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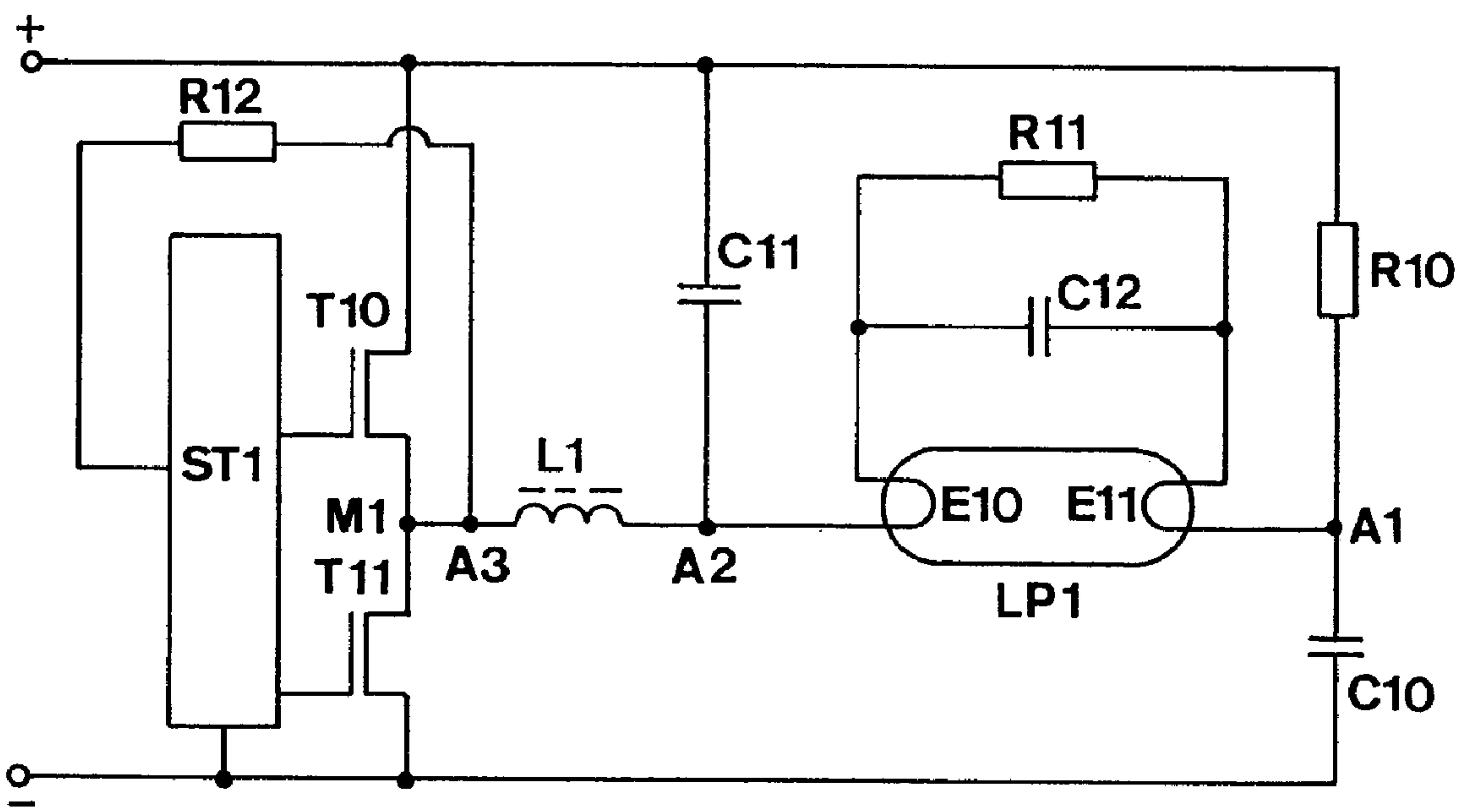
(54) Titre : CIRCUIT DE FONCTIONNEMENT POUR AU MOINS UNE LAMPE A DECHARGE BASSE PRESSION, NOTAMMENT POUR UNE LAMPE FLUORESCENTE OU PLUS; METHODE DE FONCTIONNEMENT DE SECURITE
(54) Title: OPERATING CIRCUIT FOR AT LEAST ONE LOW-PRESSURE DISCHARGE LAMP, ESPECIALLY FOR ONE OR MORE FLUORESCENT LAMPS, AND METHOD OF SAFE OPERATION



(57) Abrégé/Abstract:
To prevent operation of an inverter starting and oscillation control circuit for one or more fluorescent lamps (LP1; LP4; LP5; LP6; LP20, LP21; LP30, LP31) if electrode filaments (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) of any one of the lamps should be broken, a high-resistance d-c path is provided which connects the energy supply source with the control circuit (ST1; ST2; ST3; RK4b, C43; RK5b, RK5c; C54; L6c, C67) for the inverter circuit, so that, if one of the electrodes (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) should be broken, oscillation of the inverter, typically a half-bridge transistor or MOSFET circuit, is prevented. The circuit is particularly suitable to operate compact fluorescent lamps in which the operating voltage is in excess of the input voltage supplied to the inverter, and which requires resonant voltage enhancement during operation, and after ignition.

ABSTRACT OF THE DISCLOSURE

To prevent operation of an inverter starting and oscillation control circuit for one or more fluorescent lamps (LP1; LP4; LP5; LP6; LP20, LP21; LP30, LP31) if electrode filaments (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) of any one of the lamps should be broken, a high-resistance d-c path is provided which connects the energy supply source with the control circuit (ST1; ST2; ST3; RK4b, C43; RK5b, RK5c; C54; L6c, C67) for the inverter circuit, so that, if one of the electrodes (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) should be broken, oscillation of the inverter, typically a half-bridge transistor or MOSFET circuit, is prevented. The circuit is particularly suitable to operate compact fluorescent lamps in which the operating voltage is in excess of the input voltage supplied to the inverter, and which requires resonant voltage enhancement during operation, and after ignition.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

"OPERATING CIRCUIT FOR AT LEAST ONE LOW-PRESSURE DISCHARGE LAMP, ESPECIALLY FOR ONE OR MORE FLUORESCENT LAMPS, AND METHOD OF SAFE OPERATION"

Reference to related publication:
German DE 43 03 595 A1,
the disclosure of which is contained in
U.S. Serial 08/186,825, filed January 26, 1994, Reiser
(attorney docket 930716-shf, GR 93P5508 US), abandoned.

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FIELD OF THE INVENTION

The present invention relates to an operating circuit for one discharge lamp, or a plurality of discharge lamps, typically fluorescent lamps, from a source of d-c electrical energy, for example obtained from a rectifier coupled to an a-c power network, and especially to a circuit to operate compact fluorescent lamps or miniature fluorescent lamps.

BACKGROUND

Various circuits have been proposed to operate compact fluorescent lamps, and miniature fluorescent lamps, in which operating voltage is derived from a d-c source which, then, is coupled to an inverter which provides a-c energy for the lamp itself at an operating voltage which is in excess of that generated by the inverter itself. Such circuits used the principle of resonance voltage enhancement not only to generate the required ignition voltage for the discharge lamp, but also to provide operating voltage therefor.

The referenced publication, German Patent Disclosure Document DE 43 03 595 A, describes a circuit which has an inverter to which an inductance - capacitance (LC) circuit is coupled. The LC circuit forms a resonant output circuit, in which a compact fluorescent lamp is connected. The lamp has filamentary electrodes. Reactive impedances are coupled in parallel to the filaments of the lamp, which prevent excessive current flow through the filaments and hence excessive heating of the electrodes during the electrode preheat phase, as well as high damping of the resonant circuit during the ignition and operating phase. The circuit as described operates even if a lamp electrode has failed, for example is broken, since the resonant circuit is not interrupted by the defective lamp electrode.

For safety reasons, and under some conditions, it is undesired to permit the lamp to start and then to operate with a broken filament, since it may lead to excessive heating of components of the lamp, as well as possible destruction of the operating circuit.

THE INVENTION

It is an object to provide a circuit to operate one or more low-pressure discharge lamps, especially compact fluorescent lamps and miniature fluorescent lamps, which will not operate upon re-energization, when an electrode filament has failed.

Briefly, a high resistance d-c circuit path is provided which couples the control circuit for the oscillation circuit, incorporated in the inverter, to the source of energy. This high-resistance circuit path includes the filaments of the electrodes of the lamp, or lamps. Thus, upon failure of any one of the filaments of the electrodes of the lamp, or lamps, the d-c circuit path will be interrupted, thereby disabling the oscillation control circuit and one or more semiconductor circuit elements thereof. As soon as operating energy is removed from the circuit, the inverter will fail to oscillate and will not start anymore in oscillation, even if the operating energy is reestablished, since there will be no control signal to the inverter circuit anymore.

In general, the filaments of the electrodes of the fluorescent lamps are integrated into the high-resistance d-c circuit. More than one such circuits may be provided. Under normal operation, and as soon as the supply voltage is turned ON, the high-resistance d-c path ensures that the control circuit for the inverter becomes active, causing the inverter to oscillate. The lamp electrodes, typically formed as coiled filaments, are so connected into the d-c circuit path that, if any one of the lamp filament breaks, the inverter will no longer start to oscillate if, after disconnection, it is reconnected and again turned ON. The high-resistance d-c circuit path requires addition of only few electrical or electronic components, so that the entire circuit can be placed within the base of a compact fluorescent lamp.

Low-pressure discharge lamps, hereinafter for short fluorescent lamps, are usually operated from a-c network supply terminals. The a-c network voltage is rectified, to supply energy to the inverter. Typically, the inverters are half-bridge controlled semiconductor inverters having one or more, if more, parallel connected, LC output circuits, in which the fluorescent lamp or lamps are electrically integrated. If the inverter has only a single LC output circuit in which one or more serially connected fluorescent lamps are connected, then preferably, the circuit has only a single high-resistance d-c path. This d-c path connects, for example, the positive terminal of a d-c source, for example the output from the rectifier, with the control circuit of the inverter, the d-c path including the serially connected filaments of the electrodes of the fluorescent lamps. Upon breakage of any one of the filaments, the high resistance d-c path is interrupted, and the inverter can no longer begin to oscillate when the supply voltage is reestablished, after disconnection.

The inverter may have a plurality of parallel connected LC output circuits, which are connected to one or more serially connected fluorescent lamps. In such a circuit arrangement, as many d-c circuit paths as there are LC output circuits are preferably provided. Each one of the high-resistance d-c paths then has a series circuit of lamp filaments connected in the associated respective LC output circuit of the fluorescent lamp or lamps. The high-resistance d-c paths, then, may start from for example the positive terminal of the d-c supply, connected to the input of an AND-gate, the output of which, in turn, is connected to the control circuit of the inverter. This ensures that upon interruption of any one of the d-c paths, for example due to a defective lamp electrode, the inverter cannot start to oscillate when being reconnected to a source of electrical energy.

DRAWINGS

Fig. 1 is a highly schematic diagram of the circuit in accordance with the present invention, omitting all elements not necessary for an understanding of the present invention;

Fig. 2 is a schematic diagram to operate two serially connected fluorescent lamps;

Fig. 3 is a schematic diagram to operate two parallel connected fluorescent lamps;

Fig. 4 is a schematic, somewhat more detailed, diagram of the circuit of Fig.1 having pre-heated lamp electrodes, and a freely oscillating inverter under current feedback control, started by means of a DIAC;

Fig. 5 is a schematic diagram of a fluorescent lamp circuit having electrodes that are not preheated and using a freely oscillating inverter under current feedback control without starting by a DIAC; and

Fig. 6 is a circuit for a compact fluorescent lamp of about 23 W nominal rating for operation from a network voltage of about 120 V.

DETAILED DESCRIPTION

Referring first to Fig. 1:

An inverter which includes two transistors T10, T11, for example MOSFETs, is connected in form of a half-bridge circuit, energized by a d-c source, schematically indicated by plus and minus symbols. The inverter is controlled into oscillation by a control circuit ST1. The common connection M1 of the half-bridge inverter formed by transistors T10, T11 is coupled to an LC output circuit formed by capacitor C11 and inductance L1. The LC elements form a resonant circuit. The resonance capacitor C11 is connected to the resonance inductance L1 and to the positive terminal of the d-c energy source. The circuit also includes a coupling capacitor C10 which is connected both to the negative terminal of the energy source and to a junction A1, and then through a resistor R10 to the positive terminal of the d-c energy source. The low-pressure discharge lamp LP1, typically a fluorescent lamp, is connected between junctions A1 and A2. Junction A2 is formed by the junction between capacitor C11 and inductance L1.

The electrodes E10, E11 of the lamp LP1 are filaments and have, each, two electrical terminals, as appears from Fig. 1. One terminal of filaments E10, E11 is connected, respectively, to the junctions A1 and A2. The second terminals of the filaments E10, E11 are, respectively, connected to a terminal of the ignition capacitor C12, and to respective terminals of a parallel connected capacitor R11, so that both the ignition capacitor C12 as well as the resistor

R11 are connected in parallel to the discharge path of the lamp LP1.

In accordance with a feature of the invention, an ohmic galvanic high-resistance path is formed by an additional resistor R12 which is connected to junction A3 and hence to the center terminal M1 between transistors T10, T11 and the inductance L1 and, further, is coupled to the control circuit ST1.

Basic Operation:

Assume lamp LP1 is in normal operating condition: The half-bridge inverter T10, T11 will start to oscillate as soon as a connection to the energy supply plus and minus is established. By resonant voltage enhancement at ignition capacitor C12, the necessary ignition voltage will be available for ignition of the lamp LP1, and the lamp will fire without preheating of the lamp electrodes. During operation, a high-frequency alternating current will flow between the junctions M1 and A1 over the discharge path of the lamp. Typically, this high-frequency current has a frequency in the range of between about 20 kHz to 200 kHz. As seen in Fig. 1, the resonant circuit L1, C11 will form a closed circuit even if lamp L1 should be missing, since the lamp electrodes are not integrated in the resonant circuit. The half-bridge inverter, thus, could provide operating voltage even if the lamp were missing, or defective.

Operation in accordance with the invention:

The d-c path: resistor R10 - filament E11 - resistor R11 - filament E10 - resonance inductance L1 -

resistor R12, all galvanically d-c connected in series, forms a d-c connection between the positive terminal of the energy supply source and the input to the oscillating control circuit ST1. After the supply circuit is energized, supply of control signals or control voltage to the control system ST1 will be over the d-c path, to permit oscillation of the half-bridge inverter including transistors T10, T11. If, in operation, one of the filaments should break, the lamp will continue to operate and the inverter, once started, will continue to provide a-c supply voltage to the lamp. However, as soon as the energy supply is turned OFF, new re-energization of the energy supply will not permit the inverter to commence oscillating, since the d-c path to the oscillation control circuit ST1 is interrupted. No voltage will be supplied to the control circuit ST1, thus inhibiting the inverter transistors T10, T11 from beginning to oscillate. Of course, if the lamp should be removed from the circuit, again, the inverter could not start upon re-energization.

The invention is equally applicable for a plurality of low-pressure discharge lamps. Fig. 2 illustrates application of the invention to a circuit having two fluorescent lamps LP20, LP21, which are serially connected and which, also, have a preheating circuit for the respective electrodes.

The circuit of Fig. 2 has two field effect transistors (FETs) T20, T21 connected in an inverter circuit, supplied from a source of d-c energy, and controlled to oscillate by an oscillating control circuit ST2. The center junction M2 of the inverter, including the transistors T20, T21, is connected, over an LC output circuit through a coupling capacitor C20. The coupling capacitor C20 is connected to the resonance inductance L20, electrode filament E23 of fluorescent lamp LP21, resonance capacitor C21, electrode filament E20 of the fluorescent lamp LP20, and back to the positive terminal of the d-c source.

In accordance with a feature of the present invention, a d-c path is provided: positive terminal of the d-c source - the electrode filament E20 of the low-pressure discharge lamp LP20 - resistors R21, R22 - electrode filament E21 of low-pressure discharge lamp LP20 - inductance L21, inductively coupled to the resonance inductance L20 - the filament of electrode E22 of the low-pressure discharge lamp LP21 - resistors R23 and R24 - the filament of electrode E23 of the low-pressure discharge lamp LP21 - resonance inductance L20 - resistor R20 to the input of the oscillation control circuit ST2.

The circuit, further, includes a capacitor C23 which is connected to the negative terminal of the d-c source and further to the resonance inductance L20, and to one terminal of the filament of electrode E23. A heating capacitor C22, together with the electrode filaments E21, E22 and the secondary winding L21, forms a closed a-c circuit, and provides for preheating of the lamp electrodes E21, E22 by high-frequency alternating current, induced in the secondary winding L21.

If, due to malfunction for example, there is failure of any one of the filaments of the lamp electrodes E20, E21, E22, E23, then, in accordance with the invention, the d-c connection to the control circuit ST2 will be interrupted, and renewed reconnection of the supply voltage at terminals plus and minus will prevent oscillation of the inverter which includes the transistors T20, T21.

Fig. 3 illustrates the principle of the present invention for two parallel connected low-pressure discharge lamps, LP30, LP31.

The half-bridge inverter includes two FETs T30, T31, controlled to oscillation by an oscillation control circuit ST3. The center junction M3 of the inverter T30, T31 is connected to two parallel LC output circuits, one for each one of the fluorescent lamps LP30, LP31. The first LC output circuit includes a coupling capacitor C30, the resonance inductance L30, and capacitors C32, C33, which, effectively, are operating in parallel. The fluorescent lamp LP30 is connected in parallel to the resonance capacitors C32, C33.

The second LC output circuit includes the coupling capacitor C31, the resonance inductance L31 and the effectively parallel connected resonance capacitors C34, C35. The second fluorescent lamp LP31 is connected in parallel to the resonance capacitors C34, C35.

In accordance with a feature of the invention, an AND-gate U is provided, the output of which is connected to the input of the oscillation control circuit ST3. The input to the AND-gate U is connected to two high-resistance d-c paths, which are connected between the positive terminal of the current supply source and an input to the AND-gate U. The first high-resistance d-c path includes: the filament of electrode E30 of lamp LP30 - resistors R34, R35 connected in parallel to the capacitor C33 and to the discharge path of lamp LP30 - the filament of electrode E31 - the resonance inductance L30 - junction A4 - resistor R30 - junction A6 - one input to AND-gate U. Junction A4 is also connected through capacitor C30 to the center junction M3.

The second high-resistance d-c path is formed by: the filament of electrode E32 of lamp LP31 - resistors R36, R37 connected in parallel to capacitor C35 and to the discharge path of lamp LP31 - the filament of electrode E33 - resonance inductance L31 - junction A5 - resistor R32 - junction A7 - another input to AND-gate U. Junction A5 is connected through capacitor C31 to junction M3, so that the coupling capacitor C31 is serially integrated with the resonance inductance L31. The resistors R31, R33 are, respectively, connected between the junctions A6, and A7, and then to the negative terminal of the d-c energy supply source. Junctions A6, A7 form the inputs to the AND-gate U.

<u>Operation, circuit of Fig.3:</u>

Upon energization, that is, connection of the energy source at terminals plus and minus, the two parallel connected d-c paths and the AND-gate U form a d-c supply connection between the positive terminal of the energy source and the control circuit ST3, causing the inverter including transistors T30, T31 to oscillate, and hence operate the lamps. If, however, any one of the two d-c paths are interrupted, for example by break of any one of the filaments of the electrodes E30, E31, or E32, E33, respectively, renewed energization of the circuit from the supply source plus and minus will be inhibited since the oscillation control circuit ST3 will not receive operating energy through AND-gate U, thus preventing oscillation of the oscillatory half-bridge inverter circuit including the transistors T30, T31.

Fig. 4 illustrates another embodiment of the invention, in combination with a preheat circuit for the lamp LP4. The inverter is a freely oscillating current feedback half-bridge oscillator with transistors Q40, Q41. The filaments E40, E41 of lamp LP4 are constructed as preheatable filamentary electrodes. The circuit has two bi-polar transistors Q40, Q41 connected as a half-bridge inverter circuit, fed by a d-c current source. The center tap M4 of the half-bridge inverter formed by transistors Q40, Q41 is coupled to an LC output circuit formed by the primary winding RK4a of a toroidal transformer RK4, a resonance inductance L4 and a resonance capacitor C42. The resonance capacitor C42 is coupled with one of its terminals to the positive source of the d-c energy supply. The circuit in accordance with Fig. 4 additionally has two serially connected coupling capacitors C40, C41 coupled to a central junction A8. The coupling capacitor C40 is connected to the collector of the bi-polar transistor Q40 and to the positive terminal of the d-c supply source. The coupling capacitor C41 is connected to the emitter of the bi-polar transistor Q41 and with the negative terminal of the d-c energy supply. The low-pressure discharge lamp LP4 is connected between the center junction A8 and the junction A9, which is positioned in the LC output circuit between the resonance inductance L4 and the resonance capacitor C42, so that the lamp is included and integrated in the circuit.

Ignition and preheat capacitors C44, C45 are serially connected and have a common junction V1. They are connected in parallel across the discharge path of the lamp LP4 to form a parallel circuit. In parallel to the two capacitors C44, C45 is a resistor series circuit formed by an ohmic resistor R43 and a positive temperature coefficient (PTC) resistor KL4. The two ignition capacitors C44, C45 and the resistors R43, KL4 have their central junctions V1, V2 connected together.

The oscillation control circuit for the inverter is, essentially, formed by the toroidal transformer RK4, the primary winding RK4a of which is connected in the LC output circuit. It has two secondary windings, RK4b and RK4c, which, respectively, are connected through resistors R40, R41 to the bases of the transistors Q40, Q41. A start circuit is provided, formed essentially by a DIAC DC4, a capacitor C43 and a diode D4.

In accordance with a feature of the present invention, a high-resistance d-c path is provided which prevents starting of oscillations of the half-bridge inverter transistors Q40, Q41 if one of the lamp electrodes should be defective by forming an open circuit. This d-c path controls charging of capacitor C43. It starts from the positive terminal of the energy supply source - resistor 44 - one terminal C43a of capacitor C43 - the other terminal C43b of capacitor C43 - center junction M4 - primary winding RK4a - inductance L4 - filament of electrode E40 - resistors R43 - PTC resistor KL4 - filament of electrode E41 - junction A8 - ohmic resistor R42 which is connected in parallel to the coupling capacitor C41 - negative terminal of the d-c current source. All elements of the high-resistance d-c circuit are serially connected.

All the above elements of the high-resistance d-c path, supplying the capacitor as a single chargeable element, are serially connected.

Operation

Let it be assumed that the electrodes E40, E41 are in order. Upon energization, the d-c path which includes the capacitor C43 permits charging of the capacitor C43. The DIAC DC4, thus, can provide trigger pulses to the base of the bi-polar transistor Q40, which triggers oscillations of the half-bridge inverter Q40, Q41. As soon as the inverter Q40, Q41 operates, capacitor C43 will discharge over diode D4 to such an extent that the DIAC DC4 will no longer generate trigger pulses applied to the base of the transistor Q40. The half-bridge inverter Q40, Q41 continues to oscillate and generates a high-frequency alternating current. Typical frequencies are between about 20 kHz to 200 kHz. This high-frequency current is applied between the center junctions M4, A8, and, first, forms a heating current for the filaments of the electrodes

E40, E41, and also flows through the heating capacitor C44 as well as over the cold conductor, or PTC resistor KL4. When the electrode preheating phase terminates, the PTC resistor KL4 becomes highly resistive, so that, with the assistance of the now effective ignition capacitor C45 and the LC output circuit, formed as a resonant circuit, the lamp LP4 will receive the requisite ignition voltage by resonant voltage enhancement.

Operation, in accordance with the present invention:

If the lamp LP4 is operating and becomes defective, e.g. one of the filaments of the electrodes E40, E41 breaks, then, starting from the center terminal M4, and over winding RK4a, L4, and capacitor C42, the collector of transistor Q40 will still be within a closed LC output circuit, so that the inverter Q40, Q41 would still be operative even with a broken filament. However, and in accordance with the present invention, the high-resistance d-c path is interrupted if the lamp is defective, by breakage in one of the filaments. Upon re-energization after disconnecting the circuit from the energy supply source, no charge will be applied to the capacitor C43 through the resistor 44, so that the capacitor C43 will not charge, and thus cannot provide trigger pulses for the DIAC DC4, and thereby start the transistor Q40 to oscillate. Consequently, the entire half-bridge inverter Q40, Q41 will not oscillate and, if the lamp is defective, the circuit will not operate and no high voltage will appear on the terminals of the lamp.

Embodiment of Fig. 5:

The circuit in accordance with the present invention is highly versatile, and Fig. 5 illustrates the circuit applied to a lamp LP5 operating as a cold start fluorescent lamp, that is, without preheating of the filaments.

The supply circuit has a freely oscillating current feedback inverter circuit, supplied by a d-c current source. The circuit includes two bi-polar transistors Q50, Q51 connected to a center junction M5. Junction M5 is connected over the primary winding RK5a of a toroidal transformer, coupling capacitor C50, a resonance inductance L5, and a resonance capacitor C51. Capacitor C51 is connected to the positive supply voltage, as is the collector of the transistor Q50. The low-pressure discharge lamp LP5 has an individual parallel circuit formed by resonance capacitor C52 and an ohmic resistor R50.

The control circuit for the half-bridge inverter formed by transistors Q50, Q51 is formed by the toroidal transformer RK5, the primary winding RK5a of which is connected in the LC output circuit of the inverter. The secondary windings RK5b, RK5c are connected to the bases of the respective transistors Q50, Q51, which include capacitors C53, C54 and parallel connected diodes D50, D51.

In accordance with the present invention, a high-resistance d-c path is established which connects the base of the bi-polar transistor Q51 to the energy source. This high-resistance d-c path can be traced as follows: Starting from the positive terminal of the d-c source - electrode E50 of lamp LP5 - resistor R50 - electrode E51 - resonance inductance L5 - ohmic resistor R51 - base of transistor Q51. The base of transistor Q51 is further connected to diode D51, the parallel capacitor C54 and the transformer winding RK5c. Diode D51, as can be seen from Fig. 5, is connected to the base Q51 in d-c blocking connection. An additional resistor is provided, namely a resistor R52, which connects the base of the first transistor Q50 to the positive terminal of the d-c source, to form a d-c connection for the base of transistor Q50.

Operation

Upon energization, the resistor R52 and the high-resistance d-c path cause the transistors Q50, Q51 to oscillate due to spurious disturbances, introduced by a switching pulse, line noise or the like. Consequently, the inverter Q50, Q51 will self-oscillate by the always present line noise on the plus and minus terminals. This noise is amplified by the positive feedback due to the secondary windings RK5b, RK5c, so that a first one of the two bi-polar transistors will become conductive, thus initiating oscillation of the inverter.

In accordance with the invention, if there is an interruption in the high-resistance d-c path, for example due to a break in one of the filaments of the electrodes E50 or E51, the base electrode of the transistor Q51 will not receive a control voltage upon re-energization of the circuit after it has been turned OFF, thus preventing oscillation of the inverter formed by transistors Q50, Q51 and the circuits connected thereto.

The dimensioning of the various components described above depends on the power rating of the lamp, and the energy supply, schematically indicated by the plus and minus symbols in the drawing.

Fig. 6 illustrates the complete embodiment of the circuit to operate a compact fluorescent lamp of, for example, 23 W power rating from a network supply of 120 V at 60 Hz. The components used for the circuit of Fig. 6 are listed in the table forming part of this specification.

The circuit has a freely oscillating half-bridge inverter formed by MOSFETs T60, T61 in a current feedback circuit. An electrolytic capacitor C60, connected to the output of a rectifier GL, provides the plus and minus d-c energy for the circuit. The rectifier GL is connected through a radio noise filter F and a fuse SI with the power supply. The center junction M6 of the half-bridge inverter formed by the MOSFETs T60, T61 is connected to an LC output circuit which, starting from the center terminal M6, is connected through the resonance inductance L6a and the resonance capacitor C61 to the drain connection of the MOSFET T60. A coupling capacitor C64 and a resonance capacitor C61 are connected in parallel to the discharge path of the lamp LP6.* Two parallel circuits are connected across the electrodes E60, E61, including a high-resistance resistor R60 and a PTC resistor KL6. The center junction V4 is connected to a center

*A high-resistance resistor R61 is connected in parallel to the coupling capacitor C64.

junction between two capacitors C62, C63, which form preheat and ignition capacitors. The center junctions V3, V4 between the capacitors C62, C63 and the resistors R60, KL6 are interconnected. In this respect the circuit is identical to the circuit of Fig. 4. The inverter formed by MOSFETs T60, T61 includes, essentially, two secondary windings L6b and L6c, inductively coupled to the resonance inductance L6a, and respectively, connected to the gate electrodes of the transistors T60, T61. In addition, the gate electrodes of the respective transistors are connected to a low-pass filter R63, C65 and R64, C66, respectively. A start circuit is provided which includes a DIAC DC6, capacitor C67 and a diode D6, as described in connection with Fig 4. The operation of the circuit likewise is similar to that described in connection with Fig. 4.

In accordance with a feature of the present invention, a high-resistance d-c path is provided which can be traced: starting from the positive terminal of the electrolytic capacitor C60 - filament of electrode E60 of lamp LP6 - resistor R60 - PTC resistor KL6 - filament of electrode E61 - resistor R61 which bridges the capacitor C64 - resonance inductance L6a - junction M6 - a further resistor R62 - terminal C67a of capacitor C67 - terminal C67b of capacitor C67 - negative terminal of the electrolytic capacitor C60. The resistor R62 is connected, further, to the center junction M6 between the transistors T60, T61.

Operation:

Upon first energizing the circuit by connecting it to a source of a-c supply, the inverter will receive d-c energy from the electrolytic capacitor C60. The start capacitor C67 is charged over the above-mentioned d-c path, so that the DIAC DC6 can supply trigger pulses to the gate of the transistor T61 and thus cause the half-bridge inverter T60, T61 to oscillate. After oscillation has started, starting capacitor C67 is discharged over the diode D6 to such an extent that no further trigger pulses will be derived from the DIAC DC6. The inverter T60, T61 supplies a high-frequency alternating current to the LC output circuit and hence to the lamp LP6 as well as the parallel circuits connected to the lamp LP6. Typical frequencies are between about 20 kHz and 200 kHz. First, current will flow through the filaments E60, E61, through the heating capacitor C62 and the PTC resistor KL6. This heating current is of high frequency. As the PTC resistor heats, its resistance increases, which terminates the preheating phase. The PTC resistor becomes very highly resistive so that, with the assistance of the now effective, that is, not essentially bridged, ignition capacitor C63 and the LC output circuit, the necessary ignition voltage for the lamp will be obtained by resonant voltage enhancement.

When the lamp LP6 has fired, a high-frequency current will flow over the discharge path of the lamp LP6 and a d-c current through the d-c path. The amplitude of this d-c current is less by two orders of magnitude than the a-c generated by the inverter, so that no interference with the operation of the lamp will result.

In accordance with the invention, if one of the filaments of the electrodes E60 or E61 should break, the above-described high-resistance d-c path is interrupted, since the electrodes E60, E61 are serially integrated in the d-c path. The lamp will continue to function so long as it is energized, even if a filament should break. Upon re-energizing the lamp, however, it will not be possible to start the lamp. Upon renewed connection of the circuit to ON, the starting capacitor C67 will not be charged, and thus no trigger pulses will be available from the DIAC DC6 for the gate of the transistor T61. Consequently, the half-bridge inverter T60, T61 will not start to oscillate.

Various changes and modifications may be made and the invention is not restricted to the above-described embodiments or examples. The d-c path can be provided in various circuit arrangements with different types of inverters, for example with full-bridge inverters or the like. It is also possible to incorporate the d-c path in single transistor blocking oscillators which can be used advantageously to operate low-pressure discharge lamps from low-voltage supply sources. Any features described in connection with any one of the embodiments, thus, can be used within the scope of the inventive concept, not only for the embodiments described but also in different circuits.

Suitable values for a circuit as shown in Fig. 6 are shown in the table below. Suitable values for circuits shown

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in Figs. 1 to 5 can then be derived by engineering knowledge, considering the power rating of the lamp involved and the voltage of the supply source.

R60, R61	100 KΩ
R62	220 KΩ
R63, R64	680 Ω
C60	47 μF
C61, C62	10 nF
C63	4.7 nF
C64	47 nF
C65, C66	6.8 nF
C67	100 nF
T60, T61	MOSFET, IRFU224
L6a	1.2 mH

According to one aspect of this invention there is provided operating circuit for operation of one (LP1; LP4; LP5; LP6) or more than one (LP20, LP21; LP30, LP31) low-pressure discharge lamp or lamps from a source of d-c electrical energy, having an inverter circuit coupled to said source and providing high-frequency a-c operating energy for said lamp or lamps, said inverter circuit including at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) connected in an oscillatory circuit; an inverter starting and oscillation control circuit (ST1; ST2; ST3; RK4b; C43; RK5b, RK5c; C54; L6c, C67) providing oscillation starting and maintenance control signals to at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61), said operating circuit comprising, in accordance with the invention, means for inhibiting application of starting and oscillation maintenance control signals to the at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) of the inverter circuit, said circuit means including at least one high-resistance d-c circuit path coupling the oscillation control circuit

(ST1; ST2; ST3; RK4b; C43; RK5b, RK5c; C54; L6c, C67) to the at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) of the inverter to said source, said high-resistance d-c path including all the filaments of the electrodes (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) of the lamp or lamps (LP1; LP4, LP5; LP6; LP20, LP21; LP30, LP31), whereby, upon failure of any one of the filament of the electrodes (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61), the d-c circuit path will be interrupted, thereby decoupling said oscillation control circuit (ST1; ST2; ST3; RK4b, C43; RK5b, RK5c; C54; L6c, C67) from the at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) and inhibiting oscillation upon reenergization of the operating circuit from the d-c energy supply.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. Operating circuit for operation of one (LP1; LP4; LP5; LP6) or more than one (LP20, LP21; LP30, LP31) low-pressure discharge lamp or lamps from a source of d-c electrical energy, having

an inverter circuit coupled to said source and providing high-frequency a-c operating energy for said lamp or lamps,

said inverter circuit including

at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) connected in an oscillatory circuit;

an inverter starting and oscillation control circuit (ST1; ST2; ST3; RK4b; C43; RK5b, RK5c; C54; L6c, C67) providing oscillation starting and maintenance control signals to at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61),

said operating circuit comprising, in accordance with the invention,

means for inhibiting application of starting and oscillation maintenance control signals to the at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) of the inverter circuit,

said circuit means including

at least one high-resistance d-c circuit path coupling the oscillation control circuit (ST1; ST2; ST3; RK4b; C43;

RK5b, RK5c; C54; L6c, C67) to the at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) of the inverter to said source,

said high-resistance d-c path including all the filaments of the electrodes (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) of the lamp or lamps (LP1; LP4, LP5; LP6; LP20, LP21; LP30, LP31),

whereby, upon failure of any one of the filament of the electrodes (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61), the d-c circuit path will be interrupted, thereby decoupling said oscillation control circuit (ST1; ST2; ST3; RK4b, C43; RK5b, RK5c; C54; L6c, C67) from the at least one semiconductor element (T10, T11; T20, T21; T30, T31; Q40, Q41; Q50, Q51; T60, T61) and inhibiting oscillation upon reenergization of the operating circuit from the d-c energy supply.

2. The circuit of claim 1, wherein the inverter circuit is a half-bridge inverter;

at least one LC output circuit being connected to the half-bridge inverter, said lamp or lamps (LP1; LP4, LP5; LP6; LP20, LP21; LP30, LP31) being connected in said LC output circuit;

wherein each of the electrodes (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) of the lamps include filaments;

wherein each of said filaments (E10, E11; E20, E21, E22, E23; E30, E31, E32, E33; E40, E41; E50, E51; E60, E61) is connected in series, in said high-resistance d-c path; and

wherein said high resistance d-c path provides a connection for the control circuit (ST1; ST2; ST3; RK4b, C43; RK5b, RK5c; C54; L6c, C67) of the inverter with the source of d-c energy.

3. The circuit of claim 1, wherein at least two serially connected low-pressure discharge lamps (LP20, LP21) are provided, connected in an LC output circuit from the inverter;

the electrodes (E20, E21, E22, E23) of the serially connected low-pressure discharge lamps (LP20, LP21) all being formed by filaments and serially connected in said high resistance d-c path; and

wherein the high-resistance d-c path connects the control circuit (ST2) of the inverter with the source of d-c energy.

4. The circuit of claim 1, wherein the inverter includes a plurality of parallel connected LC output circuits;

each LC output circuit includes at least one low-pressure discharge lamp (LP30, LP31);

one each high-resistance d-c circuit path being provided for each LC output circuit, in which the low pressure discharge lamp (LP30, LP31), or lamps, connected to the respective output circuits have all their electrodes formed as filaments, and serially connected in the respective high-resistance d-c paths;

an AND-gate (U) is provided, connecting the high-resistance d-c paths with the inputs to the AND-gate and to a voltage supply source; and

wherein the output of the AND-gate (U) is connected to the control circuit (ST3) for the inverter.

5. The circuit of claim 1, wherein the inverter is a half-bridge inverter.

6. The circuit of claim 1, wherein the inverter is a freely oscillating current feedback inverter.

7. The circuit of claim 1, wherein the inverter comprises an oscillation controlled inverter, controlling the oscillations thereof.

FETHERSTONHAUGH & CO.
OTTAWA, CANADA

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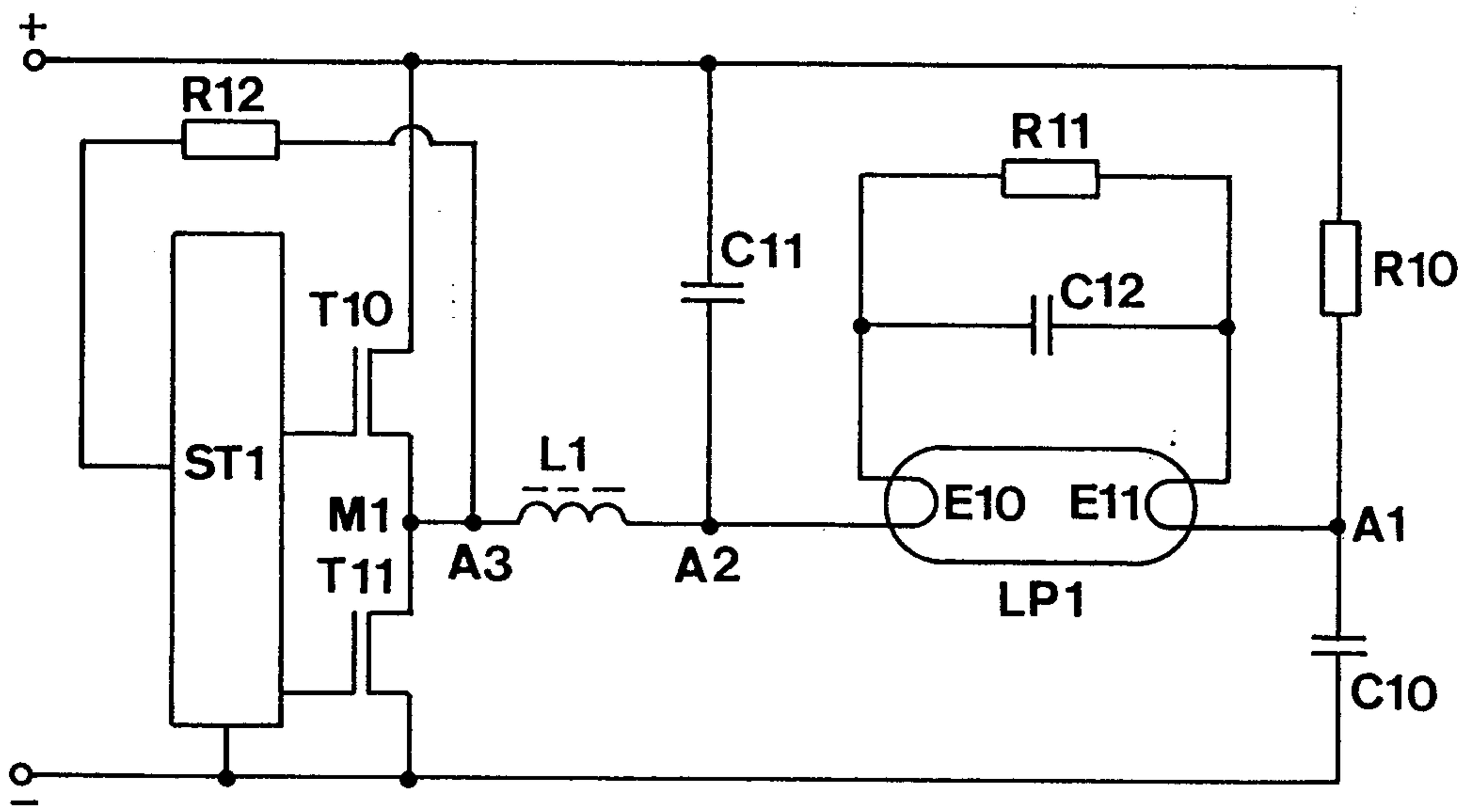

FIG. 1

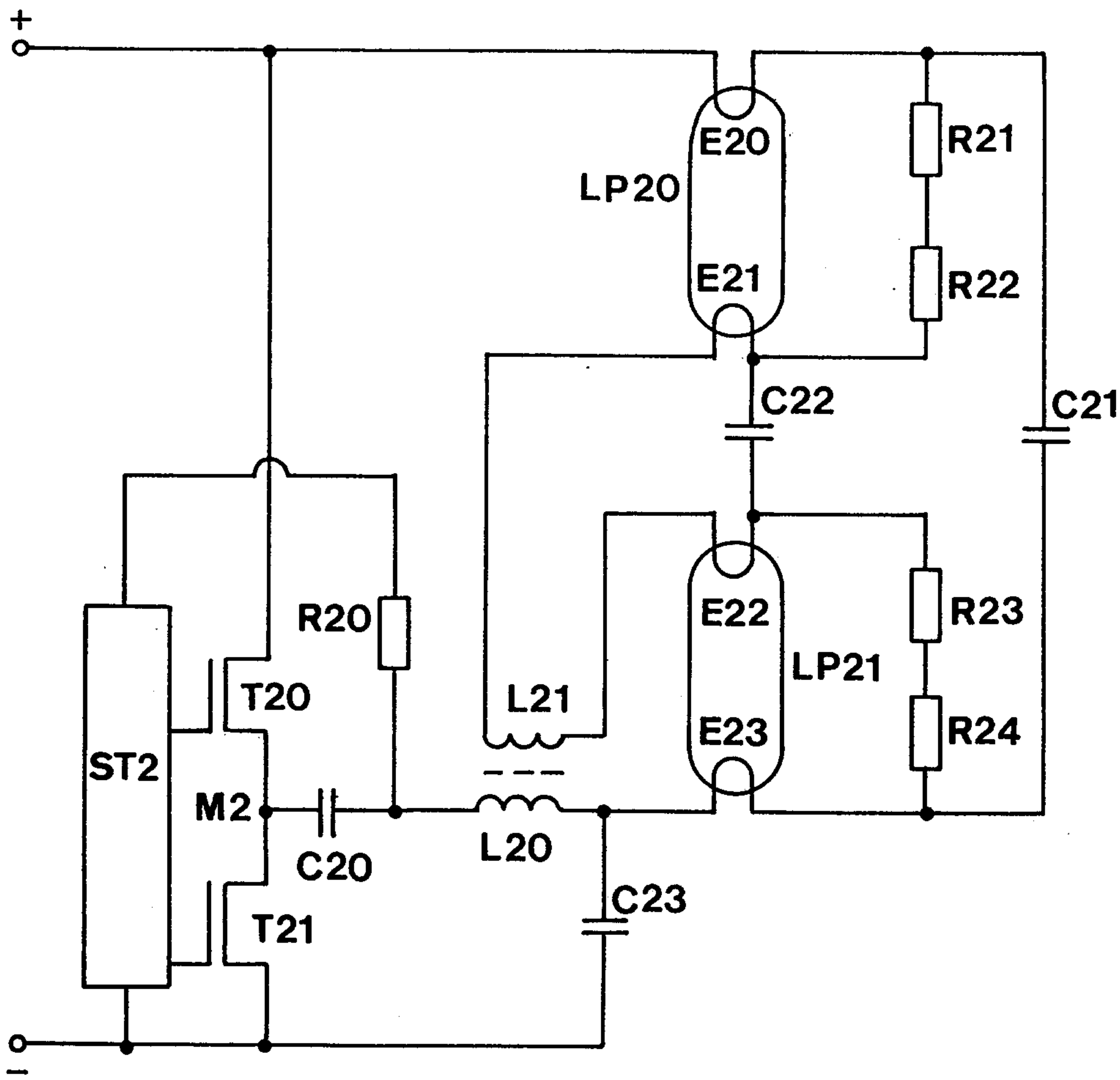

FIG. 2

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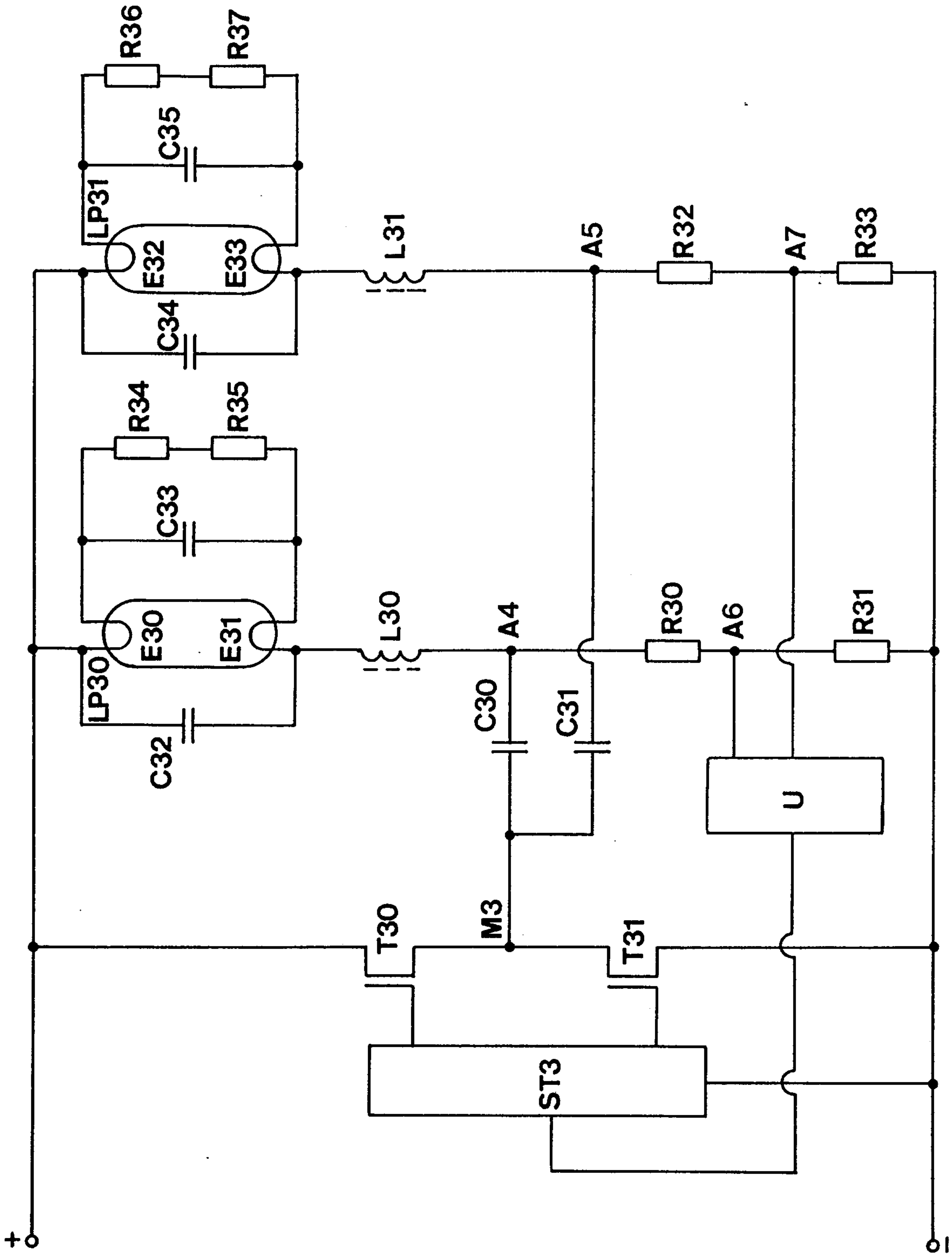
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R37
C35
LP31
E32
E33
C34
L31
A5
R32
A7
R33
R34
R35
C33
E30
E31
LP30
C32
L30
A4
R30
A6
R31
C30
C31
U
T30
M3
T31
ST3
+
-

FIG. 3

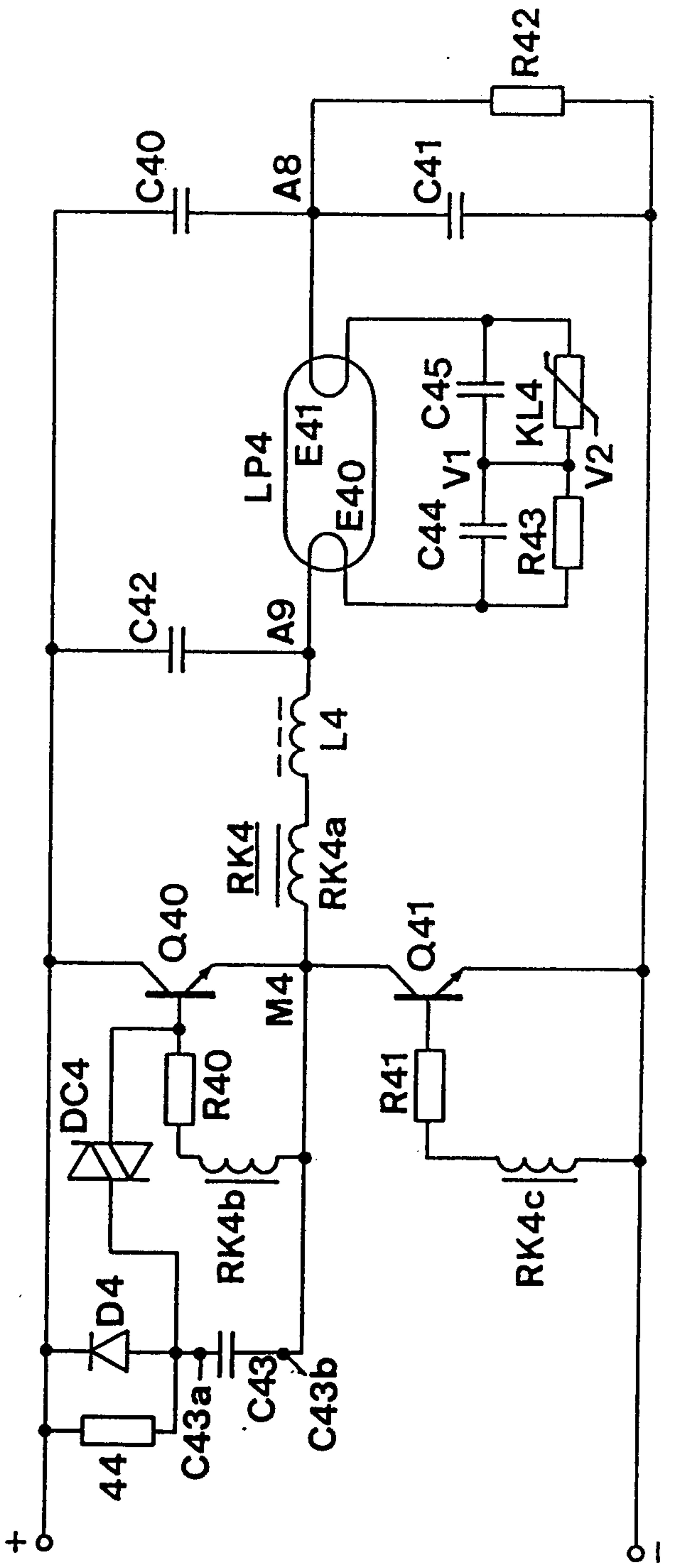

FIG. 4

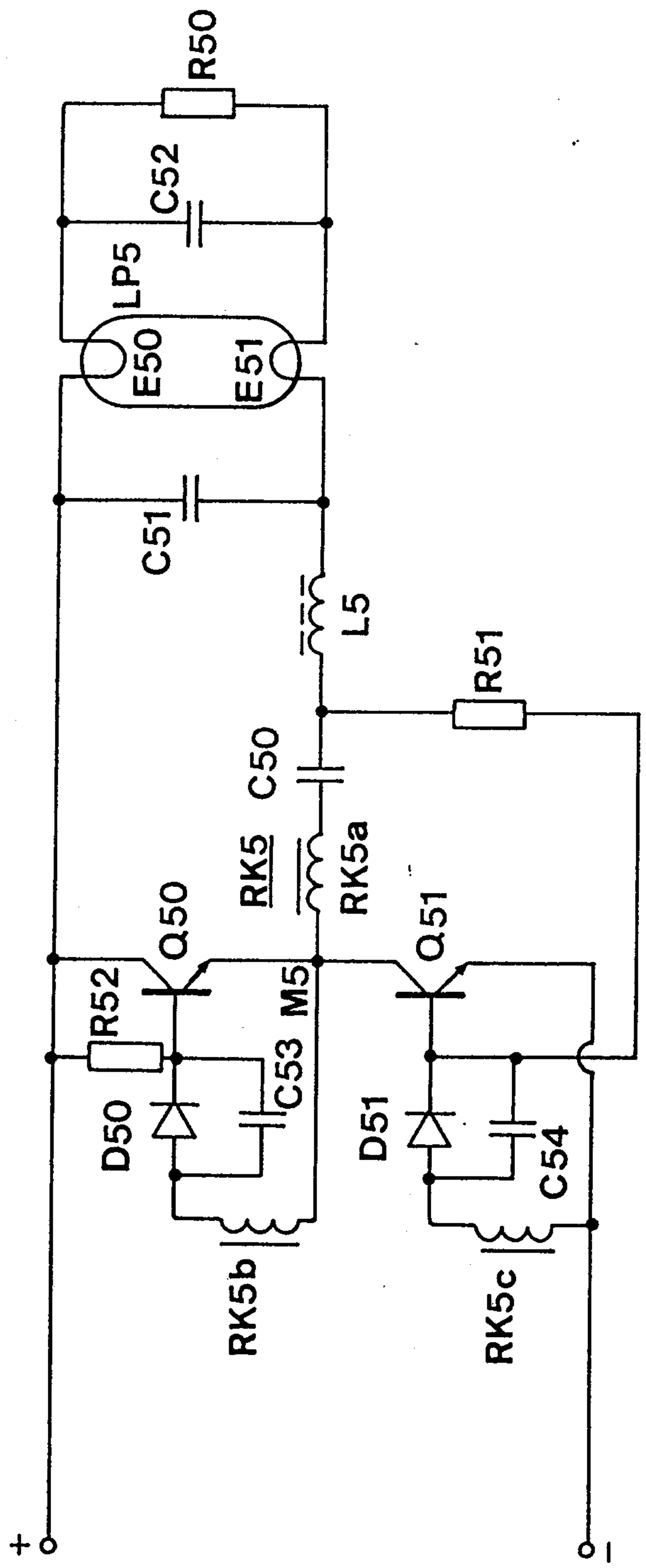

FIG. 5

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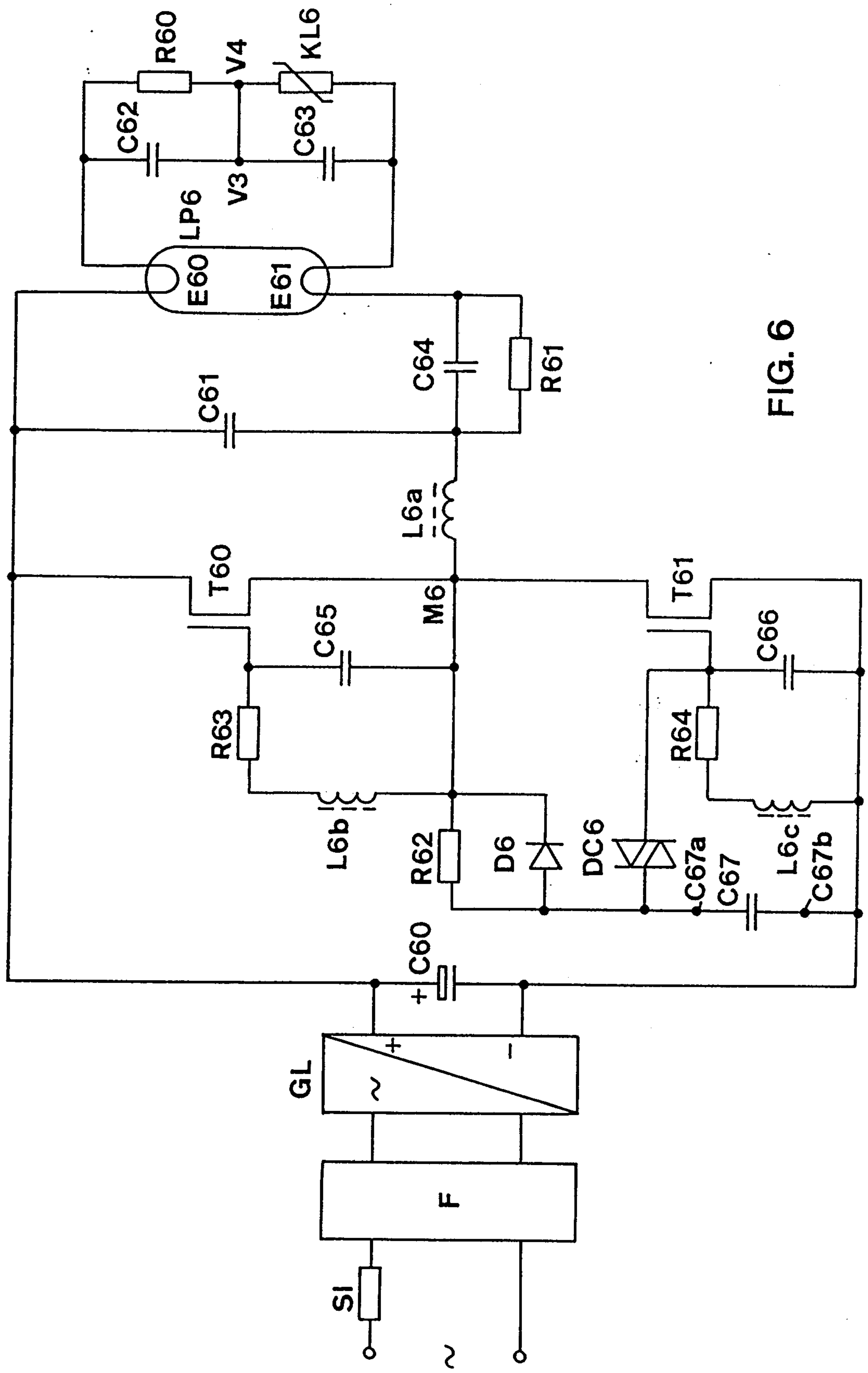
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V4
KL6
C62
C63
V3
LP6
E60
E61
C64
R61
C61
L6a
T60
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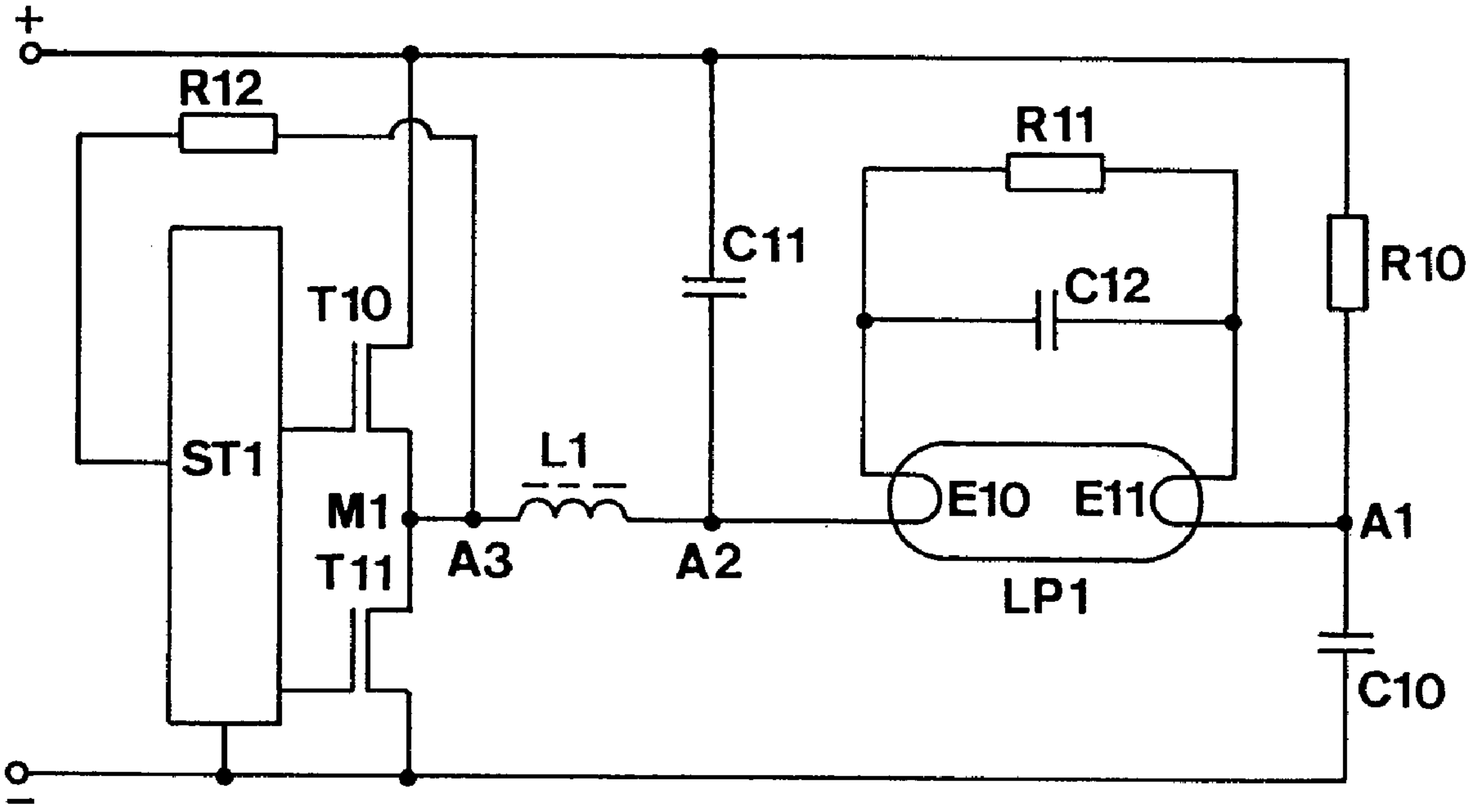
T61
C65
C66
R63
R64
L6b
R62
D6
DC6
C67a
C67
L6c
C67b
C60
GL
F
SI

FIG. 6



+
R12
R11
C11
R10
C12
T10
ST1
L1
M1
E10
E11
A1
A3
A2
T11
LP1
C10
−