# United States Patent [19]

**Konopka**

[11] **3,842,403**

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[54] **OPTICAL REMOTE CONTROL SYSTEM**


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[52] **U.S. Cl.** ..... **340/170**, 340/276, 340/258, 317/124

[51] **Int. Cl.** ..... **H04q 1/00**, G08b 13/18

[58] **Field of Search** ..... 340/310, 170, 276, 258; 250/199, 205, 210, 221, 217 R; 332/3; 330/59; 317/124



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*Attorney, Agent, or Firm*—Hofgren, Wegner, Allen, Stellman & McCord



[57] **ABSTRACT**

A control including a transmitter and a receiver for remotely operating a device wherein the receiver and transmitter are powered by alternating current power supplies having a known phase relationship. The system transmits a signal comprising a series of single polarity pulses having a known phase relationship to and derived from the output of the alternating current power supply and different receiver outputs are provided depending on the polarity of the transmitted pulses. The transmission may be by light radiation.


**8 Claims, 5 Drawing Figures**

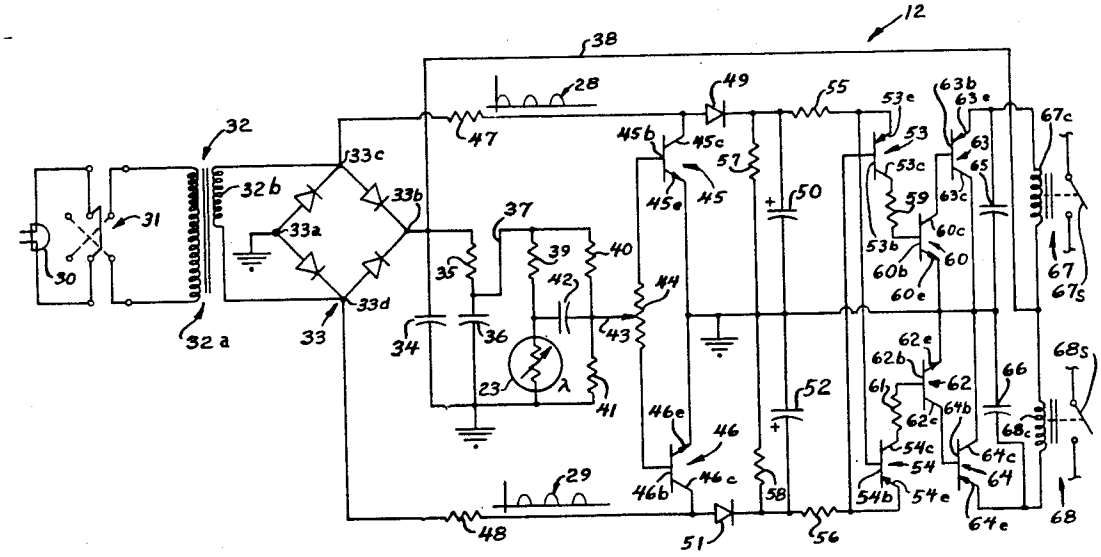
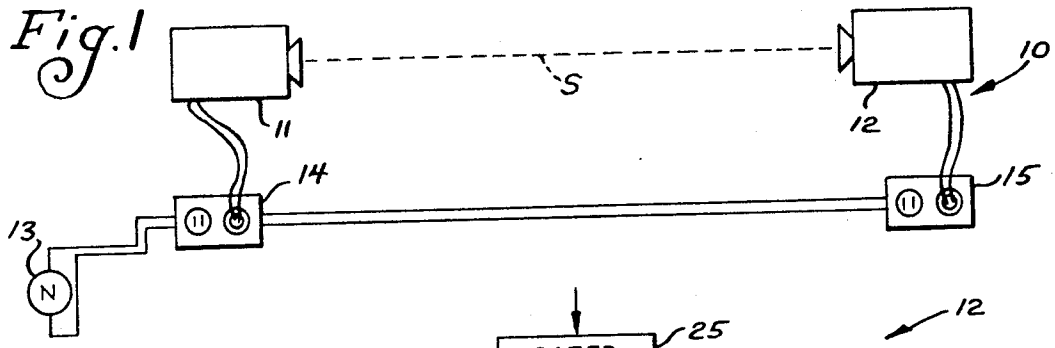


Fig. 1



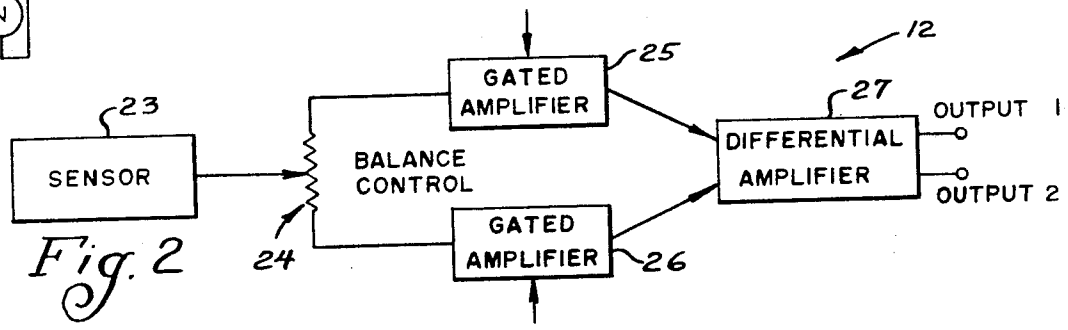




Fig. 2

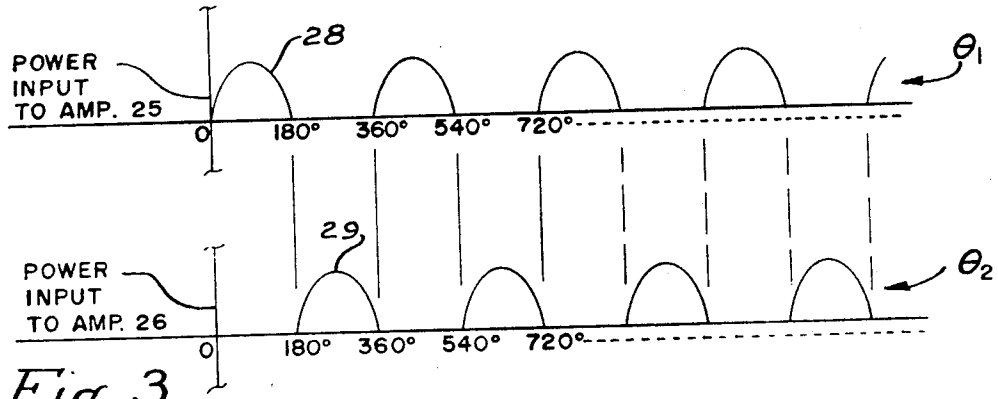



Fig. 3

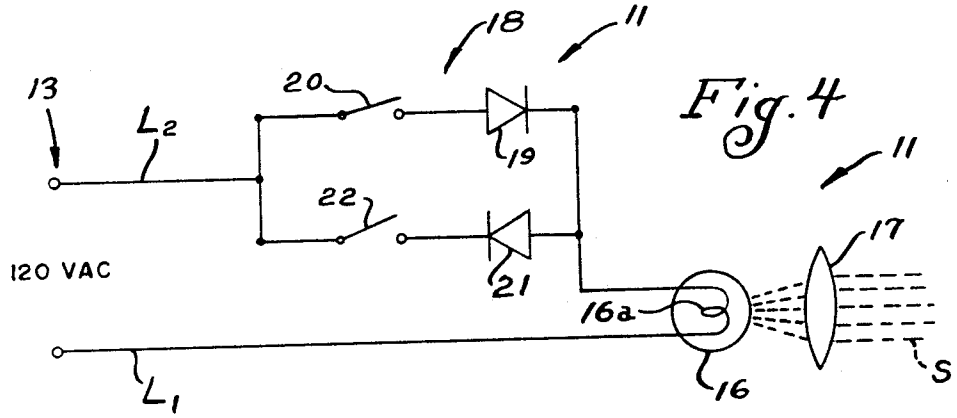
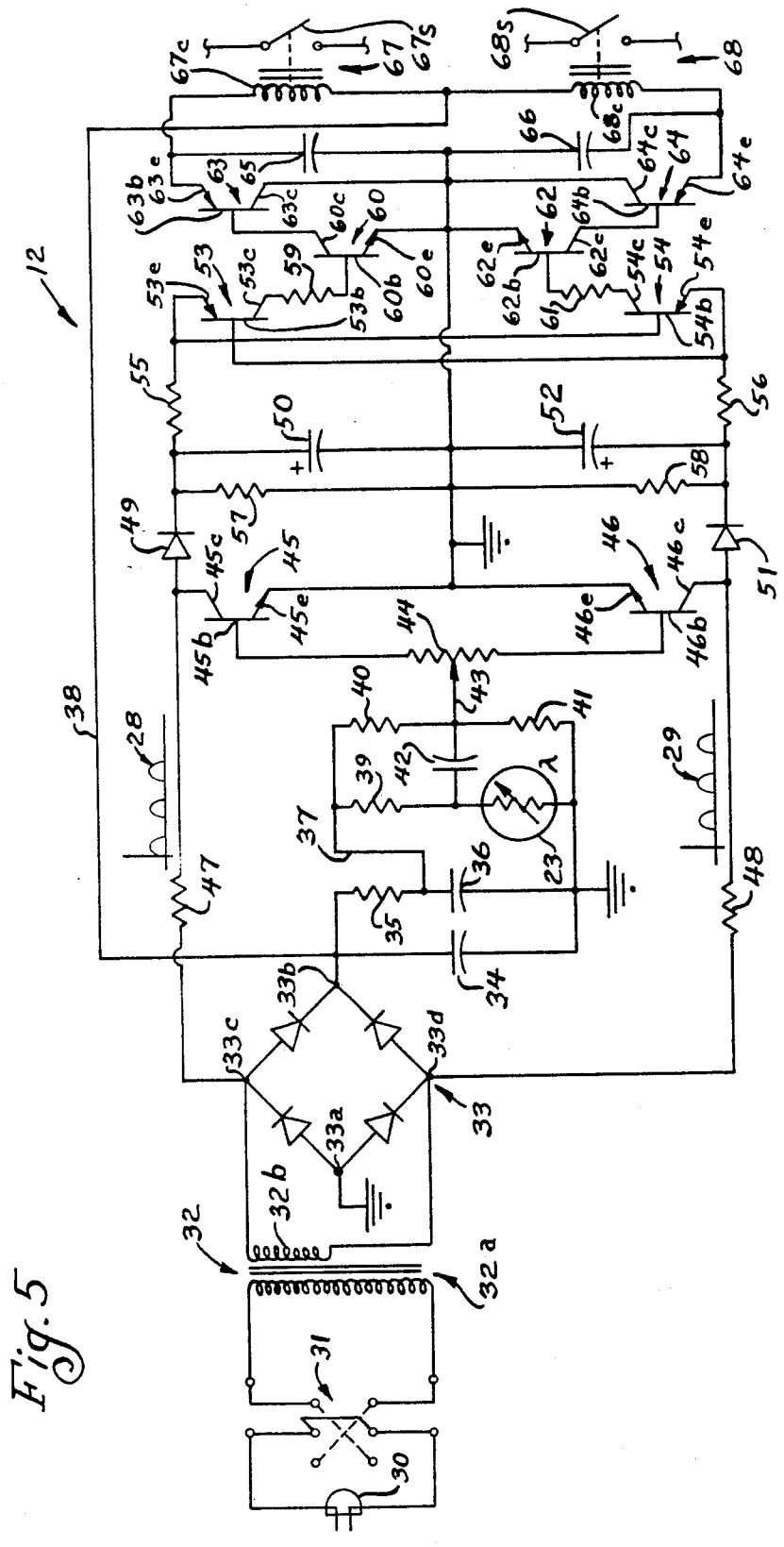



Fig. 4


12
67c
67
67s
68s
68
68c
66
64c
64
64e
63b
63e
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65
63c
60c
60
62
64b
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46e
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37
36
23
47
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48
34
33b
33c
33d
33a
33
32b
32
32a
31
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Fig. 5

# OPTICAL REMOTE CONTROL SYSTEM

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to control systems and in particular to remote control systems.

2. Description of the Prior Art

A number of different transmitter-receiver combinations have been provided in the prior art for remotely controlling the operation of an electrical device. Examples of United States Letters Patent illustrating such remote control systems are those of:

| | | |
|---|---|---|
| 2,209,883 | Gohorel | Remote Control System |
| 2,591,837 | Lee | Method and Apparatus for Signaling Employing Polarized Lights |
| 3,475,092 | Harvey | Wireless Remote Control Slide Changer |

Gohorel U.S. Pat. No. 2,209,883 shows a remote control system wherein the receiver operates selectively in accordance with the polarity of A.C. pulses received. The transmitter includes means for selectively controlling the polarity of the A.C. pulses sent to the receiver. Parallel switch controlled diodes are connected in series with an alternating current generator to provide A.C. pulses having a predetermined polarity.

Lee U.S. Pat. No. 2,591,837 shows a method and apparatus for signaling, employing oppositely polarized light signals wherein the output state of the receiver depends on the relative response of two different light sensitive devices, each of which is responsive only to polarized light signals having a predetermined axis of polarization. The output of two receiver photocells is fed into a differential amplifier which amplifies only the difference between the two outputs so that oppositely polarized light striking the two photocells having the same intensity will not operate the receiver to provide a signal.

Harvey U.S. Pat. No. 3,475,092 shows a wireless remote control slide changer which utilizes a pulse length modulated beam of actinic radiation obtained by chopping a beam of light by means of an alternately opaque and transparent moving grate.

A number of prior art systems utilize coded light as a transmitting media. One disadvantage of the known systems is the complexity and high cost such as in the need for use of a plurality of receiver photocells to provide a plurality of outputs. Further, such devices utilizing a plurality of receiving elements have high maintenance requirements because of the necessity of maintaining precise matching of the characteristics of the receiving elements in the receiver.

Another disadvantage of known prior art devices is the sensitivity thereof to ambient conditions, such as ambient light conditions, where the device utilizes a light signal. One attempted solution to this problem is to provide a high intensity signal as compared to the level of the ambient radiation and utilize an insensitive receiver. One such device is utilized in connection with conventional burglar alarm systems where a light beam is directed to a photocell receiver. Such a system may be readily "fooled" by the simple expedient of directing a flashlight or the like against the receiver photocell, thereby permitting breaking of the system beam without operation of the control. Such systems relying on a difference in the intensity of the signal beam and the ambient light are not adapted for use where the ambient lighting conditions vary widely.



## SUMMARY OF THE INVENTION

The present invention comprehends an improved remote control system eliminating the disadvantages of the prior art systems in a novel and simple manner.

More specifically, the present invention comprehends a remote control system wherein the transmitter and receiver are powered by alternating current power supplies having a known phase relationship to each other. The transmitter provides a signal in the form of a series of pulses occurring during selected phase angle intervals of the signal provided by the alternating current power supply. In the illustrated embodiment, the transmitter provides light pulses during only positive or negative polarity of the power source signals.

The power supply of the receiver may be in phase with that of the transmitter or, alternatively, may be 180° out of phase with the transmitter power supply. Means may be provided in the control for reversing the phase thereof as desired.

The control utilizes a single sensor which, in the illustrated embodiment transmitting a light signal, comprises a single photocell. The photocell operates in conjunction with a differential amplifier so that the output of the amplifier depends upon the phase relationship of the light pulses received by the photocell and the alternating current of the receiver power supply.

The remote control system of the present invention is insensitive to ambient light conditions and, thus, is adapted to work under widely varying ambient light conditions. The control is adapted to be connected to an A.C. power line connected also to the transmitter so as to provide a substantially simplified construction. The radiation may be any alternating radiation permitting selection of one or the other of the different polarities thereof. Illustratively, the control may be used as a remote control for operating a television receiver.

More specifically, the invention comprehends the provision of such a remote control for use with an A.C. power supply comprising a transmitter connected to the power supply and having means for transmitting a signal during a known phase angle interval of the signal provided by the power supply, and a receiver connected to the power supply to have phase correlation with the transmitter and having means for detecting the transmitted signal and correlating its time of arrival with the phase angle interval of the A.C. power supply signal to provide an output corresponding thereto.

Further, the transmitter may provide a signal corresponding selectively to either polarity of the A.C. signal provided by the power supply and the output means may provide selectively different outputs corresponding to the signal while yet utilizing only a single receiver sensor.

In broad aspect, the control system is defined by a transmitter means arranged to be operated from an alternating current power supply for providing a single polarity transmitted pulsed signal, and a receiver means for receiving the signal and correlating the signal with the phase angle of the power supply to provide a controlled output.

Thus, the control system of the present invention is extremely simple and economical of construction while

yet providing the highly desirable advantages discussed above.

## BRIEF DESCRIPTION OF THE DRAWING

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

FIG. 1 is a side elevation of a remote control system embodying the invention;

FIG. 2 is a block diagram of the remote control receiver;

FIG. 3 is a graph illustrating the phase relationship of the supply voltages delivered to the amplifier circuitry included within the remote control receiver;

FIG. 4 is a schematic wiring diagram illustrating the electrical circuitry of the transmitter; and

FIG. 5 is a schematic wiring diagram illustrating the electrical circuitry of the receiver.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

In the exemplary embodiment of the invention as disclosed in the drawings, a remote control system generally designated **10** is shown to comprise a transmitter **11** and a remote receiver **12.** The transmitter is connected to an A.C. power supply **13** at a first electrical outlet **14** and the receiver **12** is connected to power supply **13** at a second, remotely located electrical outlet **15.**

In the illustrated embodiment, the transmitter **11** transmits a signal S across the space between the transmitter and receiver in the form of a light beam. The invention comprehends providing the light in a unique form permitting the receiver to comprise a simple low cost unit adapted to provide multiple outputs.

More specifically, signal S comprises a series of light pulses which correspond to either the positive or negative going portion of the voltage provided by A.C. power supply **13.** Thus, as shown in FIG. **4,** the transmitter **11** includes a conventional incandescent lamp **16** radiating light through a suitable condensing lens **17** to define the signal beam S. Filament **16***a* of lamp **16** is connected across the power supply leads L1 and L2 in series with a parallel, switched inverse diode circuit generally designated **18.** More specifically, circuit **18** includes a first diode **19** in series with a first single pole, single throw switch **20** connected between power supply lead L2 and filament **16***a*. A second diode **21,** arranged reversely to diode **19,** is connected in series with second switch **22** between power supply lead L2 and filament **16***a*. The series combination of diode **21** and switch **22** is connected in parallel with the series circuit of diode **19** and switch **20.** Thus, when switch **20** is closed, diode **19** permits flow through filament **16***a* of only the positive half cycles of the alternating current provided by power supply **13.** When switch **22** is closed, diode **21** permits flow through filament **16***a* of only the negative half cycles of A.C. power. Resultingly, signal S comprises pulses of light which are synchronized with either the positive or negative half cycle portions of the alternating current provided by power supply **13.**

Referring now to FIG. **2,** receiver **12** includes a sensor portion **23** for receiving the transmitted signal S and delivering the signal to a balance control generally designated **24.** The signal is delivered from the balance control to a pair of gated amplifiers **25** and **26** and therefrom to a differential amplifier **27** which provides selectively different outputs corresponding to the selected half cycle of the alternating current passed through lamp filament **16***a*. As illustrated in FIG. **3,** positive going half cycle pulses **28** from power supply **13** are delivered to gated amplifier **25** which corresponds in phase to the positive going half cycles of the power provided to transmitter **11.** Positive going half cycles **29** of alternating current which are 180° out of phase with pulses **28** are provided to amplifier **26.** These pulses correspond in phase to the negative going half cycle pulses of power supply current delivered to transmitter **11.** As shown in FIG. **3,** power pulses **28** are identified as Phase **1** pulses and power pulses **29** are identified as Phase **2** pulses.

Ambient light received by sensor **23** affects the sensor similarly to the provision of signals of both positive and negative polarity as would be produced by transmitter **11** if both switches **20** and **22** were closed. Such bi-polarity light will cause the output from amplifiers **25** and **26** to be equal and no output will be produced by the differential amplifier **27.** However, if transmitter **11** is operated to produce light only during the positive or negative going portion of the alternating current supplied by power supply **13** as by closing either of the switches **20** or **22,** the output from the corresponding gated amplifier **25** or **26** will be greater than that from the other amplifier and the unbalanced output delivered to the differential amplifier **27** will produce an output corresponding to the polarity of the transmitter lamp current. Illustratively herein, the circuit is arranged so that when switch **20** is closed to pass current through the lamp filament **16***a* only during positive going portions of the alternating current power supply, the output from amplifier **25** will exceed that from amplifier **26** so as to cause the differential amplifier **27** to produce an output **1.** Conversely, if switch **22** is closed to transmit light flashes only during the negative going portions of alternating current power, amplifier **26** will produce an output greater than that produced by amplifier **25** so as to cause an output to be provided as output **2.** Thus, control system **10** provides selectively two different outputs corresponding to a selected one of two different inputs in conformity with the phase angle of the A.C. voltage supplied to the amplifiers **25** and **26** at the instant the signal light pulses are received by sensor **23.**

The operation of receiver **12** is illustrated in detail in the control circuit diagram of FIG. **5.** The receiver is connected to electrical outlet **15** by means of a conventional plug **30.** Where the plug comprises a simple symmetrical two-prong plug, it is desirable to provide a single pole, double throw reversing switch **31** to permit selective reversing of the connection to the primary winding **32***a* of an input transformer **32.** The secondary winding **32***b* of the transformer is arranged to provide a reduced A.C. control voltage, such as approximately 15 volts. The transformer secondary is connected across a conventional full wave bridge **33** having one terminal **33***a* grounded. The full wave rectified power provided at terminal **33***b* is filtered by a filter network including a capacitor **34** connected between terminal **33***b* and ground, and resistor **35** and capacitor **36** connected in series between terminal **33***b* and ground. Line **37** connected between resistor **35** and capacitor **36** resultingly carries a filtered 15 volt direct current signal. A line **38** connected to bridge terminal **33***b* carries a

voltage having a greater ripple component than the voltage on line 37 since, in effect, the voltage on line 38 is filtered only by the capacitor 34.

Sensor 23 herein comprises a light dependent resistor (LDR), having a resistance value which varies in accordance with the amount of light impinging thereon. As shown in FIG. 5, the LDR is connected in series with a resistor 39 between line 37 and ground. A series combination of two resistors 40 and 41 is connected between line 37 and ground and a capacitor 42 is connected from the junction of resistor 39 and photocell 23 to the junction of resistors 40 and 41 to provide a network for transmitting a control signal to the wiper 43 of a balance control potentiometer 44. The resistance element of potentiometer 44 has one end connected to the base 45*b* of a transistor 45 and its opposite end connected to the base 46*b* of a transistor 46.

Supply voltage to collector 45*c* of transistor 45 is provided through a resistor 47 from terminal 33*c* of the bridge 33 so that the voltage applied to collector 45*c* is a pulsating A.C. voltage corresponding to the Phase 1 power input illustrated in FIG. 3 as defined by alternating current half cycle pulses 28. Voltage for collector 46*c* of transistor 46 is provided from terminal 33*d* of bridge 33 through a resistor 48 and, thus, the collector voltage defines a reference signal comprising a pulsating voltage corresponding to the Phase 2 waveform shown in FIG. 3 as comprising pulses 29. As indicated previously, pulses 28 and 29 are 180° out of phase as a result of the taking of the voltages from the opposite ends of bridge 33. Resultingly, transistor 45 is provided with power only during positive going half cycles of A.C. power as provided by power supply 13 and transistor 46 is provided with power only during negative going half cycles thereof.

When ambient light impinges on LDR 23 and the wiper 43 of potentiometer 44 is properly adjusted, equal bias voltages will be applied to transistors 45 and 46 during both negative and positive going swings of the A.C. voltage supplied by power supply 13. Such is the case since the signal delivered to the biasing circuit for the transistors is similar during both positive and negative going half cycles of the A.C. voltage provided by supply 13. When an appreciable amount of light strikes LDR 23, transistor 45 is biased so as to provide substantially no conduction during the positive going portions of the A.C. supply voltage. Thus, voltage pulses will pass through a diode 49 to a capacitor 50 and build up a charge thereon. Likewise, voltage pulses during the negative going portions of the A.C. supply voltage are delivered through a diode 51 to a capacitor 52 to build up a charge on capacitor 52. Thus, equal charges and equal voltages will be maintained on capacitors 50 and 52 under a high ambient light condition. Under a low ambient light condition, the resistance of LDR 23 will rise. This will result in biasing both transistors 45 and 46 on during respective positive and negative going half cycles of the A.C. voltage provided by supply 13. Thus, no charge and hence no voltage will build-up on either capacitor 50 or 52 during low ambient light conditions.

Where light strikes LDR 23 only during positive or negative going half cycles of the A.C. voltage provided by supply 13, the resistance of the LDR will be less during the time when the selected half cycle appears on the A.C. line. Illustratively, if switch 20 is closed to provide light pulses only during the positive going half cycles of the A.C. voltage from the supply, the resistance of LDR 23 will be less during the time when the positive going half cycles are provided by the power supply as illustrated by pulses 28 in FIGS. 3 and 5. Resultingly, the bias provided to transistor 45 during positive swings of the A.C. supply voltage will be less than the bias provided to transistor 46 during the negative going portions of the A.C. supply voltage. Thus, more current is passed by diode 49 to capacitor 50 than is passed by diode 51 to capacitor 52. This differential in the capacitor voltage is applied to a second pair of transistors 53 and 54. As shown in FIG. 5, the base 54*b* of transistor 54 is connected through a resistor 55 to capacitor 50 and the base 53*b* of transistor 53 is connected through a resistor 56 to capacitor 52. A discharge resistor 57 is connected in parallel with capacitor 50 and a second discharge resistor 58 is connected in parallel with capacitor 52. The emitter 45*e* of transistor 45 and the emitter 46*e* of transistor 46 are both connected to ground. Emitter 53*e* of transistor 53 is connected to base 54*b* of transistor 54 and emitter 54*e* of transistor 54 is connected to base 53*b* of transistor 53. Collector 53*c* of transistor 53 is connected through a resistor 59 to the base 60*b* of a transistor 60. Collector 54*c* of transistor 54 is connected through a resistor 61 to the base 62*b* of a transistor 62. Emitter 60*e* of transistor 60 and emitter 62*e* of transistor 62 are connected to ground. Collector 60*c* of transistor 60 is connected to the base 63*b* of a transistor 63 and collector 62*c* of transistor 62 is connected to the base 64*b* of a transistor 64. Emitter 63*e* of transistor 63 is connected through a capacitor 65 to ground and emitter 64*e* is connected through a capacitor 66 to ground. Collector 63*c* of transistor 63 and collector 64*c* of transistor 64 are connected to ground. A coil 67*c* of an output relay 67 is connected between emitter 63*e* and line 38 and a coil 68*c* of a relay 68 is connected between emitter 64*e* and line 38. Relay 67 includes a single pole, single throw switch 67*s* and relay 68 includes a single pole, single throw switch 68*s* controlled by the energization of coils 67*c* and 68*c*, respectively, to provide selectively output 1 or output 2, as shown in FIG. 2.

Transistors 45 and 46, and the associated circuit, effectively define the gated amplifiers 25 and 26 and transistors 53 and 54, and the associated circuit, effectively define the differential amplifier 27. Thus, illustratively, transmission of a light signal S by closing of the switch 20 in transmitter 11 to provide a greater charge on capacitor 50 as compared to the charge on capacitor 52, as discussed above, will cause PNP transistor 54 to conduct less current during its respective half cycle of operation than PNP transistor 53. This decreases the drive through resistor 61 and tends to bias NPN transistor 62 off. Current flow out of base 64*b* of transistor 64 now decreases and transistor 64 moves toward an off condition. Since transistors 53, 54, 60, 62, 63 and 64 are connected in differential amplifier fashion, a decrease in current through transistor 64 causes an increase in current through transistor 63. Thus, current through coil 67*c* rises and switch 67*s* is closed. Reversely, the control 10 causes energization of coil 68*c* when switch 22 of transmitter 12 is closed. Capacitors 65 and 66 smooth the direct current applied to their respective coils which could otherwise cause hum and impositive closing of the switches. Thus, either switch 67*s* or switch 68*s* is closed as a result of a transmission

of light from transmitter **11** to receiver **12** under the selective control of switches **20** and **22** so that a remote control of a device (not shown) connected through switches **67***s* and **68***s* is provided.

The control requires that the phase relationship between the power supply to which transmitter **11** is connected and the power supply to which the receiver **12** is connected be known so as to identify the half cycle pulses transmitted by the lamp **16.** In the average home, the convenience outlets are conventionally in phase with each other or 180° out of phase with each other depending upon which side of the 220 volt grounded center power supply they are connected to. As discussed above, the use of the reversing switch **31** permits ready reversal of the phase relationship in the event that the plug **30** is connected to an outlet **15** such that the power supply to receiver **12** is 180° out of phase with the power supply for transmitter **11.**

In describing the invention, it has been considered that the receiver **12** be remotely located relative to the transmitter **11.** The receiver and transmitter, however, can be disposed adjacent each other as by means of a reflector for reversing the direction of the transmitted light. Similarly, the receiver **12** need not be remotely located while providing substantial advantage over prior art control systems, such as photoelectric burglar alarm systems. Thus, the present control, in being completely insensitive to normal ambient light, prevents false maintenance of the output of the control as by a burglar shining a flashlight on the photocell **23,** as the flashlight would provide mere ambient light not having any preselected phase relationship to the receiver. Further, in many applications, such as in counting, the insensitivity to ambient light permits improved functioning of the control system for such purposes.

The present control utilizes a single sensor LDR **23** in combination with the differential amplifier **27** to provide the selective outputs **1** and **2** by the selective closing of switches **67***s* and **68***s* as discussed above. This improved simplified structure is permitted by the use of the maintained phase relationship between the pulsed signal S and the alternating current powering the receiver **12.**

The foregoing disclosure of specific embodiments is illustrative of the broad inventive concepts comprehended by the invention.

I claim:

**1.** A remote control for use with a power supply providing alternating current power, comprising: a transmitter connected to said power supply having means for transmitting a signal during an interval of time corresponding selectively to either the positive going or negative going portion of said alternating current power, said transmitter including radiation means, first and second diodes, and switch means connected in circuit with said first and second diodes and said radiation means whereby either said first or said second diode may be connected in series with said radiation means; and a receiver connected to said power supply to have phase correlation with the transmitter and having means for detecting the transmitted signal and means providing selectively different outputs corresponding to the time at which said signal is transmitted, said receiver including a pair of electronic switches, one switch being responsive to a signal transmitted during an interval of time corresponding to the negative going portion of said alternating current power to provide a first output and the other switch being responsive to a signal transmitted during an interval of time corresponding to the positive going portion of said alternating current power to provide a second output, and means for causing operation of one or the other of said switches.

**2.** A remote control for use with a power supply providing alternating current power, comprising: a transmitter connected to said power supply having means for transmitting a signal during an interval of time corresponding selectively to either the positive going or negative going portion of said alternating current power; a receiver connected to said power supply to have phase correlation with the transmitter and having means for detecting the transmitted signal and means providing selectively different outputs corresponding to the time at which said signal is transmitted; and a reversing switch for reversing the polarity of the connection of the receiver to said power supply whereby the receiver may be caused to be in phase with the transmitter when the connector to said power supply causes said receiver to be 180° out of phase therewith.

**3.** A remote control for use with a power supply providing alternating current power, comprising: a transmitter connected to said power supply having means for transmitting a signal during an interval of time corresponding selectively to either the positive going or negative going portion of said alternating current power; and a receiver connected to said power supply to have phase correlation with the transmitter and having means for detecting the transmitted signal and means providing selectively different outputs corresponding to the time at which said signal is transmitted, said receiver including a balance control, a differential amplifier, parallel gated amplifiers connected between said balance control and differential amplifier, and sensing means for receiving said signal and delivering it to said balance control.

**4.** A remote control for use with a power supply providing alternating current power, comprising: a transmitter connected to said power supply having means for transmitting a signal during an interval of time corresponding selectively to either the positive going or negative going portion of said alternating current power; and a receiver connected to said power supply to have phase correlation with the transmitter and having means for detecting the transmitted signal and means providing selectively different outputs corresponding to the time at which said signal is transmitted, said receiver including a single sensing element for receiving said signal from the transmitter and said signal is transmitted with the phase of the alternating current power provided to the receiver to control the output from said differential amplifier.

**5.** A remote control transmitting information by means of a light beam generated by an alternating current power supply, comprising:

a light transmitter connected to said power supply having means for transmitting light pulses during intervals of time corresponding selectively to only one of the positive polarity or negative polarity portions of said alternating current power;

a light sensing receiver connected to said power supply and having means for detecting the transmitted single selected polarity light pulses and means providing selectively different outputs corresponding to the selected polarity of said transmitted light

pulses, whereby said receiver is insensitive to full wave light to prevent spurious operation of the output means; and

selector means for causing the polarity of said receiver to be in phase with the polarity of said transmitter.

**6.** The remote control of claim **5** wherein said light transmitter comprises lamp means, first and second reverse, paralleled diodes, and switch means connected in circuit with said first and second diodes and said lamp means whereby either said first or said second diode may be connected in series with said lamp means to provide said selected single polarity pulses.



**7.** The remote control of claim **6** wherein said receiver comprises a pair of electronic switches, one switch being responsive to a negative polarity pulse corresponding to the negative polarity portion of said alternating current power to provide a first output and the other switch being responsive to a positive polarity pulse corresponding to the positive polarity portion of said alternating current power to provide a second output.

**8.** The remote control of claim **5** wherein said receiver comprises a single sensing element.

* * * * *