

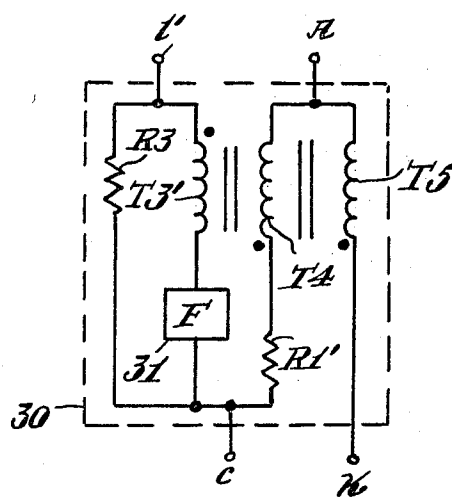
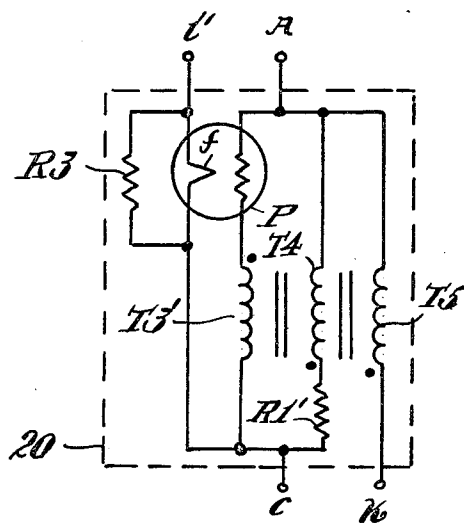
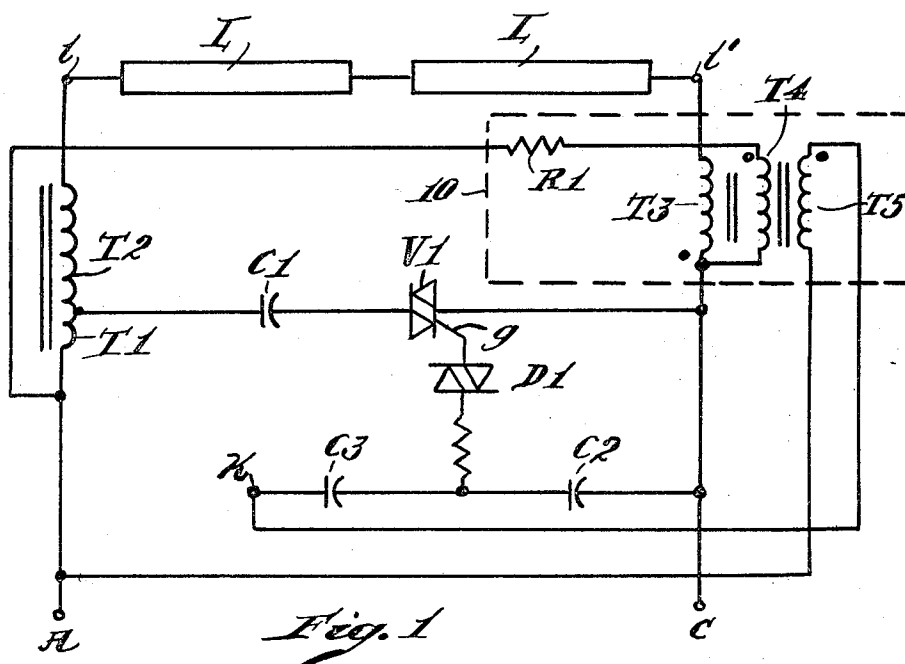
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FLUORESCENT LAMP CURRENT REGULATING CIRCUIT

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FLUORESCENT LAMP CURRENT REGULATING CIRCUIT

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ABSTRACT OF THE DISCLOSURE

An electronic circuit having a semiconductor pulse generating circuit for applying periodic ionizing pulses to a fluorescent lamp, and a transformer with a primary sensing current drawn by the lamp, a secondary sensing line voltage as a reference, and a tertiary providing a control voltage for phasing the ionizing pulses to oppose deviations in the lamp current.

Conventional fluorescent lamp starting and operating circuits have comprised a ballast for applying a high starting voltage to the lamp to ionize it and start discharge and for inductively limiting current through the ionized lamp. Because of the weight and bulk of the ballast and its high expense, heating and noise, control circuits have been proposed which start and control the lamp discharge by various electronic switching circuits. Some of the advanced electronically valved circuits comprise pulse generating or gating means for periodically applying a voltage pulse to the lamp thereby ionizing the lamp sufficiently to support an arc discharge for a limited period, usually a half-cycle or less of the alternating current supply. If the phase, amplitude, and duration of the pulse are very precisely controlled the lamp will tend to extinguish after each pulse application, rather than draw increasingly greater run-away current as its negative resistance characteristic would otherwise allow.

Despite the above-described inherent current control of electronic pulse applying circuits, it is desirable to employ further current control to allow for changes in lamp characteristics with temperature and time, variations in applied line voltage, and variations and tolerances in circuit components. It is the object of the present invention to provide a circuit which cooperates with advantageous electronic pulse applying circuits positively to control current drawn by a fluorescent lamp.

According to the invention a fluorescent lamp regulating circuit comprises discharge terminals for connection to a lamp, power terminals for connection to a supply of alternating voltage, a power circuit connecting said power terminals to said discharge terminals including controllable electronic valve means for applying periodic voltage pulses to said discharge terminals thereby to support an arc discharge by ionization in the lamp and to draw current from said alternating voltage supply dependent on the amount of ionization, said valve means having a control electrode, and control means connected to said control electrode including transformer means for sensing the amplitude of current in said power circuit and for providing a control voltage dependent thereon, operable to control said valve means, thereby to control ionization in and current drawn by said lamp.

For the purpose of illustration typical embodiments of the invention are shown in the accompanying drawing, in which:

FIG. 1 is a schematic diagram of one form of fluorescent lamp regulating circuit; and

FIGS. 2 and 3 are schematic diagrams of modifications of a portion of FIG. 1.

The regulating circuit of FIG. 1 comprises discharge

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terminals 1 and 1' between which are connected two four-foot HO lamps L which may be considered as one lamp. Power for the lamps is supplied from 120 volt, 60 cycle alternating current line terminals A and C, terminal A being connected to terminal 1 through an autotransformer primary T1 (200 turns #23 AWG wire) and secondary T2 (600 turns #23 AWG wire) of very low reactance compared to a conventional ballast. Terminal C is connected to lamp terminal 1' through the primary T3 (28 turns #22 AWG wire) of a control core transformer having a secondary T4 (2520 turns #42 AWG wire) and a tertiary T5 (3590 turns #32 AWG wire), later to be described with reference to the current stabilizing function performed by the portion 10 of the circuit.

A voltage pulse discharging circuit includes a triac V1 (RCA type TA 2893), a diac D1 (Texas Instruments Co. type TI-43), a primary voltage pulse storage capacitor C1 (10 microfarad), a secondary storage capacitor C2 (0.1 microfarad), a coupling capacitor C3 (0.047 microfarad), and a resistor R2 (1000 ohms). The primary storage capacitor C1 and triac V1 are connected in series between the power terminals A and C through the autotransformer primary T1, so that during each half-cycle of alternating current the primary storage capacitor C1 charges through the triac V1. The secondary storage capacitor C2 is connected between the power terminals A and C through coupling capacitor C3 and the control transformer tertiary T5, so that during the succeeding half-cycle the voltage across the secondary capacitor C2 rises toward the breakdown voltage of the diac D1. When this breakdown voltage is exceeded the diac D1 conducts allowing the secondary capacitor C2 to discharge through resistor R2 to the gate electrode g of the triac and trigger the triac into avalanche conduction. The primary capacitor C1 then discharges through the triac and the autotransformer primary and reverses its charge. The discharge voltage is stepped up by the 200 to 600 ratio of autotransformer primary to secondary, and the stepped up voltage is applied to the lamp terminals 1 and 1'. At this instant a limited number of ions are established in the lamps L, and the lamp fully ignites and conducts line current for part or all of the half-cycle. About when the line voltage passes through zero the arc tends to extinguish depending on the amplitude, duration, and phase of the ionizing pulse. If the pulse is too high in amplitude or too long in duration (causing excessive ionization), or if the pulse is too late in phase (allowing insufficient time for recombination of ions before conduction), the lamp, because of its negative resistance characteristic, would tend to draw increasingly greater current and reach run-away condition causing failure of the lamp or some part of the lamp circuit or supply. Similarly, if ionization is insufficient because the pulse is too low in amplitude, too short in duration, or too early in phase, the lamp will fail to draw proper current.

According to the present invention, lamp current control is achieved by transformer means which sense the current in the circuit and produce a control voltage controlling the phase of the ionizing voltage pulse according to the amplitude of the lamp current. In FIG. 1 the transformer means has its primary T3 connected in series with the lamp L, producing in the transformer core a flux directly responsive to lamp current. The secondary T4 is connected between power terminals A and C through resistor R1 (100,000 ohms), producing in the core an opposing reference flux chosen to be slightly greater than the flux due to primary T3. The algebraic sum of the fluxes due to T3 and T4 induces in tertiary T5 a control voltage the magnitude of which depends upon the error (or deviation) of lamp current from the desired or normal level. As here described the reference flux due to

secondary T4 is slightly greater than the flux due to primary T3 so that the core has a residual flux under normal current conditions. The control voltage across tertiary T5 is then the error voltage plus a voltage due to this residual flux. The control voltage appearing across tertiary T5 is introduced in the pulse discharging circuit between power terminal A and terminal *k*, in series with capacitor C2 thereby to control its rate of charging and to cause a phase shift of the ionizing pulse in the direction required to correct a deviation of lamp current away from normal. For example, if lamp current goes up due to a change in lamps or components, then the voltage induced in tertiary T5 decreases, the voltage available for charging secondary capacitor C2 (line voltage minus control voltage) increases, and capacitor C2 reaches the breakdown voltage of diac D1 earlier, thereby causing primary storage capacitor C1 to discharge through triac V1 earlier in the cycle. Not only is the phase of the ionizing pulse thus advanced to allow greater recombination of ions to limit conduction in the lamps L, but also the pulse amplitude is reduced, because capacitor C1 has charged to a lower voltage, further limiting ionization and conduction through the lamp L.

In FIG. 2 (illustrating a modified circuit portion 20 to replace portion 10 illustrated in FIG. 1), the transformer means makes use of a filtering means to avoid some of the non-linear effects that are present when the non-sinusoidal lamp current is referred against the sinusoidal line voltage. The transformer means has its primary T3' (3000 turns #42 AWG wire) connected across power terminals A and C through a photoresistor R1 of a device P (Sylvania Electric type PL466E) with an integral filament *f*. The filament *f* is connected in series with the lamp L between terminals 1' and C and is shunted by resistor R3 (one ohm). An increase in lamp current causes the filament *f* to emit more light, which lowers the resistance of photoresistor R1 and allows more current to flow through primary T3' of the control transformer, which thereby senses the variation in lamp current. Alternately, R1 could be a thermistor sensitive to heat emitted by the filament *f*. In either case, primary T3' produces in the transformer core a flux directly responsive to lamp current, secondary T4 is connected between power terminals A and C through resistor R1' (15,000 ohms) to produce in the core a slightly larger opposing reference flux, and the fluxes due to windings T3' and T4 induce in tertiary T5 a control voltage the magnitude of which depends upon the deviation of lamp current from the normal level. As in FIG. 1 this control voltage is introduced into the pulse discharging circuit between terminals A and *k* to cause a phase shift of the ionizing pulse in the direction required to correct a deviation of lamp current away from normal. The response of filament *f* to lamp current is sufficiently slow so that non-linearities and harmonics in lamp current are effectively filtered out and the signal sensed by primary T3 is essentially sinusoidal.

In FIG. 3 (illustrating a modified circuit portion 30 to replace portion 10 illustrated in FIG. 1) a different filter means is used. The transformer means has its primary T3' connected between lamp terminal 1' and power terminal C in series with a 60 cycle bandpass or lowpass filter 31 of conventional RC or LC construction. Resistor R3, shunting primary T3 and filter 31, is in series with lamp L and provides a voltage proportional to lamp current. This voltage, with non-linearities and harmonics removed by filter 31, appears across primary T3' and induces in the transformer core a flux directly responsive to lamp current. Secondary T4, resistor R1', and tertiary T5 are connected as in FIG. 2, tertiary T5 having a control voltage induced therein which is introduced in the pulse discharging circuit to cause a phase shift of the ionizing pulse in the direction required to correct a deviation of lamp current.

While three desirable embodiments of the invention have been illustrated by way of example, it should be understood that the invention is broadly inclusive of all

modifications and equivalents within the scope of the appended claims.

I claim:

1. A fluorescent lamp regulating circuit comprising discharge terminals for connection to a lamp, power terminals for connection to a supply of alternating voltage, a power circuit continuously connecting said power terminals to said discharge terminals including controllable electronic valve means for superimposing periodic voltage pulses upon the alternating voltage at said discharge terminals thereby to support an arc discharge by ionization in the lamp and to permit the lamp to draw current from said alternating voltage supply dependent on the amount of ionization, said valve means having a control electrode, and control means connected to said control electrode including transformer means having a primary winding connected to vary its current with current in said lamp and for inducing across another winding a control voltage dependent on said lamp current, said control voltage being applied to continuously control the phase of said ionizing pulses according to the magnitude of said control voltage by advancing phase to correct increases in lamp current.
2. A circuit according to claim 1 wherein said control means includes means chargeable to a predetermined voltage for actuating said electronic valve means, and wherein said control voltage is applied to said chargeable means to control its rate of charging thereby to control the phase of said ionizing pulse.
3. A circuit according to claim 1 wherein said transformer means comprises a primary sensing the amplitude of current in said power circuit and producing a flux dependent thereon; a secondary opposing the primary and producing a reference flux; and a tertiary responsive to said fluxes to induce thereacross said control voltage, whereby said control voltage depends upon deviation in lamp current, said valve means being responsive to said control voltage to change the phase of said ionizing pulse to correct said deviation.
4. A circuit according to claim 3 wherein said secondary is responsive to the amplitude of said supply voltage.
5. A circuit according to claim 3 wherein said primary is connected in series with said lamp and carries said lamp current.
6. A circuit according to claim 3 further comprising filtering means for attenuating non-linear distortions in lamp current sensed by said primary.
7. A circuit according to claim 6 wherein said filtering means comprises means emitting energy dependent upon said lamp current, and means varying resistance in response to said emitted energy.
8. A circuit according to claim 7 wherein said energy emitting means comprises a light-emitting filament connected in series with said lamp, and wherein said means varying resistance comprises a photoresistor connected in series with said primary.
9. A circuit according to claim 6 wherein said filtering means comprises a filter adapted to impede frequencies greater than the frequency of said alternating voltage supply, said filter being connected in series with said primary.
10. A fluorescent lamp regulating circuit comprising discharge terminals for connection to a lamp, power terminals for connection to a supply of alternating voltage, a power circuit connecting said power terminals to said discharge terminals including controllable electronic valve means for applying periodic voltage pulses to said discharge terminals thereby to support an arc discharge by ionization in the lamp and to draw current from said alternating voltage supply dependent on the amount of ionization, said valve means having a control electrode,

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said power circuit comprising time constant means (C1) for varying the energy of said ionizing pulse; control means connected to said control electrode including transformer means for sensing the amplitude of current in said power circuit and for providing a control voltage dependent thereon operable to control said valve means, thereby to control ionization in and current drawn by said lamp, 5
 said control means comprising a switching device (D1) connected to said control electrode for actuating said valve means, and means (C2) chargeable to a critical voltage actuating said switching device; 10
 said transformer means comprising a primary (T3, T3') sensing lamp current and producing a flux dependent thereon, a secondary (T4) opposing the primary and connected across said power terminals to produce a reference flux, a tertiary (T5) responsive to said fluxes to induce thereacross said control voltage, whereby said control voltage depends upon deviation in said lamp current; 15
 said control voltage being applied in series with said chargeable means to control its rate of charging to said critical voltage thereby to control the time at which said switching means is actuated to produce 20

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said ionizing pulse, and thereby to control the phase and energy of said ionizing pulse to control conduction in said lamp.

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