

US006734845B1

(12) **United States Patent**
Nielsen et al.

(10) **Patent No.:** **US 6,734,845 B1**
(45) **Date of Patent:** ***May 11, 2004**

(54) **EYETRACK-DRIVEN ILLUMINATION AND INFORMATION DISPLAY**

(75) Inventors: **Jakob Nielsen**, Atherton, CA (US);
Bruce Tognazzini, Woodside, CA (US);
Bob Glass, Los Gatos, CA (US)

(73) Assignee: **Sun Microsystems, Inc.**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

5,636,332 A * 6/1997 Hibino 395/112
5,699,115 A * 12/1997 Hiraki et al. 348/333

FOREIGN PATENT DOCUMENTS

DE 003837620 * 4/1989 345/156
DE 29610766 U1 1/1997
EP 0622721 A1 11/1994

OTHER PUBLICATIONS

Arne John Glenstrup, Theo Engell-Nielsen, “Eye Controlled Media: Present and Future State”, Jun. 1, 1995, pp. 1–45.
“Fourward Eyetracker”, SRI Homepage at <http://www.sri.com>, Apr. 30, 1996.
Jakob Nielsen, “Noncommand User Interfaces”, Communications of the ACM, Apr. 1993, vol. 36, No. 4, pp. 83–99.
Dixon Cleveland and Nancy Cleveland, “Eyegaze Eyetracking System”, Jan. 29–31, 1992.
IBM Technical Disclosure Bulletin, vol. 37, No. 9, Sep. 1, 1994, pp. 121–122, “Ultrasonic Motion Sensor for Display Monitor Power Saving”.
IBM Technical Disclosure Bulletin, vol. 36, No. 8, Aug. 8, 1993, pp. 343–345, “Personal Computer Environment Control Via a Proximity Sensor”.

* cited by examiner

Primary Examiner—Lun-Yi Lao
(74) *Attorney, Agent, or Firm*—Finnegan, Henderson, Farabow, Garrett & Dunner L.L.P.

(57) **ABSTRACT**

An eyetracker is used to control power to an electrical device such as a computer display screen so that power consumption is reduced when a user’s eyes and therefore a user’s attention are not directed to the device. A motion detector activates a proximity detector and/or an IR detector to ensure that power is applied only when a user is actually present.

Related U.S. Application Data

(62) Division of application No. 08/655,134, filed on May 30, 1996, now Pat. No. 5,835,083.

(51) **Int. Cl.**⁷ **G09G 5/00**

(52) **U.S. Cl.** **345/211**; 345/690; 713/310; 713/320

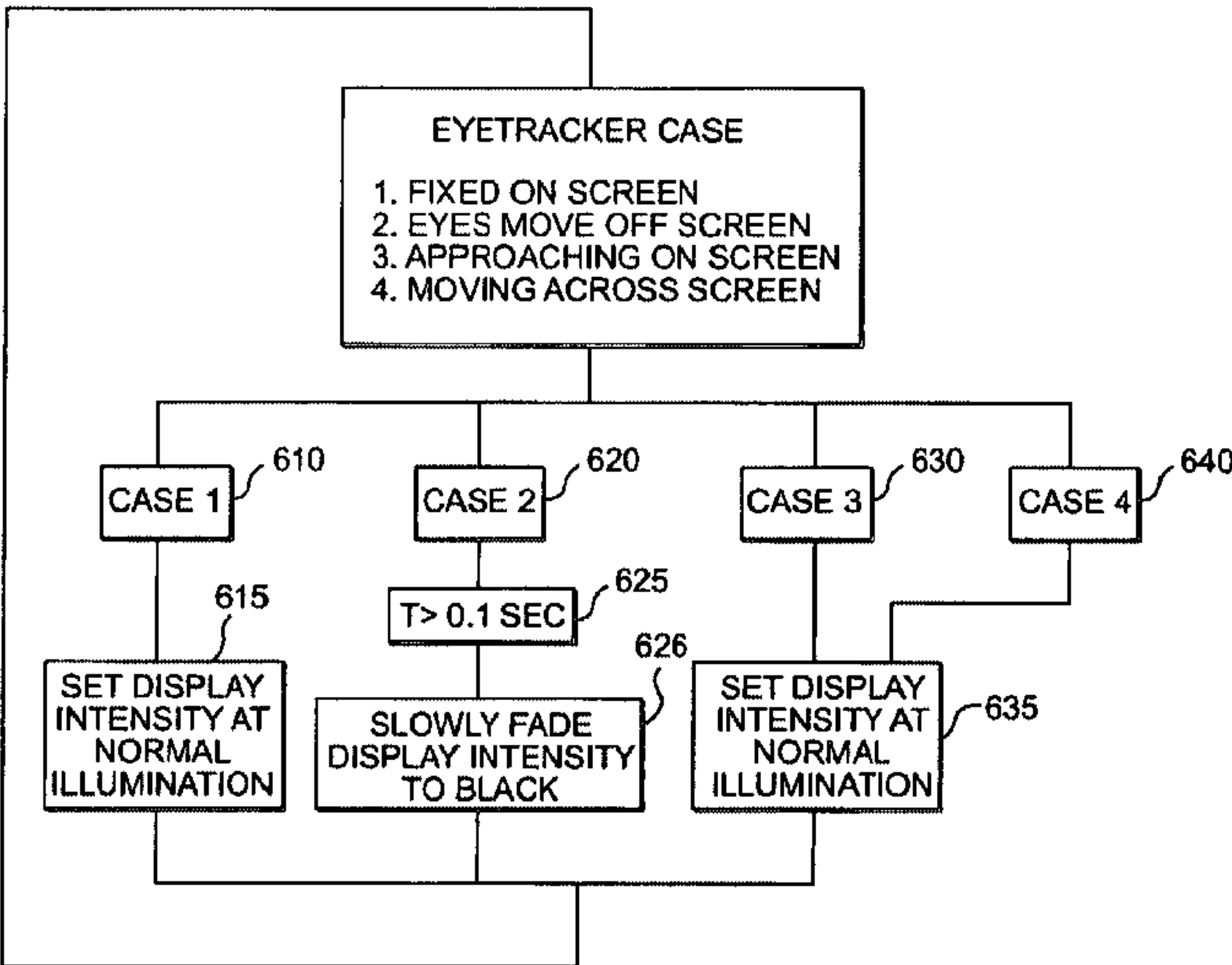
(58) **Field of Search** 713/300, 321, 713/310, 320; 345/211, 7–9, 173, 690; 348/53; 359/630

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,513,317 A * 4/1985 Ruoff, Jr. 348/384
4,713,659 A * 12/1987 Oyagi et al. 340/825.44
4,836,670 A 6/1989 Hutchinson 351/210
5,281,957 A * 1/1994 Schoolman 345/8
5,532,935 A * 7/1996 Ninomiya et al. 364/528.31
5,635,948 A * 6/1997 Tonosaki 345/8

2 Claims, 9 Drawing Sheets



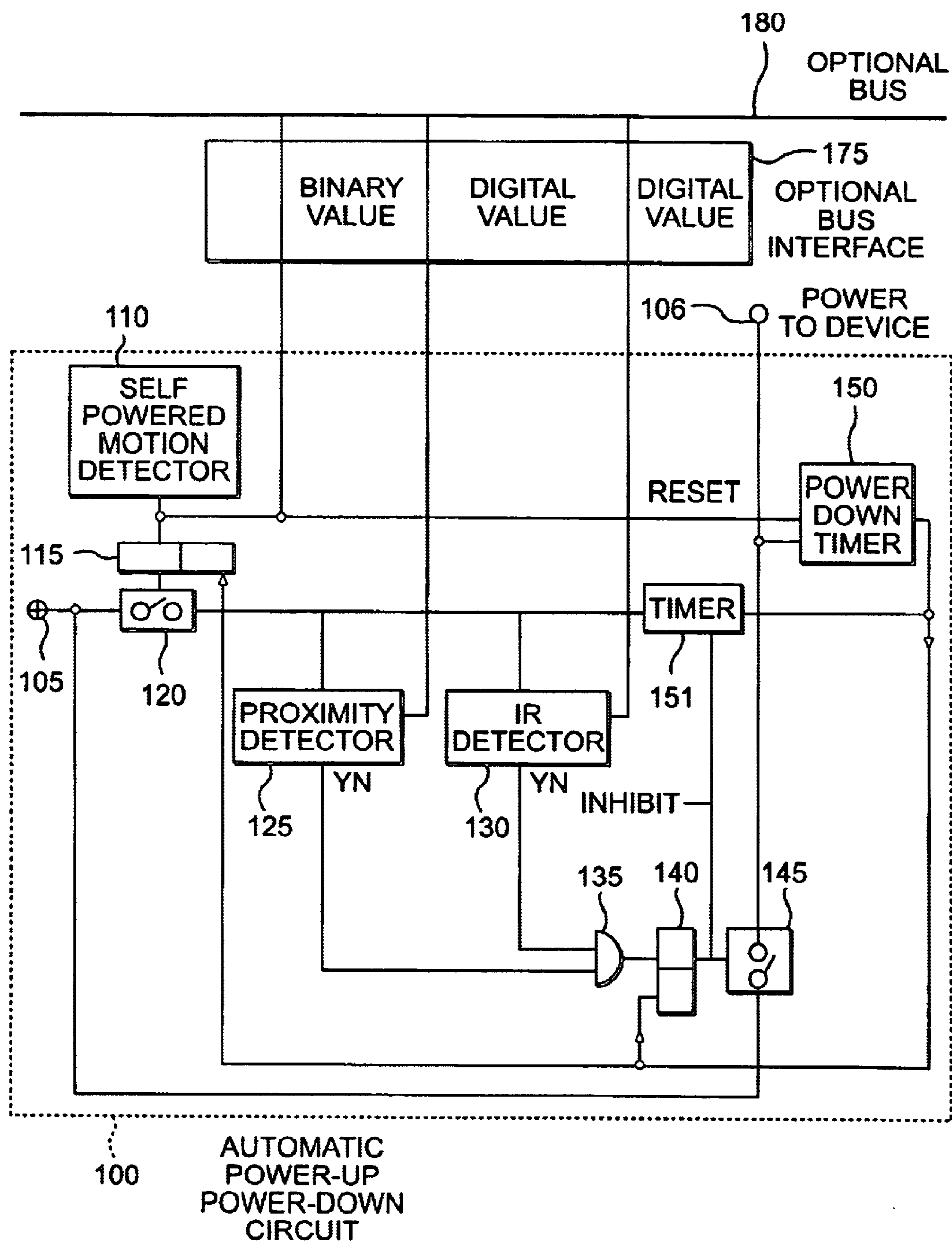


FIG. 1

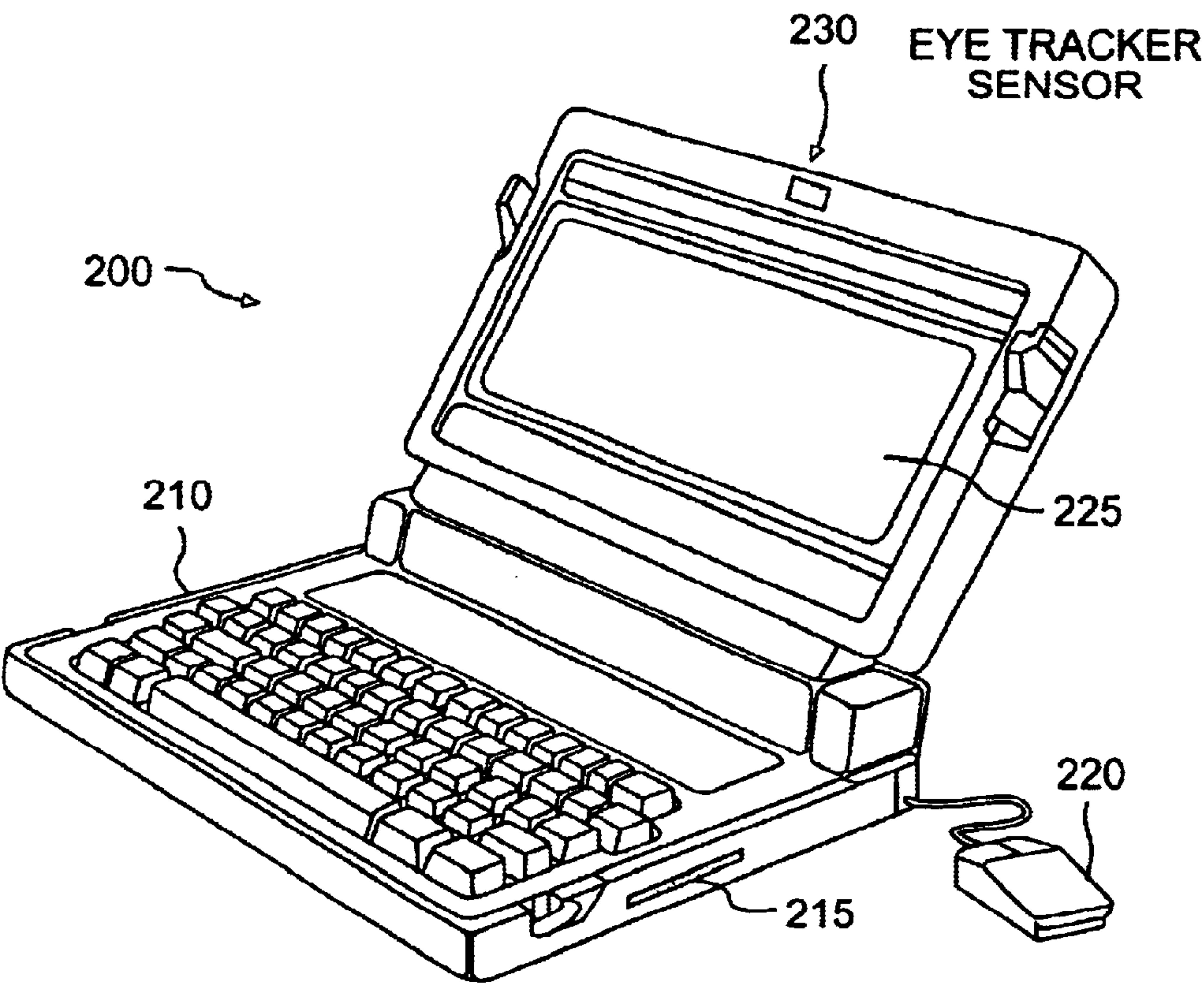


FIG. 2A

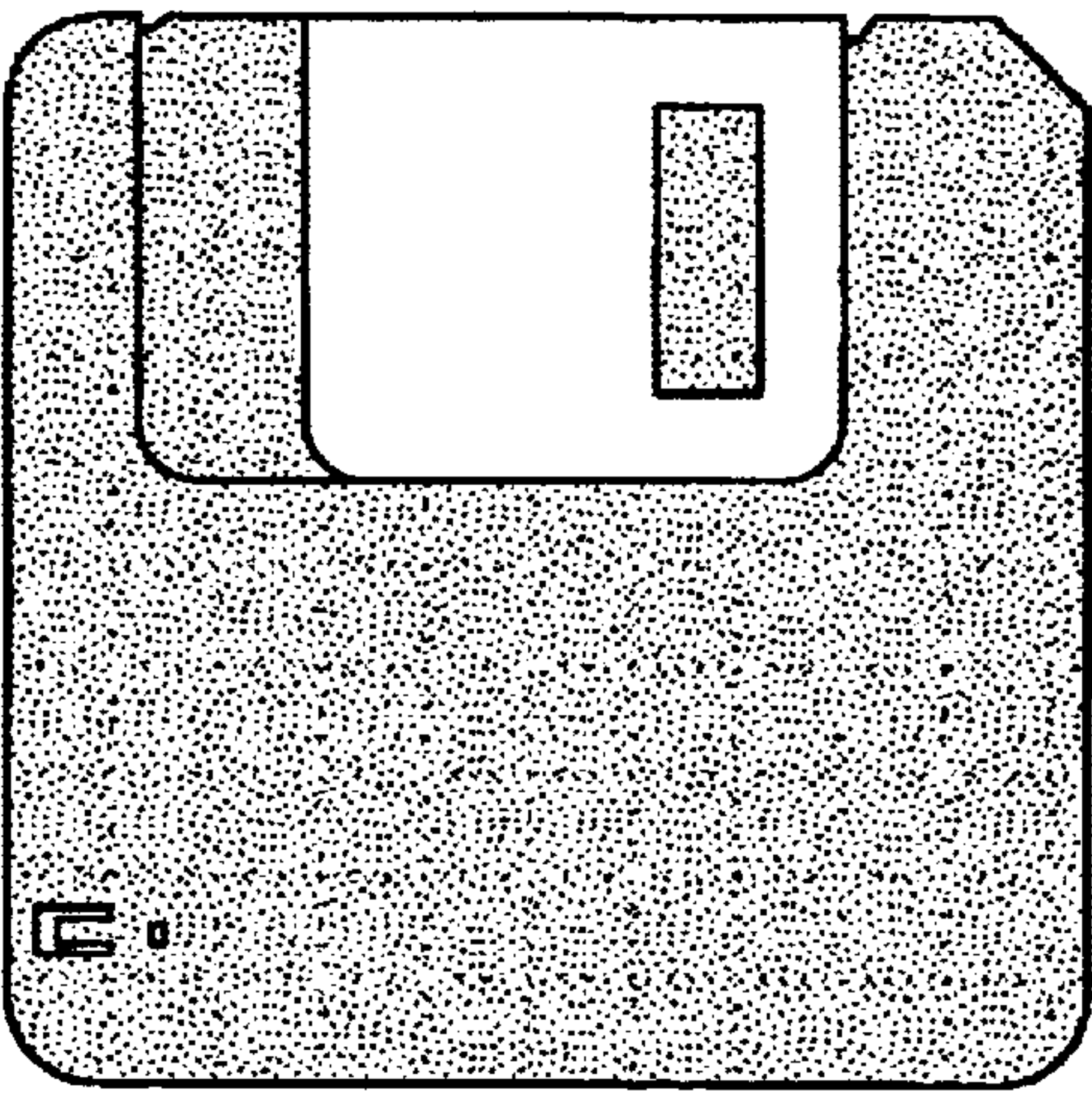


FIG. 2C

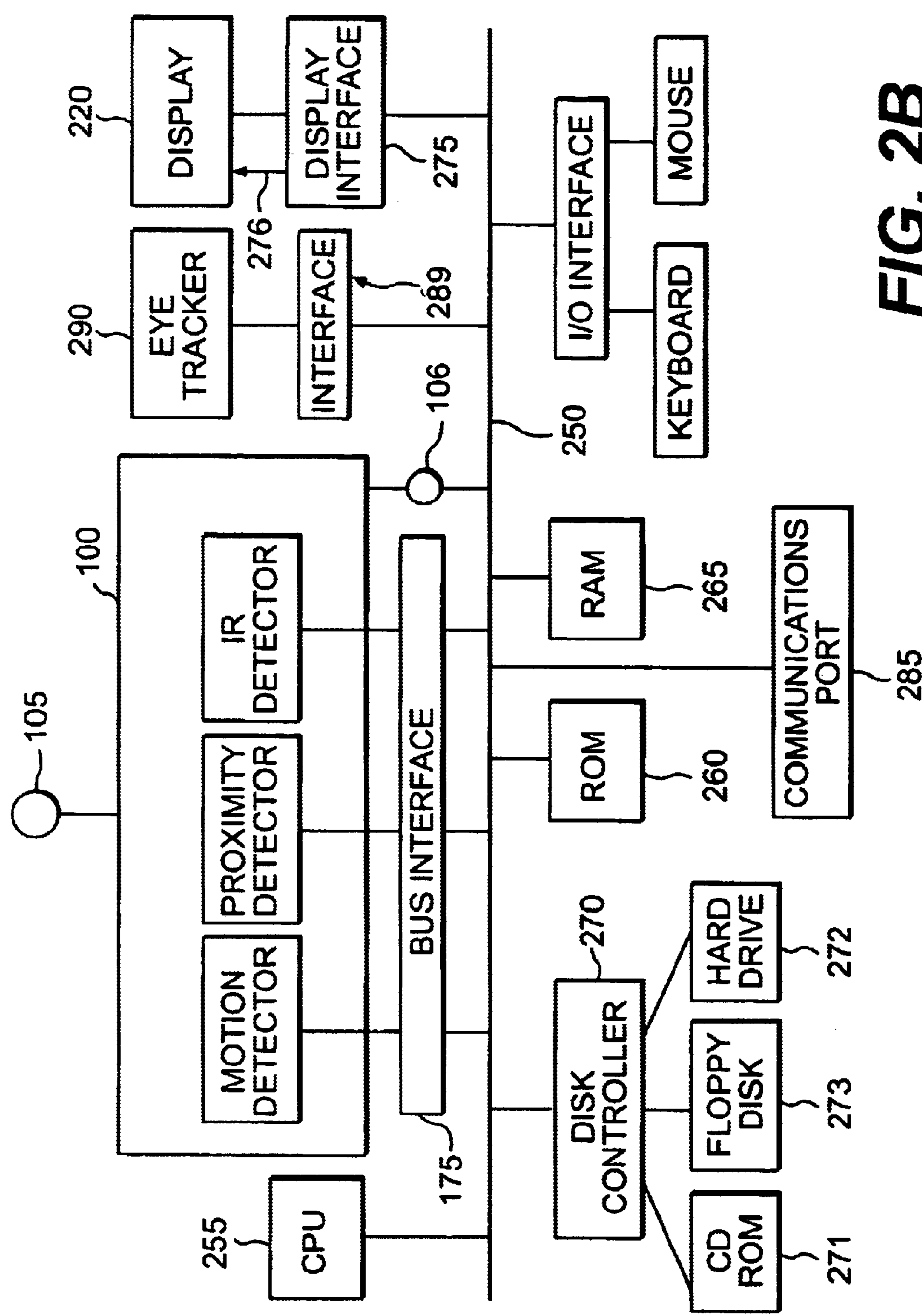


FIG. 2B

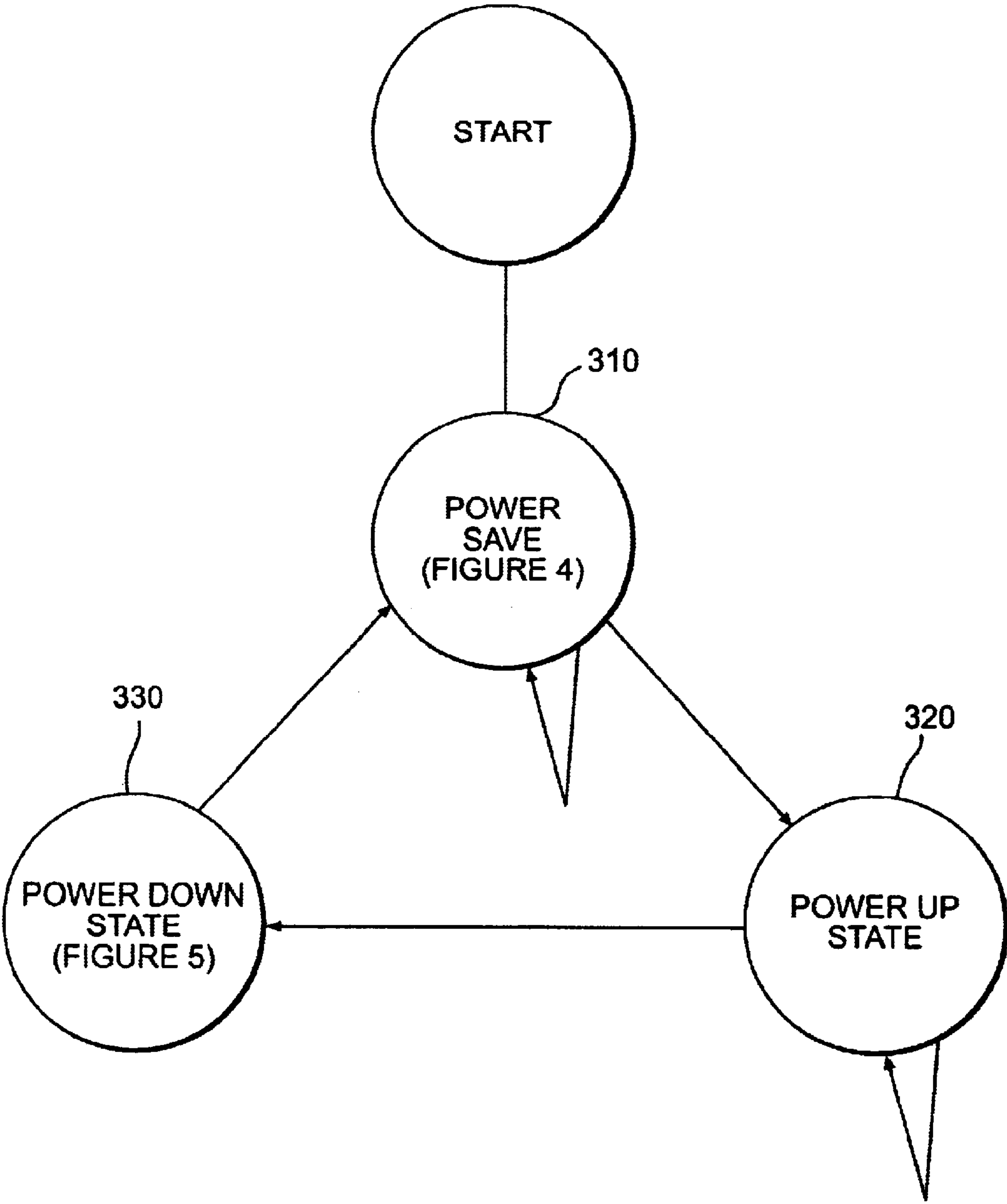


FIG. 3

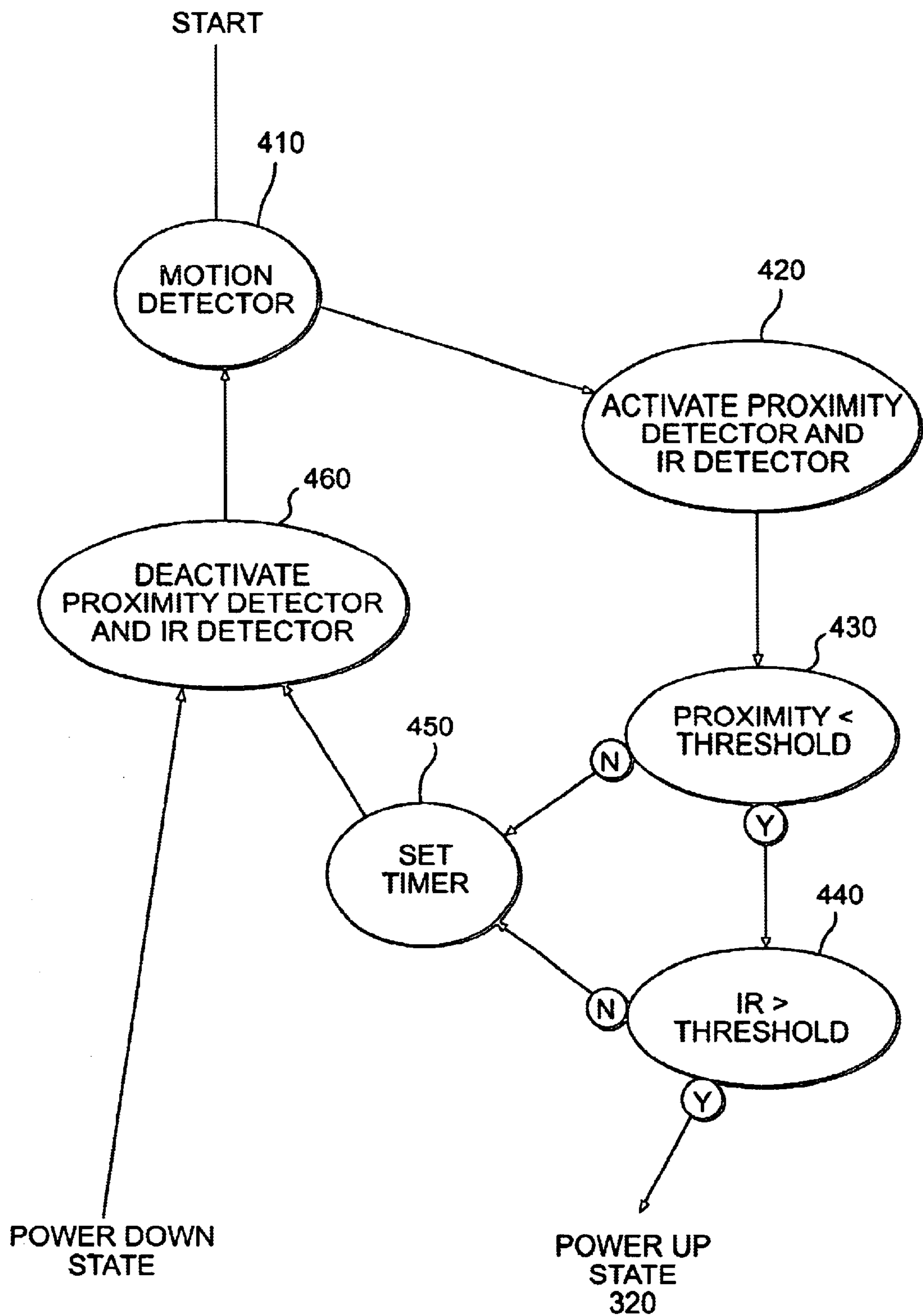


FIG. 4

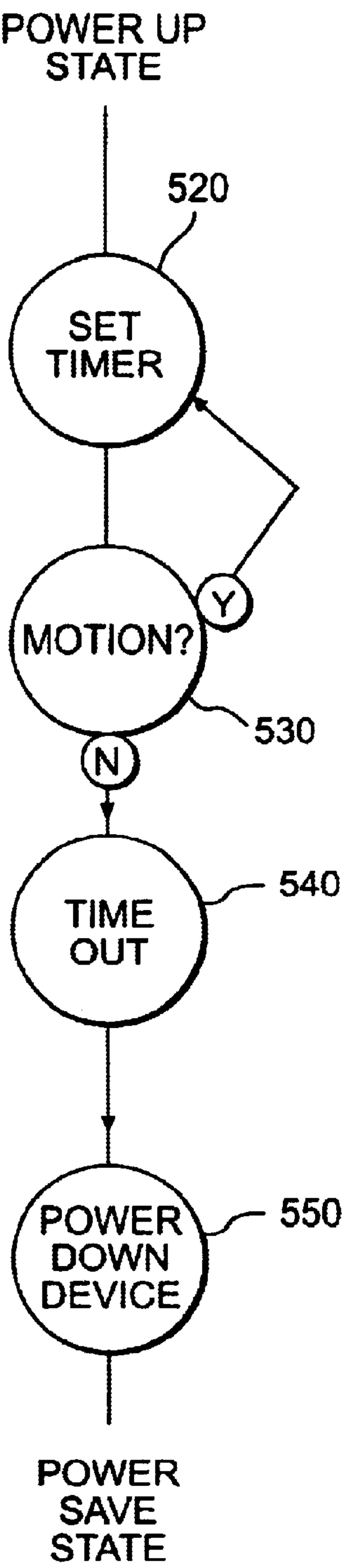


FIG. 5

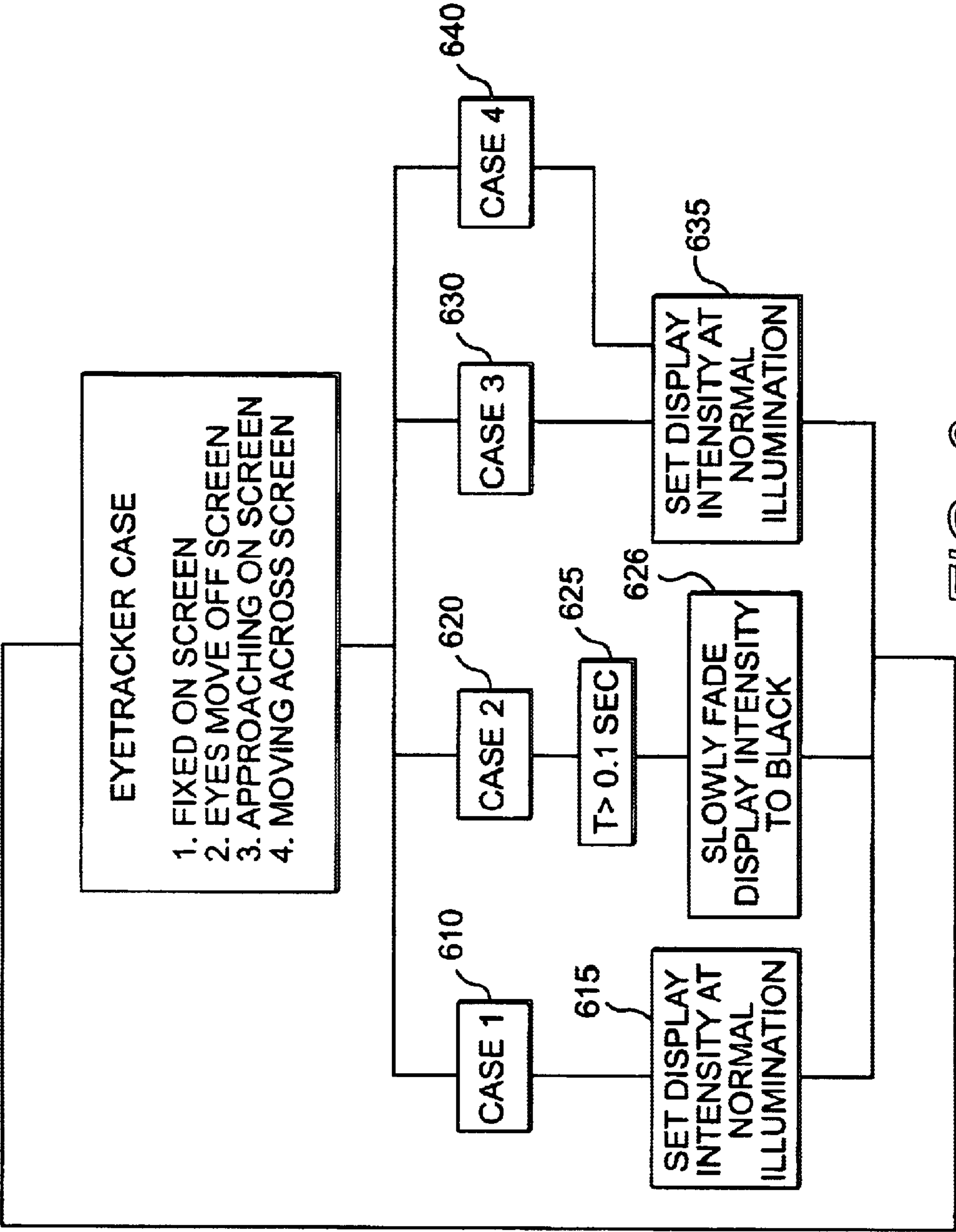


FIG. 6

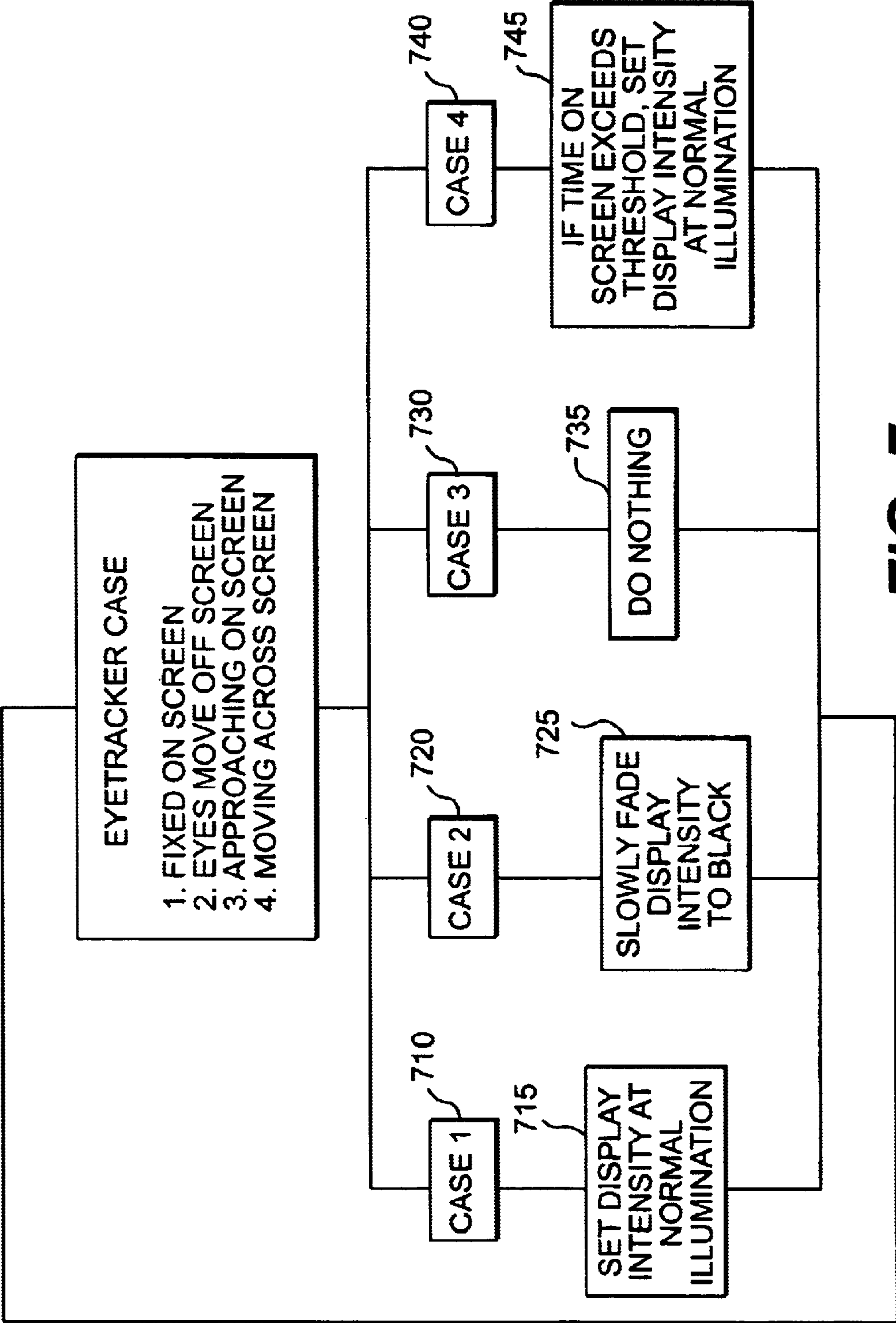


FIG. 7

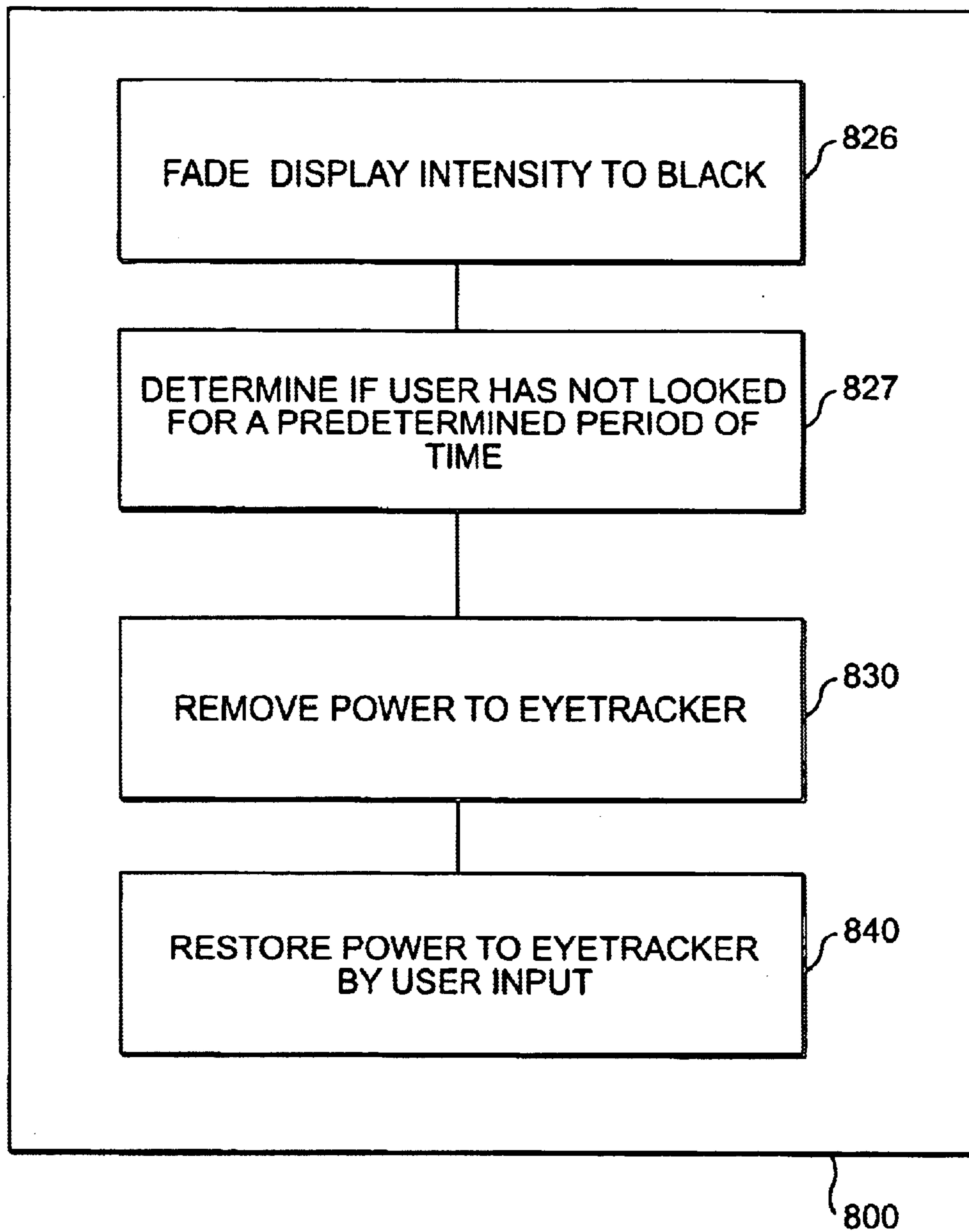


FIG. 8

EYETRACK-DRIVEN ILLUMINATION AND INFORMATION DISPLAY

This application is a division of application Ser. No. 08/655,134 filed May 30, 1996, now U.S. Pat. No. 5,835, 083.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to controlling power consumption in electrical devices having a finite source of energy, such as battery driven devices and, more particularly, to controlling power consumption in the use of computer displays.

2. Description of Related Art

Computer displays face a problem that if some types of display are left running for a long period of time with a particular image formed on the screen, each portion of the image formed on the screen would become more or less permanently etched into the screen. CRT displays are particularly susceptible to this problem.

Screen savers were developed to minimize this type of occurrence. A screen saver program is loaded and activated if a period of time elapses during which nothing is typed or no mouse movement is detected. In short, when a computer is left unattended with no activity, a screen saver would blacken the screen totally, except, perhaps, for a moving display which would cross the screen in an irregular pattern so that the same pattern would not be displayed at the same location on the screen for extended periods of time.

Flat panel displays, and other types of display also utilize screen saver programs in part to equalize the on and off times of driver circuit elements so that certain driver circuits or light emitting elements were not utilized substantially more than others, aging more rapidly and becoming thus more prone to failure.

Eyetracking devices are known particularly in conjunction with heads up displays in certain control applications in aircraft. An eyetracker device monitors the eyes of a user and calculates the direction in which the user is looking and, in some applications, the particular point in three dimensional space on which the user's eyes focus.

One commercial eyetracker is the Dual-Purkinje-Image (DPI) Eyetracker, manufactured by Forward Optical Technologies, Inc. of El Chaon, Calif. It determines the direction of gaze over a large two dimensional visual field with great accuracy and without any attachments to the eye. It operates with infra-red light which is invisible to the subject and does not interfere with normal vision. The eyetracker has a pointing accuracy on the order of one minute of arc and response time on the order of one millisecond. One can utilize the DPI Eyetracker with an infra-red optometer to allow a continuous measure of eye focus, producing a three dimensional eyetracker.

The Problems

The prior art has failed to adequately address the need for controlling power consumption in electrical devices having a finite source of energy, e.g. in battery driven devices such as computer displays. In such devices, power is frequently wasted by permitting the device to continue to run even though no user is in the vicinity. In the context of a computer display, display power is certainly wasted if no one is looking at the display. In addition, in the prior art, when a screen saver switches on, and the screen suddenly goes black, a user, in the vicinity of the display, has his attention abruptly distracted toward the screen which switched off.

There is thus a need for improving the control of power consumption in electrical devices, particularly in computer displays. There is also a need for improving the way in which screen savers are activated.

SUMMARY OF THE INVENTION

The present invention provides apparatus, processes, systems and computer program products which have the overcome the problems of the prior art. This is achieved by detecting when a user's attention is directed to the electrical device and reducing the power consumption when his attention is not so directed. It is also directed to detecting the absence of a user in the vicinity of the electrical device and shutting down power consumption to an even greater level when that occurs. When a user returns, power is automatically reapplied.

The invention is directed to apparatus for automatically applying power to an electrical device, including a motion detector, a proximity detector and an optional infrared (IR) detector, activated by the motion detector's detecting motion, and a switch connected to a source of power and to the electrical device and controlled by the motion detector and the proximity detector for applying power to the electrical device when the proximity detector detects an object within a predetermined distance from the electrical device while it is activated by the motion detector. A power off timer, activated when power is applied to the electrical device, is reset by the motion detector's detecting motion. It may be used for controlling the switch to remove power from the electrical device when the timer times out.

The invention is also directed to a computing device having a processor, a display having a controllable intensity, an eyetracker providing a signal indicating where a user's eyes are looking and a control for changing intensity of the display based on that signal. The control reduces the intensity gradually when a user looks away from the display so as not to distract the user. When the user's eyes return to the display for a predetermined period of time, the control reestablishes the intensity level of the display in effect before the user looked away. The user's eyes returning to the display can be an instantaneous return, an return to the screen for a predetermined time interval or when the user's eyes fix on a particular point on the screen. Alternatively, the intensity level can be reestablished when the user's eyes begin to move toward the display. Power to the eyetracker is removed when the user has not looked at the display for a predetermined period of time.

The invention also relates to a method for automatically applying power to an electrical device, by detecting motion, by detecting proximity of objects to the device; and by applying power to the device when an object is within a predetermined distance from the electrical device within a predetermined period of time after motion has been detected.

The invention also relates to a method of controlling intensity of images on a display, by detecting where a user's eyes are looking and by changing intensity of images on the display based on where a user's eyes are looking.

The invention is also directed to a computer system including a network, a plurality of computers connected to the network, one of which is a computer equipped with a motion detector a proximity detector activated by the motion detector detecting-motion; and a switch connected to a source of power and to the electrical device and controlled by the motion detector and the proximity detector for applying power to the at least a particular one of the plurality of computers when the proximity detector detects an object within a predetermined distance from the computer.

The invention is also directed to computer program products each including a memory medium and containing one or more computer programs and data used to implement the above methods, apparatus and systems.

Still other objects and advantages of the present invention will become readily apparent to those skilled in the art from the following detailed description, wherein only the preferred embodiment of the invention is shown and described, simply by way of illustration of the best mode contemplated of carrying out the invention. As will be realized, the invention is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the invention. Accordingly, the drawing and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF DRAWINGS

The objects, features and advantages of the system of the present invention will be apparent from the following description in which:

FIG. 1 illustrates apparatus for automatically powering up and powering down an electrical device having an optional interface to a computer bus.

FIG. 2A is an illustration of a computer which is selectively battery operated and suitable for use with the invention.

FIG. 2B is an illustration of an exemplary computer architecture incorporating the invention.

FIG. 2C is an illustration of an exemplary memory medium used to store computer programs and data of the invention.

FIG. 3 is a state transition diagram of a computer process used in accordance with the invention.

FIG. 4 is a state transition diagram of a power save process shown in FIG. 3.

FIG. 5 is a flow chart of a power down process shown in FIG. 3.

FIG. 6 is a flow chart of one power control process used as part of the invention.

FIG. 7 is a flow chart of another power control process used in accordance with the invention.

FIG. 8 is a flowchart illustrating another power control process consistent with the invention.

NOTATIONS AND NOMENCLATURE

The detailed descriptions which follow may be presented in terms of program procedures executed on a computer or network of computers. These procedural descriptions and representations are the means used by those skilled in the art to most effectively convey the substance of their work to others skilled in the art.

A procedure is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. These steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It proves convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like. It should be noted, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities.

Further, the manipulations performed are often referred to in terms, such as adding or comparing, which are commonly associated with mental operations performed by a human operator. No such capability of a human operator is necessary, or desirable in most cases, in any of the operations described herein which form part of the present invention; the operations are machine operations. Useful machines for performing the operation of the present invention include general purpose digital computers or similar devices.

The present invention also relates to apparatus for performing these operations. This apparatus may be specially constructed for the required purpose or it may comprise a general purpose computer as selectively activated or reconfigured by a computer program stored in the computer. The procedures presented herein are not inherently related to a particular computer or other apparatus. Various general purpose machines may be used with programs written in accordance with the teachings herein, or it may prove more convenient to construct more specialized apparatus to perform the required method steps. The required structure for a variety of these machines will appear from the description given.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 depicts an apparatus for automatically powering up and powering down an electrical device in accordance with the invention. An automatic power-up, power-down circuit **100** is shown optionally connected to bus **180** over optional bus interface **175**. The automatic power-up, power-down circuit connects a source of power **105** to an output terminal **106** powering the electrical device as described more hereinafter. A self-powered motion detector **110**, detects motion in the vicinity of the electrical device. When motion is detected a bistable device **115** is set to close switch **120** to power-up proximity detector **125** and IR detector **130**. With these detectors powered up, if the motion detected by motion detector **110** is within a certain proximity of the electrical device and if the amount of infra-red radiation emitted by the object detected is adequate, that is, above a certain threshold, both inputs to AND gate **135** are activated, setting bistable **140** which then closes switch **145** permitting power from source **105** to go to electrical device over terminal **106**. With the application of power, power-down timer **150** begins timing, counting down from a certain value. Any motion in the vicinity of the electrical device will trigger a motion detector periodically resulting in reset of the power-down timer. However, when a period of time goes by with no motion detected, one may assume that a user has left the area and eventually power-down timer **150** will time out, resetting bistables **140** and **115**, thus turning off power to the electrical device at terminal **106** and turning off power to the proximity detector **125** and the infra-red detector **130**. As the user walks back toward the electrical device, the motion detector will first sense the presence and power-up proximity detector and infra-red detectors **125** and **130** respectively and the cycle begins again.

Motion detector **110** can not distinguish between motion caused by a large object at a far distance or a small object at a close distance. Proximity detector **125** can distinguish how close an object is and also whether or not the object is closer than a particular threshold. The infra-red detector detects whether or not the moving object within a certain proximity is a living object or not, and, based on the amount of infra-red radiation, can determine the approximate size of the object. By using all three of these detectors, one may

ensure that a human operator is close enough to the electrical device to want to use it. Under those conditions, the electrical device is powered-up.

The optional bus interface **175** and the optional computer bus **180** are used as discussed hereinafter for activating computer display screens.

The infra-red detector can also be utilized to distinguish the situation in which the computer is being carried by a person from one in which a motion results from a person approaching. If a person is approaching, the IR intensity will be increasing, whereas if the device is being carried, the IR levels will remain constant.

FIG. 2A is an illustration of a computer which is selectively battery powered and suitable for use with the invention. The illustration of the computer corresponds to any one of a variety of standard battery powered portable computers **200**. Such computers typically have a keyboard **210** which is exposed when open, a disc drive **215**, a mouse **220**, which may be incorporated into the keyboard, and a display **225** for displaying output from the processor. In one embodiment, the display is a touchscreen display. In accordance with the invention, an eyetracker sensor is shown at **230**, positioned so as to be able to view the user's eyes. The use of the eyetracker sensor will be described more hereinafter.

FIG. 2B is a block diagram of the internal hardware of the computer of FIG. 2A. A bus **250** serves as the main information highway interconnecting the other components of the computer. CPU **255** is the central processing unit of the system, performing calculations and logic operations required to execute a program. Read only memory (**260**) and random access memory (**265**) constitute the main memory of the computer. Disk controller **270** interfaces one or more disk drives to the system bus **250**. These disk drives may be floppy disk drives, such as **273**, internal or external hard drives, such as **272**, or CD ROM or DVD (Digital Video Disks) drives such as **271**. A display interface **275** interfaces display **220** and permits information from the bus to be displayed on the display. Communications with external devices can occur over communications port **285**.

An automatic power-up/power-down circuit **100** is connected to the bus **250** over bus interface **175**. Power from power source **105** is utilized to power-up the computer and the bus structure over terminal **106**. The outputs from the motion detector, proximity detector and IR detector of the automatic power-up/power-down circuit **100** are connected to the bus and are utilized as more fully described hereinafter.

An eyetracker **290** is interfaced to the bus over interface **289** and provides information for control of the power and described more hereinafter. The display **220** is interfaced to the computer bus over display interface **275**. A separate control line **276** is shown between the display interface **275** and the display **220**. This line is utilized to control the intensity of illumination of images on the surface of the display. It effectively serves as a power control for the display device.

FIG. 2C illustrates an exemplary memory medium which can be used with drives such as **273** in FIG. 2B or **210A** in FIG. 2A. Typically, memory media such as a floppy disk, or a CD ROM, or a Digital Video Disk will contain, inter alia, program information for controlling the computer to enable the computer to perform its testing and development functions in accordance with the invention.

FIG. 3 is a state transition diagram showing the control processes used in accordance with the invention. The process begins with a power save state **310** which is described

more in detail in FIG. 4. From the power save state, the state can transition either to a power-up state **320** or return to itself. From power-up state **320**, the invention can transition to a power-down state shown more in detail in FIG. 5 (**330**) or return to itself.

Turning to FIG. 4, if motion detector **110** shown in FIG. 1 detects motion (**410**), the proximity detector and the IR detector are activated (**420**). If they are both activated, then a check is made to determine if proximity of the object whose motion is detected is less than the threshold (**430**) and then a check made to see if the IR level is greater than a threshold (**440**). If it is, switch **145** shown in FIG. 1 is closed and power is applied to terminal **106** to power-up the external device thus entering the power-up state **320** shown in FIG. 3. States **430** and **440** can transition to "set timer" state **450** if their conditions are not met. After timer **450** times out, it will transition to state **460** where the proximity detector and the IR detectors will be deactivated. State **460** will transition back to state **410** and the process begin again. State **460** may also be entered externally from the power-down state **330** shown in FIG. 3.

FIG. 5 shows more in detail the power-down state transition diagram **330** of FIG. 3. When entered from the power-up state **320** of FIG. 3, a set timer state **520** is entered which corresponds to power-down timer **150** shown in FIG. 1. If motion is detected (state **530**) timer **520** is reset. If no motion is detected, state **540** results from a timeout which triggers a power-down device state **550**. This corresponds to resetting of flip-flops **140** and **115** if FIG. 1. State **550** transitions back to power save state **300** shown in FIG. 3 and more specifically to state **460** within that state.

FIG. 6 is a flow chart of a one power control process used as part of the invention. Eyetracker **290**, shown in FIG. 2B is utilized to control the illumination of images on the display **220**. How this is done is shown in FIG. 6. The eyetracker outputs are processed to distinguish four conditions shown in FIG. 6, namely:

1. Whether the eyes are fixed at a point on the screen,
2. Whether the eyes move off the screen,
3. Whether the eyes are approaching the screen from a position off the screen, and
4. Whether the eyes are moving across the screen.

These four cases are distinguished by separate processing branches shown in FIG. 6. When the eyetracker determines that the eyes are fixed on the screen, case 1 (**610**) obtains and the display intensity is set at normal illumination (**615**).

In case number 2 (**620**), when the eyes move from the screen to a point off the screen, a time interval of, preferably, $\frac{1}{10}$ of a second (**625**) is set. If that time expires without the eyes returning to the screen, the screen will slowly fade the display intensity to black (**626**). In the embodiment shown in FIG. 6, once the eyes have been off the screen for a period of time greater than the time set in item **625**, cases 3 and 4 are treated identically. That is, whether the eyes are approaching the screen or moving across the screen without fixing on the screen, the display intensity will resume normal illumination as quickly as possible. Normal illumination will thus continue until such time as the eyes leave the screen again.

In one embodiment, step **626** includes steps shown in FIG. 8. In step **830**, power to the eyetracker is removed when it is determined in step **827** that the user has not looked at the display for a predetermined period of time. In step **840**, power to the SEP eyetracker is restored after the user has not looked at the display for a predetermined period of time by a user input. If the display is a touchscreen display, the user input is provided by touching the touchscreen display.

The embodiment shown in FIG. 7, is identical for cases 1 and 2 as that shown in FIG. 6. However, cases 3 and 4 are treated separately. In case 3, where the eyes are approaching the on-screen condition, in this embodiment, nothing happens. That is, the screen remains blank. However, case 4 results in measurement of the time that the eyes are on the screen. If the time the eyes are on the screen exceeds some threshold, the display intensity is resumed at normal illumination as quickly as possible.

Thus, in accordance with the invention, electrical devices powered by energy sources of finite capacity can utilize the energy available to the maximum extent possible and reduce energy waste to a minimum.

In this disclosure, there is shown and described only the preferred embodiment of the invention, but, as aforementioned, it is to be understood that the invention is capable of use in various other combinations and environments and is capable of changes or modifications within the scope of the inventive concept as expressed herein.

What is claimed is:

1. A computing device comprising:

- a processor;
- a display having a controllable intensity connected to said processor;
- an eyetracker providing a signal indicating where a user's eyes are looking to said processor; and

a control for changing intensity of said display based on said signal,

wherein the display is a touchscreen display, and

wherein power to the eyetracker is removed when the user has not looked at the display for a predetermined period of time and power to the eyetracker is restored by touching said touchscreen display.

2. A computing device comprising:

- a processor;
- a display having a controllable intensity connected to said processor;
- an eyetracker providing a signal indicating where a user's eyes are looking to said processor;
- a control for changing the intensity of said display based on said signal,
- a motion detector; and
- a proximity detector, activated by said motion detector detecting motion;

wherein power to the eyetracker is restored when the proximity detector detects an object within a predetermined distance from the computing device while activated by said motion detector.

* * * * *