April 7, 1970 A. R. MORRIS 3,505,664

SWITCH CONDITION INDICATOR

Filed July 7, 1967 2 Sheets-Sheet 1

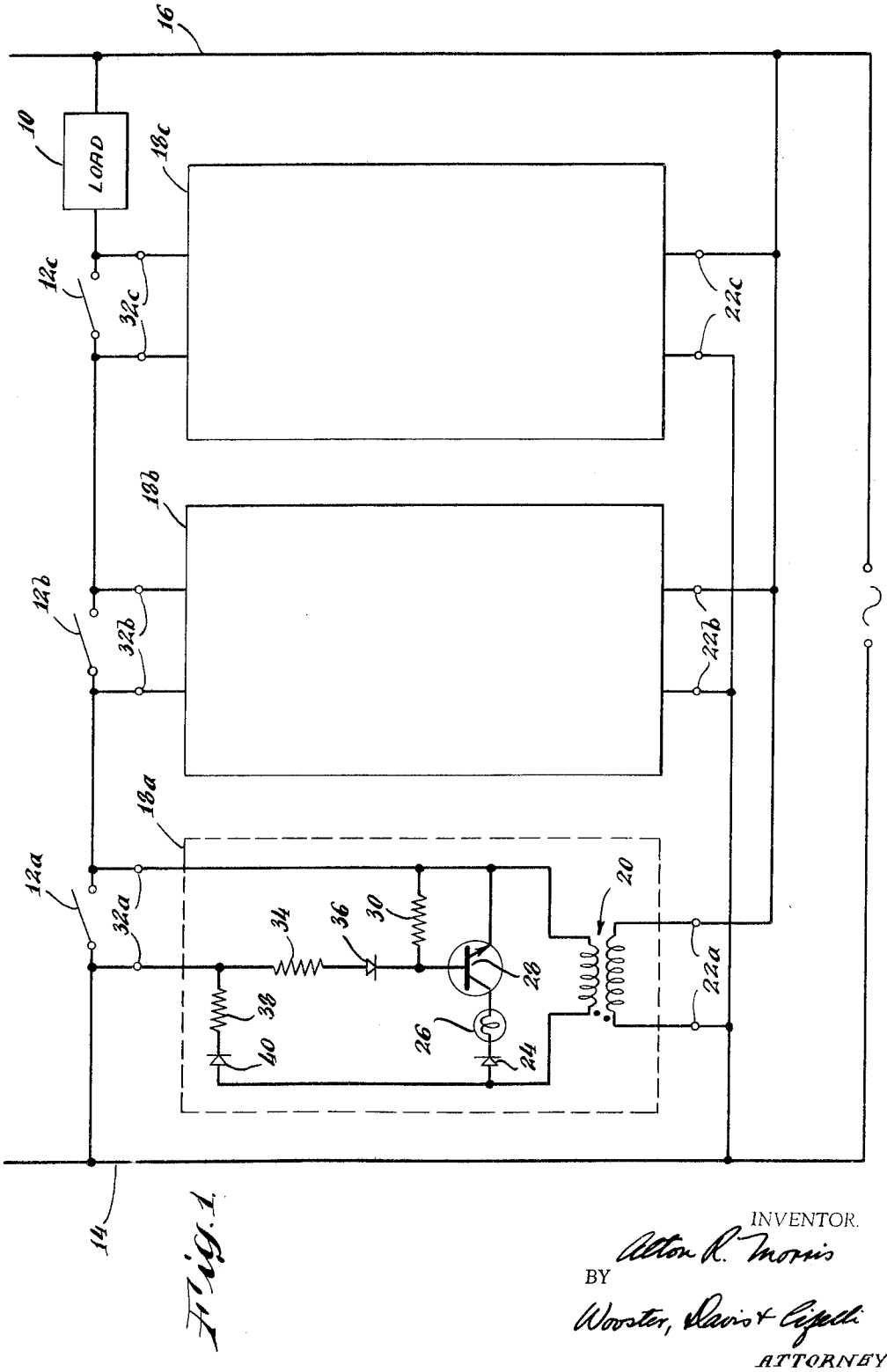


Fig. 1.

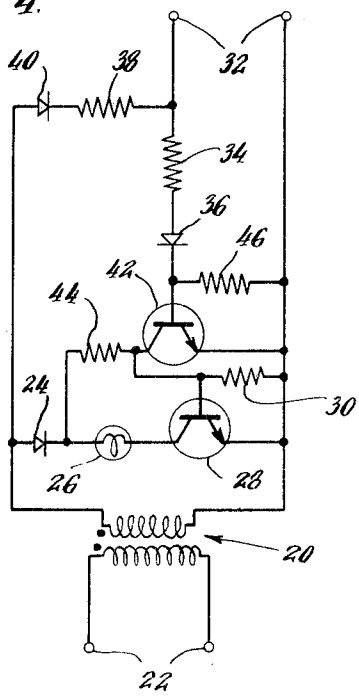
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Fig. 4.



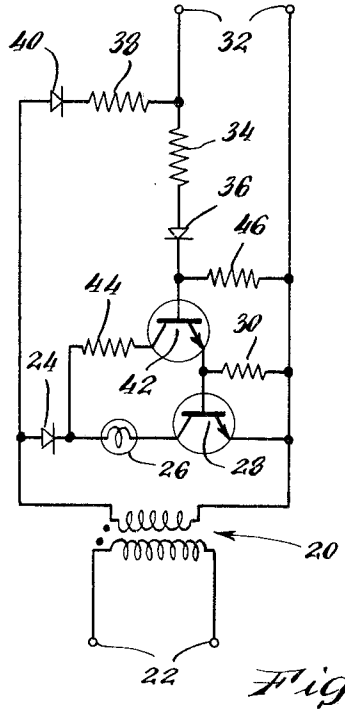


Fig. 2.

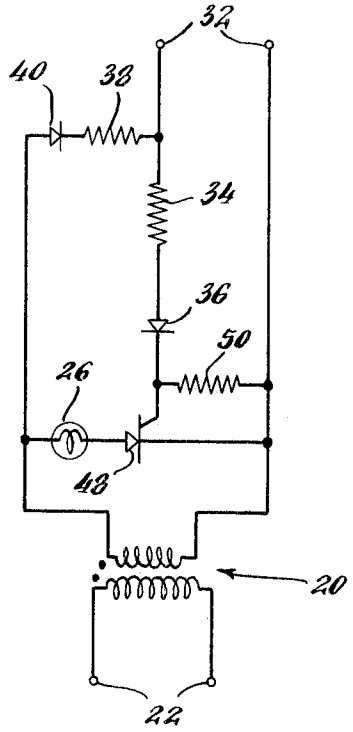


Fig. 3.

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SWITCH CONDITION INDICATOR

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ABSTRACT OF THE DISCLOSURE

A circuit for indicating the open or closed condition of an external switch. A current control device is connected to control an indicating lamp. A biasing resistor applies a triggering voltage from either the voltage at the external switch or from a separate power supply to permit conduction through the current control device when the switch is open. When the switch is closed, the biasing resistor is shorted so that the current control device does not conduct. Conduction or non-conduction of the current control device controls the on and off condition of the lamp.

This invention relates to a switch condition indicator and, more particularly to pilot light circuitry for indicating the open or closed position of a switch.

In industrial control circuitry it is often necessary or desirable to remotely monitor the condition of a series string of electrical switches. This has been accomplished in the past by several approaches, all of which have certain disadvantages. In one such system, for example, the load breakers are relay-controlled. Each breaker includes a normally open load contact which is in the series circuit and a pair of normally closed indicating contacts. Each pair of indicating contacts is in series with an individual pilot light, the circuit so formed being supplied from a suitable power source. Still another approach is described in U.S. application Ser. No. 462,902 for Switch Condition Indicator filed June 10, 1965 by Robert M. Murphy and assigned to the same assignee as the present invention. In the arrangements described therein, each of the load switches in the series string is provided with a back contact in addition to the load contact. The pilot lights are energized when the switch blade makes an electrical connection to the back contact.

It is an object of the present invention to provide a simplified arrangement which avoids the requirement of a relay for each monitored switch.

Another object is to provide a circuit which may be used to monitor any type of switch, the switch needing no special back contact.

Other objects, features and advantages will be apparent from the following description, the appended claims, and the figures of the attached drawing wherein:

FIG. 1 illustrates a circuit employing three switch condition indicators constructed in accordance with the present invention;

FIG. 2 illustrates a modified form of switch condition indicator in accordance with the present invention;

FIG. 3 illustrates still another modification of a switch condition indicator usable in the present invention; and

FIG. 4 illustrates a further modification of the circuit of FIG. 2.

The objects of this invention are achieved by means of a switch condition indicator circuit which includes current switching means variable to either of a high impedance or low impedance state. Indicating means is provided which is controlled by the switching means and the circuit includes means for applying a voltage across the current switching means and the indicating means. A triggering circuit is connected in parallel with the current switching means and the indicating means and is connected to normally trigger the current switching means into its low impedance state. Terminal means associated with the triggering circuit means are connectable across an external switch. The external switch is operable when in its closed position to disable the triggering circuit means to maintain the current switching means in its high impedance state.

With particular reference to the drawing, there is illustrated in FIG. 1 an electrical load **10** connected in series with a plurality of monitored load switches **12***a*, **12***b*, **12***c* across line conductors **14**, **16** which are energized from a 115 volt, 60 c.p.s. power supply. Each of the load switches is connected to a corresponding switch condition indicator circuit **18***a*, **18***b*, **18***c*. As these indicator circuits are identical, only that of **18***a* is shown in detail. The circuit includes a step-down transformer **20** having a 4:1 turns ratio with its primary being connected to input terminals **22***a*. The input terminals of the three circuits are connected in parallel across the supply voltage so that a reduced voltage of approximately 28 volts is supplied by the secondary of transformer **20**. Connected in series across the secondary of transformer **20** are a diode rectifier **24**, an incandescent indicator light **26**, and the collector-emitter circuit of an NPN silicon transistor **28**. A bias resistor **30** is connected across the base-emitter terminals of transistor **28**. A pair of output terminals **32***a* are associated with the circuit, one being connected directly to the resistor **30** and the emitter of transistor **28**. The other of terminals **32***a* is connected through a current limiting resistor **34** and a diode rectifier **36** to the base of transistor **28**. The same terminal is connected through a current limiting resistor **38** and a diode rectifier **40** to the opposite side of the transformer secondary winding and to diode rectifier **24**. The output terminals **32***a* are connected directly across the load switch **12***a* to be monitored. The polarity of the transformer windings is as indicated by the polarity symbols. It will also be noted that the rectifiers **24**, **36**, **40** are polarized in the direction of the transistor **28**.

Transistor **28** is an NPN silicon transistor having a large current gain and characterized by low collector to base leakage. The only time this transistor will conduct through its collector-emitter circuit is when the base is forward biased with respect to the emitter and a sufficient base to emitter current is flowing. With the circuit connected as shown to a 115 volt, 60 c.p.s. power supply, there are approximately 28 volts across the secondary of transformer **20**. This voltage is rectified by rectifier **24** so that the transistor always "sees" the proper polarity. The rectifiers **36**, **40** supply a bias of proper polarity to cause the transistor to conduct.

When the output terminals **32***a* are open as, for example, when load switch **12***a* is open, a bias voltage is applied across its base-emitter circuit by bias resistor **30**. This bias is applied through rectifiers **40**, **36** and resistors **38**, **34**. This forward biasing occurs during the half cycles in which rectifier **24** permits collector-emitter current to flow. Thus the transistor is activated so that lamp **26** is lighted for almost a full half cycle. To the eye the light appears to be lighted continuously during this time, even though it is actually lighted only during the positive half cycles.

Assuming now that switch **12***a* is closed, the effect will be to short the output terminals **32***a*. This, in turn, shorts the base-emitter circuit of transistor **28** so that transistor **28** is no longer biased for conduction. The transistor goes into its high impedance state and the light **26** goes out—indicating that the load switch **12***a* is closed.

The operation of this invention is based solely upon the open or closed condition of the associated load

switch, independently of the load being controlled by the switch, so long as the relationship between the voltage being applied to the input terminals, the polarity of the transformer windings, and the disposition of the diode rectifiers is as illustrated. This may be illustrated, for example, by assuming switches **12***b* and **12***c* to be closed so that an AC voltage is across switch **12***a*. During the positive half cycles, the light **26** would remain lighted because sufficient current passes across the biasing resistor **30** and through the base-emitter circuit of transistor **28** to maintain the transistor in conduction. During the negative half cycles, there would be no current flow through these elements because of the disposition of rectifiers **36** and **40**.

The number of indicator circuits that may be connected in a series string of switches is limited only by the potential across the series string. The total potential divides evenly and the potential across each must be adequate to allow the base-emitter circuit to be forward biased and allow a sufficient base-emitter current to flow for the lamp to light. A typical value of voltage was found to be 16.0 v. RMS across an impedance of 33,000 ohms, yielding a current of approximately .5 ma.

If the indicator circuits are connected in a series string and there is no potential across the series string, the lamps will still indicate the position of the switches they are monitoring. A potential is always present on the line side of the circuits but as each has its own power supply, no external source is required on the load side for the light to indicate.

The modification of FIG. 2 is basically similar to the circuit of FIG. 1 and similar reference numerals are used for similar elements. However, an additional transistor **42**, with its associated current limiting resistor **44** and biasing resistor **46**, is added to increase the current gain. In one specific embodiment of the circuit of FIG. 2, each transistor was a 2N3417 and each diode was a 1N457. Lamp **26** was a No. 757 and transformer **20** had a 4:1 stepdown turns ratio. Each of resistors **34**, **38** was rated at 33,000 ohms, resistors **46** and **30** at 27,000 ohms, and resistor **44** at 10,000 ohms.

In FIG. 3 there is illustrated a modification wherein the switching transistor is replaced by a silicon controlled rectifier **48**. The circuit operates in essentially the same manner—the gating voltage being produced across gating resistor **50** which is connected to the gate-cathode terminals of the SCR.

FIG. 4 illustrates a modified version of the circuit of FIG. 2. The modification permits the lamp to light when the external switch is closed, rather than open. This is accomplished by connecting the emitter of transistor **42** directly to one secondary terminal of transformer **20**. The collector of transistor **42** is connected to the base of transistor **28**. The resistor **30** remains across the base-emitter terminals of the latter transistor. With this arrangement, the current flow through transistor **42** when the external switch is open short circuits resistor **30** and prevents transistor **28** from conducting so that lamp **26** is unlighted. When the external switch is closed, transistor **42** will not conduct. The base of transistor **28** is then forward biased by the voltage appearing at the connection between resistors **30**, **44** so that the transistor conducts, lighting lamp **26**.

It will be understood by those skilled in the art that a number of variations and modifications may be made

in this invention without departing from its spirit and scope. For example, while the described embodiments illustrate the use of a transistor or an SCR for switching purposes, other solid state devices may also be employed.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A switch condition indicator circuit which comprises: current switching means variable to either of a high impedance or a low impedance state; an incandescent lamp in series with said switching means; a two winding transformer having a secondary winding connected across said switching means and said incandescent lamp and a primary winding connectable to an A.C. power supply; triggering circuit means in parallel with said current switching means and incandescent lamp connected to normally trigger said current switching means to its low impedance state; and terminal means shunting a portion of said triggering circuit means and connectable across an external switch, said external switch being operable, when in its closed position, to disable said triggering circuit means to maintain said current switching means in its high impedance state.

2. The circuit of claim **1** wherein said current switching means comprises a transistor.

3. The circuit of claim **1** wherein said current switching means comprises a solid state controlled rectifier.

4. The circuit of claim **1** wherein said triggering circuit means is energizable from both of said supply voltage and the voltage across said external switch.

5. A switch condition indicator circuit which comprises: first current switching means variable to either of a high impedance or a low impedance state; second current switching means connected to said first current switching means to be triggered into an opposite conducting state from that of said first switching means; an incandescent lamp in series with said second switching means; a two winding transformer having a secondary winding connected across said first and second current switching means and said incandescent lamp and a primary winding connectable to an A.C. power supply; triggering circuit means in parallel with said first and second switching means and incandescent lamp connected to normally trigger said first current switching means to its low impedance state; and terminal means shunting a portion of said triggering circuit means and connectable across an external switch, said external switch being operable, when in its closed position, to disable said triggering circuit means to maintain said first current switching means in its high impedance state.

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