

[54] **CAPACITANCE-RESPONSIVE
CONTROL SYSTEM**

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1969, abandoned.

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[58] Field of Search.....307/252 C, 252 B, 308;
340/258 C

[56]

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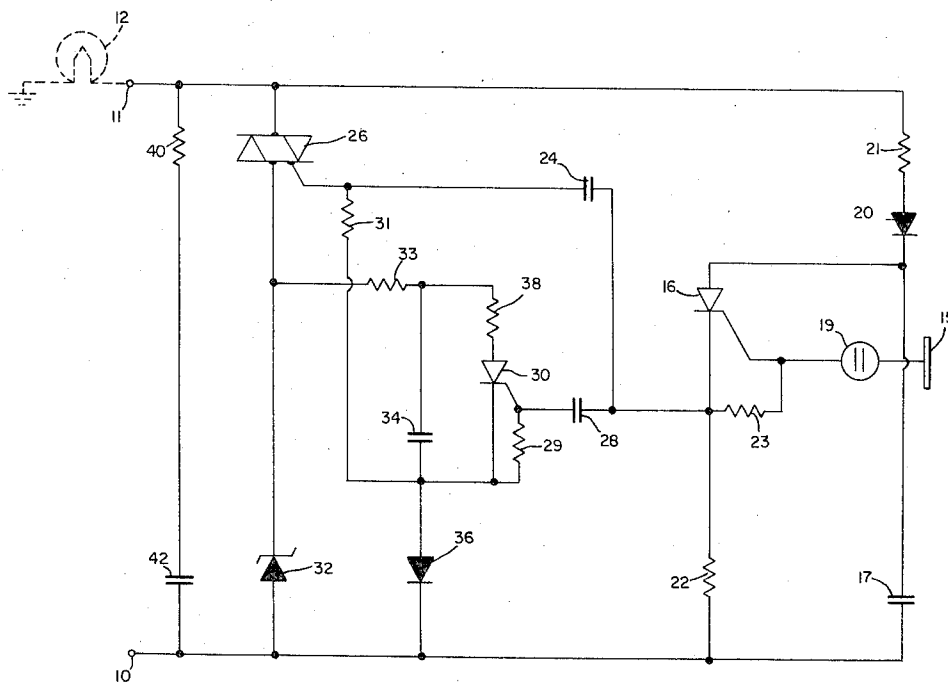
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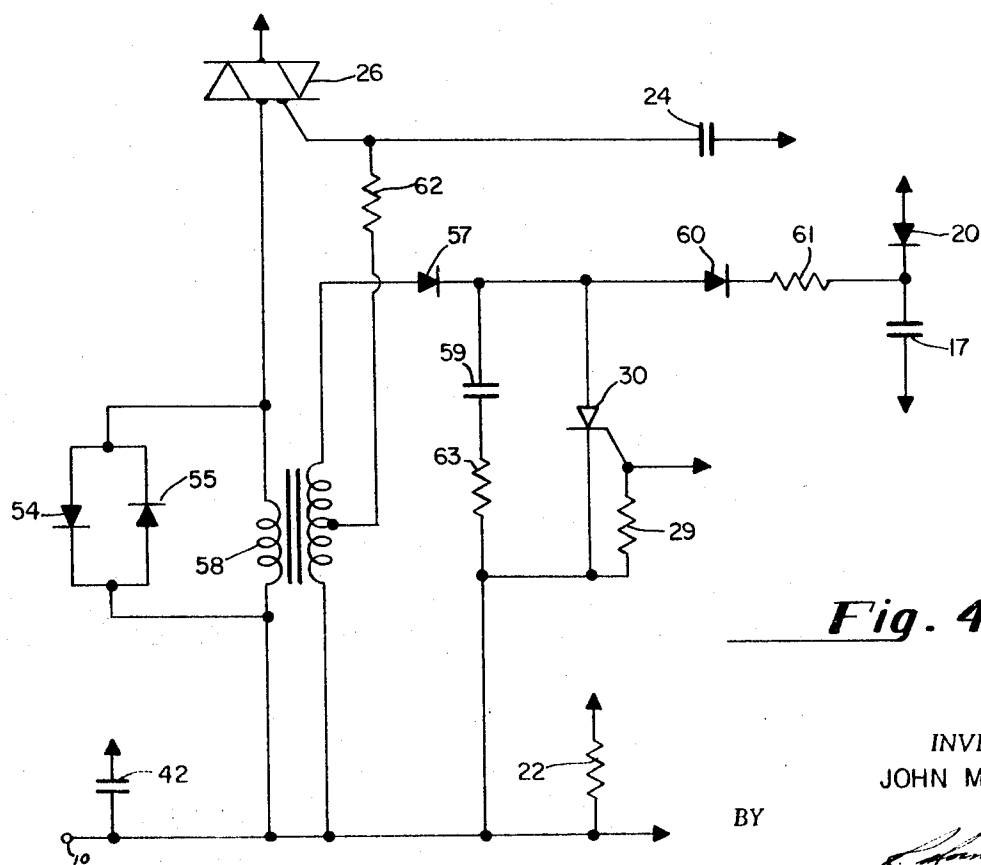
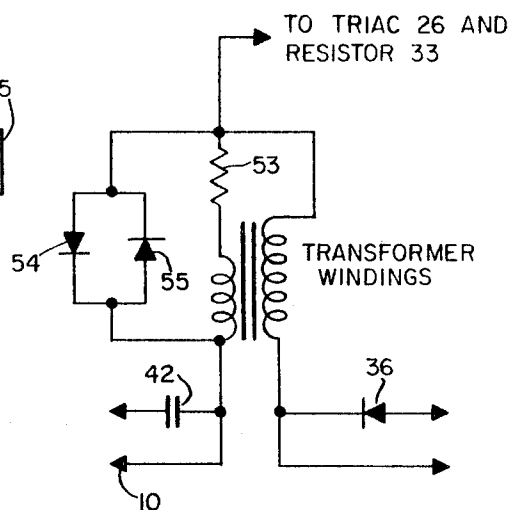
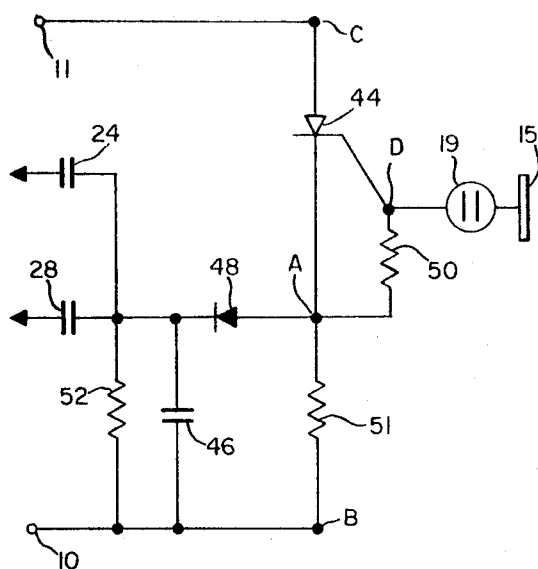
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ABSTRACT

A capacitance-responsive control system embodying a pulse generator, an electronic switch, an electronic latching circuit and a shorting circuit is disclosed.

11 Claims, 6 Drawing Figures





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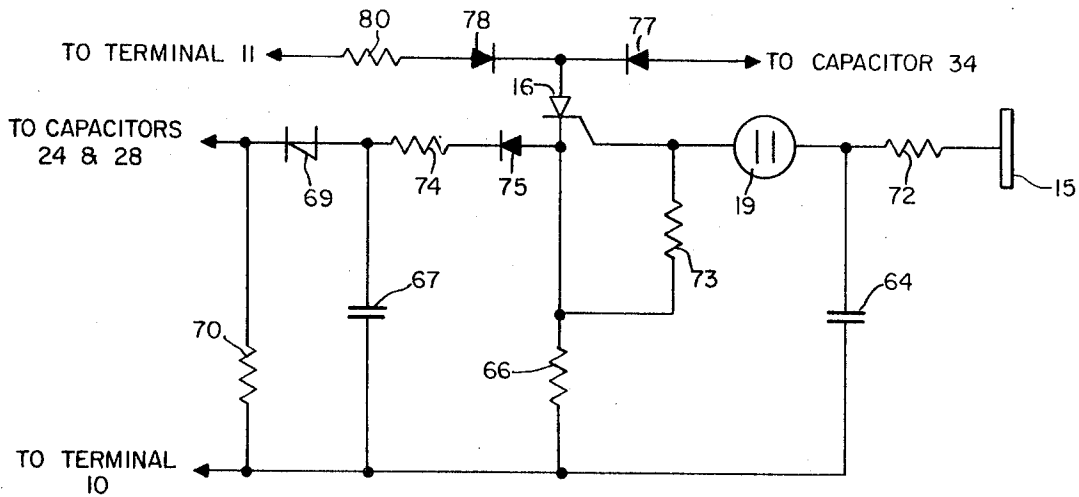


Fig. 5

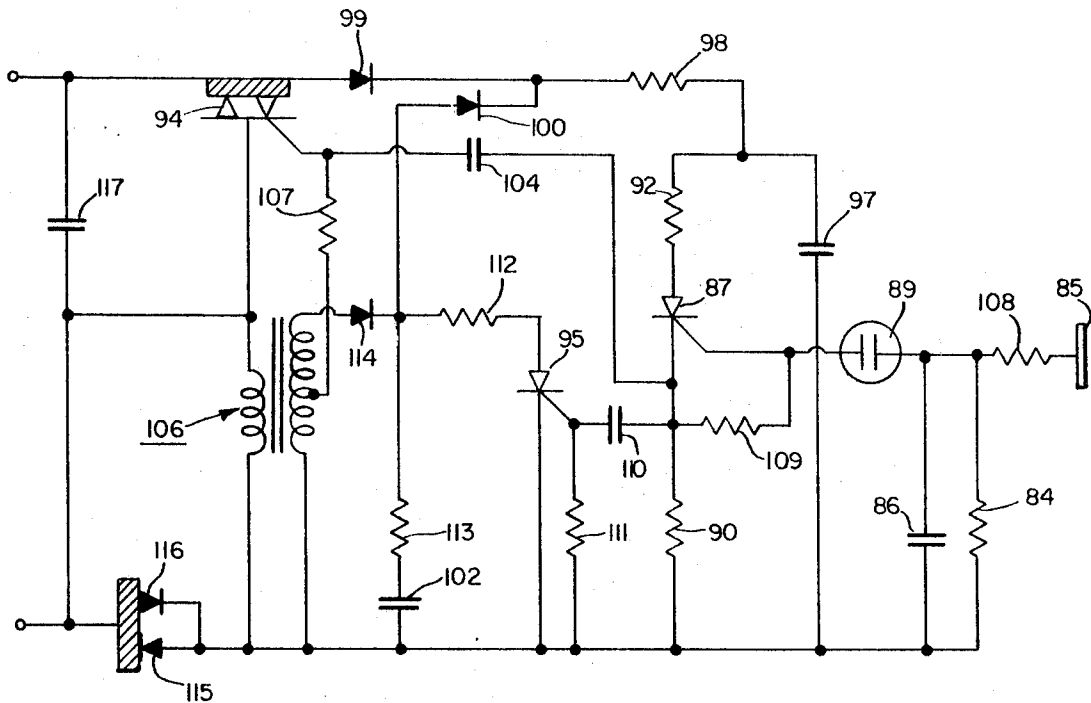


Fig. 6

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CAPACITANCE-RESPONSIVE CONTROL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part application of U.S. Ser. No. 807,243, filed Mar. 14, 1969, now abandoned.

BACKGROUND OF THE INVENTION

The present invention relates to a capacitance-responsive control system and more particularly, to a capacitance-responsive control system employing a conductive plate, simulating a pushbutton, which is responsive to the capacitance of the human body.

In general, the increase of capacity caused by bringing a finger or another part of the human body close to a touch switch of a capacitance-responsive control system causes some action within a circuit. For example, the action may cause a pair of contacts to open or close, which in turn controls the circuit desired to be regulated. Such control systems are used for a variety of purposes, including turning on and off radio receivers, alarm clocks, operating door openers, and for other purposes. Capacitance-responsive control systems find particular application for use in the control of lighting circuits such as a circuit of a table or floor lamp or the lighting circuits controllable by the usual wall switches.

In the past, capacitance-responsive control systems have been rather complex, frequently involving several vacuum tube amplifiers, and difficult to install. Aside from expense and size, many capacitance-responsive control systems have had such further drawbacks as: (a) lacking the ability to be both activated and deactivated solely by human capacitance, (b) involving moving parts which are subject to wear and failure, (c) requiring significant power whether energized or deenergized and (d) involving three wires for installation.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a capacitance-responsive control system which is relatively simple and economical to construct and install.

Another object of the present invention is to provide a capacitance-responsive control system in which critical adjustment is not required for activation and deactivation.

A further object of the present invention is to provide a capacitance-responsive control system which has no moving parts, which is completely silent in its operation and which draws essentially no current in its off position.

Yet another object of the present invention is to provide a capacitance-responsive control system which can be both activated and deactivated by human capacitance.

Still another object of the present invention is to provide a capacitance-responsive control system which requires only two wires for its installation.

With these and other objects in mind, the capacitance-responsive control system of the present invention embodies a pulse generator circuit which is activated by human capacitance, an electronic switch, an electronic latching circuit for maintaining the electronic switch in an "on" position and a shorting circuit for turning the electronic switch "off" when another pulse is generated by the pulse generator.

A pulse is generated when the pulse generator circuit is activated by human capacitance. This pulse triggers the electronic switch into an "on" position. The electronic latching circuit maintains the electronic switch in its "on" position until another pulse is generated by the pulse generator circuit. The second pulse causes the shorting circuit to turn the electronic switch to an "off" position and thereby deactivate the capacitance responsive control system.

BRIEF DESCRIPTION OF THE DRAWINGS

Other and further objects, advantages, and features of the invention will be apparent to those skilled in the art from the following detailed description thereof, taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic illustration of a circuit embodying the present invention;

FIG. 2 is a schematic illustration of a circuit which can be used in the present invention to generate a single pulse;

FIG. 3 is a schematic illustration of a transformer circuit which can be employed in an electronic latching circuit of the invention;

FIG. 4 is a schematic illustration of a modified electronic latching circuit and shorting circuit which can be used in conjunction with the electronic switch in the present system; and

FIG. 5 is a schematic illustration of a pulse integrator and threshold circuit; and

FIG. 6 is a schematic illustration of a circuit embodying the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, the illustrated circuit is composed of a single pulse generator circuit, an electronic switch, an electronic latching circuit, a shorting circuit and a transient filter. In particular, the single pulse generator circuit comprises conductive plate 15, silicon-controlled rectifier 16, capacitors 17, 24 and 28, neon bulb 19, diode 20 and resistors 21, 22 and 23. The electronic switch is a gate-controlled full wave AC silicon switch, also known as a triac, and is shown at 26. The electronic latching circuit comprises resistors 31 and 33, zener diode 32, capacitor 34 and diode 36. The shorting circuit comprises silicon-controlled rectifier 30 and resistors 29 and 38. The transient filter comprises capacitor 42 and resistor 40.

Load 12, an incandescent lamp, is connected to terminal 11, the grounded side of an AC or DC power line, and the power source, which may be the usual 110-volt, 60-cycle household wiring supply line, is connected to terminal 10. Assuming the electronic switch is in an "off" position, the capacitance-responsive control system shown in FIG. 1 is activated when conductive plate 15 is touched by the human body, the human body being essentially at ground potential. This causes a voltage to be applied across neon bulb 19 until it breaks down, partially discharging through the ultrasensitive silicon-controlled rectifier 16 and causing this silicon controlled rectifier to trigger.

The triggering, i.e., conduction, of silicon controlled rectifier 16 discharges capacitor 17, which has been charged to a positive voltage equal to the line voltage by the diode 20, into resistor 22 thereby causing a single pulse a few microseconds wide to appear at the output of resistor 22. After capacitor 17 has discharged, it cannot charge again to any appreciable voltage until the operator removes his hand from conductive plate 15. This is due to the long time constant of capacitor 17 and resistor 21, which is about 0.2 second.

The single pulse generated by silicon-controlled rectifier 16 passes through capacitor 24 to the gate of triac 26 and through capacitor 28 to the gate of silicon-controlled rectifier 30. Since there is no voltage across silicon-controlled rectifier 30 during the short triggering period, rectifier 30 is not activated. However, the pulse at the gate of triac 26, which switches from a blocking state to a conductive state for either polarity of applied voltage with positive or negative gate triggering, turns the triac on. When triac 26 is on, a voltage drop (of about 5 volts in one direction and almost a zero drop in the opposite voltage direction) appears across zener diode 32. Capacitor 34 charges up through diode 36 to the voltage across zener diode 32. The gate of triac 26 now has a negative voltage across it which keeps the triac conducting. Thus, as long as there is current through load 12, which in turn causes a voltage drop through zener diode 32, triac 26 is electronically latched in the "on" position.

The circuit is deactivated by the capacitance of the human body when conductive plate 15 is again touched. By touching conductive plate 15 another single pulse is generated, but this time it is a much smaller voltage because capacitor 17 has only charged up to about 5 volts, which is the voltage drop across zener diode 32 when the hot side of the line is negative. The

single pulse which is generated has no effect on triac 26 because it is already conducting due to the voltage across capacitor 34. However, when the single pulse arrives at silicon-controlled rectifier 30, this silicon-controlled rectifier conducts since there is a voltage across it that is sufficient for triggering purposes (i.e., 1 to 2 volts). Capacitor 34 now discharges through resistor 38 and silicon-controlled rectifier 30 until the voltage becomes so low (about 0.8 volt) that neither triac 26 nor the silicon-controlled rectifier 30 continues to conduct. The capacitance-responsive control system is then deactivated and will remain deactivated until conductive plate 15 is again touched to generate another single pulse.

To prevent large line transients from falsely triggering any of the circuits, a transient filter composed of resistor 40 and capacitor 42 can be placed between terminals 10 and 11, as shown.

The following table sets forth a specific combination of elements which can be used for the capacitance responsive control circuit of FIG. 1.

Item	Value or Type
16	200 volt (e.g., G.E. C106B)
17	0.1 microfarad
19	Any high current neon (e.g., GE 5 AH)
20	200 volt, 1 milliamper
21	2 megohm
22	390 ohm
23	10 K
24	100 micro-microfarad
26	200 volt (e.g., RCA 040526)
28	500 micro-microfarad
29	1 K
30	30 volt (e.g., GE C106Y)
31	100 ohm
32	3.9 volt, 10 watt
33	100 ohm
34	100 microfarad
36	50 volt, 1/4 ampere
38	50 ohm
40	10 ohm
42	0.5 microfarad

RCA triac 40668 can be used in place of RCA triac 40526. The plastic case of the former provides ease of mounting and low thermal impedance.

Various modifications can be made to the circuit illustrated in FIG. 1. For example, a 10-microhenry inductance can be added between the anode of silicon-controlled rectifier 16 and the cathode of diode 20. This modification increases the life of the silicon-controlled rectifier. Another modification of the circuit of FIG. 1 is the addition of a 100K resistor in series with conductive plate 15 and neon bulb 19 in order to protect the neon bulb against the possible grounding of conductive plate 15. Still another modification which can be made to the circuit illustrated in FIG. 1 is the addition of a diode in series with resistor 31. This diode is connected so that it is normally conducting when the electronic switch is on and the diode improves the turnoff responsiveness at elevated temperatures when the gate turn-on sensitivity of triac 26 is high. In FIG. 1, conductive plate 15 is shown as having infinite impedance until neon bulb 19 fires. There are occasions when it is desirable to reduce this impedance to prevent unwanted triggering by high voltage fields caused by lightening storms or static charges picked up by individuals. The effective DC impedance can be reduced by adding a resistor of several hundred megohms between the conductive plate side of neon bulb 19 and some relatively low impedance point, such as terminal 10 or the gate of silicon controlled rectifier 16. Similarly, an AC capacitance connected between the same two points will filter out any transients present in the electrostatic field surrounding the conductive plate 15. A capacitance of about 20 to 50 picofarad connected in this manner will also tend to increase the life of the silicon-controlled rectifier 16 by providing more energy to the gate when neon bulb 19 fires.

The main requirement of the single pulse generator circuit of FIG. 1 is that only one pulse be generated each time there is contact with the conductive plate. Accordingly, suitable single-pulse generator circuits such as the circuit illustrated in FIG. 2 can be substituted for the single-pulse generator circuit specifically set forth in FIG. 1. The single-pulse generator circuit specifically illustrated in FIG. 2 comprises conductive plate 15, neon bulb 19, silicon-controlled rectifier 44, capacitors 24, 28 and 46, diode 48 and resistors 50, 51 and 52. This circuit is shown connected to the switch terminals 10 and 11 of FIG. 1.

When point B is negative with respect to point C, diode 48 can conduct when the gate is 1 to 2 volts positive with respect to the cathode of diode 48. Neon bulb 19 fires when point D is about 65 volts either above or below the ground potential--which can only occur when touch plate 15 is touched. When point B is 65 volts negative with respect to point C, neon bulb 19 glows and any increase in voltage between points B and C now appears across resistors 50 and 51. Therefore, when the voltage across resistor 50 is positive 1 or 2 volts with respect to point A, silicon controlled rectifier 44 will fire.

The following table sets forth a specific combination of elements which can be used for this alternative single pulse generator circuit illustrated by FIG. 2.

Item	Value or Type
19	Any high current neon (e.g., GE 5 AH)
24	100 micro-microfarad
28	500 micro-microfarad
44	200 volt(e.g., G.E. C106B)
46	0.1 microfarad
48	200 volt, 50 milliamper
50	10 K.
51	20,000 ohm
52	1 megohm

Since the wattage of the zener diode 32 shown in FIG. 1 may be quite high for large loads, the transformer illustrated in FIG. 3 can be substituted for zener diode 32. The transformer circuit shown in FIG. 3 comprises resistor 53 and diodes 54 and 55. The relationship of this circuit to triac 26, resistor 33, diode 36, and capacitor 42 is also shown.

A specific combination of elements which can be used for the transformer circuit of FIG. 3 is set forth in the following table.

Item	Value or Type
36	50 volt, 1/4 ampere
42	0.5 microfarad
53	0.24 ohms
54	10 volt, 3 ampere
55	10 volt, 3 ampere
Transformer 1:14 turns (primary to windings Secondary)	

A modified electronic latching circuit and shorting circuit are illustrated in FIG. 4 together with triac 26. These circuits are shown in their relationship to capacitors 17, 24 and 42, diode 20 and resistor 22 of FIG. 1.

In the embodiment illustrated in FIG. 4, once triac 26 has been triggered by the single pulse generator circuit (not shown) conduction through the triac continues until the end of a half-wave cycle. Near the end of the AC cycle, transformer 58 reaches a condition when it is no longer saturated and the magnetic flux decreases to zero. This produces a negative pulse overshoot that triggers the triac 26 for the next half cycle. Similarly, at the end of the next half cycle the decrease of the magnetic flux to zero produces a positive overshoot which retriggers the triac. Thus, once triac 26 has been triggered it continues to be automatically triggered each succeeding half cycle due to the overshoot voltage produced across the transformer secondary. However, when another single pulse is generated capacitor 59 is discharged and silicon-controlled rectifier 30 conduction loads up the transformer secondary so the triggering pulse amplitude is no longer sufficient to

trigger triac 26. Triac 26 remains "off" until the next single pulse arrives to once again trigger it into an "on" position.

A specific combination of elements which can be used for the modified electronic latching circuit and shorting of FIG. 4 are set forth in the following table.

Item	Value or Type
17	0.1 microfarad
20	200 volt, 1 milliamper
22	390 ohm
24	100 micro-microfarad
26	200 volt(e.g. RCA No.40526 or No.40668)
29	1 K
30	30 volt(e.g., G.E. C106Y)
42	0.5 microfarad
54	10 volt, 3 ampere
55	10 volt, 3 ampere
57	30 volt
58	1.14 turns (primary to secondary)
59	10 microfarad, 15 volt
60	200 volt
61	2.2 megohm
62	68 ohms
63	1,000 ohms

In place of the gate-controlled full wave AC silicon switch, i.e., the triac, two silicon-controlled rectifiers can be employed. This is accomplished by providing a second identical secondary winding for driving the inverted silicon-controlled rectifier and diodes to provide for only positive gate triggering. However, silicon controlled rectifiers cannot be substituted for the triac in circuits such as that shown in FIG. 1 because the triac gate in that figure is turned on by DC voltage.

By increasing the size of the conductive plate 15 the capacitance-responsive control system of the present invention will respond to the nearness or proximity of a human, rather than merely to touch by a human being. In such a modified form, the system is suitable for such applications as burglar and other alarm systems, safety systems and door openers.

It will be understood that while the operation of the capacitance-responsive control system of the present invention has been described by reference to a preferred system embodying a single-pulse generator, modifications of the described system can be made to permit multiple-pulse generators to be used or operation only after a predetermined number of pulses have been generated by a pulse generator. One example of a multiple-pulse circuit is illustrated by FIG. 5 in which multiple pulses are needed to turn the switch on.

The pulse integrator and threshold circuit of FIG. 5 is a modification of the circuit shown in FIG. 1 which prevents the accidental triggering of the capacitance-responsive control system by lightning storms and other extraneous sources. Specifically, the circuit of FIG. 5 can be substituted for components 15, 16, 17, 19, 20, 21 22 and 23 of FIG. 1.

When conductive plate 15 of FIG. 5 is touched, a voltage appears across capacitor 64 and when this voltage exceeds the voltage required to break down neon bulb 19 (about 65 volts) ultrasensitive silicon-controlled rectifier 16 is triggered. As long as a person's hand is held on conductive plate 15, pulses are generated across resistor 66 and these pulses slowly charge capacitor 67. Finally, the voltage across capacitor 67 becomes high enough to cause the four-layer diode 69 to conduct. The voltage drop across the four-layer diode then falls to about 1 volt so most of the energy in capacitor 67 is transferred to resistor 70 causing a sharp pulse to be produced.

The following table sets forth a specific combination of elements which can be used for the pulse integrator and threshold circuit illustrated by FIG. 5.

Item	Value or Type
16	200 volt(e.g. G.E. C106B)
19	G.E. 5AH(high current neon)
64	20 picofarad
66	20 K.

67	50 microfarad, 15 volt
69	Motorola M4L 3054 (referred to as 1N 5158)
70	390 ohm
72	100 K.
73	15 K.
74	1 K.
75	30 volt, 30 milliampere
77	200 volt
78	200 volt
80	5 K.

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A preferred embodiment of the invention is shown in FIG. 6. The operation of the circuit illustrated in this figure is similar to the operation of the other circuits. A 400-megohm resistor 84 prevents accidental triggering by reducing the impedance so static charges will not produce sufficient voltage to fire the neon until contact is made with touch plate 85. Capacitor 86 supplies gate power to trigger the silicon-controlled rectifier 87 when neon bulb 89 fires. A single pulse then appears across resistor 90. Resistor 92, on the anode side of silicon-controlled rectifier 87 merely reduces the single-pulse voltage to a reasonable value to trigger either triac 94 or silicon-controlled rectifier 95. When the switch is "off," capacitor 97 charges up through resistor 98 and diode 99. When the switch is turned "on," capacitor 97 charges up through resistor 98 and diode 100, the voltage coming from capacitor 102.

Once triac 94 has been triggered to an "on" position by the single pulse through capacitor 104, it stays on because current through the primary of transformer 106 produces a voltage across the transformer secondary which triggers triac 94 through resistor 107. The triac stays "on" because the rapidly decaying current at the end of the half cycle is enough to produce a voltage overshoot ($E=L di/dt$) in the opposite direction causing the triac to automatically trigger at the beginning of the next half cycle. The voltage across the primary of transformer 106 is maintained constant, regardless of load values, due to diodes 115 and 116 which are in parallel with the primary of transformer 106.

The switch is turned off when another single pulse is generated and silicon-controlled rectifier 95 loads up the transformer secondary so that no voltage overshoot occurs to keep the triac in an "on" position. Thus the time constant through resistor 113 and capacitor 102 must be sufficiently long that the silicon-controlled rectifier is still drawing current and loading down the transformer secondary when the voltage overshoot would normally occur to keep the circuit electronically latched in an "on" position. The off current utilized by the circuit of FIG. 6 is about 0.1 milliamper. This circuit can provide sufficient gate current to drive a 10-amp. triac.

The following table sets forth a specific combination of elements which can be used for the capacitance-responsive control circuit of FIG. 6.

Item	Value or Type
84	400 megohm
86	20 picofarad
87	TIC 47 (or Motorola 2N5063)
89	any high current neon (e.g., NE83)
90	390 ohm
92	510 ohm
94	ECC Thermotab, a triac having an insulated heat sink (or RCA 40668)
95	TIC 44 (or Motorola 2N5056)
97	0.068 microfarad
98	3.3 megohm
99	200 volt (e.g., 1N4383)
100	200 volt (e.g., 1N4383)
102	20 microfarad
104	0.003 microfarad
106	8 ohm primary and 1200 ohm secondary, having a ratio of turns of about 12:1
107	120 ohms
108	100 K.
109	15 K.
110	0.001 microfarad
111	1 K.

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112	68 ohms
113	2 K.
114	20 volts (e.g., 1N98)
115	50 volts
116	50 volts
117	0.003 microfarad

From the foregoing it will be seen that this invention is well adapted to obtain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the system. It will be understood that the touch plate or conducting plate employed can be made of metal or consist of a conductive plastic material or plastic-coated material to eliminate any annoying spark when the individual touching the plate has a static charge.

Thus, the capacitance-responsive control system of the present invention responds to the capacitance of the human body to alternately switch AC (or DC in systems not employing a transformer) on or off to a load each time any part of the human body is brought into proximity with the surface of the conductive plate. The system is completely electronic, relatively inexpensive, compact in size and, having no moving parts, is totally silent. The capacitance-responsive control system is both activated and deactivated by simple touching of the conductive plate. Accordingly, auxiliary circuits to deactivate or reset the system are not required. Another advantage is the fact that only two wires are required for the installation of the capacitance-responsive control system. It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matters herein set forth or shown in the accompanying drawings are to be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A capacitance-responsive control system comprising in combination:

- a pulse generator circuit which generates an electrical pulse when activated by human capacitance, which circuit comprises a silicon-controlled rectifier;
- a gate-controlled electronic switch for controlling a remote load;
- an electronic latching circuit which maintains the gate-controlled electronic switch in an on position when an electrical pulse is generated by the pulse generator while said gate-controlled electronic switch is in an off position; and
- a shorting circuit comprising a silicon-controlled rectifier for switching the gate-controlled electronic switch from an on position to an off position when an electronic pulse is generated by the pulse generator circuit while said gate-controlled electronic switch is in an on position.

2. A capacitance-responsive control system as in claim 1, in

which the pulse generator circuit also includes a neon bulb and the gate controlled electronic switch is a gate-controlled full wave AC silicon switch.

3. A capacitance-responsive control system as in claim 1, in which the gate-controlled electronic switch is a triac.

4. A capacitance-responsive control system as in claim 1, in which the system also includes a transient filter, comprising a capacitor, in parallel with the system.

5. A capacitance-responsive control system as in claim 1, in which the electronic latching circuit comprises a circuit in series with the gate-controlled electronic switch for triggering said electronic switch and supplying power to said pulse generator.

6. A capacitance-responsive control system as in claim 5, in which the electronic latching circuit comprises a transformer low-impedance primary in parallel with two paralleled diodes of opposite conduction polarity and a transformer high-impedance secondary.

7. A capacitance-responsive control system as in claim 5, in which the electronic latching circuit comprises a zener diode.

8. A capacitance-responsive control system as in claim 1, in which the silicon-controlled rectifier of the shorting circuit is connected across a constant voltage source used to trigger the gate-controlled electronic switch and wherein means are present for delaying the voltage source to the silicon-controlled rectifier of the shorting circuit when the gate-controlled electronic switch is in an off position and an electronic pulse is generated by the pulse generator circuit.

9. A capacitance-responsive control system as in claim 1, wherein the pulse generator circuit also includes a neon bulb.

10. A capacitance-responsive control system as in claim 1, in which the pulse generator circuit is connected to a conductive plate.

11. A capacitance-responsive control system comprising in combination:

- a pulse generator circuit comprising a neon bulb and a silicon-controlled rectifier for generating an electrical pulse when activated by human capacitance;
- a gate-controlled full wave AC silicon electronic switch for controlling a remote load;
- an electronic latching circuit comprising a circuit in series with the gate-controlled full wave AC silicon electronic switch for triggering said electronic switch and supplying power to said pulse generator for maintaining the electronic switch in an on position when an electrical pulse is generated by the pulse generator while said electronic switch is in an off position; and
- a shorting circuit comprising a silicon-controlled rectifier for switching the gate controlled full wave AC silicon electronic switch from an on position to an off position when an electronic pulse is generated by the pulse generator circuit while said electronic switch is in an on position.

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