March 27, 1962 R. L. SEIDLER 3,027,491

LAMP CONTROL CIRCUIT

Filed May 7, 1959 3 Sheets-Sheet 1

FIG. 1

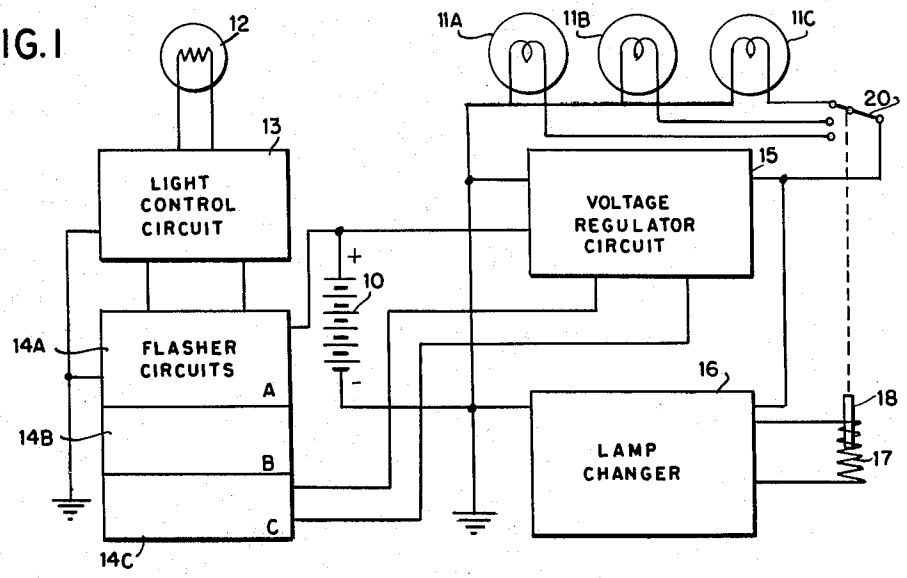
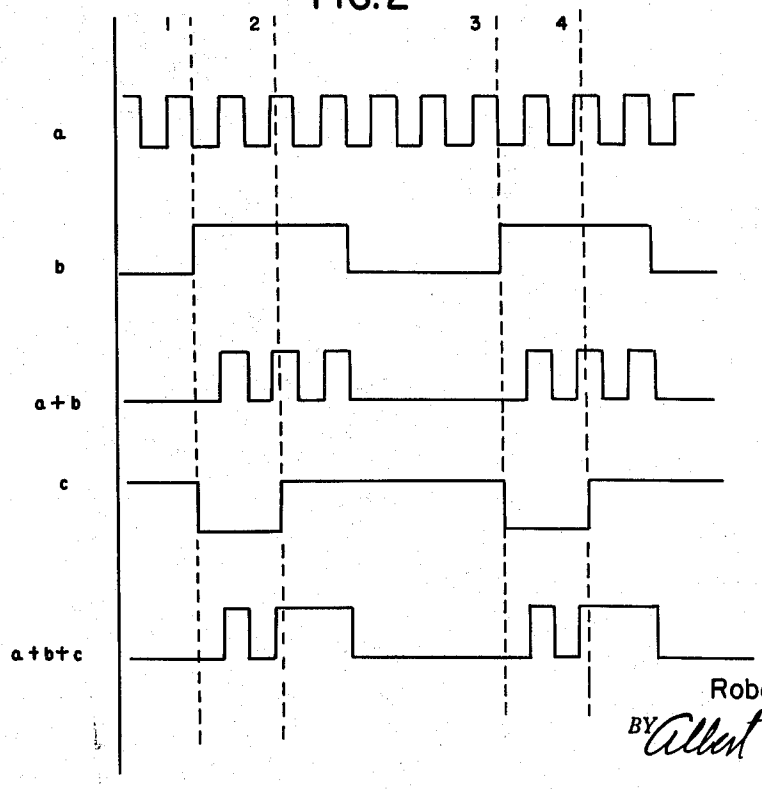


FIG. 2



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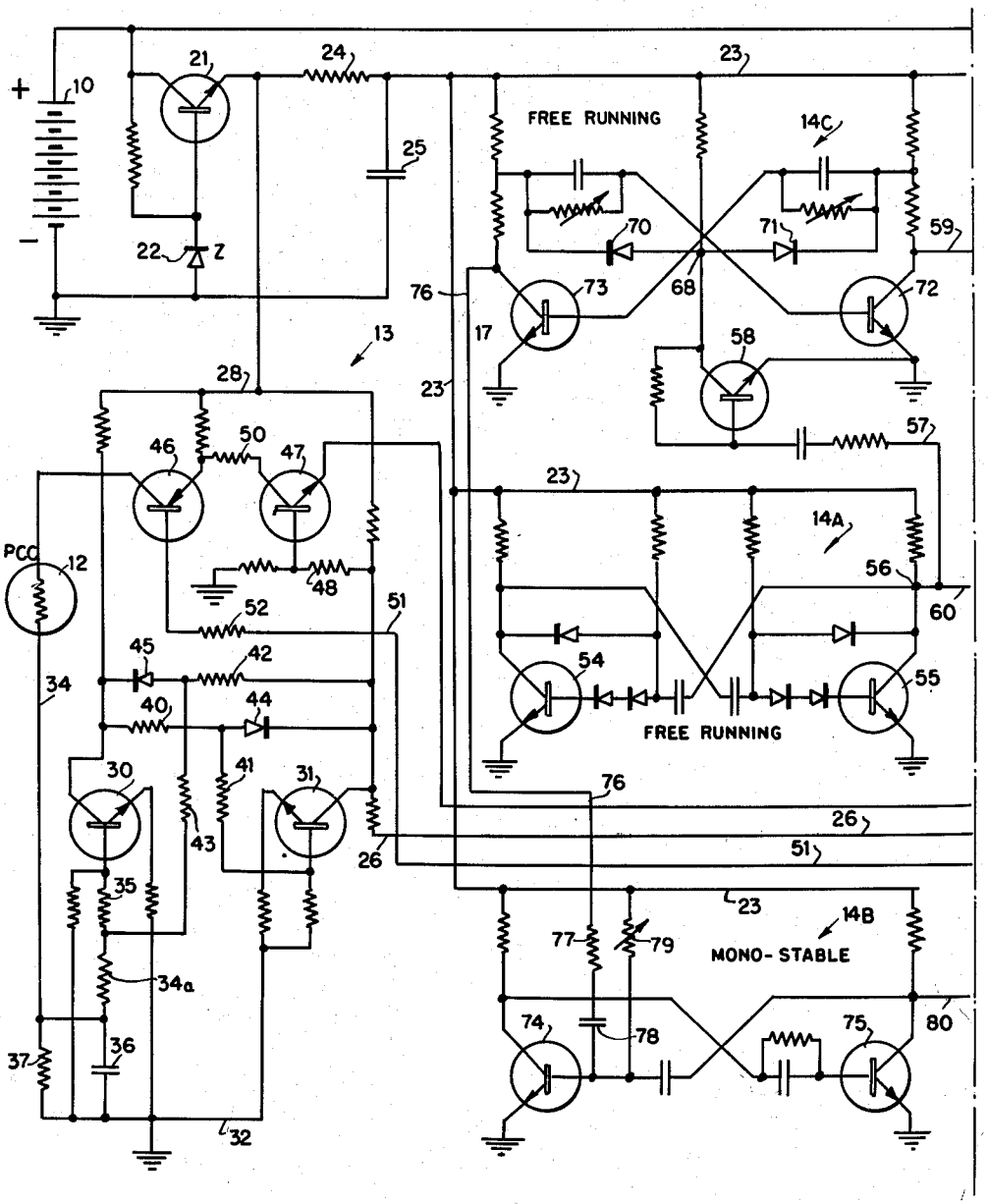


FIG. 3

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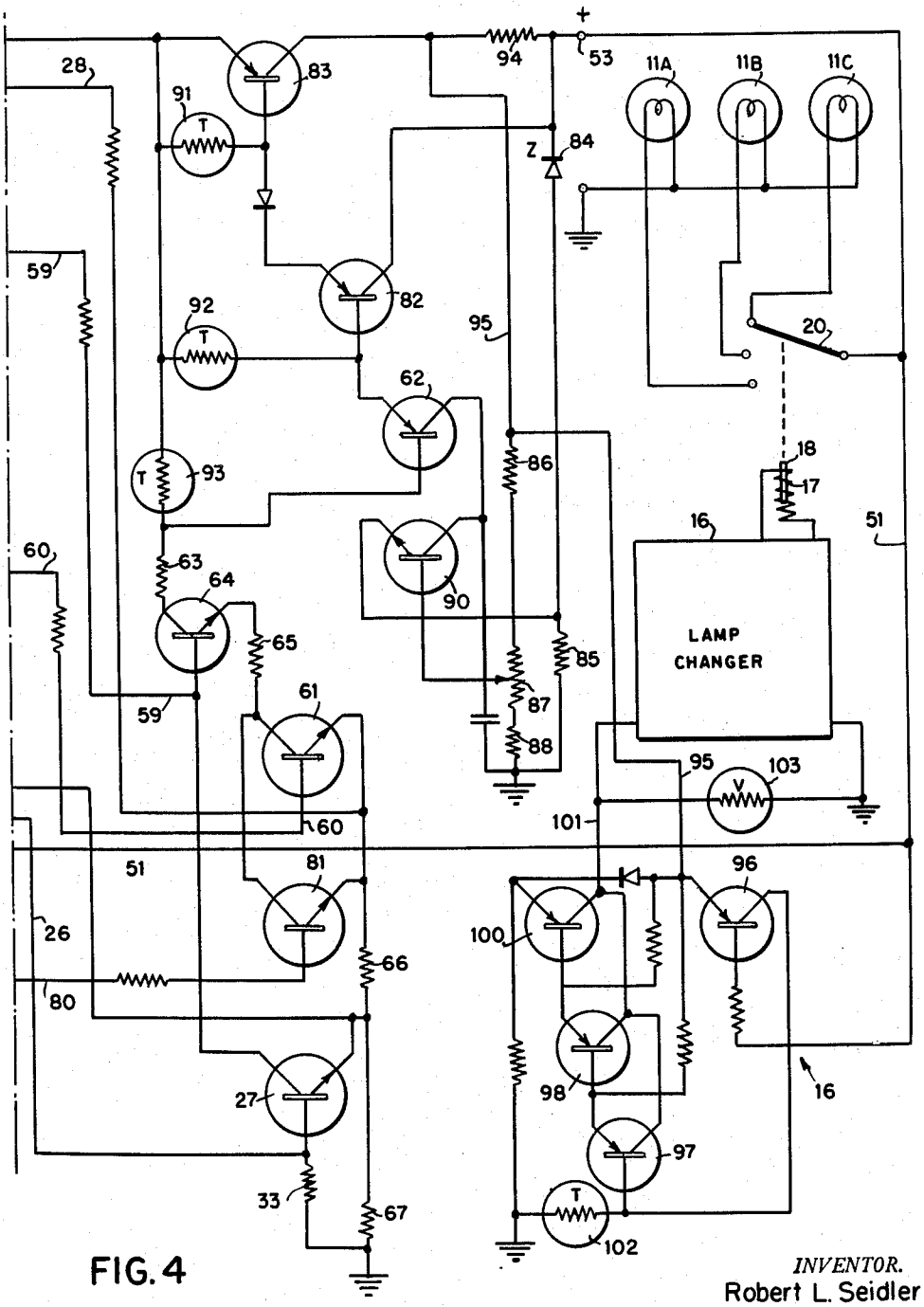


FIG. 4

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LAMP CONTROL CIRCUIT

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This invention relates to a lamp control circuit which is operated by semi-conductor components and includes a control for lighting signal or illuminating lamps only when the ambient illumination is reduced below a predetermined level. The control circuit also relates to means for short and long flashing by the lamps in accordance with a predetermined program.

Many types of lamp control units have been made and used but nearly all these control systems have employed moving parts such as motors and relays, and nearly all prior art control circuits have contained electrical contacts which make and break electric circuits and are therefore subject to pitting, sparking, and short-circuiting. The present control circuit contains no moving parts and no electrical contacts. All switching operations and circuit variations are made by the means of semi-conductor components such as transistors and diodes and therefore have extremely long life and not subject to the disadvantages met in the usual type of control circuit.

One of the objects of this invention is to provide an improved lamp circuit which avoids one or more of the disadvantages and limitations of prior art circuits.

Another object of the invention is to control the flashing of signal or illuminating lamps by sensing the value of the ambient illumination.

Another object of the invention is to turn the electrical power on and off at a predetermined rate to produce a flashing signal.

Another object of the invention is to permit adjustment of the various control circuits so that the light flashes produced by a lamp may include long and short alternate light signals.

Another object of the invention is to prevent the illumination produced by the flashing lamps from operating the light-sensitive circuit.

Another object of the invention is to regulate the voltage applied to the lamps.

Another object of the invention is to operate a motorized lamp changer when a lamp burns out.

Another object of the invention is to provide a lamp control circuit which is small, compact, has no mechanical moving parts, and has an exceedingly long life.

One feature of the invention includes a photoconductive cell which controls an amplifier and a switching transistor to turn the system on or off depending upon the value of steady ambient illumination.

A second feature of the invention includes three multivibrator circuits (generally called flip-flops) which operate together to produce light flashes having a predetermined frequency and a short-long program. The invention also includes a sensing device connected in series with the current supplied to the flashing lamps, the information of this sensing device being applied through a transistor to a lamp changer for changing lamps whenever the device is on and the current to the lamp is zero.

For a better understanding of the present invention, together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawings.

FIGURE 1 is a schematic diagram of connections showing most of the circuits of the lamp control device in block form.

FIGURE 2 is a graph showing the current pulses produced by the three multivibrator circuits and the combination of all three.

FIGURES 3 and 4 when combined are a schematic diagram of the entire circuit showing in detail all the electrical components.

Referring now to FIGURE 1, the control circuit will be described in general in order to show the overall operation of the system. The circuit is powered by a direct current source of potential **10** which may be a battery. This source of potential is the only one needed in the entire circuit and provides electrical power for all the components including one or more lamps **11A**, **11B** and **11C**. A photo-conductive cell **12** is employed to sense the ambient illumination and determine whether or not the lamps **11** should be turned on. The photo-conductive cell **12** is connected to a light control circuit **13** which contains an amplier unit and a switching transistor for controlling the other circuits in the system.

The lamp control circuit described herein includes three flasher circuits **14A**, B, and C; the combination of these circuits producing the novel short-long combination of signals shown in the last graph in FIGURE 2. It will be obvious that if such a combination of signals is not necessary and only symmetrical on and off signals are desired, only one free running multivibrator would be necessary. Group flashing may be obtained by using circuits **14A** and **14B** of FIGURE 1 as shown in $a+b$ of FIGURE 2.

The pulses from the flasher circuits **14** are applied to a voltage regulator circuit **15** which regulates the voltage and applies a constant voltage to one of the lamps **11**. The control circuit also includes a lamp changer circuit **16** which operates a motorized device to change the lamps after one has burned out. The invention herein described does not include the lamp changer nor any of its details. Many lamp changers have been devised and used. Some merely switch current from one lamp to another while other changers remove the damaged or burned out lamp from a desired position in an optical system and replace another in the same position while at the same time switching electrical power to the new lamp. The present invention operates to supply a control voltage to the lamp changing device whenever zero current is sensed in the lamp's circuit when the lamp should be lighted. In the drawing in FIGURE 1 (also FIGURE 4) the lamp changer circuit **16** is shown connected to a solenoid winding **17** which moves an armature **18**, thereby actuating a lamp switch **20**. It is to be understood that this simplified arrangement is for illustration only, and any other type of lamp changer can be used.

The light control circuit **13** receives its power from the emitter electrode of a transistor **21** shown in FIGURE 3 which acts as a simplified voltage regulator, supplying a regulated voltage to circuit **13** and also to the three multivibrator circuits **14A**, **14B**, and **14C**. Transistor **21** has its collector connected to the positive terminal of the source of potential while its base is connected to ground in series with a zener diode **22** which acts as a voltage reference. The regulated power applied to the multivibrator circuits on conductor **23** first passes through a filtering circuit including resistor **24** and capacitor **25**. This circuit eliminates transients from the flasher circuits

that otherwise might trigger the multivibrator when the lamps 11 are switched on and off.

The light control circuit 13 is primarily controlled by the resistance of the photoconductive cell 12. The output of circuit 13 is delivered over conductor 26 to the base of transistor 27 (FIGURE 4) which in turn controls other transistors to be described later. Circuit 13 includes transistors 30 and 31, the bases of which are connected to voltage divider circuits which include resistors connected between the positive source conductor 28 and the ground conductor 32. These resistors provide potentials to the bases of transistors 30 and 31 such that, when no light is incident on cell 12, transistor 30 is non-conductive, transistor 31 is conductive, and transistor 27 is non-conductive due to the bias current from transistor 31 through base resistor 33. As the amount of light incident on cell 12 increases, the resistance of the cell decreases and the voltage of conductor 34 increases, causing an increase in voltage at the base of transistor 30, through resistors 34_a and 35. The application of this voltage is shunted by a time delay circuit composed of capacitor 36 and resistor 37 which prevents false operation by intermittent light flashes, such as lightning, moving auto headlights, etc. which do not affect the operation of this circuit because the voltage pulses produced by them are absorbed by capacitor 36. The transistor 46 serves to reduce the voltage at the photoconductive cell 12 thereby preventing transistor 30 from conducting.

When transistor 30 starts to conduct, the voltage of its collector decreases causing a drop in the base current of transistor 31 supplied through resistors 40 and 41. This reduces the current through the collector-emitter circuit of transistor 31 and further increases the base current in transistor 30 by raising its base voltage through resistors 42, 43 and 35. Resistor 34A is made relatively high (100K) so that this action can proceed rapidly without charging capaci tor 36. Diodes 44 and 45, in conjunction with resistors 41 and 43, prevent saturation of transistors 30 and 31, thereby improving the switching characteristics. In a similar manner, when the light incident on cell 12 decreases, a condition is reached where transistor 30 begins to turn off and transistor 31 starts to turn on. The operation is then reversed and transistor 27 is made non-conductive.

The light control circuit 13 also includes two other transistors 46 and 47, having base voltages at the start of the cycle which cause transistor 46 to conduct and transistor 47 to be non-conductive. The base of transistor 47 is connected through resistor 48 to the collector of transistor 31, so that when transistor 31 is conducting, transistor 47 is non-conducting.

Transistor 47 provides a resistance in parallel with the photocell 12 in series with a resistor 50 and transistor 46 and decreases the voltage applied to the base of transistor 30 through the photoconductive cell 12 thereby decreasing the differential between the values of ambient light required to turn the device on or off.

Transistor 46 has its emitter-collector circuit in series with the photoconductive cell 12 and operates to reduce the sensitivity of the control circuit when the signal lamps 11 are turned on. Due to this suppression, the device cannot turn itself off. In order to accomplish this result, the base of transistor 46 is connected by conductor 51 (in series with resistor 52) to the positive terminal (FIGURE 4) 53 of the flasher. During the time the lamps are lighted, transistor 46 is made non-conductive and the resistance of cell 12 does not control the rest of circuit 13, thereby preventing turn off of the device while the lamp is flashing.

The flashing signals which turn the lamps 11 on and off are derived from three multivibrator circuits 14A, 14B and 14C. Circuit 14A is a free running multivibrator including transistors 54 and 55 with the usual capacity coupling between bases and collectors. This type of circuit is well-known in the art and need not be described in detail. The rectifier diodes 110, 111, 112, 113, 114 and 115 are added to the circuit in order to prevent saturation and lock up when the power is applied initially. The output of this circuit is taken from point 56 and is applied over conductor 57 to the base of transistor 58, also over conductor 60 to the base of transistor 61. The output wave is shown graphically in curve *a* in FIGURE 2.

Transistor 61 is turned on and off, from full conduction to non-conduction, by the wave from circuit 14A, and this change of resistance is applied to the base bias circuit of a switching transistor 62. The base circuit of transistor 62 may be traced from the base, through resistor 63, the emitter-collector circuit of transistor 61, resistors 66 and 67, to ground. It should be noted that transistors 64 and 61 have equal control of the operation of switching transistor 62.

The pulses sent over conductor 57 to transistor 58 are then applied to the terminal 68 of free running multivibrator 14C. When transistor 55 is made non-conducting, a sharp negative pulse is sent to the base of transistor 58 and produces a sharp positive pulse at point 68 between two diodes 70 and 71 coupled to transistors 72 and 73. This pulse triggers the circuit and transfers conduction from one transistor to the other. The output of this circuit is applied to the base of transistor 64 by conductor 59. The curve showing the wave form produced by this circuit is shown in curve *b*, FIGURE 2.

The flasher circuit is further modified by the addition of circuit 14b which is a mono-stable multivibrator having transistors 74 and 75. The circuit is arranged so that transistor 74 is normally conducting while transistor 75 is non-conducting. A coupling between circuit 14B and circuit 14C is provided by conductor 76 which connects the collector of transistor 73 with the base of transistor 74 (through resistor 77 and capacitor 78). When transistor 73 conducts, a negative pulse is sent to the base of transistor 74 turning it off. A short time interval later, which may be adjusted by resistor 79, conduction shifts back automatically to transistor 74. When transistor 74 is made non-conductive, 75 conducts, thereby lowering the voltage on its collector and conductor 80 and applying a negative bias to the base of transistor 81 making it non-conductive. The wave form produced by circuit 14C and transmitted over conductor 80 is shown in FIGURE 2 by curve *c*.

The conduction periods of transistors 61, 81 and 64 are shown in FIGURE 2 as curves *a*, *b*, and *c*, each showing the periods of conduction as positive pulses. Transistor 61 produces a series of non-conducting periods which are applied to gate transistor 62. Transistor 64 produces a similar series of non-conducting periods (of longer duration) which are also applied to the same gate. The combination of the two results in the conduction characteristics shown in curve $a+b$ in FIGURE 2. When the pulses of circuit 14C are added, the conduction characteristic is represented by curve $a+b+c$.

The above described current pulses are applied to gate transistor 62 and are, in turn, amplified by transistor 82 and passing transistor 83 connected with its emitter-collector circuit in series between the positive terminal of the battery 10 and the positive lamp terminal 53. Passing transistor 83 operates as a gate to either pass current to operate the lamp 11 or cut it off completely.

In addition to the on-off characteristics of the circuit, a voltage regulator system is built into the control to provide a compensated voltage for the signal lamp 11 when the passing transistor 83 is conducting. Two voltage dividers are used to form a bridge circuit to produce an error voltage. One voltage divider includes a zener diode 84 and resistor 85. A second voltage divider includes resistors 86, 87 and 88. The junction point of zener diode 84 and resistor 85 is connected to the emitter of transistor 90, while a tap on resistor 87 is connected to the base. In this manner the error voltage is applied to transistor 90 and is amplified by transistor 82 to control

the resistance of passing transistor **83** during the period when the lamp **11** is lighted. Thermistors **91**, **92** and **93** are added to the circuit to correct for changes in the transistor characteristics produced by changes in ambient temperature.

The lamp changer circuit operates by sensing the voltage drop across a series resistance **94** connected in series between the passing transistor **83** and the lamp terminal **53**. However, this circuit operates only during the time the lamp **11** is lighted and during the dark intervals it is non-operative. Connections to resistor **94** are made by conductors **95** and **51** and are applied to the base and emitter of an amplifier transistor **96** which, in turn, is coupled to amplifying transistors **97**, **98** and switching transistor **100** to deliver a strong signal current over conductor **101** to lamp changer device **16**. Resistor **94** serves also to provide constant voltage regulation with varying output current. A thermistor **102** is added to the circuit for temperature compensation, and varistor **103** serves to reduce inductive surges caused by the operation of the lamp changer **16**. When lamp **11** is lighted, there is a voltage between conductors **51** and **95**, transistor **96** is conductive and transistors **97**, **98** and **100** are not conducting. When there is no load current, there is no voltage drop across load resistor **94**, and the base and emitter of transistor **96** are at the same potential. This condition causes transistors **97**, **98** and **100** to conduct and deliver a signal to the lamp changer.

It should be understood that the invention as herein disclosed comprises the several circuit components and their modifying connections. The details of each circuit have been described only to show one form of the invention as it may be constructed and operated.

Having thus fully described the invention, what is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A lamp control circuit for operating a flashing lamp in accordance with a predetermined program comprising; a source of direct current power for lighting the lamp, a controllable resistance connected in series between said source of power and the lamp, a photosensitive cell which converts ambient illumination into an electrical signal, an amplifier circuit controlled by said signal and adapted to deliver an amplified voltage to a switching means when the ambient illumination falls below a predetermined value, a first free-running multivibrator generator adapted to produce a series of current pulses applied to said switching means, a second free-running multivibrator triggered by the voltage pulses from the first free-running multivibrator and adapted to produce a series of voltage pulses differing in time duration from the pulses produced by the first free-running multivibrator, said second multivibrator connected to said switching means, and circuit coupling means between the switching means and the controllable resistance for causing the interruption of power flow from the power source to the lamp whenever either of the multivibrators is not producing a voltage pulse.

2. A lamp control circuit as set forth in claim 1, wherein said circuit includes a voltage regulator for maintaining the lamp voltage within a restricted range of values.

3. A lamp control circuit as set forth in claim 1 wherein said circuit includes a means for delivering a current pulse to a lamp changer device whenever the lamp current is zero during the time interval the lamp terminals have voltage applied thereto.

4. A lamp control circuit for operating a flashing lamp in accordance with a predetermined program comprising; a source of direct current power for lighting the lamp, a controllable resistance connected in series between said source of power and the lamp, a photosensitive cell which converts ambient illumination into an electrcal signal, an amplifier circuit controlled by said signal and adapted to deliver an amplified voltage to a switching means when the ambient illumination falls below a predetermined value, a first free-running multivibrator adapted to produce a series of voltage pulses, a second free-running multivibrator triggered by the voltage pulses from the first free-running multivibrator and adapted to produce a series of pulses differing in time duration from the pulses produced by the first free-running multivibrator, and a mono-stable multivibrator actuated by the voltage pulses produced by the second free-running multivibrator, all of said multivibrators connected to said switching means to disable said controllable resistance and cut off the flow of current from the power source to the lamp.

5. A lamp control circuit as set forth in claim 4 wherein said circuit includes at least one free-running multivibrator.

6. A lamp control circuit as set forth in claim 4 wherein the circuit includes a coupling means between one of the lamp terminals and the amplifier circuit which disables the amplifier during the time the lamp is lighted.

7. A lamp control circuit as set forth in claim 4 wherein the circuit includes a voltage regulator circuit coupled between the lamp terminals where an error voltage is sensed and said controllable resistance, said regulator adapted to maintain the lamp voltage within a restricted range of values.

8. A lamp control circuit comprising, a source of direct current power for lighting the lamp, a passing transistor with its collector-emitter circuit connected in series between the source of power and the lamp, a photoconductive cell connected to an amplifier circuit whose output produces an electrical signal when the ambient illumination falls below a predetermined value, a first free-running multivibrator adapted to produce a series of voltage pulses, a second free-running multivibrator triggered by the voltage pulses from the first free-running multivibrator and adapted to produce a series of pulses longer than the pulses produced by the first free-running multivibrator, a mono-stable multivibrator actuated by the voltage pulses produced by the second free-running multivibrator, all of said multivibrators connected to a switching circuit coupled to the base of said passing transistor with circuit means for raising resistance of the collector-emitter circuit to a cut-off value, circuit means between one of the lamp terminals and said amplifier circuit for disabling said circuit during the time the lamp is lighted, a voltage regulator circuit coupled between one of the lamp terminals and the base of the passing transistor for sensing an error voltage and applying it to the passing transistor for maintaining the voltage at the lamp within a restricted range of values, and a lamp changer circuit for applying a current pulse to a motorized changer device, said changer circuit coupled to a resistor in series with the lamp and receiving direct current power from the output of the passing transistor.

9. A lamp control circuit as set forth in claim 8 wherein said lamp changer circuit includes a plurality of transistors connected as amplifiers and switches.

10. A lamp control circuit as set forth in claim 8 wherein said voltage regulator circuit includes a four-armed bridge circuit with a zener diode.

11. The combination of three multivibrator circuits coupled to a utilization circuit comprising; a first free-running multivibrator generator which produces a series of electrical voltage pulses; a second free-running multivibrator circuit which is triggered by the first free-running multivibrator to produce a series of voltage pulses longer than those produced by the first free-running multivibrator; a mono-stable multivibrator controlled by the voltage pulses from the second free-running multivibrator and adapted to produce a voltage pulse having a time duration longer than the first multivibrator but shorter than the pulses from the second free-running multivibrator; all three of said multivibrators connected for delivery of their pulses respectively to the bases of two normally nonconducting transistors and one normally conducting transistor, and connecting means for joining said three transistors in series-parallel arrangement;

a passing transistor connected in series between a source of direct current power and said utilization circuit; coupling means between said three transistors and the passing transistor to change it from conducting to non-conducting condition in accordance with the pulses produced by said three multivibrator circuits; and a voltage regulator circuit controlled by a sensing circuit connected across the utilization circuit for maintaining the utilization voltage within a narrow range of values when the passing transistor is conducting.

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