May 14, 1963 D. LOVINGER 3,089,979

BALLAST APPARATUS FOR STARTING AND OPERATING GASEOUS DISCHARGE LAMPS

Filed June 1, 1961 2 Sheets-Sheet 1

FIG. 1

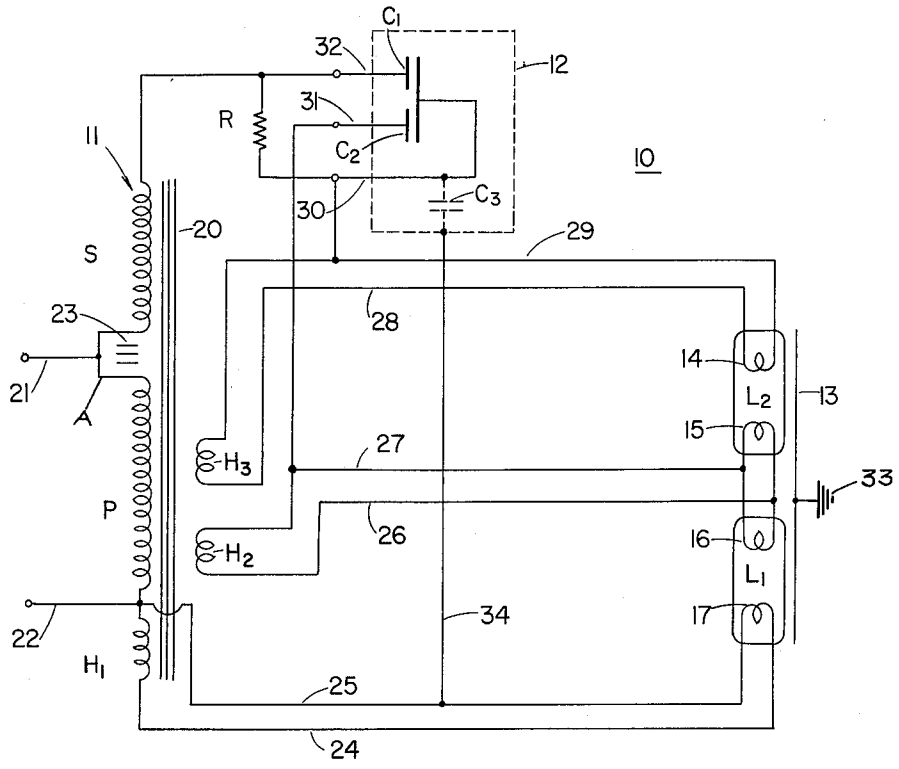
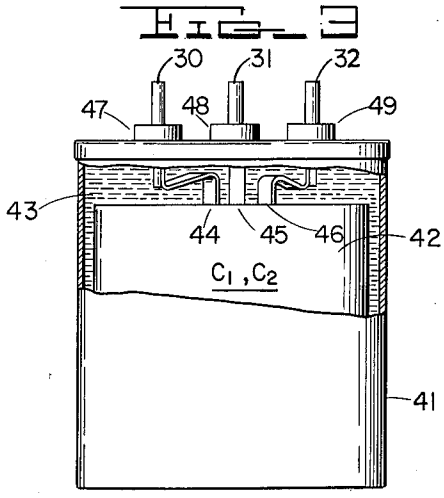


FIG. 3



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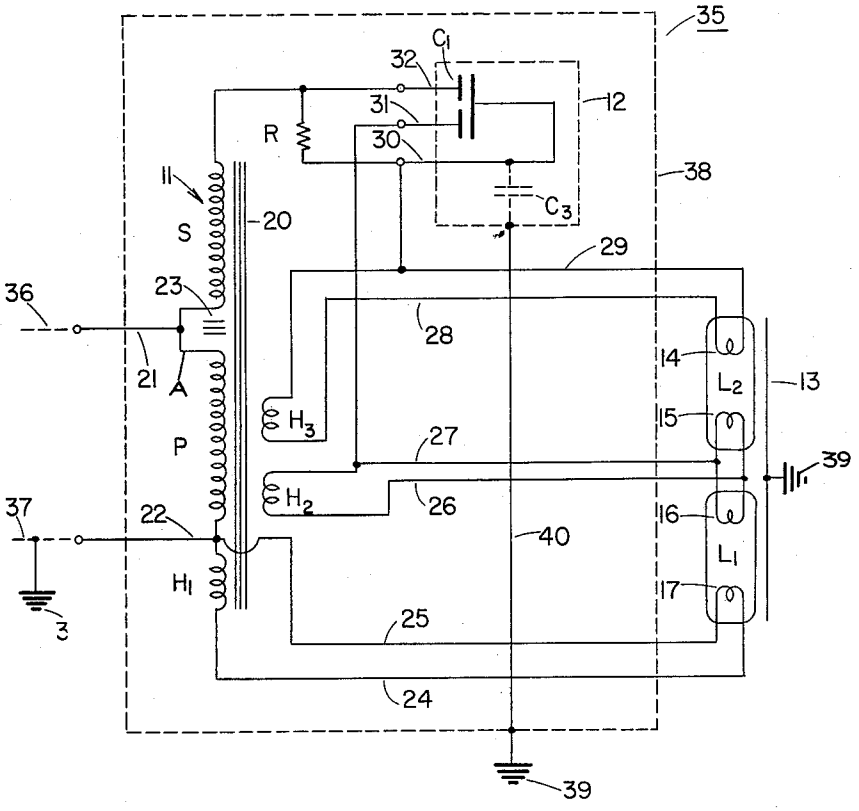
Filed June 1, 1961 2 Sheets-Sheet 2

FIG. 2



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BALLAST APPARATUS FOR STARTING AND OPERATING GASEOUS DISCHARGE LAMPS

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This invention relates to ballast apparatus for starting and operating gaseous discharge lamps. More particularly, it relates to improved ballast apparatus for starting and operating two or more gaseous discharge lamps wherein radio interference resulting from line feedback in the apparatus is effectively minimized.

In general, a ballast apparatus must not only provide the requisite starting and operating voltages, but must also provide a ballasting action to limit lamp current during the lamp arcing period because of the negative slope of the lamp resistance characteristic. Also, the ballast apparatus may include some means for minimizing line feedback which may cause radio interference. For example, in a ballast apparatus for operating two rapid start 40 watt lamps, a small condenser having a capacitance of approximately .01 microfarad may be connecting across the lamps or across the input leads to reduce line radiation and line feedback in the broadcast range.

Essentially, a gaseous discharge device, such as a fluorescent lamp, is an evacuated glass tube having a cathode or an electrode at each end. The inside of the glass tube contains mercury vapor and a small amount of argon or Krypton gas, and the inside wall of the tube is covered with a thin layer of fluorescent powder. When the electrodes are heated by passing current through them, electrons are emitted from the coating on the electrodes and the mercury vapor is ionized. When an alternating current voltage of sufficient magnitude is applied across the electrodes, a current will flow, each electrode acting as a cathode for one-half cycle. The current flow from one end of the tube to the other through the mercury vapor sets up radiations which excite the fluorescent coating on the glass tube. The action of the arc at the electrodes produces a continuous series of radio frequency waves which may cause radio interference by direct radiation from the electric supply lines to the aerial circuit of a radio and by line feedback from the lamp through the supply lines to the radio.

In order to minimize the effects of line radiation and feedback resulting from the action of the arc at the electrodes of a fluorescent lamp during operation, a separate radio interference condenser was generally employed in the past. The condenser was usually connected across the input leads of the ballast apparatus provided for connection across the power supply lines or was connected across the lamps. The use of a separate radio interference condenser adds to the cost of a ballast apparatus since the condenser must be connected in the ballast circuit thereby adding to the labor and material cost of a ballast. There is a need, therefore, for a ballast apparatus wherein the radio interference condenser can be eliminated and the ballast apparatus will still perform the function previously performed by the apparatus with the separate condenser in the circuit.

Accordingly, it is an object of my invention to provide a new and improved ballast apparatus for operating one or more gaseous discharge lamps wherein the need for a separate radio interference condenser is eliminated.

In one form of my invention I have provided a ballast apparatus for starting and operating at least one gaseous discharge lamp wherein the capacitance between an electrically conductive container and capacitor roll is placed in circuit across the lamp or lamps. It was found that this capacitance is effective in the circuit to minmize the feed-back of frequencies resulting from the arcing action of the lamp or lamps which may cause radio interference.

The subject matter which I regard as my invention is particularly pointed out and distinctly claimed in the concluding portion of this specification. My invention, however, both as to organization and mode of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic circuit diagram of a ballast apparatus incorporating the features of the present invention.

FIG. 2 is a schematic circuit diagram of another embodiment of the invention; and

FIG. 3 is a view partly in section of a three-terminal capacitor such as is conventionally employed in a ballast apparatus to provide the capacitance required for the starting circuit and for power factor correction.

Referring now more specifically to FIGS. 1 and 2, I have illustrated therein a ballast apparatus **10** and **35** for operating a pair of hot cathode type of fluorescent lamps identified as L_1 and L_2. Since the ballast apparatus or ballasts **10**, **35** are generally similar except for the connections to the capacitor container **12**, the same reference numerals and letters are used to identify the corresponding parts thereof. The ballast apparatus **10** and **35** include a high reactance transformer **11**, a series capacitor C_1 and a starting capacitor C_2, the capacitors C_1, C_2 having an electrically conductive container **12** represented schematically by the dashed rectangle. The lamps L_1 and L_2 are positioned in proximity to a grounded conductive plate **13** so that the cathodes **14**, **15**, **16**, **17** of the lamps L_1 and L_2 are capacitively coupled with the conductive plate **13**. In most applications, the lighting fixture in which the lamps L_1 and L_2 are mounted serve as the conductive plate **13**.

The high reactance transformer **11** includes a magnetic core **20**, a primary winding P, a secondary winding S, cathode heating windings H_1, H_2, H_3, and input terminal leads **21**, **22** which are provided for connection to a suitable alternating current supply, such as a 60 cycle, 110 volt commercial supply. Primary winding P and the secondary winding S are inductively coupled and disposed side by side on a winding leg of the magnetic core **20**. Magnetic shunts **23** are disposed between the primary winding P and the secondary S. As may be required in a given application, the leakage reactance of the transformer **11** may be readily varied by the inclusion of a high reluctance leakage path or shunts of magnetic material between the primary winding P and the secondary winding S. In the illustrated embodiment of the invention as shown in FIGS. 1 and 2, inserted shunts **23** of magnetic material were employed to provide a flux leakage path. It will be appreciated that a flux leakage path may be formed either through nonmagnetic material, such as air, or through magnetic material by the provision of projecting shunt legs integrally formed on the magnetic core **20** or by inserting shunts between the primary and secondary windings P, S.

Continuing with the description of the ballast apparatus **10**, it will be seen that the cathode heating windings H_1, H_2, H_3 continually supply the cathodes **14**, **15**, **16**, **17** of lamps L_1 and L_2 with a heating current. Cathode heating winding H_1 which is an extension of the primary winding P is connected in circuit with cathode **17** by lead **24** and output lead **25**. Cathode heating windings H_2, H_3 are connected in circuit with cathode **14**, **15**, **16** by leads **26**, **27**, **28** and output lead **29**. Cathode heating windings H_2, H_3 are tightly coupled with the primary winding P and may, if desired, be wound directly over the primary winding P. One end of the secondary winding

S is connected in circuit with the primary winding P by an autotransformer connection A. Input terminal lead 21 is connected to the autotransformer connection A. The other end of the secondary winding S is connected with the series capacitor C_1. Thus, one end of the secondary winding S is connected with the serially connected lamps L_1, L_2 by circuit means which includes the series capacitor C_1 and output lead 29.

The starting capacitor C_2 and the series capacitor C_1 are preferably contained within the same electrically conductive container 12. Although a three terminal type of capacitor having terminals 30, 31, 32 was employed in the exemplification of the invention, it will be appreciated that invention may be practiced in a ballast apparatus employing a two-terminal type of capacitor.

As shown in FIG. 1, the capacitor container 12 is connected in electrical circuit with output lead 25. The ballast apparatus 10 shown in FIG. 1 is particularly adapted for use with an alternating current supply system, such as a domestic supply, which normally is not effectively grounded. It will be noted that the input terminal leads 21, 22 are not shown as being adapted for connection to either the grounded or ungrounded side of the power supply.

In FIG. 2 it will be seen that input terminal lead 21 is shown as being provided for connection to the ungrounded side of the alternating current supply which is schematically shown by the dashed line 36. Input terminal lead 22 is shown as being adapted for connection to the grounded side of the power supply shown schematically by the dashed line 37 connected to ground 39. The ballast apparatus 35 is particularly adaptable for use in connection with power supplies, such as are available in industrial and commercial type of buildings.

In order to connect the capacitance of capacitor C_3 in circuit across the lamps L_1, L_2, the conductive container 12 was connected to the ballast case 38. The ballast case 38 is adapted to be connected to a lamp fixture which is normally grounded. Thus, in FIG. 2 the ballast case 38 is schematically shown as being connected to ground 39. In this embodiment of the invention, the connections placing the capacitance of capacitor C_3 across the lamps L_1, L_2 are as follows: Output lead 29, terminal 30, capacitor C_3, lead 40, the ground 39, input terminal lead 22 and output lead 25.

As shown in FIGS. 1 and 2, the capacitor container 12 is represented schematically by a dashed rectangle and the capacitance between the capacitor container, and the capacitor roll is represented schematically by a capactor C_3 and connections shown in dashed outline. The capacitors which can be employed in the ballast apparatus of the invention are conventional static capacitors having liquid or solid dielectric material and include a capacitor roll with interleaved sheets of paper and metallic foil sealed in a metallic or conductive container. Since the metallic or conductive container is separated from the outer metallic foil by the dielectric contained within the container, a capacitance exists between the container and the outer metallic foil of the capacitor roll. The amount of this capacitance is a function of the area of the two surfaces, the spacing between the surfaces and the properties of the dielectric material. By connecting the metallic container in circuit in a ballast apparatus, it was found that this capacitance can be effectively employed in the circuit to minimize line feedback of frequencies produced by the arcing action of the lamp electrodes that may cause radio interference.

Referring now to FIG. 3, I have illustrated therein a conventional capacitor assembly of the three-terminal type which is commonly used in fluorescent lamp ballasts. The capacitor assembly 41 is comprised of a container 12, usually fabricated of a conductive material such as steel, a capacitor roll 42, tap straps 44, 45, 46, and the terminals 30, 31, 33. A dielectric liquid 43, such as chlorinated diphenyl, fills the capacitor container 12. The capacitor roll 42 is of convolutely wound roll construction and is formed of a pair of metal electrode foils, such as aluminum, and interleaved insulating material, such as kraft paper, all interwound into the compact capacitor roll 42. The container 12 is hermetically sealed by a cover 50 which is provided with insulating bushings 47, 48, 49. The tap straps 44, 45, 46 are electrically connected to the wound electrode foils which comprise the capacitors C_1, C_2. Because of the spacing between the outer foil of the capacitor roll 42 and the capacitor container 12, a capacitance exists between the two metallic surfaces.

The operation of the ballast apparatus 10, 35 shown in FIGS. 1 and 2 is substantially the same and will now be more fully described.

When the high reactance transformer 11 is energized by connecting the input terminal leads 21, 22 in circuit with a suitable alternating current supply, a voltage will be induced in the secondary winding S as determined by the respective turns ratio of the primary winding P and the secondary winding S. Since ballast apparatus 35 shown in FIG. 2 is adapted for use in conjunction with a grounded power supply, the input terminal lead 22 would be the white lead or the lead provided for connection to the grounded side of the power supply. Input lead 21 would be the black lead or the lead provided for connection to the ungrounded side of the power supply 36.

When the input terminal leads 21, 22 are connected across the power supply, a voltage is immediately induced in cathode heating windings H_1, H_2, H_3, and a cathode heating current is supplied to cathodes 14, 15, 16, 17 of lamps L_1, L_2. Further, the open circuit voltage developed across the primary winding P and secondary winding S is applied across lamp L_1 because of the shunting action of the starting capacitor C_2. Also, during the open circuit condition, the combined voltages across the primary winding P and the secondary winding S are applied to cathode 16 of lamp L_1 which is in a capacitive relation with the conductive plate 13 and a small current flows thereacross to aid in starting.

After the lamp L_1 has ignited, lamp L_1 is ionized and conducts current, and therefore a current is caused to flow through the starting capacitor C_2. Since lamp L_2 is also disposed in close proximity to the conductive plate 13, a starting aid potential is applied to cathode 14 by the auxiliary starting aid circuit which includes the grounded conductive plate 13. The gas in the vicinity of the cathode 14 ionizes, and the open circuit voltage across cathodes 14, 15 causes a breakdown of the gas contained within the lamp thereby igniting lamp L_2. The starting capacitor C_2 has sufficient impedance so that no appreciable operating current will flow through it when both lamps L_1 and L_2 have ignited. After both lamps L_1 and L_2 are ignited, only a negligible amount of current will flow from the lamp cathodes to the conductive plate 13 because of the impedance of the capacitive coupling between lamps L_1, L_2 and the conductive plate 13. Further, in accordance with the invention, the capacitance between the outer foil and the capacitor container 12 is now effective in the operating circuit to minimize line feedback of the frequencies produced by the arcing action of lamps L_1, L_2 that may cause radio interference.

It will be apparent that in ballasts when a starting capacitor C_2 is employed the capacitance provided by the starting capacitor C_2 may be utilized to suppress frequencies resulting from the arcing action of lamp L_2 that may cause radio interference. Thus, the capacitance between the capacitor roll and capacitor container 12 may be utilized to suppress the frequencies produced by the arcing action of lamp L_1.

It will be understood that while I have illustrated my invention by specific embodiments thereof, the invention has general applicability to ballast apparatus wherein it

is required that some provision be made to minimize line feedback resulting from the arcing action of the electrodes of arc discharge lamps. The invention may be employed in ballast circuits that are used to operate both rapid start and instant start type of fluorescent lamps. It will be understood that many modifications may be made by those skilled in the art without actually departing from the invention. It is therefore intended in the appended claims to cover all such changes and modifications that fall within the true spirit and scope of the invention.

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

1. A ballast apparatus for starting and operating at least one gaseous discharge lamp from a source of alternating current, said apparatus comprising a transformer having a primary winding and a secondary winding inductively coupled therewith on a magnetic core, a pair of input terminal leads connected across said primary winding, a capacitor connected in series circuit relation with said secondary winding, said capacitor including a capacitor roll disposed in capacitive relation with a conductive container to provide a predetermined capacitance, circuit means including a pair of output leads for applying the output of said transformer across said lamp and for connecting said capacitor container in circuit with said lamp whereby said predetermined capacitance is connected in circuit across said lamp to minimize radio interference resulting from the arcing action of the lamp.

2. A ballast apparatus for starting and operating at least one gaseous discharge lamp disposed in a capacitive relation with a conductive fixture, said apparatus comprising a transformer having a primary winding and a secondary winding inductively coupled therewith on a magnetic core, a pair of input terminal leads connected across said primary winding, a series capacitor connected in series circuit relation with said secondary winding to cause a leading current to flow therethrough, a conductive ballast case housing said apparatus, said series capacitor including a capacitor roll disposed in capacitive relation with a conductive container for housing at least said capacitor and providing a predetermined capacitance, and circuit means including a pair of electrical output leads for applying the output of said transformer across said lamp and for connecting said container in electrical circuit across said lamp to minimize line feedback of radio frequency waves resulting from the arcing action of said lamp.

3. A ballast apparatus for starting and operating from a grounded alternating current supply at least one gaseous discharge lamp, said apparatus comprising a first and a second input terminal lead for connection with the alternating current supply, a ballast means, at least one capacitor, said capacitor having a capacitor roll and a conductive container disposed in capacitive relation with said roll to provide a capacitance therebetween, said first input terminal lead being provided for connection to the grounded side of the power supply and said second input terminal lead being provided for connection to the ungrounded side of the power supply, circuit means including a pair of output leads to apply the output of said apparatus across said lamps, one of said output leads being connected in circuit with said first input lead, circuit means including electrical leads connecting the conductive container in circuit across said lamp so that the capacitance between the conductive container and the capacitor roll is effective to minimize radio interference caused by the arcing action of the gaseous discharge lamp.

4. A ballast apparatus for starting and operating at least a pair of gaseous discharge lamps from an alternating current supply comprising a transformer having a magnetic core, a primary winding and a secondary winding inductively coupled therewith, an autotransformer connection between the one end of said primary winding and one end of said secondary winding, a first input terminal lead provided for connection to the grounded side of the alternating current supply, a second input terminal lead provided for connection to the ungrounded side of the alternating current supply, said second input terminal lead being connected in circuit with the end of the primary winding connected to said autotransformer connection and said first input lead being connected to the other end of said primary winding, a capacitor connected in series circuit relation with said secondary winding, said capacitor including a capacitor roll disposed in capacitive relation with a conductive container to provide a capacitance therebetween, circuit means including electrical leads for applying the output of the transformer across said pair of lamps and for connecting said capacitance developed between said conductive container and said capacitor roll in circuit across said pair of lamps to provide the sole means for minimizing the feedback of frequencies caused by the arcing action of said lamps during operation that may cause radio interference.

5. A ballast apparatus for starting and operating a pair of fluorescent lamps from a grounded alternating current supply comprising a transformer having a magnetic core, a primary winding and a secondary winding inductively coupled therewith, a first input terminal lead provided for connection to the grounded side of the alternating current supply, a second input terminal lead provided for connection to the ungrounded side of the power supply, a capacitor connected in series circuit relation with said secondary winding, said capacitor including a capacitor roll disposed in an electrically conductive container filled with dielectric material so that a capacitance is provided between the capacitor roll and the conductive container, circuit means including at least a pair of output leads for applying the output of the transformer across said pair of lamps, said first input lead being connected in circuit with one end of the primary winding and with one of said output leads, said second input terminal lead being connected in circuit with the other end of said primary winding, circuit means including electrical leads for connecting the conductive container in circuit with ground so that the capacitance between the conductive container and the capacitor roll is connected in circuit across said lamps and is solely effective to minimize radio interference caused by the arcing action of the lamps.

6. A ballast apparatus for starting and operating at least a pair of gaseous discharge lamps from a grounded alternating current supply, said ballast apparatus comprising a transformer having a magnetic core, a primary winding and a secondary winding inductively coupled therewith, an autotransformer connection between one end of said primary winding and one end of said secondary winding, a first input terminal lead provided for connection to the grounded side of said alternating current supply, a second input terminal lead provided for connection to the ungrounded side of the alternating current supply, a series capacitor connected in series circuit with said secondary winding, a starting capacitor, said series capacitor and said starting capacitor having a common capacitor roll disposed in capacitive relation with an electrically conductive container filled with dielectric material to provide a capacitance therebetween, and circuit means including electrical leads for applying the output of said transformer across said pair of lamps and for connecting said starting capacitor across one of said lamps, said circuit means including a lead connected with said conductive case for making a grounded connection to place the capacitance developed between said capacitor roll and said conductive container across said lamps, said second input terminal lead being connected to the end of the primary winding connected in circuit with said autotransformer connection and said first input terminal lead being connected to the other end of the primary winding, said capacitance being the sole means provided

in said apparatus to minimize radio interference caused by the arcing action of said lamps.

7. A ballast apparatus for starting and operating from a grounded alternating current supply a pair of gaseous discharge lamps, said apparatus comprising a first input terminal lead provided for connection to the grounded side of the alternating current supply, a second input terminal lead provided for connection to the ungrounded side of the alternating current supply, a ballast means, a capacitor connected in series with said ballast means, a starting capacitor, said capacitors having a common capacitor roll and an electrically conductive container disposed in capacitive relation with said roll to provide a capacitance therebetween, circuit means including a pair of output leads for connection with said pair of lamps and for connecting the starting capacitor in shunt across one of said lamps, said circuit means connecting said first input terminal lead in circuit with one of said output leads and connecting said second input terminal lead in circuit with said ballast means and with the other of said output leads so that a current limiting impedance is provided for said pair of lamps during operation, said circuit means including a connection to said conductive container connecting said container in circuit so that the capacitance between said capacitor roll and said conductive container is applied across at least one of said lamps and is effective to minimize radio interference caused by the arcing action of said lamp.

8. A ballast apparatus for starting and operating at least a pair of gaseous discharge lamps from a grounded alternating current supply, said ballast apparatus comprising a first input terminal lead for connection to the grounded side of the alternating current supply, a second input terminal lead for connection to the ungrounded side of the alternating current supply, a ballast means, a capacitor, said capacitor having a capacitor roll and an electrically conductive container disposed in capacitive relation with said roll to provide a capacitance therebetween, an electrically conductive ballast case for housing the apparatus and arranged for connection to ground, circuit means including electrical leads and a pair of output leads for connection with said lamps, said circuit means connecting said first input terminal lead with one end of said primary winding and one of said output leads, and connecting said second input terminal lead in circuit with said ballast means and said capacitor in order to ballast said lamps and supply a leading current thereto, and circuit means connecting said conductive container in circuit with said conductive ballast case so that the capacitance developed between said capacitor roll and conductive container is applied across at least one of the lamps thereby minimizing radio interference caused by the arcing action of said lamp during operation and being solely effective to minimize radio interference produced by said lamp.

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