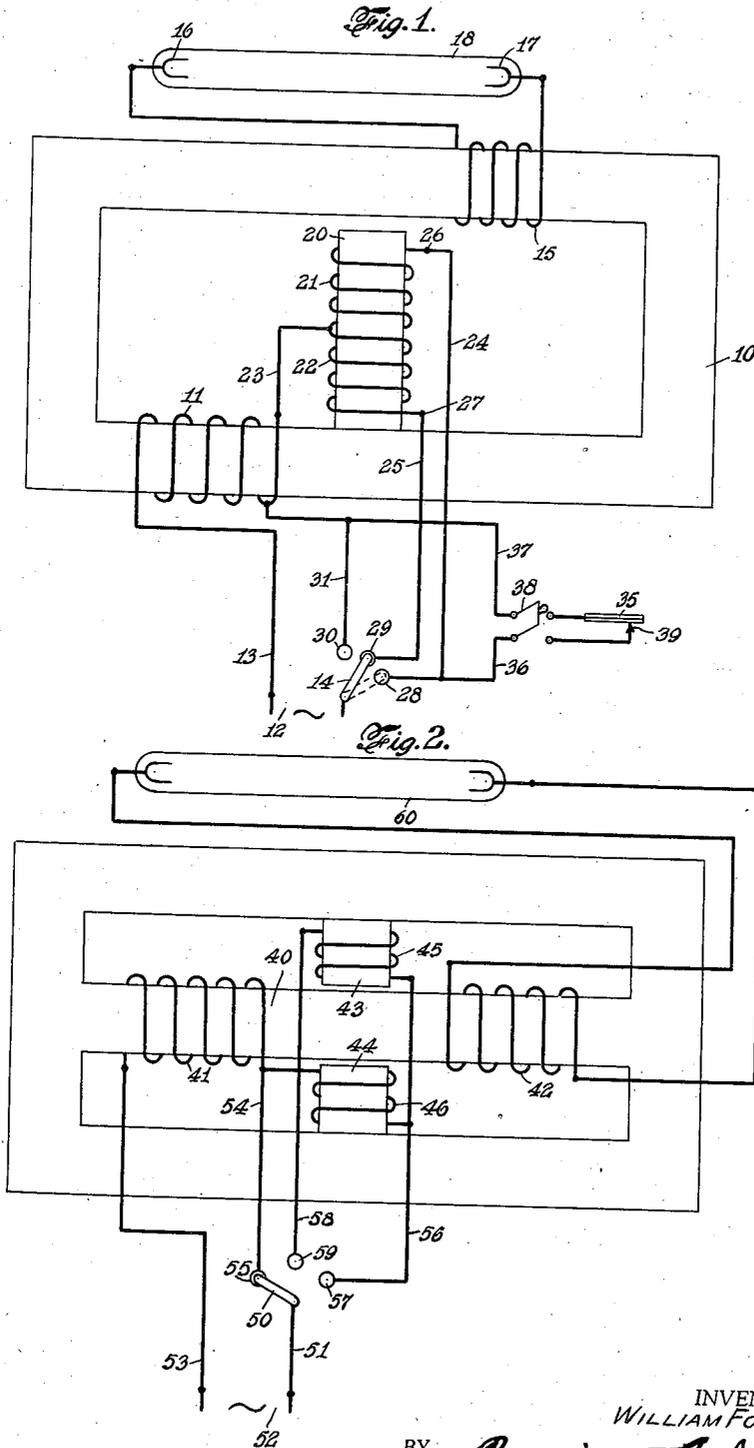


Jan. 15, 1946.

W. FOERSTE  
MEANS FOR CONTROLLING THE OPERATION OF LUMINESCENT  
LAMPS AND OTHER ELECTRICAL APPARATUS  
Filed Sept. 26, 1941

2,392,845

3 Sheets-Sheet 1



INVENTOR.  
WILLIAM FOERSTE  
BY *Frederick Schuetz*  
ATTORNEY.

Jan. 15, 1946.

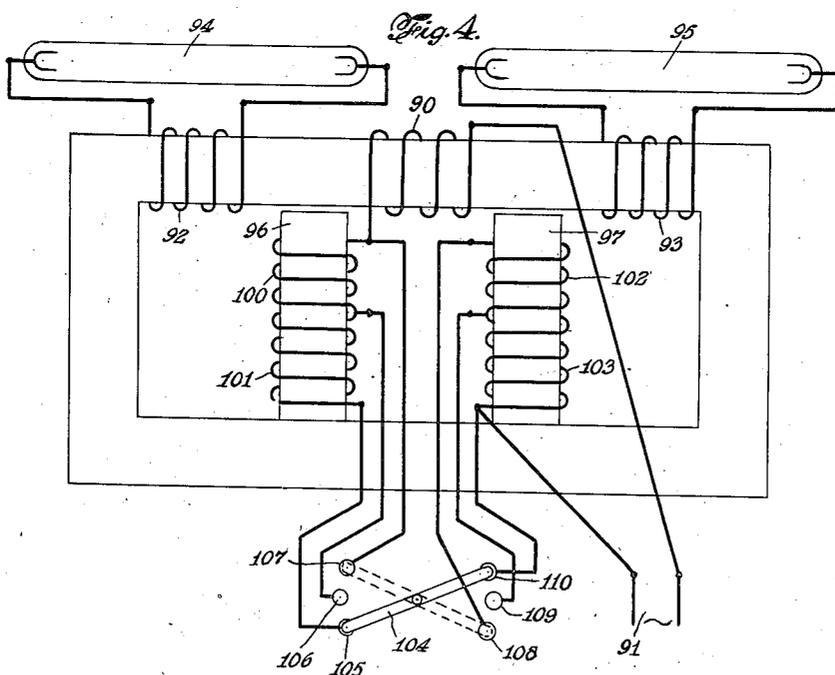
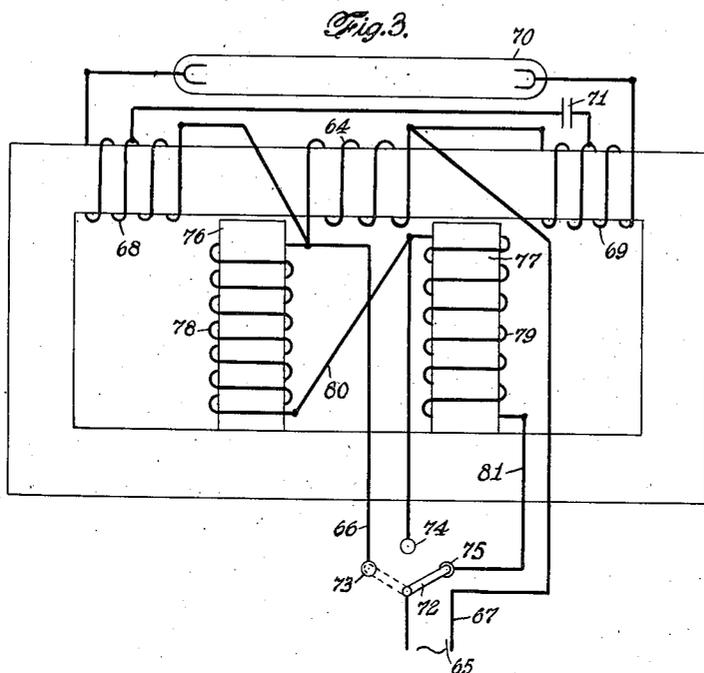
W. FOERSTE

2,392,845

MEANS FOR CONTROLLING THE OPERATION OF LUMINESCENT  
LAMPS AND OTHER ELECTRICAL APPARATUS

Filed Sept. 26, 1941

3 Sheets-Sheet 2



INVENTOR.  
WILLIAM FOERSTE

BY

*Fred Schuetz*

ATTORNEY.

Jan. 15, 1946.

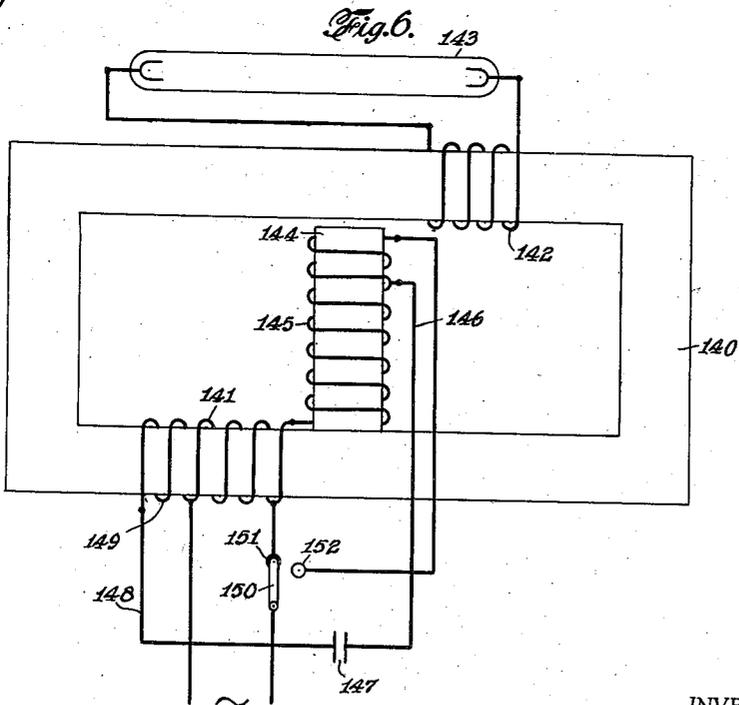
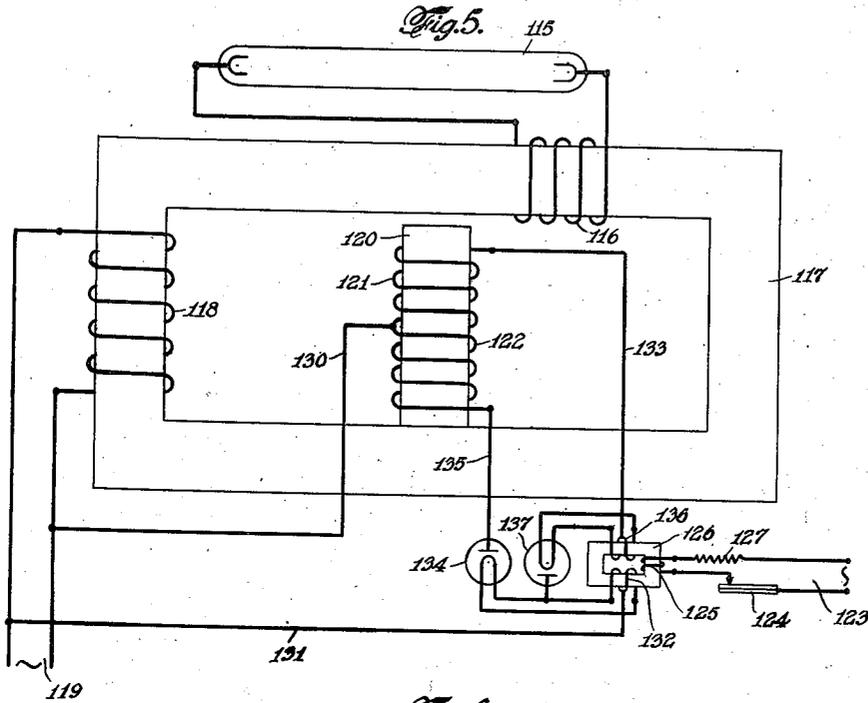
W. FOERSTE

2,392,845

MEANS FOR CONTROLLING THE OPERATION OF LUMINESCENT  
LAMPS AND OTHER ELECTRICAL APPARATUS

Filed Sept. 26, 1941

3 Sheets-Sheet 3



INVENTOR.  
WILLIAM FOERSTE

BY

*Frederick Schuetz*

ATTORNEY.

# UNITED STATES PATENT OFFICE

2,392,845

## MEANS FOR CONTROLLING THE OPERATION OF LUMINESCENT LAMPS AND OTHER ELECTRICAL APPARATUS

William Foerste, Pelham Manor, N. Y., assignor of one-half to Eugene A. Quarrie, Scarsdale, N. Y.

Application September 26, 1941, Serial No. 412,492

9 Claims. (Cl. 315-278)

The invention relates to the operation of rare-gas-filled lamps of the ordinary luminescent type as well as of the fluorescent type, wherein to effect the illumination an electrical discharge is provided between electrodes at opposite ends of an envelope containing a suitable gaseous medium. These lamps are usually operated by connecting the electrodes to the secondary of a transformer, the secondary voltage having a high open-circuit value. The transformers, as a rule, are constructed to have a high reactance, the gaseous tube element requiring a relatively high initial voltage to ionize the contained gas but only a relatively low operating voltage thereafter. Control of the intensity of illumination has heretofore been attempted by including in circuit with the primary of the operating transformer large value impedance which, of course, reduces the applied voltage. This results, generally, in inefficient and unsatisfactory operation of a lamp, particularly due to excessive flickering.

It is an object of the present invention to provide means, including a high reactance transformer, whereby the required high initial voltage will be afforded and at the same time variations in the output of the secondary of the transformer may be effected within the primary circuit to control, for example, the intensity of the illumination provided by a luminescent tube operated from the transformer.

A further object of the invention is to maintain substantially constant the open-circuit voltage for the lower impedance loads.

Still another object of the invention is to provide a simple and rugged construction by embodying the control features as an integral part of the transformer.

The invention has for an object, also, to provide means in connection with the novel transformer arrangement for correcting the power factor and to preserve at the same time against welding, pitting, and general deterioration the control contacts employed for varying the output of the transformer.

In carrying out the invention, there is associated with the usual transformer core means such as a solenoid or one or more supplementary or auxiliary cores inviting magnetic leakage. Such solenoid means alone, or when associated in a novel manner with a core or cores, directs the flux produced in the transformer core by the primary winding of the transformer to control correspondingly the output of the secondary winding of such transformer. Suitable switching means

are associated with these control or flux-directing windings to secure the desired output, the whole arrangement being such, however, that a substantially constant, open-circuit secondary tube-ionization voltage is maintained at all times. The provision of auxiliary reactance, moreover, will not be detrimental in that it supplements the secondary voltage.

The nature of the invention, however, will best be understood when described in connection with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view illustrating the novel control arrangement in its simplest embodiment and affording three degrees of control, as well as an intermittent operation at consecutively different intensities of illumination.

Fig. 2 illustrates a modification in the arrangement.

Fig. 3 illustrates an auto-transformer type embodying the novel arrangement.

Fig. 4 illustrates the control arrangement for multi-tube operation from a transformer common thereto.

Fig. 5 illustrates a further modification.

Fig. 6 illustrates a form of transformer control similar to that shown in Fig. 1, but provided with a novel arrangement for power-factor correction.

Referring to the drawings, more particularly Fig. 1 thereof, 10 designates the closed core structure of a transformer, which may be constructed in the usual manner of laminated iron, said core affording a closed magnetic circuit. A primary winding 11 is provided thereon and derives its power from the main 12 through a lead 13 and a switch-arm 14. A secondary winding 15 is also provided on the core, and is shown as connected directly to the electrodes 16 and 17, either of the hot or cold type, of a luminescent lamp including a transparent envelope 18. Winding 15 is thus in inductive relationship to the primary and supplies the lamp with the requisite voltage for its proper operation. In the operation of these lamps it is understood that an initially high voltage must be supplied by the secondary to effect the ionization of the rare gas in the envelope, this voltage then dropping to a much lower sustaining or working value when the lamp is in service. The novel arrangement hereinafter set forth, however, affords at the same time a ballast to prevent overheating of the tube and disintegration of the tube elements, thereby maintaining the current density and the light intensity.

In accordance with the invention, an auxiliary core 20 extends within the main core structure to

afford a high leakage reactance element or magnetic shunt, there being provided over said core a winding divided, for example, into two coil portions 21 and 22. As shown, the winding is divided midway to this end by connection of the lead 23 from the primary 11 substantially to the mid-point of the said winding. Respective leads 24 and 25 connect the terminals 26 and 27 of the said winding to contact points 28 and 29, respectively.

Connection is also made from lead 23 to a contact point 30 through lead 31, all contacts being associated with the switch-arm 14 designed for engagement therewith. By this expedient, the winding on the auxiliary core is constituted of two coils 21 and 22 either one of which may be connected in circuit with the primary 11, or the latter may be connected without either of these coils in circuit by setting the switch-arm 14 on the switch-point 30. In the latter instance, the transformer will operate in the usual manner with core 20 introducing a certain amount of reactance due to the normal magnetic leakage provided thereby. However, the amount of this reactance may be respectively increased or decreased accordingly as one or the other of the coils 21 or 22 is energized by setting the switch-arm 14 to switch-point 28 or switch-point 29, respectively—the one coil being subtractive in its effect, developing an opposing flux, and the other additive, developing a like flux, with respect to the reactance normally introduced by the core 20.

The magnitude of the flux of the core may thus be varied and while this will accordingly vary the current supplied, the open-circuit voltage delivered by the secondary 15 remains substantially constant in accordance with the requirements of the lamp and the relationship between the number of primary and secondary turns. The dimensions of the core, more especially its length, will be according to the requirements of the variation desired and the core may be omitted entirely in some instances and merely the solenoid utilized. The leakage effect of the core will then, of course, be missing and only the solenoid is effective to provide for leakage and in accordance with the current flowing in the primary winding.

This particular type of control lends itself, also, to the production of flasher apparatus or light beacons and in which it is possible, moreover, to provide automatically consecutive illuminations of different intensities. For example, a thermostatic circuit-controlling device 35 may be included in series in a circuit across the contact points 28 and 30, and there is included in the two leads 36 and 37 of said circuit a switch 38 whereby the effect of the thermostatic device 35 may be introduced or dispensed with accordingly as the switch 38 closes the circuit or opens the same. When the switch 38 is in the closed position, and the contact 39 of thermostatic device 35 also is in position to close the said circuit at this contact, one of the windings on core 20 is by-passed and opposes the core flux. The current supplied to the secondary 15 and the lamp connected thereto will then be of one intensity, switch-arm 14 having been moved first to the position indicated in the broken lines, on switch-point 28. This connects the primary 11 directly with the supply main 12; and current flowing through the leads 36—37 will eventually cause the thermostatic device 35 to operate to open said by-passing circuit at the contact 39 thereof.

This latter circuit is then ineffective and the current to the primary 11 must also flow through a selected one of the windings on core 20, in the

present instance the winding 21. This will afford a secondary current of a different value with corresponding change in the light intensity of the lamp.

Various combinations, of course, are possible by providing for different connections of the thermostatic device to other switch-points, as will be readily understood; and in instances where the auxiliary or leakage core contains but a single winding, a simplified arrangement becomes possible involving cutting out merely such winding alternatively with its inclusion with the primary.

Fig. 2 illustrates an additional form of transformer construction in which the main core structure includes a cross-core 40 upon which the primary winding 41 as well as the secondary winding 42 are located. In addition, two auxiliary cores or high-leakage reactance elements 43, 44 are provided extending midway of the transformer structure toward the cross-core 40. Each one of these latter cores 43 and 44 is provided with a corresponding winding 45 and 46, respectively, which are arranged to be placed alternatively in circuit with the primary winding 41. This may be effected by the switch-arm 50 connected to one lead 51 of the supply main 52, the other lead 53 being connected directly to one terminal of the primary winding 41. The other terminal of said primary winding is connected through lead 54 to a switch-point 55, as well as to one terminal of the winding 46 whose other terminal is connected through lead 56 to a switch-point 57. This latter terminal of the winding 46 also is connected to one terminal of the winding 45 whose other terminal is connected through lead 58 to switch-point 59.

In accordance with the position of arm 50 with respect to the switch-points 55, 57, and 59, various currents will be supplied to secondary winding 42 for illumination of the lamp 60 at different intensities.

An auto-transformer arrangement is indicated in Fig. 3 as equipped with the current-modifying circuits hereinbefore described. As shown, a primary winding 64 fed from the main 65 through leads 66 and 67 energizes the secondary comprising the separated halves 68 and 69 which afford the supply current to energize lamp 70. A condenser 71 across the secondary minimizes the power factor loss of the power supply device, as well as facilitating starting.

A switch-arm 72 when positioned on the switch-point 73 effects this direct connection of main 65 with the primary 64, other switch-points 74 and 75 being provided for affording different current values as set up in the secondary coil 68—69. For example, two auxiliary cores 76 and 77, affording high leakage reactance, are provided with corresponding windings 78 and 79, respectively. One terminal of the former winding is connected to the lead 66, the other terminal of said winding being connected by lead 80 with the switch-point 74. This lead 80 is also connected with one terminal of the winding 79 whose other terminal is connected by lead 81 with the switch-point 75. When the switch-arm 72 is positioned on switch-point 74, only the winding 78 will be effective to alter the secondary output; whereas, when located on the switch-point 75, both windings 78 and 79 will be included in series with the primary winding 64. If the windings 78, 79 be arranged such that the direction of flow will effect magnetization of the respective cores in opposition to the leakage effects, a regulating effect on the tube supply current results which

prevents overheating and resultant rapid destruction of the said tube.

In Fig. 4 is indicated an arrangement for multiple-lamp operation simultaneously and in a like amount by the secondary output variations. The transformer structure is substantially similar to that hereinbefore described in connection with the transformer shown in Fig. 3, but the windings are not for a transformer of the auto-type. A primary winding 90 is provided, being arranged for connection with the supply main 91, as hereinafter set forth. In the present instance, two independent secondaries 92 and 93 are provided for operation respectively of the lamps 94 and 95. Two auxiliary cores or high leakage reactance elements 96 and 97, similar to those shown in Fig. 3, are included in the transformer structure, but the windings thereon are differently arranged from those indicated in Fig. 3 for the corresponding elements.

Each core 96 and 97 is provided with a double winding, the former having the windings 100 and 101, and the latter the windings 102 and 103. The particular switching arrangement in this embodiment includes the double-pole switch-arm 104 and the corresponding sets of switch-points 105, 106, 107, and 108, 109, 110.

When arm 104 is in the position indicated, the light of one of the tubes 94, 95 is dimmed and of the other intensified; and when moved to the position indicated by the broken lines, the reverse action takes place. In the intermediate position, viz: when the points 106 and 109 are bridged by the arm 104, both tubes operate at the same intensity. Under all the conditions, the primary load, however, remains substantially constant, which is not the case in the embodiments hereinbefore described.

In Fig. 5 there is illustrated a further modification in the flasher arrangement of control and wherein the modified illumination effect is imparted gradually rather than instantaneously at its full value. Thus, lamp 115 is operated from the secondary 116 of transformer 117 whose primary 118 is connected to the main 119. There is provided, also, an auxiliary leakage core 120 with the two windings 121 and 122 thereon whose effects on the core are additive. These windings are arranged to be energized automatically through a circuit 123 including a thermostatic device 124 energizing the primary winding 125 of a transformer 126. There is included in this circuit, also, a ballast resistance 127 for the purpose hereinafter set forth.

A lead 130 connects the mid-point, for example, of the winding on core 120 to one lead of the main 119 and from the other lead of the main a lead 131 is connected to a secondary winding 132 on the transformer 126. The respective ends of the windings 121 and 122 are connected through lead 133 to another secondary winding 136 of transformer 126 and to the plate of a thermionic rectifier 134 through a lead 135. The windings 132 and 136 serve to energize respectively the filament of rectifier 134 and the filament of an additional rectifier 137. When the primary circuit of transformer 126 is energized through the operation of the thermostatic device 124, one of the rectifiers will become operative for a half wave and then the other rectifier so that the windings 121 and 122 are alternately energized to vary the effect of transformer 117 and thus the current delivered to lamp 115 through its secondary 116.

As the temperatures of the respective filaments

of the two rectifiers increase, their resistances correspondingly increase, resulting in lesser primary current flow in transformer 126 and reduced voltage drop across the ballast resistance 127. Initially, this resistance serves to reduce materially the current flow through the cold filaments and thus cause the variation in light intensity of lamp 115 to be applied gradually.

Apparatus of the nature hereinbefore set forth may readily be corrected for power factor loss by bridging a condenser across the primary coil and associated auxiliary core winding. As indicated in Fig. 6, the transformer 140 is provided with a primary 141 and secondary 142 which energizes the lamp 143. The auxiliary core 144 carries the winding 145 from which a tap is taken through lead 146 to one electrode of a condenser 147, the other electrode being connected through lead 148 to a tap 149 of the primary. By this expedient, these taps, in providing an increased voltage, allow of the use of a smaller capacity condenser. Moreover, the tap portions may be in the nature of buffer coils to momentarily check the surge of condenser discharge on closing of the circuit through a switch-arm 150 to the switch-points 151 and 152, thereby obviating welding of the arm to a point.

I claim:

1. The combination with a luminescent discharge lamp of the gas-filled type operating at a substantially constant ionization voltage; of means to vary at substantially constant open-circuit voltage the power supplied to the lamp to alter the intensity of illumination thereof, including a transformer having a closed magnetic core, only one primary and at least one closely coupled secondary connected to the lamp; and a high reluctance variable reactor in single-acting shunt magnetic relationship with said core and including a coil in series with the primary, said reactor being magnetically positioned between the primary and secondary and separated from the core by a non-magnetic gap to invite magnetic leakage and to divert flux from a portion of said core.

2. The combination with a luminescent discharge lamp of the gas-filled type operating at a substantially constant ionization voltage; of means to vary at substantially constant open-circuit voltage the power supplied to the lamp to alter the intensity of illumination thereof, including a transformer having a closed magnetic core, only one primary and at least one closely coupled secondary connected to the lamp; a high reluctance reactor in single-acting shunt magnetic relationship with said core and including a coil in series with the primary, said reactor being magnetically positioned between the primary and secondary and separated from the core by a non-magnetic gap to invite magnetic leakage and to divert flux from a portion of said core; a source of electrical energy supply; and means for connecting alternatively thereto either said single primary or said primary in series with the said reactor.

3. The combination with a luminescent discharge lamp of the gas-filled type operating at a substantially constant ionization voltage; of means to vary at substantially constant open-circuit voltage the power supplied to the lamp to alter the intensity of illumination thereof, including a transformer having a closed magnetic core, only one primary and at least one closely coupled secondary connected to the lamp; high reluctance reactor means in single-acting shunt

magnetic relationship with said core and magnetically positioned between the primary and secondary and separated from the core by a non-magnetic gap to invite magnetic leakage and to divert flux from a portion of said core, and including a winding having a plurality of taps adapted to divert flux in phase with the transformer flux; a source of electrical energy supply; and switching means for connecting alternatively thereto either the winding of said single primary or the winding of said primary in series with selected taps of the winding of the said reactor.

4. The combination of claim 1, wherein a means is provided for automatically controlling the reactor means.

5. The combination of claim 3, wherein a circuit is provided for short-circuiting the reactor means winding, and a circuit-interrupting means is included therein.

6. The combination of claim 1, wherein a condenser is connected across the lamp, and an inductance is included between the said condenser and each terminal of the lamp.

7. The combination of claim 1, wherein a condenser is connected with the primary and with the reactor means.

8. The combination of claim 1, wherein the primary has an auxiliary winding constituting with the primary winding an autotransformer, and a connection is provided from the free end of the auxiliary winding to the reactor means with a condenser included in series in the said connection.

9. The combination with a luminescent discharge lamp of the gas-filled type operating at a substantially constant ionization voltage; of means to vary at a substantially constant open-circuit voltage the power supplied to the lamp to alter the intensity of illumination thereof, including a transformer comprising only one closed magnetic circuit, only one primary, and at least one closely coupled secondary connected to the lamp; and a variable reactor magnetically positioned between the primary and secondary in single-acting shunt magnetic relationship with said closed magnetic core and separated therefrom by a non-magnetic gap for shunting from the said secondary a portion of the flux generated by the said primary, and including a coil on the reactor for controlling the load of said single primary.

WILLIAM FOERSTE.