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This invention relates to a circuit for starting a discharge lamp, such as a fluorescent lamp, and particularly to the types of fluorescent lamp starter circuit which utilise half-wave rectified current to pre-heat the lamp cathodes.

A particular application of the invention is to starter circuits which employ a fluorescent lamp electronic starter switch device of the kind described in Specification GB-A 2201307 (Martin). More particularly the starter switch device is a device such as that known as a Fluoractor available from Texas Instruments. The Fluoractor device and its use in starter circuits for fluorescent lamps is described in Specifications EP-A 0118309 and EP-A 0269485 (Texas Instruments).

The starter circuits disclosed in the three specifications referred to in the preceding paragraph are concerned with the use of Fluoractor devices in full-wave operation, that is the circuits are energised on each half-cycle of the applied mains power supply, as by feeding the circuits through a bridge rectifier. The present invention is concerned with starter circuits in which the Fluoractor device is triggered in half-cycles of one polarity of the applied mains supply. An example of this type of circuit is described in Specification GB-A 2234868 (Martin). Fig. 1 of the accompanying drawings is reproduced from this specification to which reference can be made for a fuller description of that circuit. It is noted that the device F shown in Fig. 1 is a Fluoractor having anode, gate and cathode terminals A, G and K respectively. The device F provides the main current path of the starter circuit.

The timing means of fluorescent lamp starter circuits is commonly provided by deriving a low voltage as a result of the main current flow and using that voltage to charge a timing capacitor through a resistor. This is exemplified in Fig. 1 by the forward voltage of diodes D2, D3 and D4 charging capacitor C1 through R12 and R13. An alternative to the three diodes of Fig. 1 is to place a low voltage Zener diode (Z1) in the current path to achieve the same effect (Fig. 2). The Zener diode voltage is typically 4.7 volts. Because the RC timing is fed from a low voltage and because the timing relies on the capacitor C1 charging from zero to typically 1.5v, the value of the capacitance needed in practice is high. Values of 22 μ to 100 μ F are common. The only reasonable course is to use an electrolytic capacitor in positions such as C1.

Electrolytic capacitors are small and inexpensive but they have a number of disadvantages. In particular the temperature range over which they will operate is restricted and their working and shelf lives are limited. The variation of the initial capacitance value of an electrolytic capacitor and changes of value during use are both high so that variations in timing values for starters relying on these capacitors is considerable (typically +/- 40% or more).

Embodiments of the present invention will be de-

scribed hereinafter in which it is possible to replace the low voltage, high capacitance of the timing means by much lower values of capacitance working over much larger voltage excursions. Such capacitors are readily available with close tolerance values and good stability when working over wide temperature ranges. They also maintain their characteristics over a long working life.

Broadly stated, according to one aspect of the present invention there is provided a fluorescent lamp starter circuit in which one polarity of the AC voltage is used for heating the lamp cathodes and the other polarity is used to charge a capacitor in a series of steps resulting from the charge and discharge of a second capacitor, in order to define and control the time of heating and high voltage pulsing provided by the starter.

Other aspects and features of this invention are set out in the Claims following this description.

For a better understanding of the invention and its practice embodiments of it will now be described with reference to Figs. 3 - 13 of the accompanying drawings. In the drawings:

Fig. 1 shows a prior half-wave starter circuit employing a Fluoractor device;

Fig. 2 shows a modification of the circuit of Fig. 1;

Fig. 3 shows a half-wave starter circuit embodying the present invention;

Fig. 4. is a diagram of the waveform developed on the capacitor C4 in the circuit of Fig. 3;

Figs 5, 6 and 7 are waveforms illustrating the operation of the circuit of Fig. 3 during successive phases of its operation;

Figs 8, 9 and 10 show modifications in the charge pump arrangement of the circuit of Fig. 3;

Fig. 11 shows a modification of the circuit Fig. 3 to use a field effect transistor (FET) instead of the bipolar transistor controllable switch to control the gate of the Fluoractor;

Fig. 12 shows a modification of the starter circuit of Fig. 3 which reduces the voltage rating required of certain components; and

Fig. 13 is a table illustrating typical circuit values for the circuit of Fig. 12.

In Figs 3 - 12, circuit elements corresponding to those of Figs. 1 and 2 discussed above are given the same reference symbols. The description that follows will concentrate on those parts of the starter circuits and their operation that differ from the circuit of Fig. 1. As already mentioned, further description of that circuit is to be found in GB-A 2234868.

Circuits of the type shown in Figs. 1 and 2 are characterised by the fact that they operate on only one polarity of mains voltage. They are known as rectifying or half-wave types. In the circuits of Figs. 1 and 2, as drawn, only the positive half cycle of the supply is conducted by the starter for heating and high voltage

generation. When conduction ceases in the positive direction the voltage at the starter terminals goes fully negative to the value of the supply voltage.

This negative voltage excursion is used in embodiments of the present invention to derive the main timing function.

Fig. 3 shows a half-wave type of starter circuit as connected to a lamp. A fluorescent lamp or tube T of the type having heated cathodes is connected to the mains supply V_s through the conventional ballast inductor L. The starter circuit is connected between the circuit points X and Y so as to be in series with the cathodes of tube T for the flow of heating current and in parallel with the tube for the generation of the high voltage ignition pulses. The heating current path extends through the controllable Fluoractor device F. The half-wave operation of device F and its gate control circuitry (on positive half-waves as shown) is ensured by diode D1. The flow of triggering current to gate G of device F is controlled by the fully controllable transistor switch TR2 which is constituted by a Darlington pair transistor. The switch transistor is operable when turned on by control of its base to divert current from the gate G. This control includes diverting triggering current from entering the gate to turn the device F on, and also, when the device F is conducting, diverting latching current from the gate in order to turn the device off.

The large value capacitor C1 of Fig. 1 or Fig. 2 is replaced in the circuit of Fig. 3 by C4 a small value capacitor (typically 10 to 30nF) and C4 is charged negatively via a main timing capacitor C3 (value typically 30 to 150nF). The capacitor C3 is connected to the mains supply side of diode D1 through the oppositely-poled diode D5, capacitors C3 and C4 being in series with this diode between starter terminals X, Y. The circuit operates as follows (referring to Fig. 3).

Initially the capacitors are at zero voltage. When the mains supply is applied the first negative going half cycle which occurs causes C4 and C3 to charge negatively through the diode D5. The capacitance value of C4 is smaller than that of C3 (typically $C3 \geq 5 \times C4$) so C4 charges to a higher negative voltage than C3. The negative voltage on C4 gives a negative voltage on the base of the clamping transistor TR2 and maintains TR2 in a non-conducting state. In the following positive half cycle, the Fluoractor, or similar device, F, acts in its thyristor mode and triggers and conducts without any modification of the operation by the clamp device TR2. During the positive conduction half cycle, C4 is charged towards the Zener diode Z1 voltage via resistors R12 and R13. Values are chosen such that, at first, the voltage on the base of TR2 stays below zero.

On the next negative half cycle, the voltage on C4 is driven negative again, but not quite as far as the previous negative half cycle because C3 has retained a voltage from the previous negative excursion. Re-

sistor R15 connected across C3 and C4 is made sufficiently high in value to allow this. Repeated cycling causes C3 to charge up whilst C4 cycles up and down again in voltage with the mean voltage rising as C3 charges up over successive cycles. The resulting waveform of voltage on C4 is shown in Fig. 4.

In practice, the negative voltage maximum occurring at the base of TR2 can be quite high and it would be necessary with the basic circuit as given in Fig. 3 to place a diode, connected in the same sense as the base-emitter junction of TR2, in series with the base connection from R12 and R13 in order to prevent damage from too high a reverse V_{be} .

The functioning of the circuit of Fig. 3 operates in four distinct phases. Whilst the voltage on the base of TR2 is cycling below zero (the left-hand portion of Fig. 4), the Fluoractor F is triggered into conduction on each positive half cycle and provides heating current to the cathodes. This first phase of operation is illustrated by the waveforms of Fig. 5 in which dash line V_s is the mains supply, full line V_x is the voltage between terminals X and Y, and I_A is the heating current flowing through the Fluoractor F.

When the charge built up in C3 is sufficient to allow the voltage excursions of C4 to reach a level high enough to permit TR2 to turn on under control of current in R12 from Z1 (as the waveform of Fig. 4 enters the right-hand portion where the CLAMP THRESHOLD refers to the voltage at which TR2 turns on), then high voltage pulses are generated by device F because TR2 clamps the gate during part of the conduction cycle and causes a gate turn-off action when the current I_A in the Fluoractor F reduces to approximately 200mA (assuming that the device F is the Texas Instruments Y1111, Y1112 or similar). This constitutes the second phase of operation illustrated in Fig. 6, where I_H is the holding current value, reduction below which turns-off device F causing the generation of the high voltage pulse in the waveform V_x . It will be seen that because the turn-off is late in the half cycle, there is a combination of heating current and pulsing in this phase.

The third phase occurs as C3 charges still further so that TR2 comes on increasingly early in the conduction period of device F. If it does so when the main current is below 200mA, device F is caused to unlatch immediately so high voltage pulsing occurs early in the positive half cycle as seen in Fig. 7. In this phase there is no significant heating current.

Finally when the voltage on C3 is high enough to in effect block any significant discharging (or negative charging) of C4, then TR2 remains on all the time and no current flows in device F. The starter is then in its quiescent or timed-out phase.

The advantage of two phases of high voltage pulsing - one with heating current still applied and one without, is that under normal conditions the lamp will start as soon as the high voltage pulses start, but a

lamp which is not sufficiently warm at this stage will continue to heat and start later in the second phase or if necessary in the third. The starter is thus adaptive i.e. the start time adapts in length of operation to the requirements of the particular lamp.

Another advantage of this method of timing the starter is that when a lamp runs in the normal way, the voltage to which C3 must charge to make the start action cease is the comparatively low voltage of the lamp. Thus if the lamp extinguishes, eg. because of a short break in the supply, the start action described above will recommence and the lamp will restart. Starters of the kind shown in Fig. 1 cannot do this as they require a finite resetting time. Variations of the basic circuit of Fig. 3 will now be described.

The principle of operation is the same as already described but there are practical advantages and disadvantages to various ways of achieving the charge pumping action of the two capacitors, C3 and C4 to provide the desired starter circuit timing.

In contrast to the embodiments so far discussed, Fig. 8 shows C4 connected to the opposite terminal of C3. C4 is connected directly between the points X and Y through the diode D5 to be charged in negative half-cycles. As before, C4 is subject to large excursions of negative voltage, whilst C3 charges in smaller increments which accumulate over a number of cycles. The charge from C4 empties into C3 between successive negative charging half-cycles through the cathode circuit of the Fluoractor F.

Figs. 9 and 10 show alternative connections of the electrode of capacitor C4 remote from C3 which leads to the Y terminal. These alternatives have advantages in providing greater stability in the timed out or quiescent condition. In Fig. 9 the capacitor C4 is connected to the Y side of the starter circuit via the Zener diode Z1; in Fig. 10 it is connected to the Fluoractor gate G and hence to the Y side of the circuit through internal resistance (not shown) in the gate-cathode path of the Fluoractor F and the diode 21. These alternative connections of C4 can apply to circuits based on Fig. 3 or Fig. 8.

Fig. 11 shows the Darlington Transistor TR2 to be replaced with a Field Effect Transistor (FET) TR1 in the circuit of Fig. 3. The FET TR1 can be substituted for the bipolar transistor TR2 generally in the various circuits that have been described.

In the basic circuit of Fig. 3, capacitors C3 and C4 need a voltage rating equal to the peak mains voltage. Fig. 12 shows a circuit in which this requirement is eased. A resistor R16 of relatively high value is placed in series with D5 to provide a voltage drop because of the current in R15 and the charging current in C3 and C4. This resistor also has the effect of reducing the negative maximum voltage at the base of transistor TR2. Also, in the circuit of Fig. 3, diode D5 must have a very high PIV rating (2000V), but if it, as well as the Fluoractor gate circuit, is fed through R1, with an extra

diode D6 connecting R1 to the gate of device F, the PIV rating of D5 can be reduced to 400V. It will be noted that diode D1 is now placed separately in the anode circuit of the Fluoractor. The table of Fig. 13 shows suitable values for the starter circuit of Fig. 12. These values provide an initial start time (until the first high voltage pulse) of approximately 0.3 seconds and a total start time until time-out of approximately 0.75 seconds.

Claims

1. A starter circuit of the half-wave (rectifying) type for controlling the flow of heating current in, and generation of ignition pulses for, a heated cathode type of discharge lamp connected in series with a ballast inductor to an alternating current supply, the starter circuit including a timing circuit for causing the starter circuit to enter a quiescent mode if the discharge lamp fails to ignite, and the timing circuit including a first capacitor for receiving increments of charge over a succession of supply cycles to cause entry into said quiescent mode in the absence of ignition of the discharge lamp, characterised by: a second capacitor and rectifier means connected to charge the second capacitor in supply half-cycles of the opposite polarity to those in which the starter circuit is normally operative, and said first and second capacitors being connected in a charge pump circuit to transfer an increment of charge from the second to the first capacitor following each charging of the second capacitor.

2. A starter circuit of the half-wave (rectifying) type for controlling the flow of heating current in, and generation of ignition pulses for, a heated cathode type of discharge lamp connected in series with a ballast inductor to an alternating current supply, the starter circuit comprising terminals for connection to the discharge lamp, a gate-controlled thyristor device in a main current path between the terminals, half-wave rectifier means to ensure the thyristor device is triggered on supply cycles of one polarity only; and a gate control circuit for the thyristor device including a timing circuit for causing the starter circuit to enter a quiescent mode if the discharge lamp fails to ignite, said timing circuit including a first capacitor for developing a bias voltage on reaching a predetermined value of which said quiescent mode is entered, characterised by:

a second capacitor and rectifier means connected between said terminals to charge the capacitor on supply half-cycles of the opposite polarity to said one polarity and said first and second capacitors being interconnected to transfer a

portion of the charge developed on said second capacitor in one supply half-cycle to the first capacitor on the succeeding half-cycle to increment the voltage on the first capacitor towards said predetermined value.

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3. A starter circuit as claimed in Claim 2 in which said thyristor device is a fluorescent lamp electronic starter switch device (such as a Fluoractor).

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4. A starter circuit as claimed in Claim 2 or 3 in which said gate control circuit comprises a controllable switch device connected to the gate of the thyristor device and operable when turned on to divert current from the gate, said switch device having a control terminal to which said timing circuit is connected to apply said bias voltage thereto, said bias voltage acting to turn on the switch device on reaching said predetermined value.

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5. A starter circuit as claimed in Claim 4 in which said first and second capacitors are connected in series with a diode between said terminals, and the control terminal of said switch device is connected to a circuit point intermediate said capacitors.

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6. A starter circuit as claimed in Claim 5 in which means are connected in the cathode circuit of said thyristor device to develop a predetermined voltage during conduction of the thyristor device, said means in the cathode circuit being connected to said control terminal.

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7. A starter circuit as claimed in Claim 5 or 6 in which the electrode of said second capacitor remote from said first capacitor is connected directly to one terminal of the starter circuit.

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8. A starter circuit as claimed in Claim 6 in which the electrode of said second capacitor remote from said first capacitor is connected to a circuit point intermediate the cathode of said thyristor device and means in the cathode circuit.

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9. A starter circuit as claimed in Claim 5 or 6 in which the electrode of said second capacitor remote from said first capacitor is connected to the gate of said thyristor device.

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10. A starter circuit as claimed in any one of Claims 5-9 in which said first capacitor is connected to an intermediate point of a resistive divider arrangement in series with said diode between the terminals of the starter circuit.

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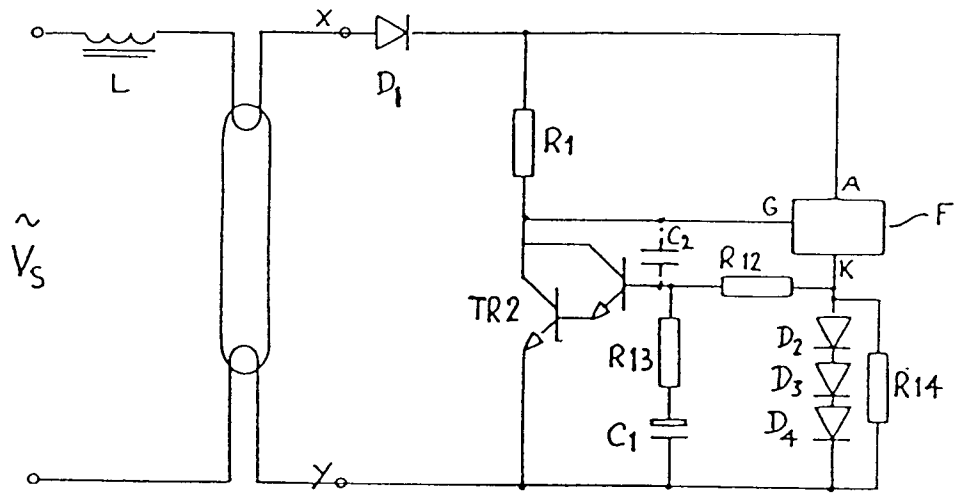


FIG 1

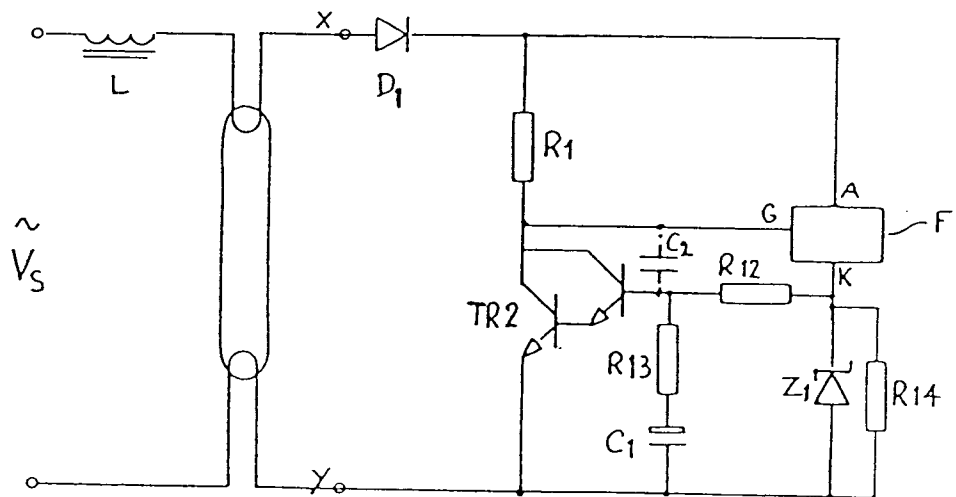


FIG 2

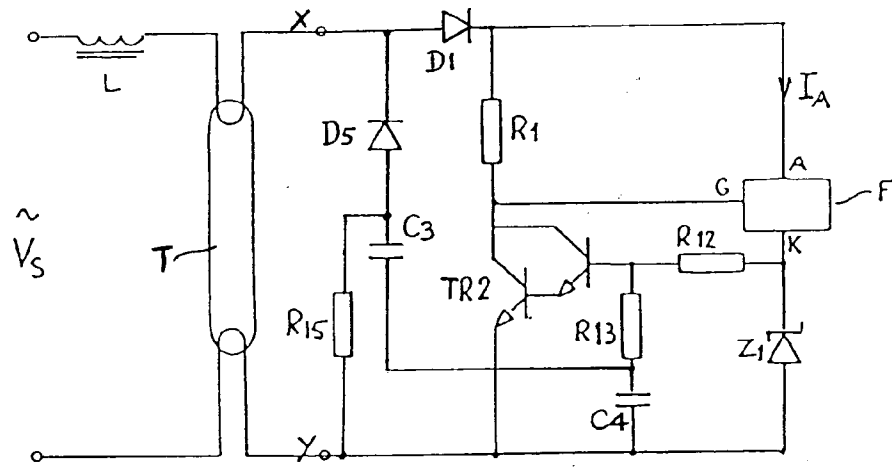


FIG 3

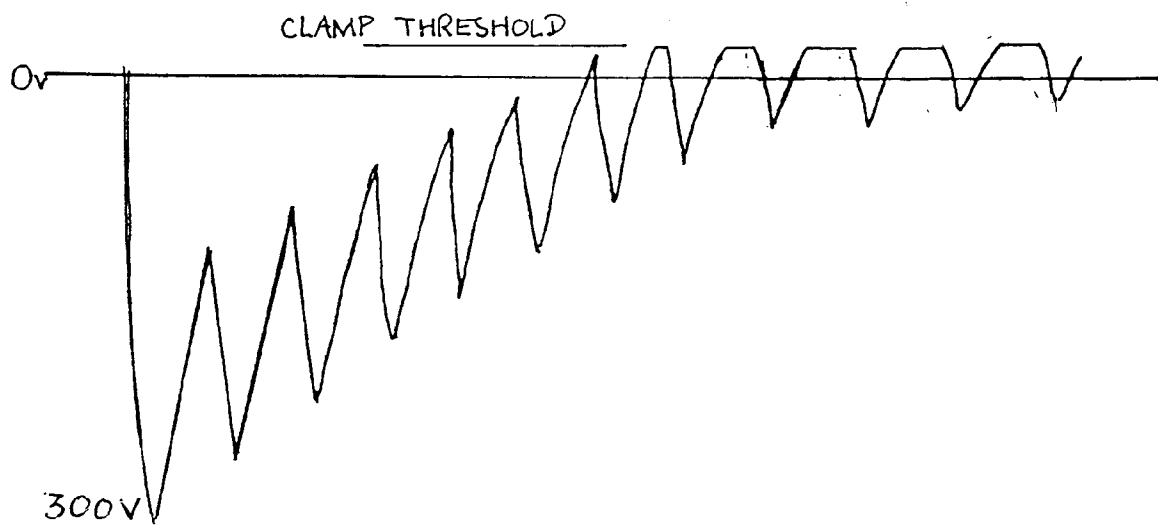
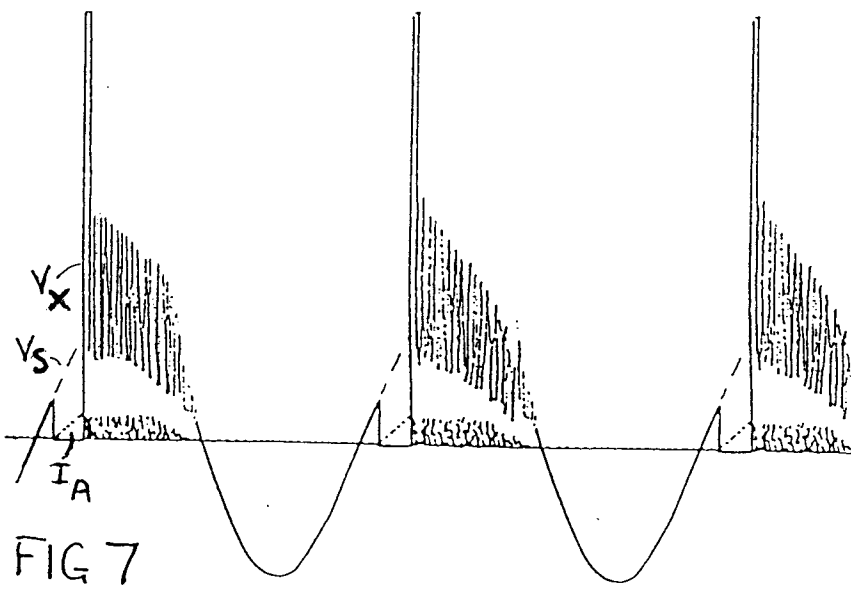
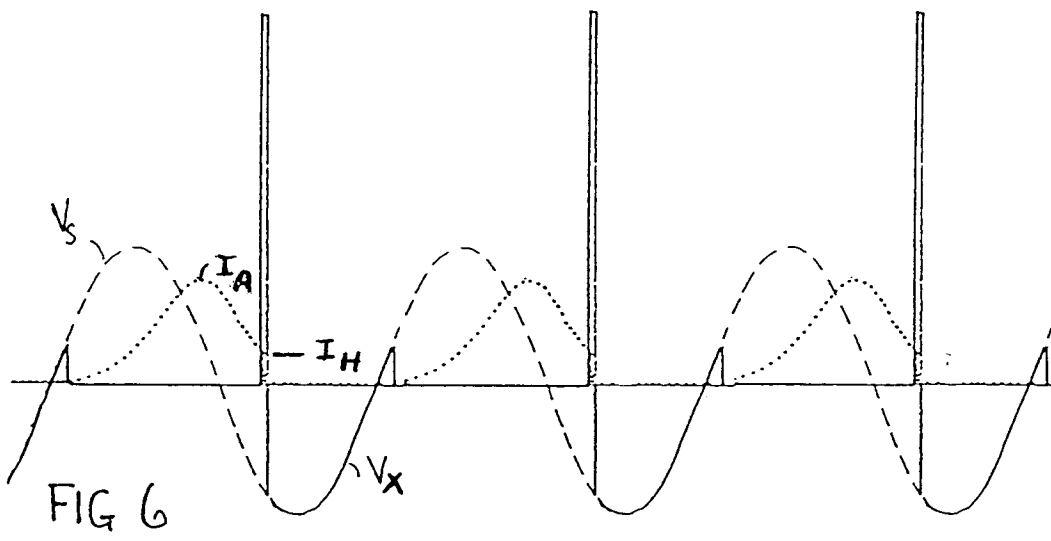
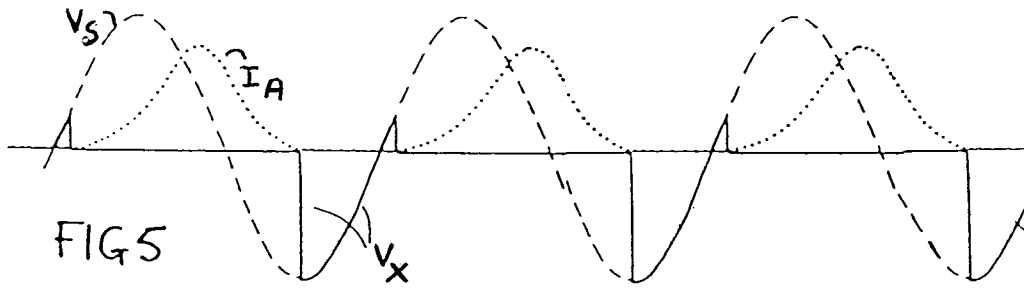


FIG 4



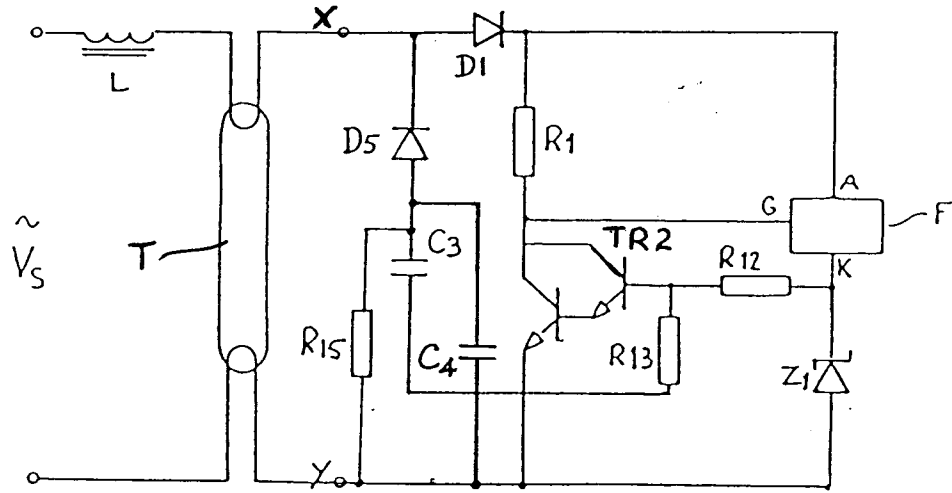


FIG 8

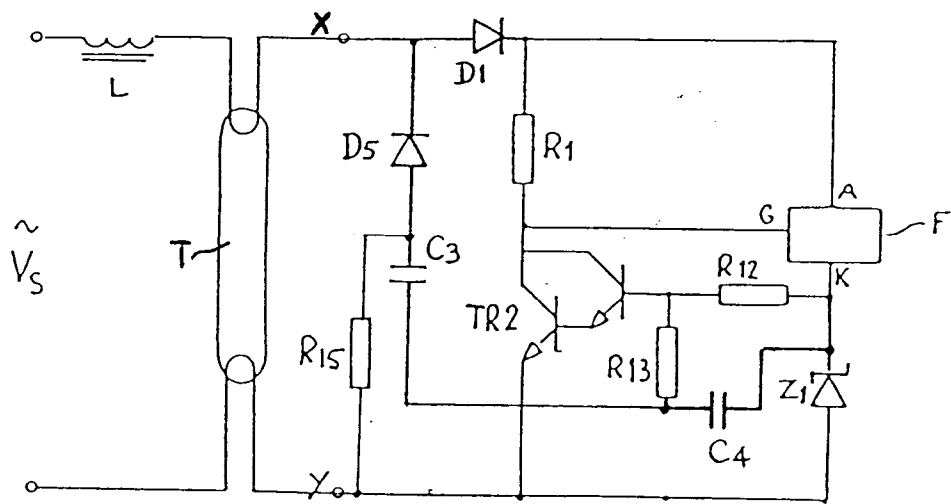


FIG 9

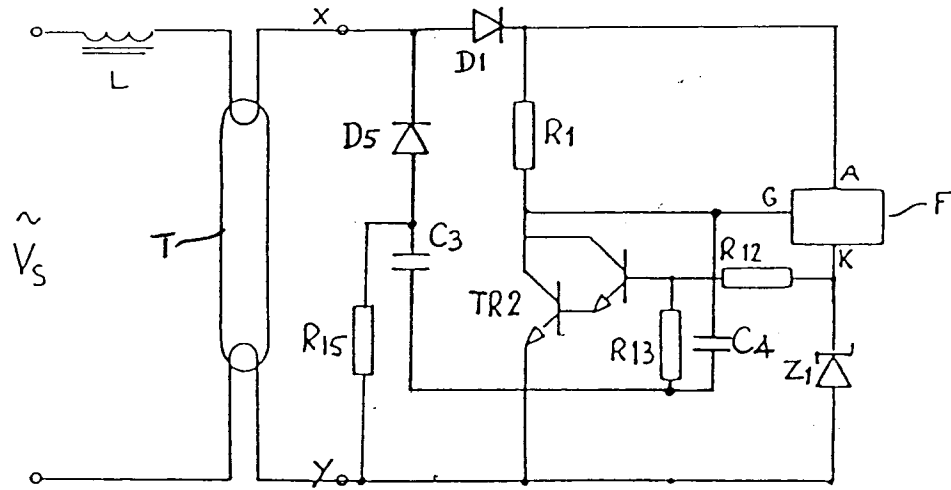


FIG 10

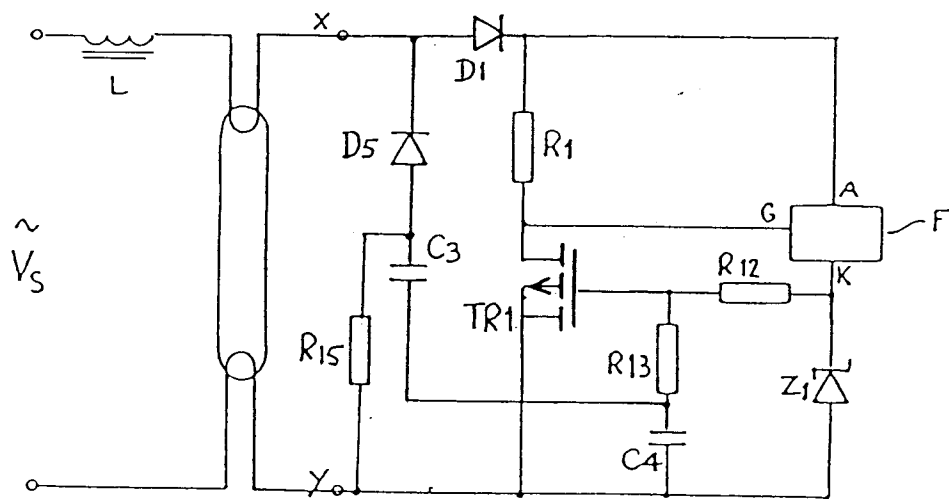


FIG 11

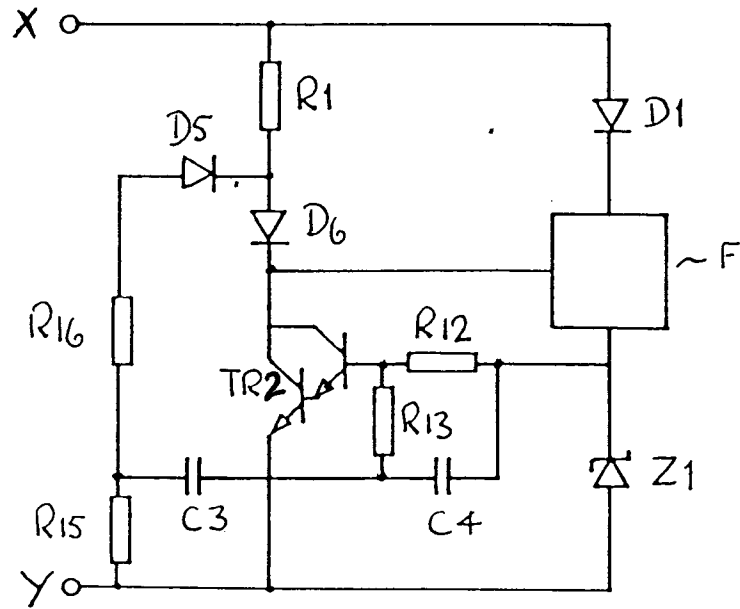


FIG 12

REF	VALUE	REF	VALUE
R1	68K	R16	1M2
R12	390K	C3	•022 μ F
R13	2M2	C4	•1 μ F
R15	4M7	Z1	4•7v

FIG 13



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 30 5744

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 170 528 (MARTIN) * page 6, line 8 - page 7, line 25; figures 1,2 * ---	1, 2, 5, 8-10	H05B41/04
A	EP-A-0 333 359 (THORN) * column 5, line 57 - column 6, line 27; figure 1 * ---	1-4, 6	
A	EP-A-0 407 170 (MOTOROLA) * abstract; figure 1 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H05B
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 02 SEPTEMBER 1992	Examiner SPEISER P.
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