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Schacket

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[54] **LAMP FAILURE DETECTOR ASSEMBLY**

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[52] **U.S. Cl.** **340/251**
[51] **Int. Cl.** **G08b 21/00**
[58] **Field of Search**..... 340/213.2, 251, 256

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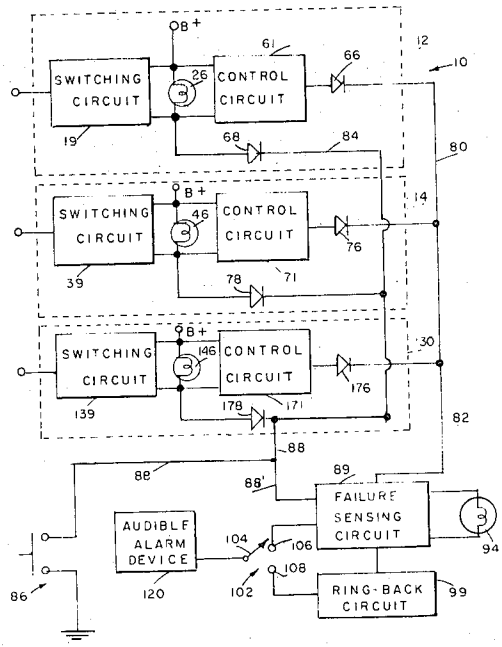
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Primary Examiner—Donald J. Yusko
Attorney, Agent, or Firm—Friedman & Goodman

[57] **ABSTRACT**

A lamp failure detector assembly includes a plurality of lamp filament sensors. Each lamp filament sensor includes a switching circuit which is connected to an associated pilot lamp to be monitored and to a transducer which is capable of assuming one of two states. In one state of the transducer, the switching circuit causes a current having one level to flow through the lamp, the level being sufficient to visibly light the lamp. In the other state of the transducer, the switching circuit causes a current to flow through the lamp which is insufficient to visibly light the lamp. A control circuit is connected to the pilot lamp to be monitored — the control circuit being so arranged so as to cause a monitoring current to flow through the pilot lamp when the filament of the latter is good irrespective of the state of the transducer, the monitoring current which passes through the bulb and through the control circuit having a level sufficient to be detected by the control circuit yet insufficient to visibly light the lamp. Each control circuit of a respective lamp filament sensor is arranged to sense the level of current flow through an associated pilot lamp and for generating a control signal when current flow through the pilot lamp is interrupted. A failure sensing circuit is connected to each of the control circuits for receiving a control signal when one of the monitored pilot lamps fails and for energizing a failure indicator lamp as well as an audible alarm device. A ring-back circuit connected to the failure sensing circuit is connectable to the audible alarm device so that when the audible alarm device is connected to the ring-back circuit while one of the monitored pilot lamps is faulty, the audible alarm device is not energized. When the faulty pilot lamp is replaced by a good lamp, the failure sensing circuit and the ring-back circuit change their respective states so that the failure indicator lamp is deenergized and the audible alarm device is energized. The latter energization of the audible alarm device is termed the ring-back and gives an indication that a faulty bulb has been replaced by a good one — the ringing back being continued until the audible alarm device is again connected to the failure sensing circuit.

5 Claims, 4 Drawing Figures



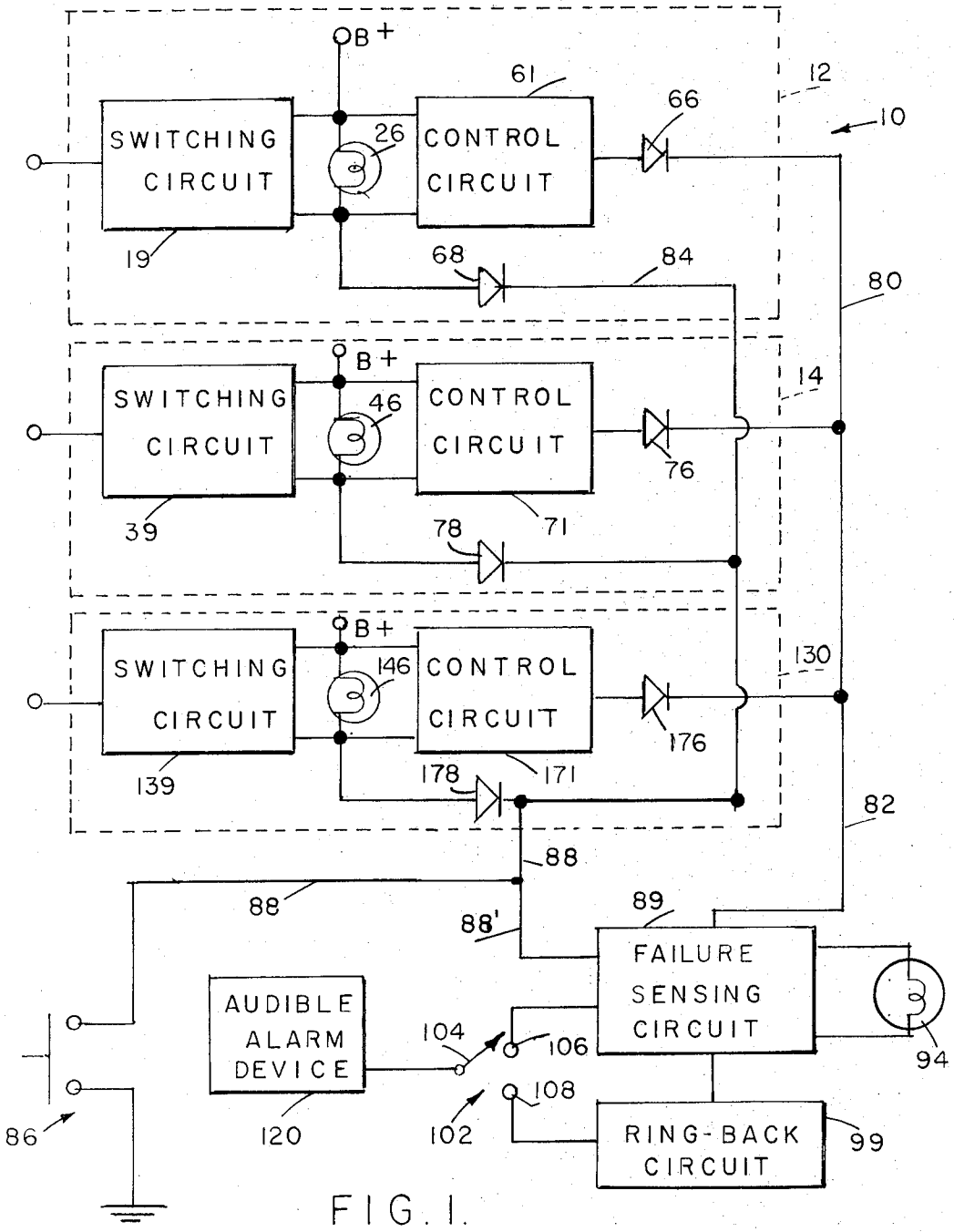

B+
SWITCHING CIRCUIT
19
26
CONTROL CIRCUIT
61
66
12
10
68
84
80
B+
SWITCHING CIRCUIT
39
46
CONTROL CIRCUIT
71
76
14
78
B+
SWITCHING CIRCUIT
139
146
CONTROL CIRCUIT
171
176
130
178
82
88
88
88'
89
FAILURE SENSING CIRCUIT
94
AUDIBLE ALARM DEVICE
120
104
106
108
102
RING-BACK CIRCUIT
99
86

FIG. 1.

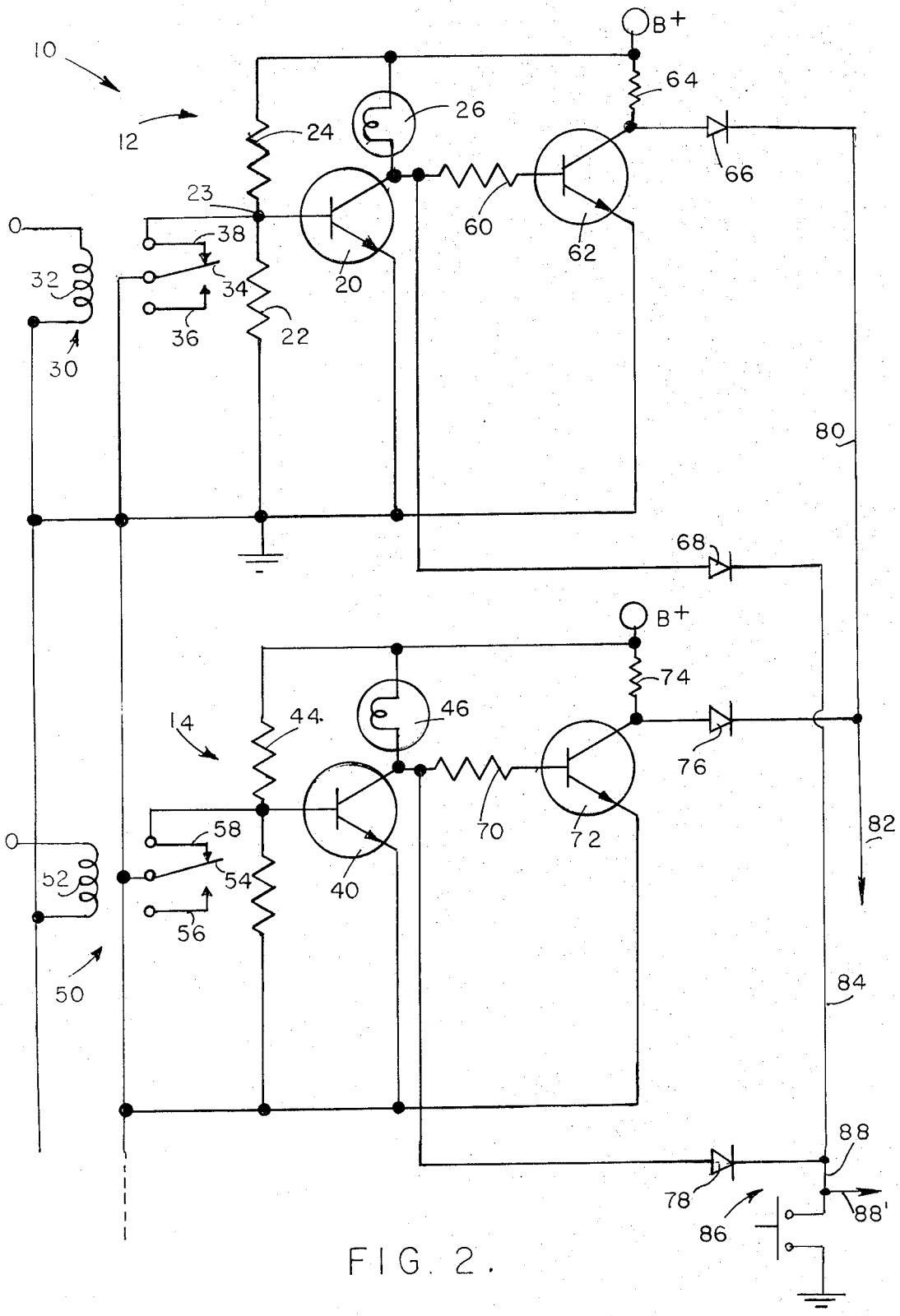

10
12
B+
64
26
24
66
23
60
62
38
20
32
34
36
22
30
80
68
B+
74
14
44
46
76
58
70
72
82
52
54
40
56
50
84
88
78
86
88'

FIG. 2.

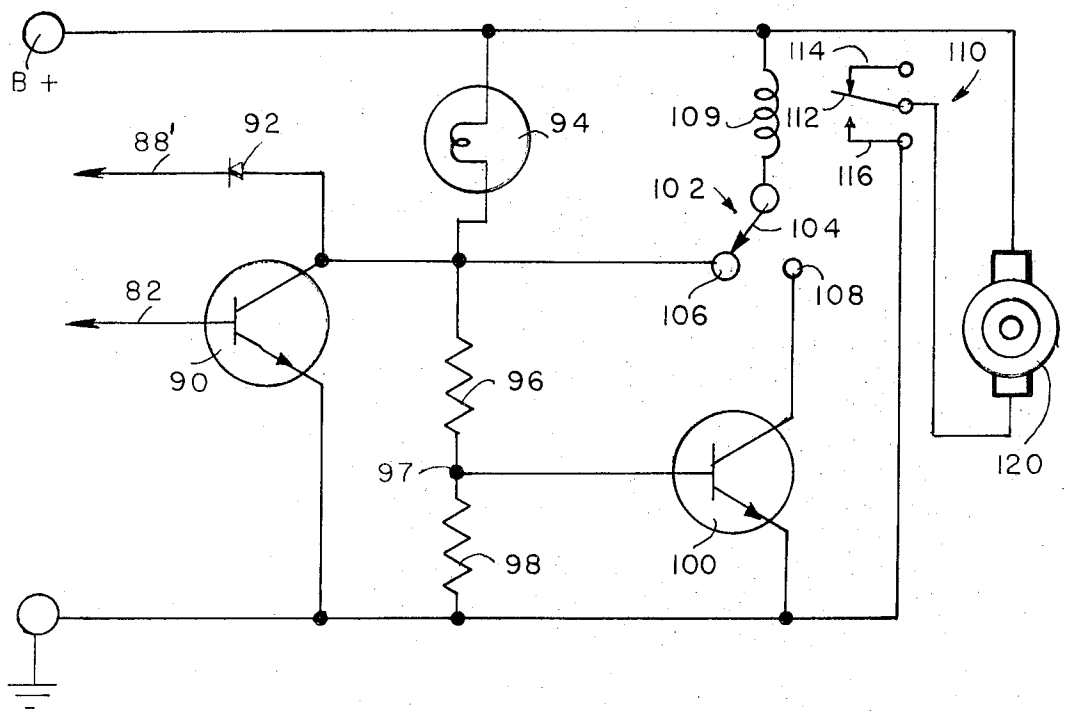

B +
88'
92
94
109
112
114
110
116
102
104
106
108
82
90
96
97
98
100
120

FIG. 3.

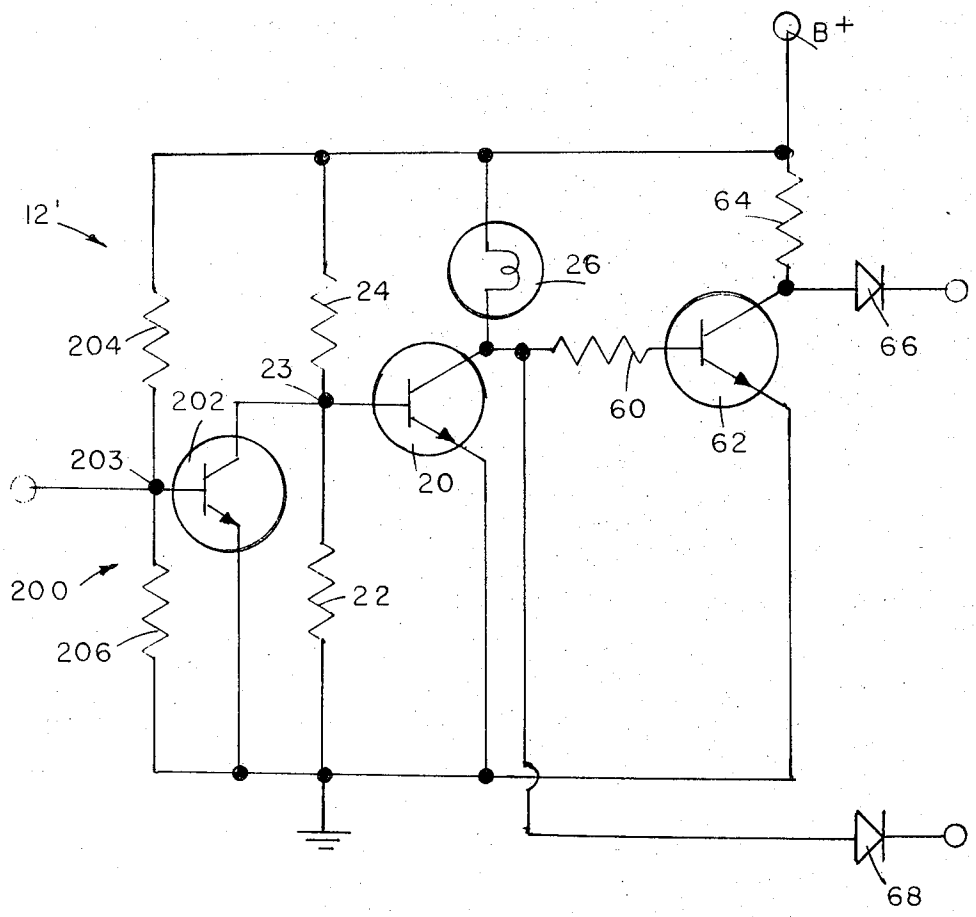


FIG. 4.

LAMP FAILURE DETECTOR ASSEMBLY

BACKGROUND OF THE INVENTION

The present invention generally relates to monitoring circuits, and more particularly to a lamp failure detector assembly suitable for monitoring a plurality of lamps simultaneously and for providing both visible as well as audible information when a pilot lamp which is monitored becomes faulty. A ring-back feature is provided which provides audible information when the faulty bulb has been replaced by a good bulb.

Monitoring systems of various types are already known. For example, it is common to monitor the operation of components in a circuit to insure continued proper operation thereof. This is especially true when the appearance of the component does not change in appearance between its normal and its inoperable conditions. However, many of the known monitoring assemblies are complex and costly to manufacture. This is especially true in cases where numerous components must be simultaneously monitored.

For example, indicator lamps are frequently utilized in connection with multi-station intercom systems to provide an indication of which stations are in communication with one another. Also, indicator lights are commonly utilized in conjunction with burglar and fire detection systems, wherein master panels are provided with a plurality of lamps to indicate the numerous normal and alarm conditions. Further, indicator lamps are very frequently utilized in electronic equipment to indicate the on-off conditions of components, assemblies or sub-assemblies.

The present invention for a lamp failure detector assembly is suitable for monitoring the lamps in any of the above-mentioned equipment. The monitoring function which the present invention provides is important because frequently a burned out light appears to give a particular type of condition when, in reality, the other condition exists but cannot be communicated to an observer due to a faulty or burned out lamp or bulb. Failure of an indicator lamp may be critical where the function monitored is an important one. For example, indicator bulbs in automobiles which indicate the oil pressure in the engine must always be operative if engine damage is to be prevented. However, because of the unavailability of suitable monitoring means in the prior art, indicator bulbs in automobiles, as well in other equipment, has hitherto been unmonitored.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a lamp failure detector which does not have the disadvantages possessed by similar prior art detectors.

It is another object of the present invention to provide a lamp failure detector which is simple in construction and economical to manufacture — thereby making it practical to use in conjunction with many pilot lamps.

It is still another object of the present invention to provide a lamp failure detector as described above which can monitor one or a plurality of pilot lamps simultaneously and provide a visible or audible alarm, or both, when any of the monitored pilot lamps becomes faulty.

It is yet another object of the present invention to provide a lamp failure detector which includes means for testing the operability of the pilot lamps which are monitored.

It is a further object of the present invention to provide a lamp failure detector assembly wherein a plurality of pilot lamps are simultaneously monitored without interference of one filament sensor monitoring one pilot lamp with the other filament sensors monitoring the other lamps.

It is still a further object of the present invention to provide a lamp failure detector for monitoring a pilot lamp while the latter is fully operable to indicate the state of a remote transducer.

It is yet a further object of the present invention to provide a lamp failure detector of the type presently under discussion which includes a ring-back means suitable for sounding an audible alarm once a faulty lamp has been replaced by a good lamp.

Accordingly, in order to achieve the above objects, as well as others which will become apparent hereafter, the lamp failure detector for monitoring at least one pilot lamp arranged to show the state of a transducer comprises at least one lamp filament sensor connected to a lamp. The lamp filament sensor includes input terminal means adapted to be connected to a transducer capable of assuming first and second states. Switching means also forms part of said lamp filament sensor and is connected to said input terminal means and to the lamp for controlling the magnitude of the current flowing through the lamp between two levels as a function of the state of the transducer. One level of the current flowing through the lamp is sufficient to visibly light the lamp while an other level of current is insufficient to visibly light the lamp. Control means, also forming part of said lamp filament sensor, is provided for sensing the level of current flow through the pilot lamp and for generating a control signal when current flow through the pilot lamp is interrupted. Failure sensing means is provided and connected to said control means for receiving said control signal. Indicator means are provided and connected to said failure sensing means for providing an indication when current flow is interrupted in the pilot lamp and a control signal is received by said failure sensing means.

According to a presently preferred embodiment, a plurality of pilot lamps are to be simultaneously monitored and a plurality of lamp filament sensors are provided, each respectively connected to an associated pilot lamp. All said lamp filament sensors are connected to said failure sensing means. Each lamp filament sensor is arranged to generate a control signal receivable by said failure sensing means when the current in a respective pilot lamp is interrupted. In this manner, an indication is provided whenever any lamp filament fails and prevents current flow therethrough.

Said control means is connected to said one pilot lamp and is arranged to cause a monitoring current to flow through said one pilot lamp when the filament of the latter is good. Said monitoring current has a level sufficient to be detected by said control means yet insufficient to visibly light the lamp.

According to another advantageous feature of the present invention, ring-back means are provided, said indicator means comprising an audible alarm device switchably connected to said failure sensing means and to said ring-back means. Said failure sensing means and

said ring-back means being so arranged in cooperative relation with one another so that said audible alarm device is energized when connected to said failure sensing means only when a control signal is generated and is only energized in the absence of a control signal when connected to said ring-back means.

BRIEF DESCRIPTION OF THE DRAWINGS

With the above and additional objects and advantages in view, as will hereinafter appear, this invention comprises the devices, combinations and arrangements of parts hereinafter described and illustrated in the accompanying drawings of a preferred embodiment in which:

FIG. **1** is a block diagram of the lamp failure detector assembly in accordance with the present invention, showing three lamp filament sensors associated with three respective pilot lamps to be monitored;

FIG. **2** are schematic diagrams of two of the lamp filament sensors of FIG. **1**;

FIG. **3** is a schematic diagram of the failure sensing circuit and the ring-back circuit of FIG. **1**; and

FIG. **4** is a schematic diagram of one lamp filament sensor in accordance with another embodiment thereof.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the FIGURES, wherein similar or identical components have been designed by the same reference numerals, and first referring to FIG. **1**, a block diagram of the lamp failure detector assembly is shown and designated by the reference numeral **10.** The lamp failure detector assembly **10** is shown to comprise three lamp filament sensors **12, 14** and **130.** Although three lamp filament sensors have been shown, it should be pointed out that any number of lamp filament sensors may be provided — the number possibly ranging from one to any desired number, as will become apparent hereafter. Each lamp filament sensor is identical in construction to the other lamp filament sensor and therefore it is only necessary to specifically describe the construction of one such sensor.

The lamp filament sensor **12** includes a switching circuit **19** whose specific construction as well as function will be more fully described in connection with FIG. **2.** The switching circuit **19** has an input terminal which is connectable in a conventional manner to a transducer (not shown). The specific transducer utilized is not critical for the purpose of the present invention. As suggested in the Background of the Invention, the transducer may originate in an intercom system, in an automobile oil pressure test circuit, and electronic control board, etc. In each case, the transducer connected to the switching circuit can generally assume one of two states. A pilot lamp or bulb **26** is connected to the switching circuit **19** and is so associated with the latter, as to be described hereafter, so that when the transducer changes states, the lamp **26** becomes energized or deenergized, as the case may be.

Connected to the pilot lamp to be monitored is a control circuit **61** whose function is to monitor current flowing through the lamp **26.** The switching circuit **19** is so arranged in relation to the lamp **26** so that the current in the lamp **26** may change between two levels as a function of the state of the transducer. One level of the current through the lamp **26** is sufficient to visibly light the lamp while the other level of current is insufficient to visibly light the lamp. Whether one or the other level of current is caused to flow through the lamp **26** is primarily determined by the switching circuit **19.**

Independently of the switching circuit **19,** the control circuit **61** causes a monitoring current to flow through the pilot lamp **26** so long as the filament of that pilot lamp is good. The monitoring current which passes through the lamp **26** has a level sufficient to be detected by the control circuit **61,** yet insufficient to visibly light the lamp **26.**

So long as a current is detected in the lamp **26** by the control circuit **61,** the output of the control circuit **61** is maintained at a low level, as will be more further described hereafter. When current is interrupted in any pilot lamp, its associated control circuit generates a control signal, to be more specifically described hereafter.

Similarly, the switching circuit **39** and the control circuit **71** are connected to the lamp **46** while the switching circuit **139** and the control circuit **171** are connected to the pilot lamp **146.** The outputs of the control circuits **61, 71** and **171** are each connected to a failure sensing circuit **89** through respective isolating diodes **66, 76** and **176.** Also connected to the failure sensing circuit **89** via respective isolating diodes **68, 78** and **178** are one terminal of each of the pilot lamps **26, 46, 146** while the other respective terminals of the lamps are connected to the source of potential B+.

When a control signal is generated by any one of the control circuits, the control signal is applied to the failure sensing circuit **89** via an associated isolating diode — the failure sensing circuit **89** energizing the failure indicator lamp **94.** An audible alarm device **120,** being connected to a movable contact **104** of a two-position switching **102,** is simultaneously energized when the movable contact **104** is engaged with a fixed contact **106** connected to the failure sensing circuit.

A ring-back circuit **99** is connected to the failure sensing circuit **89** and also connected to a fixed contact **108** of the switch **102.** When the movable control **104** is engaged with the fixed contact **108,** while a control signal is generated by any of the control circuits, the audible alarm device **119** is deenergized, as to be further described hereafter. However, as soon as a faulty bulb is replaced and none of the control circuits generates a control signal, the ring-back circuit energizes the audible alarm device — this being termed "ring-back"— until the movable contact **104** is again engaged with the fixed contact **106.**

The lamps **26, 46** and **146** are each connected to a source of potential B+ and to a common test buss or line **88** via associated diodes **68, 78** and **178.** The line **88** is connected to a normally open momentary contact switch **86** at one terminal thereof while the other terminal of the switch is grounded. By momentarily closing the switch **86,** currents are caused to flow in each of the pilot lamps being monitored of sufficient magnitude or level so as to light the same. Simultaneously, the switch **86,** also being connected to the failure sensing circuit **89,** via line **88'** causes the lamp **94** as well as the audible alarm device **120** to be energized to signify that a test is being performed for the purpose of determining which, if any, of the lamps being monitored are faulty.

The circuit associated with the block diagram of FIG. **1** will now be described in more detail by way of spe-

cific embodiments which are, however, merely illustrative. It will become apparent from a description of the specific circuitry that numerous variations are possible which function similarly to the circuits to be described. All minor variations which will be evident to one skilled in the art are also contemplated to be included within the scope of the invention.

Referring to FIG. **2**, the switching circuit **19** of FIG. **1** is shown to comprise a switching stage including an NPN transistor **20** whose emitter is connected to the circuit ground. The base of the transistor is connected to a center tap **23** of a voltage divider consisting of series connected resistors **22** and **24**, the latter two transistors being connected in series between a source of energy in the form of a power supply having a potential B+ and the circuit ground. Connected between the center tap **23** and a transducer (not shown) which may be remote, is a relay **30** having a coil **32.** One terminal of the coil **32** is advantageously connected to the circuit ground while the other terminal of the coil **32** is connectable to the transducer whose state is to be indicated by a bulb or pilot lamp **26.** The pilot lamp **26** is connected between the power supply voltage B+ and the collector of the transistor **20.** The coil **32** of the relay **30** cooperates with a movable contact **34** and two fixed contacts **36** and **38.**

The switching circuit **19** of the lamp failure sensor **12** described thus far functions to regulate the level of current which may flow through the pilot lamp **26** as a function of the state of the transducer which is connected to the coil **32.** Thus, when the transistor **20** is "on" or conducting, the collector of the transistor **20** is placed at a relatively low potential level and the substantial part of the power supply potential B+ is placed across the pilot lamp **26.** Thus, a conducting transistor **20** causes a level of current to flow through the pilot lamp **26** which is sufficiently high so as to visibly light the pilot lamp **26.** Advantageously, the pilot lamp **26** is so selected so that the level of current which flows therethrough when the transistor **20** is conducting is the rated current for the lamp **26** to thereby provide the maximum brightness when the switching circuit **19** is energized.

When the transistor **20** is "off" or non-conducting, the current flowing through the pilot lamp **26** is reduced to a level which cannot visibly light the lamp. As should be clear, if only the pilot lamp **26** were connected to the collector of the transistor **20,** the turning off or making the transistor **20** non-conductive would fully interrupt the current flow in the pilot lamp **26.** However, the current through the pilot lamp does not drop to zero as a result of the control circuit stage **61** of FIG. **1,** as to be described hereafter.

The conductive and non-conductive stages of the transistor **20** are controlled or regulated by a usually remote transducer connected to an actuatable means which, in FIG. **1,** is in the form of the relay **30.** The relay **30** is so selected so that a movable contact **34** is normally, i.e. when the coil **32** is not energized, connected to a contact **38** which is connected to the center tap **23.** When the coil **32** is energized, the movable contact **34** is moved into engagement with a fixed contact **36** which is left floating.

In the normal states of the transducers, accordingly, the bases of the switching stage transistors **20, 40,** etc. are placed at ground potential or the same potential as the emitters of said transistors. The switching stage transistors are thereby non-conductive and the pilot lamp **26, 46,** etc., are not visibly lit. Should the coil **32** be energized by the application of a potential thereto in a conventional manner by a remote transducer, the relay **30** is energized and the movable contact **34** disengages from the fixed contact **38** to thereby remove the ground potential from the base of the transistor **20.** Once the ground potential is removed from the base of the transistor **20,** the voltage divider, consisting of resistors **22** and **24,** determines the potential applied to the base of the transistor **20** relative to its emitter. The values of the resistors **22, 24** are so selected so as to supply a sufficiently positive biassing voltage to the base of the transistor **20** so as to make the transistor **20** fully conductive. Simultaneously, the pilot lamp **26** becomes visibly lit as described above. As soon as the transducer reverts to its original or normal state, the coil **32** is again deenergized and the base of the transistor **20** is again grounded. In this manner, the pilot lamps **26, 46,** etc., indicate the states of their associated transducers.

Although only two of the lamp filament sensors **12, 14** of FIG. **1** are shown, it should be clear that any number of lamp filament sensors may be provided to correspond with as many pilot lamps **26, 46,** etc. as are to be monitored. In each case, the construction of the switching circuits **19, 39** and **139** described above may be identical.

As described above, the switching circuit transistors regulate the level of the current flowing through the pilot lamps being monitored. The current flowing through the lamps may be switched from an approximately rated current to approximately a zero current depending on the conductive or non-conductive state of the associated switching stage transistor. An important feature of the present invention is the maintenance of a slight monitoring current through the pilot lamps to be monitored irrespective of the states of the switching stage transistors and always monitoring the current flowing through the pilot lamps as an indication of their respective operabilities or filament conditions. Thus, so long as a current can be made to flow through a pilot lamp, this is an indication that the pilot lamp is in good operating order. However, as soon as a current, however slight, cannot be passed through a pilot lamp, this is an indication that the pilot lamp is faulty and must be replaced.

In FIG. **1,** control circuits **61, 71, 171** are each shown connected to an associated pilot lamp for monitoring current flow therethrough. In FIG. **2,** the control circuit **61** is shown to comprise a control stage NPN transistor **62** whose collector is connected to the energy supply having a potential of B+ through a load resistor **64.** The emitter of the transistor **62** is grounded while the base of the transistor is connected to the collector of the transistor **20** by means of a current limiting resistor **60.** Each of the control circuits associated with a different pilot lamp is similarly constructed. The value of the resistor **60** is so selected so as to prevent excessive current flow through the base-emitter junction of the transistor **62** which may damage said transistor. However, the resistor **60** is selected to have a value sufficiently low so as to permit a monitoring current to flow through the pilot lamp **26,** the resistor **60,** and the base-emitter junction of the transistor **62.** The monitoring current must be one which is sufficiently small so as not to visibly light the lamp **26** while being sufficiently large

so as to be capable of detection by the control stage transistor **62.** Otherwise stated, the monitoring current which flows through the lamp **26** and the transistor **62** must be sufficiently large so as to provide base current to the transistor which will maintain the transistor **62** in a conductive state so long as the monitoring current is permitted to flow. Thus, the potential at the control stage transistor **62** base must be maintained at a sufficiently positive voltage and a sufficiently large base current must be available in order to maintain the transistor "on" or conductive whenever the pilot lamp **26** conducts a current. When the transistor **20** is not conductive, the potential at the collector of the transistor **20** becomes highly positive and sufficient base current is provided to maintain the control stage transistor **62** conductive. However, when the transistor **20** becomes conductive, the collector-emitter saturation voltage is approximately one volt — the value of resistance of the resistor **60** being selected to provide sufficient base current for the transistor **62** when the collector voltage of the transistor **20** is at its lowest contemplated positive level. Thus, the lower limit for the resistor **60** value is determined by the maximum transistor **20** collector potential and the maximum base current which can be safely supplied to the transistor **62** while the upper limit of the resistor **60** resistance value is determined by the minimum anticipated transistor **20** collector voltage as well as the minimum transistor **62** base current which is sufficient to maintain the latter transistor in a conductive state.

From the above, it should be clear that so long as the filament of the pilot lamp **26** is not burned out or as long as the lamp is operable, sufficient positive potential and base current will be provided at the base of the transistor **62** to maintain the same conductive. Accordingly, the potential at the collector of the transistor **62** will be maintained at a low level. However, as soon as a filament, e.g. the filament of the lamp **26,** burns out or the pilot lamp becomes faulty and no further current can flow therethrough, the conductive connection between the positive supply voltage B+ and the collector of the transistor **20** as well as the base of the transistor **62** is interrupted and no positive potential can be applied thereto. As soon as positive potential is removed from the base of the control stage transistor **62,** the latter transistor becomes non-conductive and the collector thereof rises substantially towards the power supply potential B+. It should be clear that as soon as any one of the pilot lamps being monitored becomes faulty, its associated control stage transistor collector rises in potential. The normally low collector potentials of the control stage transistors are termed "no control signal" conditions while the rise in collector potential in the manner described in connection with a faulty bulb is termed generation of a "control signal" by the associated control circuit. As described in connection with FIG. **1,** all the control circuits are connected by respective lines, e.g. line **80** of the lamp filament sensor **12,** to a lamp failure signal buss **82.** Referring to FIGS. **2** and **3,** the lamp failure signal buss is connected to the base of a failure sensing stage transistor **90.** The collectors of the respective control stage transistors **62, 72,** etc. are connected to the base of the transistor **90** via respective isolating diodes **66, 76,** etc. The isolating diodes are so arranged so that the generation of a positive control signal at the collectors of the control stage tansistors are transmitted to the base of an NPN transistor **90.** However, when the control stage transistors **62, 72,** etc. are normally conductive, when their associated bulbs are operable, the collector voltages of the respective control stage transistors are sufficiently low so that the potentials applied to the lamp failure signal buss **82,** in view of the additional voltage drop across the isolating diodes, are insufficient to cause the transistor **90** to become conductive when its emitter is grounded. However, when a control signal is generated, i.e. the base of a control stage transistor rises in response to failure of an associated pilot lamp, the control signal becomes sufficient, even with the isolating diode voltage drop, for making the transistor **90** conductive.

The transistor **90** forms part of the failure sensing circuit **89** as shown in FIG. **1.** The failure indicator lamp **94** is connected between the collector of the sensing stage transistor **90** and the power supply potential B+. As similarly described in connection with the switching stage transistors, when the sensing stage transistor **90** is conductive, sufficient current is permitted to flow through the failure indicator lamp **94** so as to make the same visibly lit. However, when the failure sensing stage transistor **90** is non-conductive, insufficient current flows through the lamp **94** and the latter is not visibly lit.

The ring-back circuit **99** as shown in FIG. **1** comprises a ring-back stage NPN transistor **100** whose emitter is grounded. Series connected resistors **96, 98** form a voltage devider having a center tap **97.** The series connected resistors are connected between the collector and emitter of the transistor **90.** The base of the ring-back stage transistor **100** is connected to the center tap **97.** Thus, when the transistor **90** is non-conductive, the collector-emitter voltage of the transistor **90** is sufficiently large so as to provide a potential at the center tap **97** which tends to make the ring-back stage transistor **100** conductive. On the other hand, when the transistor **90** is conductive, the collector-emitter voltage thereof is very low and the potential at the center-tap **97** is insufficient to tend to cause the transistor **100** to be conductive. Thus, it should be clear that the transistors **90** and **100** are so arranged so as to operate complementarily to one another so that when one transistor is conducting the other is not and vise versa. A two position switch **102** is provided having a movable contact **104,** a fixed contact **106** connected to the collector of the transistor **90** and a fixed contact **108** connected to the collector of the transistor **100.** The fixed contact **106** will be termed the normal position of the switch while the contact **108** will be termed the ring-back or the silent position.

Connected to the movable contact **104** is a coil **109** of a relay **110.** The coil **109** represents a load which is switchable between the contacts **106** and **108.** When the movable contact engages the contact **106,** the coil **109** becomes a load of the transistor **90** parallel with the failure indicator lamp **94.** When the movable contact **104** is engaged with the fixed contact **108,** the coil **109** becomes a load of the transistor **100.**

The coil **109** cooperates with the contacts **112, 114** and **116** of the relay **110** to control the operation of the audible alarm device **120.**

The movable contact **104** is normally in contact with the fixed contact **106** in the so-called normal position. In the normal position of the switch **102,** the operation of the relay **110** is controlled by the failure sensing transistor **90.** Accordingly, when the failure sensing

transistor **90** is non-conducting, the coil **109**, similarly to the failure indicator lamp **94**, is not energized and the relay contacts are so arranged so that the movable contact **112** is engaged with the floating fixed contact **114**. Accordingly, the audible alarm device **120** will similarly be deenergized.

With the switch **102** still in its normal position, when the failure sensing stage transistor **90** becomes energized, its collector potential drops to substantially the saturation voltage of the transistor and the failure indicator lamp **94** as well as the coils **109** become energized. Accordingly, the lamp becomes visibly lit and the movable contact **112** engages the grounded fixed contact **116** to thereby energize the audible alarm device **120.**

When the switch **102** is moved to its ring-back or silent position, wherein the movable contact **104** engages the fixed contact **108,** the failure indicator lamp **94** and the audible alarm device **120** operate out of phase. Thus, with the switch **102** in the ring-back position, when the transistor **90** is non-conductive the indicator lamp **94** is not visibly lit while the coil **109** is energized due to the conductive state of the ring-back transistor **100.** Thus, while the failure indicator lamp is deenergized the audible alarm device **120** is energized. On the other hand, when the failure sensing stage transistor becomes energized, the failure indicator lamp **94** becomes visibly lit while the coil **109** becomes deenergized due to the now non-conductive ring-back transistor **100.** Now, while the failure indicator lamp **94** is visibly lit, the audible alarm device **120** is deenergized.

The isolating diodes **66, 76,** etc., respectively connected to the control circuit transistors **62, 72,** etc., are advantageously provided as shown in FIGS. **1** and **2** for the purpose of isolating the collectors of the respective control stage transistors. In the absence of the control isolating diodes **66, 76,** etc., the generation of a control signal in the form of a rising potential at one of the control stage transistor collectors, may be loaded by the other still heavily conducting control stage transistors. Such interference may prevent the rise of voltage at the base of the transistor **90** sufficiently to make the latter conductive.

In accordance with another feature of the present invention, means are provided for simultaneously testing all the pilot lamps being monitored to determine which, if any, of the lamps is faulty. Referring to FIGS. **1** and **2,** each switching circuit has associated therewith, a switching isolating diode **68, 78, 178,** etc., are all connected to a common lamp test buss **88** via individual lines, e.g. line **84** associated with the isolating diode **68.** The common lamp test buss **88** is connected to the circuit ground by way of a normally open momentary contact switch **86.** The common lamp test buss **88** is also connected, via line **88'** and an isolating diode **92,** to the collector of the failure sensing stage transistor **90.** Closing of the momentary contact switch **86** grounds the collectors of all of the switching transistors **20, 40,** etc., — this simulating the conductive states of said transistors. Thus, so long as the momentary contact switch **86** is maintained in a closed position, all of the pilot lamps being monitored are simultaneously energized and made visibly lit. It is now possible by an observer to determine which, if any, of the pilot lamps are faulty. It is clear that all but the faulty pilot lamps will become visibly lit when the momentary contact switch is closed.

The switch and isolating diodes **68, 78,** etc., serve two functions. Firstly, the switching isolating diodes isolate the respective collectors of the various switching stage transistors **20, 40,** etc., from each other. Such isolation is necessary if the bases of the control stage transistors **62, 72** etc., are to be deprived of potential and base current upon failure of an associated pilot lamp. Deletion of the switching isolating diodes would result in application of potential as well as the provision of current from one lamp failure sensor to another lamp failure sensor via the common lamp test buss despite the failure of a pilot lamp. Thus, the switching isolating diodes **68, 78,** etc., assure that the control stage transistors become non-conductive when their associated pilot lamps become faulty.

Secondly, switching isolating diodes **68, 78** serve the further function of maintaining somewhat positive voltages at the collectors of the switching stage transistors **20, 40,** etc., equal to the voltage drop across said switching isolating diodes. These somewhat positive voltages at the collectors of the switching stage transistors may be sufficient to maintain the control stage transistors **62, 72,** etc., conductive despite the grounding of the common lamp test buss **88.**

The common lamp test buss **88** is also connected to the collector of the failure sensing stage transistor **90** via the isolating diode **92** as described above. The effect of closing the momentary contact switch **86** grounds the collector of the transistor **90** — this simulating the conductive state of the transistor. Accordingly, the failure indicator lamp **94** will become energized independently of the conductive states of the control stage transistors or the state of the failure sensing stage transistor **90.** Similarly, if the switch **102** is in its normal position, the audible alarm device will become energized. If the switch **102** is in the ring-back position or silent position, closing of the momentary contact switch **86** will cause the audible alarm device **120** to become deenergized so long as the momentary contact switch is maintained in a closed state.

In FIG. **4,** a lamp filament sensor **12'** is shown which is another embodiment of the lamp failure sensor **12** of FIG. **2.** In FIG. **4,** the relay **30** of FIG. **2** has been replaced by a transistor circuit generally designated by the reference numeral **200.** The transistor circuit **200,** similarly to the relay **30,** constitutes actuatable means which are connectable to a remote transducer. The transistor circuit **200** comprises a transistor **202** whose collector is connected to the center tap **23** and whose emitter is connected to the circuit ground. The base of the transistor **202** is connected to a center tap **203** of a voltage divider comprising resistors **204, 206** which are series connected with each other and connected between the positive supply potential B+ and the circuit ground. The base of the transistor **202** is connectable to a remote transducer as was the one terminals of the coil **32.** In connection with this actuating means **200,** the remote transducer advantageously grounds the base of the transistor **202** when it changes from one state to another. Accordingly, when the base of the transistor **202** is grounded, the transistor **202** is non-conductive and the potential of the center tap **23** is determined by the voltage divider resistor **22, 24** — the potential formed at the center tap being sufficient to make the transistor **20** conductive. When the transducer changes states and ungrounds the base of the transistor **202,** a potential is applied to the base of the

transistor as determined by the values of the resistors **204, 206.** The potential at the center tap **203** is advantageously selected so that when the base of the transistor **202** is not grounded, the transistor becomes conductive to thereby ground the base of the transistor **20** and causing the latter to become non-conductive. In all other respects, the lamp failure sensor **12'** is similar and functions similarly to the lamp failure sensor **12.** As will be evident to those skilled in the art, numerous other forms of actuatable means can be substituted for the relay **30,** or the transistor circuit **200.**

The operation of the lamp failure detector assembly, to the extent to which it has not been set forth above, will now be described. In describing the operation, it will be assumed that the lamp failure detector assembly merely comprises two lamp filament sensors **12** and **14.** However, as has already been made clear above, any number of lamp filament sensors may be provided each respectively connected to the lamp failure signal buss **82** and the common lamp test buss **88** as described above. First it will be assumed that the pilot lamps **26, 46** are both operative. When neither of the coils **32, 52** are energized, the transistors **20, 40** are non-conductive. Accordingly, the monitoring currents which flow through the lamps **26, 46** are insufficient to visibly light the lamps. However, the monitoring currents passing through the pilot lamps are sufficient to maintain the control stage transistors **62, 72** respectively in a conductive state. As described above, this represents a "no signal" condition on the lamp failure signal buss **82** and the failure sensing stage transistor **90** is non-conductive, with the attendant non-energized states of the failure indicator lamp **94** and audible alarm device **120** (when the switch **102** is in its normal position in engagement with the fixed contact **106**).

When a remote transducer energizes a coil, e.g. coil **32,** the transistor **20** is made conductive and a current is permitted to flow to the pilot lamp **26** of sufficient level to make the pilot lamp visibly lit. However, as described above, the potential at the collector of the transistor **20** is sufficiently positive so that the conditions at the base of the control stage transistor **62** are still such as to make the latter transistor conductive as before change of states of the transducer. Accordingly, the change of states of the transducer merely effects the conductive states of the switching stage transistor **20** and does not regulate the control circuit **61** and the circuitry beyond.

It is noted that while all the control stage transistors are conductive, the failure sensing stage transistor **90** is non-conductive and the ring-back stage transistor **100** is conductive. Thus, while the failure indicator lamp **94** is deenergized, the audible alarm device **120** may be energized if the movable contact **104** is moved from its normal position into engagement with the fixed contact **108.**

Similarly, if the coil **52** is energized instead of the coil **32,** the switching stage transistor **40** becomes conductive and the pilot lamp **46** becomes visibly lit. As before, the control stage transistor **72** remains energized and fails to generate a control signal which can energize the transistor **90.** If both coils **32** and **52** are simultaneously energized, in any conventional manner, then both transistors **20** and **40** become energized and pilot lamps **26** and **46** become visibly lit. Again, the control stage transistor **62, 72** remain conductive and no control signals are generated.

It will now be assumed that the pilot lamp **26** filament burns out or the lamp becomes faulty. Although the description is to be made in connection with the pilot lamp **26,** it should be clear that similar operation will hold true with respect to any other pilot lamp so being monitored. As soon as the pilot lamp **26** becomes faulty, the source of positive potential at the collector of the transistor **20** and the base of the transistor **62** is removed. This results from the open circuit now existing between the source of positive potential B+ and the collector of the transistor **20.** With no voltage and current applied to the base of the transistor **62,** the control stage transistor **62** becomes non-conductive and its collector rises towards the B+ potential. This constitutes, as described above, a control signal which is transmitted through the control isolating diode **66** via the lamp failure signal buss **82** to the base of the transistor **90.** The application of a positive control signal to the base of the failure sensing stage transistor **90** makes the latter transistor conductive with atendant energization of the failure indicator lamp **94.** Since the switch **102** is normally set so that the movable contact **104** is engaged with the fixed contact **106,** the generation of a control signal simultaneously energizes the coil **109** and the audible alarm device **120.**

Although the function of monitoring pilot lamps and providing indicator means for indicating a faulty condition of a monitored pilot lamp has thus been accomplished, another feature of the present invention consists in providing a ring-back or other suitable indication when a faulty bulb has been replaced by a good or operable bulb. In accordance with this feature, as soon as the failure indicator lamp **94** becomes visibly lit and the audible alarm device **120** becomes audible, the switch **102** is changed in state so that the movable contact **104** engages the fixed contact **108.** As described above, so long as a faulty pilot lamp is monitored, the failure sensing transistor stage **90** is conductive. Accordingly, during this time, the ring-back stage transistor **100** is non-conductive as described above. Consequently, moving the switch **102** while the audible alarm device is energized to the ring-back or silent position deenergizes the audible alarm device. At this time, while a faulty bulb is being detected, the failure indicator lamp **94** is energized while the audible alarm device **120** is deenergized.

When the faulty pilot lamp **26** is replaced by a good pilot lamp which can conduct the requisite monitoring current to the base of the transistor **62,** the control signal on the lamp failure signal buss **82** is removed and the transistor **90** becomes non-conductive while the ring-back transistor **100** becomes conductive. Accordingly, when a faulty lamp is replaced by a good one, the failure indicator lamp **94** becomes deenergized while the audible alarm device **120** becomes energized to provide a ring-back audible signal denoting that such lamp replacement has taken place. At this time, the switch **102** is again moved to its normal position to deenergize the audible alarm device **120.** The lamp failure detector assembly is now reset to its original standby position for monitoring a further possible failure of a pilot lamp being monitored.

As described above, once failure of a lamp is indicated, the momentary contact switch **86** can be momentarily closed to determine which pilot lamp is faulty since all the lamps except the faulty ones will become visibly lit on the closing of the switch.

Numerous alterations of the structure herein disclosed will suggest themselves to those skilled in the art. However, it is to be understood that the present disclosure relates to a preferred embodiment of the invention which is for purposes of illustration only and is not to be construed as a limitation of the invention.

What is claimed is:

1. Lamp failure detector for monitoring at least one pilot lamp arranged to show the state of a transducer, said detector comprising at least one lamp to be monitored; switching means connected to said lamp for controlling the magnitude of a signal current flowing through said lamp between two levels, one level being sufficient to visibly light the lamp and another level insufficient to visibly light the lamp; control means for sensing the level of current flow through said lamp and for generating a control signal when current flow through said lamp is interrupted; failure sensing means comprising a transistor having a base connected to said control means for receiving said control signal; indicator means comprising an audible alarm device connected to the collector of said transistor for providing an indication when current flow is interrupted in said lamp and a signal is received at said base of said transistor; ring-back means connected to said collector of said transistor; and movable contact means for switching said audible alarm device to said collector of said transistor and to ring-back means, said failure sensing means and said ring-back means being arranged in cooperative relation with one another to energize said audible alarm device when connected to said collector only when a control signal is generated while only being energized in the absence of a control signal when connected to said ring-back circuit.

2. Lamp failure detector as defined in claim **1,** wherein said indicator means further comprises a failure indicator lamp.

3. Lamp failure detector as defined in claim **1,** wherein said ring-back means comprises a transistor, first and second series-connected voltage divider resistors having a center tap, said resistors being connected between said collector of said failure sensing means transistor and the emitter of the latter, said ring-back transistor having a base connected to said center tap and a collector to which said audible alarm device can be switched.

4. Lamp failure detector as defined in claim **3,** further comprising a two-position switch having a movable contact connected to said audible alarm device, a first fixed contact connected to said collector of said failure sensing transistor means, and a second fixed contact connected to said collector of said ring-back means, said audible alarm device being arranged to be energized only when connected to said first contact in the presence of a control signal while being arranged to be energized only when connected to said second contact in the absence of a control signal.

5. Lamp failure detector for monitoring at least one pilot lamp arranged to show the state of a transducer, said detector comprising at least one lamp to be monitored; switching means connected to said lamp for controlling the magnitude of a signal current flowing through said lamp between two levels, one level being sufficient to visibly light the lamp and another level insufficient to visibly light the lamp; control means for sensing the level of current flow through said lamp and for generating a control signal when current flow through said lamp is interrupted; failure sensing means connected to said control means for receiving said control signal; indicator means connected to said failure sensing means for providing an indication when current flow is interrupted in said lamp; ring-back means connected to said failure sensing means; and movable contact means for switching said indicator means to said failure sensing means and to said ring-back means, said failure sensing means and said ring-back means being arranged to energize said indicator means when connected to said failure sensing means only when a control signal is generated while only being energized in the absence of a control signal when connected to said ring-back means.

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