United States Patent [19]

Powell et al.

[11] **3,872,350**

[45] **Mar. 18, 1975**

[54] **BALLAST HAVING INTEGRAL TIME DELAY RELAY**

[75] Inventors: **Walter F. Powell**, Danville; **Charles Grimshaw**, Fulton, both of Ill.

[73] Assignee: **General Electric Company**

[22] Filed: **Mar. 20, 1973**

[21] Appl. No.: **342,993**

[52] **U.S. Cl.**..... **315/104,** 174/52 PE, 174/DIG. 2, 315/DIG. 5, 337/27

[51] **Int. Cl.** **H05b 39/04**

[58] **Field of Search** ..... 315/100, 102, 104, DIG. 5; 337/22, 23, 26, 27; 174/DIG. 2, 52 PE

[56] **References Cited**

UNITED STATES PATENTS

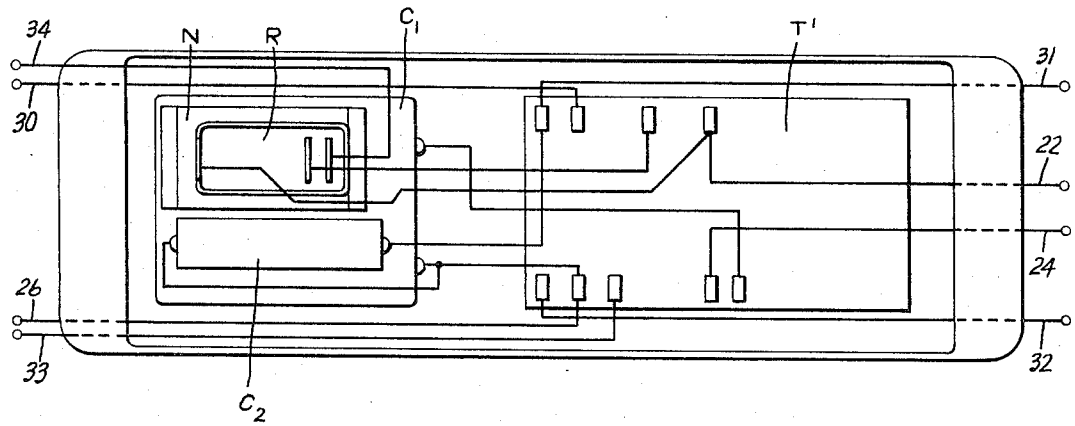
2,722,628	11/1955	Cates et al.	315/104 X
3,116,437	12/1963	Harvey	174/52 PE
3,173,059	3/1965	Stake	315/DIG. 5
3,250,956	5/1966	Lovinger	174/52 PE X

Primary Examiner—James B. Mullins

[57] **ABSTRACT**

A ballast for starting and operating gaseous discharge lamps having spaced apart electrodes. The ballast includes an elongated casing and a transformer received in the casing. The transformer has a primary winding and a secondary winding inductively coupled to the primary winding. There is input circuitry for connecting the primary winding to a source of electrical energy and output circuitry for connecting at least the secondary winding to the gaseous discharge lamps. The transformer also includes electrode heating windings electrically coupled to the primary winding. These windings provide heating power for the electrodes of the gaseous discharge lamps. A time delay relay also is received in the casing and includes a heater and a switch. The heater is electrically connected to one of the electrode heating windings for energization when the primary winding is energized. The switch is connected in the output circuit for energization of the gaseous discharge lamps. the heater causes the switch to close and energize the gaseous discharge lamps only after a predetermined time has elapsed to allow sufficient heating of the lamp electrodes for them to reach their thermionic emission temperature. The heater and switch are connected in a three terminal network and the time delay relay includes a housing which is partially constructed of electrically conductive material. The housing forms one of the terminals of the network. A capacitor may also be included in the ballast casing and interconnected with the transformer. A potting material is received in the casing and substantially encapsulates the transformer, the time delay relay and the capacitor.

6 Claims, 4 Drawing Figures



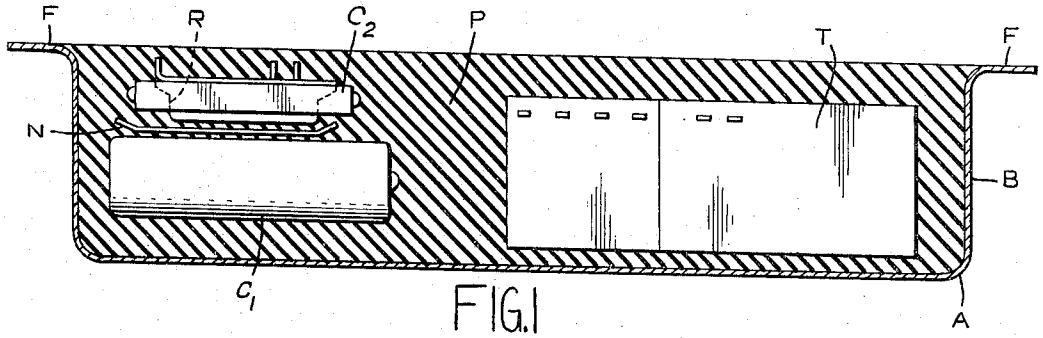


FIG.1

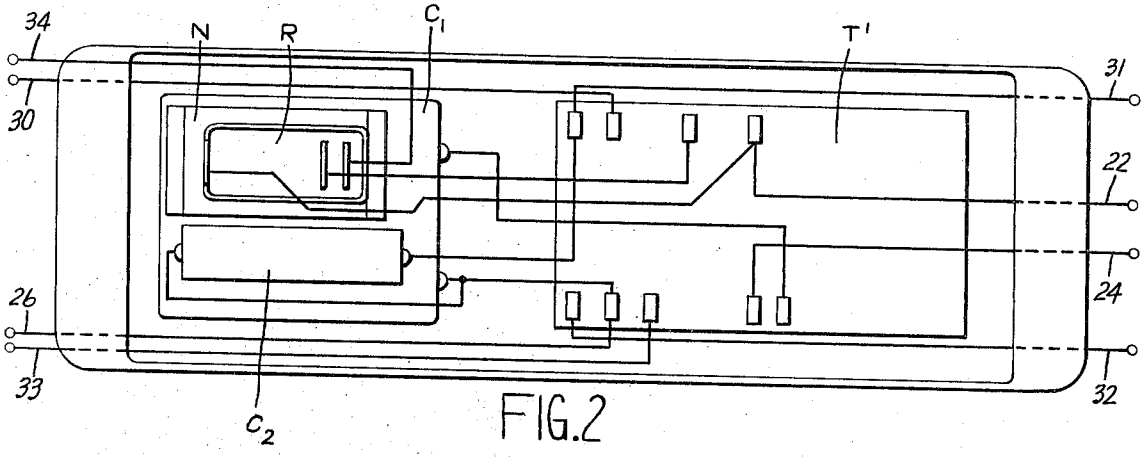


FIG.2

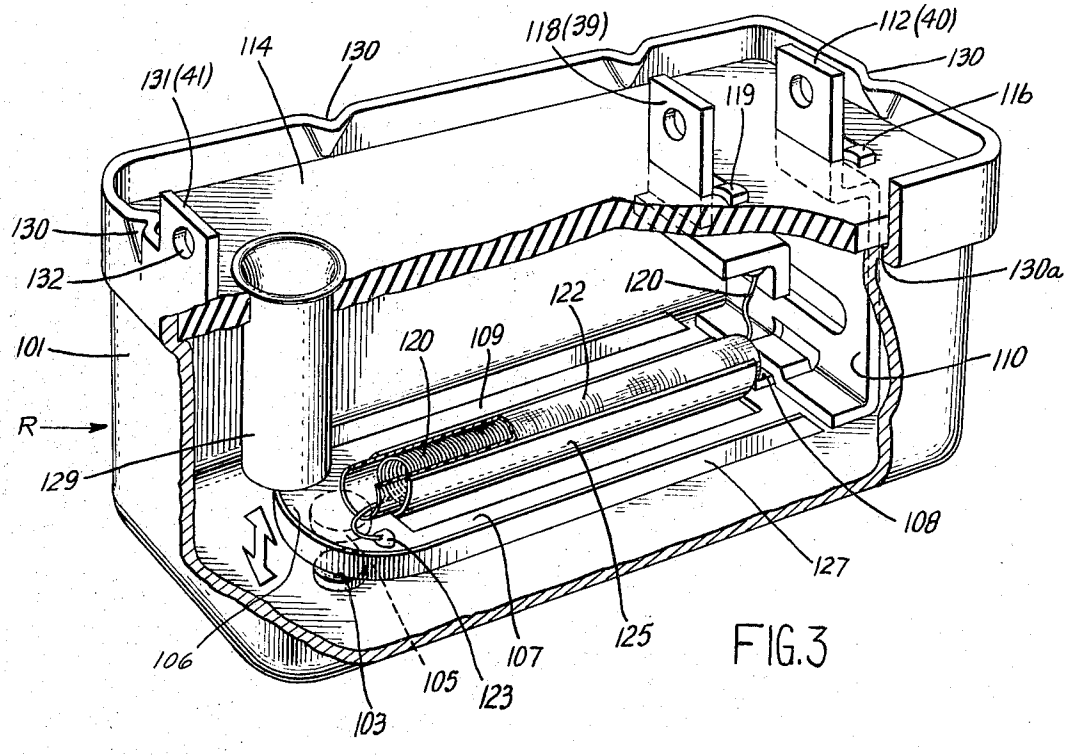


FIG.3

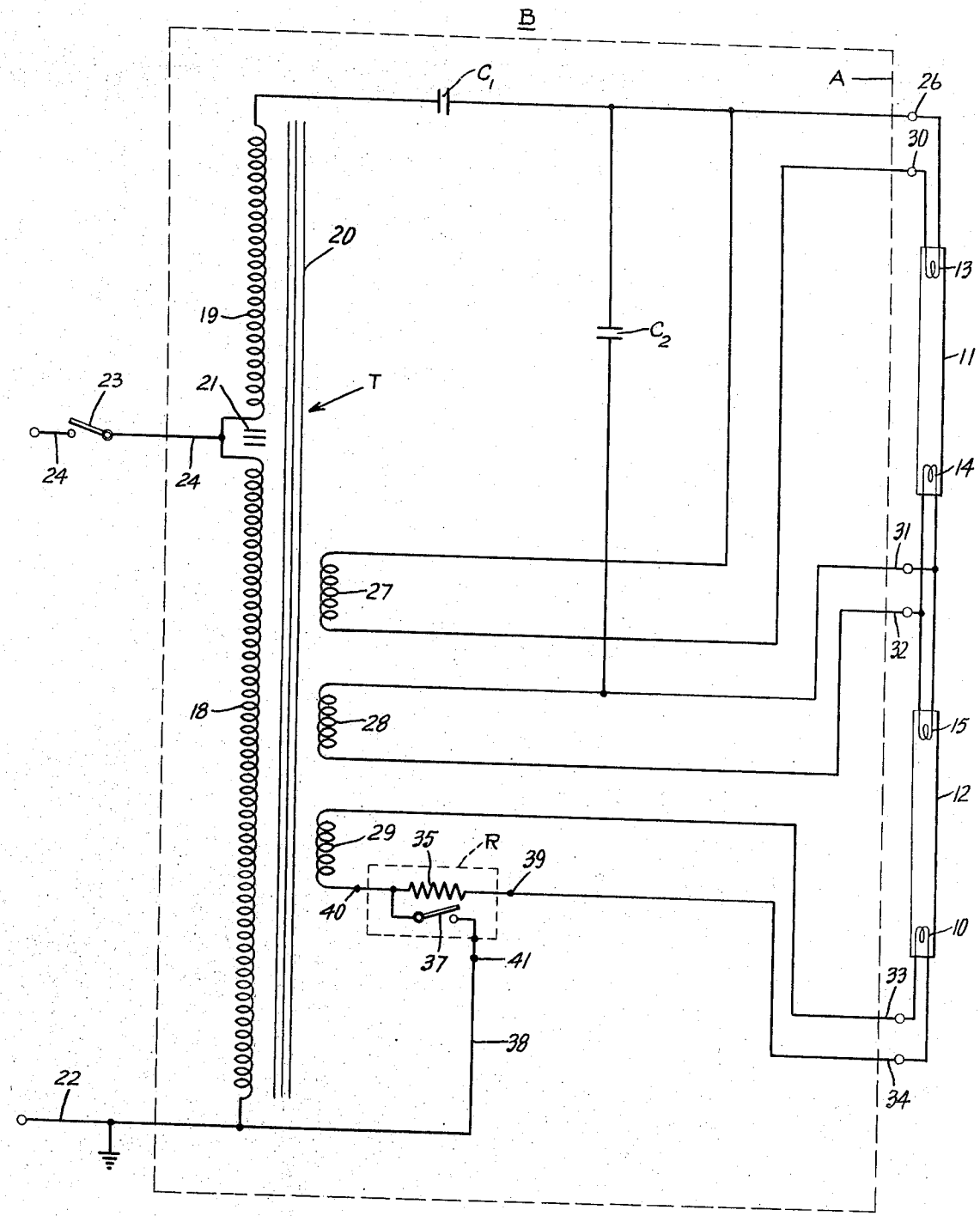

B
A
C1
C2
T
20
19
21
23
24
24
26
30
13
11
14
31
32
27
28
18
15
12
29
35
R
39
40
37
41
38
10
33
34
22

FIG.4

BALLAST HAVING 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 lamp. 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 in order to reach the signs. 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 cause initial 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 lamps. The electrodes of fluorescent lamps typically are of a filamentary 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 each of the electrodes that can serve as vehicles for electrical conduction. If the 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.

For this reason fluorescent lamp operating circuits, particularly in the outdoor sign industry, have included means for delaying the 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.

Another approach used a relay mounted internally of the ballast case. Relays of this type included a thermally actuated switch and a heater. However, normally, the heaters were of the high voltage type, energized from the supply voltage. Because of the high voltages involved it was necessary to use high dielectric strength materials. Also the thermal motors were sensitive to variations in the supply voltage so that a different heater design was necessary for each voltage rating. Since the thermal motors operated from high voltage they had relatively high power losses in the form of generated heat. This heat had to be dissipated from the ballast. While such relays reduced the complexity of the wiring somewhat they were normally four terminal networks which still involved fairly complicated wiring.

As indicated by all the above-mentioned reasons, among others, the prior art approaches 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 for operating at least one gaseous discharge lamp.

It is another object of this invention to provide a new and improved ballast apparatus including an integral time delay relay.

It is yet another object of this invention to provide a ballast with a new and improved time delay relay which generates very little heat.

It is still another object of the present invention to provide a ballast and time delay relay which is compact in size and economical to manufacture.

It is still another object of the present invention to provide a ballast and time delay relay in which a single time delay relay design may be utilized for ballast operating from a number of different supply voltages.

The present invention, in accordance with one embodiment thereof, provides a ballast for starting and operating at least one gaseous discharge lamp, comprising a casing at least partially filled with a potting material. A transformer, a capacitor and a time delay relay are received in the casing. The time delay relay includes a heater and a switch connected in a three terminal network with the heater being connected to the transformer for energization of the heater. The transformer, the capacitor and the switch are interconnected for starting and operating at least one gaseous discharge lamp. The potting material in the ballast casing substantially encapsulates the transformer, the capacitor and the time delay relay.

The above-mentioned and other features and objects of this invention, as well as one 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.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view of a ballast embodying one form of the present invention, the view being partially in cross-section and the ballast circuitry being omitted for clarity of illustration.

FIG. 2 is a top plan view of the ballast apparatus of FIG. 1 with ballast circuitry schematically included and with the potting material omitted.

FIG. 3 is a perspective view of a time delay relay used in the ballast of FIG. 1 and FIG. 2, with portions of the relay housing broken away for purposes of illustration.

FIG. 4 is a schematic electrical diagram of a ballast circuit incorporating a ballast apparatus such as that shown in FIGS. 1 and 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, and particularly to FIG. 1, there is shown an illustrative ballast B incorporating one form of the present invention. The ballast B includes a hollow, cold-rolled steel casing A which houses a transformer T, two capacitors or capacitor banks C_1 and C_2, and an ambient temperature compensated time delay relay R. The transformer, the capacitors and the relay are received in the casing in spaced apart relationship thereto and to each other. The casing A is elongated, having its longitudinal axis extending from side to side as seen in FIG. 1. The transformer T and the first or main capacitor C_1 are spaced apart within the casing along the longitudinal axis of the casing. The time delay relay R is spaced from the transformer along the longitudinal axis of the casing and is spaced from the capacitor C_1 in a direction transverse to the longitudinal axis of the casing. The capacitor C_2, being somewhat smaller than C_1 may be placed side by side with the time delay relay R. A sheet of electrical insulation N, such as Mylar, is placed between the relay R and the capacitor C_1. The relay R in the exemplification ballast includes a housing which is at least partially electrically conductive. The sheet N of insulating material prevents contact between relay R and capacitor C. A potting compound, such as asphalt or a polyurethane resin for instance, at an elevated temperature is poured into the casing to a level above components and solidifies by cooling to room temperature. The potting material essentially completely fills the casing A and substantially encapsulates the transformer T, the capacitors C_1 and C_2 and the relay R. Finally, a steel cover, not shown, is secured to the top of the casing A at flanges F to complete the structure.

It will be understood that the usual potting compounds, such as asphalt or polyurethane, are electrically insulative. Thus, if the time delay relay is spaced away from the other components of the ballast, including the metal case, the sheet N is not necessary. Such sheets, either as flat pieces or wrapped about the relay, may be used to simplify the manufacturing process. Also it will be apparent that both of the capacitors C_1 and C_2 may be packaged in a single container.

A more complete description of a method for positioning components within a ballast casing and supporting them in a suitable potting material may be had by reference to U.S. Pat. No. 3,655,906, assigned to General Electric Company, assignee of the present invention.

Prior to completely filling the casing with potting material the electrical leads are attached to the various coils of the transformer T, to the relay R and to the capacitors C_1 and C_2 so as to interconnect these components to form a ballast circuit. Certain of the leads are extended to the outside of the ballast through appropriate openings in the casing, not shown, for connecting the ballast circuit to a suitable source of electrical energy and to one or more gaseous discharge lamps. The interconnections and leads are schematically illustrated within the ballast in FIG. 2 and an exemplification circuit is shown in FIG. 4, in which the ballast casing A is schematically illustrated by the dashed line A.

Referring now to FIG. 4, the exemplification ballast circuit is 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 transformer T has a primary winding 18 and a secondary winding 19 which are serially connected in an autotransformer relationship in a voltage additive configuration. They are wound upon a core schematically illustrated at 20 and are magnetically loosely coupled. The loose magnetic coupling may be provided by using 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 while the other input lead 24 is connected to the junction between the primary and secondary windings. The lead 22 is grounded for grounding the ballast circuit. A main switch 23 is included in a input lead 24 for selectively energizing the ballast. The distal end of the secondary winding is connected to a power factor compensating capacitor C_1, which in turn is connected on one output lead 26 of the ballast.

The transformer T also includes three auxiliary windings, in the form of electrode heating windings 27, 28 and 29. Each of the electrode heating windings comprises a relatively small number of turns and is closely inductively coupled to the primary winding as by being wound directly over the primary winding. One side of the winding 27 is connected to ballast output lead 26 and 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 or resistor 35 of the time delay relay R is connected in the lead 34. The time delay relay also includes a switch 37 which is connected to 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 switch 37 is constructed so as to be thermally responsive to the heat generated by the heater 35. More particularly, switch 37 is normally open and closes in response to a predetermined amount of heat from the heater 35. The thermal relationship between heater 35 and switch 37 is indicated by the close proximity of the heater and switch in the schematic diagram. The heater and switch are so interconnected that the circuit of the relay R is a simple three terminal network, having terminals 39, 40 and 41.

A start capacitor C_2 is connected from the ballast output lead 26 to the ballast output lead 31. 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 the electrodes 14 and 15 while the output leads 33 and 34 are connected across the electrode 16. Thus, assuming switch 37 is closed, a ballast circuit is completed from the output lead 26 through the serially connected lamps 11 and 12, the output lead 34, heater 35, switch 37 and the lead 38 to the distal end of primary winding 18. Electrode heater winding 27 is effectively connected across electrode 13

to provide heating power for that electrode. Electrode heating winding **28** is effectively connected across both of electrodes **15** and **16** 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.

Turning now to the operation of the ballast circuit, 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 switch **37** is initially open. Concurrently, normal low level voltages are induced in the auxiliary winding **27,** 28 and **29** and applied to the electrodes **13, 14, 15** and **16.** For the sake of simplicity the illustrative electrodes **13-16** 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 windings **27–29** would be connected to the electrode heaters rather than to the electrodes themselves.

The heating current flowing through electrode **10** 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 R 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 the secondary windings is applied across lamp **12** through the start capacitor C_2. After lamp **12** fires a starting voltage is applied across lamp **11** and lamp **11** fires. When lamp **11** fires the voltage across capacitir C_2 is reduced to a level which makes the current flow through capacitor C_2 inconsequential relative to the current flow through lamps **11** and **12.** So long as the lamps are operating, current flows through 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 to cool to 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 to the lamps will be delayed until the switch **37** has been heated sufficiently for the switch to reclose.

Additional details of the illustrative circuit of FIG. **4** and additional circuits suitable for use with the present invention may be had by reference to copending application Ser. No. 342,994, filed Mar. 20, 1973, and assigned to General Electric Company.

Since there is a very low voltage gradient between switch **37** and heater **35,** it is not necessary to provide a substantial degree of electrical isolation between them. This gives improved heat transfer between the heater and switch and makes possible the use of a low power heater.

The present invention takes advantage of these features, among others, to provide a new and improved ballast with an integral time delay relay. The switch and heater of the relay are interconnected in a three terminal network which simplifies the wiring of the ballast. A small, compact relay is incorporated within the ballast casing itself. The small size of the relay which is utilized enables the use of previously designed ballast components such as casings and transformers. This provides a cost savings as special components do not have to be provided for the ballasts, which include time delay relays. Such small, low voltage relays produce such small amounts of heat that they do not create a heat dissipation problem for the ballast. In one preferred embodiment the construction of the ballast and time delay relay are simplified by making the relay housing at least partially of an electrically conductive material and utilizing that portion of the housing as one of the terminals. With the low voltages involved, this can be done without creating substantial electrical insulation problems between the heater and switch.

Turning now to FIG. **3,** there is illustrated a time delay relay of the ambient compensating type suitable for use in the ballast of FIGS. **1–2.** The relay R includes a metallic housing **101** to which a stationary switch contact **103** is mounted. A movable switch contact **105** is mounted to the bridge portion **106** of a switch blade having three spaced, substantially parallel leg portions **107, 108** and **109.** The legs **107** and **109** are mounted along a plane to the bottom of a U-shaped mount **110,** while center leg **108** is mounted off the plane to an upper surface of the mount. A switch terminal **112** projects from the mount **110** through a dielectric laminated board **114** to which it is crimped and staked by ears **116.** Similarly, heater terminal **118** is crimped and staked to the board **114** by means of ears **119.**

A nichrome wire **120** is welded to terminal **118** beneath the board **114.** The wire **120** passes through a tube **122** of insulating material such as Kapton and exits the Kapton tube where leg **108** joins bridge **106.** The wire **120** is shaped into an elongated, multiturn coil within the tube. The wire is welded to the bridge as illustrated by weld **123.** The tube **122** is held snugly against the leg **108** by leg flanges **125,** which provide good heat conductivity between the coiled portion of the wire and the leg. At the same time the Kapton tube electrically insulates the coiled portion of the wire from the leg **108.** A stiffening rib **127** projects from the upper frame of the switch blade and terminates at the points at which the legs **107** and **109** engage mount **110.** This causes the hinge like attachment of the blade to be restricted to the area at which the legs **107** and **109** are attached to the mount **110.** A metallic stop **129** is staked to the board **114** above the bridge **106.** The board itself is secured to the shell by peripheral crimps **130** which firmly hold the board against a peripheral flange **130***a* formed in the housing **101.** An integral projection **131,** formed at one end of the housing **101,** serves as the third terminal for the switch.

In operation, the contacts **103** and **105** initially are disposed apart. When voltage is applied to the primary winding of transformer T a normal low voltage is placed across the terminals **112** and **118** by the previously described circuitry. This causes current to pass from terminal **112** through the switch-blade legs, the

nichrome wire **120** and the terminal **118.** The coil of nichrome wire within the Kapton tube **122** heats and the heat is conducted through the tube to the leg **108.** This causes its temperature to be elevated above that of legs **107** and **109.** The temperature differential between leg **108,** on the one hand and legs **107** and **109,** on the other hand, causes leg **108** to expand or lengthen relative to legs **107–109.** This causes the bridge **106** to move downwardly (as seen in FIG. **3**) toward stationary switch contact **103.** Downward movement of the bridge **106** brings movable contact **105** into an engagement with stationary contact **103.** This completes a circuit from terminal **112** through the switch-blade legs **107–109,** contact **105,** contact **103** and housing **101** to terminal **131.** Changes in the ambient temperature to which the time delay relay is subjected have little if any effect on the operation of a switch, as the ambient temperature effects all three of the legs **107, 108** and **109,** while the switch is operated as a result of a differential between the temperature of leg **108** and that of legs **107** and **109.** This relay is particularly suitable in the use of a ballast as shown in FIGS. **1** and **2** and the circuit shown in FIG. **4.** The appropriate connection of the relay R in the circuit of FIG. **4** is illustrated by the inclusion of the reference numerals **39, 40** and **41** in parentheses adjacent to the reference numerals **118, 112** and **131** in FIG. **3.** This double numbering illustrates which of the terminals of the relay R is connected in what position in the circuit in FIG. **4.**

Additional details of a relay illustrated in FIG. **3** may be had by reference to copending application Ser. No. 416,514 filed Nov. 16, 1973 assigned to General Electric Company, assignee of the present invention.

It will be apparent to those skilled in the art that while we have described what, at present, are considered to be the preferred embodiments of this invention, in accordance with the patent statutes, changes may be made in the illustrative embodiments without departing from true spirit and scope of this invention. For instance the relay R is shown positioned adjacent to capacitor C_1 in a direction transverse to the longitudinal axis of the ballast casing. If desired the transformer T could be moved to a more central location within the casing with the capacitors being placed on one side of the transformer, longitudinally of the casing, and the relay being placed on the other side of the transformer.

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

1. A ballast comprising:
- a casing at least partially filled with a potting material;
- a transformer received in said casing, said transformer including at least one auxiliary winding for providing low voltage electrical energy;
- at least one capacitor received in said casing;
- a time delay relay received in said casing; said time delay relay being connected to said at least one auxiliary winding for low voltage energization of said time delay relay when said transformer is energized;
- said time delay relay including a housing at least partially constructed of electrically conductive material, said relay housing being electrically insulated from other components of said ballast;
- said time delay relay being of the three terminal network type; and said relay housing forming one of the terminals of the three terminal network;
- said potting material substantially encapsulating said transformer, said at least one capacitor and said time delay relay.

2. A ballast comprising:
- a casing at least partially filled with a potting material;
- a transformer received in said casing;
- at least one capacitor received in said casing;
- and a time delay relay received in said casing; said time delay relay including a heater and a normally-open switch connected in a three terminal network; said heater being connected to said transformer for energization of said heater for effecting closing of said switch after a predetermined delay;
- said transformer, said at least one capacitor and said switch interconnected for starting and operating at least one gaseous discharge lamp;
- said potting material substantially encapsulating said transformer, said at least one capacitor and said time delay relay.

3. A ballast as set forth in claim **2** wherein: said time delay relay includes a housing at least partially constructed of electrically conductive material and said housing forms one of the terminals of the three terminal network.

4. A ballast for starting and operating at least one gaseous discharge lamp having spaced apart electrodes; said ballast comprising:
- an elongated casing at least partially filled with a potting material;
- a transformer received in said casing, said transformer including a primary winding and a secondary winding inductively coupled therewith;
- input circuit means for connecting said primary winding to a source of electric energy;
- output circuit means for connecting at least said secondary winding to the at least one gaseous discharge lamp;
- said transformer also including auxiliary windings inductively coupled to said primary winding for providing heating power for the electrodes;
- a time delay relay received in said casing; said time delay relay including a heater electrically connected to one of said auxiliary windings for energization therefrom;
- said time delay relay also including a switch connected in said output circuit means, said switch normally being open and moving to a closed condition upon a predetermined energization of said heater.

5. A ballast as set forth in claim **4** wherein: said switch and said heater are interconnected in a three terminal network.

6. A ballast as set forth in claim **5** wherein: said time delay relay includes a housing at least partially constructed of electrically conductive material, and forming one terminal of the three terminal network.

* * * * *