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CONDITION RESPONSIVE APPARATUS

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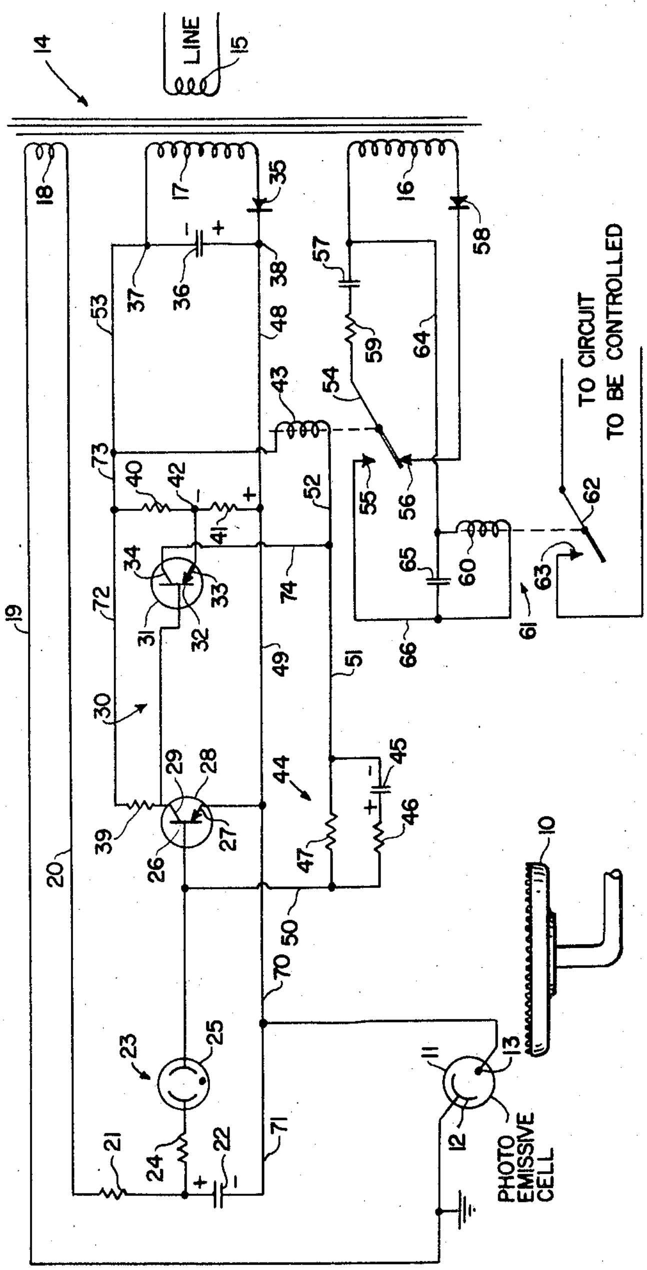

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CONDITION RESPONSIVE APPARATUS

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This invention is concerned with an improved condition responsive apparatus and more particularly with a condition responsive apparatus having a self-checking arrangement.

Condition responsive apparatus is usually utilized to check a condition which causes the apparatus to change from a first condition of operation to a second condition of operation. For example, a photocell may be utilized to check for the presence of fire or flame and to control an output relay in accordance therewith. These devices are capable of an unsafe failure wherein the unit fails to properly respond to either the presence or absence of the condition. The present invention is directed to an improved condition responsive apparatus having a self-checking feature and also utilizing a novel signal transmission arrangement.

The present invention utilizes semi-conductor devices which are essentially current operated devices. By use of a relaxation oscillator arrangement, the minute electrical currents derived from a condition sensing means are periodically supplied to a semi-conductor type of monostable network to cause the network to cycle between a stable and an unstable condition, with output means provided to respond only to the continuous cycling of the monostable network between the two conditions. In such a manner, in the event that the components of the apparatus fail to cause the monostable network to continuously operate in one or the other of its two conditions or states, the output means is not actuated.

It is an object of the present invention to provide a condition responsive apparatus having condition sensing means arranged to charge a capacitor of a relaxation oscillator upon being subjected to a condition, and periodically discharging the capacitor of the relaxation oscillator to trigger a monostable electronic network to thereby control a cycling relay.

It is a further object of the present invention to provide a condition responsive apparatus having condition detecting means arranged to provide pulsating signals of relatively short time duration which are applied to a pulse stretching circuit to thereby derive pulsating signals of relatively long time duration, and having cycling means connected to the output of the pulse stretching means.

These and other objects of the present invention will be apparent to those skilled in the art upon reference to the following specification, claims, and drawing, of which

The single figure is a schematic representation of the preferred embodiment of the present invention.

In the single figure, the reference numeral **10** designates a fuel burner unit which may be a burner in a furnace. The manner in which fuel is admitted to burner **10** and is ignited has not been shown as it forms no part of the present invention.

The reference numeral **11** designates a photo emissive cell so positioned and arranged as to respond to the presence of flame at the burner unit **10**. Photo emissive cell **11** is provided with a cathode **12** and an anode **13**. Upon the electromagnetic wave energy, supplied by a flame, impinging upon the cathode **12** in the photocell, electrons are emitted from the cathode and when the anode **13** has a positive voltage thereon, the electrons pass to the anode. Therefore, photo emissive cell **12** acts as a rectifying diode upon being subjected to electromagnetic wave energy present in the flame. It should be noted at this time that it is within the teaching of the present invention to provide other types of condition sensing means other than the specific one represented by the photo emissive cell **11**. For example, photo emissive cell **11** could be replaced by a flame rod.

Photocell **11** derives its operating voltage from a transformer **14** having a primary winding **15** and having secondary windings **16**, **17** and **18**. The primary winding **15** of this transformer is connected to a source of alternating voltage, not shown. The secondary winding **18** has its upper terminal connected by means of conductor **19** to the cathode **12** of the photocell **11**. The lower terminal of this secondary winding is connected by means of conductor **20**, resistor **21** and capacitor **22** to the anode **13** of photocell **11**.

Upon photocell **11** being subjected to the condition to be detected, in the preferred embodiment this is a flame at the burner unit **10**, the photocell **11** rectifies the alternating voltage present in the secondary winding **18** and the capacitor **22** is charged, the polarity of this charge being indicated in the single figure.

Capacitor **22** forms a part of a relaxation oscillator designated generally by the reference numeral **23** and including a resistor **24** and a gas tube **25**. As is well known, gas tube **25** is normally nonconducting and upon sufficiently high voltage being applied to the electrodes thereof, the gas breaks down and the tube substantially becomes a short circuit.

Also included in circuit of the relaxation oscillator is a base electrode **26** and an emitter electrode **27** of a transistor **28**, a transistor **28** also having a collector electrode **29**. Transistor **28** forms a portion of a pulse stretching and pulse amplifying circuit designated generally by the reference numeral **30**. This pulse stretching circuit includes a second transistor **31** having a base electrode **32**, an emitter electrode **33**, and a collector electrode **34**. The base electrodes **26** and **32** are also known as common electrodes while the emitter electrodes **27** and **33** and the collector electrodes **29** and **34** are also known as input and output electrodes respectively. While P–N–P type transistors are shown, the invention is not limited thereto.

The operating voltage for the pulse stretching circuit **30** is provided by means of secondary winding **17** which in cooperation with a rectifying diode **35** and a capacitor **36** forms a direct current source of voltage having a negative terminal at **37** and a positive terminal at **33**. The pulse stretching circuit **30** is a monostable type network having the two transistors or electronic valves **28** and **31** and having a first stable condition of operation wherein the transistor or electronic valve **28** is conductive and wherein the transistor or electronic valve **31** is nonconductive. This stable condition of the network **30** can be seen by considering the specific circuit connections of the transistors to the source of operating voltage.

The emitter electrode of transistor **28** is directly connected to the positive terminal **38** while the collector electrode of this transistor is connected through a load resistor **39** to the negative terminal **37**. Resistors **40** and **41** comprise a voltage dividing means which is connected across the terminals **37** and **38** and which has an intermediate terminal **42** which is directly connected to the emitter electrode **33** of transistor **31**. The base electrode **32** of transistor **31** is directly connected to the collector electrode **29** of transistor **28**. The collector electrode **34** of transistor **31** is connected by means of a load in the form of a relay winding **43** to the negative terminal **37** of the direct current voltage source.

The collector electrode **34** of transistor **31** is likewise connected through an RC network designated generally by the reference numeral **44** and having a capacitor **45** and resistors **46** and **47** to the base electrode **26** of transistor **28**. From the above traced connections, it can be seen that the voltage present across resistor **41** in the voltage dividing means is of the polarity indicated in the single figure. This voltage is of the proper polarity to make it possible and practical for transistor **28** to bias transistor **31** toward and into the nonconducting region. Furthermore, the emitter to base current of transistor **28** flows through the capacitor **45** of the RC network to charge the capacitor as indicated. The charge on this capacitor continuously tends to leak off through the resistors **46** and **47** and therefore the emitter to base current continuously flows in transistor **28**. This current flow circuit can be traced from positive terminal **38** through conductors **48** and **49**, emitter **27** and base **26** of transistor **28**, conductor **50**, RC network **44**, conductors **51** and **52**, winding **43**, and conductor **53** to the negative terminal **37**. In this above traced circuit, by far the greater portion of the voltage present between the terminals **37** and **38** is dropped across the RC network **44** and therefore very little voltage is developed across the relay winding **43**, thereby causing the relay winding **43** to remain effectively de-energized.

As is well known, when an emitter to base current flows in transistor **28**, also an emitter to collector current flows in this transistor. If now resistor **39** is of such value of resistance that the emitter to collector voltage of transistor **28** is less than the voltage present across resistor **41** then the base electrode **32** of transistor **31**, being directly connected to the lower terminal of resistor **39** is positive with respect to emitter electrode **33** of transistor **31**, thereby causing this transistor to be cut off. This then is the stable condition of the monostable electronic network **30** wherein transistor **28** is in the conducting condition and transistor **31** is in the nonconducting condition.

Referring now to the relay **43**, this relay is provided with a switch means having a movable switch blade **54** and having stationary contacts **55** and **56**. This switch means of relay **43** controls a charge and discharge network for a capacitor **57**. With the switch blade **54** in the position shown, that is with relay **43** de-energized, the rectifying diode **58** charges capacitor **57** through a resistor **59** by means of a circuit which can be traced from the lower terminal of transformer secondary winding **16** through diode **58**, contact **56** and switch blade **54** of relay **43**, resistor **59**, and capacitor **57** to the upper terminal of transformer secondary winding **16**. Upon relay **43** subsequently being energized, the movable switch blade **54** disengages contact **56** and moves into engagement with contact **55**. The charged capacitor **57** is now discharged through a circuit including the winding **60** of a relay **61** having a movable switch blade **62** and a stationary contact **63**. This circuit can be traced from the right hand plate of capacitor **57** through conductor **64**, relay winding **60** and parallel connected capacitor **65**, conductor **66**, contact **55** and switch blade **54**, and resistor **59** to the left hand plate of capacitor **57**. The charge on capacitor **57** is therefore transferred to the winding of relay **61** and likewise charges capacitor **65**. This causes the winding **60** to be energized and so long as the switch means of relay **43** continues to cycle between contacts **55** and **56** at a predetermined rate the relay **61** remains continuously energized and the movable switch blade **62** of relay **61** engages contact **63**. The exact manner in which the switch means of relay **60** is utilized forms no part of this invention and in the single figure it has been indicated that the switch means of relay **61** controls a circuit to be controlled, in accordance with the presence of flame at the burner unit **10**.

The components of the improved condition responsive apparatus and a portion of the operation thereof has been above described. However, for a detailed explanation of the operation of the apparatus it will first be assumed that no flame is present at the burner unit **10**. This is the standby condition of the condition responsive apparatus wherein it is conditioned to detect a flame at the burner unit **10** should a flame subsequently be established. In this condition, the photo emissive cell **11** is nonconductive and the capacitor **22** is in an uncharged state. The monostable electronic network **30** is continuously in its first stable condition wherein transistor **28** is conductive and transistor **31** is nonconductive. The relay **43** is continuously de-energized and therefore the capacitor **57** is continuously connected through diode **58** to be charged from the transformer secondary winding **16**.

Assume now that a flame is established at the burner unit **10**. The electromagnetic wave energy emitted from this flame impinges upon the cathode **12** of photocell **11** and every half cycle of the alternating source consisting of transformer secondary winding **18** in which the anode **13** is positive with respect to the cathode **12**, a pulse of current flows to the capacitor **22**. After a given time period the voltage present on capacitor **22** builds up to a sufficiently high magnitude and the gas tube **25** fires. The capacitor **22** is then quickly discharged through a circuit which can be traced from the upper plate of capacitor **22** through resistor **24**, gas tube **25**, base electrode **26** and emitter electrode **27** of transistor **28**, and conductors **70** and **71** to the lower plate of capacitor **22**. The direction of this current flow is such that the transistor **28** is cut off. In other words, no current flows from the emitter **28** to the base **26** of this transistor and therefore no current flows from the emitter **27** to the collector **29**.

In this condition, the emitter to collector current of this transistor becomes relatively low and there is substantially no voltage drop across the load resistor **39**, thereby effectively connecting the base electrode **32** of transistor **31** directly to the negative terminal **37** of the power supply. This causes the transistor **31** to become conductive and a current flows from the positive terminal **38** of the power supply through conductor **48**, resistor **41**, emitter electrode **33** and base electrode **32**, resistor **39**, and conductors **72**, **73** and **53** to negative terminal **37**. An emitter to collector current also flows from the positive terminal **38** through conductor **48**, resistor **41**, emitter **33** and collector **34**, conductors **74** and **52**, relay **43**, and conductor **53** to the negative terminal **37**. This last traced current flow energizes the winding of relay **43** and causes movable switch blade **54** to move into engagement with contact **55**.

As above described, the charge on capacitor **57** is then transferred to the capacitor **65** shunting the winding of relay **60** and the movable switch blade **62** of relay **61** moves into engagement with contact **63**.

As has been mentioned, the pulse of current derived from the relaxation oscillator **23** is of relatively short time duration and the RC network **44** is provided in the monostable electronic network **30** to provide for a time delay giving a predetermined time period of operation of the network **30** in the second or unstable condition. This time delay is obtained in the following manner: Before the initiating pulse, derived from the relaxation oscillator **23**, occurs the voltage drop across relay coil **43** is small, so that the voltage drop across resistor **47** is slightly less than the D. C. voltage present between terminals **37** and **38**. This difference in voltage includes the residual forward biasing voltage on transistor **28**. The capacitor **45** is charged to nearly the same value of voltage as exists across resistor **47**. Incidentally at that point the charging current of capacitor **45** is very small so that the D. C. current which flows from emitter to base of transistor **28** and through resistor **47** must be sufficiently large to cause a large enough collector current in transistor **28** to hold transistor **31** biased off. As a matter of fact this current must be large enough to cause transistor 31 to become non-conductive and transistor 28 to become conductive even when starting out with transistor 31 in the conductive or on-state in order to achieve reset from the unstable to the stable condition. The initiating current pulse from the relaxation oscillator 23 must be higher in amplitude than this D. C. emitter to base bias current which normally exists in transistor 28 in order to cause a change of state in the transistors from the stable to the unstable condition. Immediate reset to the stable condition, after the very short initiating current pulse disappears, is prevented by the action of capacitor 45. This has the effect of holding transistor 31 in the conductive state for a short time after the initiating pulse has disappeared.

This comes about in the following manner: When transistor 31 is made conductive by the initiating pulse, the voltage drop across the relay suddenly increases to a value a little less than the D. C. supply voltage between terminals 37 and 38. Therefore the voltage drop across resistor 47 suddenly decreases from a relatively high voltage to a very low voltage. Capacitor 45, being charged to the high value of voltage which existed across resistor 47, must therefore discharge. One can also say that when the voltage drop across resistor 47 is suddenly decreased to a much lower value that capacitor 45 discharges through resistor 47. This in effect places a voltage source equal to discharge current of capacitor 45 times the resistance of resistor 47 in opposition to the residual forward biasing voltage, above mentioned. The charge on capacitor 45 gradually leaks off through resistor 47 and after a time interval a net forward biasing voltage is once again present on transistor 28 which causes the monostable electronic network 30 to assume its stable condition. The transistor 28 then becomes conductive and upon becoming conductive the emitter to collector voltage of transistor 28 becomes less than the voltage present across resistor 41, and as explained before, transistor 31 is biased to cutoff, thereby de-energizing relay 43 and causing movable switch blade 54 to again engage contact 56 and disengage contact 55. The above description has traced one cycle of operation of the condition responsive apparatus.

As a flame is still present at the burner unit 10, the capacitor 22 is again charged and after a time period the relaxation oscillator 23 is again effective to cut off transistor 28. Furthermore, the capacitor 57 which was discharged into capacitor 65 is now again charged from transformer secondary winding 16 by means of rectifying diode 58. Therefore, after a short time period, capacitor 22 again has a charge build up thereon sufficiently high to cause gas tube 25 to again ionize and the monostable electronic network 30 is again tripped to its unstable condition wherein transistor 28 is cut off and transistor 31 becomes conductive to thereby again energize relay 43. Energization of relay 43 causes movable switch blade 54 to move into engagement with contact 55 and to disengage contact 56. Once again, the charge on capacitor 57 is distributed to capacitor 65 and to the winding 60 of relay 61.

It can be seen that so long as the frequency of cycling of relay 43, which is caused by the cycling of the monostable electronic network 30 between its stable and unstable conditions, is of a given frequency, the charge on capacitor 65 does not have time to completely leak off through the winding 60 of relay 61 before it is recharged by capacitor 57. So long as the flame is continuously detected at the burner unit 10 by means of the photocell 11, the relaxation oscillator 23 cyclically causes the monostable electronic network 30 to cycle between its stable and its unstable condition, thereby causing relay 43 to be cyclically energized and de-energized. This in turn causes capacitor 57 to be first charged from transformer secondary winding 16 and then to be discharged into capacitor 65 and the winding 60 of relay 61 to thereby maintain relay 61 continuously energized.

It can be seen from the above description that for proper operation and proper detection of the flame at the burner unit 10, the apparatus must cycle between a first and a second condition. Any failure within the condition responsive apparatus which tends to cause the apparatus to continuously operate in one of its two conditions causes relay 43 to either remain in its energized or its de-energized condition. This in turn causes the winding 60 of relay 61 to be de-energized and the switch blade 63 of relay 61 to disengage contact 63. It can therefore be seen that I have provided an improved condition responsive apparatus which is of the self-checking type and which utilizes a novel electronic type pulse stretching circuit in the form of a monostable electronic network to control a relay in a cyclic manner in response to the presence of a condition to be detected.

Other modifications of the present invention will be apparent to those skilled in the art and it is intended that the scope of the present invention be limited solely by the scope of the appended claims.

I claim as my invention:

1. Flame responsive apparatus comprising; flame sensing means arranged to be subjected to a flame and to conduct a low magnitude electrical current when so subjected, a source of voltage, a capacitor; circuit means including said flame sensing means, said source of voltage and said capacitor arranged to charge said capacitor to a given voltage with said low magnitude current upon said flame sensing means being subjected to the flame, a relaxation oscillator including said capacitor arranged to discharge said capacitor upon said capacitor having said given voltage thereon and to produce a series of high magnitude electrical current pulses of short time duration in response to said flame sensing means being subjected to the flame, amplifying and pulse stretching means having an input and an output, circuit means connecting the input of said pulse stretching means to said relaxation oscillator to thereby apply said pulses of relatively short time duration to the input, the output of said pulse stretching means being a series of amplified electrical pulses of relatively long time duration, and cycling means controlled by the output of said pulse stretching means and responsive only to said series of electrical pulses of relatively long time duration.

2. Condition responsive apparatus comprising; condition detecting means including condition sensing means arranged to be subjected to a given condition, said condition detecting means being constructed and arranged to provide reoccurring pulses of electrical energy of a relatively short time duration upon said condition sensing means being subjected to the given condition, pulse stretching means having an input and an output, circuit means connecting said condition detecting means to the input of said pulse stretching means to thereby cause a reoccurring pulse of electrical energy of a relatively long time duration to appear at the output of said pulse stretching means, and cycling relay means including a winding connected to the output of said pulse stretching means and responsive only to said reoccurring pulses of relatively long time duration.

3. Condition sensing apparatus comprising; condition sensing means arranged to be subjected to a given condition and to conduct a law magnitude electrical current when so subjected, a first capacitor, a source of voltage, circuit means including said condition sensing means, said source of voltage and said first capacitor arranged to charge said first capacitor upon said condition sensing means being subjected to the given condition, a first and a second transistor each having a base, an emitter, and a collector electrode, a source of direct current voltage having a positive and a negative terminal, circuit means connecting said emitter electrodes of said first and second transistors to said positive terminal, circuit means con-

necting the collector electrode of said first transistor to said negative terminal, a relay having a winding and switch means controlled thereby, circuit means including said relay winding connecting the collector electrode of said second transistor to said negative terminal, a second capacitor and a resistor connected in parallel, circuit means connecting said parallel connected second capacitor and resistor between the base electrode of said first transistor and the collector electrode of said second transistor, circuit means connecting the base electrode of said second transistor to the collector electrode of said first transistor, a normally non-conductive gas tube capable of being rendered conductive upon a predetermined voltage being applied thereto, circuit means including said gas tube connecting the base and emitter electrodes of said first transistor to said first capacitor to form a relaxation oscillator circuit such that upon a predetermined charge being accumulated on said first capacitor said gas tube discharges a pulse of current of relatively short time duration through the emitter to base circuit of said first transistor in a manner to substantially cut off said first transistor, the charge on said second capacitor maintaining said first transistor cutoff for a relatively long time duration to thereby render said second transistor conductive to maintain said relay winding energized for said relatively long time duration, and means responsive to continue cycling of said relay switch means.

4. Condition responsive apparatus comprising; condition detecting means having condition sensing means arranged to be subjected to a condition to be detected, said condition detecting means being constructed and arranged to provide re-occurring pulses of electrical energy of relatively short time duration upon said condition sensing means being subjected to the condition to be detected; a monostable electronic network having a first stable condition and a second unstable condition to which said electronic network is triggered upon a pulse of electrical energy being applied to the input thereof, said monostable electronic network having a time delay means arranged to maintain said monostable electronic network in said second unstable condition for a given time period of a relatively long time duration; circuit means connecting said condition detecting means to the input of said monostable electronic network to thereby cause said monostable electronic network to be triggered from said stable to said unstable condition in a pulsating manner upon said condition sensing means being subjected to the condition, and cycling relay means having a winding connected to the output of said monostable electronic network and responsive to continuous cycling of said monostable electronic network between said stable and said unstable condition in response to the presence of the condition to be detected.

5. Condition responsive apparatus comprising; a first source of voltage, condition sensing means, a capacitor, circuit means connecting said first source of voltage, said condition sensing means and said capacitor in circuit in a manner to charge said capacitor upon said condition sensing means being subjected to a given condition; a monostable electronic network having a first and a second electronic valve, each of said electronic valves having a common electrode, an input electrode, and an output electrode, a source of direct current voltage having a first and a second terminal, circuit means connecting the input electrode of said first electronic valve to said first terminal, circuit means connecting the output electrode of said first electronic valve through a load impedance to said second terminal, voltage dividing means connected across said first and second terminals, circuit means connecting the input electrode of said second electronic valve to an intermediate point on said voltage dividing means, a relay having a winding and switch means controlled thereby, circuit means connecting the output electrode of said second electronic valve through said relay winding to said second terminal, circuit means connecting the common electrode of said second electronic valve to the output electrode of said first electronic valve, an electrical energy storage network connected from the output electrode of said second electronic valve to the common electrode of said first electronic valve, said monostable electronic network having a first stable condition wherein said first electronic valve is conductive to cause a current to flow between the input and output electrodes and said second electronic valve is cut off such that no current flows between the input and output electrodes; a gas discharge tube, circuit means connecting said gas discharge tube and the common electrode and input electrode of said first electronic valve in series across said first capacitor such that upon the voltage on said capacitor reaching a given value said gas tube is ionized and a pulse of electrical current of relatively short time duration flows between the common and input electrodes of said first electronic valve to thereby trigger said monostable electronic network from said stable condition to said unstable condition, said monostable electronic network being maintained in said unstable condition for a relatively long time duration as determined by said electrical energy storage network, said monostable electronic network thereby cycling between said stable and said unstable condition upon said condition sensing means being subjected to the given condition to thereby cyclically energize and de-energize said relay winding; and further means controlled by said relay switch means and responsive only to continuous cycling of said relay switch means.

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