United States Patent

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[54] **CONTROL SYSTEM FOR ALTERNATELY ENERGIZING TWO SIGNAL LAMPS AT A PREDETERMINED RATE AND IN A FAIL-SAFE MANNER**
17 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **340/83,** 340/248, 340/331
[51] **Int. Cl.** **G08b 5/36**
[50] **Field of Search** 340/83, 248, 331

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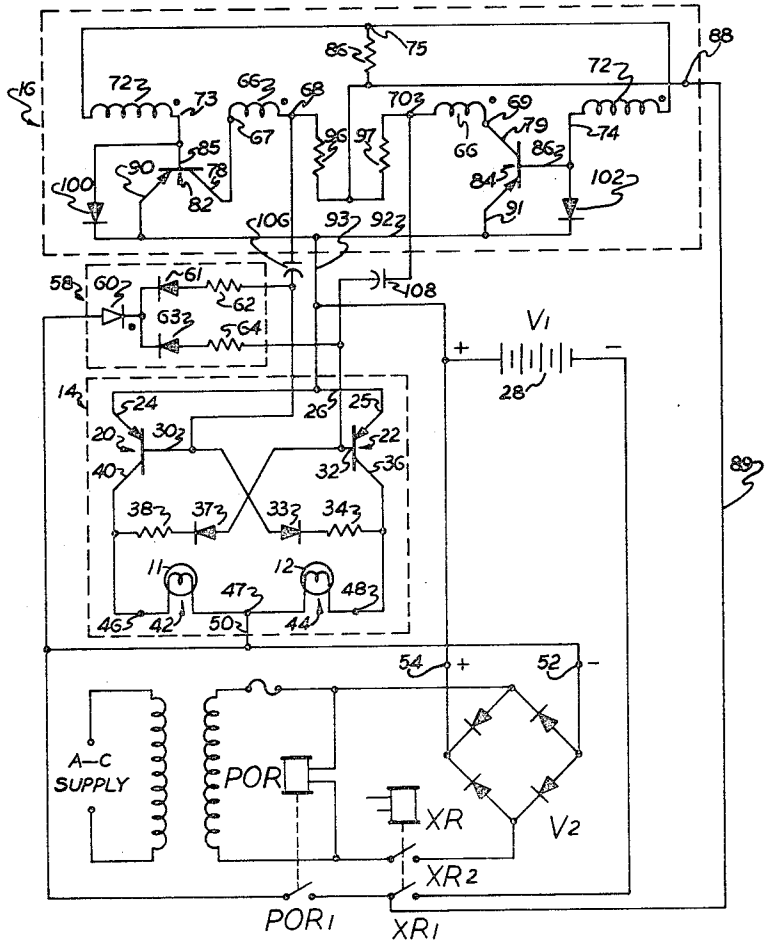
ABSTRACT: A control system for alternately energizing first and second lamp loads at a predetermined rate wherein a bistable circuit is connected with the lamp loads so that one lamp load is energized when the bistable circuit is in one stable operating state and the other lamp load is energized when the bistable circuit is in the other stable operating state. An oscillator system is coupled with the bistable circuit to effect triggering thereof between the two stable operating states. The oscillator system may be supplied from a first power source, such as a battery, and the switching system for a second power source, such as a rectifier operating from commercial power, with means provided to detect failure of the second power source and change the connection of the bistable circuit from the second to the first power source. Means may also be provided to assure that if one lamp load is short circuited the bistable circuit will toggle to and remain in the other stable state and thereby prevent damage to the system while continuing to energize the other lamp load.



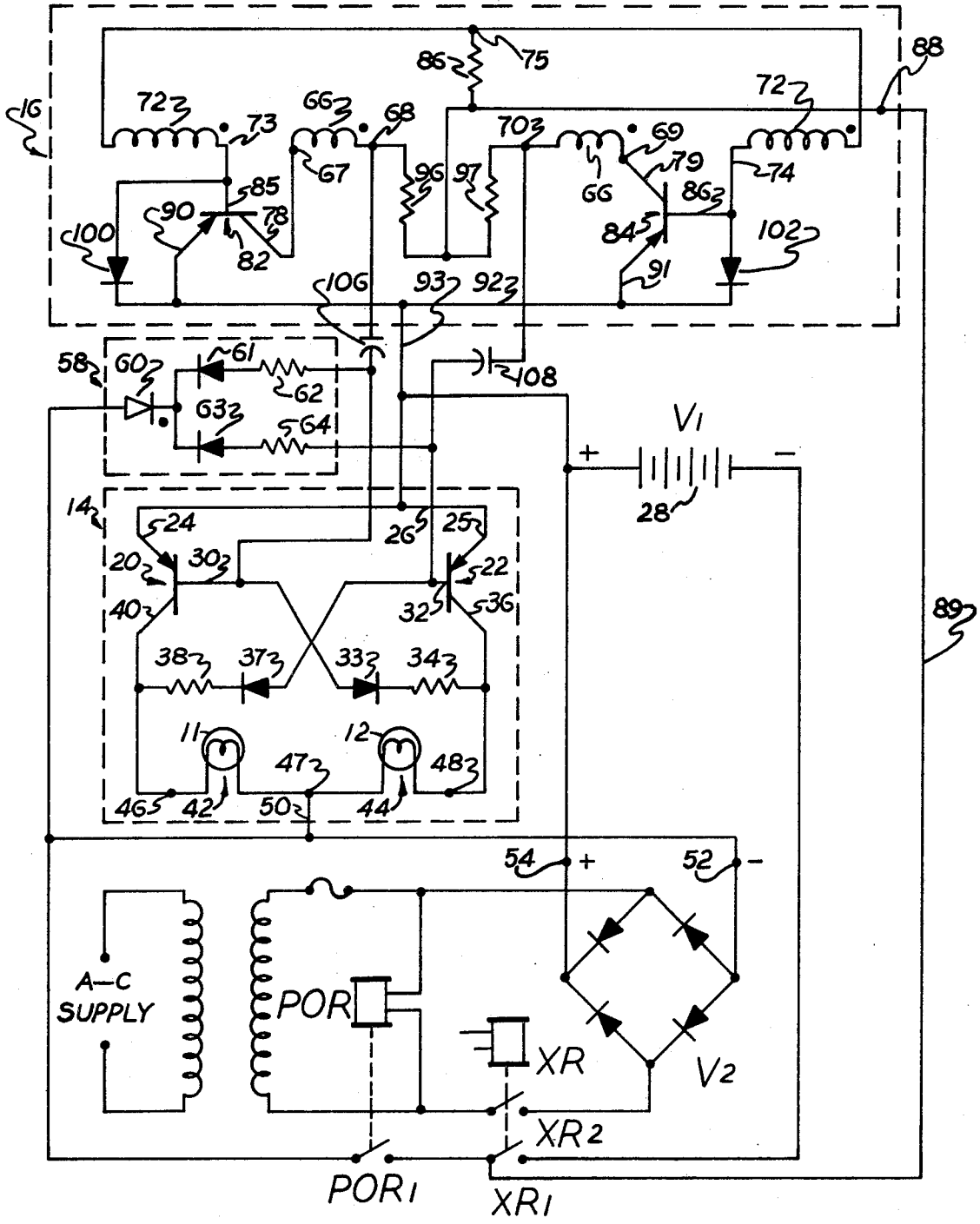


FIG. 1

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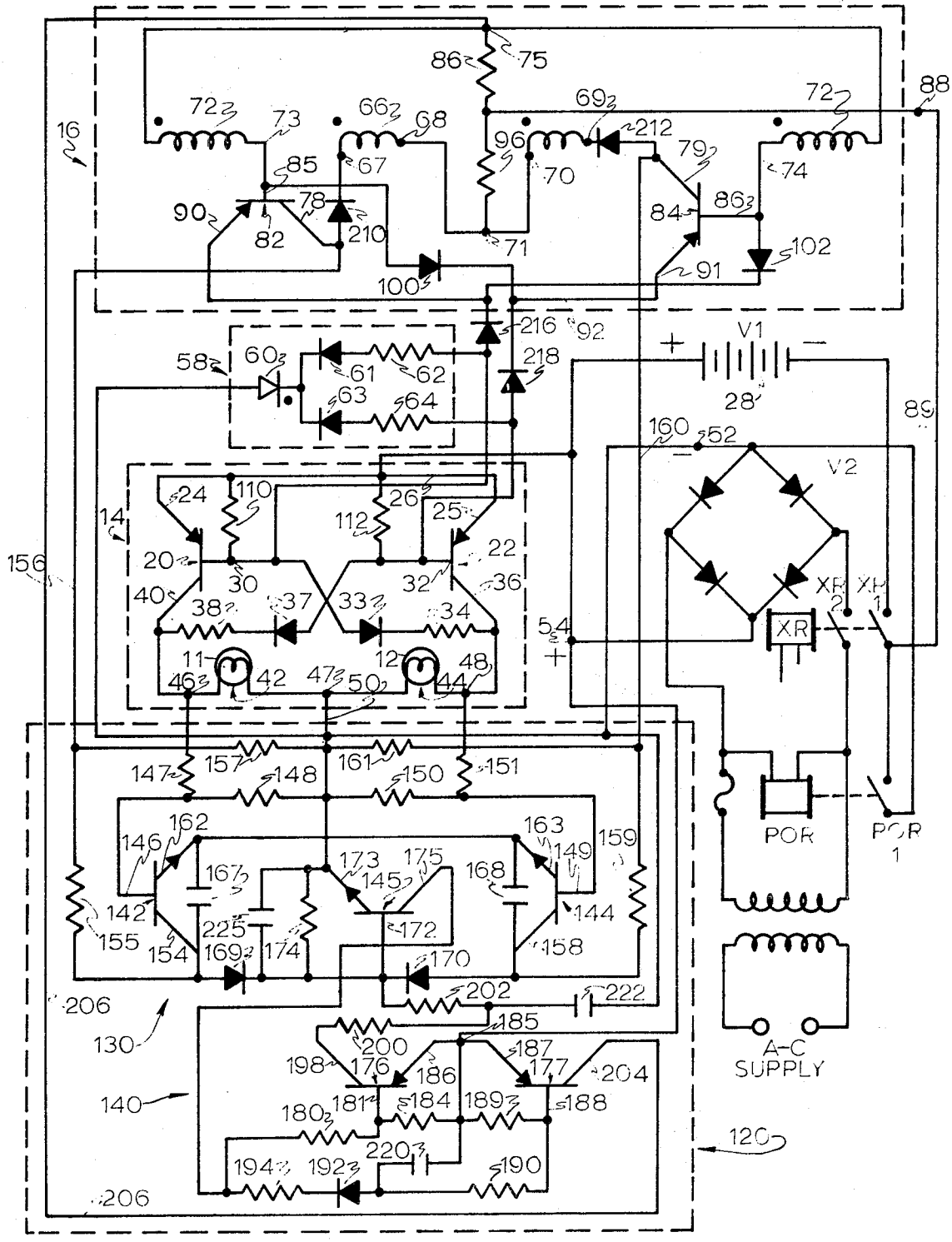

FIG. 2

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CONTROL SYSTEM FOR ALTERNATELY ENERGIZING TWO SIGNAL LAMPS AT A PREDETERMINED RATE AND IN A FAIL-SAFE MANNER

This invention relates generally to a control system for alternately energizing a plurality of electrical load means at a predetermined rate and more particularly to a lamp control system for alternately energizing first and second lamp load means to effect the alternate flashing thereof at a predetermined rate. While the control system of this invention has a wide range of applications, it is especially useful in connection with visible signals, such as the alternate flasher signals employed for traffic control. One very important application for flashing signals of this type is in marking railroad highway crossings and the invention will be particularly described in that connection.

Many types of lamp control units have been provided in the prior art most of which employ moving parts such as electric motors, flasher relays, and electric contacts. The desirability of eliminating such moving-part-type units in favor of a solid-state-type control having no moving parts has long been recognized. Solid-state lamp controls are known, however, heretofore, none of such solid-state lamp controls have been entirely satisfactory for many applications either due to undue complexity, excessive cost, or various other factors. Consequently, solid-state-type lamp controls have not previously been widely adopted for use in flashing lamp signals.

This has been especially evident in the case of the signals employed by railroads to mark their highway crossings. For example, these signals have still continued to employ flasher relays in spite of the obvious advantages and extremely long-operating lifetime which is to be expected from the use of a proper solid-state-type flasher control. Some of the reason for this may become more evident from a listing of the combination of operating characteristics which must be met by a control system for such an application. For example, in addition to being reliable and easy to maintain in proper working order, the control circuit must (1) provide alternate flashing of two lamp loads at a predetermined stable rate e.g., between 30 and 45 flashes per minute) in an environment experiencing extreme temperature variations; (2) provide normal operation of signal lamps from commercial AC power with automatic operation from an auxiliary power source (such as a battery) if the AC power is lost or falls below a level sufficient to properly operate the lamps; (3) not be damaged by the presence of high-voltage transients such as might result from lightning and the like; and (4) operate on the "open circuit principle" to assure "fail-safe" operation. This is, fail-safe means that absence of an aspect on the flashing light signal cannot be regarded as the most restrictive aspect which the signal can display so that any mode of failure must result in one or both of the lamp loads being energized.

It is an object of this invention therefore to provide a solid-state no-moving-part lamp control which meets the foregoing desiderata and provides additional desirable safety features as well.

It is another object of this invention to provide a new and improved solid-state control system for alternately energizing a plurality of electrical loads at a predetermined rate.

It is a further object of this invention to provide a new and improved solid-state control system for alternately energizing a plurality of electrical loads at a predetermined rate which is rugged in construction, reliable in operation, capable of a long maintenance free-operating lifetime, and not prone to damage due to a sustained short circuit of one of the loads or due to high-voltage transients such as might occur from lightning or the like.

Briefly stated, in its broad aspects, the invention comprises the combination of a bistable circuit and an oscillator circuit coupled with the bistable circuit to cause triggering thereof between the two stable operating states. Means are provided to connect first and second lamp loads with the bistable circuit so that the first lamp load is energized when the bistable circuit is in one stable state and the second lamp load is energized when the bistable circuit is in the other stable state.

In another aspect of the invention, the oscillator circuit is normally connected with a first power source and the bistable circuit is normally connected with a second power source which supplies energization to the electrical loads. Means may be provided to detect the voltage level of the second power source and effect the connection of the bistable circuit with the first power source, so that both the transistor-switching system and the lamp loads are supplied from the first power source, whenever the second power source is below a preselected voltage level.

Another feature of the invention is the provision of means for protecting the control system from damage in the presence of a sustained short-circuit condition associated with one of the lamp loads while allowing the other lamp load to be energized thereby assuring fail-safe operation for even such an extreme mode of failure.

The novel features believed characteristic of the invention are pointed out with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the following drawing wherein like or similar components in the different figures are designated by the same reference numerals and in which:

FIG. 1 is a schematic circuit diagram of one embodiment of the control system of this invention providing a flashing lamp signal of the type used by railroads to mark their highway crossings; and

FIG. 2 is a schematic circuit diagram of another embodiment of the invention.

Virtually, every type of signal system used by railroads depends for its safety and proper functioning upon the fundamental track circuit. Briefly, a track circuit is an electrical circuit a part of which is formed by the rails. Track circuits of various types are employed and the construction and operation of such track circuits are well known in the art. Accordingly, and since the track circuit per se forms no part of the present invention, no detailed description of such track circuits need be provided herein. In passing however, it may be helpful to state that, in general, a track circuit includes a track relay which is arranged to remain energized for all normal conditions of the track and to become deenergized when the track relay is short-circuited, the energy is shunted away from the track relay or the circuit between the source of energization and the track relay is broken.

In addition, such signal systems require a dependable source of power for their operation. Usually, a normal supply is provided with an auxiliary, or standby, supply available in the event that the normal supply gets too low in voltage for good lights or is off for any reason. Presently, the normal supply is usually alternating current from a commercial source, with a storage or primary battery for reserve. Whether storage or primary batteries are used for this purpose they must be of sufficient capacity to supply power for the flasher signal for a definite standby period, the length of which is prescribed by the railroads. For some applications it may be desirable to use primary batteries for both normal and standby power.

Although neither the track circuit nor the dependable power supply are themselves a part of the control system of this invention they form a part of an overall warning signal system. Accordingly, in order to provide for a better understanding of the invention as applied to a railroad highway-crossing flasher signal, contacts of the track relay XR and the power-off relay POR are shown in the schematic circuit diagram of the drawing. The function of the foregoing relays has already been discussed generally so that the following description incorporating such relays will provide a more complete description of both the organization and mode of operation of the present invention in this particular operating environment.

For example, operation of the flasher signal is started by the track relay XR the contacts of which are held open as long as such relay is energized. Also, as long as the normal power supply, shown as being provided from a commercial AC

supply, has a voltage sufficient to provide good lights, the power-off relay POR remains energized and the contacts thereof remain open as shown; closing of the contacts POR_1 being operative to cause the lamp loads to be energized from the auxiliary power supply, shown as a battery. The manner in which this is accomplished will become evident from the following description.

Referring now to FIG. 1 of the drawing in more detail, reference numeral **10** designates generally a lamp control system in accordance with an embodiment of this invention for effecting alternate energization of first and second lamp loads **11** and **12** respectively. As shown, control system **10** comprises a bistable circuit **14** which is coupled with a transistor-switching system **16** which causes triggering of the bistable circuit between the two stable states. Lamp loads **11** and **12** are connected with the bistable circuit **14** so that one of the lamp loads is energized when the bistable circuit is in one stable operating state and the other lamp load is energized when the bistable circuit is in the other stable operating state. Since the bistable circuit **14** is triggered between its two stable operating states by oscillator circuit **16**, the lamp loads **11** and **12** flash alternately at a rate determined by such oscillator. Conveniently, the control system **10** may be arranged to cause each lamp load to be energized for approximately the same length of time so that the total time for a pair of lamps is 100 percent. This is the mode of operation usually specified by the railroads for the signals used to mark their highway crossings.

In the particular arrangement illustrated in FIG. 1 the bistable circuit is a transistor circuit of the type sometimes referred to in the art as a flip-flop circuit. Also, oscillator circuit **16** is shown as a transistor-magnetic-switching system oscillator of the type disclosed and claimed in U.S. application Ser. No. 727,938 (Docket GS–D–19) filed concurrently herewith and assigned to the same assignee as this invention. In the oscillator circuit of that patent application a magnetic core transformer feedback coupling means is connected as a current transformer for the transistor collector current and a voltage reference means is provided against which the feedback winding of the saturable core transformer operates so as to set the rate of change of flux in the transformer core. In this way change in the switching cycle of the transistors to changes in the magnitude of the DC supply is minimized. Such an oscillator is employed herein as a very stable timing means to control the rate at which the bistable circuit **14** is triggered between its stable operating states.

Bistable circuit **14** is shown as comprising a pair of transistor devices **20** and **22** having their emitter electrodes **24** and **25** connected in common to one side of a suitable direct-current voltage source V_1, shown as battery **28**, and also to the same polarity terminal of the voltage source V_2, shown as a rectifier operating from an AC supply. The base electrodes **30** and **32** are cross-connected as shown. Thus, base electrode **30** of transistor **20** is connected through the series combination of oppositely poled diode **33** and resistance **34** to the collector electrode **36** of transistor **22**. Similarly, base electrode **32** of transistor **22** is connected through the series combination of oppositely poled diode **37** and resistance **38** to the collector electrode **40** of transistor device **20**. Collector electrodes **40** and **36** are also connected to first and second output means designated generally at **42** and **44** respectively. Output means **42** includes the terminals **46** and **47** while output means **44** includes the terminals **47** and **48**. Terminal **47** is common to both output means **42** and **44** and is connected to the conductor **50** as shown. Conductor **50** is connected through contacts POR_1 and XR_1 to the other side of the battery **28** and also through contacts XR_2 (when closed in the manner hereinafter described) to the negative side (terminal **52**) of the power source V_2, shown as bridge rectifier **53** operating from an AC supply, which may conveniently be the commercial AC supply, to provide DC at the output terminals **52** and **54**.

It is also a feature of this invention to provide means for protecting the control system **10** from damage due to the presence of high-voltage transients such as might be caused by lightning and the like, for example. To this end, means are provided for causing both transistor devices **20** and **22** of the bistable circuit **14** to become conductive simultaneously to thereby cause the energy above a preselected level to be delivered through the lamp loads **11** and **12** shown as being connected with output means **42** and **44** respectively.

Accordingly, a protection circuit means **58** is provided including voltage reference means **60**, shown as a semiconductor breakover device. Voltage reference means **60** is connected from conductor **50** and through a diode **61** and resistance **62** to base electrode **30** of transistor **20** and also through diode **63** and resistance **64** to base electrode **32** of transistor **22**. Consequently, voltage exceeding the breakover level of reference means **60** causes both transistor devices **20** and **22** to be switched to deliver the excess energy through the lamp loads **11** and **12** and prevent damage to the control system due to such higher voltage.

While a particular transistor bistable circuit has been illustrated it is to be understood that any suitable bistable circuit may be used in the control system of this invention. Also, any suitable oscillator may be used to effect the triggering of the bistable circuit between its two stable operating states. In addition, while specific conductivity-type transistors have been shown, the opposite conductivity-type devices may be employed equally well by proper reversal of the polarities of the potentials connected to the various electrodes of the device. Further, voltage source V_1 and V_2 have been shown, respectively, as being provided by a battery and a rectifier operating from an AC source. It is to be understood, however, that both voltage sources V_1 and V_2 may be batteries or, where a standby power supply is not required for fail-safe purposes, a single voltage source may be used, which may be either batteries or a rectifier operating from an AC source.

In the arrangement illustrated in FIG. 1, lamp loads **11** and **12** are arranged to be normally energized by bistable circuit **14** from the power source V_2 and the oscillator **16** energized from power source V_1. For example, a direct-current voltage is available at the output terminals **52** and **54** of the power source V_2 which is normally connected to bistable circuit **14**. As shown, terminal **54** of power source V_2 is connected to the common conductor **26** of bistable circuit **14** while terminal **52** is connected to the conductor **50** and hence to the common output terminal **47** of bistable circuit output means **42** and **44**. At the same time, oscillator **16** is supplied from the power source V_1, shown as battery **28**; power source V_1 also serving as the auxiliary, or standby, power source for the entire system if the voltage of the normal lamp source (V_2) falls below a preselected level or for one reason or another is off entirely.

As indicated, although the bistable circuit **14** may be triggered between its two stable operating states by any suitable oscillator circuit, the transistor-magnetic oscillator circuit disclosed and claimed in application Ser. No. 727,938 now U.S. Pat. No. 3,551,845, is a preferred one. Not only is such oscillator circuit relatively inexpensive, especially where high efficiency is not a factor, but the switching cycle can be made nearly constant in spite of fluctuations in the magnitude of the DC voltage supply. That is, changes in the switching cycle with fluctuations in the supply voltage are minimized. Accordingly, a very stable rate of flashing of the lamps may be provided.

Oscillator circuit **16** is shown as a stable switching system comprising a saturable core transformer including a primary winding **66** having terminals **67** and **68** and **69** and **70** and a feedback winding **72**, having terminals **73** and **74** and a center tap terminal **75**. The terminals **67** and **69** of primary winding **66** are connected to the collector electrodes **78** and **79** of a pair of transistor devices **82** and **84** while the terminals **73** and **74** of feedback winding **72** are connected between the base electrodes **85** and **86** of such transistor devices. The center tap terminal **75** of feedback winding **72** is connected through a suitable resistance **86** to a terminal **88**. Terminal **88** is arranged to be connected over conductor **89** to the negative terminal of battery **28** through contacts XR_1 of the track relay. Also, when relay POR is deenergized conductor **89** is con-

nected to the conductor 50 through contacts POR_1. The emitter electrodes 90 and 91 of transistor devices 82 and 84 are connected in common to the conductor 92 which is arranged to be connected over conductor 93 to common conductor 26 of bistable circuit 14 and also to the positive terminals of the power sources V_1 and V_2; that is, the positive terminal of battery 28 (V_1) and the positive terminal 54 of the bridge rectifier (V_2). The terminals 68 and 70 of primary winding 66 are connected through respective resistances 96 and 97 to the terminal 88.

To assure that the switching cycle of the transistors of oscillator circuit 16 will not change markedly with fluctuations in the voltage of power source V_1 (battery 28), a voltage reference means is provided to set the rate of change of flux in the core of the transformer. As described more fully in the foregoing referenced patent application Ser. No. (Docket GS–D–19b), the transformer is connected for operation as a current transformer for the transistor collector current and the secondary of the transformer (the feedback winding 72) operates against the voltage reference to set the rate of change of flux in the core. As shown in the arrangement of FIG. 1 this is conveniently accomplished, to provide a desired low-voltage reference, by providing an additional PN-junction barrier voltage in each feedback loop. To this end, a semiconductor diode 100 is connected from base electrode 85 to emitter electrode 90 of the transistor 82. Similarly, semiconductor diode 102 is connected from base electrode 86 to emitter electrode 91 of transistor 84. Thus, the voltage of the feedback winding 72 during each half-cycle of operation is set by the voltage reference established by two semiconductor barriers—the emitter base junction barrier of the conducting transistor and the PN-junction barrier of a diode.

Transistor-switching system 16 is suitably coupled with bistable circuit 14 to cause the bistable circuit to be triggered between its two stable operating states at a rate determined by the switching cycle of the switching system 16. Moreover, the coupling is such that even the occurrence of a short-circuit condition at one of the loads will not only not damage the control system but will allow for the continuous energization of the load which is free of any such short circuit.

This is accomplished in the arrangement shown in FIG. 1 by means of capacitances 106 and 108 operatively connected so as to couple, during each switching of the transistors in the oscillator circuit 16, a signal to one side of the bistable circuit 14 operative to turn the transistor associated with that side off and a signal to the other side of such bistable circuit operative to turn the transistor associated with that other side on.

For example, capacitance 106 is connected from terminal 68 of primary winding 66 to the base electrode 30 of transistor 20. Also, capacitance 108 is connected from terminal 70 of primary winding 66 to base electrode 32 of transistor 22.

With the foregoing coupling when, for example, transistor 82 switches on, a short duration pulse is developed and applied through capacitance 106 to the base electrode of transistor 20. This pulse is of a polarity to turn transistor 20 off. At the same time transistor 84 would have been switched off and a short duration pulse is developed and applied to base electrode 32 of transistor having a polarity to turn transistor 22 on. Accordingly, when transistor 82 of switching system 16 switches on transistor 22 of bistable circuit 14 is switched on and vice versa.

Since by the foregoing coupling arrangement no continuous drive is supplied from oscillator 16 to the bistable circuit 14, a short-circuit condition at one of the lamp loads will not damage the control system nor make it fail unsafely. That is, if a short circuit exists at one of the lamp loads the short duration pulses applied to bistable circuit 14 from oscillator 16 will attempt to trigger the bistable circuit to the state to supply power to the shorted load, however, due to the cross coupling of the transistors 20 and 22 bistable circuit 14 will switch back to the operating state which does not have a short circuit. Thus, the lamp load which is free from the short circuit will be substantially continuously energized.

In describing the operation of the control system it is to be assumed, initially, that the relay XR and the power-off relay POR are both energized, indicating (1) that the signal lamps are not required to be energized since there is no train or railroad car in the section of track and (2) that the normal power source V_2 is available and of a voltage sufficient to provide good lights from the lamp loads 11 and 12. Thus, contacts XR_1, XR_2, and POR_1 are in the open positions as illustrated in FIG. 1. When the section of track is occupied however, the relay XR becomes deenergized and contacts XR_1 and XR_2 are no longer held open so that battery 28 is connected across oscillator circuit 16 and the power source V_2 is connected across bistable circuit 14 thereby starting the control system into operation.

For example, with battery 28 connected to the oscillator circuit 16, the transistor devices 82 and 84, due to the feedback action of the feedback winding 72, operate to cause battery 28 to be switched with alternating polarity across the primary winding 66 of the transformer. The conducting time for the respective transistor device is determined by the time required for the transformer core to become saturated after each reversal of the conducting conditions of the transistors. Usually, this time is inversely proportional to the magnitude of the voltage of the direct current supply V_1, however, since in the arrangement shown in FIG. 1, a voltage reference means is provided to set the rate of change of flux in the core substantially independent of the magnitude of the supply V_1, this time remains nearly constant in spite of variations in the magnitude of V_1.

Aside from the novel means for stabilizing the output of the oscillator 16 as referred to above, the oscillator operates in well-known manner. That is, one transistor saturates and the other is cut off with the feedback winding 72 operating to maintain such condition. That operation continues, however, only until the transformer core saturates at which time the flux in the core collapses and the feedback voltage reverses to cause the transistors to quickly assume opposite conducting conditions, the "on" transistor turning off and the "off" transistor turning on. This condition remains until the core saturates in the opposite direction when the conducting conditions again reverse. This mode of operation continues with the switching of the transistors controlled by the buildup and collapse of the magnetic flux in the transformer core, and, since in the preferred arrangement the effect on the switching cycle due to fluctuations in the voltage supply are minimized, the system switches at a nearly constant rate.

Oscillator circuit 16 is coupled to bistable circuit 14 so that the bistable circuit is triggered between its two stable states in accordance with the switching of the transistor devices 82 and 84. For example, during one-half cycle of operation of the oscillator 16 when transistor 82 switches on a pulse is coupled through capacitance 106 to the base electrode 30 of the transistor 20 of bistable circuit 14 of a polarity to turn transistor 20 off. At the same time transistor 84 is switched off and this caused a pulse to be coupled through capacitance 108 to the base of transistor 22. The polarity of this pulse is such as to cause transistor 22 to turn on and to remain on due to the regenerative feedback of the circuit; such regenerative feedback also causing the other transistor device 20 to Similarly, during the other half-cycle of operation of the oscillator 16, opposite polarity pulses are coupled through capacitances 106 and 108 to the base electrodes 30 and 32 of transistors 20 and 22 causing transistor 20 to switch on and transistor 22 to switch off.

From the foregoing it is evident that the lamp loads 11 and 12 are energized alternately at a rate determined by the rate at which bistable circuit 14 is triggered between its two stable states. Since this triggering is provided by a relatively stable oscillator circuit 16, the rate of flashing of the lamps can be made very stable also.

In further accordance with this invention, it can be seen that as long as POR relay is energized the lamp loads will be supplied from power source V_2; POR relay being energized as

long as the voltage of power source V_2 is at least sufficient to provide good lights from the lamps. Once the voltage of power source V_2 falls below this level, or for one reason or another is entirely out, POR relay becomes deenergized causing contact POR_1 to close. When POR_1 contact closes, the bistable circuit **14** is disconnected from power source V_2 and connected to power source V_1. Thereafter, both the oscillator circuit **16** and the bistable circuit **14**, with its associated lamp loads **11** and **12**, are supplied from the power source V_1. Thus, there has been provided a system which will function in a fail-safe manner in the event of failure of the normal power source for the lamps (e.g., commercial AC power). That is, the battery power source V_1, which normally supplies only the oscillator **16**, operates at all times also as a standby power source which is available in the event the normal supply for the lamps fails.

Also, when capacitors **106** and **108** are included in the coupling between the oscillator circuit **16** and bistable circuit **14**, there will not be a continuous drive throughout the respective half-cycles of operation of the oscillator **16** to the base electrodes of the transistors in the bistable circuit **14**. Accordingly, the control system will not be damaged due to the occurrence of a short-circuit condition in one of the lamp loads. Under such a condition the bistable circuit will continuously toggle back to the stable operating state where the lamp load is not shorted to allow that lamp load to become continuously energized. Thus, even for such an extreme mode of failure as a shorted lamp load the control system still functions in a fail-safe manner since, although it is no longer possible to provide alternate flashing of two lamp loads, there is still an aspect on the signal—one lamp load energized.

In the foregoing arrangement, since a short duration pulse is applied to the base electrode of the transistor in bistable circuit **14** with which the shorted lamp load is associated tending to turn such transistor on, some short-circuit current flows through such transistor during this short period during each cycle of operation. Thus, if the short-circuit current is large and the short-circuit condition remains for too long a time, the transistor could eventually fail.

The arrangement illustrated in FIG. 2 overcomes this difficulty and provides a full and complete protection for such a sustained short-circuit condition of one of the lamp loads.

Briefly, in the arrangement of FIG. 2 essentially the same basic control system is provided, namely, a bistable circuit **14** which supplies lamp loads **11** and **12** and with such bistable circuit being triggered between its two stable operating states by an oscillator **16**.

In addition, means are provided to sense the occurrence of a short-circuit condition at the respective lamp loads and when such a condition is found to exist means are actuated to disable the oscillator **16**. That is, if a short-circuit condition has been detected, the oscillator **16** is rendered inoperative and remains inoperative as long as such a short-circuit condition exists.

In FIG. 2 oscillator circuit **16** and bistable circuit **14** have substantially the same arrangement as do those circuits in FIG. 1. In FIG. 2, however, bistable circuit **14** includes bypass resistance **110** and **112** connected between the respective base and emitter electrodes of transistors **20** and **22**. Also, since the emitter electrodes of all of the transistors **20**, **22**, **82**, and **84** are not connected in common to the positive side of the voltage source, diode **100** must be connected from the base electrode **85** of transistor **82** to the emitter electrode **91** of transistor **84**. Similarly, diode **102** is connected from base electrode **86** of transistor **84** to the emitter electrode **90** of transistor **82**. In addition diodes **114** and **115** and **116** and **118** are provided the purpose of which will become evident from the description which follows.

The operation of the control system shown in FIG. 2 is similar to the operation of the arrangement shown in FIG. 1 except that since capacitances **106** and **108** are not employed in the coupling arrangement transistor **20** of bistable circuit **14** becomes conductive when transistor **82** of oscillator **16** is conductive and transistor **22** of bistable circuit **14** becomes conductive when transistor **84** of oscillator **16** is conductive. Thus, lamp loads **11** and **12** are energized in correspondence with the conducting conditions of the transistors of oscillator circuit **16**. Thus, transistors **20** and **22** are supplied a continuous drive throughout the respective half-cycles of operation of oscillator circuit **16**.

The oscillator circuit thus, operates as previously described in connection with FIG. 1 to cause bistable circuit **14** to be triggered between its two stable operating states at a rate determined by the repetition rate of the oscillator. The lamp loads **11** and **12** are, therefore, alternately energized at the same rate.

Since in the foregoing described arrangement, continuous drive is supplied to the transistors of the bistable circuit **14**, the control system is subject to damage from a short circuit at the lamp loads. Where the application is one where this possibility of failure can be tolerated, nothing more is required to provide a good signal lamp-flasher control. Where this cannot be tolerated, there is shown in FIG. 2 means for providing short circuit protection which will not only protect the control system from damage in the event of a short circuit of one of the lamp loads but allows the other lamp load to be continuously energized.

In FIG. 2 the novel short-circuit protection arrangement is designated generally by the reference numeral **120**. As shown, the protection arrangement **120** comprises means **130** for detecting the presence of a short-circuit condition at one of the lamp loads **11** or **12** and means **140** responsive to the detection of a short-circuit condition at one of the lamp loads means **130** for rendering the oscillator circuit **16** inoperative whereby the bistable circuit **14** will assume, and remain in, the operating state effective to cause energization of the lamp load which is free of a short circuit.

Means **130** for detecting the presence of a short-circuit condition at one of the lamp loads comprises transistor devices **142** and **144**, one operatively associated with each of the output means **42** and **44** of bistable circuit **14**, and a transistor **145** operatively associated with transistor **142** during one-half cycle of operation and with transistor **144** during the other half-cycle of operation. For example, transistor device **142** is arranged in combination with transistor **145** to detect a short-circuit condition at output means **42**, to which lamp **11** is connected, while transistor device **144** is arranged in combination with transistor **145** to detect a short-circuit condition at output means **44**, to which lamp load **12** is connected.

To this end, the base electrode **146** of transistor **142** is connected through resistance **147** to output terminal **46** of bistable circuit **14** and through resistance **148** to output terminal **47** thereof. Also, the base electrode **149** of transistor **144** is connected through resistance **150** to output terminal **47** of bistable circuit **14** and through resistance **151** to output terminal **48** thereof. Collector electrode **154** of transistor **142** is connected through resistance **155** and over conductor **156** to the collector electrode **78** of transistor **82** of switching system **16**; collector electrode **78** being returned to the negative side of the voltage source through resistance **157** which is connected between conductors **156** and **50**. Similarly, collector electrode **158** of transistor **144** is connected through resistance **159** and over conductor **160** to the collector electrode **79** of transistor **84** of switching system **16**; collector electrode **79** being returned to the negative side of the voltage source through resistance **161** which is connected between conductors **160** and **50**. Emitter electrodes **162** and **163** of transistors **142** and **144**, respectively, are connected in common to the negative side of the voltage source. Bypass capacitors **167** and **168** are connected between the collector and emitter electrodes of the respective transistors **142** and **144**.

The collector electrodes **154** and **158** of transistors **142** and **144**, respectively, are connected through respective diodes **169** and **170** to the base electrode **172** of transistor **145**; the emitter electrode **173** of which is connected in common with emitter electrodes **162** and **163** of transistors **142** and **144** to the negative side of the voltage source V_2. A bypass resistance

174 is connected between the base and emitter electrodes of transistor 145. The collector electrode 175 of transistor 145 is connected to the means 140 which will now be described.

The means 140, which operates to disable the switching system 16 when the means 130 detects a short-circuit condition, comprises switch means arranged so that when a short-circuit condition has been detected by means 130 oscillator 16 is disabled. Specifically, in the circuit illustrated, the center tap terminal 75 of winding 72 of the switching system is brought to substantially the potential of the positive side of the voltage sources V_1–V_2, which action renders the switching system 16 inoperative.

This is accomplished in the arrangement shown in FIG. 2 by a pair of transistors 176 and 177. Transistor 176 is arranged to "latch" transistor 177 in its saturated condition once such transistor has been switched on. When transistor 177 is switched on it effectively connects the center-tap terminal 75 of winding 72 of the switching system 16 with the positive terminals of the voltage sources.

To this end, the collector electrode 175 of transistor 145 is connected through resistance 180 to the base electrode 181 of transistor 176 and also through resistance 184 to the common junction 185 between the emitter electrode 186 of transistor 176 and the emitter electrode 187 of transistor 177. The junction 185 is in turn connected to the positive terminals of the voltage sources. Base electrode 188 of transistor 177 is connected through bypass resistance 189 to the emitter electrode 187 thereof and also through resistance 190, diode 192 and resistance 194 to collector electrode 175 of transistor 145. The collector electrode 198 of transistor 176 is connected through resistance 200 and resistance 202 to the base electrode 172 of transistor 145. The collector electrode 204 of transistor 177 is connected over conductor 206 to the center-tap terminal 75 of oscillator 16.

Since the control system should be able to operate under normal conditions with bistable circuit 14 supplied from voltage source V_2, which is usually a rectifier operating from an AC supply, means are provided to assure base drive for transistors 145 and 177 when the rectified voltage goes to zero during each half-cycle of AC supply. This is conveniently accomplished in the arrangement shown in FIG. 2, by connecting a capacitance 220 across resistances 189 and 190 to assure the required base drive for transistor 177. Similarly, the required base drive for transistor 145 is assured by connecting a capacitance 222 from the negative side of the voltage source to the junction between resistances 200 and 202.

Under the particular situation when bistable circuit 14 is supplied by a rectifier operating from an AC supply, there will be a period during each half-cycle of such supply when terminal 52 of the rectifier will be more negative than the negative terminal of battery 28. Under such a condition, current would flow from the negative terminal of battery 28, through resistance 96 and hence in two paths to the base electrode 172 of transistor 145 causing it to turn on. For example, one path includes the portion of primary winding 66 between terminals 68 and 67, resistance 155 and diode 169 and the other path includes the portion of primary winding 66 between terminals 70 and 69, resistance 159 and diode 170. Allowing transistor 145 to be turned on at such times would result in false indications of a short circuit condition.

This difficulty can be readily overcome by blocking such current flow, such as by connecting a blocking diode in each path. To this end, diode 210 is connected between collector electrode 78 of transistor 82 and terminal 67 of primary winding 66. Similarly, a diode 212 is connected between the collector electrode 79 of transistor 84 and terminal 69 of primary winding 66.

Also, to assure that the oscillator circuit 16 will be positively disabled when the center-tap terminal 75 is connected through transistor 177 to the positive terminal of the voltage source, a diode 216 is connected from the base electrode 30 of transistor 20 to the emitter electrode 90 of transistor 82 and a diode 218 is similarly connected from base electrode 32 of transistor 22 to emitter electrode 91 of transistor 84. Diodes 216 and 218 introduce an additional voltage drop to make more certain that the transistors 82 and 84 will be reverse-biased when the terminal 75 is connected through transistor 177 to the positive terminal of the voltage source.

Detecting the existence of a short-circuit condition when the load comprises lamps is made much more difficult due to the fact that the resistance of an unheated lamp filament is only about one-tenth that of a heated filament. Accordingly, for a brief period each time the lamp loads are alternately energized they resemble a short circuit. To assure that this oscillator circuit 16 is not rendered inoperative due to this normal operating condition, a time constant is provided so that, unless what appears to be a short-circuit condition remains for more than a predetermined time, transistor 145 does not turn on. That is, unless such an apparent short-circuit condition persists beyond the predetermined time the condition is ignored by the detecting means 130.

The time constant is provided in the detecting arrangement shown in FIG. 2 by connecting a capacitance 225 from the base to emitter electrodes of transistor 145. During one half-cycle of operation of the control system, when the condition at lamp load 11 is being sensed, the time constant is provided by the combination of capacitance 225 and resistance 155 and during the other half-cycle of operation, when the condition of lamp load 12 is being sensed, the time constant is provided by the combination of capacitance 225 and resistance 159.

In describing the operation of the arrangement shown in FIG. 2, it will be assumed, initially, that both lamp loads 11 and 12 are free of any short-circuit condition. In such a case the control system operates in normal manner. That is, bistable circuit 14 is triggered between its two stable operating states at a rate determined by the switching cycle of oscillator circuit 16. Accordingly, lamp loads 11 and 12, which are supplied from bistable circuit 14, are alternately energized and deenergized at that same rate. Since in this arrangement no capacitive coupling means are required, the arrangement is such that the switching on of transistor 82 causes transistor 20 to be switched on and the switching on of transistor 84 causes transistor 22 to be switched on. Regenerative feedback operating to cause the other transistors to be turned off as has already been described.

Under the foregoing normal operating condition short-circuit protection means 120 has no effect at all on the functioning of the lamp control system. For example, assume that transistor 82 of oscillator circuit 16 has just been switched on. When this happens current begins to flow through resistance 155 and diode 169 to begin charging capacitance 225. A short time (about 0.1 millisecond, for example) after transistor 82 is switched on, transistor 20 in bistable circuit 14 is caused to be switched on and a voltage will appear at its collector electrode 40 and hence at output terminal 46. This voltage causes current to flow through resistance 147 and into base electrode 146 of transistor 142 causing such transistor to turn on, which action shunts away the current previously flowing though resistance 155 and stops any further charging of capacitance 225. The charge on capacitance 225, due to the current flow through resistance 155, discharges through resistance 174. Capacitance 225 is selected to assure that, for the worst case, capacitance 225 will not charge to a voltage sufficient to cause transistor 145 to be turned on before transistor 142 (or 144 for the other half-cycle) is turned on. This assures that transistor 145 will not be turned on due to the apparent short-circuit condition due to the very low resistance of the cold lamp filament.

Assume now, that a short-circuit condition exists at lamp load 11. Transistor 82 would switch on as previously described and capacitance 225 would begin to charge. Since a short-circuit condition exists at lamp load 11, however, there is essentially no voltage at the collector electrode 40 of transistor 20 nor at output terminal 46 so that transistor 142 does not turn on. As a result, capacitance 225 continues to charge through resistance 155 and diode 169 until it reaches a voltage suffi-

cient to cause transistor **145** to be turned on. This in turn causes transistors **176** and **177** to turn on and, due to regenerative feedback between transistors **176** and **177**, transistor **177** is maintained in its on condition. With transistor **177** fully on (saturated) the positive side of the voltage source is effectively connected to the center-tap terminal **75** of the oscillator circuit **16**. Consequently, both transistors **82** and **84** of oscillator circuit **16** are reverse biased preventing them from turning on. Oscillator circuit **16** thus becomes completely inoperative and no longer operates to trigger the bistable circuit **14**.

Because of the cross-coupling of transistors **20** and **22** of bistable circuit **14**, the existence of the short-circuit condition at lamp load **11** causes bistable circuit **14** to at once toggle back to the other stable operating state to thereby energize lamp load **12**. Since oscillator **16** has been rendered inoperative and just described, bistable circuit **14** will remain in this operating state and lamp load **12** will remain energized. Thus, although lamp load **12** does not flash on and off, it does remain on so that an aspect is present on the signal and hence the control system fails safe.

If the short-circuit condition clears itself while a train or car is still present within the zone to be protected by the signal, lamp load **12** would remain energized as just described. However, once the train or car passes through the zone and XR relay again becomes energized, the control system when again caused to operate would function in the normal flashing mode. If the short-circuit condition remains then the control system when again caused to operate would function to maintain the lamp load which is free of a short energized. That is, the oscillator **16** would remain inoperative.

While only preferred embodiments of the invention have been shown by way of illustration, many changes and modifications will occur to those skilled in the art and it is, therefore, to be understood that the appended claims are intended to cover all such changes and modification as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by letters patent of the United States is:

1. A control system for alternately energizing a pair of electrical loads at a predetermined rate comprising:

A. A bistable circuit having first and second output means connectable with first and second electrical loads, said first load being adapted to be energized when said bistable circuit is in one stable operating state and said second load being adapted to be energized when said bistable circuit is in the other stable operating state;

B. An oscillator system connectable with said bistable circuit for causing said bistable circuit to be triggered between its two stable operating states at a rate determined by the repetition rate of said oscillator system; and

C. Means coupled to the electrical loads and responsive thereto for protecting said control system from damage in the presence of a sustained short-circuit condition at one of said electrical loads while allowing for the continued energization of the other electrical load,

said means for protection said control from damage in the presence of a sustained short-circuit condition at one of the electrical loads while allowing for the continued energization of the other electrical load comprises means for rendering said oscillator circuit inoperative in the presence of a sustained short-circuit condition at one of said electrical loads,

said means for rendering said oscillator system inoperative comprises:

A. First and second transistors each operatively coupled with a respective one of said loads and arranged to be rendered conductive in correspondence with such load when the load is free of any short-circuit condition;

B. A third transistor operatively coupled with said first and second transistors and arranged to remain nonconducting so long as said first and second transistors become conductive in correspondence with the energization of said loads and to become conductive when either of said first and second transistors fails to become conductive; and

C. Switch means responsive to said third transistor becoming conductive for rendering said oscillator system inoperative.

2. The control system recited in claim **1** wherein said switch means comprises a fourth transistor operatively connected with a fifth transistor arranged to latch said fourth transistor in its conducting condition once said fourth transistor has been rendered conductive.

3. A control system for alternately energizing a pair of electrical loads at a predetermined rate comprising:

A. A bistable circuit having first and second output means connectable with first and second electrical loads, said first load being adapted to be energized when said bistable circuit is in one stable operating state and said second load being adapted to be energized when said bistable circuit is in the other stable operating state;

B. An oscillator system connectable with said bistable circuit for causing said bistable circuit to be triggered between its two stable operating states at a rate determined by the repetition rate of said oscillator system; and

C. Means coupled to the electrical loads and responsive thereto for protecting said control system from damage in the presence of a sustained short-circuit condition at one of said electrical loads while allowing for the continued energization of the other electrical load,

said means for protecting said control from damage in the presence of a sustained short circuit condition at one of the electrical loads while allowing for the continued energization of the other electrical load comprises means for rendering said oscillator circuit inoperative in the presence of a sustained short-circuit condition at one of said electrical loads,

said oscillator system includes a pair of transistor devices connected with a saturating core feedback coupling means so that switching of the conducting conditions of said transistor devices is determined by the period between the occurrence of opposite sense flux saturations in said core, said oscillator system also including voltage reference means connected with said feedback coupling means to set the rate of change of flux in said core and means for limiting the current controlled by said transistor devices whereby the repetition rate of the output signals produced by the oscillator system is substantially independent of voltage variations in the power supplied to the oscillator system.

4. The control system recited in claim **3** wherein said oscillator system is normally connectable with a first power source and said bistable circuit is normally connectable with a second power source, and including means responsive to an undervoltage condition for disconnecting said bistable circuit from said second power source and connecting it with said first power source.

5. The control system recited in claim **1** wherein said oscillator system includes a pair of transistor devices connected with a saturating core feedback coupling means so that switching of the conducting conditions of said transistor devices is determined by the period between the occurrence of opposite-sense flux saturations in said core, said oscillator circuit also including means to limit the current controlled by said transistor devices and voltage reference means connected with said feedback coupling means to set the rate of change of flux in said core whereby the repetition rate of the output signals produced by the oscillator system is substantially independent of voltage variations in the power supplied to the oscillator system.

6. The control system recited in claim **5** wherein said oscillator system is normally connected with a first power source and said bistable circuit with a second power source and including means responsive to detection of a voltage at said second power source below a preselected level for disconnecting said bistable circuit from said second power source and connecting it with said first power source.

7. The control system recited in claim 6 wherein said first power source comprises batteries and said second power source comprises a rectifier operating from an AC source.

8. A control system for alternately energizing a pair of electrical loads at a predetermined rate comprising:

A. A bistable circuit having first and second output means connectable with first and second electrical loads, said first load being adapted to be energized when said bistable circuit is in one stable operating state and said second load being adapted to be energized when said bistable circuit is in the other stable operating state;

B. An oscillator system connectable with said bistable circuit for causing said bistable circuit to be triggered between its two stable operating states at a rate determined by the repetition rate of said oscillator system; and

C. Means coupled to the electrical loads and responsive thereto for protecting said control system from damage in the presence of a sustained short-circuit condition at one of said electrical loads while allowing for the continued energization of the other electrical load,

a voltage reference means,

and means connected with said bistable circuit and said voltage reference means for energizing both electrical loads connected therewith whenever the voltage supplied to said control system exceeds said reference so that said control system will not be damaged by such higher voltages.

9. The control system recited in claim 7 including a voltage reference means, and means connected with said bistable circuit and said voltage reference means for energizing both electrical loads connected therewith whenever the voltage supplied to said control system exceeds said reference so that said control system will not be damaged by such higher voltages.

10. A signal lamp-flasher control for alternately energizing and deenergizing a pair of lamp loads at a preselected rate comprising:

A. A bistable circuit having first and second output means connectable respectively with said lamp loads, said bistable circuit being adapted for normal connection with a first power source so that said first output means is energized when said bistable circuit is in one stable operating state and said second output means is energized when said bistable circuit is in the other stable operating state;

B. An oscillator system connectable with a DC voltage supply and including a pair of transistor devices connected with a saturating core feedback coupling means so that the switching of the conducting conditions of said transistor is determined by the period between the occurrence of opposite sense flux saturation in said core, said system also including voltage reference means connected with said feedback coupling means to set the rate of change of flux in said core and means for limiting the current controlled by said transistor devices whereby the repetition rate of the output signal produced by the oscillator system is substantially independent of voltage variations in the power supplied to the oscillator system; and

C. Means coupling said oscillator system with said bistable circuit so that said bistable circuit is triggered from one stable state to the other in accordance with the operation of said oscillator.

11. The signal lamp-flasher control recited in claim 10 including means coupled to the lamp loads and responsive thereto for protecting said control from damage in the presence of a sustained short-circuit condition at one lamp load while allowing for the continued energization of the other lamp load.

12. The signal lamp-flasher control recited in claim 11 wherein said means for protecting said control system from damage includes means for detecting the presence of a sustained short-circuit condition and switch means responsive to the detection of such a condition for causing said oscillator system to be rendered inoperative.

13. The signal lamp-flasher control recited in claim 12 wherein said switch means is operative when actuated to reverse bias the pair of transistor devices in the oscillator system and maintain them in a nonconducting condition.

14. The signal lamp-flasher control recited in claim 10 including a voltage reference means and means connected with said bistable circuit and said voltage reference means for simultaneously energizing both said lamp loads whenever the voltage of said reference means has been exceeded so that voltages greater than said reference cannot cause damage to the control.

15. The signal lamp-flasher control recited in claim 10 wherein said oscillator system is normally connected with a first power source and said bistable circuit with a second power source and including means responsive to the detection of a voltage of said second power source below a preselected level for causing said bistable circuit to be disconnected from said second power source and connected with said first power source.

16. The signal lamp-flasher circuit recited in claim 15 wherein said second power source comprises a rectifier operating from an AC supply and said first power source comprises batteries.

17. A control system for alternately energizing a pair of electrical loads at a predetermined rate comprising:

A. A bistable circuit having first and second output means connectable with first and second electrical loads, said first load being adapted to be energized when said bistable circuit is in one stable operating state and said second load being adapted to be energized when said bistable circuit is in the other stable operating state;

B. An oscillator system connectable with said bistable circuit for causing said bistable circuit to be triggered between its two stable operating states at a rate determined by the repetition of said oscillator system;

C. A first power source connected to supply said oscillator system;

D. A second power source connected to supply said bistable circuit; and

E. Means responsive to detection of a voltage at said second power source below a preselected reference level for disconnecting said bistable circuit from said second power source and connecting it with said first power source.

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