

**[54] ELECTRONIC SWITCH FOR TIMED LOAD
ENERGIZATION AFTER TRIGGER SIGNAL**

[75] Inventor: **Joseph C. Stettner**, Akron, Ohio

[73] Assignee: **Novar Electronics Corporation,**
Barberton, Ohio

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[58] **Field of Search**..... 307/246, 252 B, 252 F,
307/283, 273, 293, 294; 328/129, 130, 131;
317/141 S

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FIGS. 4(a) and 4(b) relied on.

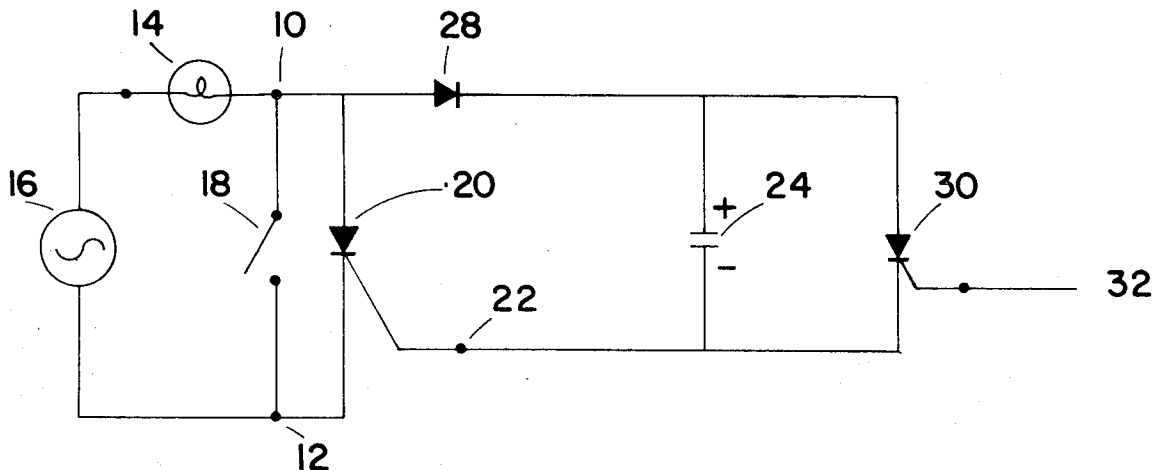
Primary Examiner—Stanley D. Miller, Jr.

Attorney—Frank H. Foster

[57] **ABSTRACT**

A burglar deterrent having a timing switch connected to the lights of a room or building for actuating these lights for a selected period of time in response to a sound made by an intruder. The timing switch has an SCR connected to the switch terminals. The gate of the SCR is connected to a timing circuit which comprises a series connected capacitance and diode connected from the gate to the anode of the SCR. A second SCR has its main terminals connected across the capacitance for, at times, discharging the capacitance in response to a trigger signal at the gate of the second SCR. A zener diode is connected for limiting the charging voltage applied to the capacitance. A variable resistance is connected from the gate of the first SCR to its cathode to permit selection and control of the delay time.

10 Claims, 4 Drawing Figures



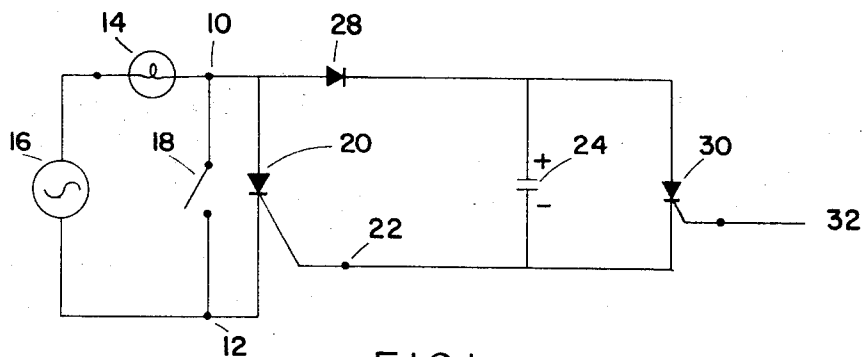


FIG. 1

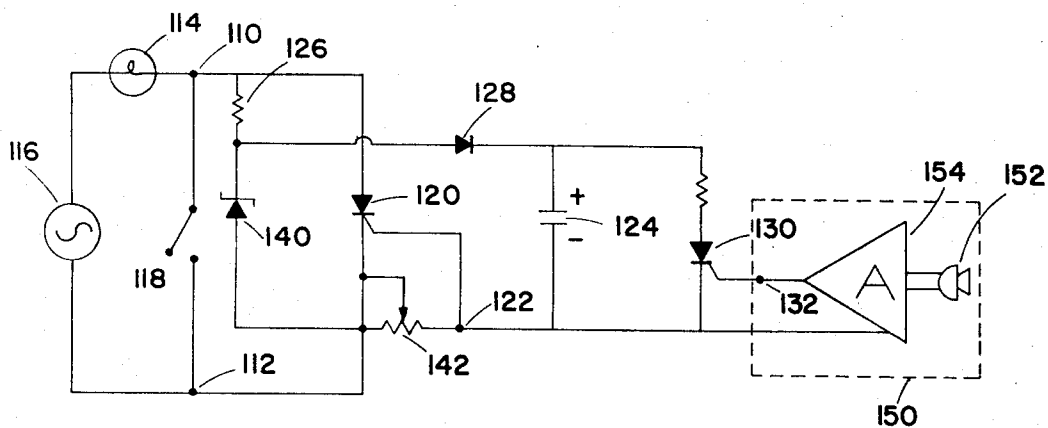


FIG. 2

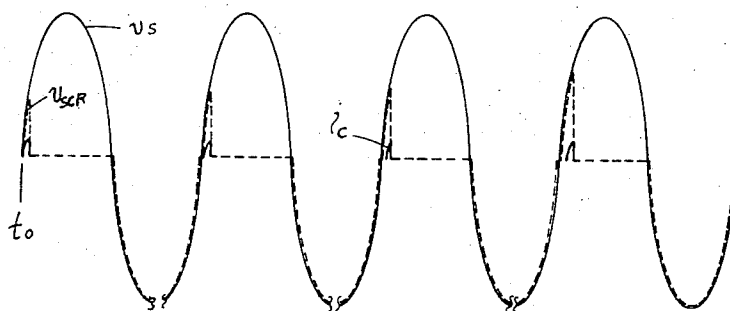


FIG. 3

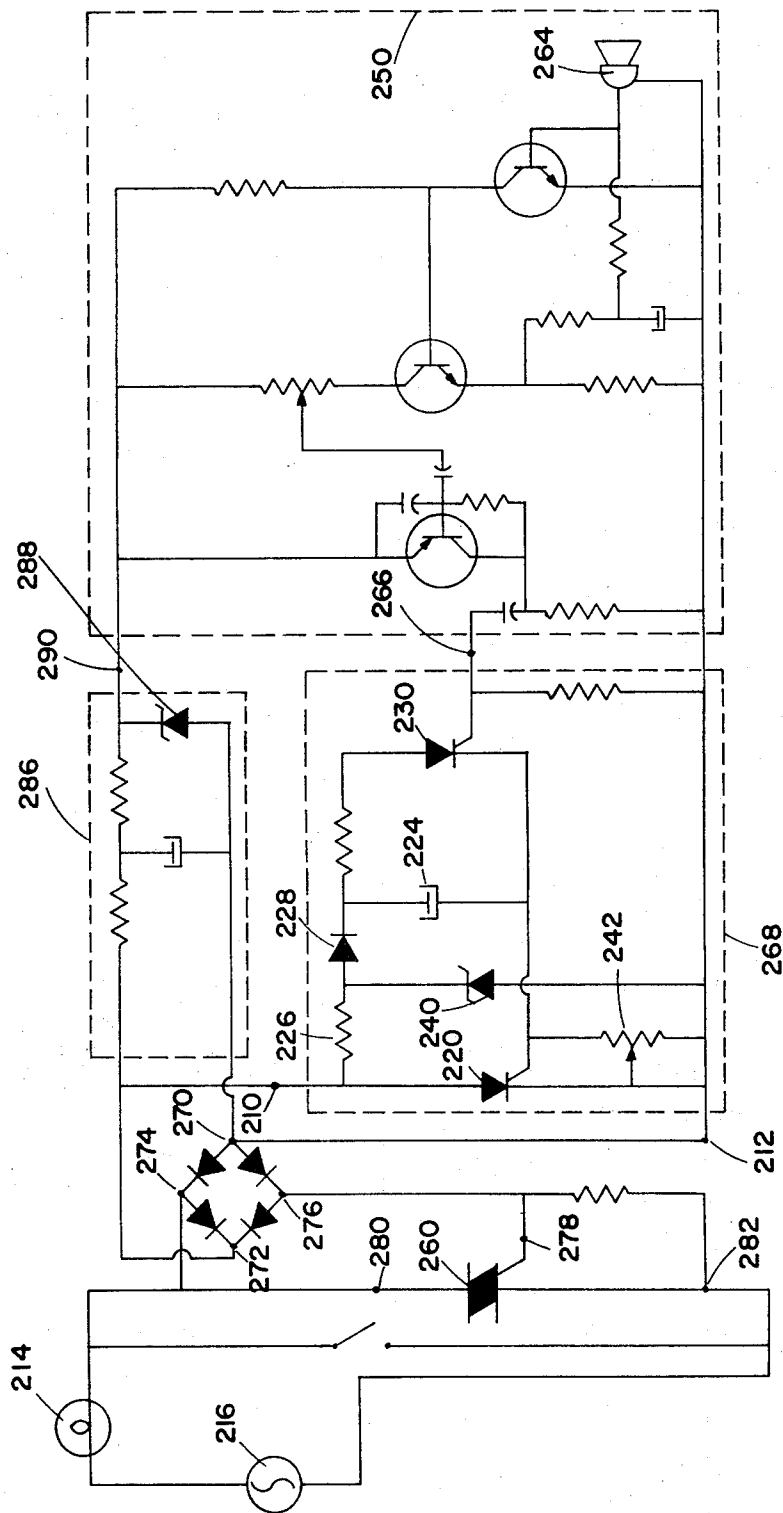


FIG. 4

ELECTRONIC SWITCH FOR TIMED LOAD ENERGIZATION AFTER TRIGGER SIGNAL

This is a division of U.S. Pat. application Ser. No. 116,331, filed on Feb. 18, 1971 now U.S. Pat. No. 3,713,126 issued Jan. 23, 1973.

BACKGROUND OF THE INVENTION

This invention relates to a timing switch, and more particularly relates to a timing switch for a burglar deterrent wherein the timing switch can actuate lighting in response to an input trigger signal and hold the lighting on for a long period of time.

As explained more completely in my copending U.S. Pat. application Ser. No. 145,134, now U.S. Pat. No. 3,700,069 I have found that burglaries may be deterred if the sound that an intruder makes is used to illuminate the lights in the room in which he is located. A circuit is needed to receive the sound and to cause the sound to turn on the lights, to hold the lights on for a selected period of time and then to extinguish the lights. This is desirable so that if the lighting if falsely actuated the circuit will reset itself. Furthermore, the intruder, upon seeing the lights illuminated, will initially fear that he has been detected. After the lights go off, he will know that his sound is causing the lights to go on and off. He will operate in fear that his next move will cause the lights to illuminate, and consequently he will most likely leave the premises before he has completed his crime.

For this purpose, a timing circuit is needed which is capable of turning the lights on in response to the sound and then holding the lights on for an unusually long period of time. Many types of timing circuits are well known in the art. Most depend on resistance-capacitance charging or discharging. However, the problem with conventional resistance-capacitance discharging circuits is that if extremely long time delays are needed, for example on the order of 5 minutes, a very large value of capacitance and a very large value of resistance are required. Unfortunately, however, such conventional timing circuits require expensive, high stability, capacitors. In addition, output circuitry, for reading the capacitor voltage causes a significant change in the circuit's time constant. The slow charge or decay of such a circuit makes the obtaining of a gate trigger signal difficult. Inexact triggering may result.

What is needed, therefore, is a timing circuit using conventionally sized resistances and capacitances, and yet which is capable of providing a time delay on the order of 5 minutes while at the same time providing an exact triggering signal for a thyristor.

Many unijunction transistor timing circuits have been designed which provide excellent timing circuits for some applications. However, such UJT timing circuits require a continuously applied power supply voltage in order to function properly. A continuously applied power supply is impractical with a burglar deterrent timing switch. The reason is that, in order to provide a timing switch which is very quickly and easily installed in conventional lighting circuitry without any significant disassembly or rewiring of the lighting circuitry, the timing switch should be connected in series with the lighting load and the AC power generator. With such a series connection, the timing switch may be simply installed in the ordinary switch box used for manually switching the lights. The timing switch together with a parallel connected manual switch if desired, is simply

connected to the pair of wires conventionally connected to the manual switch. At this pair of wires a continuous power supply is not available because these wires are shunted by the switch each time the switch turns on.

Furthermore, a trigger pulse is needed for each half cycle of operation. A UJT timing circuit would be unable to provide any timing pulses after the switch is turned on.

What is needed therefore is a timing circuit which can provide a long time delay and provide pulses for each half cycle during the timing switch on time and still be capable of being connected in simple series connection with the lights and the AC generator.

SUMMARY OF THE INVENTION

The invention is a timing switch for connection to a load and to a source of power for permitting a load energizing current flow through the load and for continuing such current flow for a selected period of time. The timing switch comprises an electronic switch means having its main terminals connected at the timing switch terminals and having a control input terminal. The timing switch also has a timing circuit which comprises a series capacitance and rectifier connected at one end to said control terminal and conductively connected at the opposite end to a source of control input power. The rectifier is polarized to permit control input current flow. A capacitance discharging means is connected across the capacitance for at times discharging the capacitance.

For burglar deterrent use, a sound transducer and amplifier means, for picking up the sounds of an intruder and converting it to an audio trigger signal is connected at its output to the input of a second electronic switch connected as a capacitance discharge means.

It is therefore an object of the invention to provide an improved timing circuit using relatively moderate or small circuit component values while providing for long time delays.

Another object of the invention is to provide a timing circuit for operating a thyristor which provides a trigger signal for each half cycle while the switch is on and the load is energized.

Another object of the invention is to provide a timing capacitance of low maximum voltage rating and therefore of small physical size.

Another object of the invention is to provide a timing switch which turns the lights off after a selected period of time without gradual light dimming.

A further object of the invention is to provide an intruder deterrent with a timing switch which turns lights on for a selected period of time in response to the intruders sounds and then extinguishes the lights.

Further objects and features of the invention will be apparent from the following specification and claims when considered in connection with the accompanying drawings illustrating embodiments of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a simplified version of the invention for use in explaining the operation of the invention.

FIG. 2 is a schematic diagram of the preferred embodiment of the invention.

FIG. 3 is an oscillogram illustrating the charging of the timing capacitance with the triggering angle enlarged out of scale for purposes of illustration.

FIG. 4 is a schematic diagram of a complete intruder deterrent circuit constructed according to the invention.

In describing the preferred embodiments of the invention illustrated in the drawings, specific terminology will be resorted to for the sake of clarity. However, it is not intended to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose. For example, the term "connected" is not limited to "directly connected" but rather includes connection through other components, such as a resistor, where the function or operation is similar to direct connection and is functionally equivalent.

DETAILED DESCRIPTION

FIG. 1 shows a simplified version of the timing switch which has timing switch terminals 10 and 12. This timing switch is connected to a load 14, such as an illumination means, and to a source of power 16. A manual switch 18 is provided to manually energize the load 14 when desired. A silicon controlled rectifier 20 functioning as a first electronic switch has its main terminals connected at the switch terminals 10 and 12 and has a control input terminal at its gate terminal 22. A series connected capacitance 24, and rectifier 28 are connected as a timing circuit. One end of the timing circuit is connected to the gate terminal 22 of the SCR 20. The other end is connected to a source of control input power at the anode of the SCR 20. The rectifier 28 is directed in a polarity to permit gate current flow through the gate of the SCR 20.

A second silicon controlled rectifier 30 is connected with its main terminals across the capacitance 24 to operate as a capacitance discharging means for at times discharging the capacitance 24. The silicon controlled rectifier 30 is actuated for discharging the capacitance 24 by a triggering signal occurring at its gate 32.

The simplified circuit of FIG. 1, can be operated manually by the manual switch 18. Closing of the manual switch 18 would illuminate the illumination means 14 in the conventional manner so long as the switch 18 remains closed. Opening of the switch 18 automatically initiates the operation of the timing switch. Operation of the timing switch would begin with it in a de-energized condition prior to the instant the manual switch 18 is opened. When the manual switch 18 is opened, current may flow through the diode 28 and the gate 22 of the SCR 20 whenever the AC voltage at the main terminals of the SCR 20 is in the positive, forward biasing polarity. With no voltage stored on the capacitance 24, the SCR 20 will fire within the first few degrees of the forward half cycle. It will fire as soon as the gate current reaches the gate firing current. This means of course that the illumination means 14 will be illuminated during each forward half cycle. During each reverse half cycle, the diode 28 prevents discharge of the capacitance 24 and, of course, the SCR 20 because of its characteristics can not conduct.

Assuming that no triggering signal is present at the gate 32 of the SCR 30, the SCR 20 will continue firing on each positive half cycle as the capacitance 24 continues to accumulate charge from the periodic and

short gate current pulses in the SCR 20. It should be noted, and is of great importance, that after the SCR 20 fires, which initially will be early in the half cycle, its main terminal voltage will go nearly to zero and consequently charging voltage will no longer be applied to the capacitance 24. Thus, the capacitance 24 charges only until the SCR 20 fires. It is charging for only a small portion, of the forward half cycle and for none of the reverse half cycle. This, as will be seen, is what accomplishes the long time delay.

Eventually, after enough gate current pulses, the capacitance 24 will become fully charged. Because of the short duration and small magnitude of the gate current pulses, this will take a long time. Current then cannot flow through the capacitance 24 and therefore the SCR 20 will no longer be able to fire. A long time delay has been obtained because the capacitance charges during only a small fraction of the positive half cycle. After the selected long period of time the capacitance will finally be fully charged, the SCR 20 will no longer fire and consequently the illumination means 14 will be turned off. The system will now await the occurrence of a trigger signal at the gate 32 of the SCR 30.

When a trigger signal is applied to the gate 32 of the SCR 30, the SCR 30 will fire and, regardless of what then occurs at the gate 32, will continue to conduct and discharge the capacitance 24. Immediately upon the firing and therefore short circuiting of the capacitance 24, gate current can again flow through the gate terminal 22 of the SCR 20, and fire the SCR 20. Thus, the occurrence of the trigger signal immediately initiates illumination of the illumination means 14 and the voltage on the capacitance 24 is returned close to zero. When the capacitance has discharged, so that it can no longer maintain a minimum holding current through the SCR 130 the discharging SCR 30 will go to its off state, assuming that no trigger signal is present at the gate 32. The capacitance will then begin recharging while the illumination means is illuminated. Again, after a long period of time the capacitance 24 will be recharged and the illumination means 14 will be turned off.

It should be pointed out that although I prefer a capacitance discharge means which is an electronic switch operated by a trigger signal, for other applications the timing circuit can use merely a bleeder resistor for discharging the capacitance. For example, the basic circuit of FIG. 1 may be modified and used to provide a delay turn off switch. A bleeder resistor can replace the SCR 30. Its resistance must be large enough so that it would drain less charge from the capacitance 24 during each cycle than is put on the capacitance 24 by the gate current pulses, in order to permit charge to accumulate and eventually turn the switch off.

With such a circuit, opening of the manual switch 18 will initiate periodic charging of the capacitance and the light will continue on for a period of time. After sufficient charge has accumulated on the capacitance 24, the lights will turn off because, as before, no gate current can flow through the SCR 20. So long as the manual switch remained open, the capacitance 24 will be maintained fully charged with the lights off. When the manual switch is closed, the lights come on, no gate current pulses can be applied and the bleeder discharges the capacitance 24. The bleeder resistance must be small enough to discharge the capacitance within a suitable time.

As another alternative, a similar shunt bleeder resistor could be used in combination with the SCR 30. Its value of resistance must be large enough so that it would remove less charge from the capacitance each cycle than is added. The result would be an increased time delay. The smaller the value of the bleeder resistor in ohms, the longer the time delay obtained.

In FIG. 2, a preferred embodiment of the invention utilizes many of the same components which are illustrated in FIG. 1 with the same reference numerals used as in FIG. 1, but with the numeral 1, added in the hundreds place. Thus, the timing circuit of FIG. 2 comprises in series a current limiting resistance 126, the diode 128 and the capacitance 124. A zener diode 140 has been connected between a node of the timing circuit and the cathode of the SCR 120. The zener diode 140 limits the voltage which is applied to the capacitance during the operation of the circuit. The resistance 126 is large enough to limit the zener diode 140 current to a current which is insufficient to significantly energize the load 114. It should be small enough to not significantly affect the timing of the circuit. For example, I have used a 22 K ohms 1 watt resistor as the resistance 140.

In functional effect, the zener diode 140 is connected across the capacitance 124 for limiting the voltage applied to the capacitance. This can be stated because, during charging, the diode 128 and the gate-cathode junction of the SCR 120 will exhibit a very low impedance. Obviously, at other times during circuit operation, because of the effect of a reversed semi-conductor junction, the zener diode 140 is electrically disconnected from the capacitance 124. However, when we refer to the zener diode as connected across the capacitance, we mean during the charging of the capacitance when this is of consequence in limiting the capacitance voltage. The relative positions of the series components could be changed or interchanged and other equivalent connections of the zener diode could be possible.

A variable resistance 142 is connected between the gate terminal 122 of the SCR 120 and the cathode terminal of the SCR 20. The variable resistance 142 controls and varies the time delay of the timing circuit so that a desired charging time may be selected. A sound transducer and amplifier means 150, for picking up the sound of an intruder and converting it to audio trigger signal, is connected to the input gate terminal 132 of the SCR 130. It comprises a microphone 152 connected to the input of an audio amplifier 154.

For reasons which will become clear, it is desirable to select a zener diode, having a zener voltage which is relatively small when compared to the maximum instantaneous voltage at the main terminals of the SCR 20. For example, I prefer to use a zener diode 140 having a zener voltage of approximately 12 volts. We can then use an electrolytic capacitor as the capacitance 124, having a capacitance of 20 microfarads and a maximum voltage rating slightly above 12 volts, thus permitting use of a capacitor having a small physical size.

Operation of the circuit illustrated in FIG. 2 similarly begins with opening of the switch 118 and with the timing switch components initially in a de-energized condition. FIG. 3 illustrates the voltage V_s of the source of power 116, the charging current i_c of the capacitance 124 and the voltage V_{scr} across the SCR 20. Beginning at time t_0 and continuing into the positive half cycle,

the voltage on the SCR will initially be the voltage of the power source 116. Initially, right after the SCR voltage passes through zero, a positive voltage will be applied to the gate 122. Within the first few degrees of the positive forward half cycle, sufficient current will flow through the discharged capacitance 124 to fire the SCR 120. When the SCR fires, the potential across the SCR will go nearly to zero with the result that charging voltage is no longer applied to the capacitance 124. Thus, immediately after time t_0 , a small spike of charging current will put a relatively small charge on the capacitance 124. For the major remainder of the forward half cycle and for all of the reverse half cycle no charging current will flow through the capacitance 124. The zener diode 140 will not yet have conducted because the firing of the SCR 20 shorts it out before its zener voltage is reached.

During the subsequent half cycles, as the capacitance 124 accumulates charge, the spikes of charging current become progressively a few degrees later in the positive half cycle. However, in all cases minimum gate firing current must be reached and the SCR 120 must fire before the voltage applied to the capacitance reaches the zener voltage of the diode 130 or the SCR 120 cannot fire at all. This is true because after the capacitance charges to the zener voltage of, for example, 12 volts, the voltage applied to the capacitance can go no higher because the zener diode 140 will conduct. If the minimum firing gate current is not exceeded when 12 volts is applied to the series capacitance and gate, it will not be exceeded in any part of the cycle. Whenever the capacitance becomes charged to the zener voltage, sufficient gate firing current cannot flow in the SCR 120. If a conventional house supply voltage is used having 117 volts RMS and therefore a peak instantaneous voltage of 165 volts, then triggering must always occur in the first few degrees of the forward half cycle before the supply voltage reaches approximately 12 volts or it will not occur at all. Therefore, as with the circuit in FIG. 1, the illumination means 114 is illuminated until the capacitance 124 is fully charged. The difference however is that the capacitance will be fully charged when it reaches the zener voltage of the zener diode 140. Furthermore, because firing of the SCR 120 occurs in the first few degrees of the forward half cycle, it always occurs where the voltage has its maximum slope. This always must result in a high-sloped gate current for accurate firing.

It should also be noted that during each reverse half cycle, the zener diode will be forward biased. This prevents application of a large reverse voltage on the diode 128 and therefore eliminates reverse leakage current in the diode 128 which would otherwise tend to discharge the capacitance 129.

Variation of the variable resistance 142 permits variation of the total series resistance of the timing circuit. This permits control of the length of time required to charge the capacitance 124 and therefore of the length of time that the illumination means 114 is energized. The smaller the resistance 142 is made, the larger the current pulses through the capacitance 124, the shorter the capacitor charge time and the shorter the time delay. With the smaller gate to cathode resistance and greater current pulses, a smaller proportion of the total current flows through the gate leg of the current divider comprising the gate and the resistance 142. Because the zener diode forces the circuit to either trigger in the

first few degrees of the positive half cycle or prohibits it from triggering at all, the lights will not gradually dim at the end of the timing cycle as they would if triggering occurred progressively later and later in the forward half cycle until it did not occur at all.

It should be noted that if the ratio of the value of the resistance 126, R_{126} , to the selected gate to cathode resistance R_{142} is extremely large, some dimming would occur. Therefore I normally avoid such operation. Dimming would occur because nearly all of the source 116 voltage V_s would be dropped across the resistance 126. In this condition, the minimum gate firing current would be reached later in the half cycle. For example, with R_{126} / R_{142} very large, 12 volts might be reached at the zener diode 140 when the source voltage V_s is at its 90° peak of 165 volts. Thus, setting of the resistance 142 to a value near zero for nearly zero time delay might produce some dimming.

After the capacitance 124 has charged and the lights are extinguished, any sound at the microphone 152, will be amplified by the amplifier 154 and will be applied to the gate of the SCR 130 to cause discharge of the capacitance 124. Discharge will occur as with the circuit of FIG. 1. The lights will be illuminated at the beginning of discharge, as soon as the SCR 130 begins conducting. When the capacitance is discharged, operation will then continue and repeat that which is described above.

FIG. 4 illustrates a complete intruder deterrent system. This system utilizes a triac 260 for direct control of the lights 214. As before, components similar to those of FIGS. 1-3 have the same reference numerals but with a "2" in the hundreds place.

Sound is received and amplified by a transducer and amplifier means illustrated generally as 250. Its internal circuitry is illustrated but not described because the internal circuitry forms no part of the present invention. It receives sound at the microphone 264 and provides a trigger signal at its output terminal 266. The timing circuit, illustrated generally as 268, is like that illustrated in FIG. 2 (although the ground connection is different to avoid firing of the triac 260 with amplifier biasing current), the similarity in reference numerals again indicating corresponding components.

However, in this circuit, the timing switch terminal 210 and 212, instead of being directly connected to the load 214 and the generator 216 as in FIG. 2, are instead connected to control the gate of a triac 260. The timing switch is connected to the uni-directional nodes 270 and 272 of a bridge rectifier. The bi-directional nodes 274 and 276 of the bridge rectifier are connected to the gate 278 and a principal terminal 280 of the triac 260. The principal terminals 280 and 282 of the triac are connected directly to the load 214 and the generator 216.

The power supply for the amplifier is taken from the same uni-directional nodes 270 and 272 where, whenever the timing switch 268 is not conducting, a full wave rectified sine wave is available. This is then filtered by a power supply filter 286 which has a zener diode 288 for regulation. The output of the power supply filter 286 is applied to the power supply terminal 290 of the transducer and amplifier means 250.

The operation of the circuit of FIG. 4 is similar to that already described above. A sound at the microphone 264 provides a trigger signal at the gate of the SCR 230. The SCR 230 then fires to turn the timing

switch 268 on and begin conduction through the SCR 220. This immediately initiates conduction of the triac 260 and illuminates the lights 214. The capacitance 224 begins its periodic charging as before and when it is sufficiently charged the SCR 220 will turn off and then so will the triac 260.

An important result is that, as soon as the timing switch 268 turns on and the SCR 220 begins conduction, the input of the filter 286 will be shunted by the timing switch itself. This will deprive the transducer and amplifier means 250 of its source of power. It is thereby disabled from providing further trigger signals. This fact insures that, after the selected time period has elapsed, the lights will go off. Also, if an audible alarm is connected paralleled to the light 214, the sound it produces will not continuously create trigger signals which would hold the lights on continuously. Once the circuit is actuated, it will turn itself off. If it was actuated by mistake by a nonrecurrent sound, it will stay off. If the sound which actuated it later recurs, it will again come on.

The timing switch 268 is operated during both half cycles; that is in full wave operation. This, of course, doubles the number of current pulses each cycle which charge the capacitance 224. The time delay will accordingly be shortened if the same component values and adjustments are used.

It is to be understood that while detailed drawings and specific examples given describe a preferred embodiment of the invention they are for the purpose of illustration only, that the apparatus of the invention is not limited to the precise details and conditions disclosed and that various changes may be made therein without departing from the spirit of the invention which is defined by the following claims:

I claim:

1. A timing switch, for connection to a load and to a source of power, for permitting a load energizing current flow through the load and for continuing the load energization for a selected period of time, the switch comprising:

- a. an electronic switch means comprising a first thyristor having its main terminals connected at the timing switch terminals and having a gate operable as its control input terminal;
- b. a timing circuit comprising a series capacitance and rectifier connected at one end to said control terminal and conductively connected at the opposite end to a source of control input power, the rectifier being polarized to permit control input current flow; and
- c. capacitance discharging means connected across said capacitance for at times discharging the capacitance, said capacitance discharging means comprising a second thyristor having its main terminals connected across said capacitance and having its gate connected to receive a triggering signal for actuating said timing switch.

2. A timing switch according to claim 1

wherein a bleeder resistor is shunted across said second thyristor for extending the time delay by bleeding of less charge from the capacitance each cycle than is added.

3. A timing switch according to claim 1 wherein said first thyristor and said second thyristor are silicon controlled rectifiers and said timing circuit is

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connected to the anode terminal of said first thyristor.

- 4. A timing switch according to claim 3 wherein a variable resistance is connected between the gate terminal and the cathode terminal of said first thyristor for control of the time delay of said timing circuit. 5
- 5. A timing switch according to claim 3 wherein a zener diode is connected to limit the voltage applied to said series timing circuit. 10
- 6. A timing switch according to claim 5 wherein said zener diode is conductively connected across said capacitance for limiting the voltage applied to the capacitance.
- 7. A timing switch according to claim 5 wherein the zener diode is connected between a node of said timing circuit and the cathode terminal of said first thyristor. 15
- 8. A timing switch according to claim 5 wherein a variable resistance is connected between the gate 20

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terminal and the cathode terminal of said first thyristor for control of the time delay of said timing circuit.

- 9. A timing switch according to claim 8 wherein the zener voltage of said zener diode is relatively small compared to the maximum instantaneous voltage at the main terminals of said first thyristor.
- 10. An apparatus according to claim 1 wherein
 - a. a triac has its principal terminals serially connected to said load and to said source of power and has a control gate terminal;
 - b. a bridge rectifier circuit is connected at its bi-directional nodes to said gate terminal and a principal terminal of said triac; and
 - c. said timing switch is connected to the unidirectional nodes of said bridge rectifier circuit, whereby said timing switch controls the firing of said triac.

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