A groundless two-wire D.C. flasher with overcurrent and overvoltage protective features. A positive and a negative terminal connect the flasher into a D.C. circuit to be repeatedly interrupted. Control transistors drive output transistors into and out of conduction between the terminals at a frequency set by a multivibrator. The interrupted circuit can be a negative or a positive ground system. Supplied by a diode, a capacitor stores sufficient energy to maintain the bias to the flasher's transistors as the flasher makes and breaks the circuit. A sampling resistor detects high currents and controls a transistor that, when it begins to conduct, reduces the base drive to the transistor output stage. Transient overcurrents, like incandescent lamp start-up currents, are permitted. Substantial, continuing overcurrents produce overvoltages across the partially conductive output stage. A Zener diode voltage sensor detects these, and after a short delay, shuts down the flasher.

13 Claims, 2 Drawing Figures
D. C. FLASHER

BACKGROUND OF THE INVENTION

This invention relates to D.C. flashers and more particularly to a flasher circuit that continually interrupts a D.C. circuit to cause a pulsing or flashing D.C. output.

Many flashers presently used today, for example in automotive lamp flashing circuits, are mechanical switches that make and break physical contact alternately to complete and to interrupt circuits into which they are connected. These switches suffer from known defects such as contact pitting, dirtying, etc. Consequently they often need replacement. Moreover, the physical making and breaking of an electrical circuit can cause sparking, dangerous if an accident results in fuel spillage or if trucks for example transport volatile loads. Usually a mechanical flasher gives no indication of the condition of the circuit it controls.

Transistorized D.C. flashers commonly suffer from several basic defects. One is that the circuit is ordinarly usable with only either a positive or a negative ground system. This requires separate circuits for each ground system, and of course, a very large increase in the cost of manufacture results in comparison with that of a single, standard circuit.

Ordinary three-wire transistorized automobile circuitry, with its own circuit ground and transistor bias connections, commonly stays on, consuming power and decreasing its life expectancy whenever the ignition switch is on, and a final connection is often used to cause the circuit to function.

Transistor overcurrent sensitivity is a second well known defect. The effect of overcurrents on a simple transistor flashing arrangement ordinarily is loss of the current controlling transistor or transistors. The flasher must, then, be replaced as a result of short circuits or even transient overcurrents. Such a characteristic is intolerable in, for example, truck circuits where hard driving, constant vibrations, and constant vehicle operation results in many intermittent short circuits. Like mechanical switches, ordinary solid state flashers may give no indication of an inappropriate circuit condition in the flashed circuit.

The susceptibility of transistors to overcurrent failure is compounded where a transistor flasher controls and flashes incandescent lamps. The current characteristics of incandescent lamps are such that extreme currents occur with each cold filament lamp starting condition. If the flashing transistors are to be protected against the over-currents, they must somehow be permitted to operate during the high-current lamp starting period. Providing current protection in transistorized flashers for lamp circuits has, therefore, presented significant difficulties.

Ordinarily, any transistor or mechanical flasher is completely separate and apart from circuit protectors for the flashed circuit. The common separate circuit protection arrangements have their own shortcomings. Fuse protection is widespread in automotive applications. Particularly in trucking and other heavy duty automotive applications, intermittent shorting is a recurrent problem. An operator faced with repetitive fuse failures and who wants to continue to drive can replace rated fuses with fuses rated much above safe current levels, or he can substitute a makeshift shorting wire for the fuse. The resulting dangers are apparent.

Other fuse deficiencies are the inability of ordinary fuses to reset, and the possibility of fuse arc fires. If emergency flashers are operated from the vehicle's electrical circuit, an extreme overcurrent, a short to ground, for example, can weld the circuitry and render the emergency lamps inoperative when they are most needed.

BRIEF SUMMARY OF THE INVENTION

The D.C. flasher of this invention overcomes the problems noted above in relation to both mechanical flasher switches and known transistorized flashers. It provides a two wire, groundless flasher, one that is not destroyed by short circuits, and in addition protects itself and the circuit it interrupts.

All of the circuitry of the flasher according to this invention relies, not on a fixed circuit ground, but on intracircuit voltage values that are independent of the ground of the electrical system. This flasher, therefore, can be connected into either a positive or a negative ground system. Supplied by a diode, a capacitor stores sufficient energy to maintain the appropriate transistor bias voltages during conduction of an output stage that is one or more transistors connected between two terminals connecting the flasher into the flashed D.C. circuit. Zener diodes measure appropriate voltages at important circuit points.

The flasher is current sensitive, responding to high currents first by increasingly reducing conduction in the output stage transistor or transistors. A very carefully adjusted sensing resistor, in series with output current path, detects currents passed by the flasher and controls a transistor that reduces, via intermediate control transistors, the base drive to the output stage transistors when currents approach an unacceptable level.

This current sensitivity coupled with voltage sensing protective features permits the flasher's use with and control of incandescent lamps. The usual high lamp starting current may be sufficient to indicate an overcurrent, thereby reducing conduction in the flasher's output transistors by increasing the voltage across the current sensing resistor as just mentioned. A voltage sensing section of the circuit prevents further conduction only if an overcurrent continues. Starting currents for incandescent lamps drop to acceptable levels soon after initial energization and the restraint on the output stage transistors is removed. The circuit can, therefore, be current sensitive and yet be used to control or flash incandescent lamps. The flasher actually alters the characteristic curve of an incandescent lamp circuit by refusing to supply the current levels ordinarily demanded with each lamp flash. In addition to the convenience and safety benefits outlined above, this reduction in starting current permits the use of transistors that carry lower currents and places less of a demand on the electrical system supply.

Returning to the voltage increase sensitive part of the circuit, if an unacceptably high current is not transient, as in lamp starting, but is the result of, say, a short, the voltage across the conducting output stage will increase as the output stage transistor drive is decreased to limit the load current. This voltage is detected and compared, by a sampling Zener diode. After a small time delay sufficient to permit a return to ordinary circuit operation, the Zener diode drives a series of control transistors to completely deprive the output transistor stage of base drive. By doing this, the flasher stops all
conduction and protects the electrical system it flashes as well as protecting the otherwise vulnerable output transistor or transistors.

An operator can install a fuse with a higher current rating, or short the fuse terminals, and still the flasher will interrupt the circuit if it detects a sustained overcurrent. Thanks to the current limiting feature, the flasher will not permit currents sufficient to weld portions of the protected electrical system even during that short portion of the conduction cycle before voltage response occurs. The flasher, if used to flash emergency lamps, prevents welding and therefore destruction of the emergency circuit.

Because the flasher circuit according to the invention is a two wire device, it can be connected in series in the circuit it is to interrupt and can be turned on by a series switch, for example the turn signal actuating switch. No part of the flasher circuit needs to continue running when the flasher is not in use.

The flasher is resetting. During each new current conducting operation or half cycle, the current is sensed, as well as the voltage, and flashing is resumed if the objectionable condition has ceased or is only transient.

If flashing does not occur this gives a clear indication to operating personnel that an unacceptable circuit condition has arisen. The flasher does not just continue to flash until a fuse interrupts the circuit or some part of the circuit is destroyed. If a substantial but intermittent short occurs, interrupted flashing operation will signal this, and yet, the flasher circuit will give all of the operation possible under the given condition.

One flasher feature gives good temperature stability, important where transistor operating voltages are used to detect and control circuit conditions. The use of off-setting PNP and NPN transistors preferably on a single integrated circuit chip, prevents the temperature dependence that might be expected.

The foregoing and other advantages of the invention will appear more fully in relation to the following detailed description of a preferred embodiment of the invention, as illustrated in the accompanying drawings.

IN THE DRAWINGS

FIG. 1 is a schematic illustration, in block form, showing a flasher according to the invention and connected into an automotive turn signal circuit.

FIG. 2 is a circuit diagram of a preferred flasher circuit.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

Turning to the drawings in detail, FIG. 1 shows a flasher 10 connected in series with a battery 12, an ignition switch 13, a directional signal switch 15, and alternate lamp loads 16 and 17. The battery 12 has a first terminal 19 connected to ground 20 and a second terminal 21 which may be either positive or negative depending on whether the automotive electrical system is a positive or negative ground system. FIG. 1 shows only a very simple system to illustrate the connection of the flasher 10 into an exemplary D.C. circuit.

FIG. 2 illustrates a preferred circuit for the flasher 10 of FIG. 1. A pair of terminals or connectors 25 and 26 are the connections of the flasher circuit in series in the D.C. circuit, for example between the ignition switch 13 and the turn signal actuation switch 15 of FIG. 1.

Whether the flashed circuit is positive or negative ground, the connector 25 need only be connected positive relative to the connector 26. If, for example, the FIG. 1 circuit is a positive ground system, connector 26, the negative connector connects with the ignition switch 13, and connector 25, the positive connector, connects with the turn signal actuating switch 15. Of course, if FIG. 1 shows a negative ground system, these connections are reversed.

Three parallel output transistors Q1, Q2 and Q3 conduct load current between output connections 25 and 26 in a load current path that includes three parallel current dividing resistors 27, 28, and 29, and a current sensing resistor 30, described in detail below. A diode 31, in parallel with the load current path, between the output connectors, completes the output stage. The diode 31 protects the circuit in the event of mistaken reverse polarity connection of the flasher 10. The diode 31 bypasses the remaining circuitry and gives continuous load energization if a positive voltage is mistakenly applied to the connector 26. The diode 31 also provides an important measure of transient protection. The diode serves as an inductive clamp in one direction of current flow, passing any transient inductive current spike flowing opposite ordinary load current.

The three output transistors Q1, Q2, and Q3 are driven together into and out of conduction. Flashing conduction of the output transistors is timed by a free-running multivibrator or flip-flop 35. The multivibrator 35 is a conventional circuit configuration with a pair of transistors Q4 and Q4' arranged in differential amplifier relation and with appropriately chosen resistive and capacitive circuit elements selected in the ordinary way to give the desired output frequency. A current amplifier that includes transistor Q5, its base-collector resistor 36, and a constant voltage base drive Zener diode 37 supplies substantially constant current to the multivibrator 35.

A Zener diode 37 maintains a substantially constant voltage thereacross to provide a constant bias to the current amplifier transistor Q5, assuring frequency stability of the flip-flop 35.

Because the transistor circuit of the flasher is not a "three wire" system, but is groundless, and because the transistor bias must be taken from the very energy source controlled by the circuit, some means must assure constant transistor operation. To this end, a diode 39 charges a capacitor 40 during the intervals of nonconduction of the output transistors Q1, Q2 and Q3. The capacitor 40, of course, maintains adequate voltage across the circuit when the output transistors do conduct.

One multivibrator output that is taken from the junction of a pair of voltage divider resistors 43 and 44 is delivered, via a line 45, as a base drive to a transistor Q6 that is connected in series with a resistor 48. The transistor Q6 is the first of a set of control transistors Q6, Q7, and Q8 that control or drive the output transistors. Conduction by the transistor Q6, when a positive multivibrator output is applied by line 45, draws current from the base of the transistor Q7, bringing that transistor into conduction. In turn, the conduction of the transistor Q7 applies the appropriate base drive to a final output stage control transistor Q8, which has its base connected to the junction of the collector of the transistor Q7 and a series resistor 49. The transistor Q8 is in series with a resistor 51. The bases of output tran-
sistors Q1, Q2, and Q3 connect with the junction of the resistor R51 and the collector of the transistor Q8. Conduction by the transistor Q8 thus triggers the output transistors into conduction.

A second output from the multivibrator 35 occurs at the junction of a pair of voltage divider resistors R53 and R54 and is delivered by a line 55 to a transistor Q9. The output delivered to the base of the transistor Q9 goes positive when the first multivibrator output on the line 45 drops to zero. Conduction by the transistor Q9 establishes a base drive for a further transistor Q10 whose base connects with the junction of a pair of voltage divider resistors R57 and R58 connected in series with the transistor Q9.

The transistor Q10 is in series with a resistor R60, and a parallel branch of series resistors R63, R64 and R65. The transistor conducts to bring the voltage at the junction 61 of the transistor Q10 and resistor R60 near that at line 32. This charges a capacitor R62, in parallel with the resistor R63, and supplies base drive to a clamping or turn off control transistor Q11. The base of the transistor Q11 connects with the junction of the resistors R64 and R65. The bias thus applied to the base of the transistor Q11 assures that no base drive at line 45 will be supplied to the base of the transistor Q6. The transistor Q11, then, acts to clamp the base drive line 45 with the negative line 32 of the circuit, and assures that the transistors Q6, Q7, and Q8, and the output transistors Q1, Q2, and Q3 are clamped off during the positive output occurring at the line 55 from the multivibrator 35. Of course each time the second multivibrator output occurring on the line 55 ends, and the first output on the line 45 begins, the output transistors Q1, Q2, and Q3 will again conduct. In ordinary operation, this sequence occurs over and over, alternately to flash connected lamps or other loads on and off.

As briefly mentioned above, a resistor R30 of low resistance, plays an important part in the protection of both the flasher circuit and the circuit into which the flasher 16 is series-connected. The resistor R30 is a current sensing resistor that has a resistance precisely selected to begin signaling a high current at a chosen load current level. In a lamp circuit, that current may be reached by the lamp starting current, the high current that ordinarily occurs upon the energization of a darkened incandescent lamp.

The current sensitive protective circuitry includes, in addition to the sensing resistor R30, a current control transistor Q12 connected in parallel with the transistor Q11. A pair of resistors R68 and R69 connect in series voltage divider relation between the Zener diode R37 and the negative connector R26 at the negative side of the sensing resistor R30. As the current through the resistor R30 increases, under ordinary lamp starting conditions for example, the voltage across the sensing resistor R30 increases, the voltage at the base of the transistor Q12 begins to be pulled down from the voltage applied by the Zener diodes R37. This transistor, then, begins to conduct and to starve the transistor Q6 of base drive, but Q12 does not necessarily come on sufficiently to clamp transistor Q6's base drive on line 45 to the negative line 33. Rather, conduction by the transistor Q6 is decreased, during the early part of the on cycle, conduction by the transistor is decreased, and in turn, the transistor Q6 conducts less thereby reducing the base drive current drawn from the base of the three output transistors. These three transistors, Q1, Q2 and Q3 begin to resist increasing current conduction.

If the increased current sensed by the resistor R30 is just normal lamp starting current or other transient high current, the three output transistors minimize the starting current, and little or no voltage increase occurs across the sensing resistor. The controlled loads then begin to conduct at their much lower, stable current levels. In the case of lamp flashing, the flasher 10 effectively reverses the typical incandescent lamp circuit operating curve by prohibiting the ordinary extreme starting currents.

If the high current sensed by the resistor R30 is an overcurrent resulting from, for example, a short circuit, normal load operating conditions with attendant normal load currents do not ordinarily return. Rather, reduction of the base drive to the output transistors Q1, Q2, Q3 causes a continuing voltage increase across the transistors, from the positive line 32 to the negative line 33. Resistors R65, R64, and R63 and a further voltage sampling Zener diode R72, connected in series across the circuit, act as a voltage sensing arrangement. Normally, when the output transistors are conducting and the transistor Q10 is non-conductive, the voltage across the Zener diode R72 is a low value, below its rated voltage of about 5 volts, because the voltage difference between the lines 32 and 33 is small. With a higher voltage across the circuit, the Zener begins to conduct, and first offsets the normal discharging of the capacitor R62, recharging the capacitor. As the capacitor R62 approaches its fully charged condition, the current through the Zener diode R72 provides base drive for the clamping transistor Q11, to clamp the line 45 to ground and shut down the output stage. The time delay provided by capacitor R62 permits sufficient time at the beginning of each on cycle to permit a return to normal operating current. An intermittent short can, therefore, be treated by the current limiting arrangement, the resistor R30 and the transistor Q12, without interrupting the flashing function completely.

Because of the importance of the voltages established across the sensing resistor R30, a very accurate resistance and good connections are important. Preferably the resistor R30 is a Monel strip with the connector R26 connected at one end and the collectors of the output transistors Q1, Q2, Q3 connected at the other end. The resistance R30 can be determined empirically for proper operating conditions by affixing the line 33 to the body of the Monel strip and affixing a line 75 at a point on the strip that gives exactly that resistance required for proper current sensing. It will be appreciated that the resistance value of the Monel strip is extremely low, the currents sensed are high, and any loss at the point of connection to the strip would produce a voltage error. For that reason connections to the strip at the lines 33 and 75 and at the collectors of the output transistors should be direct welds to the Monel strip or some other suitable lossless connection.

Transistors Q4, Q4', and Q5 can be provided by a single, commercially available integrated circuit. So, too, transistors R9, Q9, Q10, Q11, and Q12 can be a single integrated circuit. Use of an NPN transistor as Q6 and a PNP transistor as Q12 adds temperature stability to the current sensing and limiting function insofar as temperature dependent variations in operation of the transistor Q6 is offset substantially by opposing current dependent variations in transistor Q12's operating.
conditions. This effect is further enhanced by the use of a single integrated circuit for both transistors to assure that both transistors are exposed to substantially identical temperatures.

Modifications of the preferred embodiment of the flasher circuit described above will be apparent to persons skilled in the art. For example, more than one output stage with current limiting and voltage sensing arrangements could be commonly driven from the outputs of the multivibrator. Two or more flashers or flasher output control sections can be locked together in phase and frequency or driven in alternately flashing, wig-wag flasher, manner. The current sensing and voltage sensitive shut off features of the invention are useful with three wire systems as well as the preferred two wire circuit described. Other modifications will appear in connection with particular uses of the flasher circuit. The above description of a preferred embodiment is, then, not intended to limit the scope of protection of the applicants’ invention, set forth in the appended claims.

We claim:
1. A D.C. Flasher circuit for connection in series into a series connected circuit path of electrical conduction including a load and a source of D.C. potential to cause alternate opening and closing of the circuit path; the flasher circuit having first and second connectors for connecting the flasher in series connection onto said circuit path of electrical conduction, said connectors defining the only means for electrical connection of said flasher circuit into said circuit path of electrical conduction, output transistor means having a current conduction path connected in series between the connectors, means connected with the output transistor means for controlling the output transistor means to cause conduction and nonconduction of the output transistor means, timing circuit means connected with the controlling means for timing the rate of conduction and nonconduction of the output transistor means, circuit voltage supply means for deriving a stabilized voltage from voltage present across the connectors when the output transistor means is nonconductive, and means connected with the voltage supply means for establishing a substantially stable voltage of a pre-determined value between circuit points in the flasher circuit to provide transistor operating potentials independent of ground, whereby the flasher circuit is operable upon connection between two ungrounded points in the path of electrical conduction to the exclusion of any other electrical connection.
2. The flasher circuit according to claim 1 wherein the means for stabilizing is a diode-capacitor combination having a capacitor connected to establish a voltage across the circuit and a diode connected to supply the capacitor from one of said connectors and to block capacitor discharge by conduction of the output transistor means.
3. The flasher circuit according to claim 2 wherein said means for establishing a substantially stable voltage of a predetermined value includes at least one voltage establishing semiconductor means for fixing a transistor bias reference voltage.
4. The flasher circuit according to claim 3 wherein the timing circuit means is a transistor multivibrator and a transistor current amplifier supplying the multivibrator, the voltage establishing semiconductor means is a Zener diode connected to and establishing base drive for the transistor current amplifier.
5. The flasher circuit according to claim 1 further including means for detecting an overcurrent when the output transistor means conducts, and means responsive to the overcurrent detecting means for reducing the conduction of the output transistor means.
6. The flasher circuit according to claim 5 further including means for detecting a voltage increase across the conducting output transistor means when the current through the output transistor means is reduced by the conduction reducing means, and means connected with said means for detecting a voltage increase for halting conduction by the output transistor means.
7. A D.C. flasher circuit for connection to a circuit including a D.C. potential source and a load; the flasher circuit having an output transistor means alternately for conducting and blocking load current between two connectors, means connected with the output transistor means for controlling the output transistor means to cause conduction and nonconduction of the output transistor means, overcurrent sensing means for sensing the current during the conducting periods, first control means connected with the overcurrent sensing means to alter a bias applied to the output transistor means to reduce conduction of the output transistor means in response to overcurrents, means for detecting a voltage increase across the conducting output transistor means when the current through the output transistor means is reduced by the first control means, and a second control means connected with the increased voltage detecting means to stop conduction by the output transistor means in response to detected voltage increase.
8. The flasher circuit according to claim 7 wherein the overcurrent sensing means is a very low resistance resistor, and the conduction reducing first control means is a current control transistor circuit having voltage sensitive bias connections connected across the sensing resistor for reducing a bias to the output transistor means in response to an increase in the voltage across the sensing resistor.
9. The flasher circuit according to claim 8 wherein the overcurrent sensing means comprises means for establishing a substantially stable voltage including a Zener diode connected with a circuit path across the flasher circuit, and one of said voltage sensitive bias connections is a control transistor base driven connection connected into a circuit path extending from one terminal of the Zener diode to an end of the sensing resistor.
10. The flasher circuit according to claim 7 wherein the increased voltage detecting means includes a voltage sampling Zener diode and a turn off control transistor, the Zener diode being connected in a circuit branch extending across the flasher circuit, the Zener diode being ordinarily biased to below its rated voltage, whereby increased voltage across the flasher circuit raises the voltage across the Zener diode, the control transistor having its base drive connected with the circuit path of the Zener diode to conduct and turn off the output transistor means after the rated Zener diode voltage is established.
11. The flasher circuit according to claim 10 further including a capacitor connected between said circuit branch including the Zener diode and a further point of connection in the flasher circuit, the capacitor ini-
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9. Partially diverting current to prevent immediate biasing into conduction of the turn off control transistor, thereby providing a slight time delay permitting initial overcurrents and voltage increases to diminish before the output transistor means is turned off.

10. The flasher circuit according to claim 8 whereby the first control means comprises a first control transistor connected with at least one further control transistor, the further control transistor being connected to control the conduction of the output transistor means, one of the first and further control transistors being an NPN transistor and the remaining of the two control transistors being a PNP transistor to reduce temperature dependence of the combined transistor characteristics.

11. A D.C. lamp flasher of the type including at least one output transistor for connection with an incandescent lamp circuit having a D.C. potential source and at least one lamp, and for alternately conducting and blocking conduction of current to the lamp; the lamp flasher including current sensitive and voltage sensitive protective means, the flasher including at least one output transistor connected alternately to conduct and to block current from one connector to another, means connected with the output transistor for controlling the output transistor to cause the conduction and nonconduction of the output transistor, a sensing resistor in series with the output transistor for providing a voltage drop indicative of the current through the output transistor, a first current control transistor connected with the sensing resistor and changing conductance in response to changes in the voltage across the sensing resistor, additional control transistor means connected with the first current control transistor and operatively connected with the output transistor to reduce base drive to the output transistor and to oppose increased conduction thereby when the current sensing resistor voltage increases, means for sampling the voltage across the output transistor to detect increased voltage thereacross resulting from decreased conduction in the output transistor, a turn off control transistor biased by the voltage sampling means and connected with said additional control transistor means to turn off the output transistor, and means for imparting a short time delay to the bias applied to the turn off control transistor to delay the turn off sufficiently to allow transient and incandescent lamp start up currents to be controlled by the current sensitive protective means of the circuit.

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