US006933686B1

(12) **United States Patent**
Bishel

(10) **Patent No.: US 6,933,686 B1**
(45) **Date of Patent: Aug. 23, 2005**

(54) **PROGRAMMABLE AC POWER SWITCH**

(76) Inventor: **Richard Anthony Bishel**, 16020 NW. Ridgetop La., Beaverton, OR (US) 97006

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 9 days.

(21) Appl. No.: **10/754,377**

(22) Filed: **Jan. 8, 2004**

Related U.S. Application Data

(60) Provisional application No. 60/439,167, filed on Jan. 9, 2003.

(51) **Int. Cl.**[7] **G05F 1/00**
(52) **U.S. Cl.** **315/293**; 315/297; 315/320; 315/362; 307/115; 307/140
(58) **Field of Search** 315/246, 293, 315/295, 297, 307, 313, 314, 317, 320, 322, 315/360, 362; 307/112, 115, 116, 139, 140; 219/240, 490, 507, 508

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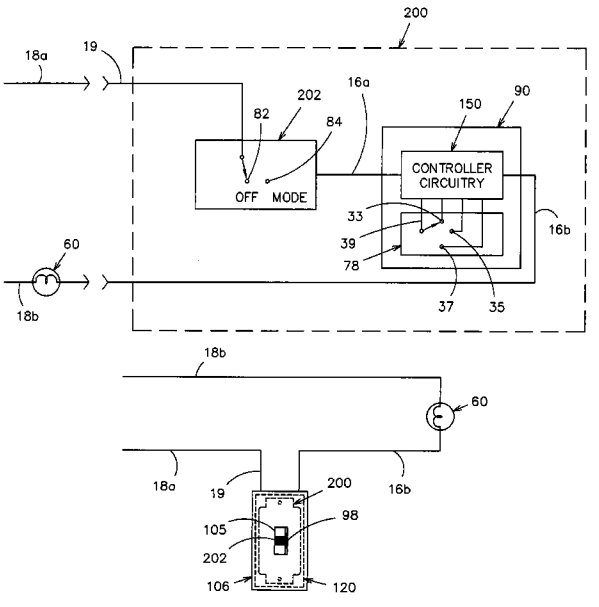
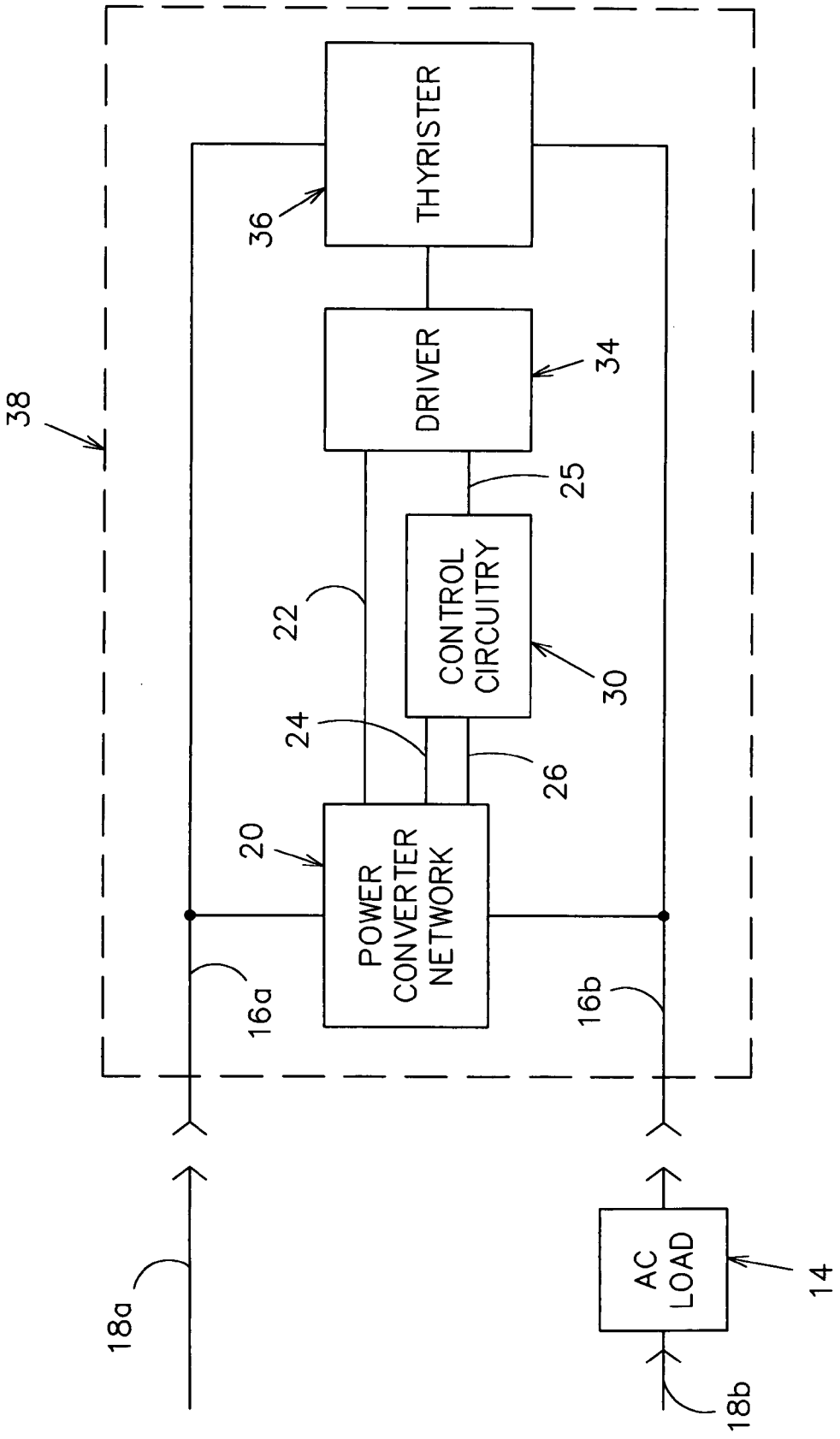
Primary Examiner—Haissa Philogene
(74) *Attorney, Agent, or Firm*—Richard A. Bishel

(57) **ABSTRACT**

An AC controller provides programmable switching of AC power flow, together with producing a source of DC power for the AC controller. The AC controller is connected in series with only one side of the AC power source and the AC load, and uses a microcontroller or a Programmable Logic Device (PLD) for the programmable capability. The AC controller can be programmed to provide a light flasher function, a time delay off function, an automatic fade function, a dimming function, a burglar deterrent function, and a time delay dim function. With a multiple-position switch replacing a current wall switch, the operator can easily select many pre-programmed functions.

30 Claims, 27 Drawing Sheets

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THYRISTER
36
DRIVER
34
25
CONTROL CIRCUITRY
30
22
24
26
POWER CONVERTER NETWORK
20
16a
16b
18a
AC LOAD
14
18b

FIG. 1

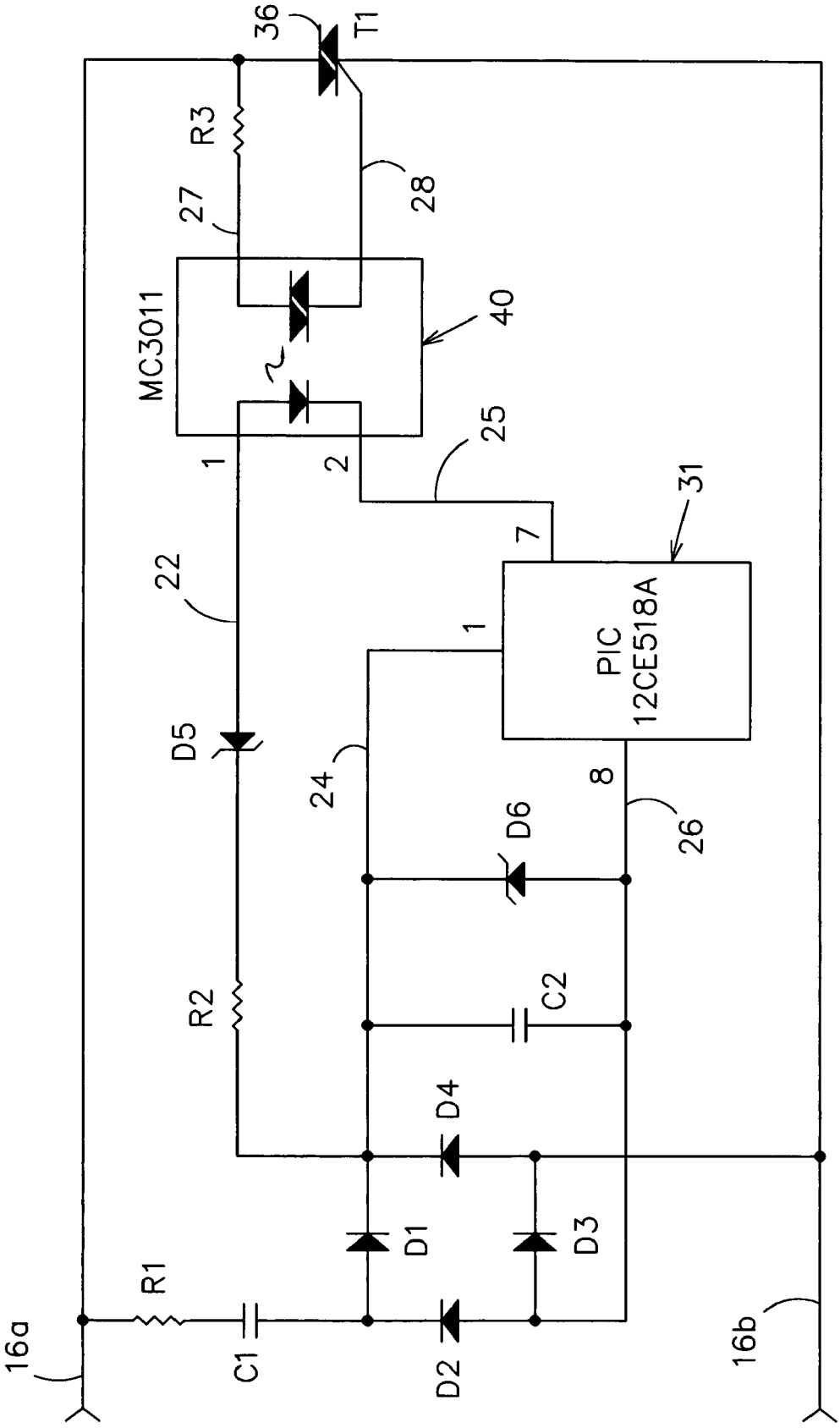

36
T1
R3
27
28
MC3011
40
1
2
25
31
7
22
PIC
12CE518A
1
D5
24
8
D6
26
R2
C2
D4
D1
D3
R1
16a
C1
D2
16b

FIG. 2

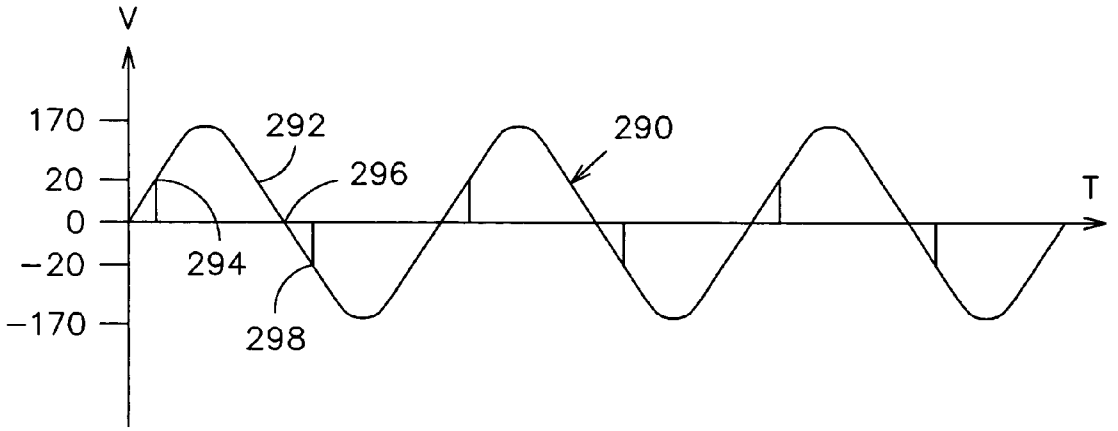

V
170
20
0
−20
−170
292
290
296
294
298
T

FIG. 3A

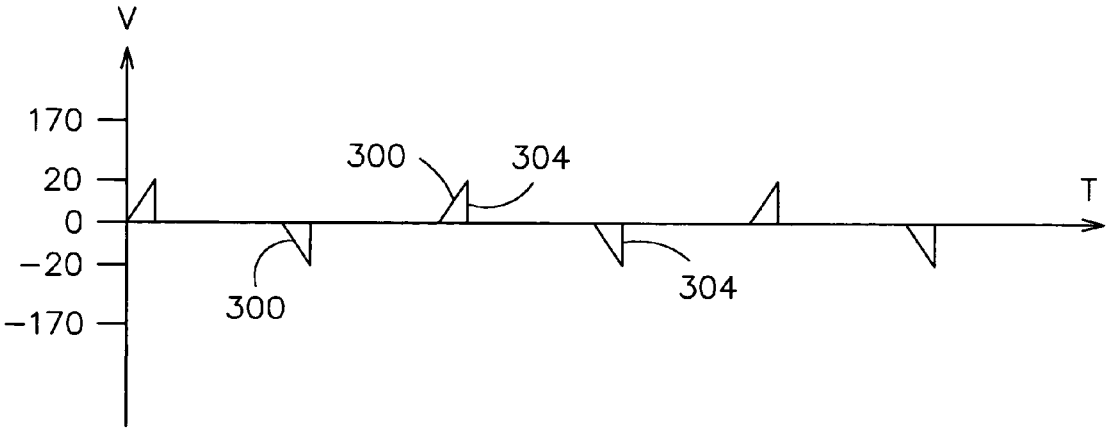

V
170
20
0
−20
−170
300
304
T
300
304

FIG. 3B

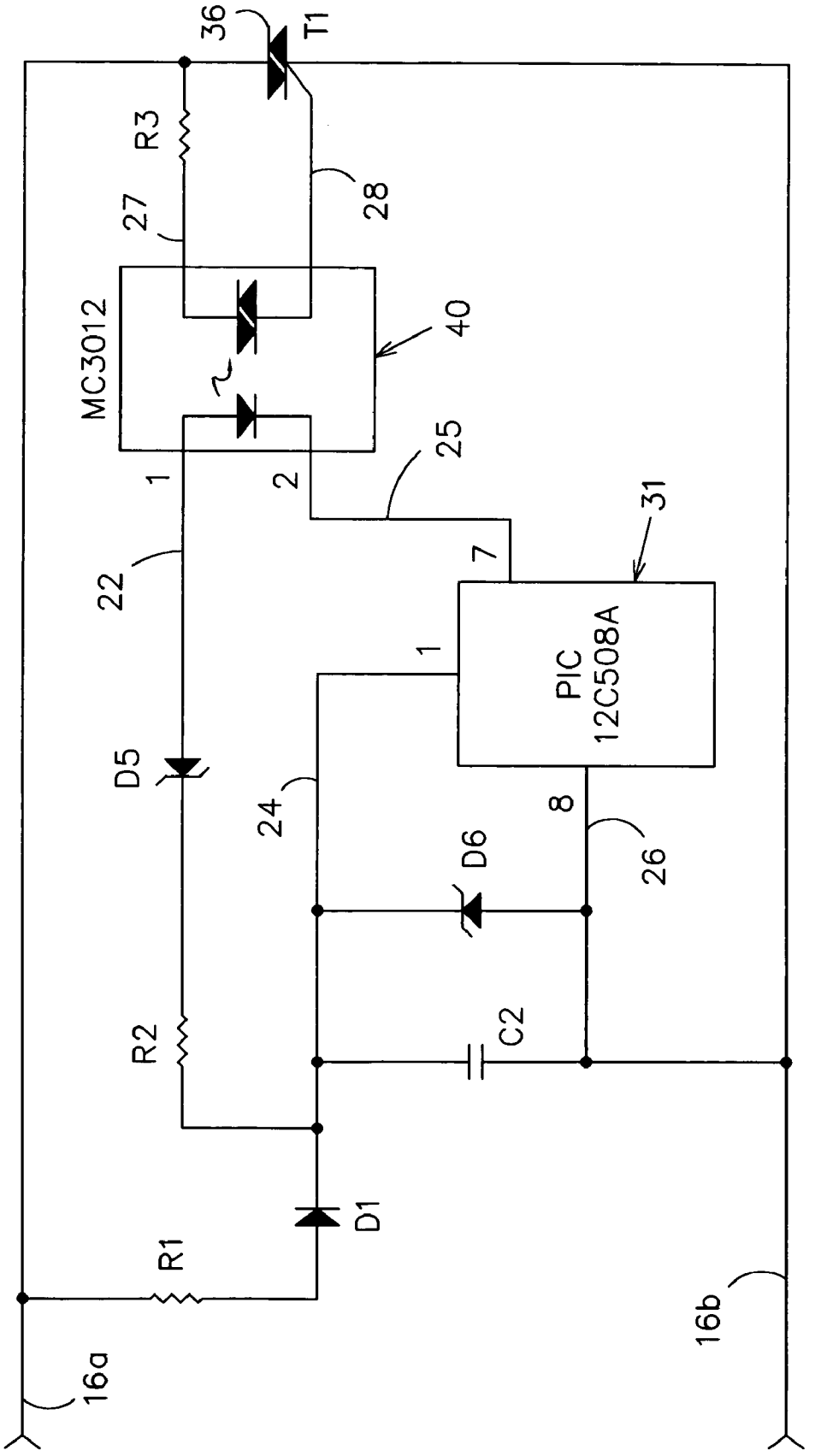
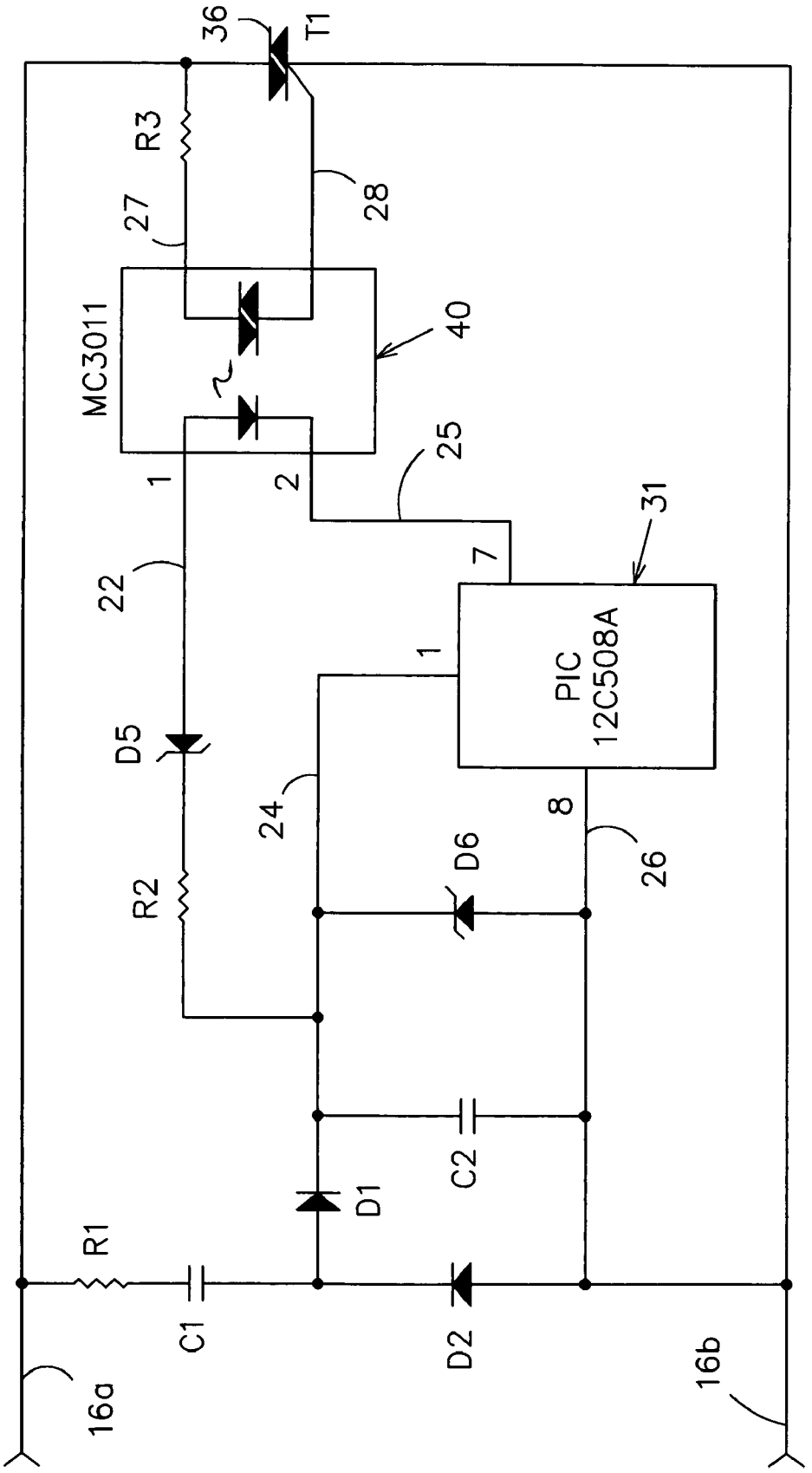

36
T1
R3
27
28
MC3012
40
1
2
25
22
7
31
PIC
12C508A
1
D5
24
8
D6
26
R2
C2
D1
R1
16a
16b

FIG. 4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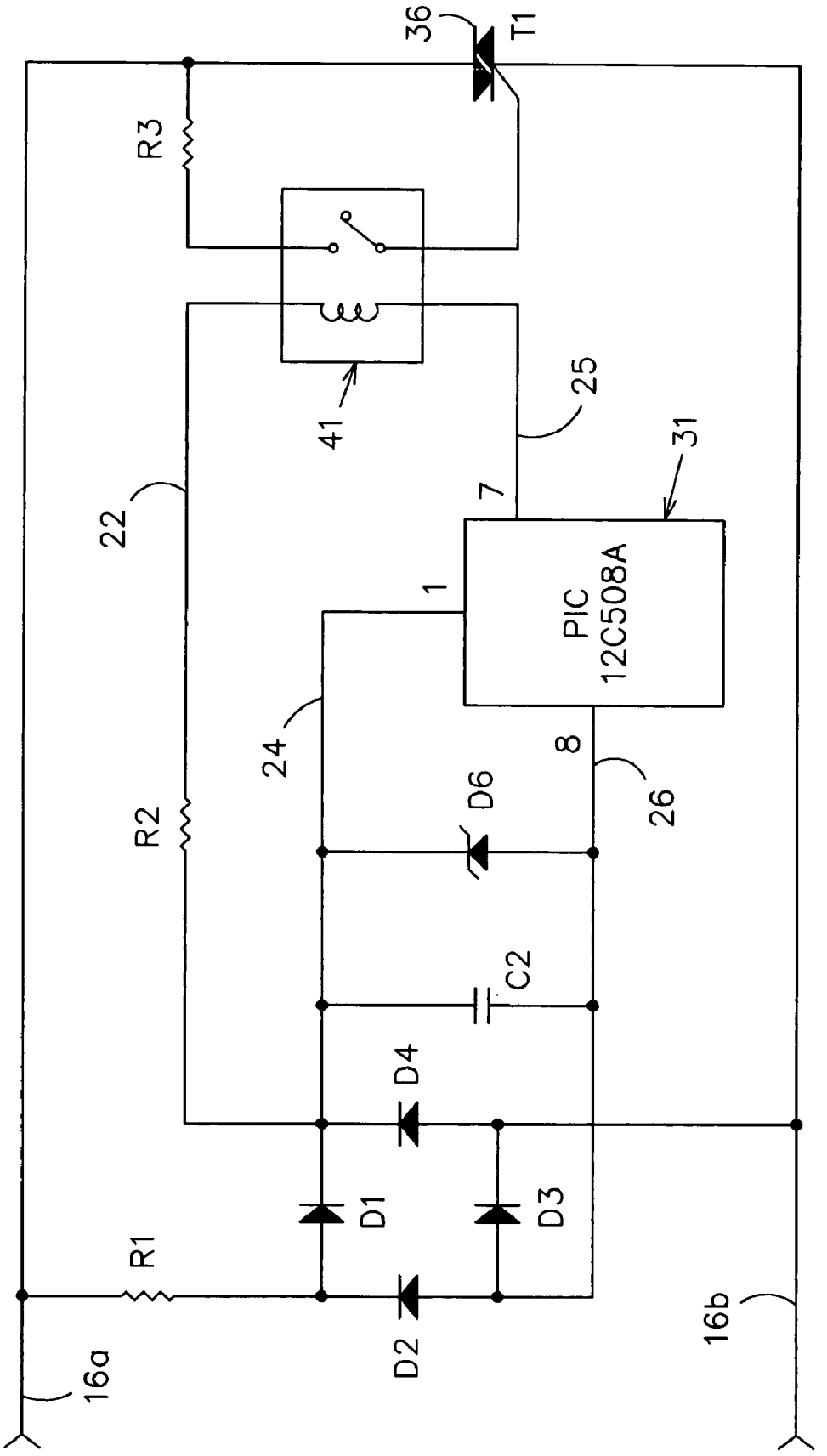
T1
R3
27
28
MC3011
40
1
2
25
31
7
22
PIC
12C508A
1
D5
24
8
D6
26
R2
R1
C2
D1
C1
D2
16a
16b

FIG. 5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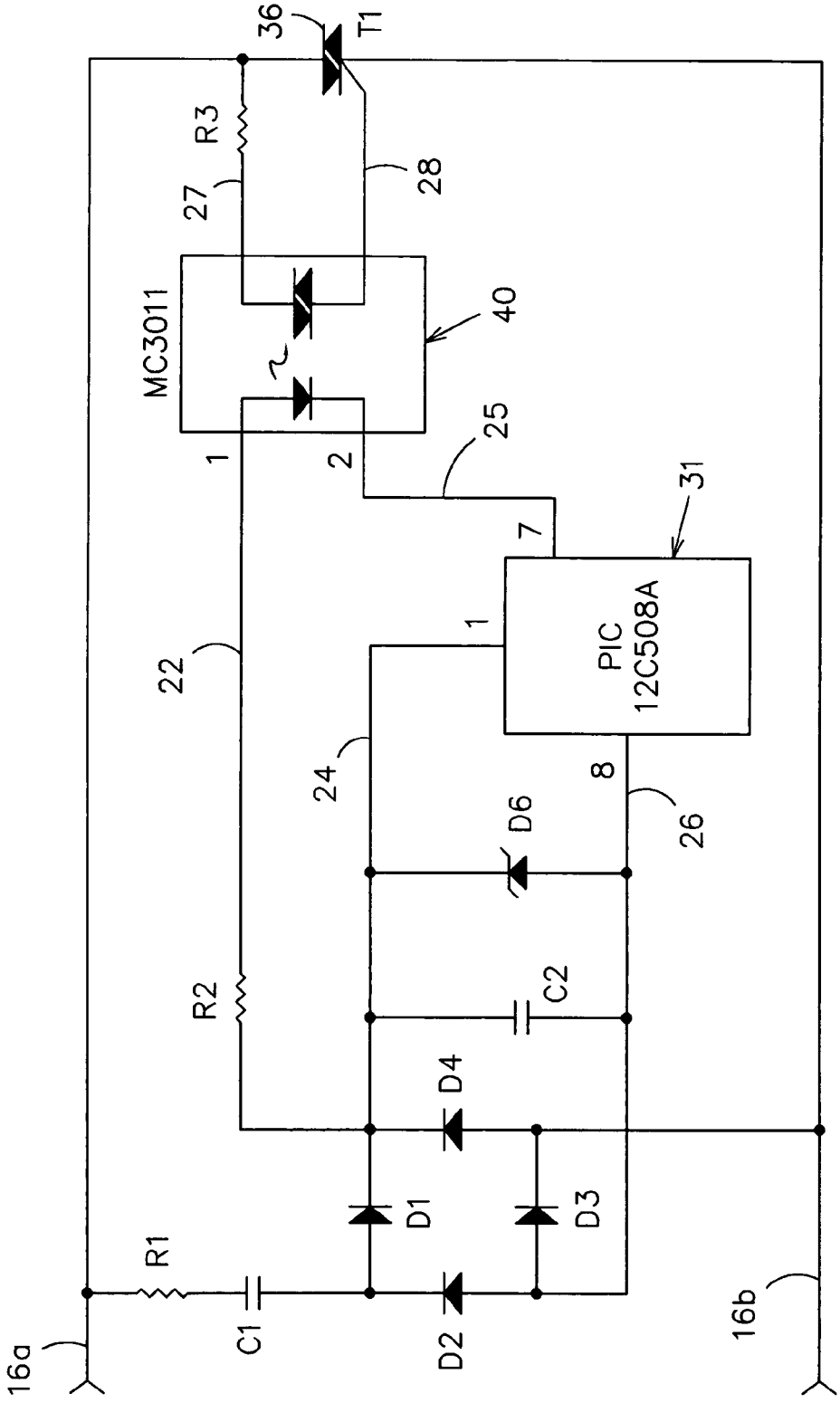
T1
R3
41
25
31
22
7
PIC
12C508A
1
24
8
26
D6
R2
C2
D4
D1
D3
R1
D2
16a
16b

FIG. 6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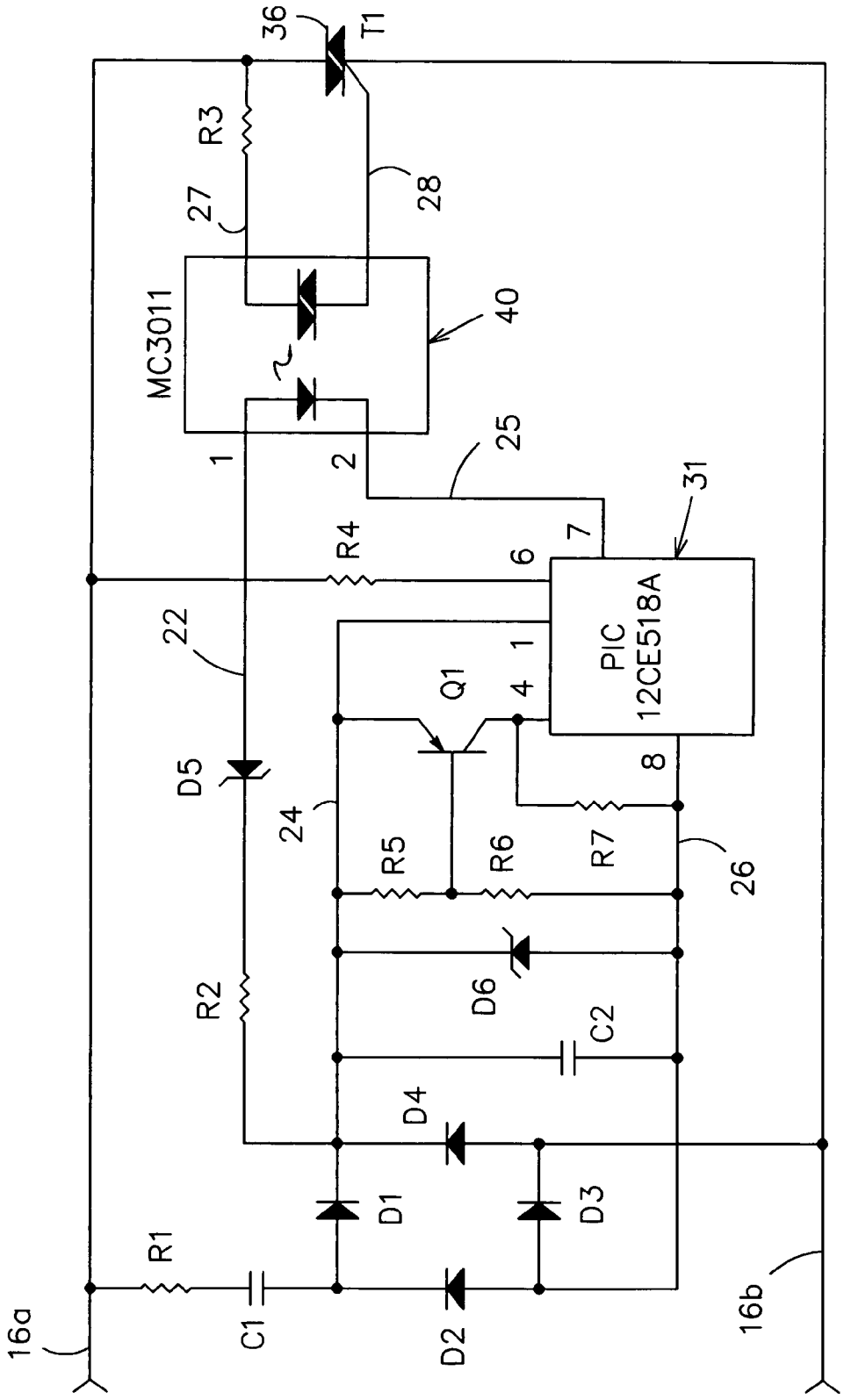
T1
R3
27
28
MC3011
40
1
2
25
31
7
PIC
12C508A
1
22
24
8
26
D6
C2
R2
D4
D1
D3
R1
C1
D2
16a
16b

FIG. 7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T1
R3
27
28
MC3011
40
1
2
25
31
R4
6
7
PIC
12CE518A
22
Q1
4
1
D5
8
24
R5
R6
R7
26
R2
D6
C2
D4
D1
D3
R1
C1
D2
16a
16b

FIG. 8

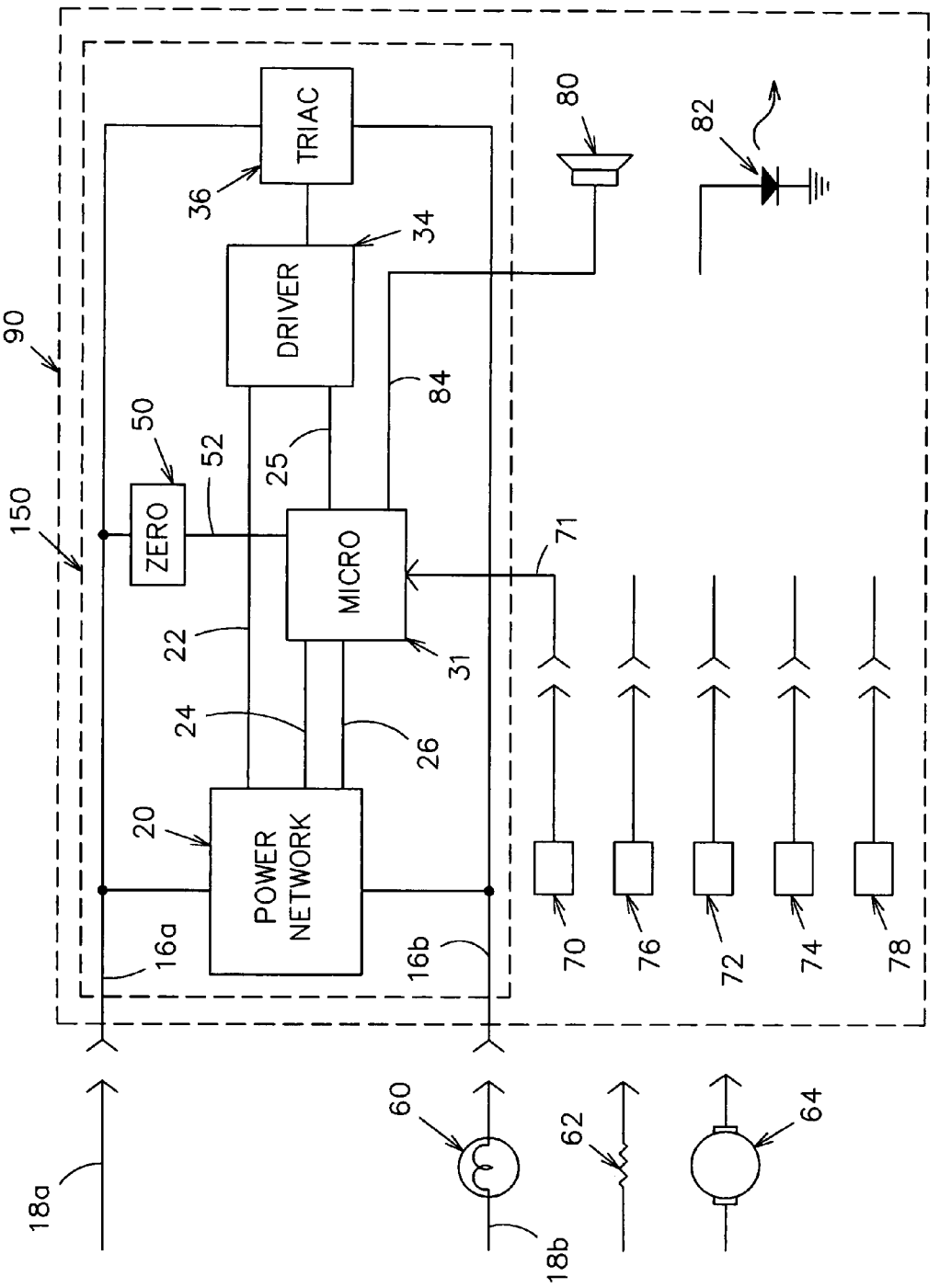

90
150
TRIAC
36
DRIVER
34
80
82
84
50
52
25
ZERO
MICRO
71
22
31
24
26
20
POWER NETWORK
16a
16b
70
76
72
74
78
18a
60
62
64
18b

FIG. 9

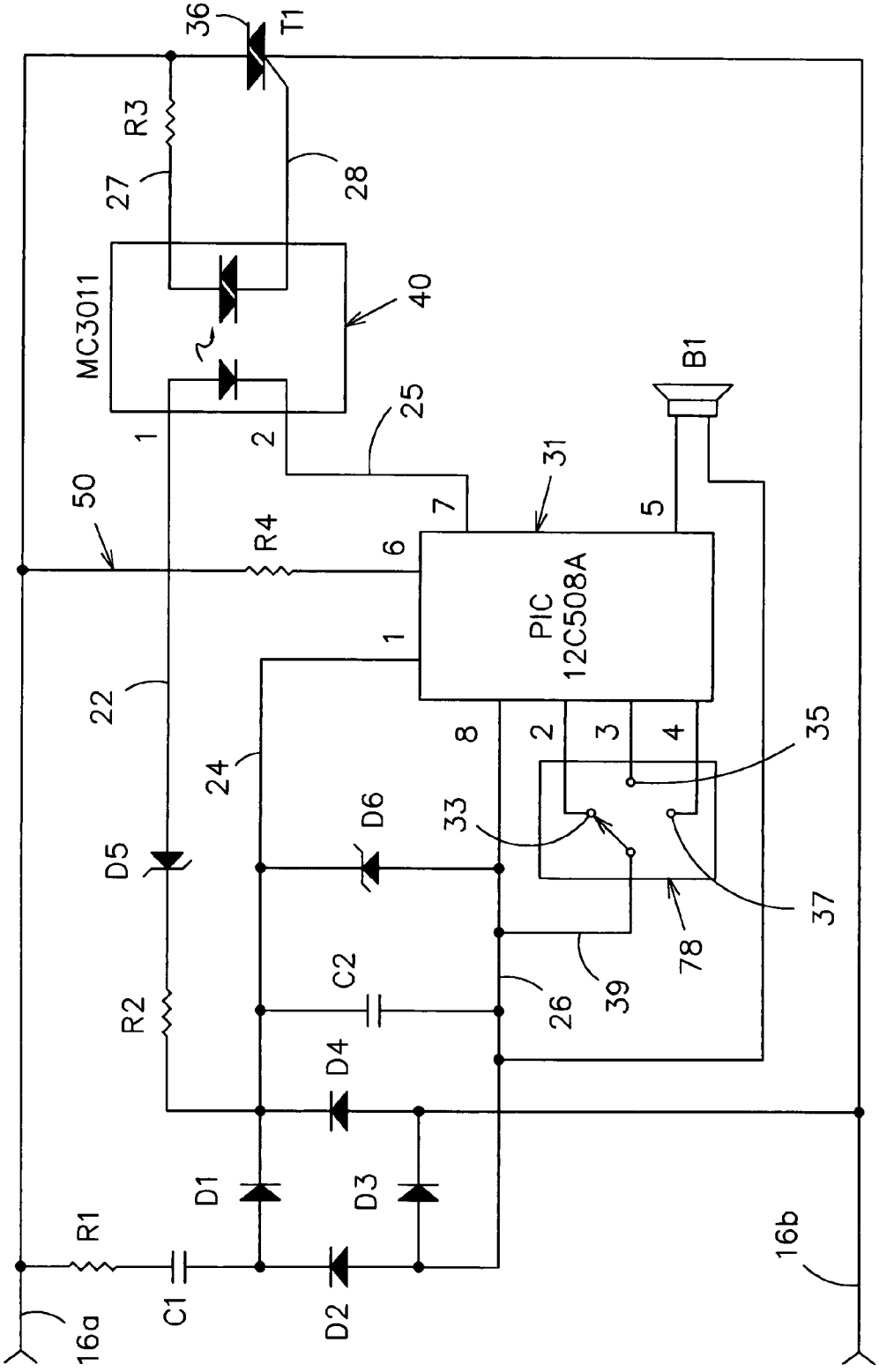

36
T1
R3
27
28
MC3011
40
B1
25
1
2
31
50
7
5
R4
6
PIC
12C508A
1
22
8
2
3
4
35
24
D6
33
D5
37
78
C2
26
39
R2
D4
D1
D3
R1
16b
C1
D2
16a

FIG. 10

FIG. 11A

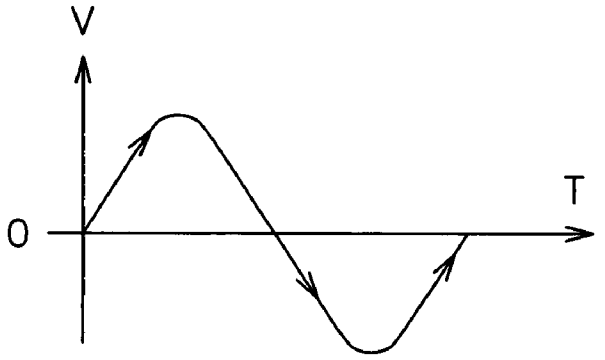


FIG. 11B

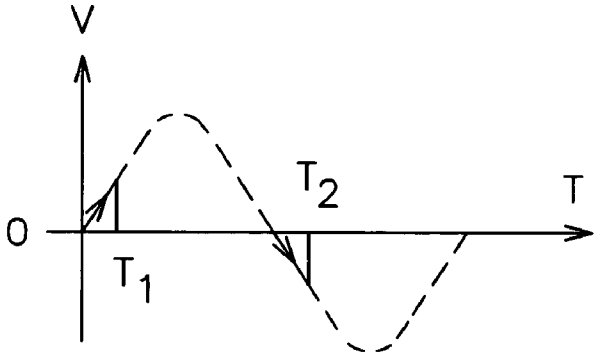


FIG. 11C

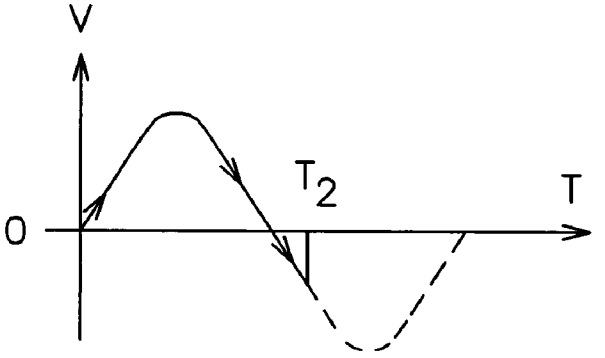
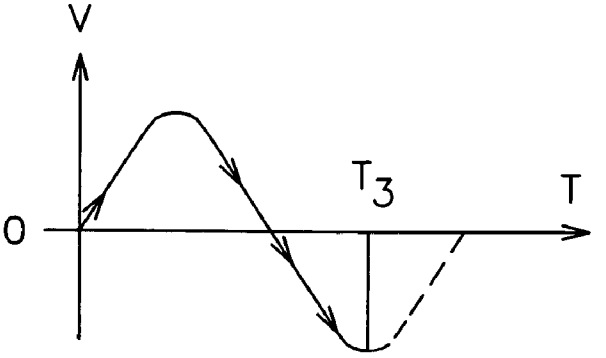


FIG. 11D



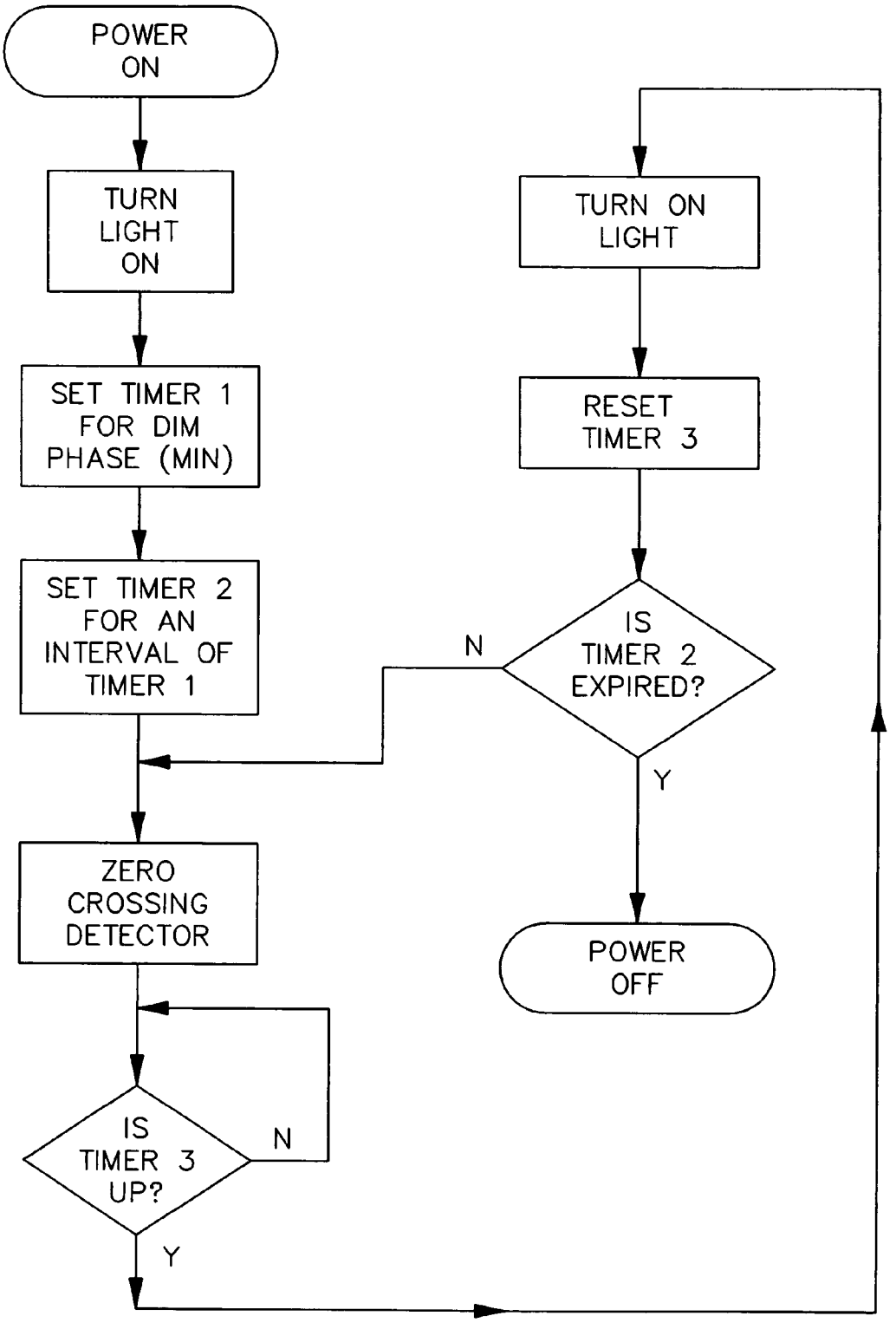

POWER ON
TURN LIGHT ON
SET TIMER 1 FOR DIM PHASE (MIN)
SET TIMER 2 FOR AN INTERVAL OF TIMER 1
ZERO CROSSING DETECTOR
IS TIMER 3 UP?
N
Y
TURN ON LIGHT
RESET TIMER 3
IS TIMER 2 EXPIRED?
N
Y
POWER OFF

FIG. 12

FIG. 13

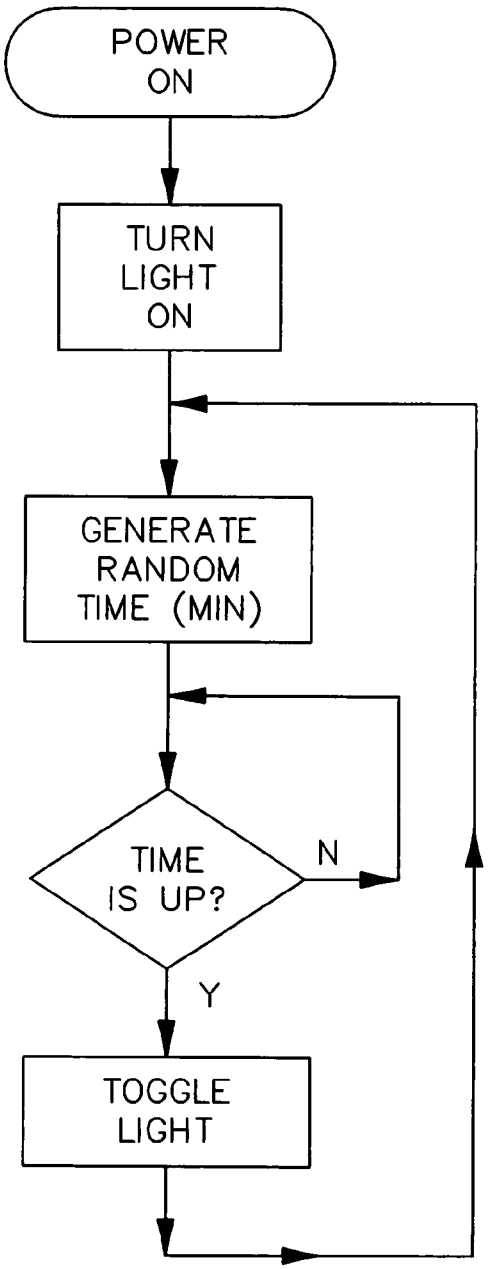

POWER ON
TURN LIGHT ON
GENERATE RANDOM TIME (MIN)
TIME IS UP?
N
Y
TOGGLE LIGHT

FIG. 14

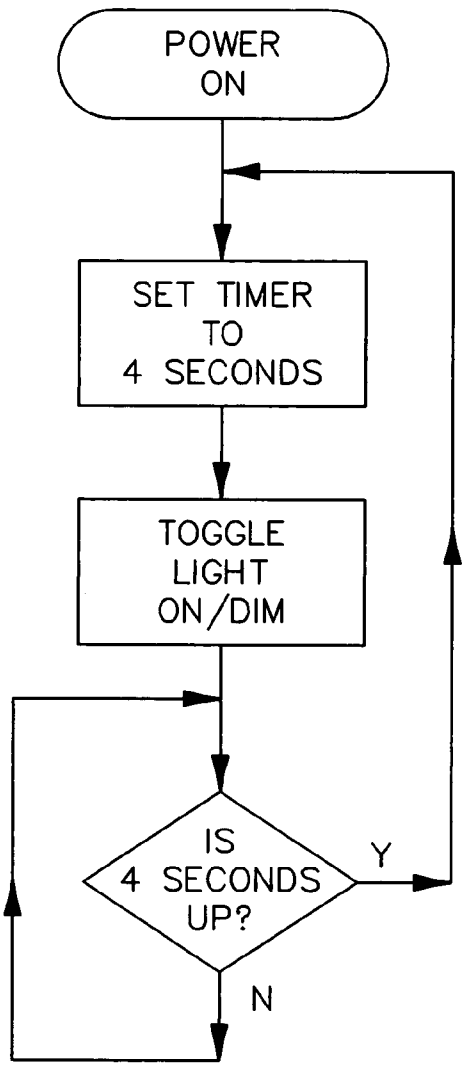

POWER ON
SET TIMER TO 4 SECONDS
TOGGLE LIGHT ON/DIM
IS 4 SECONDS UP?
Y
N

FIG. 15

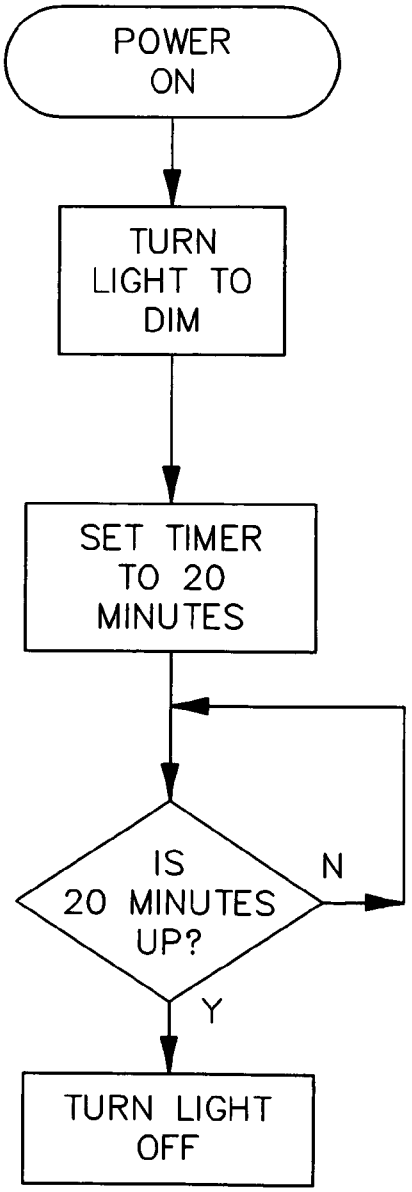

POWER ON
TURN LIGHT TO DIM
SET TIMER TO 20 MINUTES
IS 20 MINUTES UP?
N
Y
TURN LIGHT OFF

FIG. 16

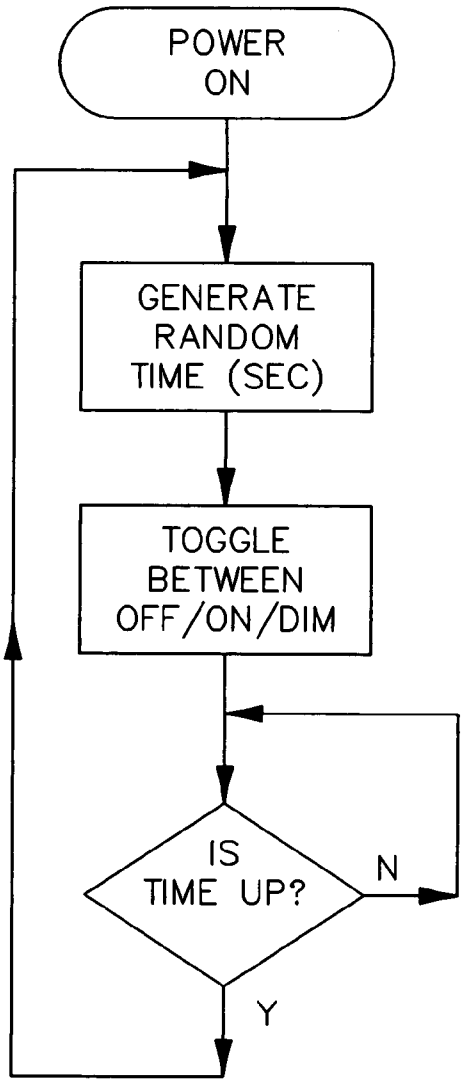

POWER ON
GENERATE RANDOM TIME (SEC)
TOGGLE BETWEEN OFF/ON/DIM
IS TIME UP?
N
Y

FIG. 17

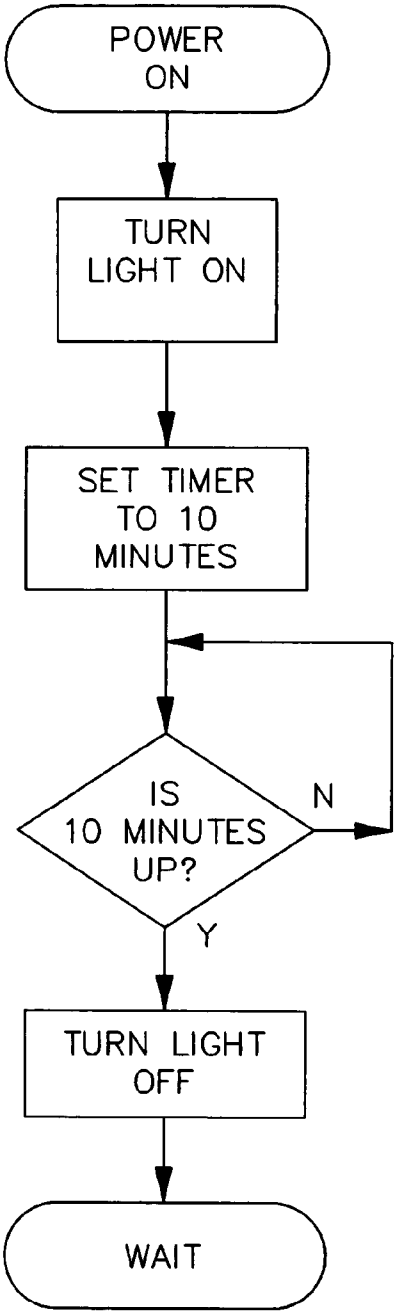

POWER ON
TURN LIGHT ON
SET TIMER TO 10 MINUTES
IS 10 MINUTES UP?
N
Y
TURN LIGHT OFF
WAIT

FIG. 18

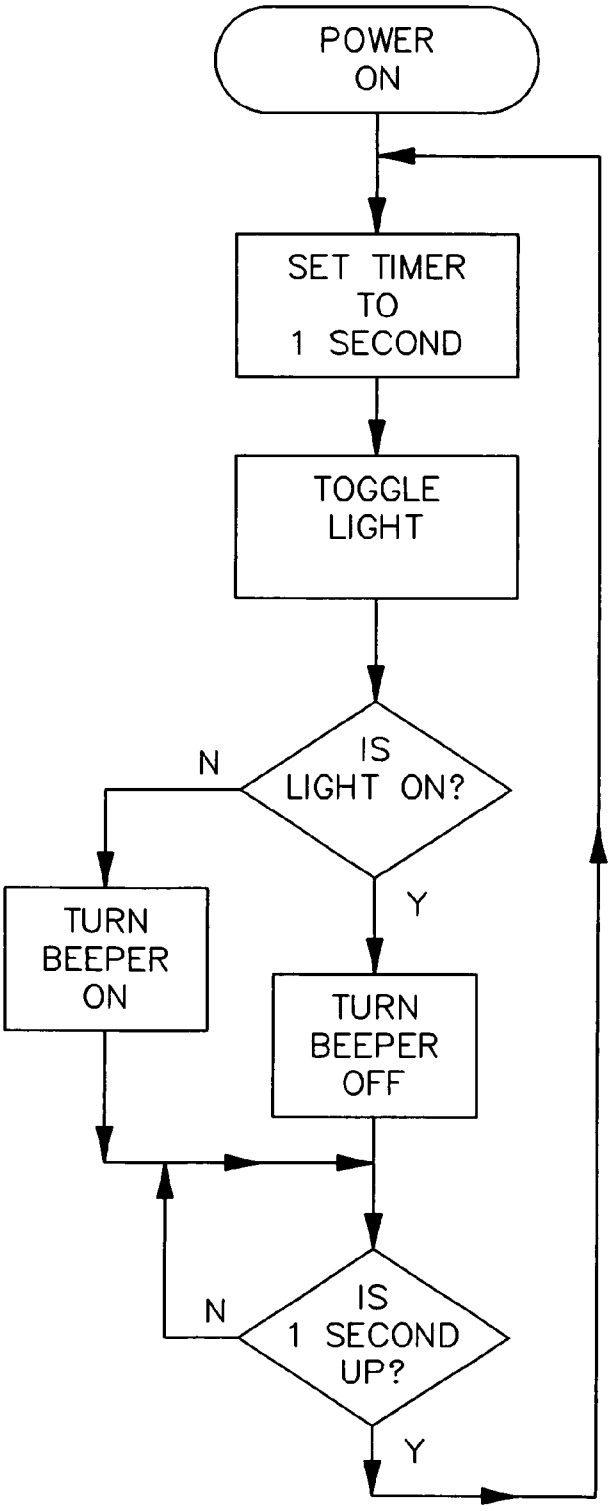

POWER ON
SET TIMER TO 1 SECOND
TOGGLE LIGHT
IS LIGHT ON?
N
Y
TURN BEEPER ON
TURN BEEPER OFF
IS 1 SECOND UP?
N
Y

FIG. 19

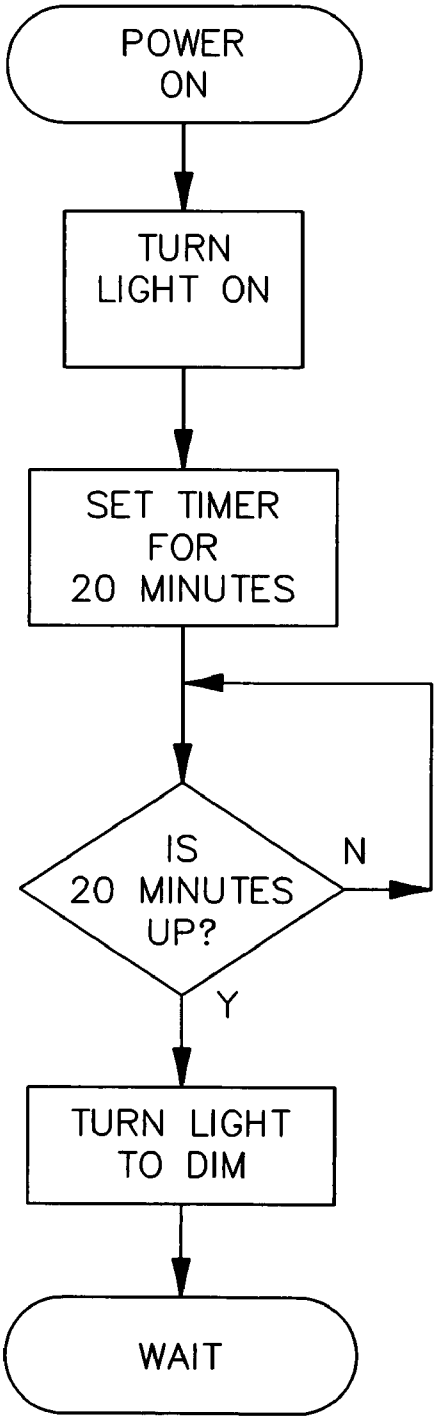
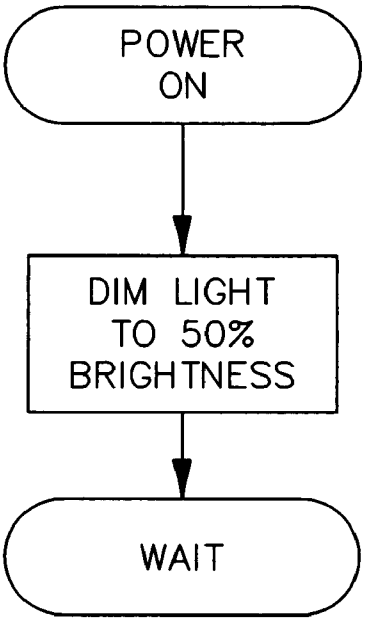

POWER ON
TURN LIGHT ON
SET TIMER FOR 20 MINUTES
IS 20 MINUTES UP?
N
Y
TURN LIGHT TO DIM
WAIT

FIG. 20


POWER ON
DIM LIGHT TO 50% BRIGHTNESS
WAIT

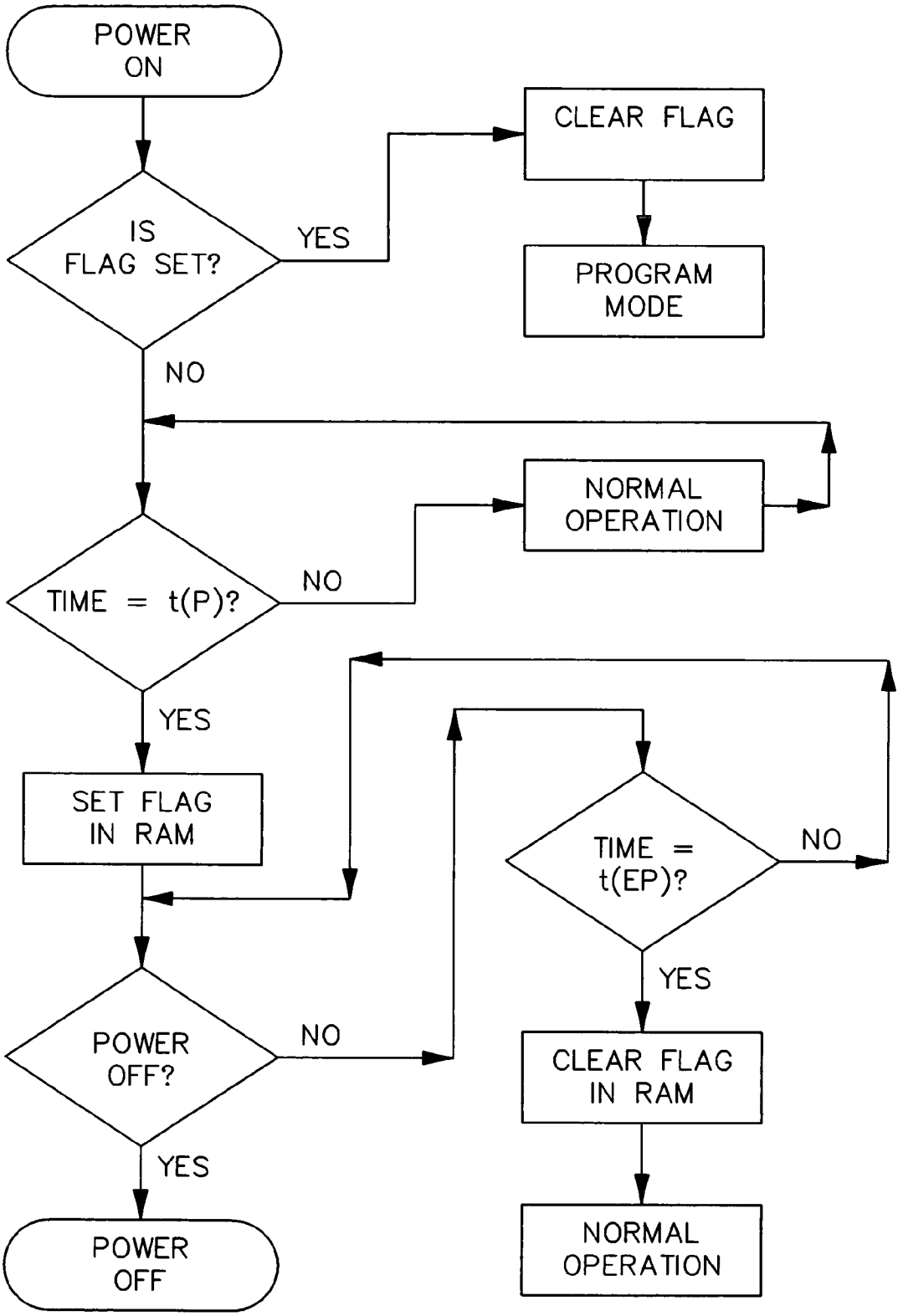

POWER ON
IS FLAG SET?
YES
CLEAR FLAG
PROGRAM MODE
NO
NORMAL OPERATION
TIME = t(P)?
NO
YES
SET FLAG IN RAM
TIME = t(EP)?
NO
YES
POWER OFF?
NO
CLEAR FLAG IN RAM
YES
NORMAL OPERATION
POWER OFF

FIG. 21

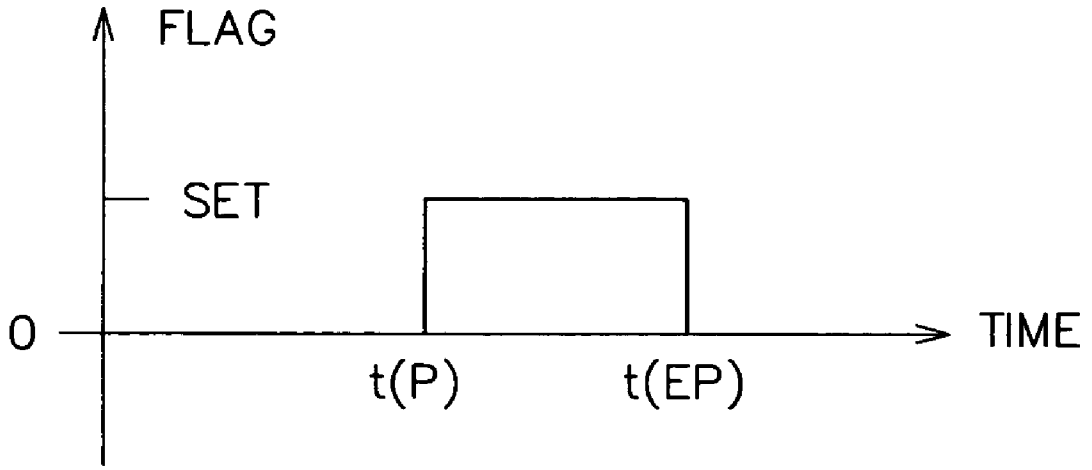


FIG. 22A

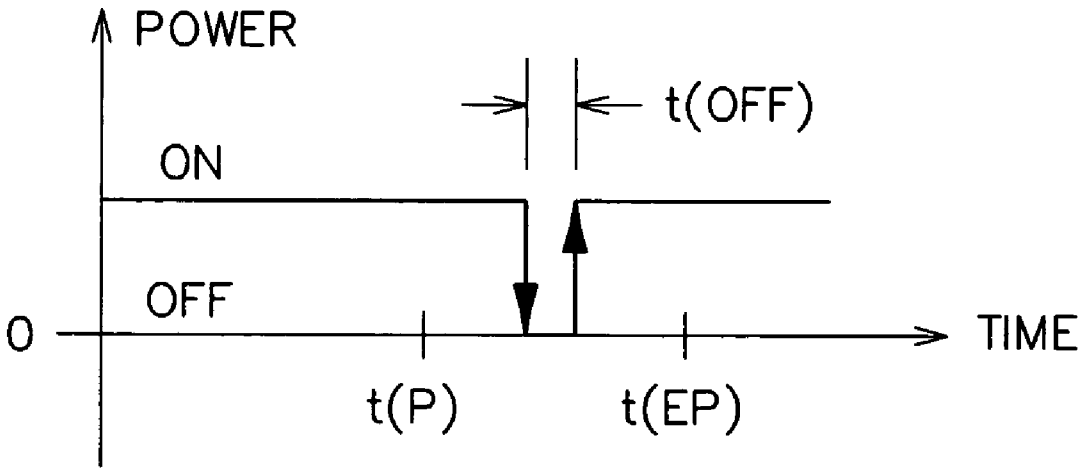


FIG. 22B

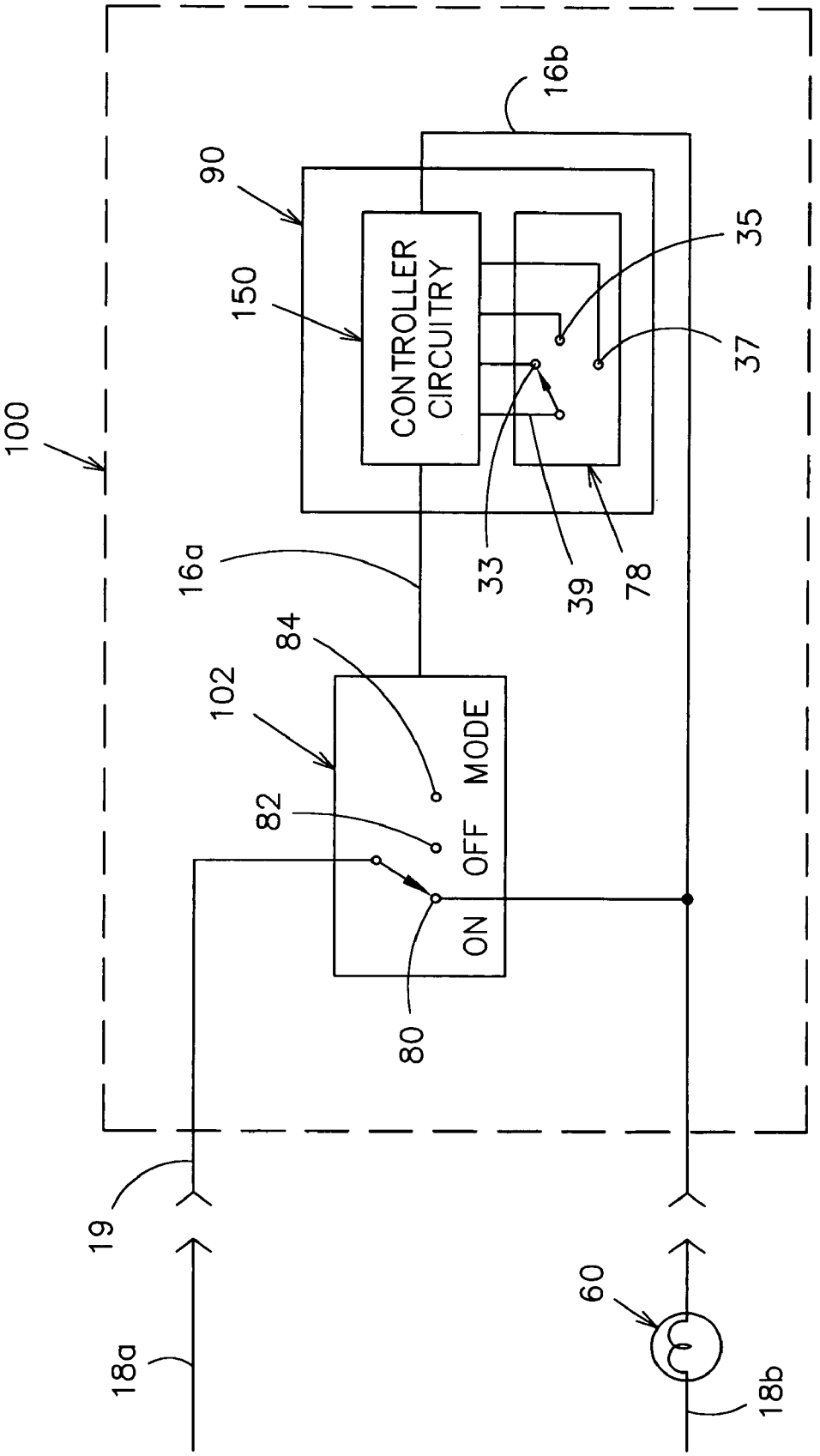

100
16b
90
150
CONTROLLER CIRCUITRY
35
37
33
39
78
16a
84
102
MODE
OFF
ON
82
80
19
18a
60
18b

FIG. 23

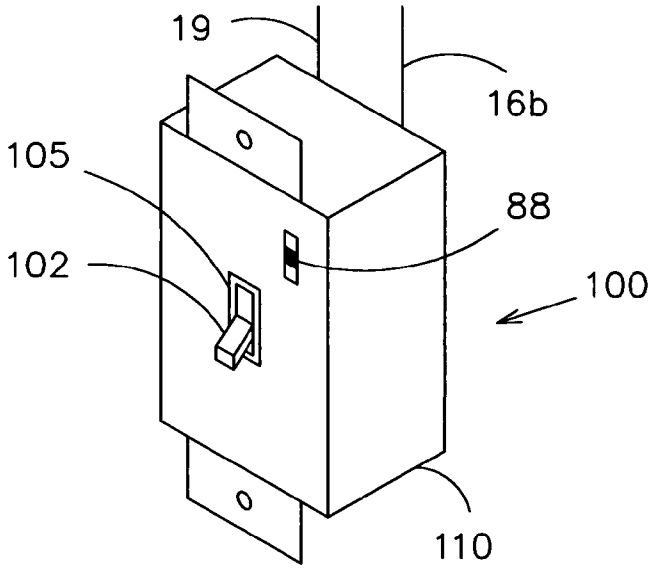


FIG. 24

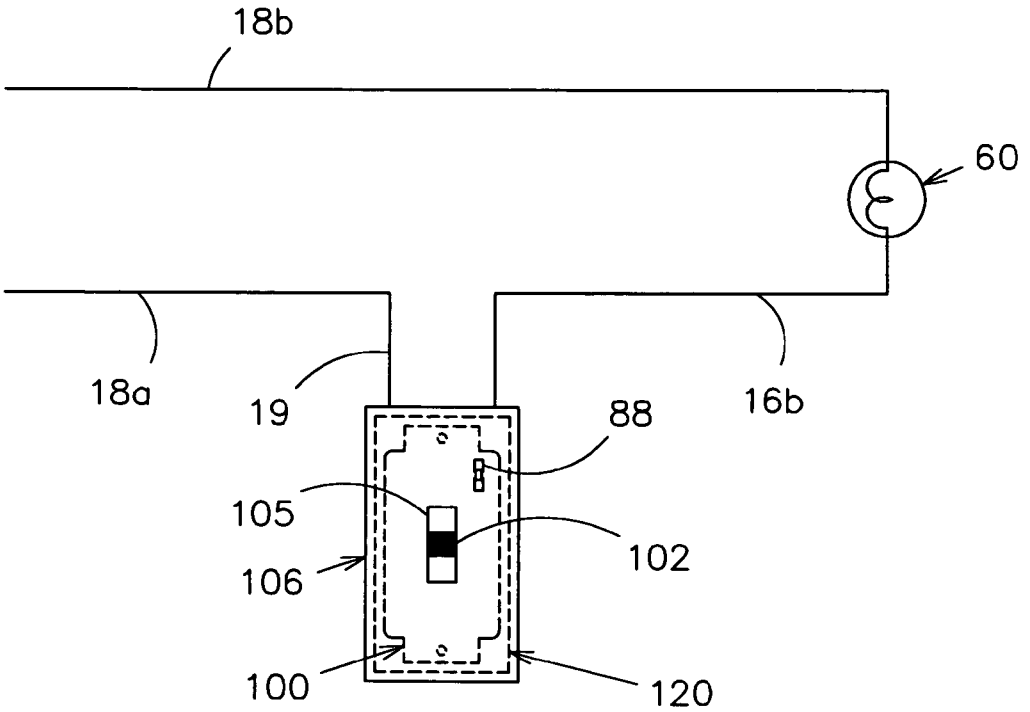


FIG. 25

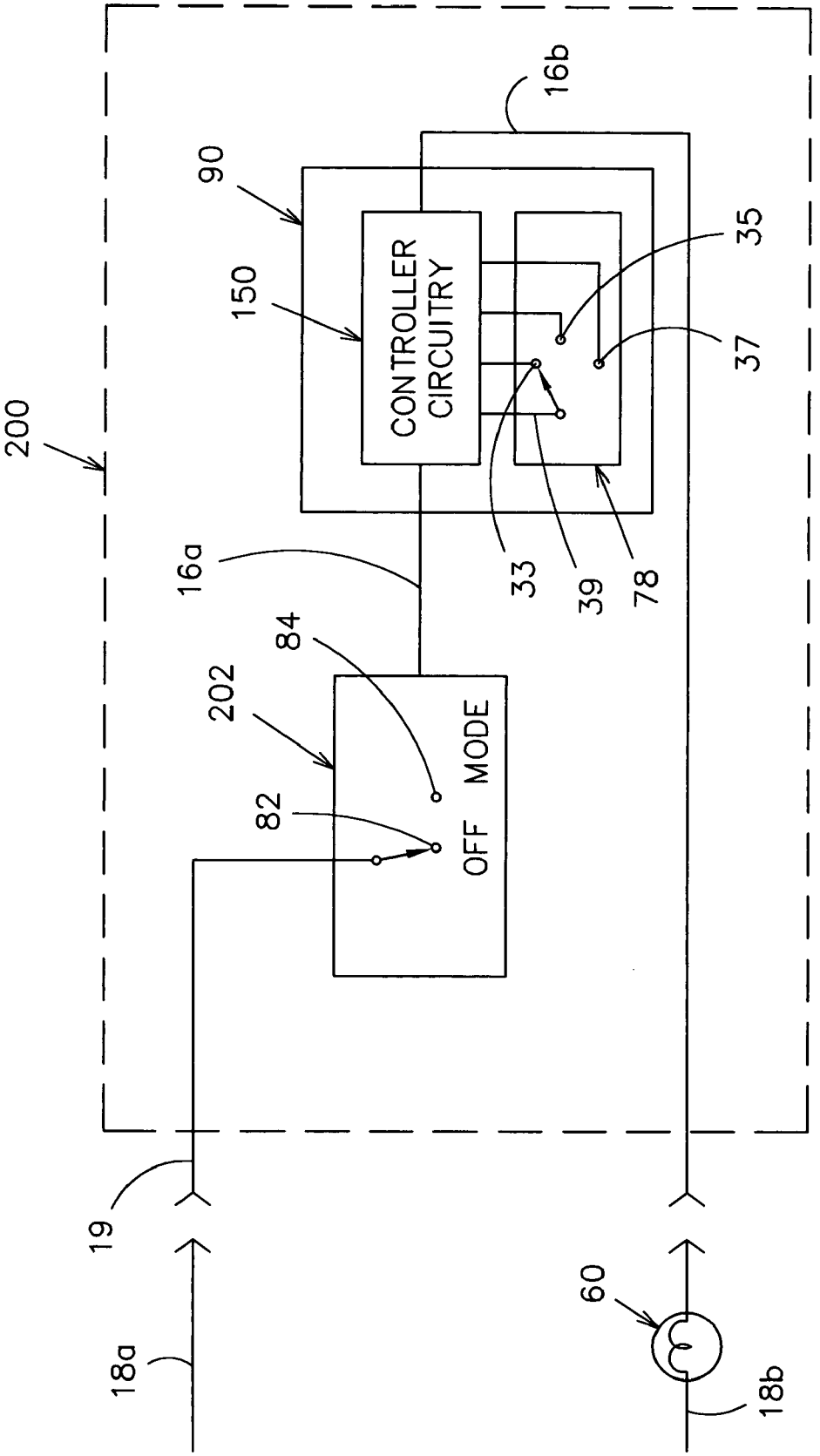

200
16b
90
150
CONTROLLER CIRCUITRY
35
37
33
39
78
16a
84
202
OFF MODE
82
19
18a
60
18b

FIG. 26

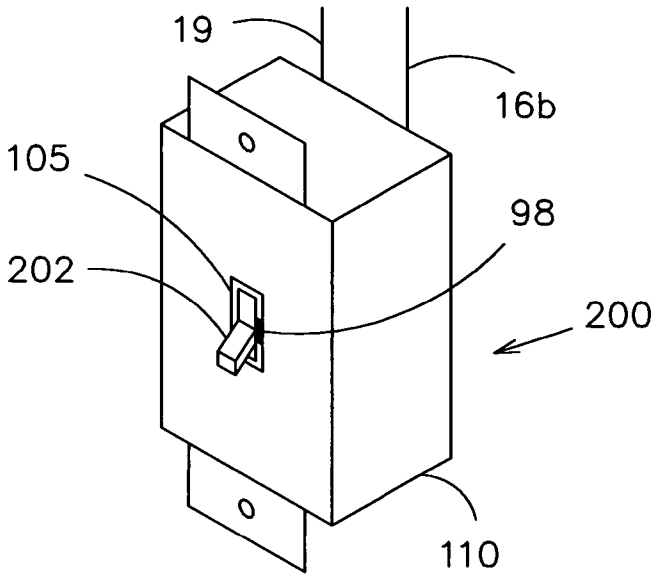


FIG. 27

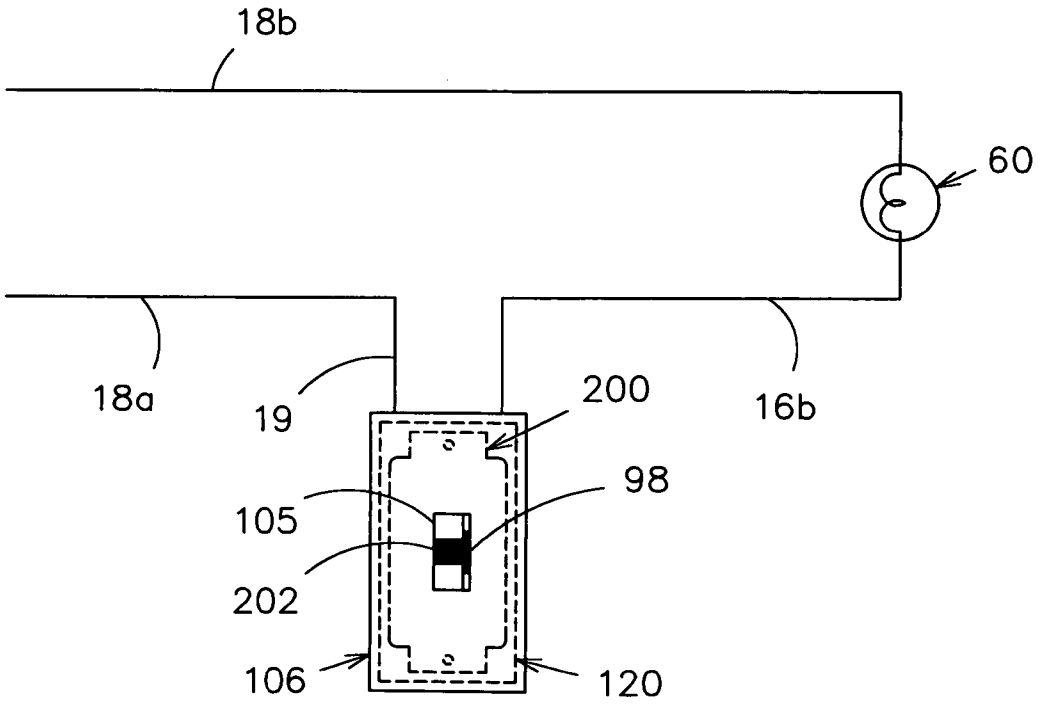


FIG. 28

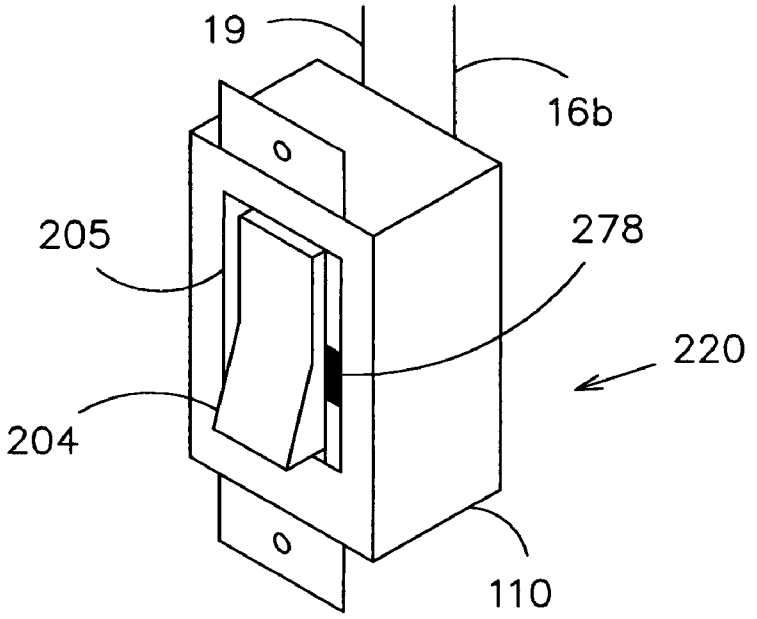

19
16b
205
278
220
204
110

FIG. 29

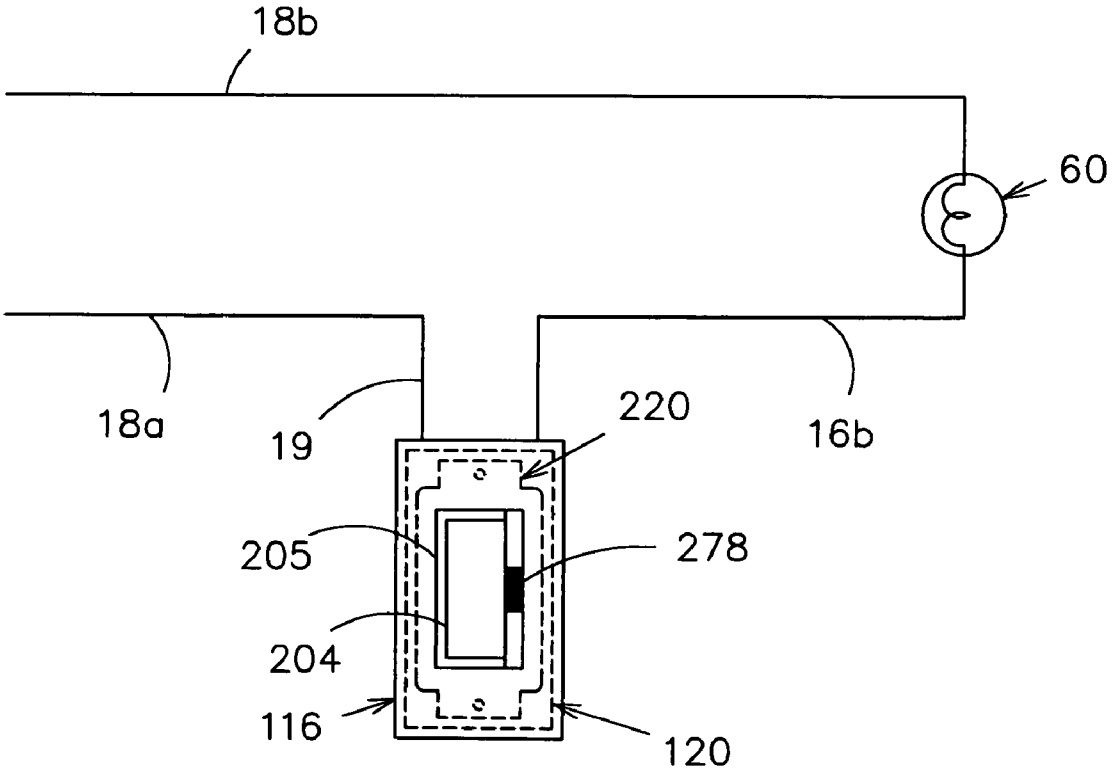

18b
60
18a
19
220
16b
205
278
204
116
120

FIG. 30

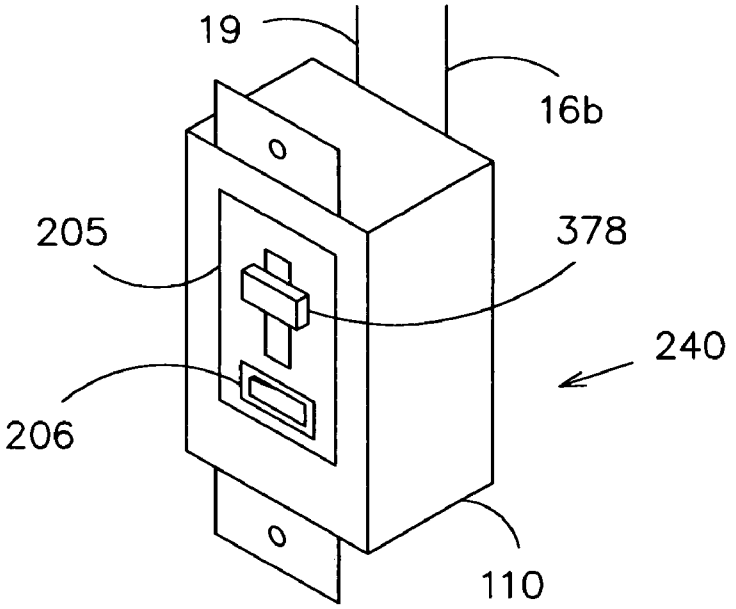

19
16b
205
378
240
206
110

FIG. 31

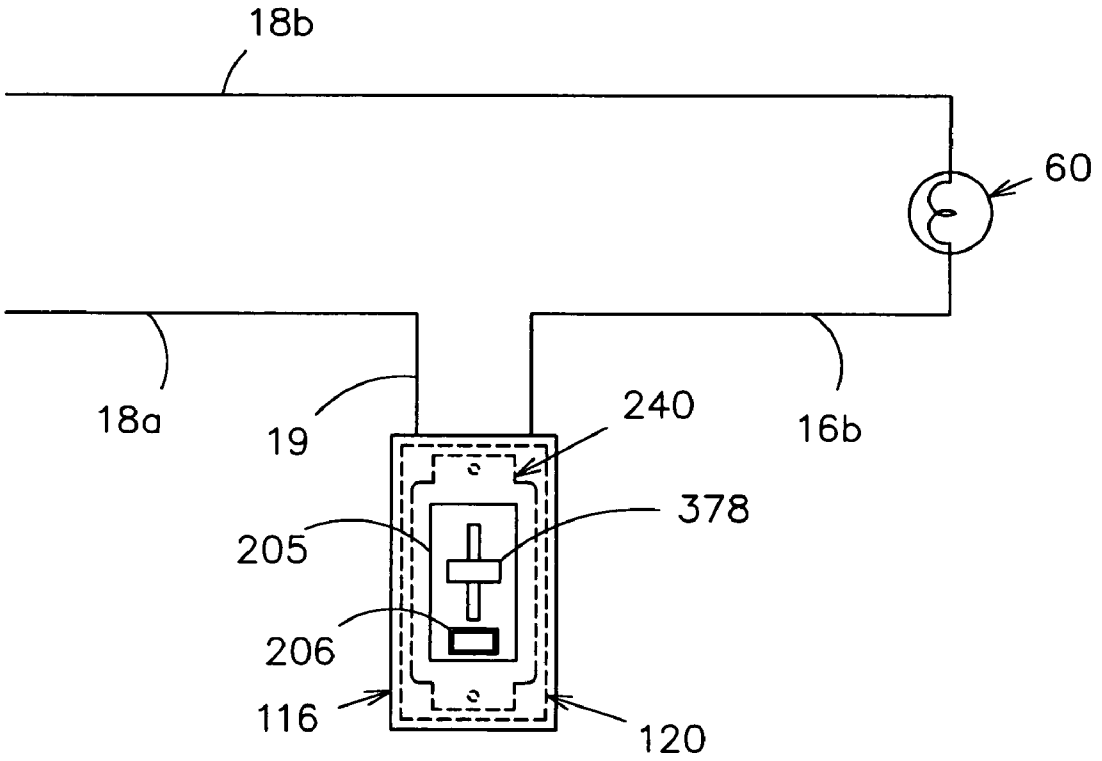

18b
60
18a
19
240
16b
378
205
206
116
120

FIG. 32

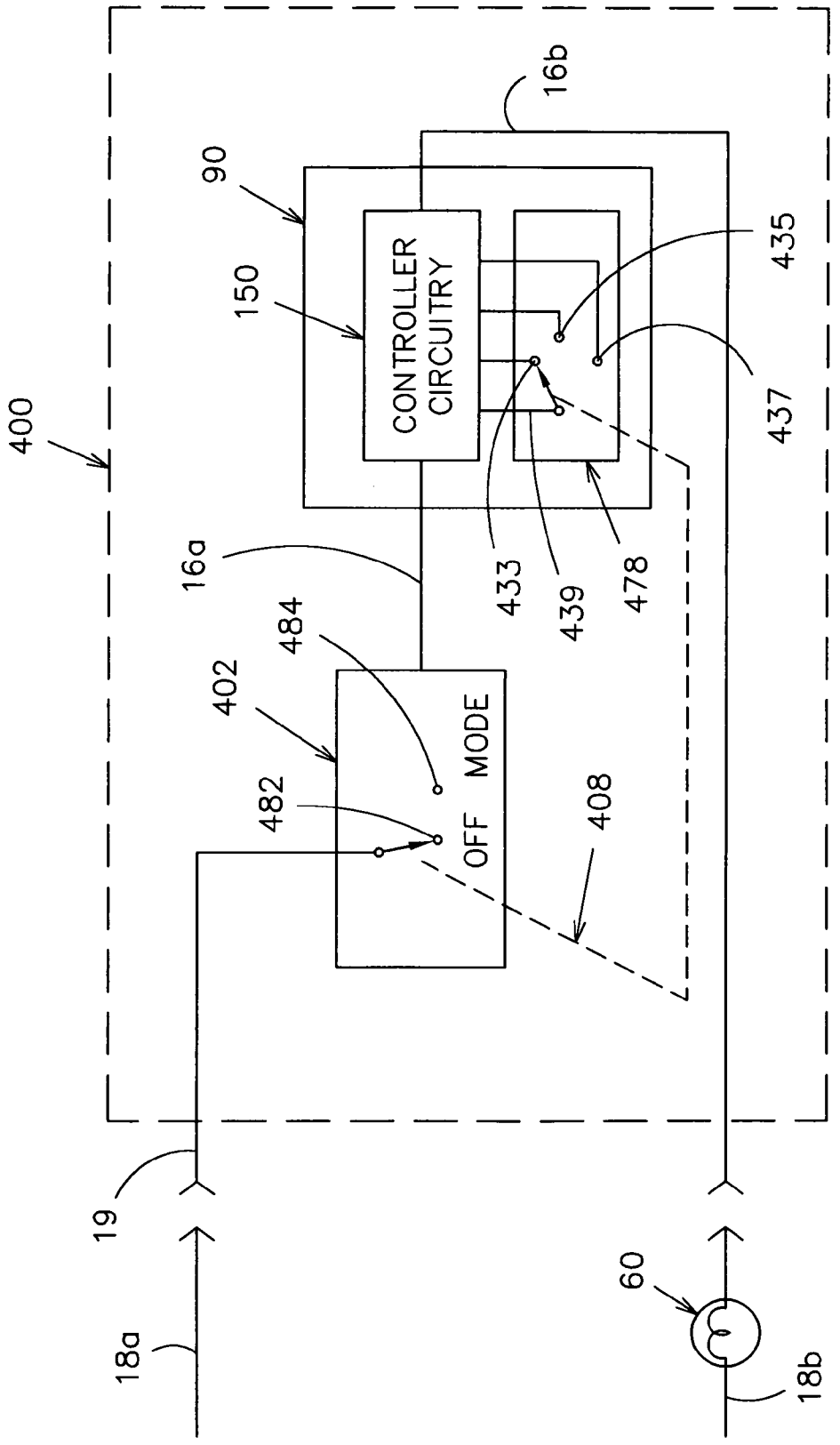

400
16b
90
150
CONTROLLER CIRCUITRY
435
437
433
439
478
16a
484
402
OFF MODE
482
408
19
18a
60
18b

FIG. 33

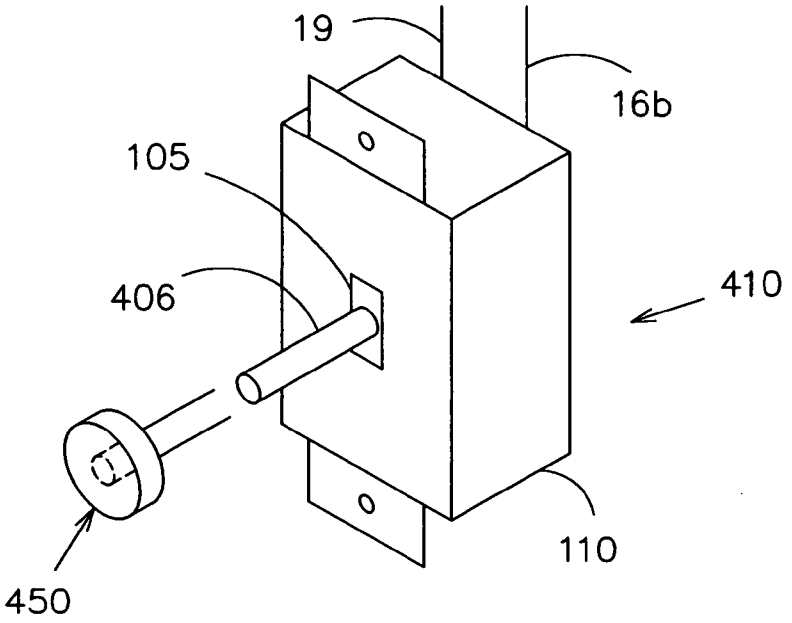

19
16b
105
406
410
110
450

FIG. 34

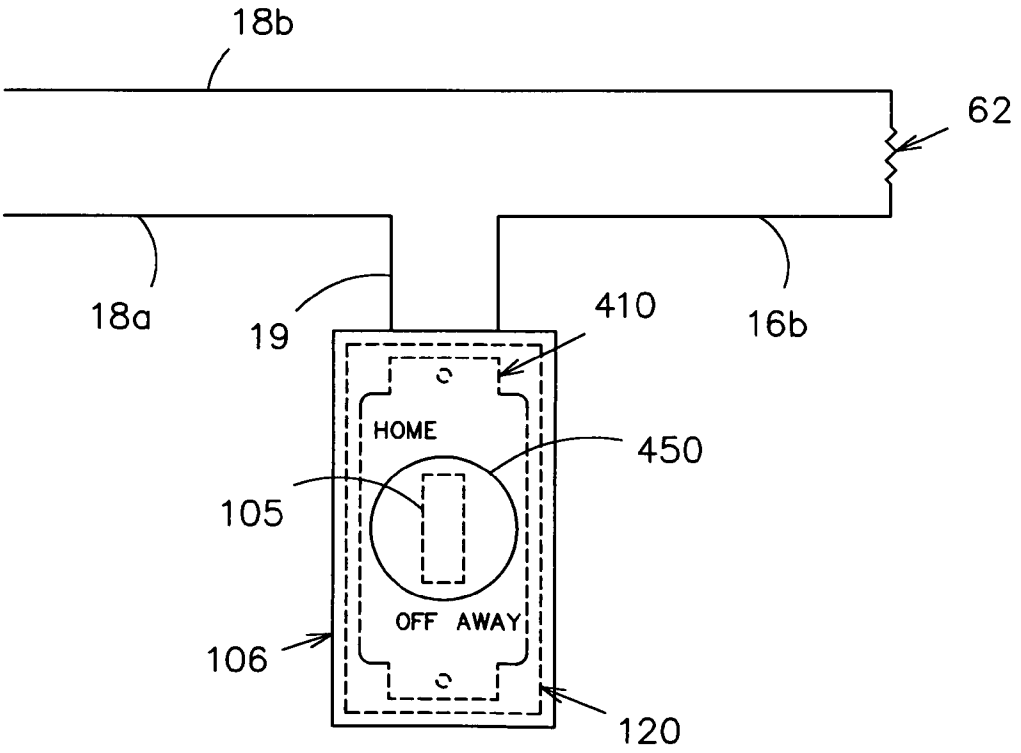

18b
62
18a
19
410
16b
HOME
450
105
OFF AWAY
106
120

FIG. 35

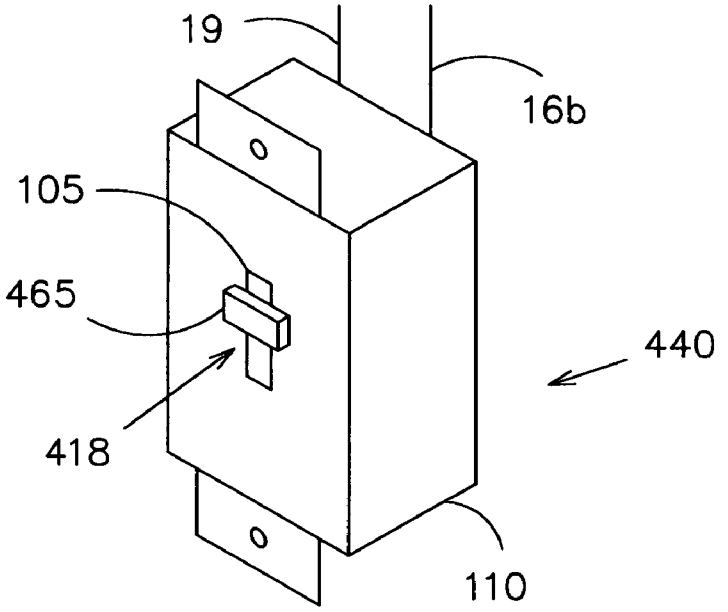


FIG. 36

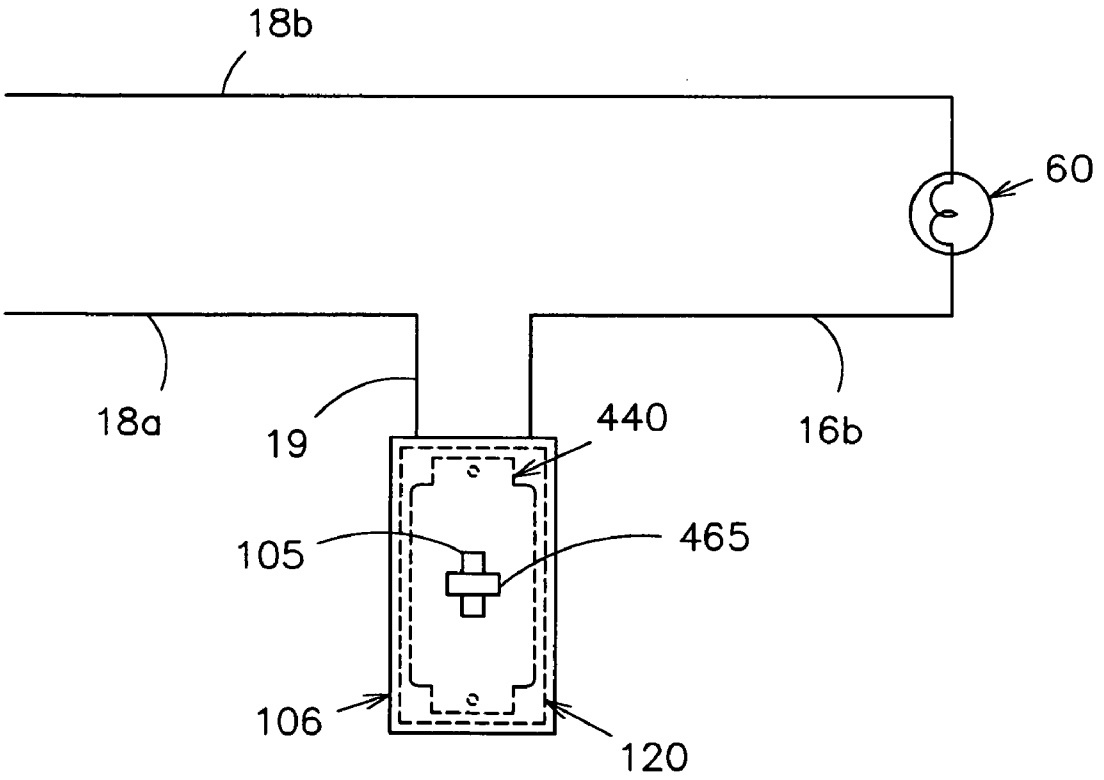


FIG. 37

PROGRAMMABLE AC POWER SWITCH

RELATED APPLICATIONS

Provisional application No. 60/439,167 filed on Jan. 9, 2003.

FIELD OF THE INVENTION

This invention relates to AC electric current control systems, such as motor controllers and illumination switches.

BACKGROUND OF THE INVENTION

Wall-mounted switches that provide capability to accomplish other functions than just on/off function are more desirable in that they provide more convenience, increase safety, and save energy. Wall-mounted switch controllers, which include dimmers, time-delay devices, variable intensity, motor controllers, and timers, are designed as dedicated devices that perform one function and usually are designed where full line power is available. If not available, then additional wiring is needed. Some of the current programmable switch controllers such as 24 hour timers required significant learning to program the features and lose their programmed functions upon loss of electrical power.

U.S. Pat. No. 4,570,216 describes a programmable switch that the user must input instructions to have the device perform its task. Usually the device is use as a timer in electrical switch box. The user interface is unique and requires extensive training to perform the task. The proposed design does not allow replacing an in-line switch since the AC power and electrical load are on the hot side and the proposed design is connected between the electrical load and ground. Current wiring practices have the wall-mounted switch wired between the hot side of AC power and the electrical load. The loss of power would require re-programming the device.

U.S. Pat. No. 5,753,983 describes a multi-function switch that fits in a standard junction box, but it has a unique user interface that requires extensive training to utilize its capabilities. The user interface relies on a conventional rocker-type actuator to input the commands to the device. The user needs to perform a sophisticated keying sequence to change the function. A user would easily be frustrated if he/she inputs an invalid sequence since the preferred embodiment of the device rejects such input. The lost of power for any length of time would require re-programming the device. This occurs anytime the light bulb is changed.

U.S. Pat. No. 5,262,678 describes a switch/dimmer assembly that provides an ON/OFF switching and a slider for controlling the amount of power to dim the light or control the motor speed. The device performs only a single function: either dimming of the light or controlling the motor speed. It has no multi-function capability or programmed intelligence. There is no DC power to control power control circuitry. It uses conventional dimming or speed controlled circuitry: a potentiometer controlling the firing angle of the triac.

U.S. Pat. No. 4,695,739 describes a multi-function lamp circuit where the device is mounted at the electrical load and a conventional single-pole, single-throw toggle switch located in the electrical wall box is used to change the function. The number of times the switch changes states determine the desired function. The user would need to learn this sequence and input the sequence every time the user wants a desired function. This not only requires extensive training, but also requires time for inputting the sequence especially if the desired function requires several state changes.

The disadvantages of the prior art are as follows:

a. Unique and extensive learning is required to re-program the functions.
b. The user interface for selecting the desired function is too complicated.
c. There is only a single function besides on/off function such as dimming or speed control.
d. The loss of power requires reprogramming.
e. There are more and higher cost components.

Accordingly, there has heretofore existed a need for an inexpensive and effective system for providing an AC power controller which provides multiple functions and does no require complicated user interface.

SUMMARY OF INVENTION

The present invention provides a highly versatile programmable multi-function switch controller. One object of the present invention is to provide multi-function switch operation capability and be installed between an AC electrical load such as a light and the source of AC power.

Another object of the present invention is that it can be easily installed in a standard electrical wall box and covered by standard wall plates. There is no need for specialized wall boxes or wall plates, but they can be used with present invention.

Another object of the present invention is to provide simple user control/s that is easy to access in order to select the desired function. One embodiment utilizes a single multi-position electrical switch which is easy to access and easy to select the desired function. Unlike prior art which requires programming and re-programming, the user can easily see which function is selected by the position of the switch.

Another object of the present invention is provide the capability to program other functions for a more sophisticated user and loss of AC power does not lose the functionality unlike prior art.

Another object of the invention is to use a rotary switch for selecting the desired function including the OFF position. There would be many pre-programmed functions into the device such as random ON and OFF function, continuous dimming function, energy saver function, flashing function, and time delay OFF function to name a few. The rotary switch is similar to dimmer controls and would fit in a standard electrical wall box and covered with standard wall plate. The position of the rotary switch would indicate which function the device would perform.

Another object of the invention is to use a slider switch for selecting the desired function including the OFF position.

Another object of the invention is to use any type of multiple-position switch for selecting the desired function.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram showing the AC power control circuit for use in the switch of the present invention;

FIG. **2** is an schematic diagram showing the AC power control circuit of FIG. **1**;

FIG. **3**A is a graphical plot of an AC waveform across the AC power control circuit of FIGS. **1–2**, when the unit is in an OFF state;

FIG. **3**B is a graphical plot of an AC waveform across the AC power control circuit of FIGS. **1**–**2**, when the unit is in an ON state;

FIG. **4** is a schematic diagram showing an AC power control circuit in accordance with an embodiment of the present invention that derives DC power using half-wave rectification and a resistor;

FIG. **5** is a schematic diagram showing an AC power control circuit in accordance with an embodiment of the present invention that derives DC power using half-wave rectification and a capacitor;

FIG. **6** is a schematic diagram showing an AC power control circuit in accordance with an embodiment of the present invention that using a relay for the thyristor driver;

FIG. **7** is a schematic diagram showing an AC power control circuit in accordance with an embodiment of the present invention that using an optoisolator for the thyristor driver and larger value for resistor R**2**;

FIG. **8** is a schematic diagram showing an AC power control circuit in accordance with an embodiment of the present invention that using a zero crossing detector to determine when to when to trigger the thyristor driver, and programmable non-volatile memory;

FIG. **9** is a block diagram showing an AC power control circuit in accordance with an embodiment of the present invention which incorporates a microcontroller having the capability of receiving different sensors and driving different AC loads;

FIG. **10** is a schematic diagramming the AC power control circuit of FIG. **9** with zero-crossing detector and mode selection functions;

FIG. **11**A is a graphical plot of an AC voltage waveform across the AC power control circuit of FIG. **10** when the device is OFF state;

FIG. **11**B is a graphical plot of an AC voltage waveform across the AC power control circuit of FIG. **10** when the device is ON state;

FIG. **11**C is a graphical plot of an AC voltage waveform across the AC power control circuit of FIG. **10** when the device is ON state for only half of the AC cycle;

FIG. **11**D is a graphical plot of an AC voltage waveform across the AC power control circuit of FIG. **10** when the device is ON state for only a quarter of the AC cycle;

FIG. **12** is a graphical flowchart of the program of the device in FIG. **10** for continuous dimming an AC lights from ON to OFF over a period of time;

FIG. **13** is a graphical flowchart of the program of the device in FIG. **10** for randomly turning an AC load ON and OFF over a period of minutes and hours;

FIG. **14** is a graphical flowchart of the program of the device in FIG. **10** for flashing a light between ON and DIM;

FIG. **15** is a graphical flowchart of the program of the device in FIG. **10** for dimming the lights for period of time and then turning the lights to an OFF state;

FIG. **16** is a graphical flowchart of the program of the device in FIG. **10** for randomly turning the light to an ON state, an OFF state, and a DIM state at a high flash rate;

FIG. **17** is a graphical flowchart of the program of the device in FIG. **10** for turning the lights to an OFF state after a period of time;

FIG. **18** is a graphical flowchart of the program of the device in FIG. **10** for flashing the light to an ON and OFF states, and sounding a beeper;

FIG. **19** is a graphical flowchart of the program of the device in FIG. **10** for turning the light to an ON state for period of time and then to a DIM state thereafter;

FIG. **20** is a graphical flowchart of the program of the device in FIG. **10** for dimming the light;

FIG. **21** is a graphical flowchart of the program of the device in FIG. **10** for re-programming the function;

FIG. **22**A is a graphical plot of time when the user can enter the program mode;

FIG. **22**B is a graphical plot of time when the user switches the power to enter the program mode;

FIG. **23** is a block diagram showing a three-position switch combined with the AC power control circuit of FIG. **10**;

FIG. **24** is a perspective view showing an electrical switch box with the three-position switch and AC power control circuit of FIG. **23** house therein;

FIG. **25** is a perspective view showing an AC electrical system with the AC power control switch of FIG. **24** in series with the light, and the electrical wall box covered with a standard conventional wall plate;

FIG. **26** is a block diagram showing a two-position switch, multi-position selection switch, and the AC power control circuit of FIG. **10**;

FIG. **27** is a perspective view showing an electrical switch box with the two-position switch and a multi-position selection switch in centered opening, and AC power control circuit of FIG. **26** house therein;

FIG. **28** is a perspective view showing an AC electrical system with the AC power control switch of FIG. **27** in series with the light, and the electrical wall box covered with a standard conventional wall plate;

FIG. **29** is a perspective view showing an electrical switch box with the two-position rocker switch and a multi-position selection switch in centered opening, and AC power control circuit of FIG. **26** house therein;

FIG. **30** is a perspective view showing an AC electrical system with the AC power control switch of FIG. **29** in series with the light, and the electrical wall box covered with a standard deluxe wall plate;

FIG. **31** is a perspective view showing an electrical switch box with the two-position toggle switch and a multi-position selection switch in centered opening with the toggle switch below the multi-position selection switch, and AC power control circuit of FIG. **26** house therein;

FIG. **32** is a perspective view showing an AC electrical system with the AC power control switch of FIG. **31** in series with the light, and the electrical wall box covered with a standard deluxe wall plate;

FIG. **33** is a block diagram showing a two-position switch and a multi-position selection switch aligned together, and the AC power control circuit of FIG. **10**;

FIG. **34** is a perspective view showing an electrical switch box with a rotary switch in the centered opening, and AC power circuit of FIG. **33** house therein;

FIG. **35** is a perspective view showing an electrical system with AC power circuit of FIG. **34** in series with the heater, and the electrical wall box covered with a standard conventional wall plate;

FIG. **36** is a perspective view showing an electrical switch box with a slider switch in the centered opening, and AC power circuit of FIG. **33** house therein; and

FIG. **37** is a perspective view showing an electrical system with AC power circuit of FIG. **36** in series with the light, and the electrical wall box covered with a standard conventional wall plate;

DESCRIPTION OF INVENTION

a. AC Power Control Circuit

FIG. **1** shows a block diagram schematic of the AC power control circuit **38** in which AC power from AC source **18***a* and **18***b* is applied to load **14** under control of series power control circuit **38**. The AC power control circuit **38** includes a thyristor **36**, the power network **20**, a thyristor driver **34**, and the control circuit **30**. The power network **20** provides low voltage through lines **24** and **26** continuously to operate the control circuit **30** and the necessary drive current pulse when needed by the thyristor driver **34** via lines **22** and **25**. The thyristor driver **34** provides the necessary gate current pulse to turn the thyristor **360**N.

A thyristor **36** is a semiconductor power switch that allows high current AC or DC to flow when trigger by a gate current pulse. Two types of thyristors are SCRs (Silicon-Controlled Rectifiers), and TRIACs (TRIode AC switches).

FIG. **2** shows an electrical schematic of one version of the AC power control circuit **38** illustrated in FIG. **1**. Here, the control circuit uses a microcontroller **31**. Programmable Logic Devices (PLDs) such as Programmable Array Logic circuits (PALs) and Application-Specific Integrated Circuits (ASICs) can also be used for the control circuit. Each block of FIG. **1** is represented by electronic components. In this circuitry, the power network **20** provides the continuous power to the microcontroller **31** shown as a Microchip PIC 12CE518A which contains the user programmable memory (EEPROM). The circuit includes R**1** and C**1**, which minimizes the current and voltage to acceptable level. Diodes D**1**, D**2**, D**3**, and D**4** convert AC power to DC power. Diode D**6** is a zener diode, which keeps the voltage level on lines **24** and **26** to an acceptable level for the microcontroller **31**. Capacitor C**2** maintains the current to the microcontroller **31** during the times when the AC power is not provided. The thyristor driver circuitry includes resistor R**2**, diode D**5**, an optoisolator triac driver **40** shown as a Motorola MC3011, and resistor R**3**. To enable the triac driver, the microcontroller **31** allows a minimum current pulse to flow through line **25**. The output lines **27** and **28** of the triac driver **40** close the path from resistor R**3** to the gate of the thyristor **36**. This provides a gate current pulse to the thyristor **36**, which causes the thyristor to conduct and be in an ON state. Once the thyristor **36** is ON, there will be no more current flowing to the control circuitry via lines **16***a*, R**1**, and C**1**. The thyristor **36** stays ON until the AC voltage across terminals **16***a* and **16***b* goes to zero, which happens every half cycle.

The minimum current pulse to trigger the thyristor driver which triggers the thyristor is provided by the power network circuitry via R**1**, C**1**, the diodes D**1**–D**4**, resistor R**2**, and diode D**5** through the output line **25** of the microcontroller **31**. Resistor R**1**, capacitor C**1** and resistor R**2** limit the current to the thyristor driver **40**. D**5** provides a minimum level of voltage to line **24** so that the microcontroller **31** has sufficient DC power during the time when it output drives the thyristor driver **40** continuously ON. Diode D**5** can be eliminated in configurations where the microcontroller monitors the zero crossings and provides the necessary gate current pulse for the minimum duration needed to trigger the thyristor or when R**2** is high enough value that the current draw from C**2** is minimal.

b. Cycle-Stealing

FIGS. **3**A and **3**B illustrate the AC waveforms appearing across lines **16***a* and **16***b* of FIG. **2** during an ON and OFF actuation. In the OFF situation, the thyristor is not provided any gate current pulses and the voltage across lines **16***a* and **16***b* is the same as the applied waveform. During this time, there is sufficient current supply whenever the voltage is above 294 for the internal circuitry. The internal voltage on lines **24** and **26** is clamped by diode D**6** in FIG. **2** to provide an acceptable source of DC power for control circuitry **30**.

In a fully ON situation, the thyristor is enabled when the instantaneous voltage **300** across the thyristor **36** provides enough power **304** to the internal circuitry both for the microcontroller and for enabling the driver **40** to provide the gate current pulse. FIG. **3**B shows the voltage across lines **16***a* and **16***b* when the thyristor is in an ON state. At the beginning of each AC half cycle, a small portion of the AC power is stolen and used by the internal circuitry. When the voltage reaches a level to supply the necessary current to trigger the thyristor driver and therefore the thyristor, the thyristor is turned ON providing a low impedance path for the AC current. The low impedance path provides power to the AC load **14** through the thyristor **36**.

From FIG. **1**, the invention utilizes the AC power source from a wire lead **18***a* to control the AC load **14**. The invention is connected in series with the AC power source **18***a* and the load **14** via first and second leads, **16***a* and **16***b*. The thyristor **36** is in series with the leads, **16***a* and **16***b*, and controls the flow of AC current to the load **14** in response to activation of the thyristor **36** by a gate current pulse. The gate current pulse is produced by the driver **34**. The driver **34** is selectively controlled by the control circuitry **30**. The control circuitry **30** obtains its DC power from the power converter network **20**. The power converter network **20** is coupled between first and second leads, **16***a* and **16***b*. The power converter network **20** adapts or steals a portion of the AC current at the beginning of each half cycle of the AC current and converts the AC current into a source of DC current for the control circuitry **30**.

c. Power Network

Some examples of different power networks that will supply DC power to the cycle-stealing device.

FIG. **4** shows a second embodiment, where the power conversion network includes resistor R**1** and diode D**1** instead of R**1**, C**1**, and diodes D**1**–D**4**. Here, the resistor R**1** has a larger power rating to handle the current flow needed for the microcontroller **31** and thyristor driver **40**. In order to minimize the current, this circuit uses a thyristor driver **40** with a more sensitive internal LED such as the Motorola MC3012. Diode D**1** only provides power on every positive-going AC cycle.

FIG. **5** shows third embodiment where the electrical circuit uses a capacitor C**1** and a smaller value for R**1** to provide the needed power. Diode D**2** is needed for allowing the AC voltage to charge and discharge capacitor C**1**. The DC power is derived from the AC power only on positive going AC cycles.

d. Thyristor Driver

FIG. **6** illustrates another embodiment of the device using a relay **41** such as 12 VDC reed relay, Radio-Shack No. 275-233, instead of an optoisolator driver **40** in the circuitry. D**5** is not needed because R**2** and the resistance of the relay coil are large enough to minimize loading of the power network.

FIG. **7** illustrates another embodiment of the device using an optoisolator driver **40** with only a higher value resistor R**2**. With this circuitry, the AC voltage across leads **16***a* and **16***b* will be much higher to produce the necessary drive current for the optoisolator driver **40**. To minimize the drive current, a more sensitive optoisolator driver such as Motorola MC3012 would be used.

FIG. **8** illustrates another embodiment of the device using the smaller value resistor R2 but includes another resistor R4 to detect the zero crossing of the AC voltage. The microcontroller **31** is programmed to pulse line **25** long enough to provide sufficient gate current pulse to trigger the triac T1. With this circuitry, the AC voltage across leads **16***a* and **16***b* will be significant smaller than in circuit of FIG. **8**. With smaller AC voltage waveform, a lower EMI (ElectroMagnetic Interference) can be achieved. Also, Resistors R5, R6, R7, and transistor Q1 provide a reset pulse when the voltage drops below a certain level which occurs when the power is turned OFF. This combination allows for a longer period for the microcontroller **31** to be in reset condition before the microcontroller's RAM memory is no longer valid.

e. Control Circuitry

FIG. **9** shows different embodiments of the control circuitry **30** of FIG. **1**. FIG. **9** shows the microcontroller **31** with various inputs from different sensors such as a motion sensor **70**, temperature sensor **76**, smoke detector sensor **72**, burglar switch **74**, mode selection switches **78**, and a zero crossing detector **50**. Also, FIG. **9** shows the microcontroller **31** driving a speaker **80** or LED **82** from its outputs in addition to driving the thyristor driver **34**. The AC power controller **90** can drive lights **60**, resistive loads **62**, and motors **64**. The microcontroller can be programmed to turn on the light when it detects motion in the room or turn on the heater motor when the temperature is low. The AC power controller **90** contains the control logic circuitry **150** with sensor inputs, line **71**, and device outputs, line **84**.

FIG. **10** shows an electrical circuit similar to FIG. **9** but with only the zero-crossing detector circuitry **50**, mode selection switch **78**, and a speaker B1. The zero-crossing detector circuitry uses resistor R4 to limit the current into the microcontroller **31**. The microcontroller **31** contains internal diodes, which limits the AC voltage to microcontroller supply voltage line **24** and supply return, line **26**. Since the zero crossings are detected, the microcontroller only needs to turn on the driver for a short time to enable the gate current pulse. FIG. **10** also shows the mode selection switch **78** which is shown as a multi-position switch. The mode selection switch **78** would connect the supply return line **26** via line **39** to one of the inputs, via lines **33**, **35**, and **37**, of the microcontroller **31**. Each position of the mode selection switch **78** would indicate to the microcontroller **31** to operate a different program. With a different program, the AC power controller **90** would perform a different operational function on the attached electrical load. Line **39** could also be connected to supply voltage line **24** instead of line **26**. The microcontroller **31** would be programmed to accept the inverse logic via the mode selection switch **78** for selecting the mode. Also, line **39** could be attached to line **16***a* via a resistor instead of line **26**. In this configuration, the microcontroller **31** would detect the AC voltage on the input lines **33**, **35**, and **37** to determine the mode selection switch **78** position.

FIGS. **11**A, **11**B, **11**C, and **11**D are a graphical plot of variable AC voltage triggered at different points on the AC cycle. The device is triggered by providing the gate current pulse after detecting the zero crossing. FIG. **11**A shows when the zero crossing detected at time T0. FIG. **11**B illustrates the voltage across the thyristor when the AC load is powered at time T1 and T2 after stealing a portion to power the microcontroller **31** and providing the gate current pulse. In FIG. **11**B, the AC load such as a light **60** would be ON state. FIG. **11**C illustrates that the load is not powered until time T2 and only a half cycle of power is applied to the load. If the AC load were a light, the light would dim to about half brightness. FIG. **11**D shows that the load is not powered until time T3 and only a portion of the half cycle is applied to the load. In FIG. **11**D, the AC load would only receive portion of the AC power. The microcontroller **31** can be programmed to provide power to the load at any time for any duration.

f. Controller's Program

FIG. **12** shows the flowchart for one function implemented in the microcontroller **31** or a Programmable Logic Device. FIG. **10** is the electrical circuitry and FIG. **11** illustrates the waveform of the operation. With the program illustrated in FIG. **12**, a continuous dimming function from 100% to OFF condition over any time period is achieved. The flowchart in FIG. **12** shows three timers. The first timer sets the time period when the light is fully ON to when the light is fully OFF such as thirty minutes. The second timer sets the time period for how long the light will be in each dimming position such as eight seconds. The third timer sets the time period from the zero crossing until the light is turned ON such as two milliseconds for one dimming setting. This example of two milliseconds can be represented of the third timer at time T1 of the cycle. When the third timer is a T3 of the cycle, the AC load would only be ON for about 25% of the time. This third timer is varied over the first timer's period from turning the light ON to full brightness to turning the light ON at the end of the full cycle is completed which is 1/60 second for a 60 Hz AC power source. Each dimming setting will be ON for the duration of second timer. Also, the microcontroller **31** is programmable for several other functions. FIG. **13** shows the flowchart of another function implemented in the microcontroller which turns the light **600**N and OFF randomly between time periods in minutes or hours. This simulates that the house is occupied and deters burglars from breaking into the home. FIG. **14** illustrates the function for flashing the light **60** between ON at full brightness and dim at a visually discernable rate, such as four seconds. If installed in the circuit for the porch light, this would bring attention to the house so that the pizza or other delivery services could easily locate the house. FIG. **15** illustrates the function for turning the lights to dim for a period of time such as twenty minutes and then OFF. This feature would allow parents to keep the light ON low for their children until they fell asleep and then automatically turn OFF to save energy. FIG. **16** illustrates a function for randomly turn the light **600**N, OFF, and DIM at a high rate in seconds. This flickering effect would provide a party-type atmosphere. FIG. **17** illustrates a function to turn the lights OFF after a pre-set period of time such as ten minutes. FIG. **18** illustrates a function to turn the lights ON and OFF at a relatively high rate, such as a second, and sounds a beeper B1 while it is in an OFF cycle. If used on the front porch light would allow emergency personnel to locate the home more quickly and alert the occupants that the device is functioning by the sound. FIG. **19** illustrates a function for turning the light **60** on for a period of time such as twenty minutes and than dim thereafter. This would be used on lights to save energy, but not eliminate the lighting. FIG. **20** illustrates the program where light **60** is turned ON every half cycle providing a dimming function. All these functions are pre-programmed into the microcontroller's memory or into a Programmable Logic Device, and can be selected via the multi-position selection switch or via the program mode.

FIG. **21** shows the flowchart for entering the program mode by turning the AC power controller **900**N and OFF at

the proper times. When the unit is first turned ON, the AC power controller **90** checks the internal RAM of the microcontroller **31** to see if a flag is set. If the flag is set, the AC power controller **38** enters the programming mode where the user can select one of the above programs.

The flag is set only if a certain t(P) has elapsed. If the AC power controller **90** is briefly turned OFF and then back ON when the flag is set, then the AC power controller **90** enters the programming mode. Once in the program mode, any function can be selected for a certain switch operation.

If the time ON exceeds a certain value, t(EP), then the flag is cleared and any OFF/ON sequence of power would not cause the AC power controller **90** to enter the programming mode. Also, the flag is changed if the AC power controller **90** is turned OFF longer then a certain period of time. The flag is stored in the microcontroller's internal RAM location, and if power is turned OFF longer then a certain period of time, the RAM location loses its set pattern. FIG. **22**A shows when the flag is set during times t(P) and t(EP). If the power as shown in FIG. **22**B is turned briefly OFF and then ON, then the AC power controller **90** enters the programming mode. If time t(OFF) is too long, then the flag is changed and any future power ON sequence from the AC power controller **90** would see the flag is not set.

g. Mounting Schemes

One embodiment is to mount the AC power controller **90** with a three-position switch **102** to provide three levels of operation as shown in FIG. **23**. The three levels of operation are the ON position **80**, the OFF position **82**, and the MODE position **84**. In the MODE position **84**, the AC power controller **90** operates the light in accordance with its programmed operation selected by mode selection switch **78** which is a multi-position switch. The position of the mode selection switch **78** determines the desired function. For example, select position **33** on the mode selection switch **78** would indicate to the controller circuitry **150** to implement the delay time off function. Similarly, selecting position **35** or selection **37** on the mode selection switch would indicate to the controller circuitry **150** another function. Lines **19** and **16***b* would connect the apparatus **100** which contain a three-position switch **102** and the AC power controller **90** to an electrical load such as the light **60**. FIG. **24** shows the apparatus **100** with physical layout of the three-position switch **102**, the multiple-position switch **88**, the housing **110**, and lines **19** and **16***b*. The three-position switch **102** is located in the center opening **105** for easy installation in an electrical wall box using standard wall plates. The center opening **105** has a height dimension of about 25 mm and a width dimension of about 10 mm, which corresponds with a standard toggle-switch wall plate. The multiple-position switch **88** is the physical realization of the mode selection switch **78** of FIG. **23**. FIG. **25** shows the mounting of the apparatus **100** into an electrical wall box **120** and connected to light **60** and the AC power via lines **19** and **16***b*. The standard wall plate **106** covers the multiple-position switch **88**, however; the three-position switch **102** mounted in the centered opening **105** would fit through the standard wall plate **106** and allow the operator to control the light **60** via the switch **102**.

Another embodiment is to use the AC power controller **90** with a single position on/off switch **202** and the mode selection switch **78**. The apparatus **200** contains this combination as shown in FIG. **26**. The mode selection switch **78** determines the desired function. The single position on/off switch **202** allows for the OFF position **82** and the MODE position **84**. There are many configurations to mount the apparatus **200** into an electrical wall box and to provide the operator for easy selection of the desired functions.

One configuration is to mount the on/off switch **202** and the multiple position switch **98** into the center opening **105** of the housing **110** for easy installation in an electrical wall box using standard wall plates as in FIG. **27**. The AC power controller **90** is mounted inside the housing with lines **19** and **16***b* connecting to AC power and electrical load. The multiple-position switch **98** is the physical realization of the mode selection switch **78** in FIG. **26**. FIG. **28** show how the apparatus **200** mounts in an electrical wall box **120** with the multiple-position switch **98** adjacent to the on/off switch **202**. The on/off switch **202** and the multiple-position switch **98** fits within the center opening **105** of a standard wall plate **106** which has a height dimension of about 25 mm and a width dimension of about 10 mm. The AC power switch **200**, which is mounted in the electrical wall box, is covered with a standard switch wall plate **106**. The user would select the desired function via multiple-position switch **98** and then turn the on/off switch **202** to the MODE position to get the desired operation.

Another configuration is to mount a rocker actuated on/off switch **204** and a larger multiple position switch **278** into a larger center opening **205** in the housing **110** as shown in FIG. **29**. The AC power controller **90** is mounted inside the housing with lines **19** and **16***b* connecting to AC power and electrical load. The larger multiple position switch **278** is the physical realization of the mode selection switch **78** of FIG. **26**. The larger center opening **205** has a height dimension of about 67 mm and a width dimension of about 34 mm, which corresponds with a standard deluxe wall plate. With this arrangement, the apparatus **220** can be installed in an electrical wall box **120** and covered with a deluxe switch wall plate **116** as shown in FIG. **30**.

Another configuration is to mount a different on/off switch **206** and a wide-paddle, multiple-position switch **378** into a larger center opening **205** in the housing **110** as shown in FIG. **31**. The larger center opening **205** has a height dimension of about 67 mm and a width dimension of about 34 mm, which corresponds with a standard deluxe wall plate. The AC power controller **90** is mounted inside the housing with lines **19** and **16***b* connecting to AC power and electrical load. With this arrangement, the apparatus **240** can be installed in an electrical wall box **120** and covered with a deluxe switch wall plate **116** as shown in FIG. **32**.

In another embodiment shown in FIG. **33** is to use the controller circuit **150** with a gang multiple-position switch **408**. The gang multiple position switch **404** ties the on/off switch capability **402** with a multiple position switch **478**. In the "off" position **482**, no power flows through line **16***a*. In the "on" position **484**, the controller circuit **150** is powered and the position of the multiple-position switch **478** selects the desired function. For example, selecting position **433** would cause the controller circuit to energize the attached electrical load such as a light **60** for a period of time. Similarly, selecting positions **435** or **437** would cause the controller circuit **150** to perform other desired functions. There are several mounting configurations for this embodiment.

One embodiment is to use a rotary switch **406** for the gang multiple position **408**. The apparatus **410** contains the controller circuit **150** and a rotary multiple-position switch **406** mounted into the center opening **105** of the housing **110** for easy installation in an electrical wall box using standard wall plates as in FIG. **34**. The center opening **105** has a height dimension of about 25 mm and a width dimension of about 10 mm, which corresponds with a standard toggle-switch

wall plate. An external knob **450** attaches to the rotary switch shaft. In FIG. **35**, the apparatus **410** is installed in the electrical wall box **120** and covered with a standard switch wall plate **106**, and connected to a heater **62** and the AC power via lines **19** and **16***b*. The user would select the desired function via the knob **450** attached to the rotary switch **406**. A brief description of the function can be applied to the wall plate **106** to indicate each switch position function as illustrated in FIG. **35**.

The preferred embodiment of the present invention is to use a slider switch **418** for the gang multiple position **408**. The apparatus **440** which contains the controller circuit **150** and the slider switch **418** is mounted into the center opening **105** of the housing **110** for easy installation in an electrical wall box using standard wall plates as in FIG. **36**. The center opening **105** has a height dimension of about 25 mm and a width dimension of about 10 mm, which corresponds with a standard toggle-switch wall plate. An external knob **465** attaches to the slider switch shaft. In FIG. **37**, the apparatus **440** is installed in the electrical wall box **120** and covered with a standard switch wall plate **106**, and connected to light **60** and the AC power via lines **19** and **16***b*. The knob **465** is installed after the standard wall plate **106**. The user would select the desired function via the knob **465**.

Other embodiments could use different types of multiple-position switches such as push-button multiple-position switch, a multiple-position toggle switch, a multiple-position lever switch, or a multiple-position rocker switch.

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than the foregoing description.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. An apparatus for selectively energizing a high-voltage AC electrical load, comprising:

a) a switch housing having an opening located in correspondence with a central opening of standard wall plates; and

b) switch means extended through and movable within said opening of said switch housing and coupled to means for selecting a pre-programmed function of said apparatus for selectively energizing said load.

2. The apparatus in claim **1**, wherein said opening has a height dimension of about 25 mm and a width dimension of about 10 mm, which corresponds with a standard toggle-switch wall plate.

3. The apparatus in claim **1**, wherein said opening has a height dimension of about 67 mm and a width dimension of about 34 mm, which corresponds with a standard rocker-switch wall plate.

4. The apparatus in claim **1**, wherein said switch means is selected from a group of multi-position rotary switches, multi-position slide switches, multi-position push button switches, multi-position toggle switches, multi-position lever switches, and multi-position rocker switches.

5. The apparatus in claim **1**, wherein said pre-programmed function is to selectively energized said AC load ON and OFF at random-time intervals.

6. The apparatus in claim **1**, wherein said pre-programmed function is to selectively energize said AC load ON and to a state that is less than full ON at a periodic rate.

7. The apparatus in claim **1** wherein said pre-programmed function is to selectively energize said AC load ON for predetermined interval time and then OFF thereafter.

8. The apparatus in claim **1**, wherein said pre-programmed function is to selectively energized said AC load ON for predetermined interval time and then slowly de-energized said AC load over a predetermined of time to an OFF state.

9. The apparatus in claim **1** wherein said pre-programmed function is to selectively energize said AC load to a state that is less than full ON for predetermined interval time and then OFF thereafter.

10. The apparatus in claim **1** wherein said pre-programmed function is to selectively energize said AC load to a state that is less than full ON.

11. An apparatus for selectively energizing a high-voltage AC electrical load, comprising:

a) a housing having an opening located in correspondence with a central opening of a standard wall plate;

b) first switch means mounted to said housing in said central opening having an "off" position and an "on" position; and

c) Second switch means extended through and movable within said central opening and coupled to means for selecting a pre-programmed function of said apparatus for selectively energizing said load.

12. The apparatus in claim **11**, wherein said opening has a height dimension of about 25 mm and a width dimension of about 10 mm, which corresponds with a standard toggle-switch wall plate.

13. The apparatus in claim **11**, wherein said opening has a height dimension of about 67 mm and a width dimension of about 34 mm which corresponds with a standard rocker-switch wall plate.

14. The apparatus in claim **11**, wherein said second switch means is selected from a group of multi-position rotary switches, multi-position slide switches, multi-position push button switches, multi-position toggle switches, multi-position lever switches, and multi-position rocker switches.

15. The apparatus in claim **11**, wherein said pre-programmed function is to selectively energized said AC load ON and OFF at random-time intervals.

16. The apparatus in claim **11**, wherein said pre-programmed function is to selectively energize said AC load ON and to a state that is less than full ON at a periodic rate.

17. The apparatus in claim **11**, wherein said pre-programmed function is to selectively energize said AC load ON for predetermined interval time and then OFF thereafter.

18. The apparatus in claim **11**, wherein said pre-programmed function is to selectively energized said AC load ON for predetermined interval time and then slowly de-energized said AC load over a predetermined of time to an OFF state.

19. The apparatus in claim **11**, wherein said pre-programmed function is to selectively energize said AC load to a state that is less than full ON for predetermined interval time and then OFF thereafter.

20. The apparatus in claim **11**, wherein said pre-programmed function is to selectively energize said AC load to a state that is less than full ON.

21. An apparatus for selectively energizing a high-voltage AC electrical load, comprising:

a) a switch housing mountable within the interior of dwelling connected to the AC power supply and said AC electrical load;

b) first switch means mounted to said housing having an "off" position, and a "on" position;

c) control means mounted in said switch housing;

d) second switch means having plurality of positions mounted in the said housing for selecting different pre-programmed functions which are predefined in said control means;

e) means responsive to each position of said second switch means for completing and interrupting said circuit so as to permit flow of current through a thyristor connected in said leads so that said AC electrical load is energized and de-energized in accordance with said pre-programmed functions and when said first switch is in the "on" position; and

f) means for deriving a source of constant DC voltage power from a small portion of every half AC cycle or full AC cycle, which appears across said thyristor and for supplying said constant DC voltage power to said control means.

22. The apparatus in claim **21**, wherein said control means comprises a programmable microcontroller.

23. The apparatus in claim **22**, wherein said programmable microcontroller contains non-volatile memory for storing said pre-programmed functions.

24. The apparatus in claim **21**, wherein said functions are user programmable.

25. The apparatus in claim **21**, wherein said second switch means is selected from a group of multi-position rotary switches, a multi-position slide switches, multi-position push button switches, multi-position toggle switches, multi-position lever switches, and multi-position rocker switches.

26. An apparatus for selectively energizing a high-voltage AC electrical load, comprising:

a) a switch housing mountable within the interior of dwelling connected to the AC power supply and said AC electrical load;

b) control means mounted in said switch housing;

c) switch means mounted to said housing having an "off" position and plurality of positions which selects different pre-programmed functions which are predefined in said control means;

d) means responsive to each other position of said switch means for completing and interrupting said circuit so as to permit flow of current through a thyristor connected in said leads so that said AC electrical load is energized and de-energized in accordance with said pre-programmed functions; and

e) means for deriving a source of constant DC voltage power from a small portion of every half AC cycle or full AC cycle, which appears across said thyristor and for supplying said constant DC voltage power to said control means.

27. The apparatus in claim **26**, wherein said control means comprises a programmable microcontroller.

28. The apparatus in claim **27**, wherein said programmable microcontroller contains non-volatile memory for storing said pre-programmed functions.

29. The apparatus in claim **26**, wherein said functions are user programmable.

30. The apparatus in claim **26**, wherein said switch means is selected from a group of multi-position rotary switches, multi-position slide switches, multi-position push button switches, multi-position toggle switches, multi-position lever switches, and multi-position rocker switches.

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