

Jan. 26, 1965

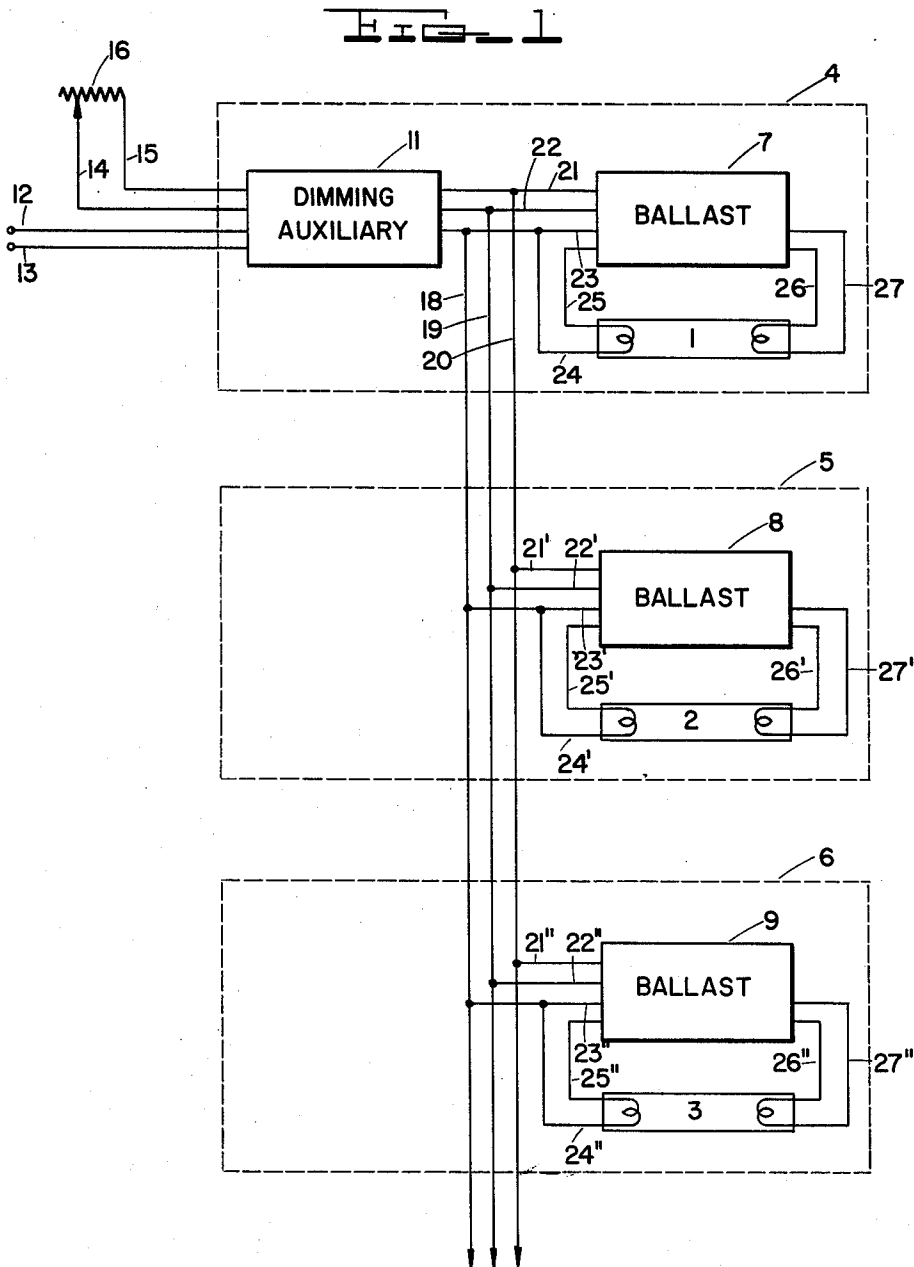
T. R. HARPLEY

3,167,683

DIMMING SYSTEM AND APPARATUS FOR FLUORESCENT LAMPS

Filed June 5, 1962

3 Sheets-Sheet 1



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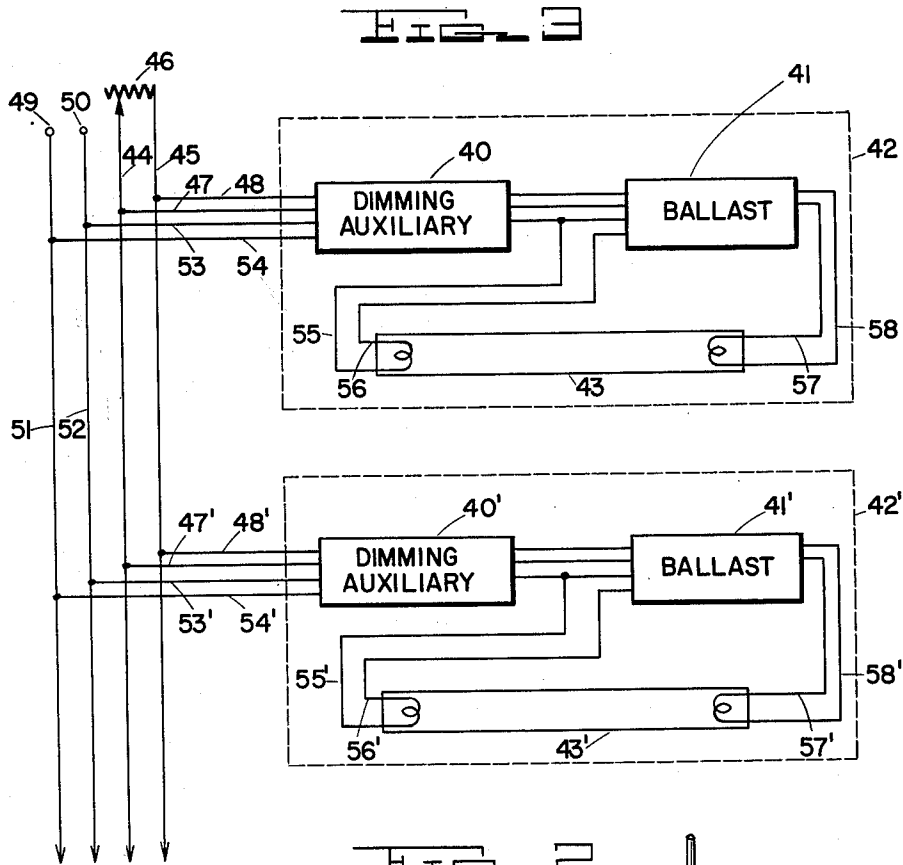
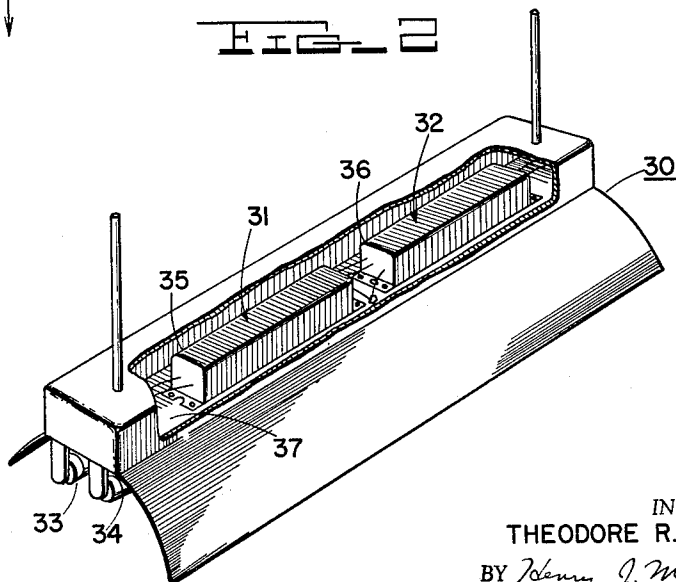
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DIMMING SYSTEM AND APPARATUS FOR FLUORESCENT LAMPS

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3 Sheets-Sheet 2



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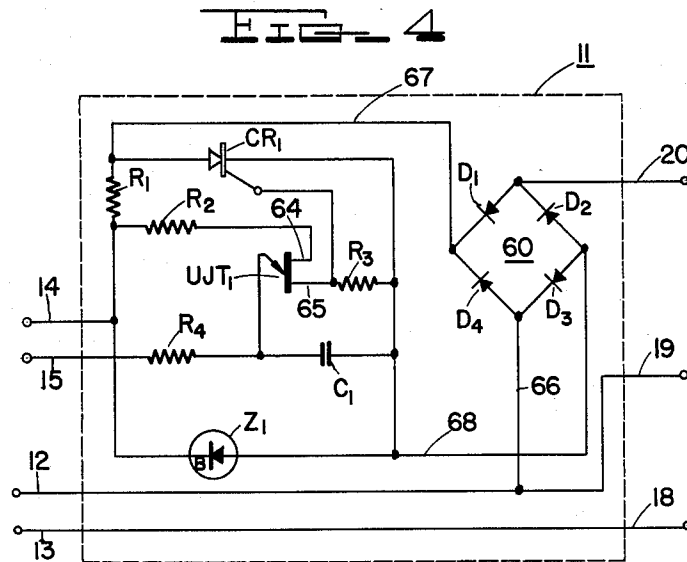
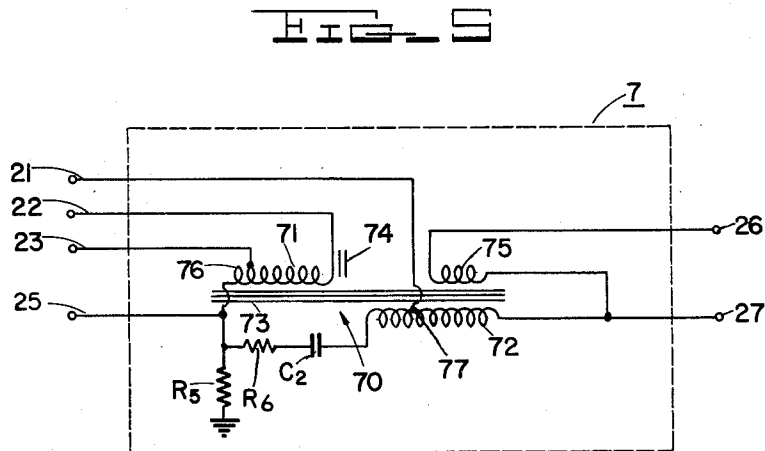
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DIMMING SYSTEM AND APPARATUS FOR FLUORESCENT LAMPS

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3 Sheets-Sheet 3



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3,167,683

DIMMING SYSTEM AND APPARATUS FOR FLUORESCENT LAMPS

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Filed June 5, 1962, Ser. No. 200,176
1 Claim. (Cl. 313-198)

This invention relates to dimming systems and apparatus for fluorescent lamps. In particular, it relates to an improved dimming system and apparatus for operating a plurality of fluorescent lamps employing a dimming auxiliary disposed in the lighting fixture.

It is a common practice in fluorescent lamp dimming systems to mount the case containing the ballast transformer and its associated components in the fixture. At least one additional lead capable of carrying the load current is brought out externally from each of the ballasts for connection in circuit with a control unit. In dimming applications where phase control circuits utilizing thyristors or solid state switching elements are employed, control units have been usually placed at locations remote from the lamps.

When installed at a remote location the control unit must be connected in circuit with the ballasts located on the lamp fixture and leads capable of handling maximum lamp current must be connected between the control unit and the ballasts in the lamp fixtures. Since the control unit contains heat generating elements, provision must be made for the removal of heat from the unit. Also, the control unit must be placed in a location where it will not present an electrical hazard to personnel. Further, since the unit may generate noise, it is required that it be located where noise is not objectionable. These restrictions on where the control unit can be located have complicated installation problems.

Accordingly, an object of the invention is to provide an improved dimming apparatus for operating a plurality of fluorescent lamps.

A more specific object of my invention is to provide an improved dimming system and apparatus which eliminates the need for leads carrying lamp current to be brought out from the lamp fixture to an externally located control unit.

It is still another object of the invention to provide an improved dimming system and apparatus wherein installation requirements are simplified.

These and other objects and advantages are achieved in one form of my invention wherein a dimming auxiliary is disposed in a housing means on a lamp fixture and controls the illumination level of the fluorescent lamp or lamps in the aforementioned fixture and also controls the fluorescent lamps in adjacent fixtures. The dimming auxiliary includes a phase control means having a switching network. A dimmer control is connected in circuit with the phase control means to vary the interval of current conduction of the switching network and is located externally of the lamp fixtures. The lamp fixture, on which the control means is disposed, serves as a control station for the fluorescent lamps of adjacent fixtures and eliminates the need for leads capable of handling lamp current to be brought out from the lamp fixture to a location remote from the fixture for connection to the phase control means.

In another form of my invention I have provided a system for dimming lamps wherein each fluorescent lamp fixture contains an individual phase control means and a ballast means. The lamp fixture is a self-contained dimming unit except for the dimmer control. Leads are brought out externally from the lamp fixture for connection to one or more dimmer controls. These leads carry the control current for the phase control means. This current is of

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relatively small magnitude as compared with the lamp current and consequently, leads of small wire size can be used to make the electrical connections. Since the phase control means is contained in the lamp fixture which is usually located in an overhead location, electrical hazards to personnel are minimized.

The subject matter which I regard as my invention is set forth in the appended claim. The invention itself however, together with further objects and advantages thereof may be understood by referring to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 illustrates in block diagram form the fluorescent lamp dimming system embodying one form of the invention;

FIGURE 2 is a perspective view of a lamp fixture containing the dimming auxiliary disposed in the channel provided for the ballast and its wiring;

FIGURE 3 illustrates in block diagram form another embodiment of the invention;

FIGURE 4 is a schematic circuit diagram of a dimming auxiliary corresponding to the dimming auxiliary shown in block form in FIGURES 1 and 3; and

FIGURE 5 is a schematic circuit diagram of a ballast corresponding to the ballast shown in block form in FIGURES 1 and 3.

Referring now more specifically to FIGURE 1, I have illustrated therein an improved system for dimming a plurality of fluorescent lamps 1, 2 and 3, which are mounted in lamp fixtures 4, 5 and 6, respectively. The lamp fixtures 4, 5 and 6 are represented schematically by the dashed rectangles and are conventional fixtures adapted for mounting on ceilings. A plurality of ballasts 7, 8 and 9 are disposed within the lamp fixtures 4, 5 and 6, respectively, and are connected in circuit with lamps 1, 2 and 3. The ballasts 7, 8 and 9 perform the current limiting function required because of the negative resistance characteristic of the fluorescent lamps and also provide the requisite starting and operating voltages for the fluorescent lamps 1, 2 and 3.

In accordance with one form of the present system invention, a dimming auxiliary 11 is placed in one of the lamp fixtures 4. The dimming auxiliary 11 serves the purpose of controlling the energy supplied to the ballasts 7, 8 and 9 in each half cycle of the alternating power supply and thereby controls the luminous output of the lamps 1, 2 and 3. In this exemplification of my invention the lamp fixture 4 serves as a control station for lamp fixtures 5 and 6 and any other lamp fixtures having ballasts connected in circuit with the dimming auxiliary 11 mounted on the control lamp fixture 4.

Terminal leads 12, 13 are provided for connection to a suitable alternating current supply, such as 120 volt, 60 cycle commercial supply. Also a pair of control leads 14 and 15 are brought out externally from the lamp fixture 4 for connection to a dimmer control or potentiometer 16. The potentiometer 16 may be located at any suitable location, such as a switch box in a wall or other convenient location from which it is desired to control the illumination level of lamps 1, 2 and 3. The potentiometer 16 and leads 14, 15 handle a current of relatively small magnitude. A wire of relatively small size, such as a number 16 AWG (American Wire Gauge), was used to make the electrical connections to the potentiometer 16.

It will be noted that ballast 7 on the control lamp fixture 4 is connected in circuit with the supply lines 18, 19 and switching line 20 of the dimming auxiliary 11 by means of electrical leads 21, 22 and 23. The output of the ballast 7 is applied across lamp 1 by the circuit means including leads 24, 25, 26 and 27. Since the circuit connections for the other ballasts 8 and 9 are identical, I have identified the circuit connections by the same refer-

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ence numerals, the primed reference numerals identifying the connections of ballast 8 and the double primed reference numerals identifying the connections of ballast 9. It will be seen that ballasts 8 and 9, which are located on the satellite lamp fixtures 5 and 6, are connected in circuit with the dimming auxiliary supply lines 18, 19 and switching line 20 by means of the leads 21', 22', 23' and 21'', 22'', 23'' respectively. The output of ballasts 8 and 9 is applied across lamps 2 and 3 by circuit means including leads 24', 25', 26', 27' and 24'', 25'', 26'', 27'' respectively.

From the foregoing description it will be apparent that the supply lines 18, 19 and the switching line 20 provide the power and switching connections for ballasts 7, 8 and 9. It will be understood that additional ballasts may be connected in circuit with the supply lines 18, 19 and switching line 20. The total number of ballasts connected in circuit is limited by the bolt-ampere rating of the dimming auxiliary 11. Where controlled rectifiers are employed in the dimming auxiliary as a phase control means, the volt-ampere rating of the controlled rectifiers will determine the number of ballasts that can be handled by the dimming auxiliary.

Referring now to FIGURE 2, I have shown therein a schematic diagram of a lamp fixture 30 having a cutaway portion to illustrate the disposition within the lamp fixture 30 of a dimming auxiliary 31 and a ballast 32 for operating and dimming a pair of lamps 33, 34. It will be noted the dimming auxiliary 31 is housed in a case 35 similar to the ballast case 36. In the illustrated exemplification of the invention the dimming auxiliary case 35 had the same cross-sectional configuration as the ballast case 36 so that it could be readily disposed within the channel 37 provided on the top of the fixture 30 for the ballast and its associated wiring. It will be appreciated that the dimming auxiliary 31 and the ballast 32 may be housed in a single elongated case.

Referring now to FIGURE 3, I have illustrated therein another embodiment of my invention wherein each lamp fixture is an integrated dimming unit. A dimming auxiliary 40 and ballast 41 are disposed in lamp fixture 42 and control the luminous output of a fluorescent lamp 43. Similarly, a dimming auxiliary 40' and ballast 41' are disposed on a fixture 42' and control the luminous output of a fluorescent lamp 43'.

As shown in FIGURE 3, the dimming auxiliaries 40 and 40' are connected to a pair of control lines 44, 45 joined in circuit with a dimmer control 46. The connections to control lines 44, 45 are made by a pair of leads 47, 48 brought out from the dimming auxiliary 40. Similar connections from the dimming auxiliary 40' are made to the control lines 44, 45 by leads 47' and 48'. Although, as shown in FIGURE 3 the dimming auxiliaries 40, 40' are connected to a single potentiometer or dimmer control 46, it will be understood that individual or ganged dimmer controls may be used.

The dimming auxiliaries 40, 40' and the ballasts 41, 41' are energized from a suitable alternating current supply (not shown) connected to terminals 49, 50 of power supply lines 51, 52. The connections to the power supply lines 51, 52 are made by the leads 53, 54 and 53', 54' brought out from the dimming auxiliaries 40 and 40', respectively. A plurality of leads 55, 56, 57, 58 and 55', 56', 57', 58' are provided for connecting the lamps 43, 43' in circuit with the ballasts 41 and 41' and the dimming auxiliaries 40 and 40', respectively.

Although in the aforescribed embodiment of my invention a single fluorescent lamp was operated within each fixture, it will be appreciated that more than one fluorescent lamp can be operated and dimmed by the integrated dimming arrangement of the invention. Further, it will be understood that additional dimming auxiliaries and ballasts may be connected in circuit with the power supply lines 51, 52 and the dimmer control lines 44, 45.

In FIGURE 4 I have illustrated a dimming auxiliary

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which may be used in the dimming systems shown in FIGURES 1 and 3. The dimming auxiliary will now be more fully described in connection with the system shown in FIGURE 1. I have used the same reference numerals of FIGURE 1 to identify the dimming auxiliary 11 and its corresponding external connections. It will be seen that leads 12, 13 are provided for connection to an alternating power supply. Control leads 14, 15 are brought out externally of the dimming auxiliary 11 for connection to the dimmer control. Further, leads 18, 19 and 20 provide the power and switching connections for the ballasts connected in circuit therewith.

The dimming auxiliary 11 is comprised of a phase control means or circuit utilizing a silicon controlled rectifier CR₁ in conjunction with a bridge rectifier 60 having diodes D₁, D₂, D₃ and D₄. The phase control circuit illustrated in FIGURE 1 is described and claimed in application Serial Number 46,189, filed in the name of Frank W. Gutzwiller on July 29, 1960, now abandoned, continued in part in application Serial No. 188,602, filed April 9, 1962, and assigned to the assignee of the present application. The bridge rectifier 60 provides a rectified supply for the phase control circuit and permits the controlled rectifier CR₁ to exercise full wave phase control of the current supplied to the ballasts as will hereinafter be more fully explained.

The controlled rectifier CR₁ is a PNP semiconductor device having three terminals, an anode represented by the arrow symbol, a cathode represented by the line drawn through the apex of the arrow symbol, and a gate represented by the diagonal line extending from the cathode. In the exemplification of the invention a silicon controlled rectifier CR₁ was used as switching element since its operating characteristic is such that it conducts in a forward direction with a forward characteristic similar to that of an ordinary rectifier when a gate signal is applied. A silicon controlled rectifier will continue to conduct even after the gate signal is removed provided a minimum holding current is supplied to the controlled rectifier.

A signal pulse is applied at the gate of the controlled rectifier CR₁ by a firing circuit that includes a Zener diode Z₁, a unijunction transistor UJT₁, a timing capacitor C₁ and the resistors R₁, R₂, R₃ and R₄. The Zener diode Z₁ and the resistor R₁ limit the maximum interbase voltage of the unijunction transistor UJT₁. Resistor R₂ is connected in circuit with the base-two electrode 64 of unijunction transistor UJT₁ and limits the current thereto. When the unijunction transistor UJT₁ is fired, the voltage drop across resistor R₃ connected with the base-one electrode 65 determines the voltage applied across the gate and cathode of the controlled rectifier CR₁. Resistor R₄ provides a minimum fixed value of resistance for the dimmer control connected across leads 14, 15.

It will be appreciated that when the controlled rectifier CR₁ is switched on in each positive half cycle as determined by the setting on the dimmer control 16, the current follows a path which includes input terminal lead 12, lead 66, diode D₄, lead 67, controlled rectifier CR₁, lead 68, diode D₂ and to the switching line 20. In the negative half cycle when the controlled rectifier CR₁ is switched on, the path of current flow includes switching line 20, diode D₁, lead 67, controlled rectifier CR₁, lead 68, diode D₃, lead 66, and input lead 13. In this manner, the controlled rectifier CR₁ in conjunction with the diodes of the bridge rectifier 60 exercises full wave control of the power supplied to the ballasts connected in circuit with supply lines 18, 19 and the switching line 20.

Referring now to FIGURE 5, I have shown therein a schematic circuit diagram of a ballast which may be used in the systems illustrated in FIGURES 1 and 3. I have identified this ballast generally by reference numeral 7, which was used to identify the ballast 7 shown in block form in FIGURE 1. To show the correspondence between the ballast 7 as shown in FIGURE 1 and the ballast 7 shown in FIGURE 5, the same reference numerals

are used to identify the corresponding external connections of the ballast 7. Leads 21, 22, 23 are provided for connection to the supply lines 18, 19 and the switching line 20 of the dimming auxiliary 11 (see FIGURE 1). Leads 24, 25, 27 are brought out from the ballast for external connection to the fluorescent lamp.

The ballast 7 shown in FIGURE 5 is more fully described and claimed in application Serial Number 104,107 filed in the name of Luther L. Genuit on April 19, 1961, and assigned to the assignee of the present application. It will be seen that the ballast 7 includes a high reactance ballast transformer 70, switching lead 21, input leads 22, 23, capacitor C_2 , resistor R_6 , and leads 24, 25, 27 which are brought out for connection to a fluorescent lamp. The ballast transformer 70 includes a primary winding 71, a secondary winding 72, a magnetic core 73, magnetic shunt 74, and the filament windings 75, 76. One end of the filament winding 76 is connected to ground through a grounding resistor R_5 . A tap 77 is provided on secondary winding 72, and switching lead 21 is connected thereto. As the controlled rectifier CR_1 is switched into a conducting state in each half cycle, it will be seen that the switching lead 21 is connected in circuit with the input lead 22 of the primary winding 71.

Having reference to FIGURES 1, 4 and 5, the operation of the dimming system shown in FIGURE 1 will now be more fully described. Operation of the system is initiated by energizing the input terminal leads 12, 13 thereby energizing the dimming auxiliary 11 in the control lamp fixture 4 and energizing the supply lines 18 and 19. The full wave bridge 60 of the dimming auxiliary 11 is also energized, and a full wave rectified voltage is applied to the unijunction transistor UJT_1 as seen in FIGURE 4. At the start of the first instantaneous rectified wave, the timing capacitor C_1 begins charging. The setting of the dimmer control 16 determines the point in each half cycle which the timing capacitor C_1 is charged to the peak emitter voltage of the unijunction transistor UJT_1 . Thus, the setting of the dimmer control 16 determines the point at which the unijunction transistor UJT_1 is fired in each half cycle.

Until the unijunction transistor UJT_1 is fired at some point in the half cycle, the controlled rectifier CR_1 is in a blocking state and the secondary windings of the ballast transformers, such as secondary winding 72 of ballast transformer 70, are in effect disconnected from the primary windings such as primary winding 71 of ballast 7 shown in FIGURE 5. When transistor UJT_1 is fired, a pulse is applied at the gate of the controlled rectifier CR_1 to switch controlled rectifier CR_1 to its low impedance state. The switching lead 21 of ballast 7 is then connected in circuit with input lead 22. Similarly, in all of the other ballasts connected in circuit with the supply lines 18, 19 and the switching line 20, the secondary windings are connected in circuit with the primary windings.

The amount of energy supplied to fluorescent lamps 1, 2, 3 and other lamps connected in the system is controlled by interval in each half cycle of the alternating power supply during which the secondary windings are connected in circuit with the primary windings of the ballast transformers or, in other words, by the conduction interval of the controlled rectifier CR_1 . If the controlled rectifier CR_1 is fired at the start of each half cycle, the lamps 1, 2 and 3 will be operated at maximum light output. The level of illumination progressive diminishes as the controlled rectifier CR_1 is fired later in each half cycle.

The operation of the system shown in FIGURE 3 is substantially similar to the system shown in FIGURE 1. Each dimming auxiliary 40, 40' controls its respective ballast 41, 41'. For a given setting of the dimmer control 46, the controlled rectifiers of the dimming auxiliaries 40, 40' are fired at a predetermined point in each half cycle of the power supply. Thus, the interval of cur-

rent conduction to the fluorescent lamps 43, 43' is fixed by the setting on the dimmer control 46, and the fluorescent lamps 43, 43' will be operated at a selected level of illumination.

The system shown in FIGURE 3 differs from the system illustrated in FIGURE 1 in that each lamp fixture 42, 42' is an integrated dimming unit. Each of the lamp fixtures 42, 42' includes a phase control means that activates a switching network in each half cycle of the alternating power supply. The leads 47, 48 and 47', 48' brought out from the dimming auxiliaries 40, 40' in the lamp fixtures 42, 42' handle a control current that is relatively small in magnitude as compared with the current supplied to operate the fluorescent lamps 43, 43'. This results in the advantage that leads of relatively small size can be used to make the required electrical connections between the dimming auxiliary on the lamp fixture and the dimmer control at some preselected remote location.

Combining the dimming auxiliary with the ballast in a lamp fixture results in an important advantage in that the system installation is considerably simplified. Since the lamp fixture not only includes the ballast as an integral part thereof but also the dimming auxiliary, the installer of a fluorescent lamp dimming system need make only the normal connections from the power supply to the lamp fixture and in addition connect the leads from the dimming control for the dimming auxiliary on the lamp fixture. Such an arrangement minimizes the possibility of system misapplication since the dimming auxiliary does not have to be mounted at some preselected location remote from the fixture. With the dimming auxiliary mounted on the lamp fixture, a satisfactory solution is provided to the problem of noise, heat generation and electrical safety usually encountered in conventional systems where the dimming auxiliary is located on a wall or other location external of the lamp fixture. By placing the dimming auxiliary in the channel in the lamp fixture, a good heat sink is provided for heat generated by the dimming auxiliary. The effects of noise generated by the dimming auxiliary and electrical hazards to personnel are minimized since the dimming auxiliary is disposed in an overhead location and buried in the lamp fixture.

From the foregoing description it will be apparent that many modifications may be made to the specific embodiments of the invention which I have described herein. It will be understood, however, that these embodiments of the invention are intended as examples of the invention and that the invention is not limited to these examples. It is to be understood, therefore, that I intend by the appended claim to cover all such modifications that fall within the true scope and spirit of the invention.

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

In a system for dimming at least one fluorescent lamp from a power supply, said lamp being associated with a lamp fixture and a ballast means for starting and operating said lamp, the illumination level of said fluorescent lamp being controlled by a dimmer control potentiometer located remotely of said fixture and a ballast means, the improvement comprising a lamp fixture, a dimming auxiliary, an elongated case housing, said dimming auxiliary mounted on said lamp fixture, said dimming auxiliary including a phase control means including a switching network and electrical leads for connection to the power supply and the ballast means, said phase control means controlling the supply of current from the power supply to the ballast means in each half cycle thereby to provide the current required to operate the fluorescent lamp at various levels of illumination, said phase control means including electrical leads for connection in circuit with the dimmer control to limit the control potentiometer current supplied to said phase control means and thereby by control the point in each half cycle at which said

switching network is activated to thereby vary the interval of current conduction in each half cycle of the power supply, said control current being relatively small in magnitude as compared with the current supplied by switching network means to the ballast means, and said channel serving as a heat sink for the ballast means and said phase control means.

References Cited by the Examiner

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3,061,744	10/62	Spira	-----	315—201 X

GEORGE N. WESTBY, *Primary Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,167,683

January 26, 1965

Theodore R. Harpley

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 63, for "13" read -- 12 --; column 6, line 61, for "a" read -- said --; line 63, after "housing" strike out the comma; same line 63, after "auxiliary" insert -- and --; line 73, strike out "potentiometer" and insert the same after "control", first occurrence, in same line 73, same column 6; column 7, line 4, after "by" insert -- said --; line 5, strike out "means", first occurrence.

Signed and sealed this 5th day of October 1965.

(SEAL)

Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents