United States Patent

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[33] **Israel**
[31] **29382**

[54] STARTER FOR FLUORESCENT LAMPS

10 Claims, 4 Drawing Figs.

[52] **U.S. Cl.** **315/99,**
315/100, 307/305

[51] **Int. Cl.** **H05b 41/02,**
H05b 41/16

[50] **Field of Search** 315/99,
100, 100 (H); 307/305

[56] **References Cited**

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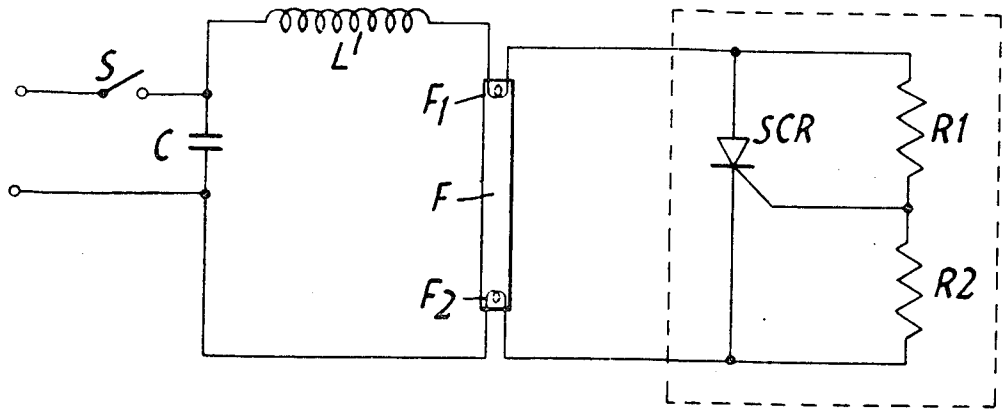
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Primary Examiner—Herman Karl Saalbach
Assistant Examiner—Wm. H. Punter
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ABSTRACT: A starter for the kind of fluorescent lamp which is used in a circuit energized from an AC source and which causes a high AC voltage across the lamp during starting and a lower voltage across the lamp during lamp operation, the starter being a semiconductor switch which during alternate half-cycles of the supply causes heating of the filaments and during the other half-cycles causes the full supply voltage to be applied to the lamp, the heating of the lamp filaments ceasing when the lamp is energized and the lamp voltage thereby falls.



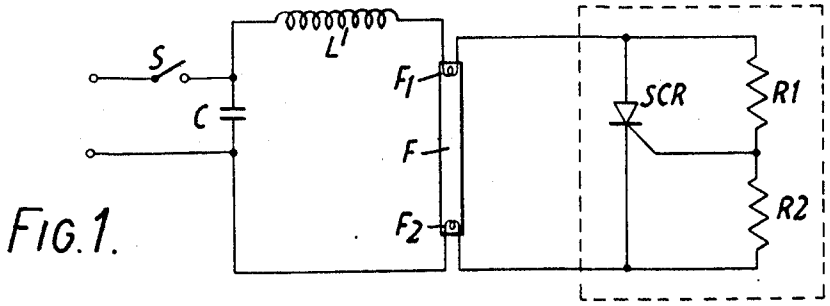


FIG. 1.

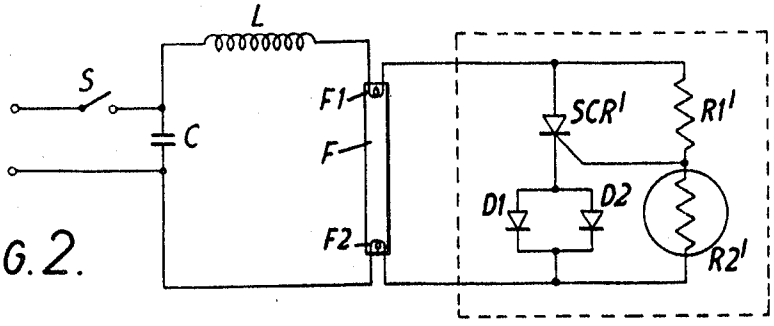


FIG. 2.

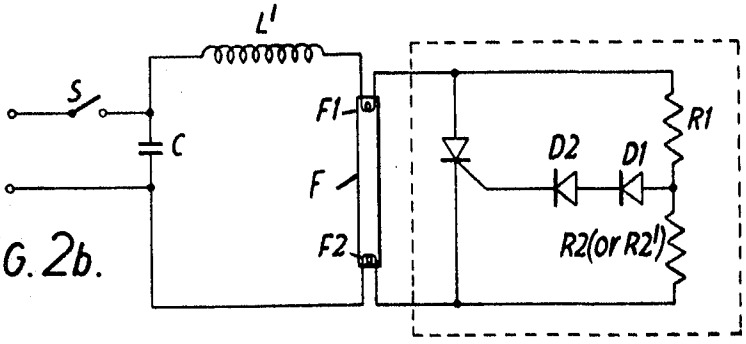
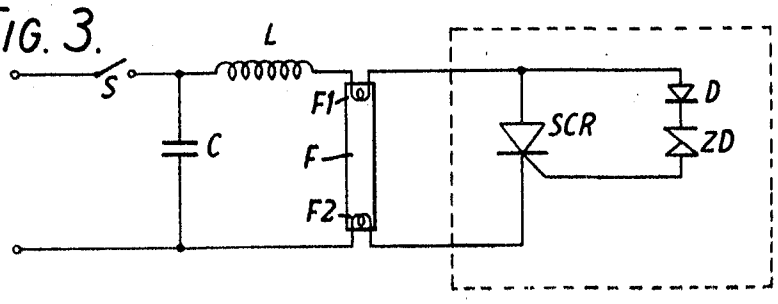


FIG. 2b.

FIG. 3.



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STARTER FOR FLUORESCENT LAMPS

The present invention relates to starters for fluorescent lamps. It relates particularly to starters for providing rapid starting of conventional fluorescent lamps.

Starters for conventional fluorescent lamps commonly include a switching device (usually magnetic or thermal) which short circuits the lamp arc for a few seconds during which current, limited in magnitude by the ballast, flows through the lamp electrodes. The starter automatically opens the short circuit after a few seconds, creating an inductive surge which starts the arc. Such starters for conventional fluorescent lamps are not always satisfactory for several reasons. First, it usually takes a number of seconds before the lamp conducts in a steady manner. Also, the starting process is usually accompanied by flickering before steady conduction is obtained.

More recently, special so-called "rapid-start" fluorescent lamps have been developed. In a rapid-start system, the filaments of the lamp are preheated until the temperature of the emissive cathode material is sufficient for arc production at a voltage not exceeding the peak supply voltage. However, these are usually operated in conjunction with special chokes which are more expensive, bulky and heavy than the normal choke required for operating conventional lamps. Moreover, it is a common feature of these rapid-start systems that two lamps must be operated on one choke; thus, rapid-start systems are usually not applicable when only one lamp is used. Also, the conversion of an existing conventional installation to a rapid-start one is expensive. Further in the commonly used rapid-start systems filament current continues to flow even after the lamp is operating, i.e. conducting current by space discharge flowing between the electrodes; in some cases, the current flows through the filaments at the full rate, and in others at a reduced rate, but usually about 5—10 percent of the total consumption of electric power is wasted by filament heating during lamp operation.

An object of the present invention is to provide novel starters for fluorescent lamps having improved features in one or more of the above respects.

A further object of the invention is to provide a starter which can be provided in a form in which it is usable with a conventional fluorescent lamp installation and which imparts to it the desirable features of a rapid-start installation.

A still further object of the invention is to provide a starter which may be constructed of all solid-state elements, thereby providing very rugged and long-life characteristics.

Briefly, the present invention operates according to the following mechanism of action; when the lamp is first switched on, the AC half-cycle alternations of one sign are used to heat the filaments to a temperature at which the lamp is able to arc during the other half-cycle alternations. This usually takes about 1 second. Once the arc is formed the voltage is reduced across the lamp, and this causes the current flow to the lamp filaments to be discontinued.

The present invention consists in a starter for a fluorescent lamp adapted to be energized from an AC source of supply providing an AC voltage across the lamp during lamp starting and a lower voltage across the lamp during lamp operation, characterized in that the starter comprises a semiconductor switch connected in series with the lamp filaments, said switch being actuated by the AC source so as, during lamp starting, to effect, during alternate half-cycles of the supply, heating of the filaments and during the other half-cycles of the supply to afford the application of the full supply voltage to the lamp, whilst upon energization of the lamp and consequent reduction of the voltage thereacross, further operation of the switch to conduct current through the lamp filaments is prevented.

Preferably the semiconductor switch comprises a controlled rectifier having an anode adapted to be connected in series with one of the filaments of the fluorescent lamp, a cathode adapted to be connected in series with the other filament of the fluorescent lamp, and a control electrode adapted to be connected to the AC source to gate the controlled rectifier when said lower voltage is applied across the lamp during lamp operation.

The controlled rectifier is preferably a silicon controlled rectifier, commonly called an SCR device. It is used to provide filament heating current during half-cycle alternations of the supply voltage so long as a sufficient voltage is supplied to the control electrode, or gate, of the SCR device. During the other half-cycle alternations, no filament current will flow, the SCR device being in a practically nonconducting state, and the whole supply voltage will be applied across the lamp. This will cause an arc to be created as soon as the lamp cathode temperature is sufficiently high. When arcing across the lamp occurs, the voltage developed at the control electrode of the SCR device is reduced to a value insufficient to maintain conduction in the SCR device, and therefore filament current will cease to flow.

Preferably, the starter includes a pair of resistors forming a voltage divider network connected across the anode and cathode of the SCR device, the control electrode of the SCR device being connected to the juncture between the two resistors.

Further features and advantages of the invention will be apparent from the description below.

The invention is herein described, somewhat diagrammatically and by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a circuit diagram illustrating one form of starter constructed in accordance with the invention; and

FIG. 2 is a circuit diagram illustrating a variation.

The circuit illustrated in FIG. 1 includes a fluorescent lamp F connected across an AC supply mains of, e.g. 220 volts, 50 cycles. The supply is controlled by a starting switch S. A conventional choke L is connected in series with the lamp, and a phasing capacitor C is connected across the supply. These are well-known elements in a conventional fluorescent lamp installation.

The improved starter constructed in accordance with the invention is illustrated within the broken box in FIG. 1. It includes a silicon controlled rectifier, commonly called an SCR device, the anode of which is connected to one filament F1 of the fluorescent lamp, and the cathode of which is connected to the other filament F2 of the fluorescent lamp. The control electrode or gate of the SCR device is connected to the junction of two resistors R1 and R2 forming a voltage divider across anode and cathode of the SCR device.

The operation of the circuit will be apparent from the foregoing description. When the starting switch S is closed, the SCR device conducts during positive half-cycle alternations of the supply voltage, and therefore heating current flows through the lamp filaments F1 and F2 during these half-cycle alternations. During the negative half-cycle alternations, there is no flow of filament current and therefore the whole AC voltage of the supply mains will be applied across the lamp electrodes. As soon as the filaments are heated to a sufficient degree, as determined by the characteristics of the lamp and of the other elements of the system, an arc discharge is produced across the lamp electrodes, and the lamp operates to give off light. This is accompanied by a heavy flow of current through the lamp F and through the choke L. The voltage drop across the choke is increased while that across the lamp is reduced. The potential of the control electrode of the SCR device thus drops, extinguishing the SCR device, and virtually all the current will now flow through the lamp.

For purposes of example only, resistor R1 may have a value of about 24,000 ohms, and resistor R2 may have a value of about 82 ohms. The voltage on the control electrode of the SCR device would be about 1 volt during starting conditions, sufficient to fire the SCR device, and will drop to about one-third volt during lamp operating conditions, insufficient to sustain conduction in the SCR device. Thus, there will be substantially no current flow through the filaments F1 and F2 during the normal operation of the fluorescent lamp.

Resistor R2 in FIG. 1 is not essential, but serves to form with register R1 a voltage divider which stabilizes the operation of the SCR device. Where extreme variations of supply voltage and/or ambient temperature are to be encountered, additional

stabilizing means may be included. Examples of each stabilizing means are illustrated in FIGS. 2, 2*b*, and FIG. 3.

For proper functioning of the starter it is required that the firing of the SCR takes place no sooner than when the instantaneous value of the supply voltage has exceeded the R.M.S. value of the supply voltage and before the instantaneous voltage had reached a predetermined level between the R.M.S. value and the peak value of the supply voltage. In the case of a supply of 220 volts R.M.S., the firing of the SCR should take place not later than when the instantaneous valve has reached 250 volts during each positive half-cycle of voltage, the peak instantaneous voltage being about 310 volts.

Should the starter be provided without any internal stabilizing means (i.e. without even the resistor R2 of FIG. 1) improper functioning could occur for the following reasons:

The operating point of the SCR (i.e. the gate current required for firing) is a function of the internal temperature of the internal temperature of the SCR. At the moment when power is applied to the SCR the internal temperature thereof rises sharply due to the onset of relatively heavy filament current in the lamp, as a result of which, the operating point shifts to a lower value of gate current, and the SCR now fires at a lower value of instantaneous supply voltage which can fall below even the required minimum value of the R.M.S. voltage, i.e. 220 volts in the case of a 220-volts R.M.S. supply. If this happens before the lamp filaments have risen to the temperature required for arc formation across the lamp, malfunction follows.

This state of affairs is dealt with by the insertion of the low value resistor R2 (FIG. 1) with appropriate readjustment of R1. The operating conditions are then largely determined by the voltage drop across the R2 or to put it another way the gate is supplied from a voltage source when R2 is present in contrast with a current source which is the situation which prevails in the absence of resistor R2. Improved stability arises because the firing voltage of the SCR is to a much lesser degree temperature dependent than is the firing current thereof.

Under adverse condition (e.g. cold lamp, low supply voltage, etc.) the improvements reached by the provision of resistor R2 alone could be found to be inefficient. Additional insertion of nonlinear elements, such as solid-state diodes in the forward-biased condition, into the gate circuit of the SCR makes the firing point of the SCR more independent of SCR junctions temperature, as is well understood by persons skilled in the art. The more diodes which are introduced (with a corresponding readjustment of resistors) in the SCr gate circuit the better will be the stabilization. The exact point of insertion is a matter of choice. Thus, FIG. 2 shows parallel-connected diodes D1 and D2 poled in the same sense as the SCR and connected in series with the cathode of the SCR. In FIG. 2*b*, however, diode D1, and diode D2 in series with diode D1, are inserted in the lead to the gate electrode of the control rectifier. Diode D2 can, if desired, be omitted. It will be noted that the diodes D1 and D2 can be arranged in series or in parallel, though the series arrangement is preferable. Also the diodes D1 and D2 can be in either the gate or cathode circuit of the SCR.

The diodes D1 and D2 are effective only insofar as the internal heating up of the SCR is caused by current through the SCR. Where the ambient temperature may be expected to rise above around 50° C., some means should be provided to account for the influence of ambient temperature on the SCR operating point. Two ways of doing this will be considered. The resistor R2 of FIGS. 2 and 2*b* can be made into or to include a thermistor R2', i.e. a resistance with appreciable temperature-coefficient of resistance. The temperature coefficient of the thermistor is chosen to be approximately equal in magnitude but opposite in sign to the temperature coefficient of the firing voltage of the SCR. It should be noted that although in FIGS. 2 and 2*b* both diodes D1 and D2 and thermistor R2 are shown, the thermistor R2' could be used in the absence of diodes D1 and D2 in which case the arrangement reduces down to that of FIG. 1 with R2 replaced by thermistor R2'. Also, the diodes D1 and D2 can be used with thermistor R2' replaced by resistor R2.

A second way of providing for the case where ambient temperature may exceed around 50° C. is illustrated in FIG. 3. Referring to FIG. 3 it will be noted that between the anode and gate electrodes of the SCR there is connected in series a diode D and Zener diode 2D. The Zener diode breakover voltage is chosen at a valve between the R.M.S. voltage of the supply and the voltage between the R.M.S. and peak values of the supply voltage at which firing is required. In the case of a 220-volt supply the Zener breakover voltage is chosen in the range of 220—250 volts. As soon as the Zener diode breakover voltage is reached, large current begins to flow into the gate electrode of the SCR causing the SCR almost immediately to fire and the firing of the SCR in turn cuts off the gate current by virtue of the collapse of the voltage drop across the Zener diode. The SCR then continues to conduct for the remainder of the positive half-cycle, i.e. the period of the positive half-cycle after the attainment of the Zener breakover voltage. The other diode D in series with the Zener diode serves to prevent gate current flow during the negative half-cycle of the supply voltage. The essential requirements are that the starter provides a semiconductor switch in series with the filament F1 and F2, which switch during starting of the lamp operates to effect heating of the filaments during alternate half-cycles of the supply whilst after energization of the lamp the lowering of the voltage across the lamp places the semiconductor switch in an open-circuit condition so that conduction through the switch of further filament current is prevented.

It will thus be seen from the foregoing that the present invention may be used for converting existing conventional fluorescent lamp installations to rapid-start installations, thus avoiding the disadvantages of flickering and longer starting periods characteristic of conventional installations. In addition, the present invention may be used with only one fluorescent lamp and does not require two lamps. Further, with the present invention filament heating is discontinued as soon as the lamp begins to operate, and thus there is no wastage of power for filament heating during lamp operation. Also the starter of the present invention can be made of all solid-state components.

The invention could advantageously be embodied in a starter of the same outline as the normal starter in a conventional fluorescent lamp installation thereby enabling the installation to be converted to a rapid-starter one in a very simple manner.

Many other modifications, variations and applications of the illustrated embodiments of the invention will be apparent.

I claim:

1. A starter for a fluorescent lamp adapted to be energized from an AC source of supply providing an AC voltage across the lamp during lamp starting and a lower voltage across the lamp during lamp operation, characterized in that the starter comprises a semiconductor switch connected in series with the lamp filaments, said switch being actuated by the AC source so as, during lamp starting, to effect, during alternate half-cycles of the supply, heating of the filaments and during alternate half-cycles of the supply, heating of the filaments and during the other half-cycles of the supply afford the application of the full supply voltage to the lamp, whilst upon energization of the lamp and consequent reduction of the voltage thereacross, further operation of the switch to conduct current through the lamp filaments is prevented.

2. A starter according to claim 1, characterized in that the semiconductor switch comprises a controlled rectifier having an anode adapted to be connected in series with one of the filaments of the fluorescent lamp, a cathode adapted to be connected in series with the other filament of the fluorescent lamp, and a control electrode adapted to be connected to the AC source to gate the controlled rectifier to conduction during lamp starting in order to effect heating of the lamp fila-

ments, and to extinguish conduction of the controlled rectifier when said lower voltage is applied across the lamp during lamp operation

3. A starter according to claim 2, wherein said control electrode is connected to a resistor by means of which a gating potential is applied to the control electrode during lamp starting which gating potential is reduced during lamp operation.

4. A starter according to claim 2, wherein said controlled rectifier is a silicon controlled rectifier (SCR) device.

5. A starter according to claim 4, further including a second resistor forming with said first-mentioned resistor a voltage divider connected across the anode and the cathode of the controlled rectifier, said control electrode being connected to the junction of the two resistors.

6. A starter according to claim 5, wherein said second resistor is or includes a temperature compensating thermistor.

7. A starter according to claim 2, further including nonlinear stabilizing means in the gate circuit or the cathode circuit of the controlled rectifier.

8. A starter according to claim 7, wherein the nonlinear stabilizing means comprise one or a plurality of solid-state diodes in the cathode or gate circuit of the control rectifier.

9. A starter as claimed in claim 8, wherein the stabilizing means comprise two diodes arranged in parallel and disposed in the gate circuit or the cathode circuit of the control rectifier.

10. A starter as claimed in claim 8, wherein the stabilizing means comprises two diodes arranged in series and disposed in the gate circuit or the cathode circuit of the control rectifier.

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,588,592 Dated June 28, 1971

Inventor(s) Isaac J. BRANDSTADTER

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 73, after "rectifier" insert

--to conduction during lamp starting in order to effect heating of the lamp filaments, and to extinguish conduction of the controlled rectifier--

Col. 4, lines 62 and 63, delete "alternate half-cycles of the supply, heating of the filaments and during"

Signed and sealed this 30th day of November 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Acting Commissioner of Patents

FORM PO-1050 (10-69)

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