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Powell

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[54] **BALLAST CIRCUIT WITH INTEGRAL TIME DELAY RELAY**

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[73] Assignee: **General Electric Company,** Indianapolis, Ind.

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[52] **U.S. Cl.** **315/97,** 315/96, 315/95, 315/114

[51] **Int. Cl.** **H05b 41/14**

[58] **Field of Search** 315/100, 104, 114, 117, 315/95, 96, 97

[56] **References Cited**

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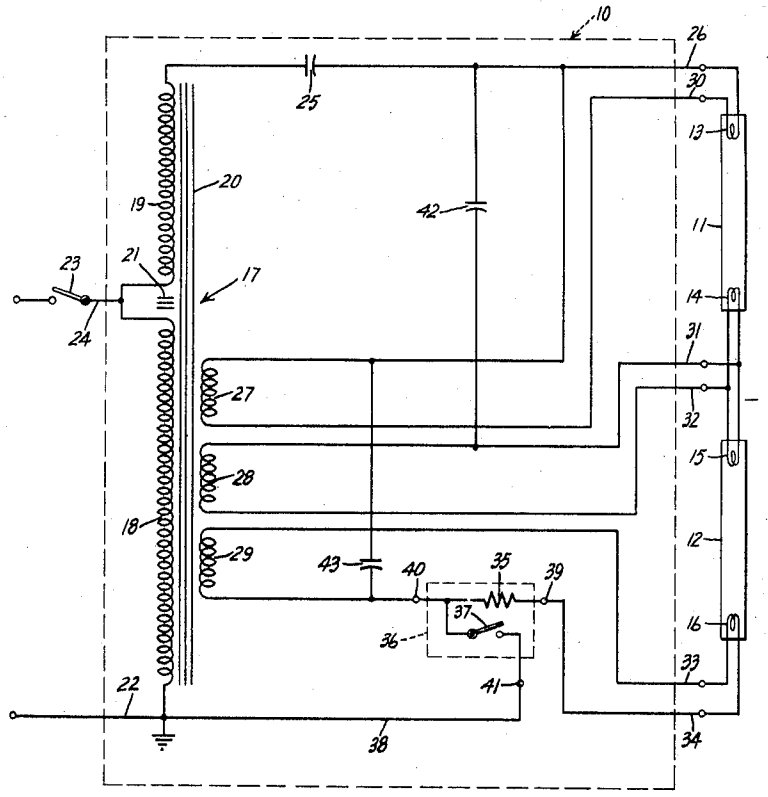
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Primary Examiner—Nathan Kaufman

[57] **ABSTRACT**

A ballast circuit for starting and operating gaseous discharge devices includes a transformer which has a primary winding and a secondary winding. There are auxiliary windings electrically coupled to the primary winding, including electrode heating windings for providing energy to heat the electrodes of the gaseous discharage devices. There is a relay including a heater and a switch. The switch is normally open and closes in response to energization of the heater. The heater is connected to an auxiliary winding for energization when the primary winding is energized. The switch is connected in series with the secondary winding for providing operating energy to the gaseous discharge devices only when the switch is closed.

10 Claims, 3 Drawing Figures



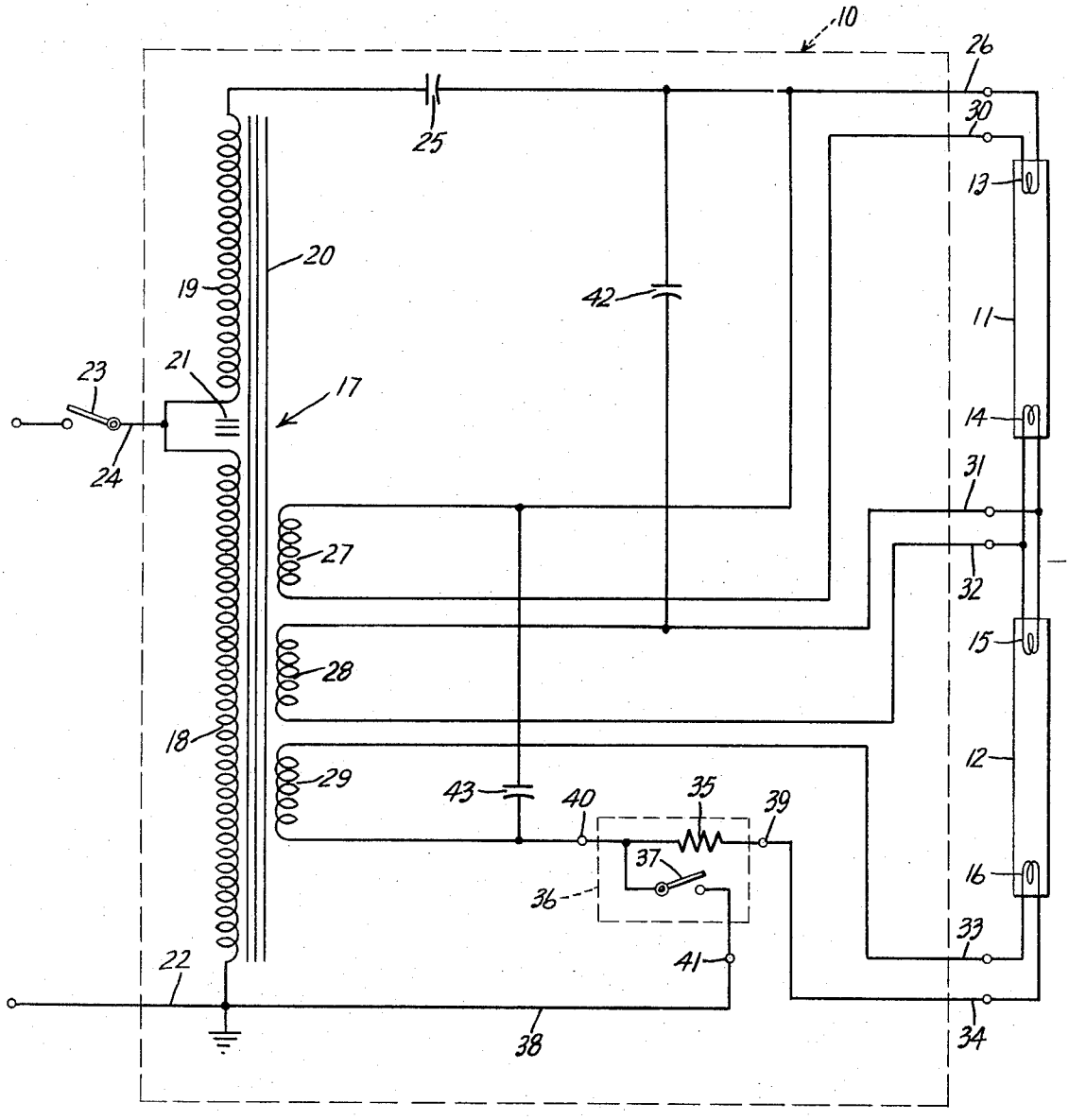

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FIG.1

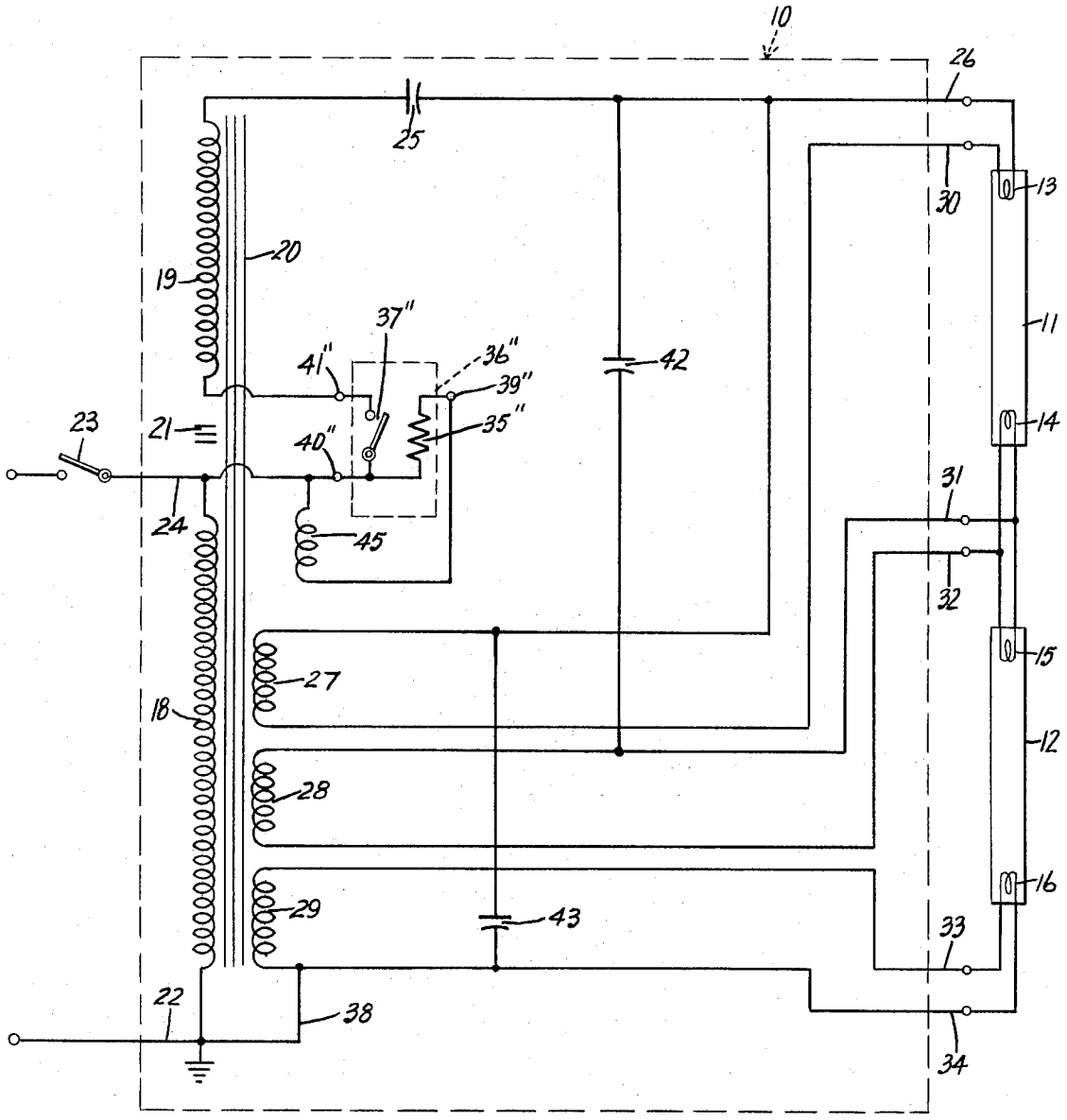

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FIG. 3

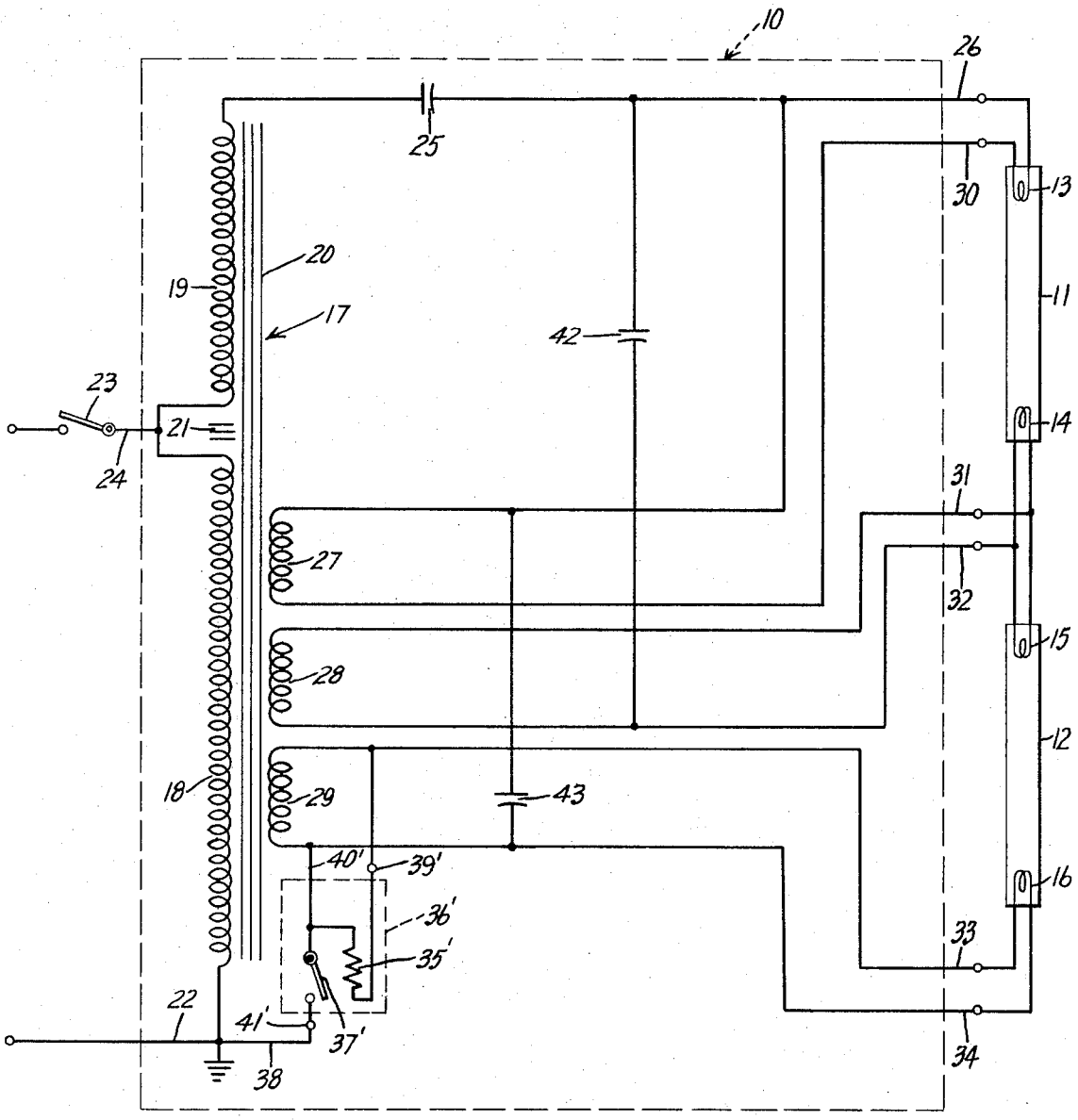

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FIG. 2

BALLAST CIRCUIT WITH INTEGRAL TIME DELAY RELAY

BACKGROUND OF THE INVENTION

Many applications of gaseous discharge devices, such as fluorescent lamps for instance, involve hard to reach locations of the discharge lamps. For instance, fluorescent lamps are often used to illuminate outdoor signs which are located well above ground level. Because of their locations, replacement of lamps in such signs is very time consuming and often requires special equipment to reach the signs. Thus, it is desirable for the fluorescent lamps to last as long as possible so that replacement will be less frequent.

Fluorescent lamps typically require a rather high voltage to initially cause ionization of the gas. After ionization, or breakdown, the impedance of the gas quickly decreases and only a relatively low voltage is required to maintain ionization and thus current flow through the lamp. The electrodes of fluorescent lamps typically are of a filamentary heating element configuration. If a sufficient voltage is impressed across the lamp terminals when the electrodes are cold the lamp will ignite and emit light. However, such operation causes rapid deterioration of the electrodes. This is primarily due to the creation of a very high electrical field gradient across the electrodes when they are cold. This high electrical gradient exists because there is not a low work function generated at the electrode surfaces by virtue of thermionic emission and there are not clouds of electrons surrounding the electrodes that can serve as vehicles for electrical conduction. If electrodes are sufficiently preheated they will emit a cloud of electrons which reduces the electrical gradient at the electrodes. This minimizes the deterioration of the electrodes due to ion bombardment at lamp ignition.

This has caused the operating circuits for fluorescent lamps, particularly in the outdoor sign industry, to include means for delaying application of lamp starting voltage until the electrodes are heated to their electron emission temperature.

Basically, in the past there have been two approaches to providing the time delay. One approach utilized a relay assembly which was mounted externally of the ballast. It included a thermally actuated switch which was energized from the supply voltage. When the thermally actuated switch closed it energized a relay coil which closed a set of power contacts to provide lamp starting energy to the ballast. This approach necessitated the use of a relay separate from the thermally actuated switch and required complex wiring between the relay and ballast. This added to the cost of the relay and ballast. Also the energization of the thermally actuated switch was sensitive to the supply voltage. As mentioned above, outdoor lighting systems are designed to operate from supply voltages which generally are between about 120 volts AC and 480 volts AC, with 120 volts AC and 277 volts AC being very common. With time delay relay mechanisms designed to have their heaters operate on supply voltage, a somewhat different heater design had to be provided for each voltage rating. This increased costs as it required additional inventory of parts.

As indicated by all of the above-mentioned reasons, among others, the prior art approaches to providing a time delay for electrode or filament heating have not been completely successful.

SUMMARY OF THE INVENTION

It is, therefore, an object of the present invention to provide a new and improved ballast circuit with an integral time delay relay.

It is another object of this invention to provide such a ballast circuit utilizing a time delay relay having low power consumption.

It is a further object of this invention to provide such a ballast circuit with a time delay relay having simplified electrical connections.

It is still another object of the present invention to provide an improved ballast circuit incorporating a three terminal time delay relay.

It is yet another object of this invention to provide such a ballast circuit with a time delay relay in which the same time delay relay mechanism may be utilized for a number of different ballast apparatus designed for use with different supply voltages.

The present invention, in accordance with one embodiment thereof, provides a ballast circuit for starting and operating at least one gaseous discharge lamp having spaced apart electrodes. The ballast circuit includes a transformer having a primary winding and a secondary winding inductively coupled therewith. There are input leads for connecting the primary winding to a source of electric energy and output leads for connecting the secondary winding to at least one gaseous discharge lamp. The transformer also includes auxiliary windings electrically coupled to the primary winding, including electrode heating windings for connection to the electrodes of the at least one gaseous discharge lamp to provide heating power to the electrodes. The circuit further includes a relay having a heater and a switch. The switch, which is connected in series with the secondary winding, is normally open and closes upon a predetermined energization of the heater. The heater is connected to at least part of one of the auxiliary windings for providing energization of the heater whenever the primary winding is connected to a source of electric energy.

The above-mentioned and other features and objects of this invention, as well as the manner of obtaining them, will become more apparent and the invention itself will be more fully understood by reference to the following description, taken in conjunction with the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic electric diagram of a ballast circuit incorporating one form of the present invention;

FIG. 2 is a schematic electric diagram of a ballast circuit incorporating another form of the present invention; and

FIG. 3 is a schematic electric circuit diagram of a ballast circuit incorporating still another form of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and particularly to FIG. 1, there is shown an electric schematic diagram of a ballast circuit **10** designed to ignite and operate a pair of gaseous discharge or fluorescent lamps **11** and **12.** The lamp **11** has a pair of spaced apart electrodes **13** and **14** while the lamp **12** has a pair of spaced apart electrodes **15** and **16.** The electrode **14** of lamp **11** is

connected to the electrode **15** of lamp **12** so that the lamps are serially connected.

The ballast **10** includes a transformer **17** having a primary winding **18** and a secondary winding **19.** The primary and secondary windings are serially connected in autotransformer relationship in a voltage additive configuration. They are wound upon a core schematically illustrated at **20** and magnetically loosely coupled. The loose magnetic coupling may be provided by using a suitable shunt as indicated at **21** or by physical separation of the primary and secondary windings on the magnetic core. One input lead **22** is connected to the distal end of primary winding **18.** The other input lead **24** is connected to the junction between the primary and secondary windings. A main switch **23** may be included in input lead **24** for selectively energizing the ballast. The distal end of the secondary winding is connected through a power factor compensating capacitor **25** to one output lead **26** of the ballast.

The transformer also includes three auxiliary electrode heating windings **27, 28** and **29.** Each of the electrode heating windings comprises a relatively small number of turns and normally is closed inductively coupled to the primary winding as by being wound directly over the primary winding. One side of winding **27** is connected to ballast output lead **26** while the other side is connected to ballast output lead **30.** The electrode heating winding **28** is connected to ballast output leads **31** and **32** while electrode heating winding **29** is connected to ballast output leads **33** and **34.**

The heater resistor **35** of a time delay relay generally indicated at **36** is connected in the lead **34.** The time delay relay also includes a switch **37** connected in a lead **38,** which is connected to the distal end of the primary winding **18.** Thus, ballast output lead **34** is connected to the distal end of primary winding **18** through heater **35** and switch **37.** The lead **38,** and thus the ballast circuit, normally is grounded as indicated.

The switch **37** is constructed as to be thermally responsive to heat generated by heater **35.** Switch **37** is normally open and closes in response to predetermined heat from the heater **35.** This interaction between the resistor or heater **35** and the switch **37** is indicated by the close proximity of heater **35** and switch **37** in the schematic diagram. The heater and switch are so interconnected that the circuit of the relay is a simple three terminal network, having terminals **39, 40** and **41.**

Additional details of construction and operation of a relay mechanism suitable for use as time delay relay **36** may be had by reference to copending application Ser. No. 416,514, filed Nov. 16, 1973 (continuation of application Ser. No. 342,978, filed Mar. 20, 1973 and now abandoned) assigned to General Electric Company, assignee of the present invention.

A start capacitor **42** is connected from the ballast output lead **26** to the ballast output lead **31.** A capacitor **43** may be connected across the three electrode heating windings **27, 28** and **29** to suppress radio interference. The ballast output leads **26** and **30** are connected to the two sides of electrode **13** of lamp **11.** The output leads **31** and **32** are connected across both of electrodes **14** and **15** while the output leads **33** and **34** are connected across the electrode **16.** Thus, assuming switch **37** is closed a power circuit is completed from output lead **26** through the serially connected lamps **11** and **12,** the output leads **34** and lead **38** to the distal end of primary **18.** Electrode heater winding **27** is effectively connected across electrode **13** so as to provide heating power to that electrode. Electrode heating winding **28** is effectively connected across both electrode **14** and electrode **15** to provide power for heating both of these electrodes and electrode heating winding **29** is connected across electrode **16** to provide heating power for that electrode.

When main switch **23** is closed the voltage across the primary winding **18** is added to the voltage across the secondary winding **19** to provide a voltage for igniting and operating the lamps **11** and **12.** However, initially, this voltage is not impressed across the lamps because the switch **37** is initially open. Concurrently, normal low level voltages are induced in the auxiliary windings **27, 28** and **29** and applied to the electrodes **13, 14, 15** and **16.** For the sake of simplicity the illustrative electrodes **13, 14, 15** and **16** are shown as being of the self-heating type. With this type of electrode the heating current flows through the electrode itself. Obviously the electrodes could be of the separately heated type in which a heater, separate from the electrode, is used to heat the electrode. With lamps of that type the auxiliary electrode heating windings **27–29** would be connected to the electrode heaters rather than to the electrodes themselves.

The heating current flowing through electrode **16** also flows through resistor **35** and the heat generated by the resistor or heater **35** impinges upon the switch **37.** When sufficient heat has impinged upon switch **37,** it closes. The time delay relay **36** is designed so that a sufficient period of time will elapse before switch **37** closes for the lamp electrodes to be heated to their thermionic emission temperature; that is, the temperature at which a cloud of electrons forms about the electrodes. This provides an abundance of charge carriers (electron cloud) in the vicinity of the electrodes such that when the arc is struck, upon the closure of switch **37,** minimal damage occurs to the electrodes.

When switch **37** closes the combined voltage across both the primary and secondary windings is applied across lamp **12** through the start capacitor **42.** After lamp **12** fires a starting voltage is applied across lamp **11** and lamp **11** fires. When lamp **11** fires the voltage across capacitor **42** is reduced to a level that makes the current flow through capacitor **42** inconsequential relative to the current flow through lamps **11** and **12.**

So long as the lamps are operating the lamp current flows through the resistor **35** and the heat it generates causes the switch **37** to remain closed. If energy is removed from the ballast, as by opening main switch **23** or as the result of a power failure for instance, the switch **37** will begin to cool as the electrodes **13–16** cool. When sufficient time has passed for the electrodes cool below their thermionic emission temperature switch **37** will have reopened. Upon an attempted reignition of the lamps, as by closing switch **23,** the application of a starting voltage will be delayed until the switch **37** has been heated sufficiently to reclose.

Additional details of construction and operation of a ballast apparatus like that in the exemplification embodiments of the present invention may be had by reference to U.S. Pat. No. 2,869,037, issued to W. W. Brooks et al on Jan. 13, 1958 and assigned to General Electric Company assignee of the present invention. Also, additional details of construction of a ballast apparatus incorporating a ballast circuit with an integral time delay relay of the type set forth herein may be had

by reference to copending application Ser. No. 342,993, filed Mar. 20, 1973, assigned to General Electric Company.

Normally in the fluorescent lamp industry the designed electrode heating voltage for similar lamps is essentially the same regardless of the supply voltage from which the ballast is operated. Thus, by utilizing a time delay relay circuit which is energized from one of the auxiliary electrode heating windings a single time delay relay design may be used for ballasts which are designed to operate similar lamps from a number of different supply voltages. Also since the electrode heating voltage is much lower than the supply voltage, ballast apparatus including a time delay circuit energized from one of the auxiliary windings will have a reduced heater size than one operating from line voltage. This results in reduced dielectric stresses between the heater and the switch so that less electrical insulation will be required between the heater and the switch. This allows improved heat transfer to the switch and reduces the cost of the relay. Additionally, since the heater is operating from a lower voltage it may be more easily manufactured. Also less heater power is required to provide proper switch actuation. This means that the heater has a reduced watts heat loss and there is less heat to be dissipated by the ballast. This obviously reduces the electrical consumption of the overall ballast circuit and reduces the problems attendent to placing the time delay relay in the normal ballast housing. Since the time delay relay may be placed within the ballast housing without adversely effecting the heating problems of the ballast the wiring required for connecting the time delay relay into the ballasting circuit is less complicated.

Since there is a very low voltage gradient between switch and heater, it is not necessary to provide a substantial degree of electrical isolation between them. Also since the heater and switch have a low voltage differential between them the switch blade can also be made to serve as the thermal motor of the relay. Therefore, the heater and combined thermal motor and switch can be interconnected in a simple three terminal network. This reduces the complexity of wiring of the relay. All of these increase the manufacturability of the overall ballast and reduce the overall ballast cost.

Referring now to FIG. **2** there is illustrated, in electrical schematic diagram form, another ballast circuit incorporating one form of the present invention. The basic ballast circuit is essentially the same as that of FIG. **1** and, therefore, like numerals have been used to indicate like components. The basic difference between the ballast circuits of FIGS. **1** and **2** is in the connection of the time delay relay **36'** of FIG. **2.** As shown in FIG. **2** relay terminals **39'** and **40'** are connected to ballast output leads **33** and **34** respectfully while terminal **41'** is connected to lead **38.** This effectively places the heater **35'** across auxiliary electrode heating winding **29** in parallel with electrode **16** and places switch **37'** between lead **34** and lead **38.** With such an arrangement lamp current does not flow through heater **35'**, as is true in the embodiment of FIG. **1.** This further decreases the heat generated by the time delay relay during ballast operation. As the operation of the ballast apparatus circuit of FIG. **2** is essentially the same as that of FIG. **1**, it will not be discussed in detail.

In the circuit shown in FIG. **2** the heater **35'** is connected across all of electrode heating winding **29** so that the entire electrode heating voltage is impressed across heater **35'**. It will be recognized that heater **35'** can be connected across only part of winding **29** and thus have an even lower voltage impressed upon it. With a lower impressed voltage a heavier wire, which is more self-supporting, can be used in manufacture of the heater. Again, only one relay need be manufactured for use with all ballasts and lamps. However, this approach does require that one of the auxiliary electrode heating windings be provided with a tap.

Referring now to FIG. **3,** there is shown an electric schematic diagram of a ballast apparatus circuit incorporating another embodiment of the present invention. Again the basic ballast circuit is the same as that of FIGS. **1** and **2** and the same reference numerals have been used to identify similar components. In the ballast circuit of FIG. **3** the connection between primary winding **18** and secondary winding **19** is made through the switch **37''** of time delay relay **36''**. The heater **35''** of the relay is connected in a loop with a separate auxiliary relay heating winding **45.** With this arrangement, upon closing the main switch **23,** voltage is generated across the main winding **18.** Also a voltage is generated across secondary **19** and each of the auxiliary windings **27, 28, 29** and **45** as a result of their inductive coupling with the primary winding. Thus, heating energy is provided to the electrodes **13, 14, 15** and **16** and heat is generated by the heater **35''** and impinges upon the switch **37''**. Since the switch **37''** is initially open, no current can flow through the switch and the combined voltages of windings **18** and **19** appear across switch **37''**. When a switch **37''** has been sufficiently heated it closes and the lamps **11** and **12** are thereafter ignited and operated in a manner as previously described with regard to FIG. **1.**

One advantage of the circuit shown in FIG. **3** is that the auxiliary relay heating winding **45** can be tailored to exactly match the power requirements of the heater **35''** and switch **37''**. Another advantage of the use of a separate isolated auxiliary winding for the time delay relay is that it makes possible the use of a non-autotransformer connection, i.e., the primary and secondary windings may be electrically separate but magnetically coupled. However, FIG. **3** shows an autotransformer arrangement for the sake of simplicity and ease of understanding.

It will be understood that, by the present invention, it is possible to provide a ballast circuit incorporating a low voltage time delay relay. This reduces the heat generated by the time delay relay so that it can be mounted in the ballast itself. It also makes possible the use of a simplified time delay relay structure and circuitry. If the time delay relay heater is connected across the supply lines then the heater must be electrically isolated from the switch and from the secondary circuit. That requires the use of a four terminal network. With a ballast circuit of the present invention the heater does not have to be so isolated and a three terminal network can be utilized. In fact it is possible to utilize a three terminal line delay relay, in which the relay case is one terminal, in ballast circuits of the present invention. This reduces even more the overall complexity and cost of the ballast apparatus.

For the sake of simplicity each of the circuits has been described, as operating two fluorescent lamps in series. However, the present invention is not limited thereto. It may be applied to ballast operating one lamp

or more than two lamps and other circuit configurations may be utilized without departing from the spirit and scope of the invention. For instance, while the auxiliary electrode heating windings **27–29** have been shown as isolated windings, it will be understood that one or more of these windings can be connected in autotransformer relationship with the primary winding.

While each of the illustrative embodiments include a normally open time delay relay, it will be understood that the invention is not so limited. The time delay relay can have a normally closed switch connected directly across the lamps. The ballast would provide short circuit current through the switch for a short period of time until the time delay relay heater causes the switch to open. Opening of the switch then applies full voltage to the lamps. Most ballasts today are designed to successfully operate under short circuit conditions for a reasonable period of time and thus can be used with such a circuit.

It will be apparent to those skilled in the art that while I have described what, at present, is considered to be the preferred embodiments of this invention, in accordance with the patent statutes, changes may be made in the illustrative embodiments without actually departing from the true spirit and scope of this invention.

What we claim is new and desire to secure by letters patent in the United States is:

1. A ballast circuit for starting and operating at least one gaseous discharge lamp having spaced apart electrodes, each electrode further comprising a heating element; said circuit including:

a. a transformer having a primary winding and a secondary winding inductively coupled therewith;

b. input leads for connecting the primary winding to a source of electric energy, and output leads connecting the secondary winding to said spaced apart lamp electrodes;

c. auxiliary windings inductively coupled to the primary winding, said auxiliary windings including electrode heating windings connected to said electrode heating elements for providing electric energy to the elements;

d. a time delay relay including a heater and a normally open switch which closes responsive to thermal energy developed upon energization of the heater, said switch being connected in series with the secondary winding and said lamp electrodes;

e. means connecting the relay heater to an auxiliary winding, said winding providing electric energy to the heater concurrent with application of electric energy to said electrode heating elements by the electrode heating windings.

2. A ballast circuit as set forth in claim **1**, wherein: said auxiliary windings include a separate relay heating winding inductively coupled to said primary winding; said heater being connected to said relay heating winding.

3. A ballast circuit as set forth in claim **1** wherein: said heater is connected across at least a portion of said electrode heating winding.

4. A ballast circuit as set forth in claim **1**, wherein: one of said output leads is at essentially ground potential and the other of said output leads is at a voltage removed from ground potential; said switch being connected to said lead at essentially ground potential.

5. A ballast circuit as set forth in claim **1**, wherein: said heater and switch are electrically interconnected to form a three terminal network.

6. A ballast circuit for starting and operating at least one gaseous discharge lamp having spaced apart electrodes, each electrode further comprising a heating element; said circuit including:

a. a primary winding and a secondary winding connected in an autotransformer relationship and having a loose inductive coupling therebetween;

b. input leads for connecting the primary winding to a source of electric energy, and output leads connecting the secondary winding to said spaced apart lamp electrodes;

c. auxiliary windings inductively coupled to the primary winding, said auxiliary windings including electrode heating windings connected to said electrode heating elements for providing electric energy to the elements;

d. a time delay relay including a heater and a normally open switch which closes responsive to thermal energy developed upon energization of the heater, said switch and said heater being interconnected in a three terminal network, said switch also being connected in series with the secondary winding and said lamp electrodes;

e. means connecting the relay heater to an auxiliary winding, said winding providing electric energy to the heater concurrent with application of electric energy to said electrode heating elements by the electrode heating windings.

7. A ballast circuit as set forth in claim **6**, wherein: said heater is connected across at least a portion of one of said electrode heating windings.

8. A ballast circuit as set forth in claim **6**, wherein: said auxiliary windings include a separate relay heating winding; said heater being connected across said separate winding.

9. A ballast circuit as set forth in claim **6**, wherein: one of said output leads is at essentially ground potential and the other of said output leads is at a voltage removed from ground potential; said switch being connected to said lead at essentially ground potential.

10. A ballast circuit as set forth in claim **6**, wherein: said switch is connected between said primary winding and said secondary winding.

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