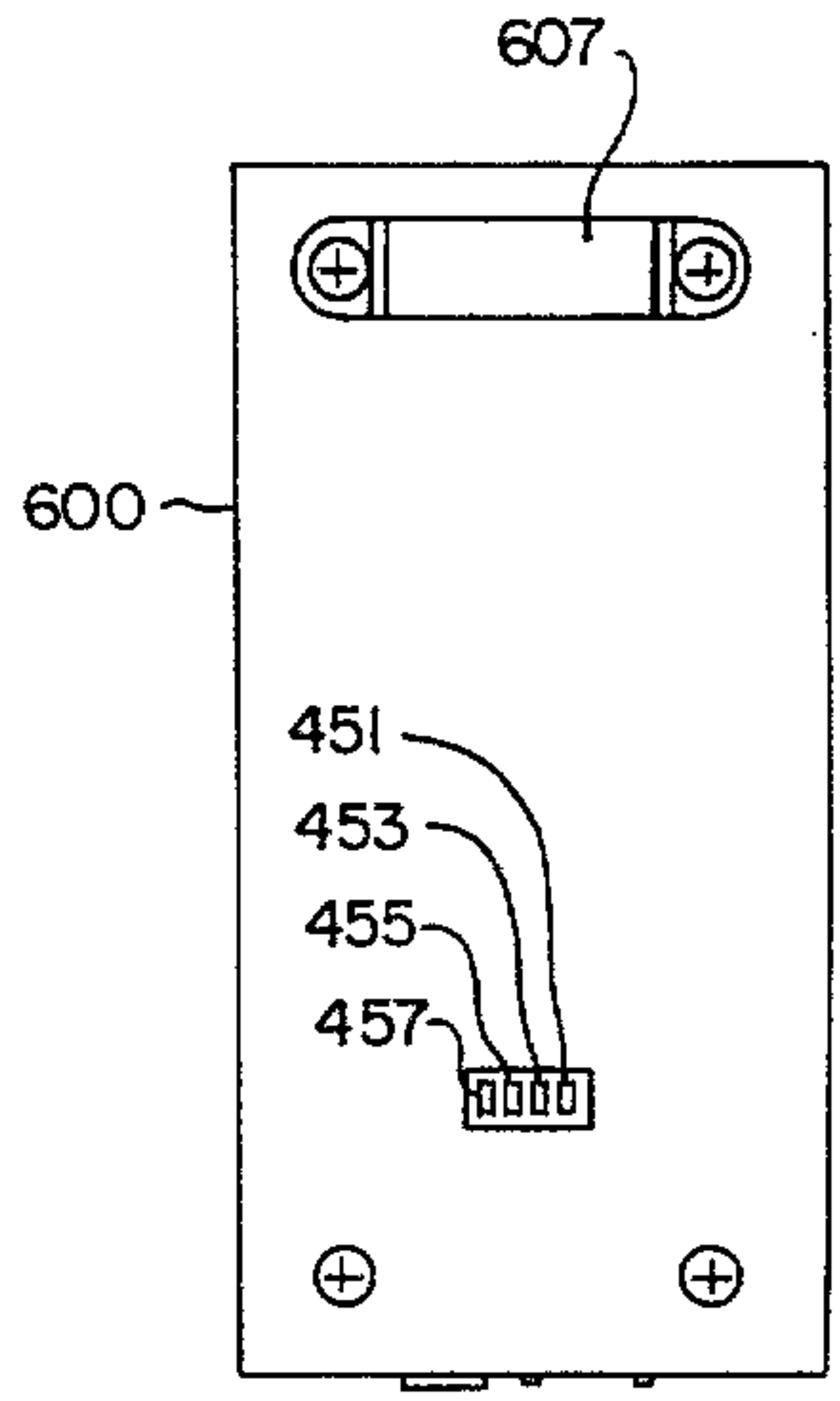



FIG. 22

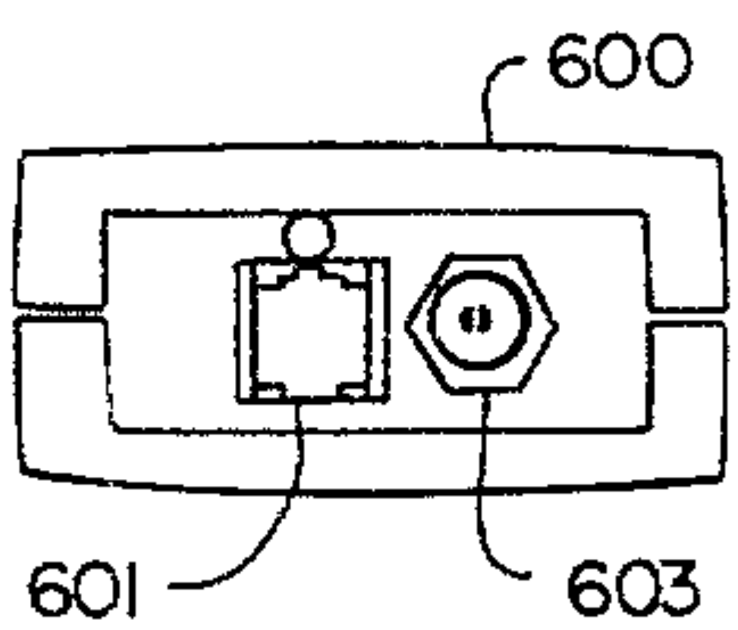



FIG. 21

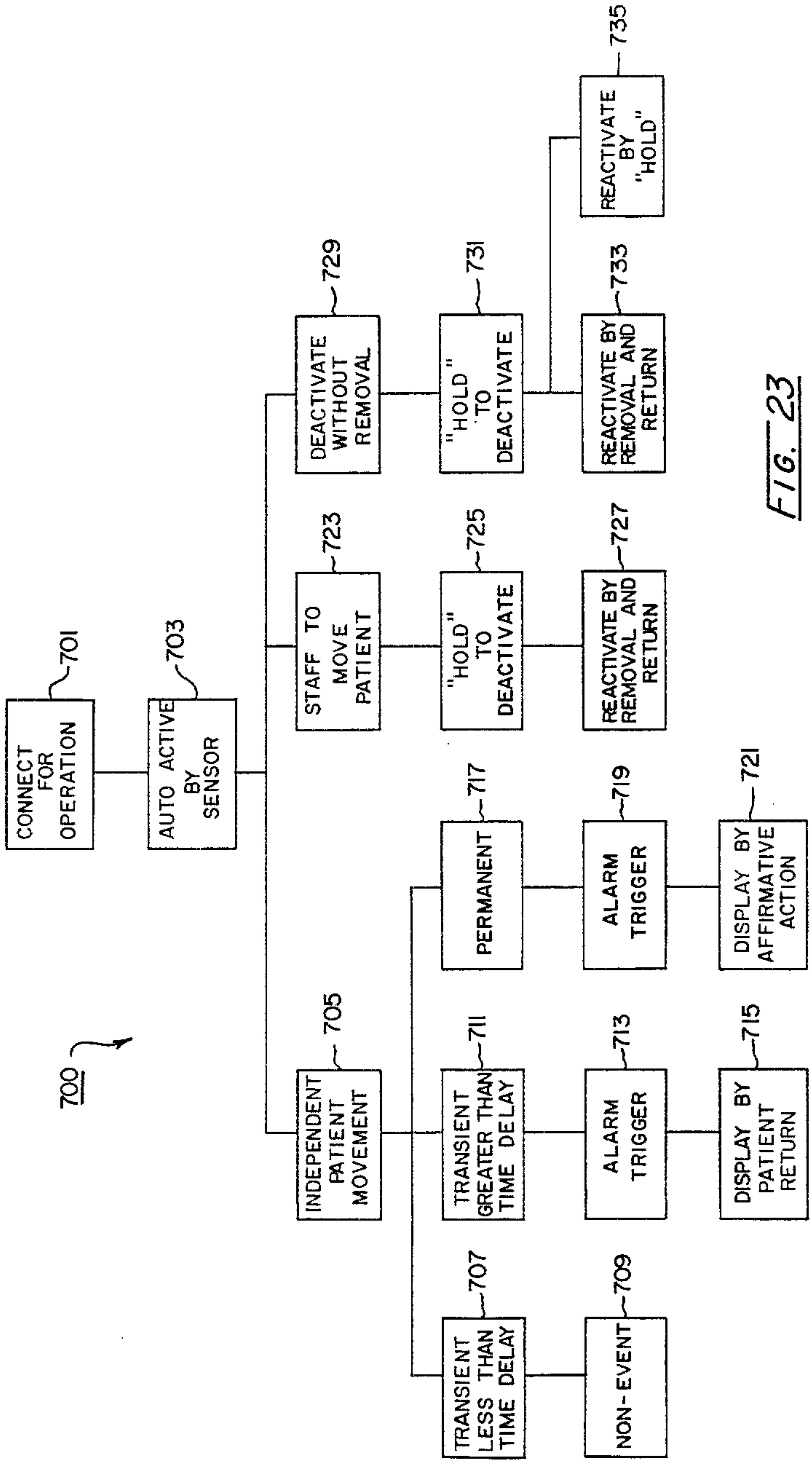

700
CONNECT FOR OPERATION
701
AUTO ACTIVE BY SENSOR
703
INDEPENDENT PATIENT MOVEMENT
705
TRANSIENT LESS THAN TIME DELAY
707
NON-EVENT
709
TRANSIENT GREATER THAN TIME DELAY
711
ALARM TRIGGER
713
DISPLAY BY PATIENT RETURN
715
PERMANENT
717
ALARM TRIGGER
719
DISPLAY BY AFFIRMATIVE ACTION
721
STAFF TO MOVE PATIENT
723
"HOLD" TO DEACTIVATE
725
REACTIVATE BY REMOVAL AND RETURN
727
DEACTIVATE WITHOUT REMOVAL
729
"HOLD" TO DEACTIVATE
731
REACTIVATE BY REMOVAL AND RETURN
733
REACTIVATE BY "HOLD"
735

FIG. 23

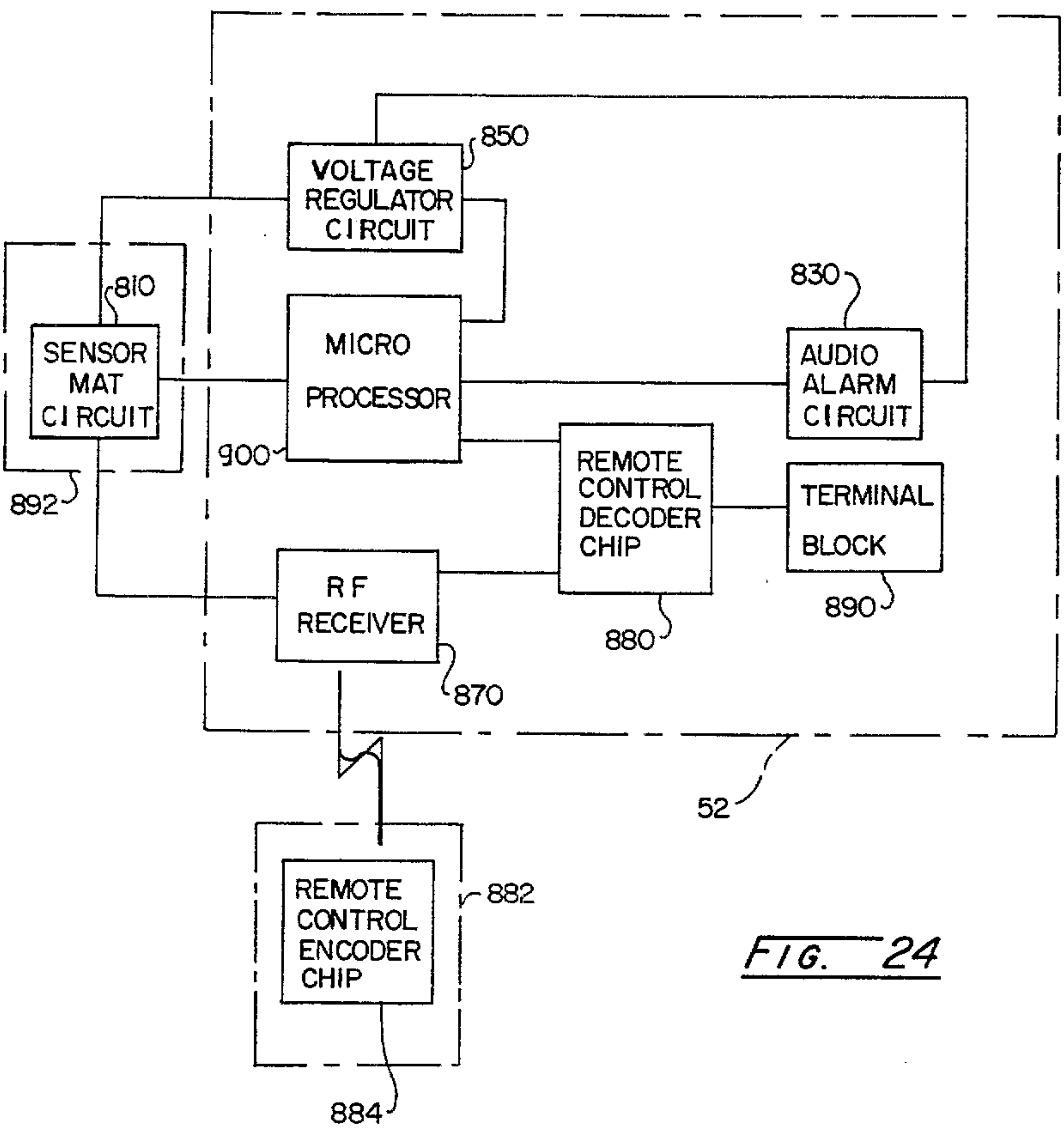

VOLTAGE REGULATOR CIRCUIT
850
SENSOR MAT CIRCUIT
810
MICRO PROCESSOR
900
AUDIO ALARM CIRCUIT
830
892
REMOTE CONTROL DECODER CHIP
TERMINAL BLOCK
890
880
RF RECEIVER
870
52
REMOTE CONTROL ENCODER CHIP
882
884

FIG. 24

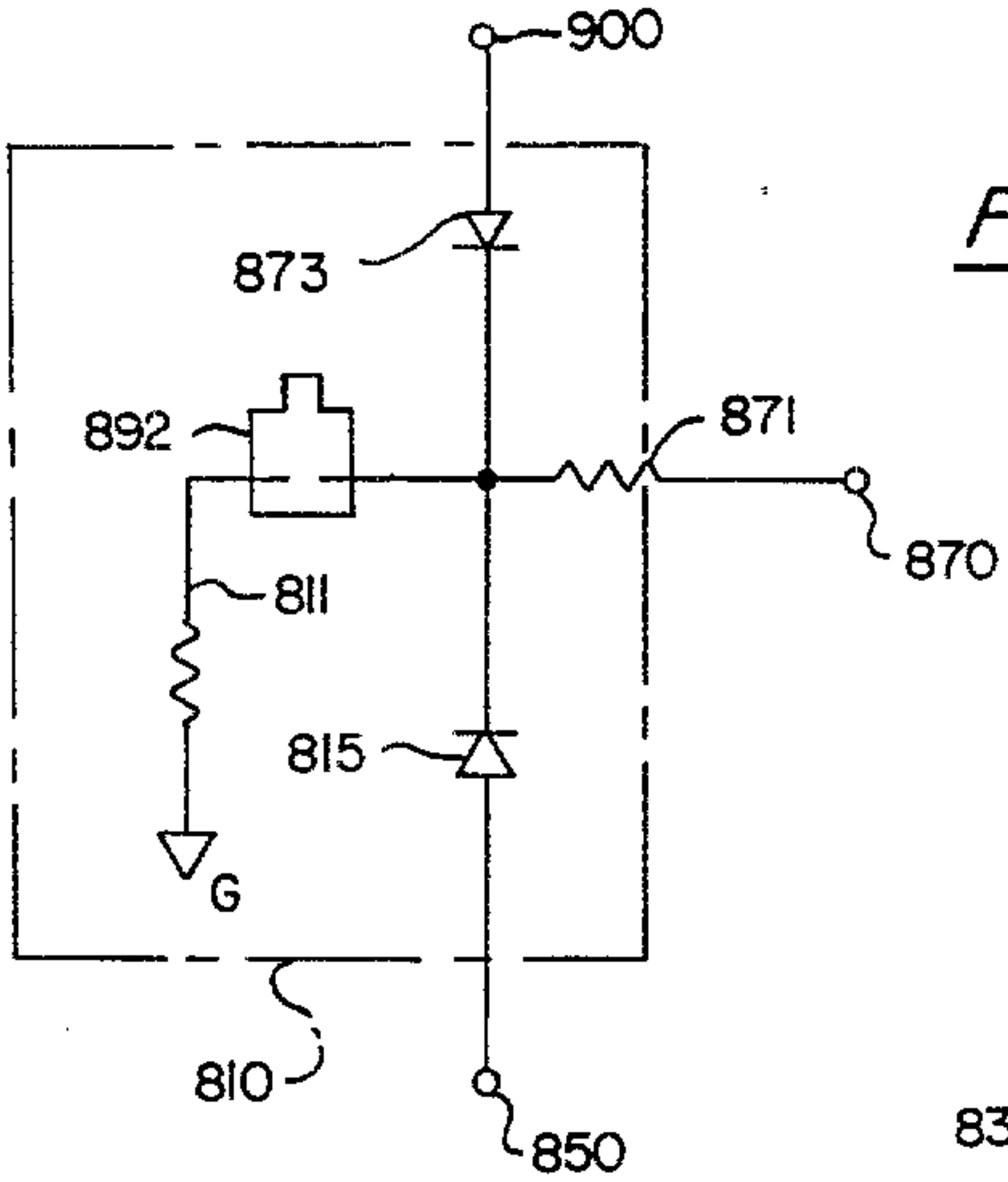



FIG. 25

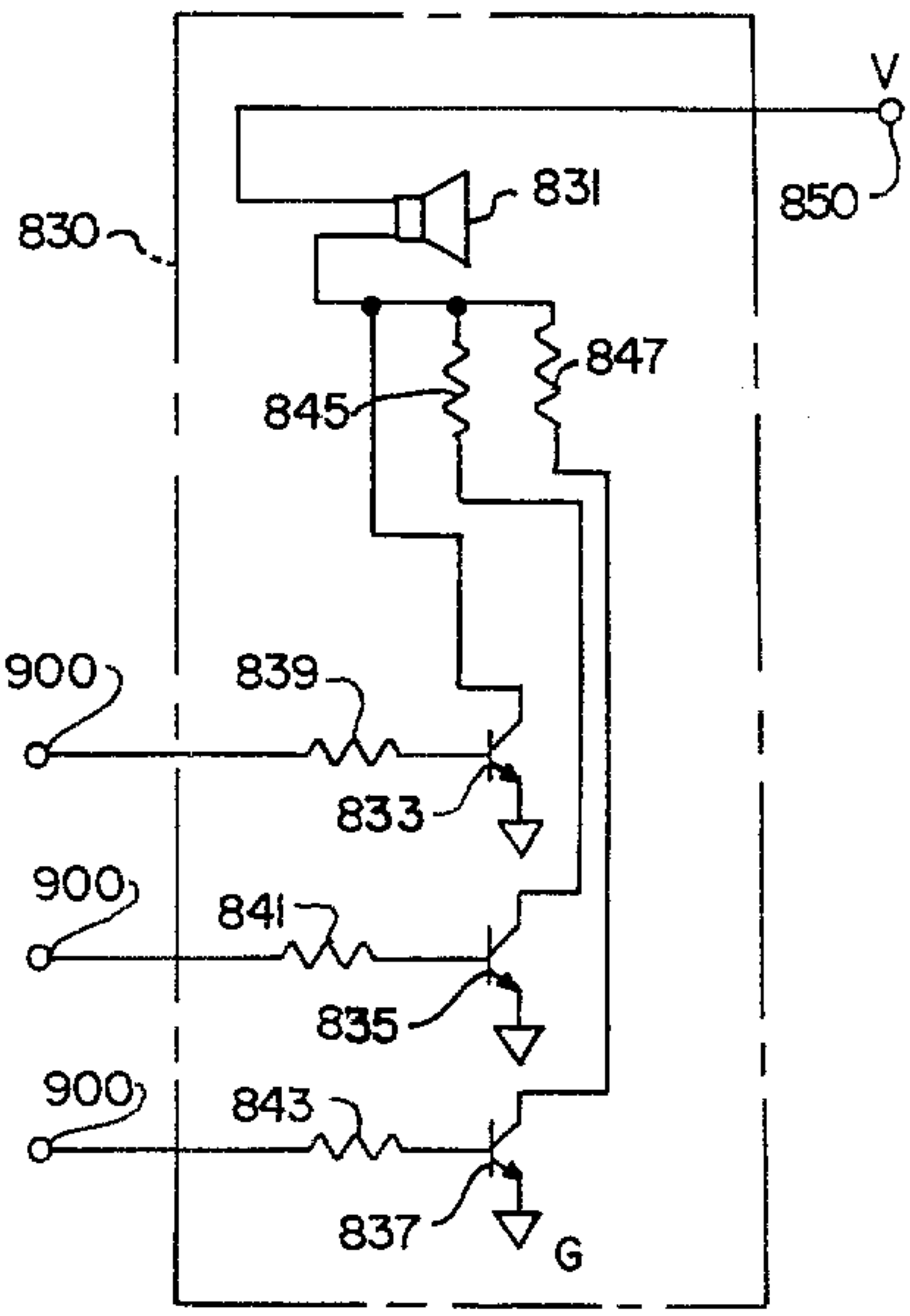



FIG. 26

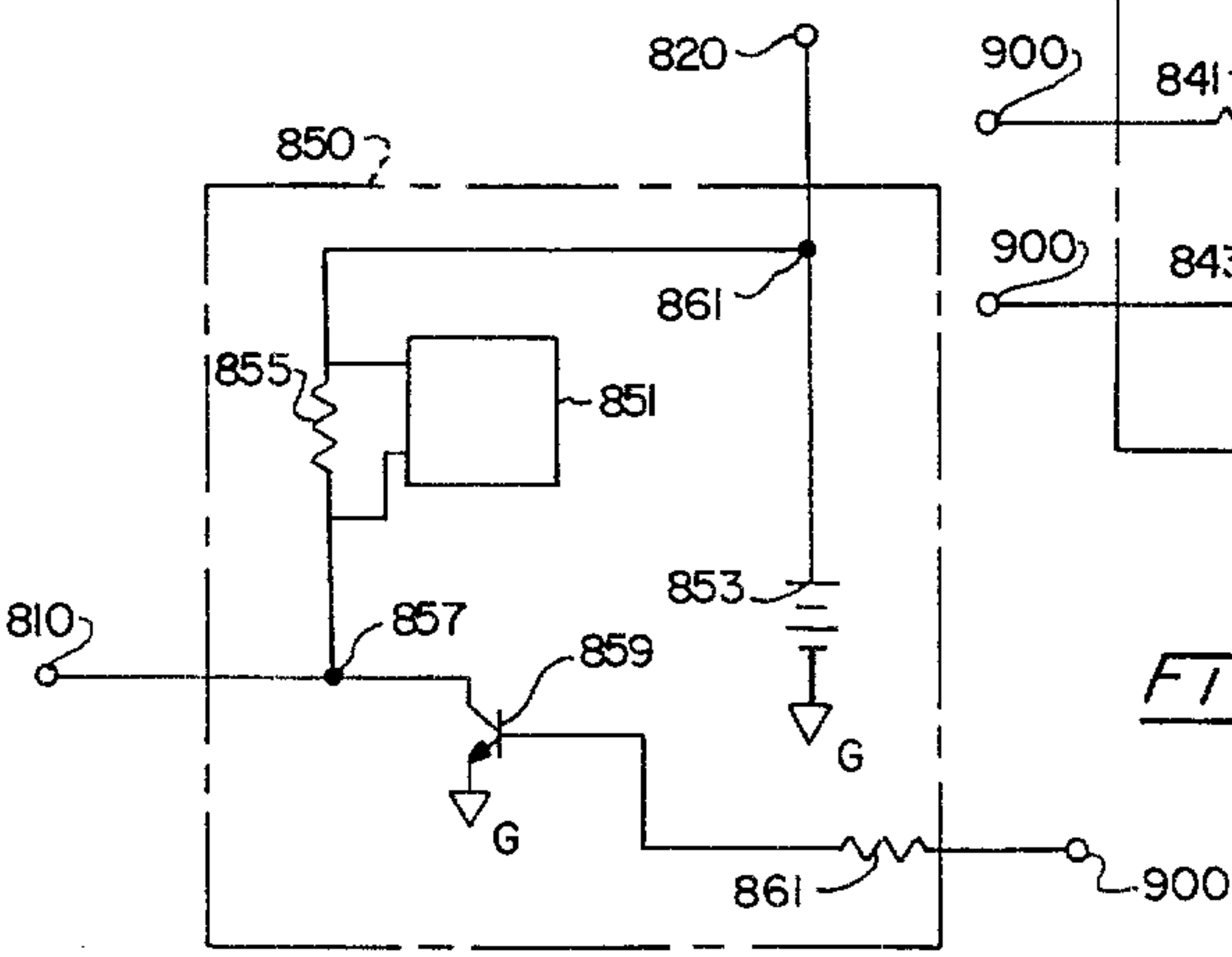



FIG. 27

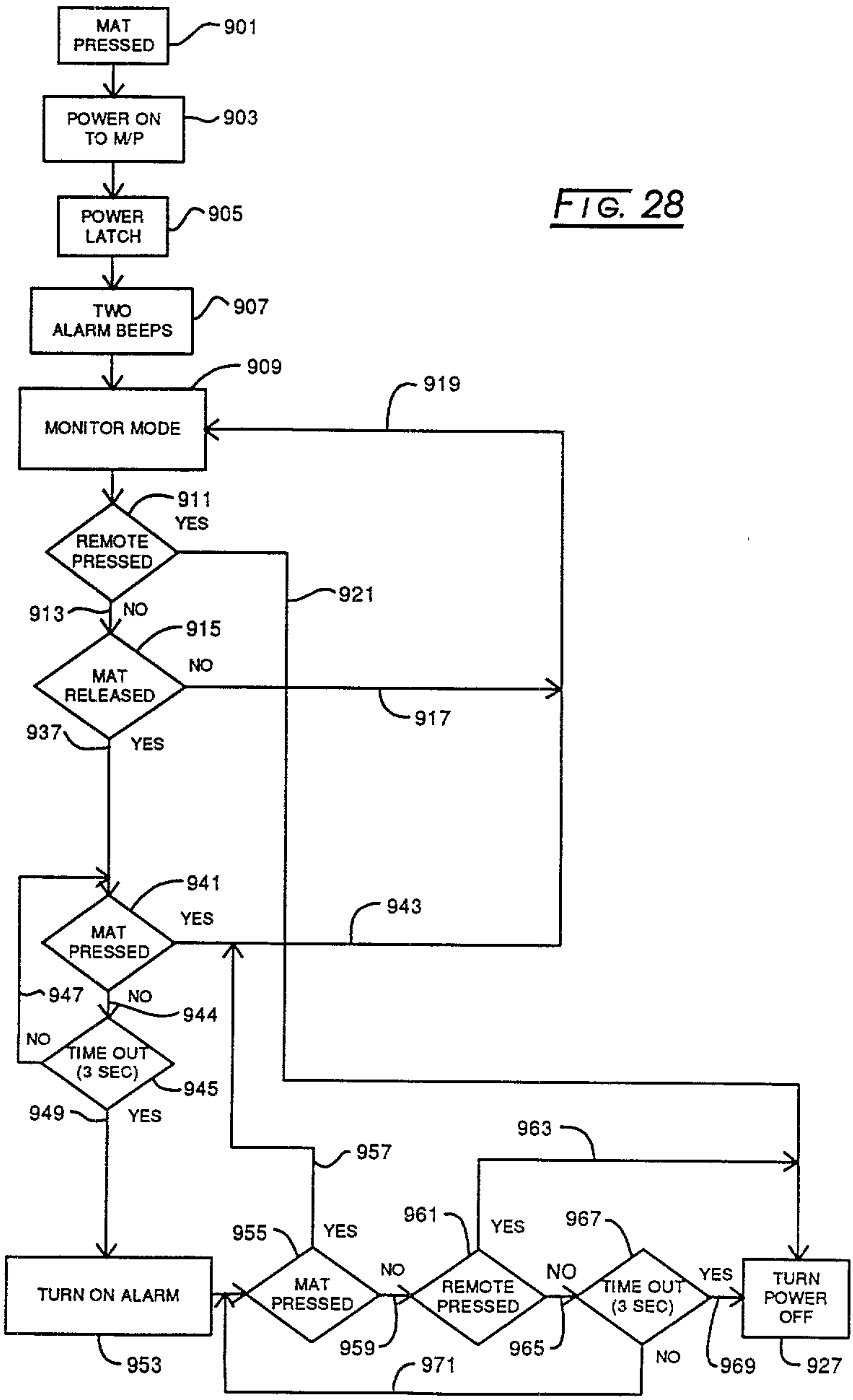

MAT PRESSED
901
POWER ON TO M/P
903
POWER LATCH
905
TWO ALARM BEEPS
907
909
MONITOR MODE
919
911
YES
REMOTE PRESSED
921
913
NO
915
NO
MAT RELEASED
917
937
YES
941
YES
MAT PRESSED
943
947
NO
944
NO
TIME OUT (3 SEC)
945
949
YES
963
957
955
YES
961
YES
967
TURN ON ALARM
MAT PRESSED
NO
REMOTE PRESSED
NO
TIME OUT (3 SEC)
YES
TURN POWER OFF
953
959
965
NO
969
927
971

FIG. 28

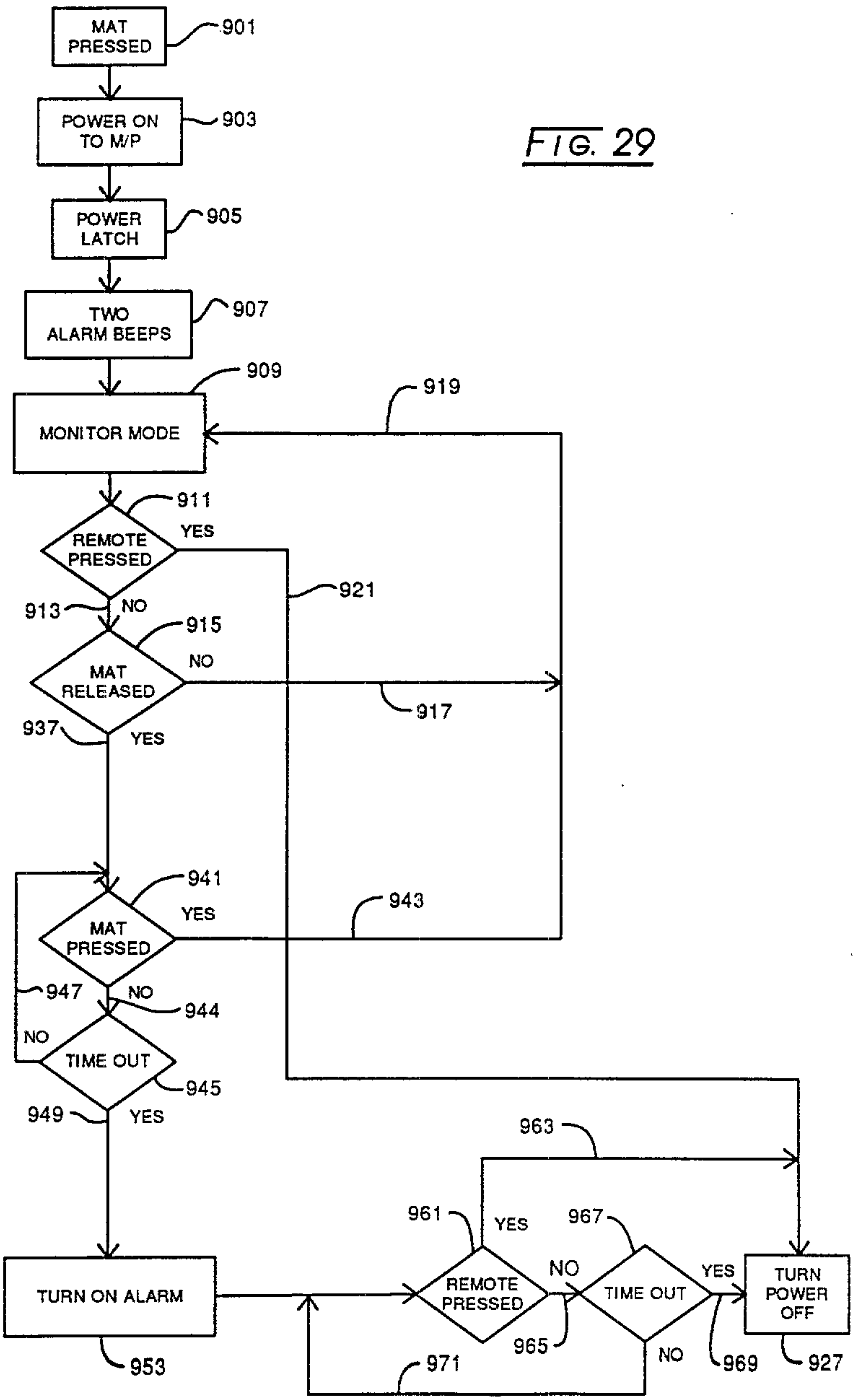

MAT PRESSED
901
POWER ON TO M/P
903
POWER LATCH
905
TWO ALARM BEEPS
907
909
MONITOR MODE
919
911
REMOTE PRESSED
YES
921
913
NO
915
MAT RELEASED
NO
917
937
YES
941
MAT PRESSED
YES
943
947
NO
944
NO
TIME OUT
945
949
YES
963
961
YES
967
TURN ON ALARM
REMOTE PRESSED
NO
TIME OUT
YES
TURN POWER OFF
953
965
971
NO
969
927

FIG. 29

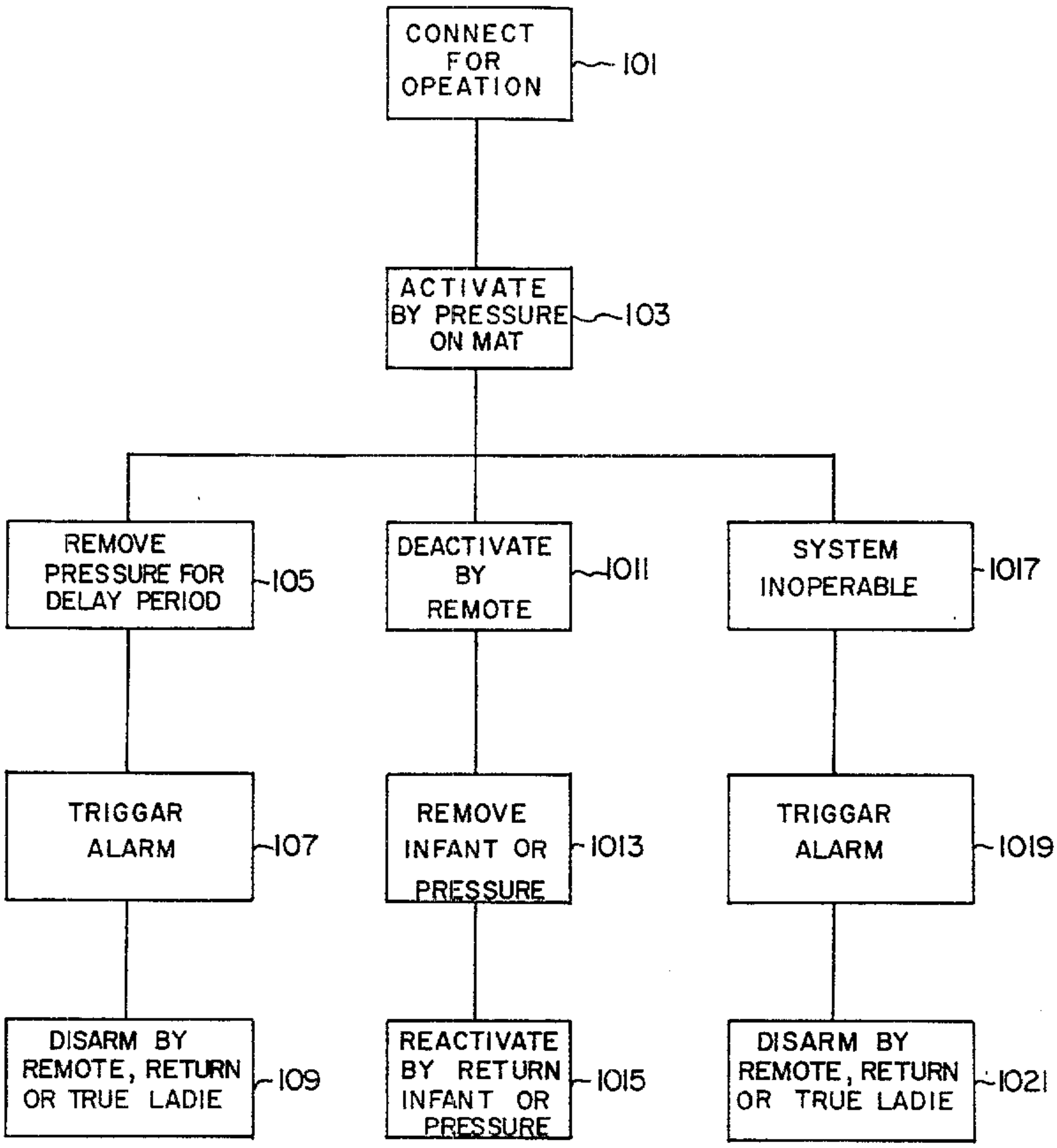

CONNECT FOR OPEATION
101
ACTIVATE BY PRESSURE ON MAT
103
REMOVE PRESSURE FOR DELAY PERIOD
105
DEACTIVATE BY REMOTE
1011
SYSTEM INOPERABLE
1017
TRIGGAR ALARM
107
REMOVE INFANT OR PRESSURE
1013
TRIGGAR ALARM
1019
DISARM BY REMOTE, RETURN OR TRUE LADIE
109
REACTIVATE BY RETURN INFANT OR PRESSURE
1015
DISARM BY REMOTE, RETURN OR TRUE LADIE
1021

FIG. 30


10
AUDIO ALARM
30
FUNCTION CIRCUITS
100
MICRO PROCESSOR
80
PROGRAMABLE SWITCHING CIRCUIT
POWER OPERATING CIRCUIT
70
NURSE CALL STATION INTERFACE
90