B — APPLICATION BY ASSIGNEE OF INVENTOR

COMMONWEALTH OF AUSTRALIA
PATENTS ACT 1952

DECLARATION IN SUPPORT OF AN APPLICATION FOR A PATENT

(Name of applicant)

In support of an application made by: FLOTRONIC TECHNOLOGY PTE LTD
291 Serangoon Road, 03-00 Serangoon Building, Singapore 0821

(Title)

for a patent for an invention entitled: SOLID STATE ELECTRONIC BALLAST

(Full name and address of signatory)

I, WILLIE TEO CHIN KIANG
of Nurnbergerstrasse 14/15, D-1000 Berlin 30, FEDERAL REPUBLIC OF GERMANY

do solemnly and sincerely declare as follows:

1. I am authorised by the above mentioned applicant for the patent to make this declaration on its behalf.

(Full name and address of inventor(s))

2. The name and address of each actual inventor of the invention is as follows:

SKALAK Peter Gregory	TEO Willie Chin Kiang
3, Clementi Crescent	Nürnbergerstrasse 14/15
Singapore 2159	D-1000 Berlin 30
SINGAPORE	FEDERAL REPUBLIC OF GERMANY

(State whether by assignment or contract of employment)

and the facts upon which the applicant is entitled to make this application are as follows:
The applicant would be entitled to have assigned to it a patent granted to any of the actual inventors in respect of the said invention.

(Delete paragraphs 3 and 4 for non-Convention application)

3. The basic application(s) as defined by Section 141 of the Act was (were) made as follows:
Country Europe on 30.01.1989
in the name(s) Flotronic Technology P.T.E. LTD
and in ..... on .....
in the name(s) .....
and in ..... on .....
in the name(s) .....

4. The basic application(s) referred to in the preceding paragraph was(were) the first application(s) made in a Convention country in respect of the invention the subject of this application.

(Place and date of signing)

Declared at Singapore this 30th day of OCTOBER 1990

Signed: [signature]

Position: Managing Director

GRIFFITH HACK & CO

SYDNEY OFFICE
G.P.O. BOX 4164
SYDNEY. N.S.W. 2001

MELBOURNE OFFICE
G.P.O. BOX 1285K
MELBOURNE. VIC. 3004

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(54) Title
SOLID STATE ELECTRONIC BALLAST

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(71) Applicant(s)
PETER GREGORY SKALAK; WILLIE CHIN KIANG TEO; FLOTRONIC TECHNOLOGY PTE. LTD.

(72) Inventor(s)
PETER GREGORY SKALAK; WILLIE CHIN KIANG TEO

(74) Attorney or Agent
GRIFFITH HACK & CO., GPO Box 4164, SYDNEY NSW 2001

(56) Prior Art Documents
US 4710682
WO 87/01552
US 4461980

(57) Claim

1. A solid state electronic ballast for a fluorescent lamp, comprising:

a power supply conversion circuit, a start-up circuit and a switching resonant circuit, characterised in that the power supply conversion circuit incorporates a full wave rectifier and a low harmonic filter consisting of a first capacitor and a first diode and a second capacitor and a second diode linked by a third diode so that all said diodes are reverse biased when rectified voltage of the full wave rectifier exceeds the total voltage of said first and second capacitors and characterised in that said capacitors are connected in series when the third diode is forward biased and are disconnected when said third diode is reverse biased, the first and second capacitors being parallel connected when said first and second diodes are forward biased.

2. A solid state electronic ballast as claimed in claim 1, characterised in that the switching resonant circuit has a transformer with an additional secondary winding short circuited by a power level detection circuit and that a shutdown results from the saturation of the core of said transformer stopping the feedback mechanism that sustains oscillations.

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(71) Applicant *(for all designated States except US)*: FLOTRONIC TECHNOLOGY PTE LTD [SG/SG]; 291 Serangoon Road, 03-00 Serangoon Building, Singapore 0821 (SG).

(71)(72) Applicants and Inventors: SKALAK, Peter, Gregory [AU/SG]; 3 Clementi Crescent, Singapore 2159 (SG). TEO, Willie, Chin, Kiang [SG/DE]; Nürnbergerstrasse 14/15, D-1000 Berlin 30 (DE).

(74) Agents: FELDMANN, Clarence, Paul et al.;. Patentanwaltsbüro Feldmann AG, Kanalstrasse 17, CH-8152 Glattbrugg (CH).

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Published

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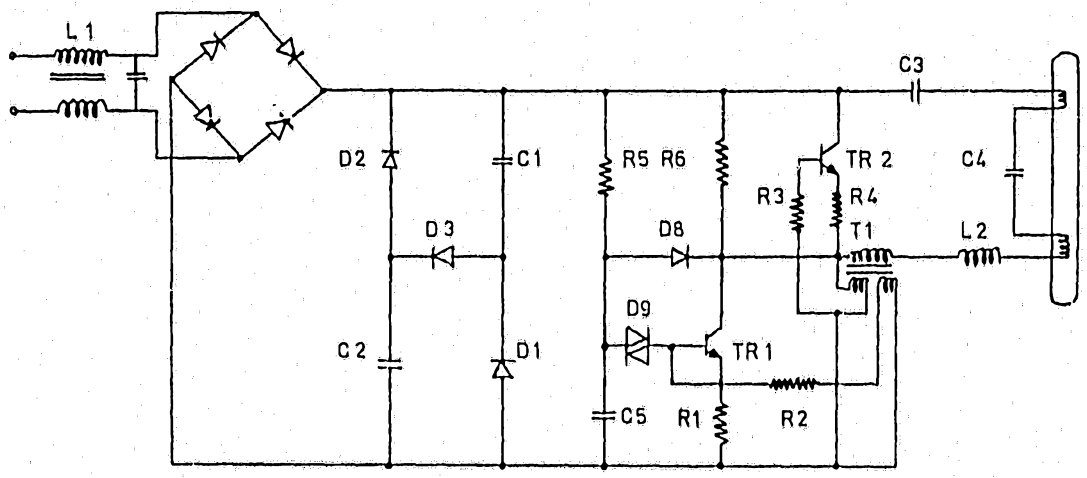
With amended claims and statement.

(54) Title: SOLID STATE ELECTRONIC BALLAST



(57) Abstract

The electronic ballast for a fluorescent lamp replaces the three main components of a traditional fluorescent lamp ballast, namely the ferro-magnetic ballast, the power factor condenser, the starter and starter holder. The solid state electronic ballast of the invention comprises a power supply conversion circuit, a start-up circuit and a switching resonant circuit. The power supply conversion circuit consists of a common mode line filter connected with a rectifier bridge circuit and a low harmonic filter. Connected in series follows the start-up circuit with a sawtooth oscillator, a diac trigger and a first transistor. A second transistor forms together with an inductor, a transformer, and a lump-load the resonant-circuit. The electronic ballast of the invention saves costs, energy and weight.

Flotronic Technology PTE Ltd
Singapore

Solid State Electronic Ballast

Background and Summary of the Invention

Since their introduction in 1938, fluorescent lamps have largely replaced incandescent lamps as the preferred lighting system for public buildings such as schools, offices, factories etc as well as in many homes. Since the early 1950's, sales of fluorescent lamps have overtaken that of incandescent lamps in most industrialized countries.

A fluorescent lamp consists of a glass tube containing a small amount of mercury and a chemically inert gas at low pressure, usually argon or krypton. Each end of the tube has an electrode which is a coil of tungsten wire with a coating of rare earth oxide. A ferro-magnetic ballast, power factor condenser and starter together with the metal housing, two tube holders, one starter holder and wiring system complete the lamp fixture.

Over the past 50 years the three significant areas of improvements to this system have been:

(1) Switch from a pre-heat starter to a rapid starter.

(2) Introduction of a warm light as an alternative to the cool light which has helped somewhat to enhance its aesthetic qualities in certain applications.

(3) Availability of a low loss ferro-magnetic ballast which has succeeded in replacing about 5-10% of the conventional ballast market.

A fluorescent lamp requires an element which will initially provide the breakdown voltage and thereafter limit the current through the lamp. This element is called a ballast and could be constructed with an inductor and a switch. A more sophisticated circuit is constructed by using active elements. The simple ballast is not very expensive but produces a low efficiency of energy transfer. The sophisticated ballast is usually expensive, not very reliable, and liable of producing electromagnetic interferences.

Solid state electronic ballasts are well known in the art. US-4,689,524 (Ureche) shows an electronic fluorescent lamp ballast with a self-adjusting frequency of operation as a function of lamp impedance variations due to age and enables constant ionization within the fluorescent lamp. This is achieved by an energy storing component, a controlling component which has two states and two socket elements. They enable the filaments of the fluorescent lamp to be connected in series with the energy storing component. A constant current flows through a portion of the energy storing component when the controlling component is in a state of producing an "energy latching" effect which will enable the ballast to achieve a very high energy transfer.

In EP 247,529 (Kim) an electronic ballast stabilizer is shown comprising a noise reduction transformer and two capacitors for regulating AC input voltage. A bridge rectifier changes the AC input into DC voltage. A noise reduction circuit comprises a resistor and a capacitor through which plus voltage passes at the time of voltage drop. The positive voltage also passes through a resistor and a diode and is applied to the emitters of two

switching transistors. The positive voltage also passes through the bases of two resistors.

A minus voltage passes through voltage regulating coils, is applied to a collector of a constant current transistor and through a series and parallel circuit comprising resistors, capacitors and diode. A coil is connected between the secondary coils of a chopper transformer coupled through noise reduction coils to filaments of fluorescent lamps respectively. This eliminates disturbing influence on the human eye because the intensity of light is constant.

It is one of the objects of the preferred embodiment of the invention to provide an electronic ballast that replaces the three main components of a traditional fluorescent lamp ballast, namely the ferro-magnetic ballast, the power factor condenser, the starter and starter holder. According to one embodiment of the invention it is an aim to minimise third and higher order harmonic distortions of the line current. A preferred feature of the invention is to eliminate start-up flicker which is one of the major draw-backs of the fluorescent system. Another feature of an embodiment of the invention is to save weight and costs.

According to the present invention there is provided a solid state electronic ballast for a fluorescent lamp, comprising:

a power supply conversion circuit, a start-up circuit and a switching resonant circuit, characterised in that the power supply conversion circuit incorporates a full wave rectifier and a low harmonic filter consisting of a first capacitor and a first diode and a second capacitor and a second diode linked by a third diode so that all said diodes are reverse biased when rectified voltage of the full wave rectifier exceeds the total voltage of said first and second capacitors and characterised in that said capacitors are connected in series when the third diode is forward biased and are disconnected when said third diode is reverse biased, the

first and second capacitors being parallel connected when said first and second diodes are forward biased.

A preferred embodiment of the present invention will now be described by way of example only with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS.

Fig. 1 is a functional block diagram of the present invention;

Fig. 2 illustrates a power conversion circuit;

Fig. 3 shows the waveform generated by the bridge circuit in the power conversion circuit;

Fig. 4 shows the waveform generated by the low harmonic filter section in the power conversion circuit;

Fig. 5 illustrates the start-up circuit that is downstream-connected to the power conversion circuit;

Fig. 6 illustrates the switching resonant circuit that is downstream-connected to the start-up circuit of fig. 5;

Fig. 7 shows the complete scheme of the solid state electronic ballast;

Detailed Description of the Preferred Embodiment

Generally an electronic ballast operates as an on/off switch alternating the voltage of the fluorescent lamp. The basic principle of the solid state electronic ballast of the invention is to convert the 50 Hz 230 V AC mains into an AC voltage at a much higher frequency (approx. 30-40 KHz) to operate the fluorescent lamp. The ballast circuit is composed of three basic function blocks. These are namely:

a power supply conversion circuit 1

a start-up circuit 2 and

a switching resonant circuit 3,

connected to the fluorescent lamp 4. All three circuits are downstream-connected as shown in fig. 1.

The primary role of the power supply circuit 1 is to convert the AC mains power into a varying DC supply voltage for the operation of the fluorescent lamp circuit. The

variation of this DC voltage is designed in a manner to minimize the third harmonic distortion of the line current. Fig. 2 shows the details of the circuit. The inductor L1 and the capacitor C7 form a common mode line filter to provide isolation and prevents the high frequency currents of the ballast circuit from being coupled back to the mains supply.

The bridge circuit, consisting of diodes D4 and D7, rectifies the mains supply into a full wave rectified voltage which is a positive sinusoidal varying voltage (fig. 3).

If a single capacitor is used to filter the above voltage, a high DC voltage with a low ripple voltage is achieved. However, the consequence is to have high and short current pulses charging the filter capacitor, resulting in unacceptable levels of third and higher order harmonic distortions to the line current. The design of the filter section is to avoid short and sharp line current pulses. Components D1, D2, D3, C1 and C2 constitute an improved low harmonic filter section (fig. 2) resulting in a filtered voltage with a waveform as shown in fig. 4.

The operation of the filter circuit is explained as follows:

The bridge circuit conducts over the period of t1, t2 and t3. During this period, power to the lamp circuit is drawn directly from the mains supply. During the period t2, the bridge conducts additional currents to charge the filter capacitors C1 and C2.

During the period t1, the rectified voltage exceeds the capacitor voltages of C1 and C2. All diodes D1, D2 and D3 are reverse biased and the capacitors C1 and C2 are prevented from charging.

In the beginning of the period t2, the rectified voltage now exceeds the total of voltages of the capacitors C1 and C2. Diode D3 is forward biased and connects the capacitors C1 and C2 in series for charging. The capacitors are charged to a maximum of 167 volts (approx.) each at the end of period t2. After this, diode D3 is reversed biased again and disconnects the capacitors C1 and C2.

When the rectified voltage falls below 167 volts, diodes D1 and D2 are forward biased thereby connecting both

capacitors C1 and C2 in parallel. Hence, over the period t4, energy to the lamp circuit is provided by the two capacitors C1 and C2. The voltages of the capacitors discharge until they equal the rectified voltage.

Downstream the power supply conversion circuit 1 and the start-up circuit 2 is connected. The role of the start-up circuit is to initiate the oscillation of the switching resonant circuit. This circuit operates during the initial power-on of the ballast. Once the switching resonance circuit is in operation, this circuit is deactivated. The circuit operates again in the event that the lamp is removed. Hence, the resonant circuit will be energized immediately when the lamp is replaced.

The start-up circuit 2 is essentially a "sawtooth" oscillator. With reference to fig. 5 capacitor C5 charges toward Vs through resistor R5 linearly until it reaches 32 volts. This is the "turn on" voltage of the diac trigger, D9, which subsequently switches the transistor TR1 on. Currents are then passed through the resonant circuit. This excitation provides induced voltages at the secondary windings of the transformer T1 to sustain self-oscillations. Resistor R6 acts as a load to transistor TR1 before

the resonant circuit is turned on. Diode D4 discharges capacitor C5 through transistor TR1 and prevents it from charging sufficiently to fire the diac during the normal operation of the resonant circuit.

Should the oscillations of the resonant circuit be halted, e.g. in the event of the lamp removal, transistor TR1 is turned off and capacitor C5 is allowed to charge to 32 volts to fire the diac trigger D9 again. If the resonant circuit can not be excited, the cycle repeats itself.

Downstream-connected with the start-up circuit 2 is the switching resonance circuit 3. The resonance circuit 3, illustrated in fig. 6, consists of capacitor C3, lamp load in parallel with a capacitor C4, an inductor L2, a transformer T1 and transistors TR1 and TR2. Transistors TR1 and TR2 conduct alternately and are switched by a feedback mechanism provided by the secondary windings of the transformer T1. The resonant circuit is series connected across the supply when the first transistor TR1 turns on. It is connected as a loop circuit when the second transistor TR2 turns on. Resistors R1 and R4 limit the current through the resonant circuit and may be used to

manipulate the luminescence level of the fluorescent lamp. Resistors R2 and R3 limit the currents in the base circuit of the transistors. The transformer T1 may have a toroid core.

On power up, the first transistor TR1 is turned on when the diac D9 fires. The resonant circuit is connected across the power supply. The operation of the first half cycle is as follows:

Current flows through the circuit and energy is stored in the reactive components. Power to the lamp is drawn from the supply. Induced voltages on the secondary windings of the transformer T1 keep the transistor TR1 turned on and hold the second transistor TR2 off until the resonant circuit current reaches its peak and begins to fall.

The second half cycle of oscillations begins when the resonant circuit current falls. The induced voltages are reversed to turn the first transistor TR1 off and to switch the second transistor TR2 on. The resonant circuit loop is closed by the second transistor TR2 and oscillates for the next half cycle. Energy stored in the reactive components are released to the lamp. When the current reverses

direction, transistor TR1 is turned on once again and the next cycle begins. In this way oscillations are self-sustaining.

Under abnormal conditions, such as a faulty lamp, an electronic shut-down mechanism is triggered. The ballast shut-down results from the saturation of the toroid core and the disability of the feedback mechanism that sustains oscillations. This is accomplished by an additional secondary winding that is short circuited by an electronic device when abnormal power level is detected.

It is obvious that the novel circuit arrangement using fewer components results in lower costs and less weight per unit in comparison with a traditional electronic lamp ballast. It is found that the ballast of the invention uses 20-25% less energy than the conventional ferro-magnetic ballast and 10-12% less than a low-loss ferro-magnetic ballast.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A solid state electronic ballast for a fluorescent lamp, comprising:

a power supply conversion circuit, a start-up circuit and a switching resonant circuit, characterised in that the power supply conversion circuit incorporates a full wave rectifier and a low harmonic filter consisting of a first capacitor and a first diode and a second capacitor and a second diode linked by a third diode so that all said diodes are reverse biased when rectified voltage of the full wave rectifier exceeds the total voltage of said first and second capacitors and characterised in that said capacitors are connected in series when the third diode is forward biased and are disconnected when said third diode is reverse biased, the first and second capacitors being parallel connected when said first and second diodes are forward biased.

2. A solid state electronic ballast as claimed in claim 1, characterised in that the switching resonant circuit has a transformer with an additional secondary winding short circuited by a power level detection circuit and that a shutdown results from the saturation of the core of said transformer stopping the feedback mechanism that sustains oscillations.

3. A solid state electronic ballast as claimed in claim 1 or 2 wherein the start up circuit comprises a diac trigger that switches a first transistor so that current passes through the switching resonant circuit.

4. The solid state electronic ballast of claim 5 wherein said start-up circuit includes a resistor that acts as a load to said first transistor before said resonant circuit is turned on.

5. A solid state electronic ballast as claimed in claim 3 or 4 wherein the switching resonant circuit comprises an inductor, a transformer and the first transistor and a second transistor, the switching resonant circuit being connected in series with the power

supply conversion circuit when the first transistor is turned on.

6. The solid state electronic ballast of claim 5 when appended to claim 2 through claim 3 wherein said transformer of said switching resonant circuit has secondary windings that are connected with said first and second transistors keeping said first transistor turned on and said second transistor turned off until the current of the resonant circuit reaches its peak and begins to fall.

7. The solid state electronic ballast of claim 1 wherein the switching resonant circuit comprises two resistors each connected to the emitter of one of said first and second transistors which are controllable to manipulate the luminescence level of the fluorescent lamp.

8. The solid state electronic ballast of claim 2 wherein said core of said transformer is a toroid core.

9. A solid state electronic ballast substantially as hereinbefore described with reference to the accompanying drawings.

Dated this 14th day of May 1992

FLOTRONIC TECHNOLOGY PTE LTD
By their Patent Attorney
GRIFFITH HACK & CO.

ABSTRACT

The electronic ballast for a fluorescent lamp replaces the three main components of a traditional fluorescent lamp ballast, namely th ferro-magnetic ballast, the power factor condenser, the starter and starter holder.

The solid state electronic ballast of the invention comprises a power supply conversion circuit, a start-up circuit and a switching resonant circuit. The power supply conversion circuit consists of a common mode line filter connected with a rectifier bridge circuit and a low harmonic filter. Connected in series follows the start-up circuit with a sawtooth oscillator, a diac trigger and a first transistor. A second transistor forms together with an inductor, a transformer, and a lamp-load the resonant-circuit.

The electronic ballast of the invention safes costs, energy and weight.

(Fig. 7)

FIG. 1

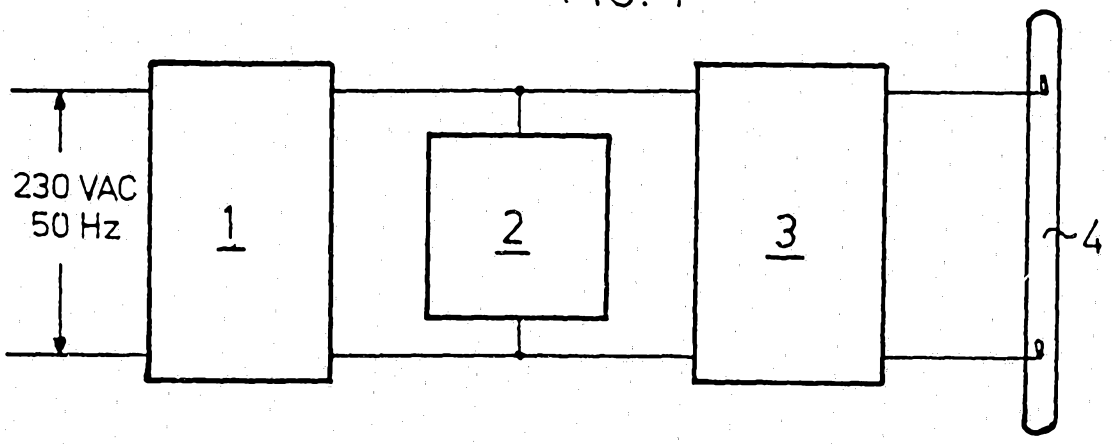
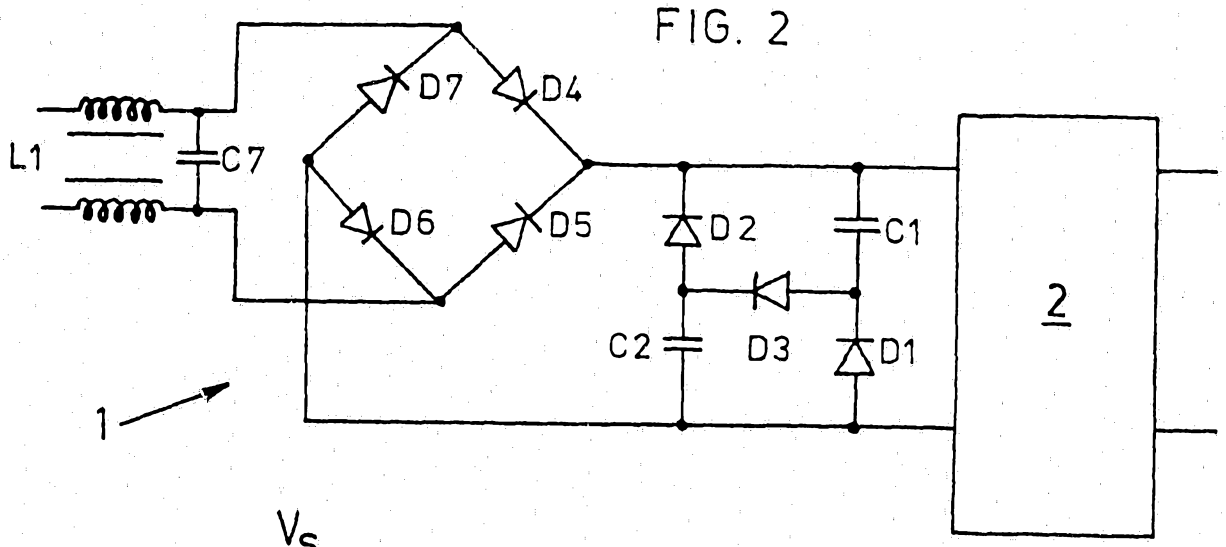


FIG. 2



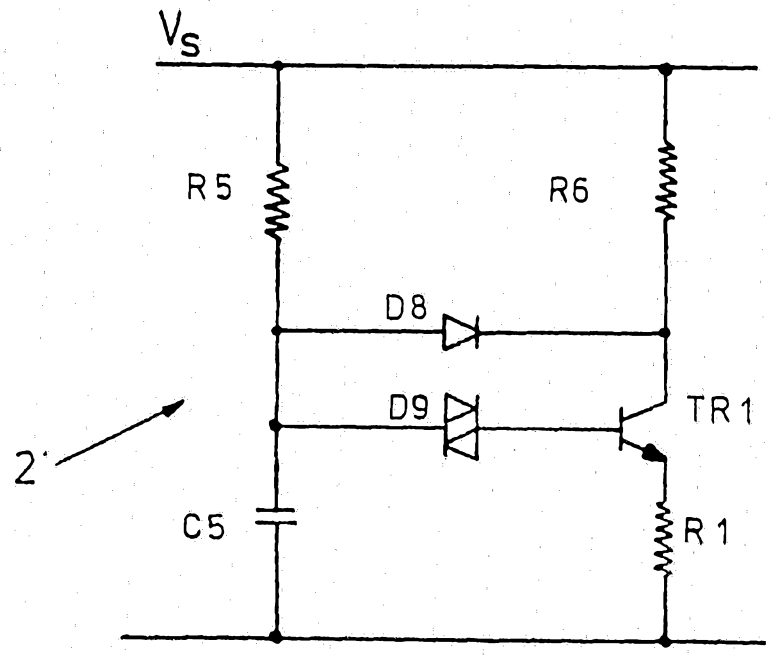


FIG. 5

FIG. 3

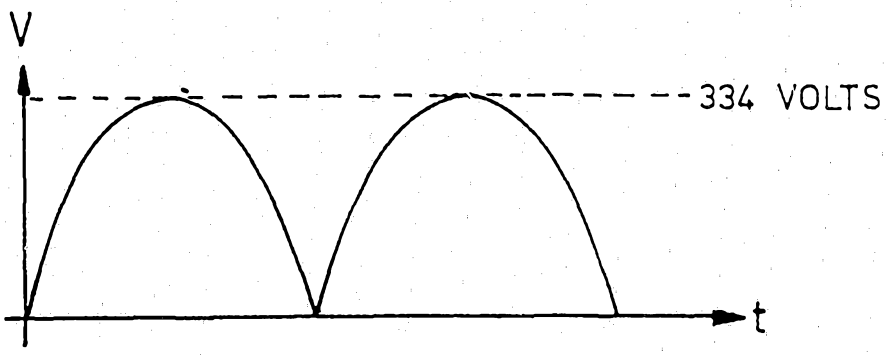
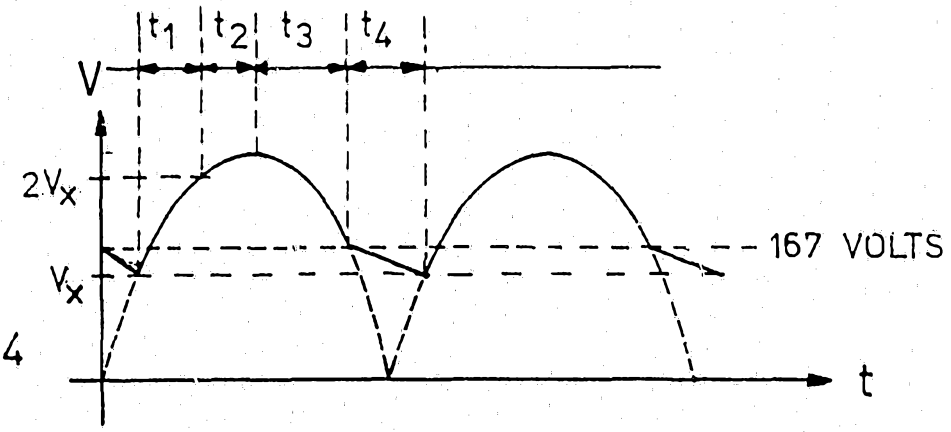


FIG. 4



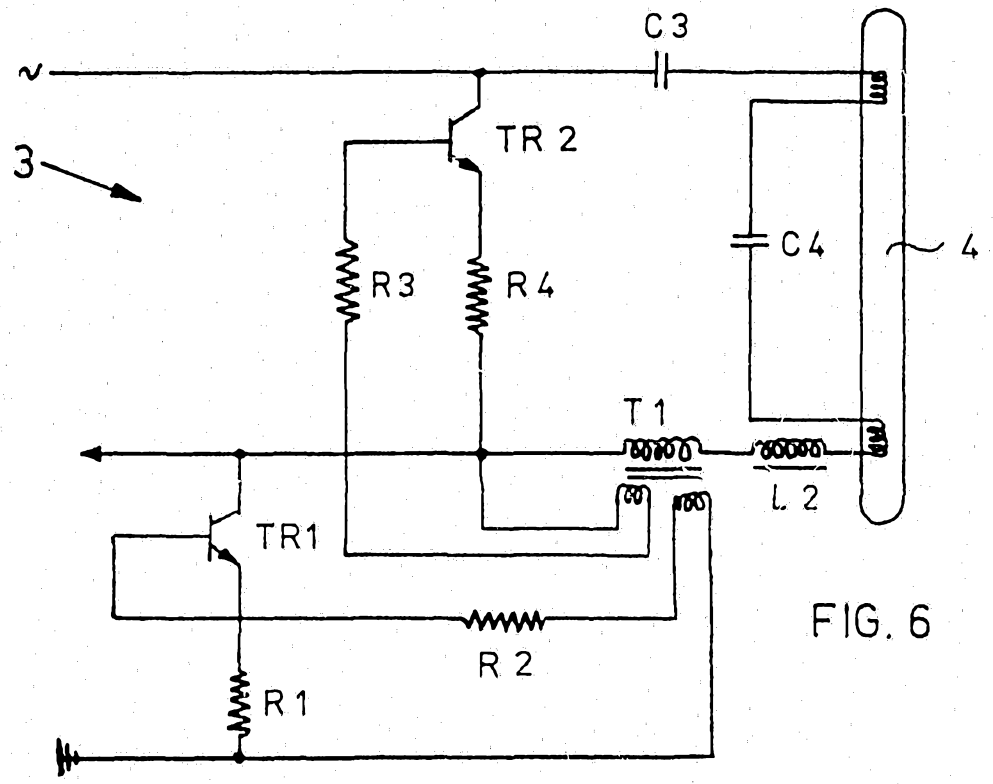
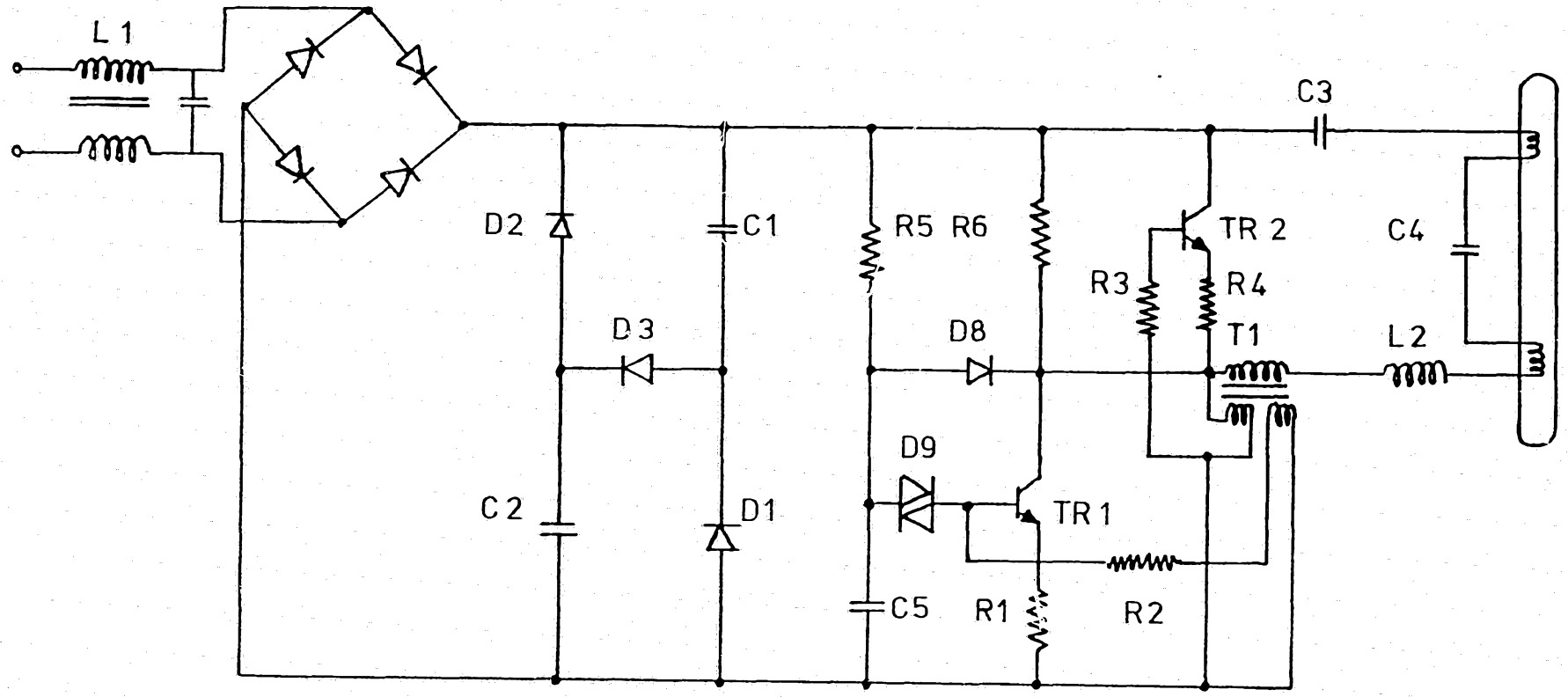


FIG. 6

FIG. 7



INTERNATIONAL SEARCH REPORT

International Application No PCT/EP / 88/ 01211

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all)[6]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl. 4 H05B41/29

II. FIELDS SEARCHED

Minimum Documentation Searched[7]

Classification System	Classification Symbols
Int.Cl. 4	H05B

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched[8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT[9]

Category °	Citation of Document,[11] with indication, where appropriate, of the relevant passages[12]	Relevant to Claim No.[13]
X	EP,A,239793 (PATENT TREUHAND) 07 October 1987 see the whole document	1, 3-6
X	WO,A,8701552 (EBTEK) 12 March 1987 see page 18, line 25 - page 19, line 2; figure 5	2
A	US,A,4461980 (NILSSEN) 24 July 1984 see abstract; figure 1	6, 7

° Special categories of cited documents:[10]

"A" document defining the general state of the art which is not considered to be of particular relevance

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"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
23 MARCH 1989	24. 04. 89
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	SPEISER P.

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

PCT/EP 88/01211
SA 26363

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A-239793	07-10-87	DE-A-	3608615	17-09-87
		US-A-	4710682	01-12-87
WO-A-8701552	12-03-87	AU-A-	6228786	24-03-87
		EP-A-	0236423	16-09-87
US-A-4461980	24-07-84	None		