INTEGRATED FLUORESCENT LAMP UNIT

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Filed: May 3, 1971
Appl. No.: 139,551

U.S. Cl. .......... 315/60, 313/109 R, 313/201, 315/335
Int. Cl. ...................... H01J 17/30
Field of Search .............. 315/60, 61, 47, 72, 315/335; 313/109, 201, 305

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ABSTRACT
A fluorescent lamp unit having integral starting and ballasting circuitry. Attached to one end of the lamp is a screw-in base containing a solid state starting circuit module. Ballasting is provided by a resistance wire series connected between the starting circuit and the cathode electrode of the lamp and spiralled about the lamp tube in a manner providing a thermal gradient. A strip of clear plastic insulating material is helically wrapped about the wire wound lamp, and cathode preheating can be provided through a strip of conductive tape connected between the starting circuit and one terminal of the cathode and helically wrapped about the lamp within overlaps of the strip of plastic insulating material.

7 Claims, 3 Drawing Figures
INTEGRATED FLUORESCENT LAMP UNIT

BACKGROUND OF THE INVENTION

This invention relates generally to fluorescent lamps and particularly to the packaging of a fluorescent lamp and its operating circuitry in an integral unit.

Heretofore, a fluorescent lamp and its starter circuit and ballast have been discrete circuit components requiring auxiliary hook-up wire and suitable component wiring, usually incorporated into a metal fixture. Such a lighting package has found universal acceptance in applications where economy of space is not critical and where high illumination levels warrant reflectorized fixtures. In instances where space is at a premium or where modular simplicity is desired, such as in appliance lighting, the discrete component system loses its appeal. The present invention is designed to fill this gap by combining the lamp, starter, and ballast into a single modular package compatible with existing screw-type incandescent sockets.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide an improved fluorescent lamp unit.

It is another object of the invention to provide a fluorescent lamp with integral starting and ballasting circuitry.

A further object is to provide an integrated fluorescent lamp unit adapted for improved DC operation.

Yet another object of the invention is to provide an integrated fluorescent lamp unit compatible with screw-type incandescent sockets.

Briefly, these objects are attained in a fluorescent lamp unit comprising: a glass tube having electrodes disposed at each end; mercury vapor contained within the tube; a lamp base attached to one end of the tube; and a starting circuit for the lamp disposed within the lamp base and electrically connected between the base and lamp electrodes.

In a preferred embodiment, the lamp base has external threads for screw-in connection and contains a solid state starting circuit including a capacitive voltage multiplier. Series ballasting is provided by a resistance wire connected between the starting circuit and one of the electrodes, the wire being externally wound about the glass tube in a manner providing a thermal gradient therealong. A protective insulating cover is provided by wrapping the wire wound glass tube with a strip of clear plastic material. Preheating of the cathode end of the lamp is provided through a conductive tape spirally wrapped about the glass tube and sandwiched between overlapping layers of the plastic insulating cover.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a simplified, exploded elevation of one embodiment of an integrated fluorescent lamp unit according to the invention;

FIG. 2 shows the form of a plastic sheet with conductive tape attached suitable for use as the outer wrap of the lamp unit of FIG. 1; and

FIG. 3 is a schematic diagram of a starting circuit suitable for use in the lamp unit of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to FIG. 1, a DC fluorescent lamp according to one embodiment of the invention is illustrated by means of a simplified exploded view. The lamp has a sealed hollow glass tube 2 containing a suitable rare gas filling, such as for example 100 percent argon. In addition, a charge of mercury is introduced into the tube, prior to sealing, to yield the necessary mercury vapor for operation of the lamp. On the inside surface of the glass tube there is a coating of phosphor which may be, for example, any suitable fluorescent lamp phosphor.

At one end of the glass tube 2 there is a conventional probe-type anode electrode 4 having a support and lead-in wire 6. Disposed at the other end of the tube is a conventional filament-type cathode electrode 8, such as an oxide-coated tungsten coil, having support and lead-in wires 10 and 12 for its respective end terminals. Although not shown in the simplified drawing of FIG. 1, the anode support wire 6 and the cathode support wires 10 and 12 are sealed in steam presses at the ends of the glass tube 2 in the conventional manner.

Attached to the anode end of the tube 2 is a lamp base 14 having a cylindrical dielectric housing 16, an externally threaded shell 18 secured to and projecting from housing 16, and a center contact 20 separated by a body of insulating material 22 from the shell 18. Housing 16 is cemented to the end of the glass tube 2, and the threaded shell 18 and center contact 22 provide a screw-in base compatible with conventional screw-type incandescent lamp sockets.

Enclosed within the dielectric housing 16 is a potted starting circuit 24 having a pair of AC lead-in wires 26 and 28, and three output terminals 30, 32 and 34. A specific starting circuit suitable for this integrated modular package will be described hereinafter. One of the AC input connections, say lead-in wire 26 is soldered to center contact 20, while the other lead-in wire 28 is soldered to the threaded shell 18.

Output terminal 30 of the starting circuit is electrically connected to the anode electrode of the lamp via lead-in wire 36, which is soldered to the anode support wire 6 at joint 38. A resistance wire 40 is electrically connected to starting circuit terminal 32, for example, by a mechanical crimp joint. Wire 40 is run straight down the outside of tube 2 toward the cathode end; then, commencing at a predetermined distance from the anode end of the lamp, the resistance wire 40 is wound about the glass tube proceeding at a fixed winding rate toward the cathode end of the lamp. At the termination of the winding, wire 40 is electrically connected to one terminal of the cathode coil electrode by means of a mechanical crimp joint 42 attached to the cathode lead-in wire 10.

With resistance wire 40 wound and connected as illustrated, an integral series ballast is provided between cathode electrode 8 and starting circuit terminal 32. In addition, however, ignition of the lamp is operative to energize the wire for providing an external source of heat. In particular, the winding provides localized heating of the lamp toward the cathode end. This produces a temperature gradient along the length of tube 2, which in turn shifts the bounds of the mercury pressure gradient in the lamp to a higher level. As described in copending application Ser. No. 139,552, now U.S. Pat. No. 3,714,492, assigned to the assignee of the present application, this shifting of the mercury pressure grad-
ent avoids the anode mercury starvation which typically accompanies the inherent mercury migration in DC lamps and thereby significantly enhances lamp efficiency.

For example, consider a 36 inch long 1.5 inch diameter fluorescent tube of standard construction. A suitable thermal gradient and ballast may be provided by spiraling about this lamp a resistance wire of 7 mils diameter and having a resistance of 8.75 ohms per linear foot. A wire length of 14.3 feet can be used to provide a desired ballast resistance of 125 ohms. The wire is wound about the lamp commencing at a point approximately two-fifths of the length of the tube from the anode end and proceeding at a fixed winding rate of 1.7 turns per inch toward the cathode and of the lamp.

The integral lamp and ballast winding are then covered by a clear plastic insulating material 44. For example, a sheet of heat shrinkable, Mylar polyester film (polyethylene terephthalate resin, Mylar is a trademark of E.I. du Pont de Nemours and Co.) about 4 mils in thickness may be employed. The Mylar film can be purchased in bulk and cut to the desired width or it can be purchased precut. According to a preferred embodiment of the invention as applied to the above mentioned 36 inch lamp tube, a Mylar sheet 6 inches wide and 4 feet long is cut in the form of a parallelogram as shown in FIG. 2. Attached to one side of the Mylar sheet 44 is a metallic conductive tape 46 of approximately ¼ inch in width. The tape is fixed to the plastic sheet, for example by adhesive, to be located approximately ¼ inch from the edge, and it runs the length of the sheet with a one inch overhang at each end.

The Mylar sheet 44 is wrapped about the wire wound lamp tube in such a fashion that the conducting surface of the tape is sandwiched in the overlap of the Mylar sheet and, therefore, is insulated from the ballast wire beneath and the outer surface above. The wrap is secured to the lamp at both ends by a strip of transparent fiber tape (not shown) after which a hot air blower is passed along the lamp while turning to heat shrink the Mylar film. One end of the conductive tape 46 is then electrically connected to the outer terminal of the cathode electrode by means of a mechanical crimp 48 to cathode lead-in wire 12. The other end of the conductive tape is mechanically crimped to the starting circuit output terminal 34. In this manner, as will be described in more detail hereinafter, the conductive tape 46 completes a cathode preheating circuit for the lamp.

To complete the lamp unit, a protective plastic cap 50 is cemented in place over the cathode end of the lamp tube to provide an insulating cover over the cathode connections.

A suitable starting circuit for use as module 24 in the integral lamp unit is shown in FIG. 3. Terminals 26 and 28 are the previously described AC input terminals respectively connected to portions 20 and 18 of the lamp base 14. Upon being energized, the AC input is applied to a full wave bridge rectifier comprising diodes 52, 54, 56 and 58 to provide a DC voltage across nodes 60 and 62. For ignition purposes, an automatic starter switch 64, such as a neon glow bottle, is connected between node 62 and output terminal 34. A cathode preheat circuit is thus provided from node 62 via starter switch 64, output terminal 34, conductive tape 46, support wire 12, cathode coil 8, support wire 10, resistance wire 40, and terminal 32 to node 60. Hence, when the lamp is energized, a voltage appears across the normally open starter switch contacts to actuate closing thereof. A capacitor 66 connected between nodes 60 and 62 serves to accelerate the closing action of the starter switch before lamp ignition by raising the average voltage across the starter to the peak level of the AC input while the starter is closing. When the starter switch 64 closes, current flows from node 62 thru the starter to output terminal 34 where it is applied to one end of the metallic conductive tape 46. The current proceeds along the tape through the cathode electrode and returns through the resistance wire to output terminal 32 and back to node 60. The circulating coil current heats the cathode electrode to an emissive level conducive to proper lamp ignition.

When the starter switch automatically opens again, a momentary high voltage builds up across the lamp. This voltage build up is provided by a capacitance voltage multiplier comprising a pair of electrolytic capacitors 70 and 76, which are arranged to have a unidirectional charge path by virtue of the blocking diodes 72 and 74. The multiplier provides an ignition voltage across capacitor 70 which is approximately twice the peak voltage of the AC input. This voltage build up results from the successive transfer of charge from capacitor 68 to capacitor 70 on alternate half cycles of the AC supply voltage. On the alternate half cycle of the AC supply, charge is replenished on capacitor 68 to maintain the pumping action of the charge transfer from capacitor 68 to capacitor 70. The resulting ignition voltage across the starting circuit output terminals 30 and 32 consists of the voltage build up across capacitor 70, modulated by the peak-to-peak AC voltage applied to input terminals 26 and 28. For example, considering a typical AC input of 120 volts at 60 Hz, the voltage across capacitor 70 will build up to a 340 potential which adds algebraically with the 170 peak-to-peak AC voltage across terminals 26 and 28 to yield an output voltage across terminals 30 and 32 which has a peak value of 510 volts, an average value of 340 volts, and a low value of 170 volts.

After lamp ignition, the starter circuitry, consisting of switch 64 and capacitors 66, 68 and 70, is essentially dormant and the operating circuit reduces to essentially that of a full wave bridge comprising diodes 52, 54, 56 and 58, the output of which is coupled across terminals 30 and 32 via diodes 72 and 74. As previously described, the remainder of the lamp operating circuit loop includes the lamp discharge tube 2 with its anode electrode 4 connected to terminal 30 and its cathode electrode 8 connected through the series ballast resistance 40 to terminal 32.

As described the starting circuit comprises capacitive elements and a neon glow bottle starter switch in combination with solid state semiconductor components, it is particularly well suited to the desired compact package configuration. For example, the circuit elements may be wired together as discrete components and the overall arrangement rigidized and insulated in a potting compound. Alternatively, the circuit components may be mounted on a small printed circuit board which is subsequently protected by a potting compound. Ideally, an integrated circuit could be employed in the lamp base.

It is to be understood, however, that alternative circuit and packaging configurations are contemplated. For example, an instant start circuit may be employed which eliminates the need for a starter switch and the
metallic tape 46, since a preheat circuit is not required. The instant start circuit design can be somewhat similar to FIG. 3 with the following changes: delete switch 64, output terminal 34, and capacitor 66; connect node 62 directly to the junction of capacitor 68 and diode 74 without the use of a diode 72; delete the connection between node 60 and output terminal 32; connect an appropriately oriented capacitor across diode 52; and connect an appropriately oriented diode and capacitor series combination across diode 56; output terminal 32 could then be taken from the junction of the capacitor and diode connected across diode 56. In like manner, a solid state, capacitive multiplier type rapid start circuit could also be employed.

It is also clear that a lamp base other than the screw-type may be employed. Although illustrated as applied to a DC lamp, the integral packaging concept may also be applied to an AC operated lamp by deleting the rectifier and multiplier circuitry and applying the AC line voltage directly to the lamp-resistive ballast combination, and using dual purpose electrodes at each end of the lamp. Of course AC applications would be limited to relatively short length lamps since the AC lamp must start from the available 120 volt, 60 Hz line supply. Also, other methods of providing a protective insulating cover may be employed other than the described plastic wrapping and end cap.

What I claim is:

1. A fluorescent lamp unit comprising, a glass tube, a phosphor coating on the inside surface of said glass tube, a first electrode disposed at one end of said tube, a second electrode disposed at the other end of said tube, mercury vapor contained within said tube, a lamp base attached to the end of said tube at which said first electrode is disposed, said lamp base being the only power input means for said lamp unit, a starting circuit for said lamp disposed within said lamp base and electrically connected between portions of said base and said first and second electrodes, and an insulating cap attached to the end of said tube at which said second electrode is disposed.

2. A lamp unit according to claim 1 further including a resistance wire externally wound about said glass tube and electrically connected between said starting circuit and said second electrode to provide series ballasting for said lamp.

3. A lamp unit according to claim 2 further including insulating means covering said wire winding on said glass tube.

4. A lamp unit according to claim 3 wherein said second electrode is a cathode coil having first and second terminals, said resistance wire is connected between said starting circuit and the first terminal of said cathode coil, and said insulating means covering the wire wound tube comprises a strip of clear plastic material helically wrapped in an overlapping manner about said wire wound tube, and further including a starter switch disposed within said lamp base, and a strip of metallic conductive tape helically wrapped about said tube, said starter switch and said strip of conductive tape being serially connected in that order between said starting circuit and the second terminal of said cathode coil, whereby a preheating circuit is provided for said lamp unit, and said strip of conductive tape being substantially narrower than said strip of plastic material and sandwiched between overlapping portions of the helical wrapping of said strip of clear plastic material.

5. A lamp unit according to claim 3 wherein said first and second electrodes are the anode and cathode electrodes, respectively, of said lamp unit, and said resistance wire is wound about said glass tube in a manner providing a temperature gradient along the length of said tube with the higher temperature toward the cathode end of said tube when said wire is energized.

6. A fluorescent lamp unit comprising, a glass tube, a phosphor coating on the inside surface of said glass tube, a first electrode disposed at one end of said tube, a second electrode disposed at the other end of said tube, mercury vapor contained within said tube, a lamp base attached to one end of said tube, a starting circuit for said lamp disposed within said lamp base and electrically connected between portions of said base and said first and second electrodes, and a resistance wire externally wound about said glass tube and electrically connected between said starting circuit and one of said electrodes to provide series ballasting for said lamp.

7. A fluorescent lamp unit comprising, a glass tube, a phosphor coating on the inside surface of said glass tube, a first electrode disposed at one end of said tube, a second electrode disposed at the other end of said tube, mercury vapor contained within said tube, a screw-in type lamp base having external threads attached to one end of said tube, and a starting circuit for said lamp disposed within said lamp base and electrically connected between portions of said base and said first and second electrodes.