June 23, 1970 A. C. McNAMARA, JR 3,517,254

CONTINUOUS LIGHTING SYSTEM FOR GASEOUS-DISCHARGE LAMPS WITH INCANDESCENT LIGHTS FOR STANDBY

Filed May 14, 1968 3 Sheets-Sheet 1

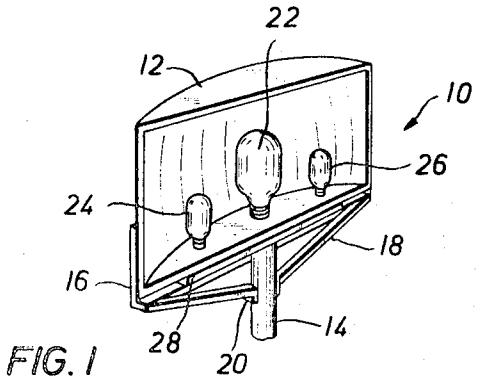


FIG. 1

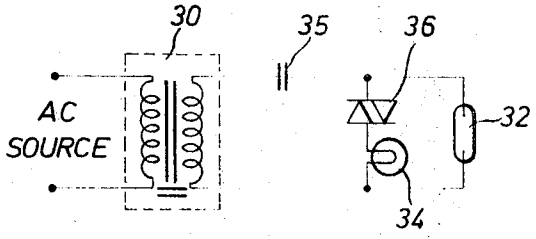


FIG. 2

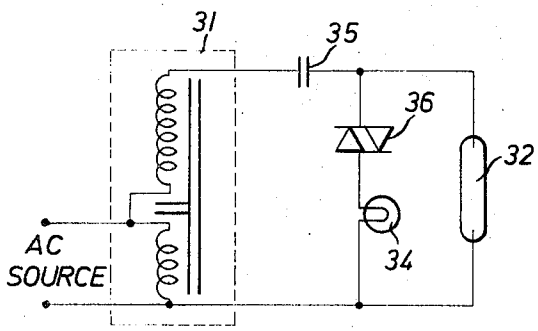


FIG. 3

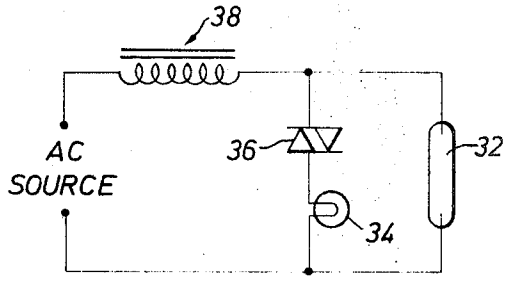


FIG. 4

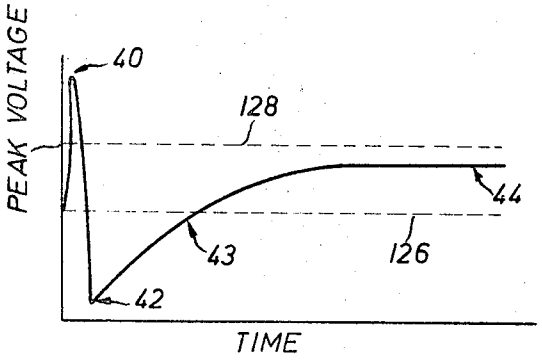


FIG. 5

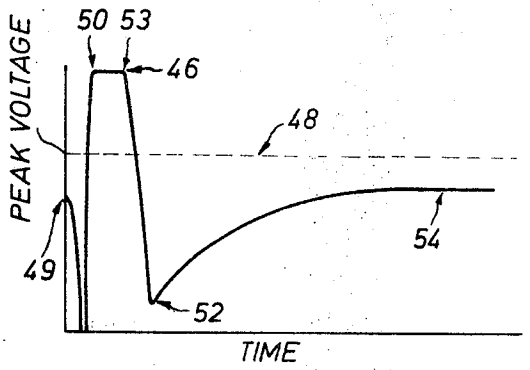


FIG. 6

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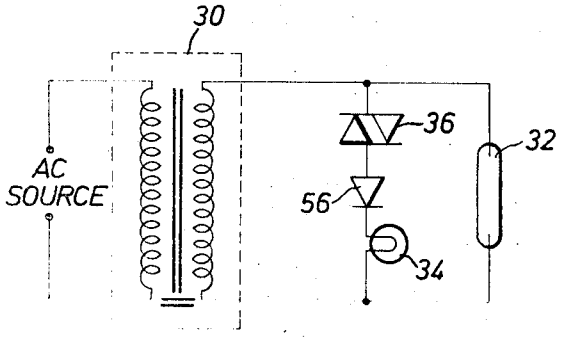


FIG. 7

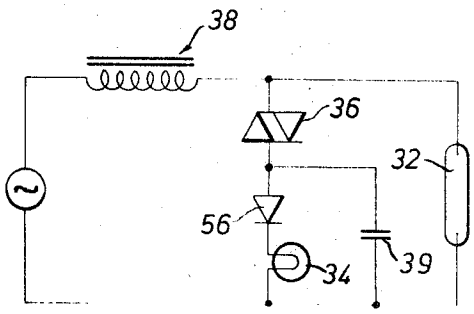


FIG. 8

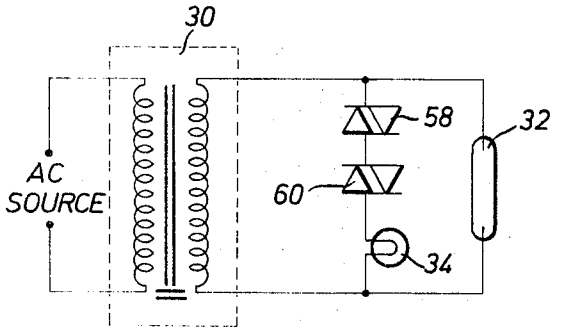


FIG. 9

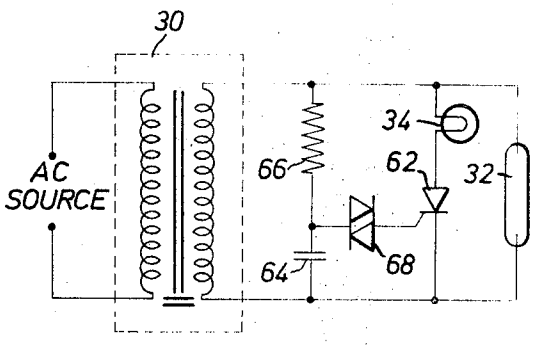


FIG. 10

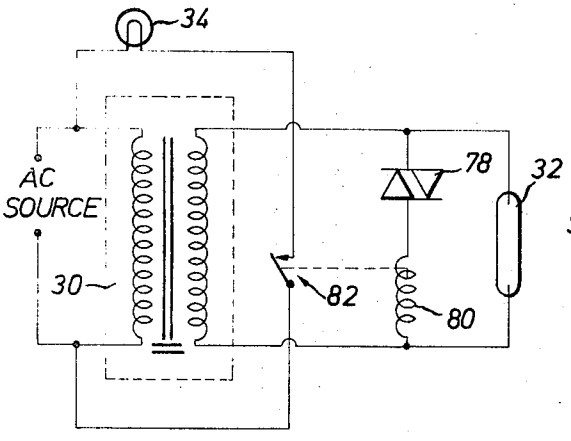


FIG. 12

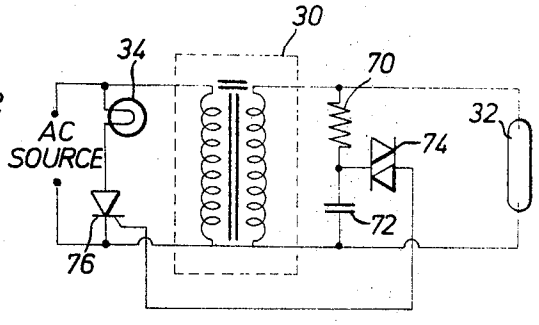


FIG. 11

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CONTINUOUS LIGHTING SYSTEM FOR GASEOUS-DISCHARGE LAMPS WITH INCANDESCENT LIGHTS FOR STANDBY

Filed May 14, 1968 3 Sheets-Sheet 3

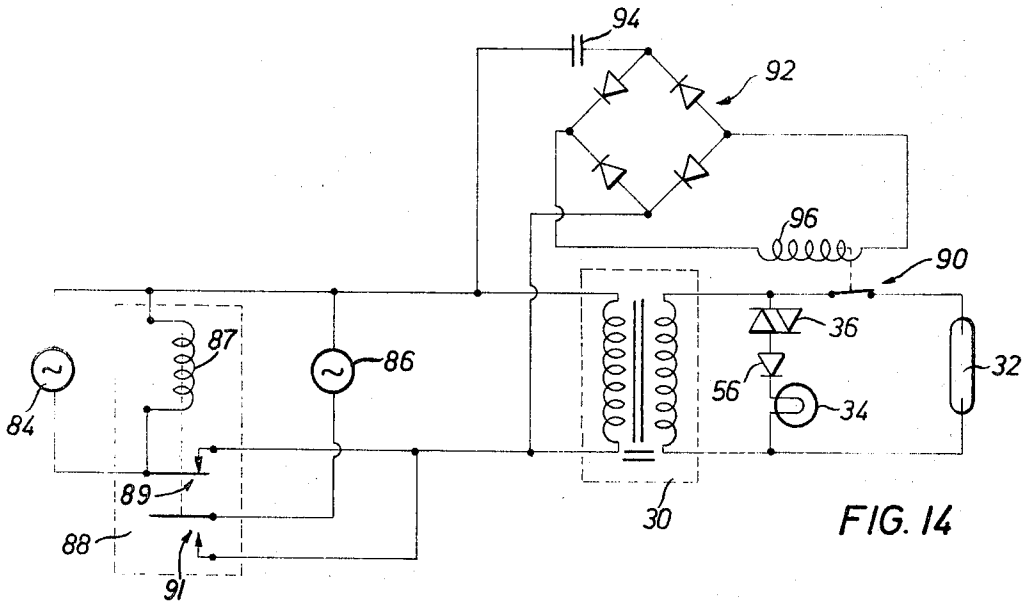


FIG. 14

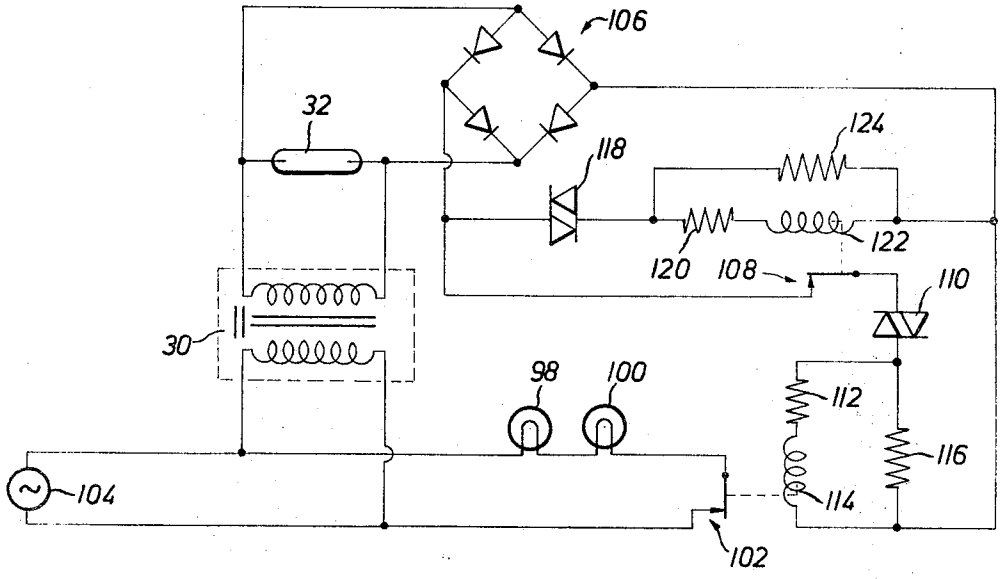


FIG. 15

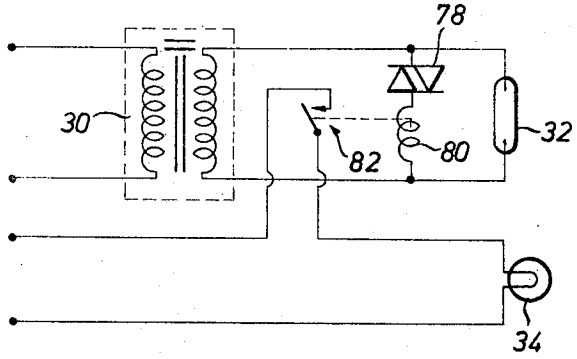


FIG. 13

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United States Patent Office 3,517,254 Patented June 23, 1970

3,517,254

CONTINUOUS LIGHTING SYSTEM FOR GASEOUS-DISCHARGE LAMPS WITH INCANDESCENT LIGHTS FOR STANDBY

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U.S. Cl. 315—91 15 Claims

ABSTRACT OF THE DISCLOSURE

This invention pertains to an emergency lighting circuit that operates with a high pressure, gaseous-discharge lamp and associated ballast. When the gaseous-discharge lamp goes out, after once being ignited, sufficient current is supplied to an incandescent light or lights to maintain illumination to the area normally illuminated by the lamp. The device for providing this current may vary, but generally incorporates a voltage breakdown means that receives higher voltage from the ballast when there is failure of the gaseous-discharge lamp than when the arc therein is struck. A preferred embodiment also lights the incandescent lights during initial warm-up of the gaseous-discharge lamp. The incandescent lights may also be used in a cold environment to maintain the gaseous-discharge lamp sufficiently above an ambient temperature level to make possible initial striking of the arc in the lamp when ambient temperature conditions might otherwise prevent it. Further, half-cycles of ballast output voltages are blocked by diodes and capacitors are used to increase the applied voltage to enhance restriking of the gaseous-discharge lamp in additional embodiments.

BACKGROUND OF THE INVENTION

Field of the invention

This invention pertains to illumination devices and more particularly to emergency lighting circuits used in connection with gaseous-discharge lamps.

Description of prior art

Gaseous-discharge lamps, such as mercury vapor and other metallic-additive vapor lamps, have long been employed in industrial lighting situations because of their extremely high efficiency when compared to other sources, such as incandescent lights.

A gaseous-discharge lamp is a source of radiant energy characterized by the emission of radiation from a stream of ionized vapor-carrying current between electrodes in the lamp. In starting the lamp, a relatively large voltage is required. However, once current flows in the lamp, the lamp exhibits a negative resistance characteristic. That is, the resistance of the lamp decreases with an increase in current. In common use in the United States are fluorescent, mercury and neon lamps.

To more fully discuss the operation of circuits of the present invention, it is first necessary to understand more fully the operation of these gaseous-discharge lamps. Typical of such lamps is the mercury-vapor lamp, which is used as an example for purposes of discussion.

The mercury-vapor lamp contains an arc tube filled with argon gas and a small amount of pure mercury. The arc tube is usually mounted within an outer bulb of glass. The arc tube itself is usually made of fused quartz. One main electrode extends into the tube from one end and a similar main electrode and a smaller starting electrode are at the other end of the tube. The starting electrode is electrically connected through a high resistance to the main electrode at the opposite end of the tube.

The mercury lamp is connected through its socket to the output leads of its ballast, which supplies proper voltage for starting and limits current during operation. 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. When resistance is low enough, an arc strikes across the main electrodes. The heat from the arc vaporizes the droplets of mercury, and they become ionized current-carriers as electrons in the arc bombard the vaporized mercury atoms. When all the mercury is vaporized, the current in the arc may reach several amperes. With this current flowing in the ballast, it no longer produces sufficient voltage to maintain the initial glow, which is extinguished. The arc is then maintained across the main electrodes with its current limited by the ballast.

If the arc is extinguished by a momentary power failure or deliberate disconnection of the power supply, it cannot be restarted immediately. 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. A cooling period, ordinarily on the order of about five minutes, is necessary to allow the mercury to condense on the arc-tube walls, lowering the pressure sufficiently for the process to begin again.

The prospect of being without light for a period of time in the presence of just a temporary cessation of power has meant that fluorescent lights have been used in installations where gaseous-discharge lamps would have otherwise been preferred.

Also, in a very cold environment, the possibility that an initial glow discharge at the starting electrode will not be initiated is a distinct probability. The ambient temperature where striking of an arc may normally be considered assured for most gaseous-discharge lamps is 50° F. When the temperature is expected to be lower than this level, and particularly where the temperature is expected to be appreciably lower than this level, the unreliable starting performance of such lamps has meant that gaseous-discharge lamps have not been used where they would have been otherwise. Before the present invention, when gaseous-discharge lamps are used in a low temperature situation, it has been necessary to use expensive ballasts having higher internal losses than ballasts normally employed.

Among the objects and the advantages of the present invention is to overcome these two principal shortcomings by providing an emergency lighting circuit that will light in the event that the gaseous-discharge lamp with which it operates fails. Also, certain embodiments of the present invention include locating the incandescent lights of the emergency lighting circuit to raise the ambient operating temperature of the gaseous-discharge lamp, thereby aiding its ignition.

The various types of vapor lamps all possess a negative resistance characteristic, wherein the resistance within the lamp envelope decreases with an increase in current. Without some form of current-limiting device in the electric circuit, current would rise swiftly after the lamp started until lamp failure occurred. This current-limiting element is external to the gaseous-discharge envelope and, as referred to above, is called the ballasts of complex structures using inductive and capacitive reactances have been employed in AC circuits and have increased efficiencies when compared with resistive-type ballasts. Ballasts may

take the form of simple chokes, transformers, autotransformers, a combination of these or other structures. Although ballast circuits of a complex nature have been used, heretofore none has operated in the manner of the present circuits, as will be explained more fully hereinafter.

The present invention operates conjunctively not only with the gaseous-discharge lamp with which it is connected, but also with a ballast, which would be required for operation of the gaseous-discharge lamp in any event. The present invention is not restricted to the type of ballast employed and should not be characterized by itself as a ballast circuit, but rather should be thought of as normally including an emergency lighting circuit.

SUMMARY OF THE INVENTION

The inventive circuit which is herein described is connected to the gaseous-discharge lamp and to the ballast and includes a voltage breakdown means, typically a diac or an SCR device, and an incandescent light located normally to illuminate the same general area as that illuminated by the gaseous-discharge lamp. In a simplified version of the circuit, a diac and an incandescent lamp are connected in series across the main electrodes of the gaseous-discharge lamp. When there is conduction between the main electrodes, the voltage applied to the diac, as determined by the lamp and ballast action, will be below the breakdown voltage for the diac. On the other hand, when there is a momentary interruption and re-establishment of power to the gaseous-discharge lamp, the lamp cannot ignite and the voltage across the diac will build up beyond the threshold level of the diac. This supplies current for lighting the emergency incandescent light.

Other embodiments include a switching arrangement of operably connecting the incandescent light to the power source so that it may be relatively free of operation of the ballast and alternately for operably connecting the incandescent light to an independent emergency source. Additional embodiments include connecting the incandescent light even during the initial period of gaseous-discharge lamp warm-up (before the discharge lamp reaches full brilliance), as well as after there has been a failure. Also, there is an embodiment described in which an emergency power system for lighting the incandescent light uses essentially the same wiring as the primary power system. And finally, there is an embodiment showing the raising of the peak applied voltage to the gaseous-discharge lamp to enhance starting, such embodiment also including an incandescent light or other resistor.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above-recited advantages and objects of the invention, as well as others which will become apparent, are attained can be understood in detail, more particular description of the invention briefly summarized above may be had by reference to the embodiments thereof which are illustrated in the appended drawings, which drawings form a part of this specification. It is to be noted, however, that the appended drawings illustrate only typical embodiments of the invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

FIG. 1 is an oblique view of a typical gaseous-discharge lamp fixture incorporating a preferred embodiment of the present invention.

FIG. 2 is a schematic diagram of an embodiment of the present invention using a conventional transformer.

FIG. 3 is a schematic diagram of an embodiment of the present invention, similar to the one shown in FIG. 2, using an autotransformer.

FIG. 4 is a schematic diagram of another embodiment of the present invention.

FIG. 5 is a graphic representation of the voltage applied to an inventive circuit during normal operation of the gaseous-discharge lamp with which it is associated.

FIG. 6 is a graphic representation of the voltage applied to an inventive circuit during arc-extinguishing and restriking in the associated gaseous-discharge lamp with which it operates.

FIG. 7 is a schematic diagram of yet another embodiment of the present invention.

FIG. 8 is a schematic diagram of an embodiment of the present invention and including means for raising the applied starting lamp voltage.

FIG. 9 is a schematic diagram of still another embodiment of the present invention.

FIG. 10 is a schematic diagram of an additional embodiment of the invention.

FIG. 11 is a schematic diagram of yet an additional embodiment of the present invention.

FIG. 12 is a schematic diagram of still an additional embodiment of the present invention.

FIG. 13 is a schematic diagram of another embodiment of the present invention operating in conjunction with an emergency power supply.

FIG. 14 is a schematic diagram of still another embodiment of the present invention operating in conjunction with an emergency power supply.

FIG. 15 is a schematic diagram of a preferred embodiment of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Now referring to the drawings and first to FIG. 1, a gaseous-discharge lamp fixture **10** is shown, such as might be used for lighting an outdoor area, typically the entrance to a building or a parking lot. Fixture **10** includes a shield **12** secured to a support post **14** by brackets **16** and **18** via bolt **20** in conventional manner. Located within shield **12** is a gaseous-discharge lamp **22**, typically of the mercury-vapor variety, and two incandescent bulbs **24** and **26**, which may be conveniently located within shield **12** on either side of lamp **22** in a symmetrical arrangement. Bolted to the bottom of shield **12** is housing **28**, in which the ballast and an electronic circuit in accordance with the invention to be described herein is located. Appropriate leads or other connections connect lamp **22** and light bulbs **24** and **26** to the circuit components within housing **28**. Appropriate power from an outside source may be brought into housing **28** through the hollow center of post **14**.

FIG. 2 shows a simplified embodiment of the invention. Applied AC power, typically at a substantially constant 440 volts, 60 Hz., is connected to a ballast transformer **30**. One end of the primary and one end of the secondary may be grounded. The secondary is connected to gaseous-discharge lamp **32**. Connected in parallel with lamp **32** is a series circuit combination comprising incandescent light **34** and diac **36** or other similar voltage breakdown means. A diac may be conveniently characterized as being a two-terminal, bi-directional current conducting semiconductor.

A capacitor **35** in series with the secondary output coil of ballast transformer **30** and lamp **32** may be employed to cause current limiting with the popular lead-type of ballast. Such a capacitor may also be used in some of the other embodiments hereafter discussed, but for simplicity the capacitor has been omitted.

FIG. 3 shows the same embodiment components as shown in FIG. 2, except the ballast transformer is illustrated as an autotransformer **31** rather than as a conventional transformer.

Alternately to a ballast transformer, as shown in FIG. 4, a ballast **38**, which may be merely an inductive choke coil, is shown connected to the applied AC source. Although strictly speaking such a coil does not have a primary and a secondary, for purposes herein the source connection may be thought of as being applied to the primary side of the coil and the lamp as being applied to

the secondary side of the coil. Gaseous-discharge lamp **32**, incandescent light **34** and diac **36** are connected as with the FIG. 2 arrangement.

The gaseous-discharge lamp **32** comprises typically three electrodes. At one end thereof is a starting electrode and a first main electrode located adjacent thereto. At the other end is a second main electrode connected to the starting electrode by an extremely high resistance. Ballast transformer **30** and ballast **38** may both be characterized as being current-limiting ballast means which are connected to a main electrode of lamp **32**.

In operation of any of the foregoing circuits, operating voltage is applied to the ballast, which is energized and produces a very high initial peak voltage **40**, such as shown in FIG. 5 across the terminals of lamp **32**. Assuming that the temperature conditions are right and that secondary voltage **40** is high enough to set up the initial glow discharge between the starting electrode and the adjacent main electrode within lamp **32**, followed rapidly by the striking of the arc between the main electrodes, the output voltage from the ballast will rapidly decrease to a low voltage condition **42**.

The time between the high voltage **40** level and low voltage **42** level is normally so short that to the casual observer it appears that the glow is initiated instantaneously with the application of source voltage. Also, voltage **42** is quite low and well below the threshold or breakdown voltage **128** for diac **36**. Therefore, no current flows through incandescent light **34** to ignite it. The voltage gradually increases along increasing slope **43** from low voltage **42** to a substantially stable voltage level **44** which is less than the threshold level for the voltage breakdown means.

Under normal operation of gaseous-discharge lamp **32**, voltage from the output of the ballast will seek a stable voltage level **44** when the metallic additive in the gaseous-discharge lamp is fully vaporized and current therethrough is at a maximum value. This is because the ballast fully compensates for the negative resistance characteristics of the glowing gaseous-discharge lamp.

Upon failure, even a momentary failure, of the applied AC source to the ballast, and hence applied voltage to gaseous-discharge lamp **32**, the arc in lamp **32** is extinguished. Normally a cooling period on the order of about five minutes is necessary before an arc discharge can occur again. However, what does happen is that the output voltage from the ballast applied to the series combination of diac and incandescent light again assumes a high level at a point which is above the voltage breakdown threshold level for diac **36**. This buildup occurs since the extinguishing of the arc means that the resistance from main electrode to main electrode again becomes large. Current now passes through diac **36** and ignites incandescent light **34**.

Again, upon extinguishing of the arc in lamp **32**, to the casual observer there is an immediate ignition of light **34**.

If light **34** is located generally to illuminate the same area as lamp **32**, there is essentially continuous lighting of this area, even though lamp **32** may be off for a period of minutes.

The diac and incandescent light do not have the negative resistance characteristics which are exhibited by lamp **32**. Therefore, during the time that light **34** is lit, the voltage applied thereto from the output of the ballast remains relatively constant and is sufficiently high to again light lamp **32** when it has cooled sufficiently.

Now referring to FIG. 6, the condition of the voltage applied to the gaseous-discharge lamp in one of the foregoing circuits during refiring of the lamp may be observed. When there is a momentary power failure, the stable voltage **49** (at the level **44** established in FIG. 5) is interrupted, causing gaseous-discharge or arc lamp **32** to extinguish. When the power is re-established at point **50**, the voltage applied to the lamp is at maximum level **46** (at the level **40** in FIG. 5), but the lamp is not in condition to refire. Level **46**, being above the threshold level **48** of diac **36**, causes current conduction therethrough and a subsequent lighting of incandescent light **34**. Hence, although arc lamp **32** is extinguished there is maintained a continuity of the existence of light.

At point **53**, lamp **32** has cooled down sufficiently to reach a favorable internal pressure for the restriking of the arc across lamp **32**. Diac **36**, being a two-terminal bidirectional current carrying semiconductor, turns on with an applied voltage **48** above its threshold level and turns off each half-cycle of the alterating current applied thereto. That is, so long as the applied voltage is above level **48**, as the current goes from one half-cycle to the next the current value passes through zero, turning off conduction in one direction through diac **36** and then establishing conduction therethrough in the opposite direction. When the voltage across the terminals of lamp **32** drops from level **46** below threshold level **48** of diac **36**, there is insufficient voltage to establish this conduction through the diac. This causes series-connected light **34** to extinguish. At the time of arc restriking, the voltage applied to arc lamp **32** reaches low point **52**. Because some of the ions of the current-carrying additive in the arc lamp are still vaporized, when the arc is restruck the light radiating therefrom is brighter than under initial conditions, providing sufficient light to the area without assistance from light **34**.

Although in the above discussion, momentary power failure has been assumed, a failure of arc lamp **32** will similarly cause light **34** to light, as above.

FIG. 7 shows a circuit employing a serially connected diac and incandescent lamp circuit together with a diode **56**. This diode permits only every other half-cycle of the voltage applied to it to operate light **34**. This means that the voltage rating of incandescent light **34** may be lower than for the light used in the FIG. 2 circuit, all other conditions being the same. Also, during the half-cycle in which **34** is off, no current is drawn through the ballast, thereby providing an increase in the peak voltage which is applied to gaseous-discharge lamp **32** during the time that this lamp is being restarted. The peak value of the applied voltage to a gaseous-discharge light is significant, rather than the average value. Hence, the voltage requirements of the overall ballast output are reduced.

Although the ballast means in FIG. 7 is illustrated as a transformer, as with the FIG. 2 and FIG. 3 structures, this means could take the form of a choke coil, such as coil **38** as shown in FIG. 4, or other equally suitable structure. This possibility exists for the other embodiments to be hereinafter described, as well.

FIG. 8 shows an embodiment of the circuit shown in FIG. 7 (illustrated to include a choke coil, rather than a transformer, merely for illustrative purposes) with the addition of capacitor **39** in parallel across diode **56** and light **34**. It may be recalled that during the period while arc lamp **32** was cooling down to the conditions for restriking, between points **50** and **53** on FIG. 6, the voltage across the terminals of lamp **32** reached a level **46**. Because current was passing through light **34** and its series circuit during this period, this voltage level **46** applied to lamp **32** was actually less than in the initial condition (level **40** in FIG. 5). With the addition of capacitor **39** it has been found that during the non-conductive half-cycles of diode **56**, the peak voltage applied to lamp **32** is larger than otherwise, thereby aiding in the restriking action. Typically, without the capacitor, the peak voltage may be 360 volts while with the capacitor, this level is increased to 625 volts.

Of course, even without the slight drop in voltage during the period before restriking occurs, the capacitor would cause a larger peak voltage on the terminals of the arc lamp than otherwise, but this is particularly important when there is a slight voltage drop as above described since the operation of the arc lamp may be made marginal by the voltage drop without the voltage increase.

The conductive half-cycles of diode **56** allow the current to bleed off capacitor **39** to prevent excessive build-up thereon. Also, since diode **56** has a very small threshold compared with diac **36**, once arc lamp **32** has an arc struck therein, and light **34** goes out, capacitor **39** will not maintain a charge, again discharging through light **34**.

It should be further noted that this voltage aiding quality of capacitor **39** in this circuit exists even when a suitable and similar-value resistor is substituted in place of light **34**, should there be no requirement for the emergency lighting benefit of light **34** in a particular installation.

Although illustrated with respect to the FIG. 8 circuit arrangement, the capacitor may be used similarly in the other circuits to be later described herein that have a diode similar to diode **56** or other rectifier-type means for causing half-cycles of the arc lamp terminal voltage to be blocked.

FIG. 9 shows yet an additional embodiment of the invention employing two symmetrical voltage breakdown means, namely, diacs **58** and **60**, in series with light **34**. This merely reduces the voltage ratings of the diacs, but otherwise the operation is identical with the circuit shown in FIG. 2.

FIG. 10 shows an embodiment utilizing for the voltage breakdown means an SCR **62** having a suitable triggering means for gating the SCR on half-cycles of the operating voltage from the ballast when there is cessation of condition in the gaseous-discharge lamp **32**. Operationally, this circuit is quite similar to that shown in FIG. 7. This triggering means comprises, conventionally, an integrator made up of capacitor **64** and resistor **66** which applies a signal through diac **68** to the gate electrode on SCR **62**. The anode and cathode of SCR **62** are connected in series with incandescent light **34**. Hence, the gate turns on the SCR when there has been failure of lamp **32**, thereby lighting the incandescent light **34** on alternate half-cycles. Also, peak voltages of alternate half-cycles are applied to gaseous-discharge lamp **32** during operation of the SCR so that lamp **32** has the maximum effective operating voltage applied thereto.

Still further embodiments of the invention are shown in FIGS. 11, 12 and 13. In FIG. 11, a trigger circuit comprising a resistor **70**, capacitor **72** and diac **74** is shown connected in parallel with the gaseous-discharge lamp **32**, as with the FIG. 10 structure. In this embodiment, however, incandescent light **34** is connected in series with the cathode and anode of an SCR **76**, the combination of which is supplied power from the primary source, rather than from the output of the ballast.

FIG. 12 shows another embodiment which places the incandescent light **34** across the input source voltage, although when light **34** comes on it is controlled by the voltage across the main electrodes of discharge lamp **32**. In this case a diac **78** is connected in series with a relay coil **80**, the series combination being connected in parallel across lamp **32**. The contacts associated with relay coil **80** are normally open when there is no conduction through diac **78**. When there is conduction through the diac **78** (signifying that there is cessation of conduction in lamp **32**) relay coil **80** is energized closing contacts **82**, thereby applying primary power to incandescent light **34**.

FIG. 13 shows the same type of operation as FIG. 12, except that upon closing of relay contacts **82** an auxiliary source is applied to the incandescent light, rather than the primary source which is applied to the gaseous-discharge and ballast circuit.

The FIG. 14 embodiment of the invention is similar to the FIG. 7 embodiment, except that this embodiment also incorporates an auxiliary emergency supply system which uses much of the same wiring as the primary system uses. Connected in parallel across main supply **84** is a normally-energized relay coil **87** of control circuit **88**, the relay coil having associated therewith normally-closed contacts **89** and normally-open contacts **91**. One connection from source **84** is tied directly to the ballast/arc lamp network and the other connection is connected through normally-closed contacts **89**. One connection from emergency supply source **86** is likewise tied directly to the ballast/arc lamp network. However, the other connection is connected through the normally-open contacts **91**.

It may be seen that upon failure of the main supply **84**, the emergency supply is placed across the input of the ballast. Since there is no return for relay coil **87** when emergency supply **86** is supplying operating power to the circuit, relay coil **87** is not energized until main supply **84** is re-established. The re-establishment of the main supply reverses the switching operation from main to emergency source operation just described. Of course, any similar control and switching circuit of similar conventional design may be employed.

Connected to the secondary of ballast **30**, as previously stated, is an arrangement of components similar to that shown in FIG. 7, although the variations shown in FIGS. 2–4 and 7–12 may also have been used. However, when a diode **56** is used in series with light **34**, the embodiments employing a capacitor in series between the ballast and the arc lamp, such as shown in FIGS. 2 and 3, cannot be used. The illustrated components include a series combination of a diac **36**, a diode **56** and incandescent light **34** connected across the output of ballast **30**. There is a difference, however, in that normally-closed contacts **90** are included in series with gaseous-discharge lamp **32**, this series combination being connected across the output of ballast **30**.

Connected across the input of ballast **30**, or across the output of main source **84**, is a typical bridge rectifier **92** in series with capacitor **94**. Connected to the output of rectifier **92** is relay coil **96** associated with contacts **90** in the gaseous-discharge circuit.

Main supply source **84** is typically at line voltage of 60 Hz., which is effectively blocked by capacitor **94**. Therefore, relay coil **96** connected to the output of rectifier **92** is not energized so long as main supply is being provided to the overall circuit. Normally closed relay contact **90** allow ignition of gaseous-discharge lamp **32** as before. However, when main supply fails, emergency source **86** operates the circuit. Typically, the frequency of source **86** is 400 Hz., or a frequency much higher than source **84**. Capacitor **94** is such that it allows this relatively high frequency to pass to bridge **92**, the output of which, in turn, energizes relay coil **96**. Relay coil **96** opens normally-closed contacts **90** to prevent lamp **32** from re-igniting from the emergency source.

Therefore, when main supply **84** is somewhat permanently disconnected from the circuit, not just merely temporarily disconnected, incandescent light **34** is lit by the emergency supply. When main supply **84** is re-established and supply **86** is disconnected by control **88**, then contacts **90** close and allow discharge lamp **32** to again be ignited. If lamp **32** is still not in a suitable state for restriking, incandescent light **34** is operated from supply **84** as described previously.

FIG. 15 shows a circuit in which the associated incandescent lights **98** and **100** operate a little bit differently than the incandescent lights in the other embodiments. Notice that connected in series with incandescent lights **98** and **100** are relay contacts **102**, all of which are connected in series with source **104**. Relay contacts **102** are normally closed, so that upon application of voltage from source **104** lamps **98** and **100** immediately light.

Also connected to source **104** is ballast **30**, as with the other embodiments, across the output of which is discharge lamp **32**, as before. Also connected across the output of ballast **30** is a typical bridge rectifier **106**. The output of the bridge rectifier is connected across two series of circuits. The first of these series circuits includes normally closed relay contacts **108**, diac **110**, resistor **112**,

and relay coil **114**. Connected in parallel across resistor **112** and relay coil **114** is resistor **116** for a purpose to be described hereinafter. Relay coil **114** is that relay coil which is associated with contacts **102**.

The other series combination connected across the output of rectifier **106** includes, in series, diac **118**, resistor **120** and relay coil **122**. Resistor **124** is connected in parallel across resistor **120** and relay coil **122**.

To consider the operation of this circuit, again refer to FIG. 5. Immediately upon initial striking of gaseous-discharge lamp **32**, the voltage output from ballast **30** is at low voltage **42**. Voltage applied to diac **110** gradually increases along slope **43** until it reaches turn-on threshold level **126** of diac **110**. At this time relay coil **114** is energized, opening relay contacts **102** and extinguishing incandescent lights **98** and **100**. By the time this happens, the light from lamp **32** is bright enough to illuminate the area.

Should the gaseous-discharge lamp be extinguished because of momentary disconnection of power thereto, the voltage applied to diac **118** will rapidly rise until its threshold level **128** is surpassed, thereby applying energizing current to relay coil **122**. When relay coil **122** is energized, relay contacts **108** associated therewith are opened, which in turn de-energizes relay coil **114**. When relay coil **114** is de-energized, normally closed relay contacts **102** associated therewith are closed, applying igniting current to lights **98** and **100** from source **104**.

As with the other embodiments, following the cooling period for lamp **32**, an arc restrikes. Although the voltage applied to diac **118** is quickly reduced below the conduction turnoff level for diac **118** so that relay contacts **108** are closed, the voltage applied to diac **110** has temporarily been removed so that it is necessary to build up to threshold level **126** before diac **110** again conducts. Conditions at this point are as they were initially, in that threshold level **126** has to be exceeded before relay coil **114** is energized, resulting in relay contacts **102** associated therewith being opened to turn off lights **98** and **100**. Also, as in the initial operating conditions, the constant level voltage under normal operation never exceeds threshold level **128** to cause diac **118** to conduct. Of course, if there is again failure as before, diac **118** will conduct automatically reinitiating the cycle again as previously described.

Resistors **112** and **120**, respectively, are provided to match relay coils **114** and **122** to the voltage drop requirements of operation, if required by the voltage rating of the coil. For example, if the voltage from the rectifier is 240 volts and relay coil is designed for 120 volt operation, the series resistor is added to provide a 120-volt drop. Resistors **116** and **124**, respectively, provide a holding current for diacs **110** and **118**, respectively, to prevent chatter of relay contacts **102** and **108**, respectively, once the respective coils are positively energized.

As has been previously mentioned, in the FIG. 1 embodiment the metallic-additive lamp is shown in the same fixture as the incandescent lights. This may be convenient to provide the necessary heating in a cold environment so that the ambient temperature is conducive to conduction for the gaseous-discharge lamp once the pressure therein is right for the striking of an arc. In fact, a high resistance means that radiant heat may be employed in place of such incandescent light if the emergency lighting feature of such light is not important in a particular installation.

It may be desirable in many instances to locate the incandescent light outside of the fixture or in an entirely different location, which in no way interferes with operation of the overall lamp operation under ordinary ambient temperatures, normally about 50° F.

While several embodiments of the invention have been described, it is obvious that various substitutions or modifications of structures may be made without varying from the scope of the invention.

What is claimed is:

1. An emergency lighting system comprising:

a gaseous-discharge lamp,

means for applying a voltage to said gaseous-discharge lamp to ignite and operate said gaseous-discharge lamp,

incandescent light means, and

control voltage breakdown means having a threshold level greater than the normal operating voltage across said gaseous-discharge lamp and less than the peak starting voltage applied to said gaseous-discharge lamp, said voltage breakdown means responsive to the extinguishment of said gaseous-discharge lamp for connecting said incandescent light means to said voltage applying means to provide emergency lighting, said voltage breakdown means further responsive to the re-ignition of said gaseous-discharge lamp for disconnecting said incandescent light means from said voltage applying means.

2. An emergency lighting system as described in claim **1**, wherein

said voltage breakdown means is connected in series with said incandescent light means to form a series combination, and said series combination is connected in parallel with said gaseous-discharge lamp.

3. An emergency lighting system as described in claim **2**, wherein

said applied voltage is an AC voltage, and

said voltage breakdown means includes an SCR having a trigger circuit for gating the SCR on first half-cycles of the operating voltage when the gaseous-discharge lamp is extinguished, providing correspondingly high peak second voltage half-cycles to the gaseous-discharge lamp.

4. An emergency lighting system as described in claim **2**, wherein

said applied voltage is an AC voltage, and

said voltage breakdown means is a two-terminal bi-directional current conducting semiconductor.

5. An emergency lighting system as described in claim **4**, wherein

said voltage breakdown means includes a rectifier in series with said two-terminal bi-directional current conducting semiconductor, the first half-cycles of current through said conducting semiconductor igniting said incandescent light means, the second half-cycles of current through said conducting semiconductor being blocked and providing correspondingly high peak voltage half-cycles to the gaseous-discharge lamp.

6. An emergency lighting system as described in claim **4** wherein said voltage breakdown means includes

a rectifier in series between said two-terminal bi-directional current conducting semiconductor and said incandescent light means, the first half-cycles of current therethrough igniting said incandescent light means, the second half-cycles of current therethrough being blocked and providing correspondingly high peak voltage half-cycles to the gaseous-discharge lamp, and

a capacitor across said rectifier and said incandescent light means to further increase the high peak voltage half-cycles to the gaseous-discharge lamp.

7. In combination with

a gaseous-discharge lamp having a first main electrode and a second main electrode,

current-limiting ballast means having an input and an output, said output connected to at least one of said first and second main electrodes, and

means for applying a voltage across the input of said ballast means,

an emergency lighting system, comprising

incandescent light means,

a switch connected to form a series combination with said incandescent light means, said series combination being connected to the voltage means applied to the input of said ballast means, and

voltage breakdown means for closing said switch in re-

sponse to the extinguishment of said gaseous-discharge lamp to light said incandescent light means.

8. An emergency lighting system as described in claim 7, wherein

said switch is the anode and cathode of an SCR, and

said voltage breakdown means includes a two-terminal bi-directional current conducting semiconductor and the gate electrode of said SCR.

9. In combination with

a gaseous-discharge lamp having

a first main electrode and

a second main electrode, and

current-limiting ballast means connected to at least one of said first and second main electrodes,

an emergency lighting circuit, comprising

incandescent light means,

a first switch connected to form a series combination with said incandescent light means, said series combination being connected to an operating voltage applied to the input of the ballast means,

trigger means for controlling said first switch, including

first voltage breakdown means having a second switch and connected to the output of the ballast means, breakdown voltage above its threshold level being applied thereto while there is conduction between the first and second main electrodes, conduction of said first voltage breakdown means opening said first switch, and

second voltage breakdown means connected to the output of the ballast means, breakdown voltage above its threshold level being applied thereto upon cessation of conduction between the first and second main electrodes, conduction of said second breakdown means opening said second switch, and thereby closing said first switch to light said incandescent light means.

10. In combination with

a gaseous-discharge lamp having

a first main electrode and

a second main electrode, and

current-limiting ballast means connected to at least one of said first and second main electrodes,

a high peak voltage restriking circuit, comprising

voltage breakdown means,

a rectifier connected in series with said voltage breakdown means,

a resistance means connected to form a series combination with said voltage breakdown means and said rectifier means,

said series combination being connected in parallel across the gaseous-discharge lamp,

operating voltage applied across the ballast means and the gaseous-discharge lamp establishing a voltage across said voltage breakdown means below its threshold level while there is conduction between the first and second main electrodes,

momentary interruption of operating voltage causing a period of cessation of such conduction resulting in voltage being applied across said voltage breakdown means above its threshold level,

the first half-cycles of current through said rectifier passing through said high resistance means, the second half-cycles of current therethrough being blocked and providing correspondingly high peak voltage half-cycles to the gaseous-discharge lamp, and

a capacitor connected across said rectifier and said high resistance means to further increase the high peak voltage half-cycles to the gaseous-discharge lamp, the charge on said capacitor discharging through said resistance means during first half-cycles of current through said rectifier.

11. In combination with a gaseous discharge lamp having current limiting ballast means connected thereto, in emergency lighting system comprising:

means for applying a voltage to the ballast means and

gaseous-discharge lamp sufficient to ignite and operate said gaseous-discharge lamp,

incandescent light means, and

voltage breakdown means for connecting said incandescent light means to said voltage applying means when said gaseous-discharge lamp is extinguished to light said incandescent light means, and for disconnecting said incandescent light means from said voltage applying means a predetermined time after said gaseous-discharge lamp is re-ignited, and upon said gaseous-discharge lamp reaching a predetermined brightness.

12. In combination with

a gaseous-discharge lamp having

a first main electrode and

a second main electrode, and

current-limiting ballast means connected to at least one of said first and second main electrodes,

an emergency lighting system, comprising

voltage breakdown means having a threshold level greater than the normal operating voltage across said gaseous-discharge lamp and less than the peak starting voltage applied to said gaseous-discharge lamp,

incandescent light means; and

means for applying an operating voltage across the ballast means and the gaseous-discharge lamp to establish a first voltage across said voltage breakdown means below its threshold level while there is conduction between the first and second main electrodes, momentary interruption of said operating voltage causing a period of cessation of such conduction resulting in a second voltage being applied across said voltage breakdown means above its threshold level, to light said incandescent light means, said second voltage being reduced to said first voltage upon re-establishment of conduction between said first and second main electrodes so that said voltage breakdown means resumes its blocking state to extinguish said incandescent light means.

13. An emergency lighting system comprising:

a gaseous-discharge lamp,

means for applying a voltage to said gaseous-discharge lamp to ignite and operate said gaseous-discharge lamp,

incandescent light means,

first voltage breakdown means connected across said gaseous-discharge lamp having a threshold level greater than the normal operating voltage and less than the peak starting voltage of said gaseous-discharge lamp,

second voltage breakdown means connected across said gaseous-discharge lamp having a predetermined threshold level less than the normal operating voltage of said gaseous-discharge lamp,

control means responsive to said first voltage breakdown means conducting upon extinguishment of said gaseous-discharge lamp for lighting said incandescent light means and for disabling said second voltage breakdown means, said control means further responsive to said first voltage breakdown means resuming its blocking state upon re-ignition of said gaseous-discharge lamp for enabling said second voltage breakdown means, said second voltage breakdown means conducting after the gaseous-discharge lamp reaches a predetermined brightness to extinguish said incandescent light means.

14. An emergency lighting system as set forth in claim 13 including

rectifier means having an input connected across the gaseous-discharge lamp and an output, and wherein said first voltage breakdown means and said second voltage breakdown means are connected across the output of said rectifier means.

15. An emergency lighting system as described in claim 14 wherein

said control means includes a first relay coil connected

to the output of said first voltage breakdown means for actuating first relay contacts which are connected in series with said second voltage breakdown means, and a second relay coil connected to the output of said second voltage breakdown means for actuating second relay contacts which are connected in series with said incandescent light means.

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307—305; 315—92, 93, 182; 317—31

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

June 23, 1970

Patent No. 3,517,254

Albert C. Mc Namara, Jr.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 29, "condition" should read -- conduction --. Column 10, line 6, "control" should be deleted. Column 11, line 74, "in" should read -- an --.

Signed and sealed this 2nd day of March 1971.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents