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[11] **3,781,841**

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[54] **LOAD RESISTANCE CHANGE ALARM**

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[52] **U.S. Cl.** **340/251**, 340/28, 340/280

[51] **Int. Cl.** **G08b 21/00**, G08b 23/00

[58] **Field of Search** 340/251

[56] **References Cited**

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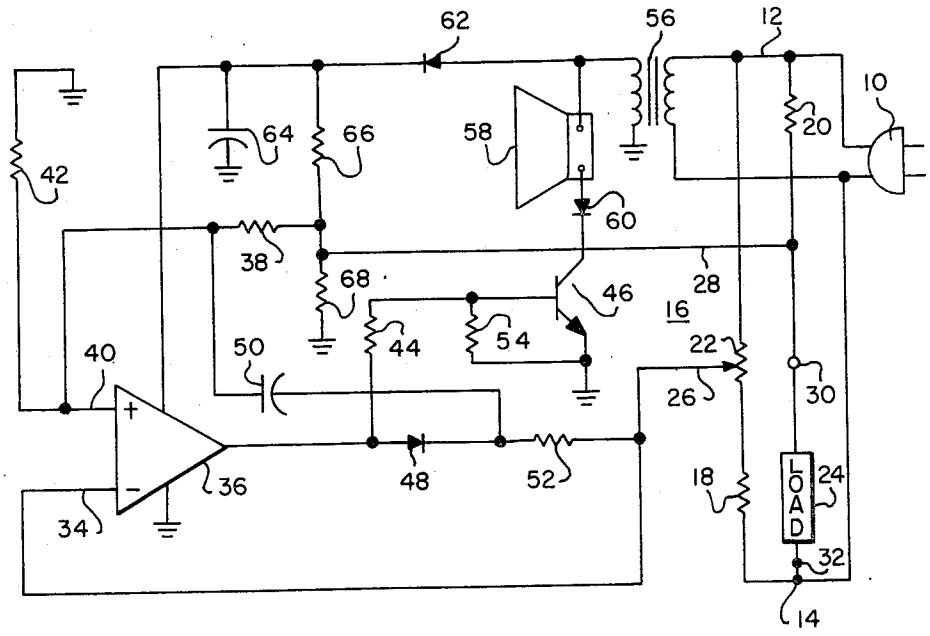
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Primary Examiner—Thomas B. Habecker

[57] **ABSTRACT**

A load resistance change alarm in which the magnitude and frequency of an audio signal are increased in proportion to an increase or decrease in resistance of the load. The load is connected in one branch of a bridge circuit. Any imbalance across the bridge circuit caused by a change in the load resistance is applied to an amplifier having a feedback circuit. The oscillations of the amplifier circuit turn on an electronic switch which allows unilateral current flow through the speaker. The current applied to the speaker is supplied through a step down transformer from the same power supply supplying current to the load.

10 Claims, 2 Drawing Figures



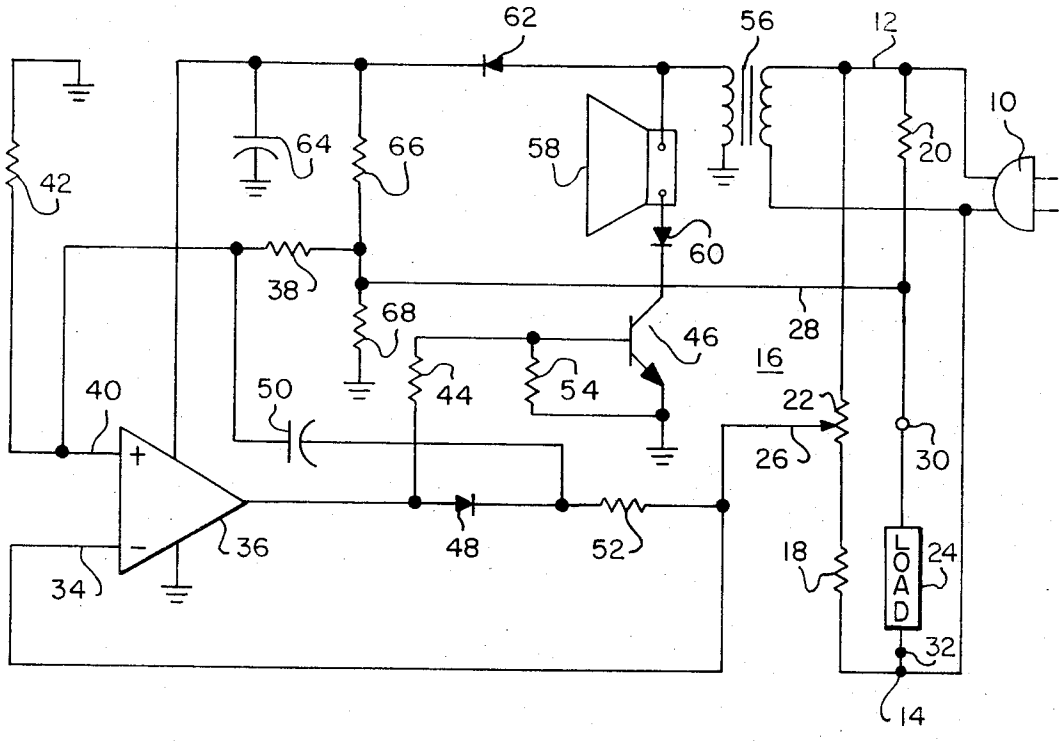

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LOAD
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FIG. 1

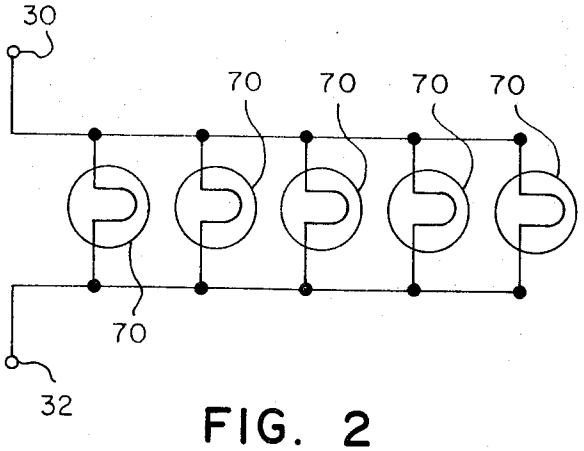

30
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70
70
70
70
32

FIG. 2

LOAD RESISTANCE CHANGE ALARM

This invention relates to a load resistance change alarm. More particularly, this invention relates to a load resistance change alarm in which an audible signal is provided which increases in magnitude and frequency as the resistance of the load is changed.

The apparatus of the present invention may be used to monitor any load in which it is required that the resistance of the load, or in other words the current drawn by the load, remains substantially constant. It is well known to those skilled in the art that an increase in resistance of a load will cause a decrease in the current drawn by the load, and vice versa, for a constant voltage applied to the load. Therefore, the apparatus of the present invention may be used to monitor any resistive load that requires a constant amperage for proper operation. For example, the apparatus of the present invention may be used to give an alarm where the resistance of electrical heating equipment varies beyond a predetermined limit.

Another very important application of the present invention is the monitoring of the resistance change of a load comprising a plurality of lights in order to detect lamp outage or removal. In most lighting arrays containing a plurality of lamps, the lamps are connected in parallel across the line supply of electrical energy. Therefore, the outage or removal of one or more lamps does not cause all of the remaining lamps to go out. However, the removal or outage of a single lamp does cause an increase in resistance of the load, or in other words a decrease in the current drawn by the load. Therefore, this change in resistance may be detected to give an alarm in the case of a lamp outage due to a burned out filament of the lamp or to the removal of the lamp by theft.

One important application of the monitoring of a light array containing a plurality of lights is to detect burned out lamps in the case of runway lighting arrays. Another advantageous use of the present invention as applied to lighting arrays is in the case of the detection of theft of light bulbs from Christmas lighting arrays. The present invention is particularly useful in detecting the theft of light bulbs from a Christmas lighting array since the magnitude and the frequency of the sound emitted by the alarm of the present invention are increased as each additional light bulb is removed from the Christmas array since the removal of each additional light bulb causes an additional increase in the resistance of the Christmas lighting array load.

In recent years there has been a rising number of incidents of theft of outdoor Christmas light bulbs in outdoor Christmas lighting arrays. Since the present invention provides a sound alarm that increases in frequency and magnitude as each additional bulb is removed from the lighting array, a clear indication is given between the burning out of a single bulb and the sequential removal of a plurality of bulbs by a thief. If only a single bulb burns out, and the owner does not have a replacement bulb or does not desire to replace the bulb at that time, the apparatus of the present invention may be adjusted by simply turning a dial which adjusts the load resistance change alarm for the new operating load condition.

In accordance with the present invention, the resistance or change in resistance of a load is monitored by connecting the load in one branch of a bridge circuit. The electrical energy supplying the load is connected

to one pair of terminals across the bridge circuit and any imbalance across the other pair of terminals of the bridge circuit caused by a change in the resistance of the load is applied to an amplifier means. The amplifier means is provided with a positive feedback circuit which causes the amplifier to oscillate in response to an unbalanced condition across the bridge circuit. The oscillation of the amplifier means turns on an electronic switch which causes a speaker to be energized in accordance with the oscillations of the amplifier means. The bridge circuit is also provided with means to adjust or initially balance the bridge circuit.

For the purpose of illustrating the invention, there are shown in the drawings forms which are presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. 1 is a schematic diagram of an apparatus in accordance with the present invention.

FIG. 2 is a schematic diagram of a particular load which may be monitored by the apparatus in FIG. 1.

Referring now to the drawings in detail, wherein like figures indicate like elements, there is shown in FIG. 1 an electrical plug **10**. The electrical plug **10** may be plugged into any suitable source of electrical alternating current. The electrical energy supplied through electrical plug **10** may be applied to a first pair of terminals **12** and **14** of bridge circuit **16**. Bridge circuit **16** is comprised of resistors **18** and **20**, potentiometer **22** and load **24**. Any imbalance in bridge circuit **16** is detected as a voltage across the second pair of terminals **26** and **28** of bridge circuit **16**. It may be noted at this point, that any imbalance in the bridge circuit may be initially adjusted out or compensated for by the adjustment of the wiper arm of potentiometer **22**. It may also be noted that load **24** is connected into the bridge circuit at terminals **30** and **32** which correspond to terminals **30** and **32** in FIG. 2 in an application where load **24** is a lighting array.

Terminal **26** of bridge circuit **16** is connected directly to the negative input **34** of amplifier **36**. Amplifier **36** may be a conventional and well known operational amplifier. Terminal **28** is connected through resistor **38** to the positive input terminal **40** of amplifier **36**. Positive input terminal **40** is connected to ground through bias resistor **42** which may be of a large resistance. Resistor **42** assures that when the bridge is nulled the circuit will not oscillate by itself, and also provides a turn-off bias which is gradually overcome by an increasing imbalance of bridge circuit **16**. The output of amplifier **36** is applied through resistor **44** to the base of switching transistor **46** and through diode **48**, when forward biased, and capacitor **50** to positive input terminal **40**. Resistor **52** is connected between the cathode of diode **48** and terminal **26** in order to maintain diode **48** reverse biased when the output of amplifier **36** is negative, thereby isolating capacitor **50** from the output of amplifier **36** and preventing spontaneous feedback-induced oscillations from occurring. Resistor **52** also serves to reverse the turn-on bias supplied by the bridge **16** to the amplifier **36** after the turn-on bias has caused the output of amplifier **36** to go positive, and thereby prevents the output of amplifier **36** from staying positive as long as the turn-on bias is present, and, instead, permits oscillations to occur as long as the turn-on bias is present. When the output of amplifier **36** goes positive, diode **48** becomes forward biased and allows posi-

tive feedback through capacitor 50 to positive input terminal 40 of amplifier 36. This results in oscillation of amplifier 36. The oscillations are limited in time for a limited half-cycle imbalance in bridge circuit 16. As the imbalance in bridge circuit 16 increases (during the line power half cycle which provides a turn-on signal from bridge circuit 16 to amplifier 36), thereby increasing the time during said half cycle when said turn-on bias is greater than the turn-off bias supplied to amplifier 36 by resistor 42, the oscillations of amplifier 36 increase in frequency and magnitude, essentially by increasing in number as said time per turn-on half cycle increases during which oscillations can occur.

The oscillations of amplifier 36 are applied through resistor 44 to the base circuit of switching transistor 46 including base-emitter resistor 54 which may be of a relatively low value of resistance. The oscillations of amplifier 36 turn on switching transistor 46 which allow positive pulses of current to be applied from step down transformer 56 to speaker or other acoustical transducer 58. Diode 60 prevents switching transistor 46 from operating when transformer 56 provides negative voltage to speaker 58. The half wave connection of transformer 56 also prevents speaker 58 from being operated by transistor 46 if the oscillations occur during the half cycle when transformer 56 is supplying negative voltage to speaker 58, said condition occurring if the bridge imbalance is in the reverse direction.

It is to be noted that this circuit is highly immune to transients in the line power voltage, since alarm-activating oscillations are induced primarily by the proper imbalance in bridge circuit 16. If the bridge is not already unbalanced so as to induce oscillations leading to an alarm output, transients in the line voltage will generally not induce said alarm-activating oscillations. For this reason, also, the shown circuit is highly immune to changes in the rms line voltage. Both transients and line voltage changes are common occurrences on AC power lines.

Diode 62 rectifies the output of step down transformer 56 and provides a source of direct current to amplifier 36 in conjunction with filter capacitor 64. Resistors 66 and 68 form a voltage divider for biasing positive input terminal 40 of amplifier 36.

Referring now to FIG. 2, there is shown one particular type of load 24 which may be connected between terminals 30 and 32. The load in FIG. 2 is comprised of a plurality of light bulbs 70 connected in parallel. It is understood that the present invention would also detect a change in resistance caused by the outrage or theft of a bulb in a series connected array. However, in the case of a series connected array, the outage or theft of a single light bulb would cause an open circuit or effectively infinite resistance upon the removal or open circuiting of a single light bulb. Therefore, the output of speaker 58 would be at a maximum frequency and magnitude upon the removal of a single light bulb. In the case of a parallel light bulb arrangement as shown in FIG. 2, the output of speaker 58 would increase in magnitude and frequency as each additional light bulb 70 is removed from the circuit.

In operation, any imbalance in bridge circuit 16 caused by an increase in the resistance of load 24, causes during each turn-on half cycle, a more negative potential to be applied to negative input terminal 34 of amplifier 36 via terminal 26. If the load has increased slightly due to the burning out of a single bulb 70, in the case of a parallel light array, and the bulb is not to be replaced immediately, the wiper arm of potentiometer 22 may be adjusted upward slightly in order to rebalance the bridge or in other words a lesser negative potential to negative input terminal 34 of amplifier 36 during the turn-on half cycles. Assuming that a plurality of light bulbs 70 are bing sequentially removed from the array by a thief, the negative potential on negative input terminal 34 will be increasing in magnitude during said turn-on half cycles. This will cause an increasing number of oscillations, per turn-on half cycle, of amplifier 36. The oscillations of amplifier 36 which are increasing in number per turn-on half cycle will be applied to the base of switching transistor 46. Switching transistor 46 will therefore be gated on in response to the output oscillations of amplifier 36 and will cause speaker 58 to emit a sound of increasing frequency and magnitude as each additional bulb is removed from the light array.

It will be apparent to those skilled in the art that various modifications may be made to the circuit and apparatus disclosed herein without departing from the spirit of the teachings of the present invention. For example, various other types of transducers may be used in place of speaker 58. A lamp may be substituted for speaker 58. That is, the lamp would glow at an increasing intensity as additional bulbs were removed from the load circuit. Further, if step down transformer 56 were wired in reverse, the turn-on half cycles would then turn on transistor 46 only if the load were to decrease below the null point. This provides a very simple method for changing from a decreasing load resistance detector to an increasing load resistance detector, and vice versa. Various other modifications will be apparent to those skilled in the art.

In view of the above, the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims, rather than to the foregoing specification as indicating the scope of the invention.

I claim:

1. Apparatus for detecting a change in resistance of a load and providing an alarm, comprising:
   - a bridge circuit having a first and a second pair of terminals connected across opposite ends thereof, said load being connected in one branch of said bridge circuit;
   - means for applying electrical power across said first pair of terminals of said bridge circuit;
   - amplifier means connected across said second pair of terminals of said bridge circuit, said amplifier means being provided with positive feedback means including a diode to control oscillation of said amplifier in response to an unbalanced bridge condition causing a voltage of predetermined polarity across said second apir of terminals; and
   - alarm means energized in response to oscillation by said amplifier means.

2. Apparatus in accordance with claim 1 wherein said bridge circuit includes means for initially balancing said bridge circuit.

3. Apparatus in accordance with claim 1 wherein said positive feedback means of said amplifier means includes a capacitor.

4. Apparatus in accordance with claim 1 wherein said alarm means comprises a speaker and a source of alter-

nating current connected to said speaker through an electronic switch, said electronic switch being turned on in response to oscillations by said amplifier means.

5. Apparatus for detecting successive changes in resistance of a load supplied with an alternating current and providing an indication which varies with the changes in resistance of said load, comprising:

a bridge circuit having a first pair of terminals connected across one pair of opposite ends of said bridge circuit and a second pair of terminals connected across the other pair of opposite ends of said bridge circuit, said load being connected in one branch of said bridge circuit;

means for applying an alternating current across said first pair of terminals of said bridge circuit;

amplifier means connected across said second pair of terminals of said bridge cicruit, said amplifier means being provided with positive feedback means including a diode in order to enable oscillation in response to an unbalanced bridge condition of a predetermined voltage polarity across said second pair of terminals;

an acoustical transducer;

means for applying said alternating current to said acoustical transducer; and

electronic switch means connected in series with said acoustical transducer and said means for applying said alternating current to said acoustical transducer, said electronic switch means allowing unilateral current flow, during half waves of a predetermined polarity of said alternating current, through said acoustical transducer in response to oscillation of said amplifier means.

6. Apparatus in accordance with claim **5** wherein said bridge circuit includes means for initially balancing said circuit.

7. Apparatus in accordance with claim **5** wherein said positive feedback means includes a capacitor.

8. Apparatus in accordance with claim **5** wherein said acoustical transducer is a speaker.

9. Apparatus in accordance with claim **5** wherein said means for applying said alternating current to said acoustical transducer is a step down transformer.

10. Apparatus in accordance with claim **5** wherein said load is a plurality of lights .

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