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Morita

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[54] **DEVICE FOR AUTOMATICALLY COMPENSATING FAILURE OF A LAMP**

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[51] **Int. Cl.** **H05b 39/10;** H05b 41/46
[58] **Field of Search** 315/88, 93; 340/46, 251

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[57] **ABSTRACT**

A device for automatically compensating failure of a lamp in which voltage drop across a series resistor is applied to the emitter of a transistor for detecting failure of a lamp and the forward voltage drop across a diode is applied to the base of said transistor to restrain the voltage drop across the series resistor, and the main current of a transistor circuit controlled by the failure detecting transistor is made to flow through a resistor to form a positive feedback to said failure detecting transistor within the range controlled by said diode and resistor thereby to further lower the voltage drop across the series resistor. The failure detecting transistor is sufficiently turned on by the above-mentioned circuit arrangement to energize a back-up lamp.

9 Claims, 3 Drawing Figures

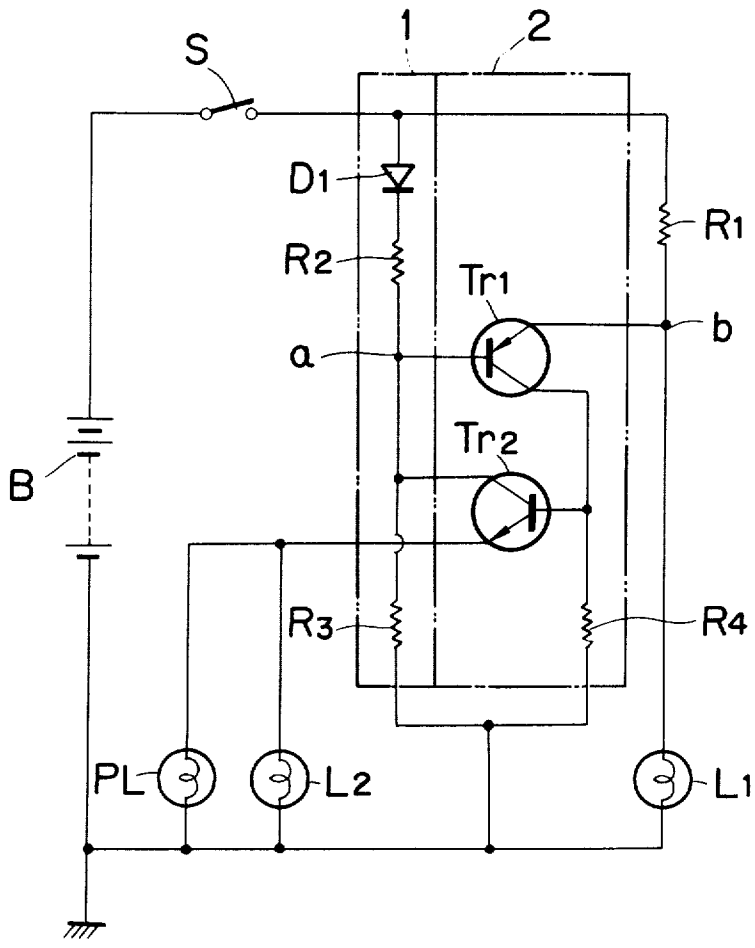


FIG. 1

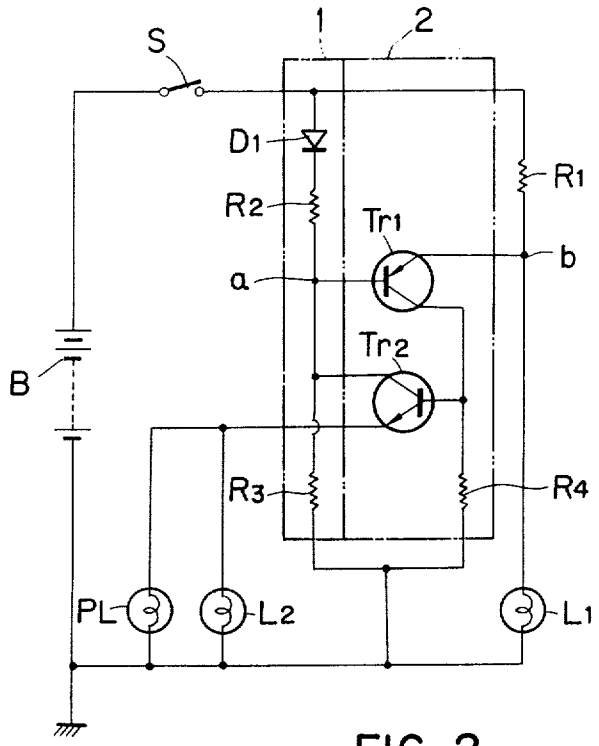

S
1
2
D1
R1
R2
Tr1
b
a
Tr2
B
R3
R4
PL
L2
L1

FIG. 2

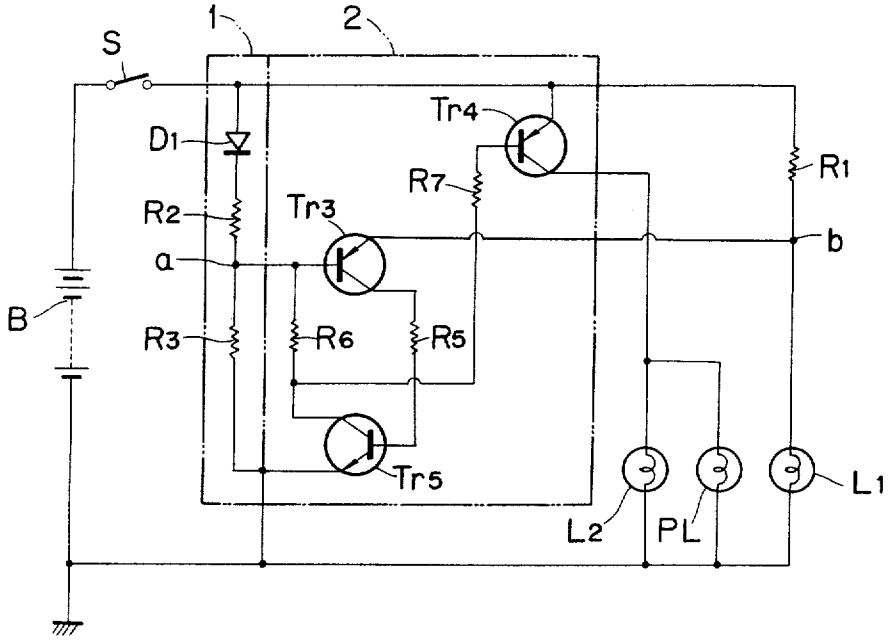
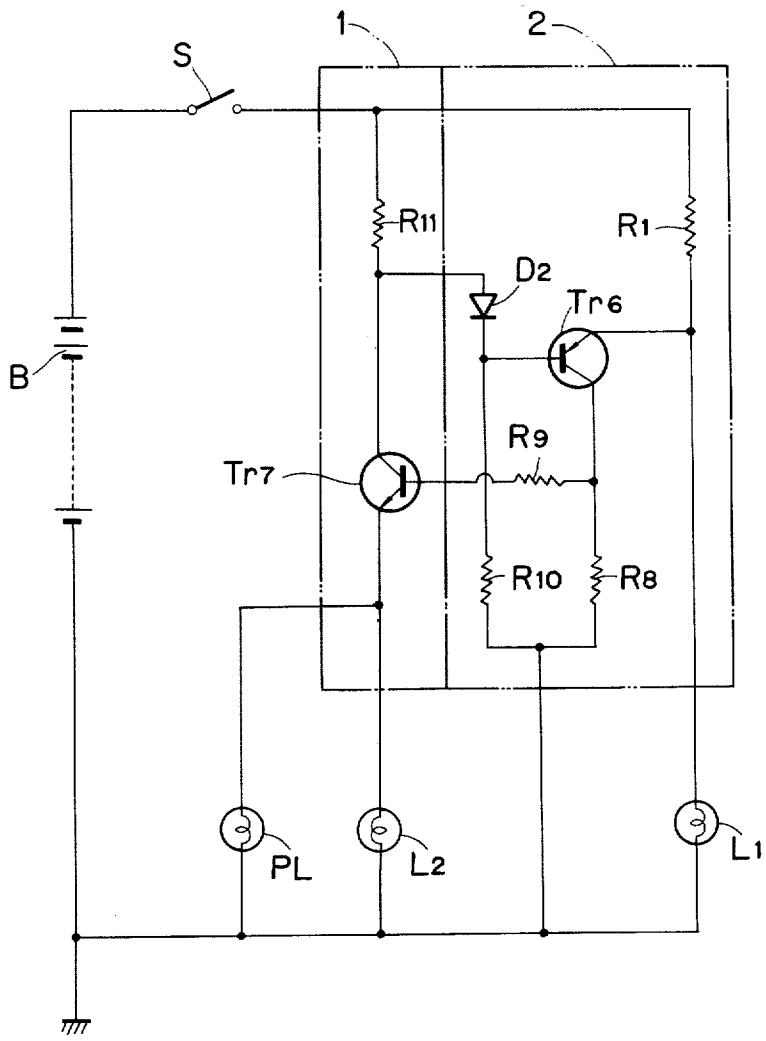

1
2
S
Tr4
D1
R1
R7
R2
Tr3
b
a
B
R3
R6
R5
Tr5
L2
PL
L1

FIG. 3



DEVICE FOR AUTOMATICALLY COMPENSATING FAILURE OF A LAMP

This invention relates to a device for automatically compensating a possible failure or burning-out of a lamp such as a headlamp of an automobile, which is capable of detecting failure of the lamp and energizing a spare or back-up lamp for the lamp burnt out upon detection of the failure.

Hitherto, there have been proposed many devices for detecting a possible failure of a lamp by the voltage drop across a resistor connected in series with the lamp in which said voltage drop across the resistor is applied between the base and the emitter of a PNP-type transistor to bias said transistor into a conducting state as long as the lamp has been in the normal condition.

These devices, however, involve some problem that power loss in the circuit is considerably large due to the necessity that the voltage drop across the resistor is to be larger than the threshold voltage (about 0.6V) of the transistor.

One way to solve the above-mentioned problem is to apply the voltage drop across the series resistor to the emitter of a transistor and the forward voltage drop across a diode to the base of said transistor thereby to enable reduction of the voltage drop across the series resistor. However, this way also has a disadvantage that sufficient base current is not obtained and several amplifiers are additionally required.

This invention was made to overcome the above-mentioned disadvantages and therefore it is an object of the present invention to provide a device for automatically compensating failure of a lamp which is capable of supplying sufficient base current with a reduced number of amplifiers thereby to simplify the circuit arrangement of the device and enable the device to be manufactured at a reasonable cost.

It is another object of the present invention to provide a device for automatically compensating a failure of a lamp which is capable of minimizing a power loss owing to its circuit arrangement in which the voltage drop across a series resistor is adapted to just slightly lower the potential at an emitter.

It is a further object of the present invention to provide a device for automatically compensating failure of a lamp which is capable of reducing the number of semiconductive elements of large capacity to be connected because of its circuit arrangement in which a main current for energizing a spare lamp is adapted to flow through one semiconductive element thereby to reduce the manufacturing cost.

According to the present invention, there is provided a device for automatically compensating failure in a lamp, which comprises said lamp; a back-up lamp which is adapted to be energized in place of said lamp when said lamp is burnt out; a series resistor connected between a power supply and said lamp; a PNP-type transistor having an emitter connected between said series resistor and said lamp, a collector connected to a base of another transistor, but of NPN-type, as mentioned below, and a base connected to the power supply through another resistor and a diode; and the NPN-type transistor connected to be turned on when the potential at the emitter of said PNP-type transistor is higher than the potential at the base thereof to further lower the potential at the base thereof; said back-up lamp being adapted to be energized upon the turning on of said NPN-type transistor.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which;

FIG. 1 is a circuit diagram of one form of a device for automatically compensating failure of a lamp and embodying the present invention;

FIG. 2 is a similar circuit diagram of another form of the device according to the present invention; and

FIG. 3 is a similar circuit diagram of a further form of the device according to the present invention.

Referring now to FIG. 1, there is illustrated one embodiment of the present invention. B is a power supply such as a battery mounted on an automobile, S is a power supply switch such as a lighting switch, L_1 is a load such as a headlamp of an automobile, L_2 is a spare or back-up lamp which is adapted to be compensatingly energized upon failure of the lamp L_1, PL is a pilot or alarm lamp for indicating a failure of the lamp L_1, and R_1 is a resistor connected in series with the lamp L_1 which causes a certain voltage drop when the lamp L_1 is energized. Numeral 1 designates a reference voltage circuit composed of a diode D_1 and resistors R_2 and R_3 wherein there is a relation $R_2 << R_3$ and the current flowing in the forward direction of the diode D_1 is determined by the resistors R_2 and R_3 and the diode D_1 to keep the forward voltage drop at point a about 0.5V. Numeral 2 designates a control circuit comprising a PNP-type transistor Tr_1 for detecting failure of the lamp, an NPN-type power transistor Tr_2 and a resistor R_4, which control circuit 2 is adapted to compensatingly light the back-up lamp L_2 when the lamp L_1 is burnt out or disconnected.

The operation of the thus constructed device will be explained in the following.

The silicon transistor is normally in a nonconducting state when the base-emitter voltage is about 0.3V, begins to be conductive when said voltage is about 0.5V and is completely turned on when said voltage is about 0.7V.

When the lamp L_1 operates properly, if the voltage drop across the series resistor R_1 is determined to be 0.2V (the electric potential at point b will be then lower than the power voltage by 0.2V) and the electric potential at point a (the juncture of the resistors R_2 and R_3) is determined to be 0.5V lower than the power voltage, a voltage of only 0.3V is applied across the base and the emitter of the transistor Tr_1, keeping said transistor Tr_1 turned off. The transistor Tr_2 is accordingly kept in a nonconducting state. As a result, there will be supplied no collector current through the diode D_1 of the reference voltage circuit 1, letting both the back-up lamp L_2 and the warning lamp PL remain deenergized.

In the event of a failure of the lamp L_1, the voltage drop across the series resistor R_1 ceases and the potential difference of 0.5V appearing at a is applied across the base and the emitter of the transistor Tr_1.

Then, the transistor Tr_1 is biased into a conducting state, permitting a collector current to flow, whereby the potential at the base of the transistor Tr_2 is raised and said transistor Tr_2 is in turn biased into a conducting state. Since the collector current of the transistor Tr_2 flows through the diode D_1, and the resistor R_2, the potential at point a is lowered from the predetermined voltage and the base bias of the transistor Tr_1 is increased accordingly, deepening the conducting of said

transistor Tr_1, which in turn further biases said transistor Tr_2 to be conductive. Thus, the switching of the transistor Tr_1 can be well sped up. In this connection, if the resistor R_2 is selected to make the potential at point *a* lower than the power voltage by 0.7 - 0.8V when the transistors Tr_1 and Tr_2 are turned on, said transistors Tr_1 and Tr_2 become conductive and the back-up lamp L_2 and the alarm lamp PL are lit without a power loss due to the transistor Tr_2.

Though in the operation as mentioned above the connection of the transistors Tr_1 and Tr_2 functions equivalently to a silicon controlled rectifier, the present circuit arrangement controls the positive feedback through the transistor Tr_2 by the potential at point *a* which is determined by the diode D_1 and the resistor R_2 so that the transistors Tr_1 and Tr_2 become turned off when the failure of the lamp L_1 is eliminated and it returns to the normal condition with a voltage drop across the series resistor R_1.

Another embodiment of the present invention will be explained referring to FIG. 2. This embodiment is identical with the first embodiment except a control circuit 2 which is composed of transistors Tr_3 to Tr_5 and resistors R_5 to R_7.

In the operation, when the lamp L_1 is burnt out or disconnected and the transistor Tr_3 is started to be conductive, the base current is supplied to the transistor Tr_5 through the resistor R_5 biasing said transistor Tr_5 into a conducting state, lowering the potential at point *a* through the resistor R_6 and supplying the base current to the transistor Tr_4 through the resistor R_7. In other words, the emitter of the transistor Tr_5 is grounded to make a positive feedback to *a* through the resistor R_6, thereby to facilitate the control of such a feedback. The power loss by the transistor Tr_4 can be reduced by employing a PNP-type transistor in which the voltage drop across the collector and the emitter thereof is smaller as compared with an NPN-type transistor. The transistor Tr_4 is protected from an inrush (high starting transient) current to be supplied to the back-up lamp L_1 and the alarm lamp PL by regulating the base current with the resistor R_7.

A further embodiment of the present invention is shown in FIG. 3 wherein numeral 1 designates a lamp energizing circuit including an NPN-type transistor Tr_7 and a collector resistor R_{11} of said transistor Tr_7 and numeral 2 designates a failure detecting circuit comprising a resistor R_1 connected in series with a lamp L_1, a PNP-type transistor Tr_6 for detecting a failure of the lamp, a diode D_2 for applying a base bias to said transistor Tr_6, a collector resistor R_8 of said transistor Tr_6, a base protective resistor R_9 of the transistor Tr_7 and a bias resistor R_{10}.

The operation of the present embodiment is as follows.

When the lamp L_1 operates properly, a current is supplied, upon closing of a swtich S, to the lamp L_1 through the resistor R_1 to energize said lamp L_1. When the current flows through the resistor R_1, there is caused a voltage drop across said resistor R_1 to lower the potential at the emitter of the transistor Tr_6. The base bias applied to said transistor Tr_6 is determined by a voltage divider formed of the resistor R_{11}, the diode D_2 and the resistor R_{10}. The base potential is substantially equal to the power source potential substracted by the voltage drop across the diode D_2 and the voltage drop across the resistor R_{11} can be disregarded because the circuit current is extremely small.

If the voltage drop across the resistor R_1 is determined to be 0.3V and the voltage drop across the diode D_2 to be 0.6V, there appears a difference of only 0.3V in potential, which is not sufficient to turn on the transistor Tr_6. Accordingly, both of said transistor Tr_6 and the transistor Tr_7 are kept in a nonconducting state and the back-up lamp is not energized.

Upon failure or burning-out of the lamp L_1, there is supplied no current through the resistor R_1 and no voltage drop across said resistor R_1, so that the emitter of the transistor Tr_6 is maintained at the power supply voltage. On the other hand, to the base of the transistor Tr_6 is applied 0.6V due to the voltage drop across the diode D_2, thus making the difference in potential between the emitter and the base be 0.6V and biasing said transitor Tr_6 into a conducting state.

As a result, the collector voltage is raised to the power supply voltage and the base current is supplied to the transistor Tr_7 through the base protective resistor R_9 biasing said transistor Tr_7 into a conducting state. When the transistor Tr_6 begins to be turned on, there occurs a voltage drop across the resistor R_{11} which deepens the base bias of the transistor Tr_6 thereby to completely turn on said transistor Tr_6 and the transistor Tr_7 is turn.

Upon turning on of the transistor Tr_7, the back-up lamp L_2 is energized for the burnt out lamp L_1 and the alarm lamp PL is lit to annunciate the failure of the lamp to the driver and prevent possible trouble due to such a failure.

The potential at the base of the transistor Tr_7 is substantially equal to the power supply potential if the base protective resistor R_9 is not connected. The potential at the emitter thereof is 0.6 to 0.8V lower than the base potential and the potential at the collector is 0.3V lower than said base potential due to the voltage drop (0.3V) across the resistor R_{11} so that the potential difference between the collector and the emitter is restrained within 0.3 to 0.5V. Thus, the resistor R_{11} acts to reduce the power loss in the transistor Tr_7.

Even when the resistor R_{11} is selected to be large and there is caused a large voltage drop thereacross, the problem of having the base bias of the transistor Tr_6 become too large does not occur. Stated illustratively, through the resistor R_{10} there flow the base current of the transistor Tr_6 and the current from the diode D_2 by which the base bias is applied to the transistor Tr_6, so that a large voltage drop across the resistor R_{11} would result simply in reluctant flow of the current from the diode D_2 and cause no lowering of the base potential. The resistor R_8 finally controls the base current of the transistor Tr_6.

The following operation will be seen when the failure of the lamp is eliminatead and it begins to operate properly. In the transistor Tr_6 turned on upon the failure of the lamp L_1, the base-emitter voltage is about 0.9V. Said base-emitter voltage of the transistor Tr_1 is lowered not more than 0.6V because the voltage drop across the resistor R_1 in the steady-state current of the lamp L_1 is 0.3V so that said transistor Tr_6 is not turned off. However, the inrush (turn-on transient) current flows through the lamp L_1 increasing the voltage drop across the resistor R_1 to level more than in the steady state, whereby said transistor Tr_6 is turned off easily. The transistor Tr_7 is in turn deenergized to extinguish

the back-up lamp and the lamp L_1 remains energized.

According to the present invention, as mentioned above, voltage drop across a series resistor is applied to the emitter of a transistor for detecting failure of a lamp and forward voltage drop across a diode is applied to the base of said transistor to restrain the voltage drop across the series resistor, and a main current of a transistor circuit controlled by the failure detecting transistor is made to flow through a resistor to form a positive feedback to said failure detecting transistor within the range controlled by said diode and resistor thereby to further lower the voltage drop across the series resistor. The failure detecting transistor is sufficiently turned on by the above-mentioned circuit arrangement to energize a back-up lamp.

As the voltage drop across the series resistor just slightly lowers the emitter voltage of the transistor, power loss can be minimized. Further according to the present invention, possible fluctuation in base-emitter voltage of the failure detecting transistor due to variation in temperature can be counterbalanced with the diode employed, so that the device of the present invention is remarkably stable against possible variation or change in surroundings or temperature.

What is claimed is:

1. An apparatus for automatically detecting and compensating failure of a first lamp normally energizable from a power supply, comprising in combination:

means including a series resistor connecting said first lamp across said power supply and responsive to conduction through said first lamp for creating a voltage drop in said series resistor;

first and second normally non-conductive transistors of opposite polarity;

means connecting a main current electrode of said normally non-conductive first transistor between said first lamp and series resistor and responsive to loss of said voltage drop upon failure of said first lamp for turning on said first transistor;

bias means connecting the base of said first transistor to said power supply for enabling said main current electrode to control turn on of said first transistor;

means coupling said first transistor to the base of said second transistor and responsive to first transistor conduction for turning on said second transistor;

feedback means coupling a main current electrode of said second transistor to said bias means and responsive to conduction of said second transistor for increasing conductive bias on said first transistor base and accelerating switching of said first and second transistors into conduction; and

a back-up lamp and means coupling same to said second transistor and responsive to conduction of said second transistor for energizing said back-up lamp.

2. An apparatus according to claim 1 in which said series resistor is of resistance sufficiently small that said voltage drop thereacross is less than the threshold voltage of said first transistor, whereby to minimize power loss in said series resistor during normal current flow through the ignited first lamp.

3. An apparatus according to claim 2 in which said bias means comprises a further resistor and a diode in series between said power supply and said base of said first transistor, said main electrode of said second transistor being connected at least through said further resistor to said power supply to provide positive feedback from said second transistor upon conduction thereof to said first transistor, whereby said series diode and further resistor and said positive feedback provide rapid and positive actuation of said transistors despite the relatively small change in voltage drop across said series resistor upon failure of said first lamp.

4. The apparatus of claim 1 in which the emitter is the electrode of said first transistor connected between said series resistor and first lamp, the collector of said first transistor is direct connected to the base of said second transistor, said bias means comprises a diode and further resistor in series, one end of said bias means being connected to said power supply and the other end being connected to the base of said first transistor and the collector of second transistor, said means coupling said back-up lamp to said second transistor comprising a conductive path connected to the emitter of said second transistor and including a path to circuit ground for said back-up lamp and first lamp and resistance means connecting the base and collector of said second transistor to said circuit ground.

5. An apparatus according to claim 1 in which said bias means comprises a diode and further resistor in series, the first recited coupling means comprising a resistor connecting the first transistor collector to the second transistor base, said feedback means including an additional resistor connecting the second transistor collector to the first transistor base, the remaining said coupling means comprising a third transistor connected in series between said back-up lamp and power supply and having a base electrode coupled to the collector of said second transistor for actuation of said third transistor upon actuation of said second transistor.

6. An apparatus according to claim 1 in which said bias means comprises a further resistor and diode in series between said power supply and said first transistor base, the diode-connected end of said further resistor being connected by said feedback means in series with the main current electrodes of said second transistor and thence through said last mentioned coupling means with said back-up lamp, said last mentioned coupling means comprising a conductive connection between the emitter of said second transistor and said back-up lamp, the first mentioned coupling means comprising a resistor connected between said first transistor collector and said second transistor base.

7. A device for automatically detecting and compensating failure in a lamp normally energizable from a power supply, which comprises:

a first lamp, the failure of which is to be detected and compensated;

a back-up lamp energizable in the place of said first lamp, when said first lamp is burnt out;

a series resistor connected between said power supply and said first lamp;

a PNP transistor having a collector, an emitter connected between said series resistor and said first lamp, and a base connected to said power supply through a bias path including a further resistor and diode in series;

an NPN transistor having a base;

means connecting said base of said NPN transistor to the collector of said PNP transistor for turning on said NPN transistor when the potential at the emitter of said PNP transistor is higher than the potential at the base thereof, said NPN transistor having main current electrodes and means coupling one thereof to said bias path for further lowering the

potential of said PNP transistor base upon conduction of said NPN transistor;

means coupling said NPN transistor and back-up lamp and responsive to conduction of said NPN transistor for energizing said back-up lamp.

8. A device according to claim **7** including an amplification transistor conductive in response to the turning on of said NPN transistor for energizing said back-up lamp therethrough.

9. A device according to claim **7** wherein said diode is connected at its cathode to the base of said PNP transistor and at its anode to said power supply through said further resistor and to the collector of said NPN transistor.

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