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[54] LAMP FAILURE INDICATING APPARATUS

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[58] Field of Search ....340/52, 251, 248 A; 315/82, 83, 129, 131

[56] References Cited

UNITED STATES PATENTS

3,421,157	1/1969	Atkins	315/82
3,457,561	7/1969	Zeisler	340/251
3,629,799	12/1971	Birtwistle	340/251
3,631,441	12/1971	Murphy	340/251
3,593,264	7/1971	Atkins	315/82
3,171,096	2/1965	Murray et al.	340/251
3,535,585	10/1970	Barnum	315/83

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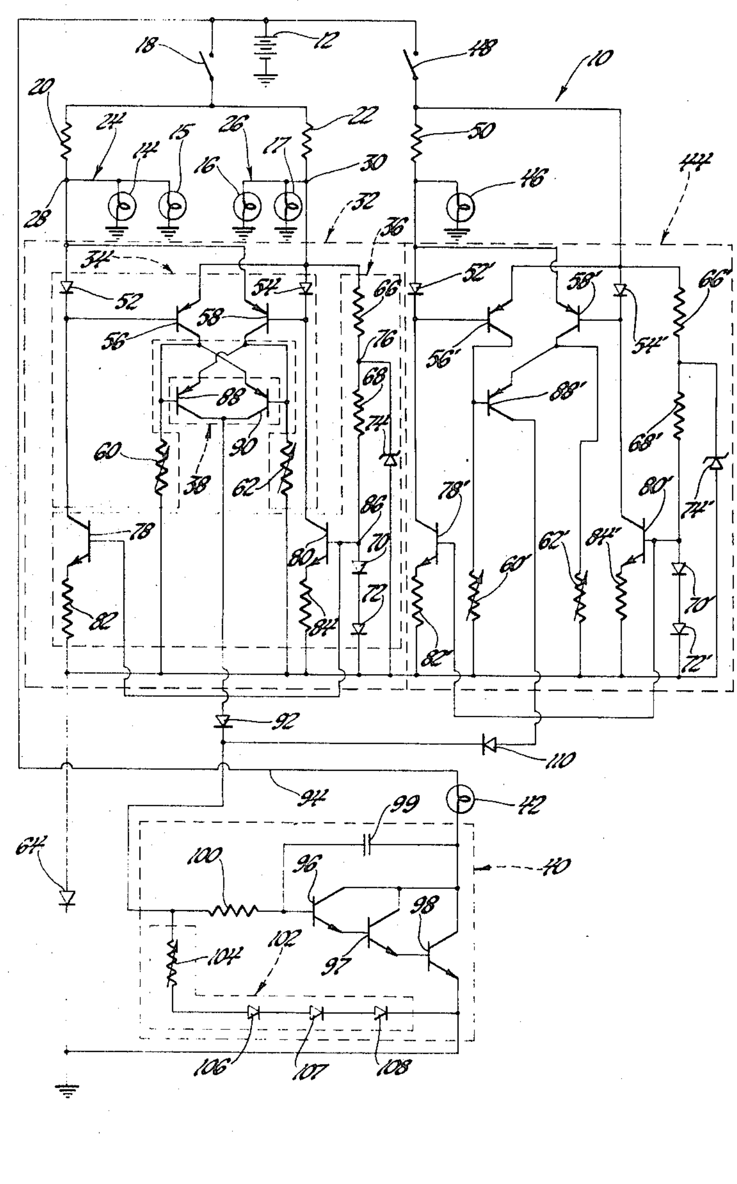
[57] ABSTRACT

Apparatus for indicating inoperativeness of a lamp in any of several lamp arrays. Each lamp array includes one or more parallel connected lamps having predetermined electrical characteristics such that each operative lamp effects a certain voltage drop across the lamp array. A detector network monitors the voltage across each lamp array, which voltage is almost the same as the supply voltage, and generates a certain control signal when one of the lamps has become inoperative. An output amplifier that is responsive to the control signal effects energization of an indicator lamp to indicate that a lamp is inoperative when the certain control signal is generated. Several detector networks may be cascaded in parallel to monitor several lamp arrays and each detector network may be employed to monitor either one or two lamp arrays.

4 Claims, 1 Drawing Figure



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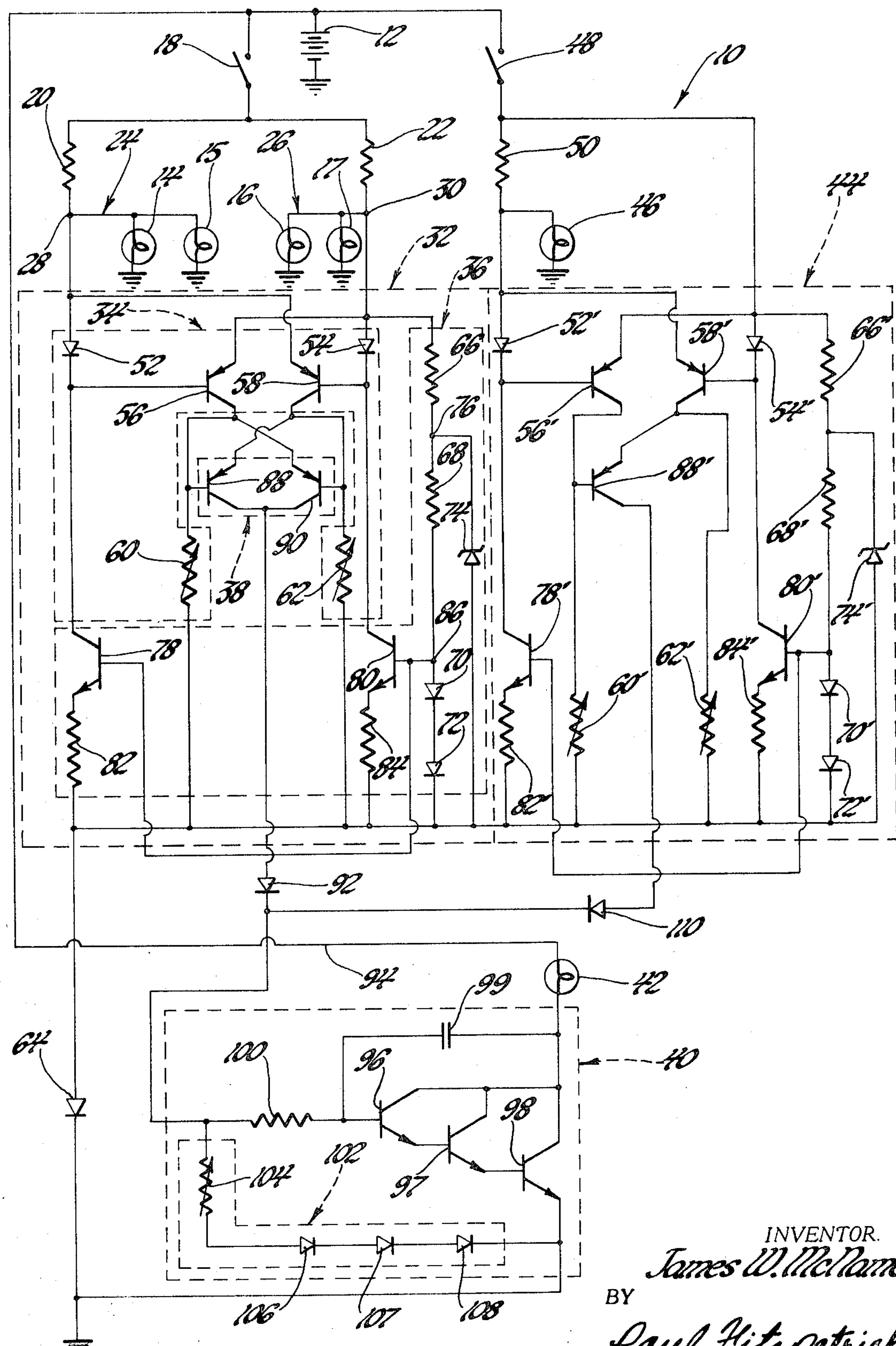

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LAMP FAILURE INDICATING APPARATUS

This invention relates to light systems and, more particularly, to light systems in which failure of a lamp in any of several lamp arrays is indicated by an indicator device.

While the subject apparatus may be employed in conjunction with many different types of equipment, it is particularly advantageous when employed in a motor vehicle which may have several lamp arrays of similar electrical characteristics. For example, a motor vehicle may employ two headlamps in each of its front fenders for illuminating the roadway. The two headlamps referred to are often called "high beams" and are connected in parallel to form a lamp array that is energized from a common power supply through a single conductor. While there have been numerous designs proposed for simultaneously monitoring two lamp arrays such as these to indicate when a lamp has failed in either of the lamp arrays, these previous proposals have not met with much success for a variety of reasons.

Among these reasons are the fact that the prior art proposals generally require that the apparatus monitoring the operativeness of the lamps consume a considerable amount of standby power even while all of the lamps are operative. Another reason is the fact that many proposals have required that resistors be inserted in series with the lamp arrays being monitored to provide a significant, and measurable, voltage drop in series with each of the lamp arrays and the power source. This proposal has similarly not received widespread acceptance as it both consumes a considerable amount of power in the added resistors and reduces efficient operation of the lamps.

Another disadvantage common to many prior proposals for indicating the presence of an inoperative lamp is the fact that each lamp array has often been monitored by a unique detector circuit which has not been readily adaptable for use in a system requiring additional detector circuits, or channels, to monitor the operativeness of other lamp arrays so that a common indicator device for indicating a failure in any of the lamp arrays being monitored could be used. Similarly, where a detector has been proposed as suitable for monitoring two or more lamp arrays, it has often been unsatisfactory in monitoring the operativeness of a single lamp. Both of the last mentioned disadvantages of the designs prevalent in the prior art naturally result in considerable economic disadvantage in applications where it is most advantageous to employ a single detector unit that is readily adaptable in conjunction with similar detector units to monitor the operativeness of any number of lamp arrays.

It is therefore an object of this invention to provide a light system which includes two lamp arrays and a detector network for indicating when a lamp has failed in either of the lamp arrays, the detector network drawing a minimum of power by monitoring a voltage substantially the same as the voltage applied by the power source.

It is also an object of this invention to provide lamp failure indicating apparatus for indicating failure of a lamp, the apparatus being operable only when the lamps are energized and designed in modular form whereby several modular channels may be cascaded in parallel to monitor a considerable number of lamp arrays while employing but a single indicator device for indicating failure of a lamp in any of the lamp arrays being monitored.

It is an additional object of this invention to provide lamp failure indicating apparatus for indicating failure of a lamp in either of two lamp arrays across which there appears a voltage drop substantially equal to the voltage of an applied power source and for monitoring but a single lamp, rather than all of the lamps in two lamp arrays, with a minimum of adaptation.

The foregoing and other objects and advantages of the subject invention will become apparent from the following description and accompanying drawing, in which is presented a schematic diagram of a light system embodying the principles of the subject invention.

As mentioned previously, the subject apparatus is particularly useful when employed in a vehicle. Accordingly, in the accompanying drawing a light system **10** is illustrated in which a suitable power source, such as a vehicle battery **12**, energizes several lamps **14** through **17** through a normally open light switch **18** and first and second resistors **20** and **22** that are each connected in series with two of the lamps **14** through **17**. The lamps **14** through **17** are thus connected to form first and second lamp arrays **24** and **26** that may each be mounted on one of the front fenders of the vehicle.

The voltages across each of the lamp arrays **24** and **26**, which voltages appear at first and second junctions **28** and **30**, are monitored by a first detector network **32** that includes a differential comparator **34**, a current source network **36**, and a full wave detector **38** that generates a certain control signal when one of the lamps **14** through **17** is inoperative. An output amplifier **40** monitors the control signal and effects energization of a lamp **42** when the certain control signal is generated.

The light system **10** also includes a second detector network **44** that is similar to the first detector network **32** but which monitors the operativeness of yet another lamp **46**. By way of example, and without limitation, the lamp **46** may be what is commonly termed a "running lamp" on the vehicle and is energized through an ignition switch **48** and a resistor **50** whenever the vehicle is in operation. Should the running lamp **46** become inoperative the second detector network **44** generates the certain control signal and effects energization of the indicator lamp **42** through the output amplifier **40**.

The light system **10** will now be explained in detail.

The resistors **20** and **22** are selected to be of substantially the same resistance. Similarly, the lamps **14** through **17** are each selected to have a certain resistance that is very much larger than the resistance of the resistors **20** and **22** so that the current through each of the resistors **20** and **22** is directly proportional to the number of lamps drawing the current. For example, if the battery **12** is selected to supply power at a continuous potential of **12** volts and the resistance of each of the lamps **14** through **17** is 599 times greater than the resistance of each of the resistors **20** and **22**, each of the lamps **14** through **17** will draw a certain current through the respective resistors **20** and **22**. In actual practice the resistors **20** and **22** have been determined by selecting the wires connecting the lamp arrays **24** and **26** to the battery **12** to have a predetermined low resistance rather than by selection of discrete resistor elements.

Accordingly, if it is assumed that current drawn by the first detector network **32** is negligible when compared with the current drawn by the lamps **14** through **17**, which assumption proves valid in practice, it thus follows that a certain voltage drop is created across each of the resistors **20** and **22** by the current drawn by each of the lamps **14** through **17**. In the example just described, the current through each of the lamps **14** through **17** effects a 20 millivolt drop across the resistor in series with the lamp. It thus follows that in the illustrated embodiment, the voltage at each of the junctions **28** and **30** is **11.96** volts when all of the lamps **14** through **17** are operative. Should one of the lamps in either of the lamp arrays **24** or **26** become inoperative it will cease to draw current and the voltage at the corresponding junction **28** or **30** will be increased to 11.98 volts. Accordingly, the first detector network **32** is designed to monitor the voltage at the junctions **28** and **30** and to generate the certain control signal when the monitored voltages are unequal by 20 millivolts.

The junctions **28** and **30** are connected to the respective anodes of first and second diodes **52** and **54** in the differential comparator **34**. The cathodes of the diodes **52** and **54** are connected to the base terminals of first and second PNP transistors **56** and **58** having their respective emitter terminals connected to the anodes of the respective second and first diodes **54** and **52**. The collector terminals of the first and second transistors **56** and **58** are connected to a point of reference potential, which is ground, through first and second bias resistors **60** and **62** and a diode **64** that protects the first and second detector networks **32** and **44** from negligent reversal of the battery **12** polarity.

The current through the first and second diodes **52** and **54** is held at a substantially constant level by the current source network **36**. The current source network **36** includes a pair of resistors **66** and **68** and a pair of diodes **70** and **72** connected between the second junction **30** and the anode of the polarity reversal diode **64**. A Zener diode **74** is connected between the anode of the polarity reversal diode **64** and the junction **76** between the resistors **66** and **68** so as to maintain the junction **76** at a constant voltage.

The current source network **36** also includes a pair of NPN transistors **78** and **80** and resistors **82** and **84** that are connected between the emitters of the transistors **78** and **80** and the anode of the polarity reversal diode **64**. The collectors of the transistors **78** and **80** are connected to the cathodes of the respective first and second diodes **52** and **54** for drawing a predetermined current through the first and second diodes **52** and **54**. The predetermined current level in a preferred design is on the order of **200** microamps and hence is so minute as not to affect the voltage at the junctions **28** and **30**. The conductivity of the transistors **78** and **80** is established by the voltage across the diodes **70** and **72**, which voltage appears at a junction **86** that is connected to the bases of the transistors **78** and **80**. Since the voltage across the diodes **70** and **72** will vary with temperature changes the diodes **70** and **72** provide temperature compensation for the transistors **56** and **58** by controlling the conductivity of the transistors **78** and **80**, as will subsequently become apparent.

When the first detector **32** is in operation the current source network **36** establishes the predetermined current through the first and second diodes **52** and **54**. The first and second diodes **52** and **54** are thus held in a conductive condition in which the voltage across each of the diodes **52** and **54** remains substantially constant. By selecting the diodes **52** and **54** to be matched so as to have substantially the same electrical characteristics the voltages which are applied to the emitter, or input, terminals of the transistors **56** and **58** are equal and the voltages applied to the bases of the transistors **56** and **58** are also equal. The voltage drop across the first and second diodes **52** and **54**, which may be on the order of 0.7 volts, thus maintains the first and second transistors **56** and **58** in a state of continuous conduction as class A operated amplifiers and their collector, or output, terminals conduct current through the bias resistors **60** and **62**. By further matching the diodes **52** and **54** to have the same characteristics as the emitter-base diodes of the transistors **56** and **58** the current through the transistors **56** and **58** may be made substantially the same as current through the diodes **52** and **54**. This establishes the operating points of the transistors **56** and **58** at the same level of conductivity.

The currents through the bias resistors **60** and **62** generate first and second voltage signals which are monitored by the full wave detector **38**, which includes third and fourth PNP transistors **88** and **90**. The bases of the respective transistors **88** and **90** are connected to the collector terminals of the respective transistors **56** and **58** and the emitter terminals of the transistors **88** and **90** are connected to the collector terminals of the respective transistors **58** and **56**. The same potential is thus applied to the base and emitter terminals of the third and fourth transistors **88** and **90** so long as the voltages on the collector terminals of the first and second transistors **56** and **58** are equal. The third and fourth transistors **88** and **90** are thus held nonconductive and their collector terminals, which are connected together, provide a low voltage control signal so long as the lamps **14** through **17** are operative. The control signal is coupled by an isolation diode **92** to the output amplifier **40** to control the energization of the indicator lamp **42**, which is connected to the battery **12** through a lead **94**.

While the output amplifier **40** in the illustrated embodiment is a lamp driver circuit for controlling the energization of the indicator lamp **42**, persons versed in the art will appreciate that the output amplifier **40** may instead be employed to control the energization of various other indicator devices. In the illustrated embodiment, the output amplifier **40** includes several cascaded NPN transistors **96** through **98** in what is known as a Darlington configuration, a capacitor **99** for protecting the transistors **96** through **98** from transients, an input resistor **100** through which the control signal is transmitted from the isolation diode **92** to the transistors **96** through **98**, and a gain control network **102** which consists of a variable resistor **104** and several series connected diodes **106** through **108**. The diodes **106** through **108** are selected to match the emitter-base diodes of the transistors **96** through **98** so as to provide temperature compensation within the output amplifier **40**.

The operation of the apparatus just described may be summarized as follows. When all of the lamps **14** through **17** are energized, the voltages at the junctions **28** and **30** are equal. The first and second transistors **56** and **58**, which have their electrical characteristics matched, are thus held in a class A operation conductive condition and their output, or collector, terminals are at the same voltage. The third and fourth transistors **88** and **90** are held in a nonconductive condition by these voltage signals and the collectors of the third and fourth transistors **88** and **90** provide a low voltage control signal to the amplifier **40.** The control signal thus provided is insufficient to forward bias the emitter-base junctions of the transistors **96** through **98** in the output amplifier so the transistors **96** through **98** are nonconductive and the indicator device **42** remains deenergized so long as all of the lamps **14** through **17** are operative.

Should one of the lamps **14** through **17** become inoperative, such as the lamp **14,** the voltage across the lamp array containing the inoperative lamp is increased from approximately 11.96 volts to 11.98 volts. In this example, the voltage increase takes place at junction **28** and causes the second transistor **58** to become more conductive by increasing its emitter voltage while its base voltage is unchanged. The increase in voltage at the junction **28** effects a corresponding decrease in conduction of the first transistor **56** since the potential applied to its base by the first diode **52** increases from approximately 11.26 to 11.28 volts while the potential applied to its emitter by the second junction **30** remains at 11.96 volts. The resultant increase in current through the second transistor **58** and decrease in current through the first transistor **56** effect a corresponding voltage increase across the second bias resistor **62** and decrease in voltage across the first bias resistor **60.**

Since the collector of the second transistor **58** is at a higher potential than the collector of the first transistor **56,** the third transistor **88** is biased to a conductive condition while the fourth transistor **90** is maintained nonconductive. Once the transistor **88** has begun to conduct the voltage on its collector attains a certain predetermined level and this certain control signal is sufficient when coupled through the isolation diode **92** and the input resistor **100** to bias the transistors **96** through **98** in the output amplifier **40** to a conductive condition, which effects energization of the indicator lamp **42** to indicate that one of the lamps **14** through **17** has failed.

While the indicator lamp **42** does not indicate which of the lamps **14** through **17** have failed, it serves to advise the vehicle operator that one of the lamps of the vehicle is inoperative so that he may visually ascertain which of the lamps has failed. Since the indicator lamp **42** may be energized whenever the certain control signal is applied to the input resistor **100** any number of detector networks similar to the first detector network **32** may be combined to provide the certain control signal when various other conditions have occurred within the vehicle.

This adaptability of the first detector network **32** has been illustrated in the drawing by provision of the previously recited second detector network **44,** which monitors the operation of the running lamp **46.** The second detector network **44** is identical in configuration to that of the first detector network **32** except for the deletion of the fourth transistor **90,** which is unnecessary in the second detector network **44,** and the employment of different resistance values for the first and second bias resistors **60** and **62.** Accordingly, circuit elements in the second detector network **44** are noted with the same identification numerals as employed for corresponding circuit elements in the first detector network **32** followed by a prime (′) notation.

The second detector network **44** is connected to monitor the voltage at each side of the resistor **50.** Accordingly, the voltage applied to the anode of the second diode **54′** is substantially **12** volts when the battery **12** is a **12** volt supply and the voltage at the anode of the first diode **52′** is approximately 11.98 volts. This voltage offset tends to bias the first transistor **56′** more conductive than the second transistor **58′.** For this reason the biasing resistors **60′** and **62′** are adjusted so the collector voltages of the first and second transistors **56′** and **58′** are equal when the lamp **46** is operative. Accordingly, the base and emitter voltages of the third transistor **88′** are equal and the control signal on its collector is at a low potential so as to preclude the second detector network **44** from effecting energization of the indicator lamp **42** when the lamp **46** is operative. It should be noted that the bias resistors **60** and **62** in the first detector network **32** could similarly be adjusted to compensate for a voltage offset caused by one of the lamp arrays **24** or **26** containing more lamps than the other lamp array **24** or **26.**

Should the lamp **46** become inoperative it will cease to draw current and substantially the entire potential of the battery **12** will be applied to the anode of the first diode **52′** as well as to the anode of the second diode **54′.** This effects an increase in the voltage applied to the base of the first transistor **56′** so as to decrease its conductivity and effect an increase in the conductivity of the second transistor **58′.** Accordingly, the voltage on the base of the transistor **88′** is decreased while its emitter voltage is increased. This turns on the transistor **88′** and causes the generation of the certain control signal on its collector. The certain control signal is coupled from the collector of the third transistor **88′** through a second isolation diode **110** to the output amplifier **40** where it effects energization of the indicator lamp **42** in the fashion previously explained. The single indicator lamp **42** may thus be employed to indicate that one of any number of lamps has failed, the number only being limited by the number of detector networks employed.

Persons versed in the art will appreciate that various modification of this invention may be made without departing from its spirit.

What is claimed is:

1. In a light system having a first lamp array connected in series with a power source and a first resistor and a second lamp array connected in series with the power source and a second resistor, each lamp array comprising a certain number of parallel connected lamps having similar impedances, the ratio of the impedance of the first lamp array to the impedance of the first resistor being the same as the ratio of the impedance of the second lamp array to the impedance of the second resistor, apparatus for indicating when a lamp in either of the lamp arrays has failed comprising, in combination, a differential comparator for comparing the voltage across each of the lamp arrays and generating first and second signals having relative magnitudes related to the difference between the voltages compared, the first and second signals being equal when the monitored voltages are equal and unequal when the monitored voltages are unequal, a full wave detector that is responsive to the first and second signals for generating a certain control signal only when the first and second signals are unequal, the control signal being other than the certain control signal when the first and second signals are equal, an indicator device for indicating that one of the lamps has failed, and an output amplifier that is responsive to the control signal for effecting an indication by the indicator device that a lamp has failed whenever the full wave detector generates the certain control signal.

2. In a light system having a first lamp array connected in series with a power source and a first resistor and a second lamp array connected in series with the power source and a second resistor, each lamp array comprising a certain number of parallel connected lamps having similar impedances, the ratio of the impedance of the first lamp array to the impedance of the first resistor being the same as the ratio of the impedance of the second lamp array to the impedance of the second resistor, apparatus for indicating when a lamp in either of the lamp arrays has failed comprising, in combination, a differential comparator comprising first and second matched diodes having their respective anodes connected to sample the voltage across the respective first and second lamp arrays, first and second matched amplifiers each having a control terminal and input and output terminals between which a controlled current path is defined, the control terminals of the respective first and second amplifiers being connected to the cathodes of the respective first and second diodes and the input terminals of the respective first and second amplifiers being connected to the anodes of the respective second and first diodes, and first and second biasing impedances connected in series with the output terminals of the respective amplifiers; means for providing a predetermined load in series with each of the diodes whereby a predetermined potential difference is established across each of the diodes, the biasing impedances being selected to effect operation of the amplifiers so as to establish equal potentials on their output terminals when all of the lamps are operative and unequal potentials on their output terminals when a lamp has failed; detector means responsive to the potentials on each of the output terminals for generating a certain output signal when said potentials are unequal; an indicator device for indicating failure of a lamp in either of the lamp arrays; and means responsive to the detector means for effecting an indication by the indicator device that a lamp has failed when the detector means generates the certain output signal.

3. A light system comprising, in combination, first and second lamp arrays, each lamp array including at least one grounded lamp; a power source having a grounded terminal; first and second resistors connecting the respective first and second lamp arrays in series with the power source so as to connect each lamp in each lamp array in parallel with the other lamps in the same lamp array, the ratio of the impedance of the first lamp array to the impedance of the first resistor being the same as the ratio of the impedance of the second lamp array to the impedance of the second resistor, the resistances of the lamps in each lamp array being equal and very much greater than the resistor resistances whereby the current through each lamp effects a predetermined voltage drop across the resistor in series therewith; first and second diodes having their respective anodes connected to the respective junctions between the first resistor and the first lamp array and the second resistor and the second lamp array for partaking of the voltage across each of the lamp arrays; first and second controlled amplifiers each having control, input, and output terminals, the control terminals of the respective first and second amplifiers being connected to the cathodes of the respective first and second diodes and the input terminals of the respective first and second amplifiers being connected to the anodes of the respective second and first diodes; first and second biasing impedances connected in series with the output terminals of the respective first and second amplifiers whereby the voltages on the output terminals are responsive to the conductivity of the respective amplifiers; means for drawing a predetermined current through the diodes so as to effect a predetermined voltage drop across each of the diodes of sufficient magnitude to render the amplifiers partially conductive, the magnitude of the biasing impedances being selected when all of the lamps are operative so that each of the amplifier output terminals are at a certain potential whereby failure of one of the lamps effects a change in the conductivity of the amplifiers and a corresponding difference in the potential on the output terminals of the amplifiers; a detector for generating a certain control signal when the output terminals are at different potentials, the detector including third and fourth controlled amplifiers each having control, input, and output terminals, the control terminals of the third and fourth amplifiers partaking of the potentials on the output terminals of the respective first and second amplifiers and the input terminals of the third and fourth amplifiers partaking of the potentials on the output terminals of the respective second and first amplifiers, the output terminals of the third and fourth amplifiers being connected so as to provide a common terminal at which the control signal is generated, equal potentials on the output terminals of the first and second amplifiers biasing the third and fourth amplifiers to a first state of conduction in which they generate a first control signal on the common terminal and unequal potentials on the output terminals of the first and second amplifiers biasing the third and fourth amplifiers to a different conductive state in which they generate the certain control signal on the common terminal; an indicator device for indicating failure of a lamp; and means responsive to the certain control signal for effecting an indication by the indicator device that a lamp has failed when the detector generates the certain control signal.

4. In a light system having a grounded lamp connected in series with a grounded power source and a resistor whereby current through the lamp effects a predetermined voltage drop across the resistor, apparatus for indicating failure of the lamp comprising, in combination, a differential comparator for monitoring the voltage across the resistor and for generating first and second signals indicative of the operativeness of the lamp, the differential comparator including first and second matched diodes having their anodes connected to the respective terminals of the resistor, the anode of the first diode being connected to the resistor terminal that is connected to the lamp and the anode of the second diode being connected to the other resistor terminal, first and second controlled amplifiers each having control, input, and output terminals, the control terminals of the respective first and second amplifiers being connected to the cathodes of the respective first and second diodes and the input terminals of the respective first and second amplifiers being connected to the anodes of the respective second and first diodes, and first and second impedances connecting the respective output terminals of the respective first and second amplifiers to a point of reference potential whereby the first and second signals are generated on

the output terminals of the respective first and second amplifiers, the first and second signals being equal when the lamp is operative and unequal when the lamp is inoperative; a detector that is responsive to the first and second signals and is effective to generate a certain control signal when the first and second signals are unequal, the detector including a third controlled amplifier having control and input terminals connected to the output terminals of the respective first and second amplifiers and an output terminal on which is generated the control signal; an indicator device for indicating that the lamp has failed; and an output amplifier that is responsive to the control signal and effective when the certain control signal is generated to cause the indicator device to indicate that the lamp has failed.

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