United States Patent

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[54] **AUXILIARY LIGHTING SYSTEM FOR ARC LAMP**

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[73] Assignee: **Sylvania Electric Products Inc.**

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[51] **Int. Cl.**.....**H05b 41/46,** H05b 39/10

[58] **Field of Search**.....315/87, 90, 91, 92, 93, 120, 315/123, 127, 129, 134, 136, 246; 314/1

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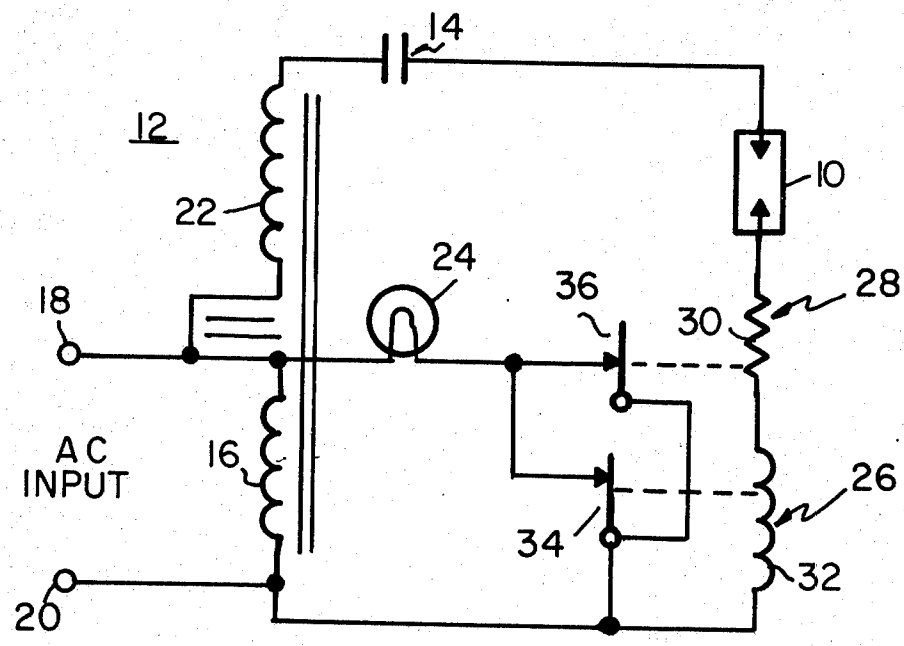
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[57] **ABSTRACT**

An auxiliary lighting system for a high pressure arc discharge lamp operated by a ballast having AC input terminals and output terminals for connecting the arc lamp in an operating circuit loop. A current sensing electromagnetic relay controls a standby incandescent lamp to provide illumination during the arc lamp cooling off period following a power interruption. The relay coil is series connected in the arc lamp circuit loop, and the relay contacts are serially connected with the incandescent lamp across the AC input of the ballast. A preferred embodiment further includes a current sensitive thermal relay for controlling the standby incandescent lamp to maintain a light output during the warm up period following restriking of the arc lamp.

5 Claims, 4 Drawing Figures



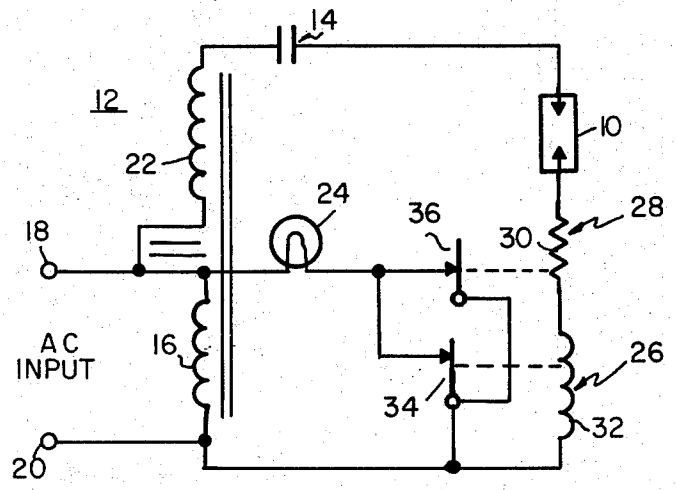


FIG. 1

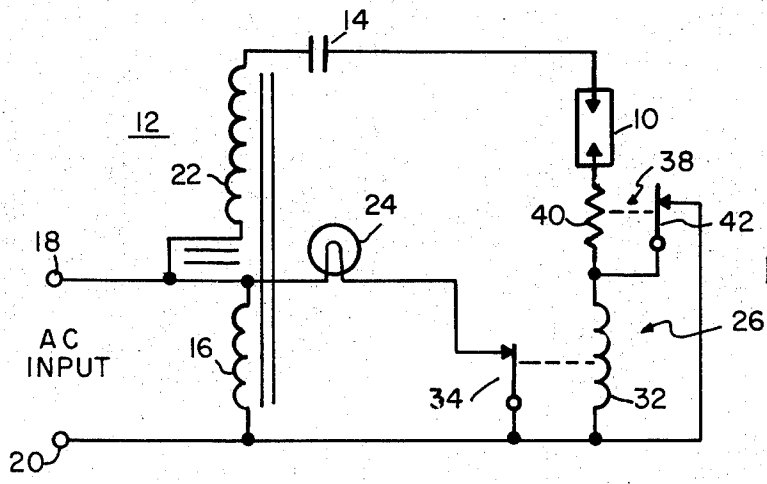


FIG. 2

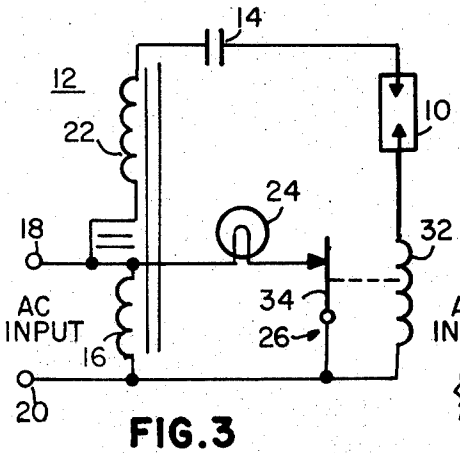


FIG. 3

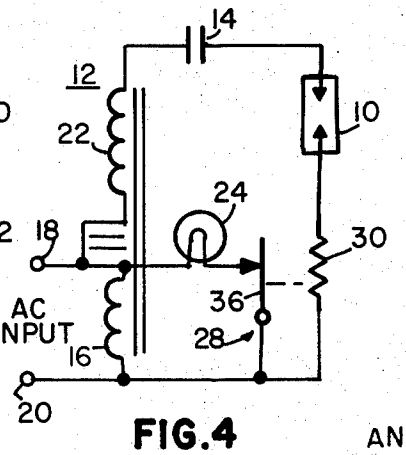


FIG. 4

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AUXILIARY LIGHTING SYSTEM FOR ARC LAMP

BACKGROUND OF THE INVENTION

This invention relates to illumination devices and more particularly to auxiliary lighting systems used in connection with high pressure arc discharge lamps.

High pressure arc discharge lamps, such as mercury vapor and other metal halide vapor lamps, have long been employed in industrial lighting applications because of their extremely high efficiency when compared to other sources, such as incandescent or fluorescent lamps. The significantly different operating characteristics of high pressure discharge lamps, however, with the prolonged warm up and cooling off periods, raises the need for supplemental or auxiliary lighting to offset the undesirable possibility of long periods of darkness.

The problem may be more clearly understood by briefly considering the nature and operation of high pressure arc discharge lamps. Such lamps typically comprise a fused quartz arc tube filled with an ionizable gas, such as, argon, and a small amount of mercury and, in the metal halide type, metal additives in the form of halogen compounds. Disposed within the arc tube are two main electrodes, one at each end, and a smaller starting electrode adjacent one of the main electrodes. The starting electrode is electrically connected through a current limiting resistor to the main electrode at the opposite end of the tube.

The arc tube assembly is usually mounted within an outer bulb of glass having a socket through which the electrodes are connected to a ballast transformer, which provides the proper voltage for starting and operating the arc lamp, and current limiting functions. When the ballast circuit is first energized, no current flows, and full starting voltage appears between the starting electrode and the adjacent main electrode. This voltage draws electrons across the relatively short gap, ionizing some of the argon gas in the tube and setting up a glow discharge between these two electrodes. The resistor in the circuit limits current to a few milliamperes. The ionized argon gradually diffuses through the tube, reducing the resistance in the gap between main electrodes, and thereby causing the initial high open circuit voltage to drop to a low level. When resistance is low enough, an arc strikes across the main electrodes. The heat from the arc vaporizes the droplets of mercury, after which the impedance of the arc slowly increases with a corresponding rise in voltage. After a warm-up period of from 2 to 4 minutes, all of the available mercury in the arc tube becomes vaporized and ionized into the arc stream, at which time the lamp reaches equilibrium and provides full light output.

The equilibrium operating condition will continue unless there is a significant dip in supply voltage, e.g. below 70 percent of the operating voltage point, or a break in the current of 30 microseconds or longer, such as due to a momentary power failure or deliberate disconnection of the power supply. The occurrence of either of these events causes the arc to extinguish, after which it cannot be restarted until cooled to an arc tube temperature consistent with the starting voltage available. More specifically, while the arc tube is still hot, the pressure created by the still vaporized mercury is too high to permit the formation of the glow discharge at

the starting electrode in response to the open circuit voltage output capability of the ballast. A cooling period is necessary to allow the mercury to condense on the arc tube walls, lowering the pressure sufficiently to allow the arc to strike.

The duration of the cooling off period differs considerably between the different types of lamps. For example, high pressure sodium lamps will restrike in about 2 minutes; the mercury lamps will restrike in from 4 to 10 minutes, and the metal halide lamps in from 10 to 20 minutes. Further, when the lamp does start, the light output is low and increases gradually to a maximum value during the above discussed warm up period of from 2 to 4 minutes.

In view of the possibility of being without light for a period of up to twenty-five minutes as a result of a momentary power interruption, it has been common practice to include a few incandescent or fluorescent fixtures to provide supplemental illumination. This, of course, added considerably to the cost of the total installation.

A more recent innovation has been the incorporation of an auxiliary lighting system with an automatic switching device integral in the fixture package. Typically, a tungsten-halogen incandescent lamp has been preferred as the standby light source because of its small envelope and high luminous output. The switching function for automatically lighting the standby incandescent lamp during the arc lamp cooling off period (and, in some cases, during the warm up period also) has generally been provided by a voltage sensitive relay or network of relays, or somewhat complex electronic circuits employing voltage breakdown principles.

The increased cost and complexity associated with sophisticated electronic switching circuits can be avoided by using a simple relay arrangement. Voltage sensing relays, however, present the operational disadvantage of increasing the likelihood of ambiguous response. More specifically, the relay circuit is required to provide reliable "turn-on" of the standby lamp in the presence of open circuit voltage, which appears across the lamp when the power supply is operating but the arc is extinguished, and to avoid false triggering in response to maximum lamp voltage, which occurs when the lamp is providing full light output. Thus, the relay must distinguish between two voltage levels, one of which, viz. maximum lamp voltage, is subject to considerable variation. In view of the typically wide tolerances on relay coil pick-up voltage and the variations in maximum lamp voltage, however, the difference between open circuit voltage and maximum lamp voltage is not so large as to preclude ambiguous operation. Of course, the reliability of operation can be improved by careful component selection and refined circuit adjustment. However, this can add significantly to product cost.

SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide an improved auxiliary lighting system for high pressure arc discharge lamps.

A more particular object of the invention is to provide a simplified auxiliary lighting system having automatic switching means which renders reliable, unambiguous operation without added cost.

Briefly, these objects are attained in an auxiliary lighting system for an AC ballast operated arc lamp which includes: a current sensing means series connected with the arc lamp, and switching means serially connected with an incandescent lamp across the AC input of the ballast, the switching means being controlled by the current sensing means. More specifically, in a preferred embodiment a current sensing electromagnetic relay controls the standby incandescent lamp to provide illumination during the arc lamp cooling off period following a power interruption, and a current sensitive thermal relay delays "turn off" of the standby lamp during the warm up period following restriking of the arc lamp. The heating element of the thermal relay and the coil of the electromagnetic relay are connected in series with the arc lamp. The contacts of both relays are parallel connected between a terminal of the incandescent lamp and one side of the AC line.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention will be more fully described hereinafter in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic diagram of an arc lamp circuit, having an auxiliary lighting system in accordance with the invention;

FIG. 2 is an alternative embodiment of the lighting system of FIG. 1;

FIG. 3 is a modification of the circuit of FIG. 1 providing the limited capability of standby illumination during the arc lamp cooling off period; and

FIG. 4 is a modification of the circuit of FIG. 1 providing the limited capability of standby illumination during the arc lamp warm up period.

DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. 1 shows a lighting system including an arc lamp **10** operated by an autotransformer ballast **12** having a lead capacitor **14**. Applied alternating current (AC) power, typically at a substantially constant 120 volts, 60 Hz., is connected to primary winding **16** of the ballast transformer via input terminals **18** and **20**, **20** being the common terminal. Arc lamp **10** is then serially connected with capacitor **14** between one end of the ballast secondary winding **22** and common terminal **20** to form a lamp operating circuit loop.

In accordance with the invention, FIG. 1 also includes an auxiliary lighting system comprising a standby incandescent lamp **24**, preferably of the tungsten-halogen type, and a pair of current sensing relays, relay **26** being an electromagnetic device and relay **28** being a thermal device. The heating element **30** of relay **28** and the coil **32** of relay **26** are series connected in the arc lamp circuit loop to thereby sense any current flowing therethrough. Incandescent lamp **24** and the switch contacts **34** of the electromagnetic relay are series connected across the AC input terminals **18** and **20**, with the bimetallic switch contacts **36** of the thermal relay being connected across contacts **34**. It will be understood, of course, that if the input voltage is higher than that required for incandescent lamp **24**, the lamp will be connected to terminal **18** via a tap on primary winding **16**.

The contacts of relays **26** and **28** are normally closed in the absence of current flow through coil **32** and heating element **30**. Upon the application of AC power to input terminals **18** and **20**, a starting voltage is applied to arc lamp **10**, and relay **26** immediately responds to the initial lamp circuit current by opening contacts **34**. The contacts **36** of thermal relay **38**, however, will remain closed until element **30** is heated to a predetermined temperature by the lamp circuit current flow. With contacts **36** closed in the presence of an AC input, the filament of incandescent lamp **24** will be energized to provide a source of light. Thus, upon energizing the lighting system of FIG. **1**, immediate standby illumination will be provided by lamp **24**, with the opening of contacts **36** and resulting "turn off" of standby lamp **24** being delayed for a period determined by the design of thermal relay **28**. As arc lamp **10** initially provides a relatively low level of illumination, building up to maximum light output over a determinable warm up period, it is generally preferred that the predetermined delay period of the thermal relay **28** approximate the arc lamp warm up period.

When arc lamp **10** is operating normally with full light output, contacts **34** and **36** are both open, and standby lamp **24** is off. If the arc lamp is extinguished by a momentary power failure, contacts **34** of the electromagnetic relay will immediately close in response to the resulting cessation of current flow in the arc lamp circuit loop. Upon the return of power at input terminals **18** and **20**, therefore, incandescent lamp **24** will be turned on via contacts **34** to provide standby illumination. More specifically, as current will not again flow through relay coil **32** until an arc is restruck in lamp **10**, standby lamp **24** provides illumination during the previously discussed cooling off period of arc lamp **10**.

As the arc lamp cooling off period is much longer than the warm up period, element **30** of the thermal relay will cool sufficiently during the absence of arc lamp current to close contacts **36** before the end of the lamp cooling off period. Hence, when arc lamp **10** has cooled sufficiently and is restarted by the voltage from ballast **12**, the standby incandescent lamp **24** will continue to be energized via thermal relay contacts **36**, even though the resulting arc lamp current flow will cause immediate opening of the electromagnetic relay contacts **34**. As previously described, the thermal relay then delays turn off of the incandescent lamp during the arc lamp warm up period until element **30** heats sufficiently to open contacts **36**.

Accordingly, the combination of thermal relay **28** and electromagnetic relay **26** provides continuous standby illumination during both the arc lamp cooling off period following a power interruption and the subsequent warm up period pursuant to reignition of the lamp. Further, this operation is provided in a simplified and highly reliable manner by monitoring an easily detectable and relatively unambiguous condition of circuit operation, viz., sensing the presence of or absence of current flow in the arc lamp circuit. This mode of current sensing provides a digital-type, go-no-go monitoring system which operates in a much more positive manner than the relatively vague sensing of the difference between voltage levels subject to variation.

FIG. 2 shows a modification of the above lighting system in which the contacts of the thermal relay are connected across the coil of the electromagnetic relay.

More specifically, FIG. 2 shows a circuit which is similar to that in FIG. 1 except that, in lieu of relay 28, a thermal relay 38 is employed having a heating element 40 series connected between coil 32 and lamp 10, and a set of bimetallic contacts 42 connected across coil 32.

In FIG. 2, the contacts of relays 26 and 38 are normally closed. Upon application of AC input power, incandescent lamp 24 is turned on via the closed contacts 34. When arc lamp 10 ignites, the resulting current flow in the arc lamp circuit bypasses relay coil 32 via bimetallic contacts 42, which remain closed until element 40 provides sufficient heat for actuation. More specifically, the impedance presented by relay coil 32 is much greater than the resistance presented by closed contacts 42, whereby the current not bypassed by contacts 42 is insufficient to energize coil 32 to the point of actuation. Accordingly, by proper selection of thermal relay 38, the light output of standby lamp 24 can be maintained during the arc lamp warm up period as a result of the thermal delay of relay 38.

When relay element 40 provides sufficient heat, ideally after arc lamp warm up and maximum light output, relay contacts 42 open thereby permitting relay coil 32 to be fully energized and actuate the opening of relay contacts 34. Incandescent lamp 24 will then be turned off. If the input power is interrupted, relay 26 will immediately respond to the cessation of arc lamp current flow by closing contacts 34 to turn on the standby lamp 24. Contacts 42 will open after element 40 cools. Thereafter, lamp 24 will provide illumination during the arc lamp cooling off period. Upon restriking of lamp 10, the resulting current flow will be bypassed through contacts 42, thereby leaving relay 26 deenergized and maintaining standby illumination during arc lamp warm up pursuant to the thermal delay of relay 38.

FIGS. 3 and 4 are simplified versions of FIG. 1 having somewhat limited standby illumination capabilities. More specifically, FIG. 3 omits the thermal relay 28, thereby giving up the delay feature and lighting incandescent lamp 24 only during the arc lamp cooling off period. FIG. 4, on the other hand, omits the electromagnetic relay 26; hence, standby illumination will be provided during arc lamp warm up by the delayed operation of thermal relay 28, but standby illumination will not be provided the moment power is restored following a short interruption.

What I claim is:

1. An auxiliary lighting system for an arc lamp operated by a ballast having an AC voltage input means and output means for connecting said arc lamp in a lamp operating circuit loop, said auxiliary lighting system comprising, in combination, a current sensing heating element series connected in said arc lamp circuit loop, and an incandescent lamp and switching means serially connected across the AC voltage input means of said ballast, said heating element and switching means comprising a thermal relay, and said switching means being the set of contacts of said relay controlled by said heating element.

2. A lighting system according to claim 1 further including an electromagnetic relay having a current sensing coil series connected with the heating element of said thermal relay in said arc lamp circuit loop and a set of contacts connected across the thermal relay contacts.

3. A lighting system according to claim 2 wherein the contacts of said thermal and electromagnetic relays are normally closed, said electromagnetic relay contacts are opened and closed in response to commencement and cessation, respectively, of current flow in said arc lamp circuit loop, and the heating element of said thermal relay is selected to delay the opening of said thermal relay contacts for a predetermined period after commencement of current flow in said arc lamp circuit loop, said predetermined period approximating the warm-up period of said arc lamp.

4. An auxiliary lighting system for an arc lamp operated by a ballast having AC voltage input means and output means for connecting said arc lamp in a lamp operating circuit loop, said auxiliary lighting system comprising in combination: a current sensing coil series connected in said arc lamp circuit loop; an incandescent lamp and switching means serially connected across the AC voltage input means of said ballast; said coil and switching means comprising an electromagnetic relay with said switching means being the set of contacts of said electromagnetic relay controlled by said coil; and a thermal relay having a heating element series connected with said coil in said arc lamp circuit loop and a set of contacts connected across said coil.

5. A lighting system according to claim 4 wherein the contacts of said thermal and electromagnetic relays are normally closed, the heating element of said thermal relay is selected to delay the opening of said thermal relay contacts for a predetermined period after commencement of current flow in said arc lamp circuit loop, said predetermined period approximating the warm-up period of said arc lamp, said electromagnetic relay contacts are opened upon energization of said relay coil after the opening of said thermal relay contacts, and said electromagnetic relay contacts are closed in response to the cessation of current flow in said arc lamp circuit loop.

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