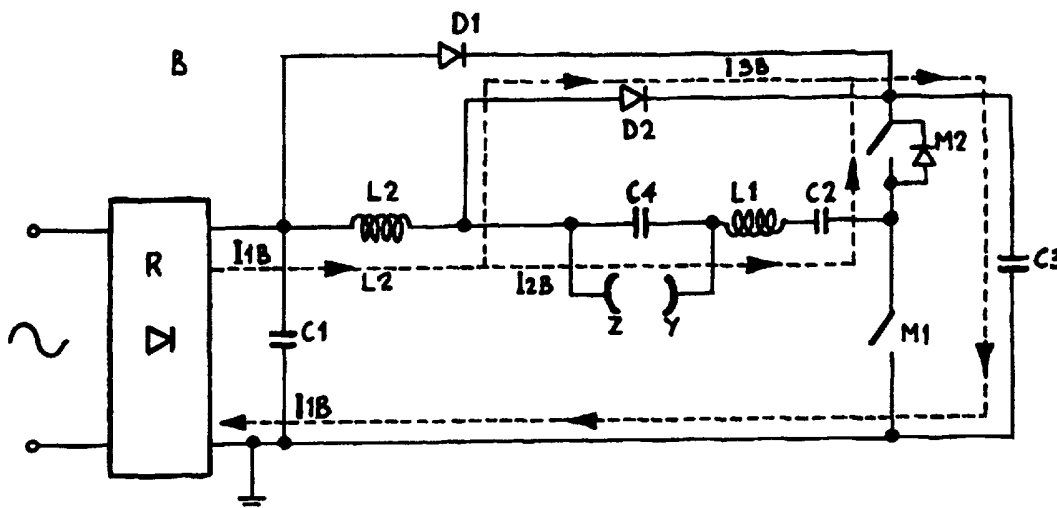




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<p>(51) International Patent Classification ⁶ : H05B 41/29</p>	<p>A1</p>	<p>(11) International Publication Number: WO 97/33454 (43) International Publication Date: 12 September 1997 (12.09.97)</p>
<p>(21) International Application Number: PCT/IE97/00016 (22) International Filing Date: 6 March 1997 (06.03.97) (30) Priority Data: S960207 6 March 1996 (06.03.96) IE (71) Applicant (for all designated States except US): TECNINTER IRELAND LIMITED [IE/IE]; The Merchant's Yard, East Wall Road, Dublin 1 (IE). (72) Inventors; and (75) Inventors/Applicants (for US only): WILLERS, Michael, J. [IE/IE]; PEI Technologies, University College Cork (IE). POWER, David [IE/IE]; PEI Technologies, University College Cork (IE). BARRY, Michael [IE/IE]; PEI Technologies, University College Cork (IE). ROCHE, Patrick, J. [IE/IE]; PEI Technologies, University College Cork (IE). EGAN, Michael, G. [IE/IE]; PEI Technologies, University College Cork (IE). MURPHY, John, M., D. [IE/IE]; PEI Technologies, University College Cork (IE). (74) Agents: O'CONNOR, Donal, H. et al.; Cruickshank & Co., 1 Holles Street, Dublin 2 (IE).</p>	<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DE (Utility model), DK, DK (Utility model), EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report.</i></p>	

(54) Title: AN ELECTRONIC BALLAST FOR A COMPACT FLUORESCENT LAMP



(57) Abstract

An electronic ballast for a CFL has two pairs of DC rails, having a common circuit ground. A booster circuit (L2, D2) boosts charge into the smoothing capacitor (C3) at certain stages in the oscillator cycle so that the charge on the smoothing capacitor (C3) is greater than the peak input voltage. This increase the duration during which current is drawn from the supply and helps to reduce harmonic distortion.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgyzstan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LJ	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

- 1 -

"An Electronic Ballast for a Compact Fluorescent Lamp"Introduction

The invention relates to an electronic ballast for a compact fluorescent lamp.

5 For many years now by far the most common type of lamp for domestic and many business uses has been the incandescent lamp. This presents a mainly resistive load to the mains AC supply. Such a load does not have any significant adverse consequences on the mains supply and indeed it is thought that the resistive nature of the load may cause
10 beneficial damping of the mains supply.

However, compact fluorescent lamps (CFLs) have been developed in the last twenty years or so and these have the major advantages of requiring considerably less power and having a longer life. Typically, the power
15 consumption is only about 20% of that of incandescent lamps. However, a major feature of CFLs is that they have an electronic ballast circuit which has a DC rectifier, across which there is a bulk or smoothing capacitor at the output stage. If this capacitance were very large, there
20 would be a very good straight-line DC output. However, load current would be drawn for a large part of the supply cycle from the smoothing capacitor and not from the rectifier. Due to the long periods of non-conduction of the rectifier, significant current surges would be from
25 the mains utility at the peaks of the input voltage, thereby resulting in a low power factor. On the other hand, if the smoothing capacitance were very low, the ballast circuit would draw current from the rectifier from most of the supply cycle, thus considerably improving the
30 power factor. However, a major disadvantage is that there would be a highly modulated DC waveform, which causes a

- 2 -

high current crest factor at the discharge tube terminals. This would cause flicker in the discharge tube and reduce the life of the tube.

5 Therefore, the tendency has been to include a medium-valued smoothing capacitor which provides a trade-off between the power factor and quality of the discharge tube drive.

10 The power factor is a function of the phase shift between the voltage supply and the fundamental component of the current drawn, and is also a function of the distortion of the current being drawn. The latter is generally quantified as the parameter total harmonic distortion (THD). In electronic ballast circuits for CFLs, phase shift is not usually a factor and thus, the harmonic
15 distortion is the most important variable affecting the power factor. The relationship is non-linear.

20 There have been many developments in ballast circuits for CFLs over the last twenty years and some of these have particularly addressed the power factor problem. An example is British Patent Specification No. GB2256099B (Ultralite). This specification describes an improvement in the manner in which current is drawn from the input stage of the ballast circuit so that it is drawn to a greater extent from the rectifier, and not the smoothing
25 capacitor. This is achieved by inserting a diode between the smoothing capacitor and the positive rail at the output stage of the rectifier.

30 While these developments have been quite effective and the power factor has indeed increased significantly, problems still remain in the extent of harmonic distortion caused in the mains supply. A good power factor level does not necessarily mean that the THD is equally improved because

- 3 -

they are related in a non-linear manner. Indeed, it has been found that for circuits currently available and which have good power factors in the region of 0.95, the THD can remain stubbornly high - often at a level of approximately 25% to 30%. This parameter is of particular importance to the electrical utilities because it is the harmonic content of the input current which causes distortion of the mains supply. Furthermore, the harmonic distortion in the line current causes distribution losses which are undesirable and unnecessary.

It is therefore an object of the invention to provide an electronic ballast circuit for a CFL which has both an improved power factor and an improved THD level. More particularly, it is an object to achieve a power factor of approximately 0.97 and a THD level of as low as 20%.

According to the invention, there is provided an electronic ballast circuit for a compact fluorescent lamp, the circuit comprising:-

- a DC rectifier providing a DC voltage across a first pair of rails,
- an LC tank circuit and lamp terminals,
- a smoothing capacitor,
- high frequency switches connected to the tank circuit at the centre point of the switches,
- an oscillator controlling the switches, and
- booster means for charging the smoothing capacitor to a value greater than the peak input voltage.

- 4 -

In one embodiment, the smoothing capacitor is connected across a second pair of rails connected to the first pair of rails via a reverse-connected diode, and both pairs of rails have the same negative rail.

- 5 Preferably, the booster means comprises for dividing current flow on the first pair of rails between the tank circuit and the second pair of rails.

10 In one embodiment, the current is divided during the on switching period of a switch connected to the positive rail of the second pair of rails.

In another embodiment, the booster means comprises a diode connected in parallel with the tank circuit to provide a path for boost current.

15 Ideally, the booster means also comprises an inductor on the first positive rail between the rectifier output and the booster diode so that it builds up an energy store during the on switching period of the switch connected to the negative rail.

20 In one embodiment, the value of the booster inductor is such that it forms part of the ballasting function of the LC tank circuit.

In another embodiment, the switches are MOSFET switches having inherent diodes which conduct during periods in which both switches are open.

25 Preferably, the booster inductor values provide a current THD of less than 15% from a voltage source having a voltage of less than 0.5% THD.

- 5 -

In a further embodiment, the circuit also comprises an EMI-reducing capacitor between a tube terminal and circuit ground.

5 Preferably, the EMI-reducing capacitor has a value of 2 to 4 nF.

The invention also provides a compact fluorescent lamp comprising an electronic ballast circuit as described above.

Detailed Description of the Invention

10 The invention will be more clearly understood from the following description of some embodiments thereof, given by way of example only with reference to the accompanying drawings in which:-

15 Fig. 1(a) is a circuit diagram of a ballast circuit of the invention and Fig. 1(b) is a diagram illustrating gate voltage for an oscillator;

20 Figs. 2 and 5 inclusive are simplified circuit diagrams of the ballast circuit illustrating its operation with switches of the oscillator at different positions to complete a full oscillator cycle; and

Fig. 6 shows waveforms of the input current and lamp current taken from a ballast of the invention.

25 Referring to Fig. 1(a), an electronic ballast circuit of the invention is described. The circuit comprises a bridge rectifier R. The output of the rectifier R is connected to a first pair of voltage rails in the circuit, across which is connected an input resonant capacitor C1.

- 6 -

A tank circuit for driving output discharge tube terminals Z and Y comprises a pair of capacitors C2 and C4 and inductors L1 and L2. L1 and C2 are connected between Y and the output of an oscillator. C4 is connected across the terminals Z and Y and the inductor L2 is connected between the terminal Z and the output of the bridge rectifier. At a position between the inductor L2 and the terminal Z is a connection to the anode of a diode D2, the cathode of which is connected to a smoothing capacitor C3. The smoothing capacitor C3 is connected across a second pair of voltage rails. Also, the first pair of voltage rails are connected to C3 via a high speed diode D1, with the diode cathode being connected to C3.

In more detail, the ballast circuit comprises capacitors C6 and C7 and an inductor L3 for input stage EMI filtering. The oscillator comprises a resistive series of R1, R2 and R3 between the positive rectifier output and a capacitor C8 which is in-turn connected to a half-bridge MOSFET gate driver IC U1, the purpose of which is to provide enough bias current to the IC on start-up. Once the circuit begins to operate, more substantial bias current is obtained from a bias winding wound on L1 via the diode D3 and series resistor R6. The components C9 and R5 set the oscillator frequency. U1 drives a pair of MOSFET high-frequency switches M1 and M2. The tank circuit of L2, C4, L1 and C2 is connected to the centre point of the switches M1 and M2.

The circuit thus has two pairs of DC rails. Both have the same circuit ground, namely the negative output of the rectifier R. The first pair of rails has the rectifier positive output as its positive rail, and the second pair has the positive side of the smoothing capacitor C3 as its positive rail.

- 7 -

As is explained in detail below, the inductor L2 has dual functions of acting as part of tank circuit and also assisting in a boosting action to C3 to reduce harmonic distortion. The latter action is carried out in conjunction with the diode D2.

Operation of the circuit will now be described with reference to the cycle illustrated in Fig. 1(b). Fig. 1(b) shows the oscillator cycle as represented by the gate voltage. There are four major sections in the cycle, as follows:-

- A - switch M1 is on.
- B - the dead time while both switches are off.
- C - switch M2 is closed.
- D - the deadtime when both switches are open after M2 has been closed.

Operation of the circuit for the stage A is shown in Fig. 2. At the beginning of this stage between a time 0 and t_a , there is a continuation of current which flowed during the end of the previous stage, namely stage D. This is described as a current I_{1A} and the reason for this current will be described in more detail below during the description referring to Fig. 5. During the short period represented by t_a , the driving voltage of C3 causes the current I_{1A} to decrease to zero, thereby causing the diode D1 to regain its reverse blocking capability. A current I_{2A} arises from capacitor C1, which is initially at the same potential as the smoothing capacitor C3. This current flows through the components L2, the output terminals Z and Y, L1 and C2, and back to the ground terminal of the bridge rectifier R via M1. This current causes the tube connected to the terminals Z and Y to be ignited and maintains illumination.

- 8 -

As the current I_{2A} (which originates from the capacitor C1) flows, the voltage across C1 drops in a resonant fashion to a level equivalent to the instantaneous magnitude of the line voltage at a time indicated by t_b in Fig. 1(b).
5 When this happens, the current flows in the same direction through the tank circuit and the terminals Z and Y, however, in this case it originates from the rectifier output and is indicated by the numeral I_{3A} . No current is drawn from the smoothing capacitor C3 because the diodes
10 D1 and D2 are reverse biased.

Referring now to Fig. 3, operation of the circuit for the second stage, B is now described. This stage is a relatively short period of time in comparison with the stages A and C. For clarity, however, the duration of
15 this stage is exaggerated in Fig. 1(b). During this stage, both M1 and M2 are open. However, a current does flow because of the inherent diode in the switch M2, this diode being illustrated in Fig. 3. The components L2 and D2 form an important part of the circuit during this
20 particular stage. The inductor L2 splits the current I_{1B} between a component I_{2B} flowing through the tank and the output terminals and a second component I_{3B} which flows through the diode D2 and re-joins the other component I_{2B} to flow through the capacitor C3 and back to the ground
25 terminal of the rectifier R. The relative magnitudes of these components of current vary over the line period and depend very much on the relative sizes of L1 and L2.

An important aspect of the stage B is that there is a boost of current into the smoothing capacitor C3 due to
30 the action of L2 and D2. The relative values of L2 and L1 are important in setting the proportion of current diverted through D2 to optimise the potential across C3. This action happens in every switching period for a significant interval around the peak of the line voltage

and is therefore particularly important as it takes energy from the mains supply into the smoothing capacitor without this current going through the tube terminals Z and Y. This helps to maintain the potential in the smoothing capacitor C3 for a significant part of the cycle and in fact, increases the potential of C3 to a value greater than the peak input voltage in a boost converter like manner. Therefore, there is no surge current from the mains utility through D1 at the peaks of the input voltage. It has been found that this feature helps to significantly reduce current total harmonic distortion (THD). Indeed values as low as 15% have been achieved from a voltage source having a THD of less than 0.5%

Referring now to Fig. 4, operation of the circuit is illustrated for the stage C when M2 is closed and M1 is open. The first current in this stage exists up to a time indicated by t_d shown in Fig. 1(b). Initially a current I_{1C} flows in the same direction as shown in Fig. 3 for the stage B, this current being a continuation of current I_{1B} during stage B. Accordingly, it is only indicated diagrammatically at its start and end positions at the bridge rectifier R. Note that since M2 turns on initially with its inherent diode conducting the current I_{2B} , then an effective phenomenon commonly known as zero-voltage-switching (ZVS) occurs, thus leading to substantially reduced switching loss in the device and reduced electromagnetic interference (EMI) generated at the switching instants. With the driving voltage applied to the output terminal Y being that of the series addition of the potential across C3 and the potential across the DC-blocking capacitor C2 which is much larger than the input voltage applied to the terminal Z via the inductor L1, then the current I_{2B} decreases rapidly, reaching a level of zero amperes at time t_d . Because of the presence of L2, the manner in which the current components I_{2B} and I_{3B}

- 10 -

reduce occurs in a controlled manner. If the component I_{3B} should reach zero before I_{2B} , then the diode D2 regains its reverse blocking capability. The component I_{2B} continues to flow in L2, Z, Y, L1, C2 and through M2 into the smoothing capacitor C3. If on the other hand, I_{2B} should reach zero before I_{3B} , then I_{3B} continues to flow through L2, D2 and the smoothing capacitor C3. The component I_{2B} reverses and flows in the path through C2, through terminals Y to Z, and returning to C2 via the conducting diode D2 and M2. The exact scenario which occurs depends on the size of L1 relative to L2, the impedance of the lamp and the instantaneous input voltage.

Once the current I_{1C} in L2 has reached zero, the conducting diodes of the bridge rectifier R cease conducting and a current I_{2C} originates in the circuit, which arises from the smoothing capacitor C3. As I_{2C} flows, the potential on C1 rises in a resonant fashion. When the potential on C1 increases to a level equal to the potential on the smoothing capacitor C3, diode D1 conducts the tank circuit current and clamps the voltage on C1 to that of C3. The tank circuit current, now denoted as I_{3C} , continues to flow in D1 for the remainder of the stage, following the path C2, L1 through terminals Y to Z, through L2, D1 and back to C2 via the conducting switch M2. At this stage, there is no current flowing through C1 or C3.

Referring now to Fig. 5, operation of the circuit during the final stage, D, is now illustrated. Again, this stage is much shorter than indicated in Fig. 1(b). As both switches M1 and M2 are open, the inherent diode in the switch M1 comes into play. The path of I_{3C} during stage C is broken by M2 opening and a current I_{1D} for stage D then arises through C3 and the inherent diode of M1. Current is in the same direction through the tube for this stage as for the latter part of stage C.

- 11 -

At the end of stage D, the switch M1 is gated on again, thus beginning a new switching cycle. As with the turn-on of the upper switch M2, the inherent diode of M1 is conducting before it is turned on and hence, it too turns on under zero voltage switching conditions.

For the preferred embodiment, typical illustrative values for the major components for a 20 W CFL output are as follows:-

- C1 = 4.7nF 630V DC
10 C2 = 100nF 250V DC
 C3 = 10 μ F 450V DC
 C4 = 4.7nF 630V DC
 L1 = 2.0mH
 L2 = 1.0mH
15 R = Bridge rectifier consisting of:-
 2 x 600V standard diodes
 2 x 600V fast recovery diodes
 D1 = 600V fast recovery diode
 D2 = 600V fast recovery diode
20 M1, M2 are 500V n-channel MOSFETs (eg. IRF820s) or form
 part of an IR51H420 integrated inverter packaged device.
 U1 is a half-bridge driver (eg. L6569A)
 Switching Frequency = 48kHz
 Dead-times (i.e. stages B and D) = 1.2 μ s.
25 These values vary greatly for different power output level
 lamps.

It will be appreciated that the invention provides for a reduction in current surges being drawn from the mains supply by the manner in which the smoothing capacitor C3 is replenished without a need for a surge from the mains.
30 It will also be appreciated that inductor L2 and diode D2

- 12 -

behave in an integrated boost converter like manner to cause the smoothing capacitor voltage to be greater than the peak input voltage. As a result of this action, no current surge occurs at the peak of the line voltage, a problem which still occurs in other ballasts. The diode D1 acts to clamp the voltage on C1 to safe levels, thereby protecting this component. Also the current is drawn off the mains utility over the whole of the line period and this, coupled with the elimination of the current surge at the peak of the line voltage reduces the line current distortion and consequently improves the power factor. Furthermore, energy is circulated between C3 and C1, thus enabling substantial currents to flow through the lamp terminals which keeps the lamp ignited even when the instantaneous input voltage is zero. Thus lamp current crest factor is also maintained at a low level.

Referring to Fig. 6(a) the input current waveform is shown superimposed on the input voltage. As is clear from this diagram, current is drawn from all of the cycle and there are no current surges. Fig. 6(b) shows the lamp arc current. There is a relatively flat modulation envelope, giving a low current crest factor. A power factor of 0.97 has been achieved. In general, the THD achieved was less than 20% and often less than 15% where the voltage source was at a voltage level of less than 0.5% THD.

Operation of the capacitor C5 has not been referred to in the description of operation of the circuit, for clarity. the purpose of this component is to provide a low-impedance path to circuit ground for high-order harmonics of the switching frequency caused by the high rate of voltage change at the lamp terminals. As a result, EMI is substantially reduced.

- 13 -

It will be appreciated that the ballast described in this document may also make use of bipolar transistors or MOSFETs driven in a self-oscillating fashion using positive feedback techniques. It will be appreciated that boosting of the smoothing capacitor could alternatively be achieved using a step-up converter including a MOSFET and associated control circuit. Further an integrated boost half-bridge circuit may be used. Further, it is envisaged that the diode D1 may be dispensed with, at the expense of high voltages appearing across C1.

If bipolar transistors are used, they may be connected to components which perform the same function as the inherent diodes of the MOSFET switches.

CLAIMS

1. An electronic ballast circuit for a compact fluorescent lamp, the circuit comprising:-
 - 5 a DC rectifier providing a DC voltage across a first pair of rails,
 - an LC tank circuit and lamp terminals,
 - a smoothing capacitor,
 - high frequency switches connected to the tank circuit at the centre point of the switches,
 - 10 an oscillator controlling the switches, and
 - booster means for charging the smoothing capacitor to a value greater than the peak input voltage.
2. An electronic ballast circuit as claimed in claim 1,
15 wherein the smoothing capacitor is connected across a second pair of rails connected to the first pair of rails via a reverse-connected diode, and both pairs of rails have the same negative rail.
3. An electronic ballast circuit as claimed in claim 2,
20 wherein the booster means comprises means for dividing current flow on the first pair of rails between the tank circuit and the second pair of rails.
4. An electronic ballast circuit as claimed in claim 3,
25 wherein the current is divided during the on switching period of a switch connected to the positive rail of the second pair of rails.

- 15 -

5. An electronic ballast circuit as claimed in any preceding claim, wherein the booster means comprises a diode connected in parallel with the tank circuit to provide a path for boost current.
- 5 6. An electronic ballast circuit as claimed in claim 5, wherein the booster means also comprises an inductor on the first positive rail between the rectifier output and the booster diode so that it builds up an energy store during the on switching period of the switch connected to the negative rail.
10
7. An electronic ballast circuit as claimed in claim 6, wherein the value of the booster inductor is such that it forms part of the ballasting function of the LC tank circuit.
- 15 8. An electronic ballast circuit as claimed in any preceding claim, wherein the switches are MOSFET switches having inherent diodes which conduct during periods in which both switches are open.
- 20 9. An electronic ballast circuit as claimed in claims 6 to 8, wherein the booster inductor values provide a current THD of less than 15% from a voltage source having a voltage of less than 0.5% THD.
10. An electronic ballast circuit as claimed in any preceding claim, further comprising an EMI-reducing capacitor between a tube terminal and circuit ground.
25
11. An electronic ballast circuit as claimed in claim 10, wherein the EMI-reducing capacitor has a value of 2 to 4 nF.

12. An electronic ballast circuit substantially as hereinbefore described with reference to the accompanying drawings.
 13. A compact fluorescent lamp comprising an electronic ballast circuit as claimed in any preceding claim.
- 5

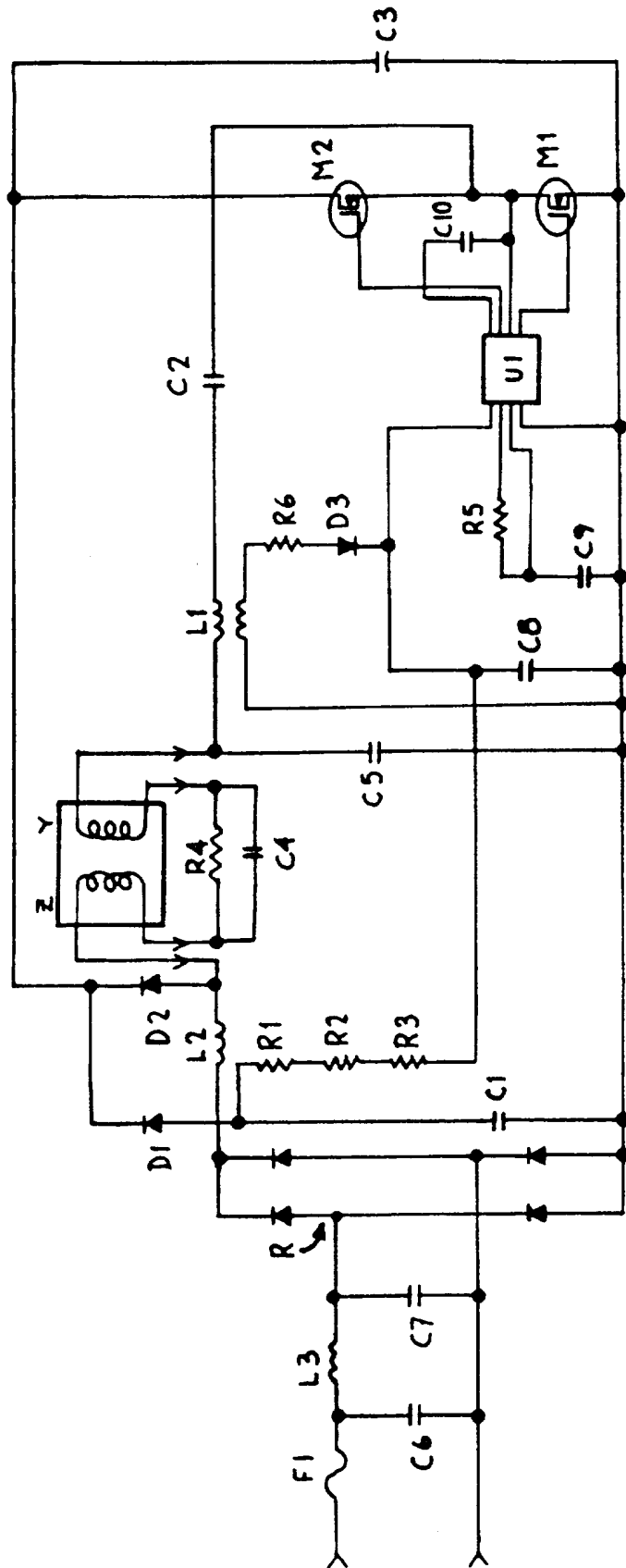


Fig.1(a)

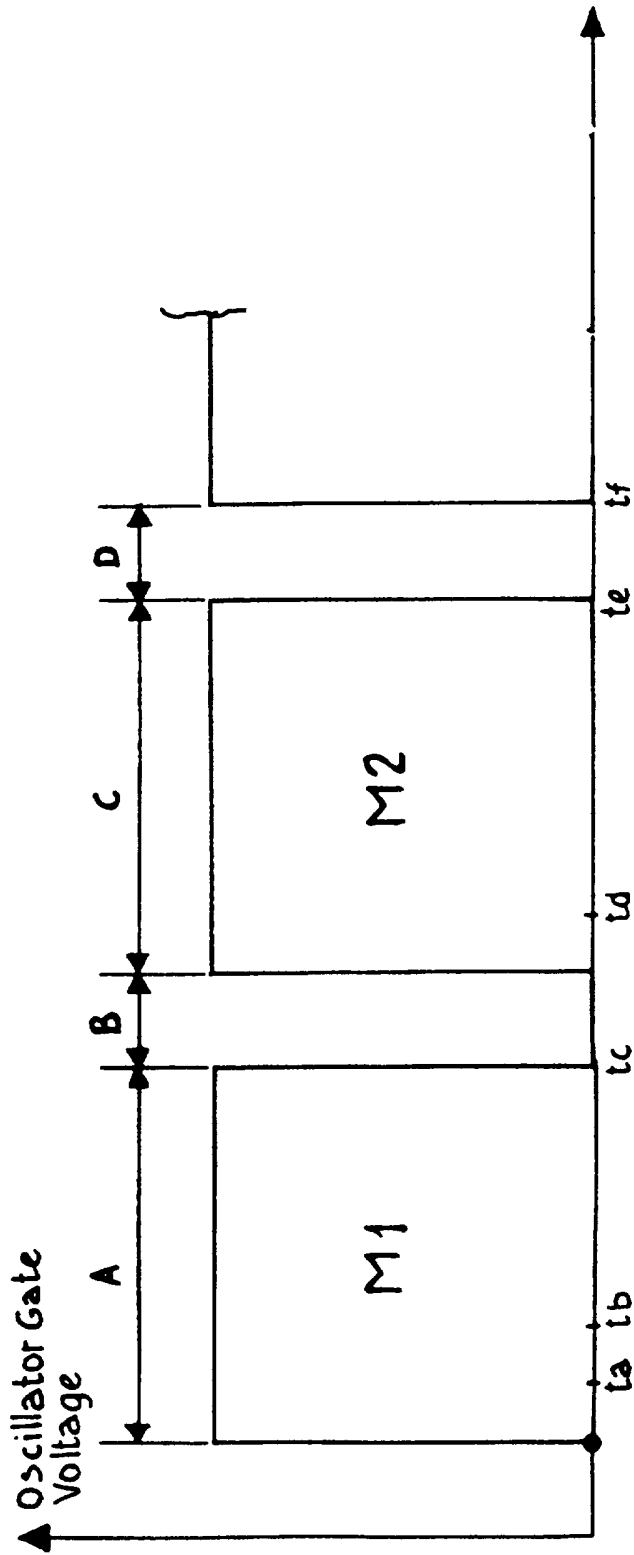


Fig.1(b)

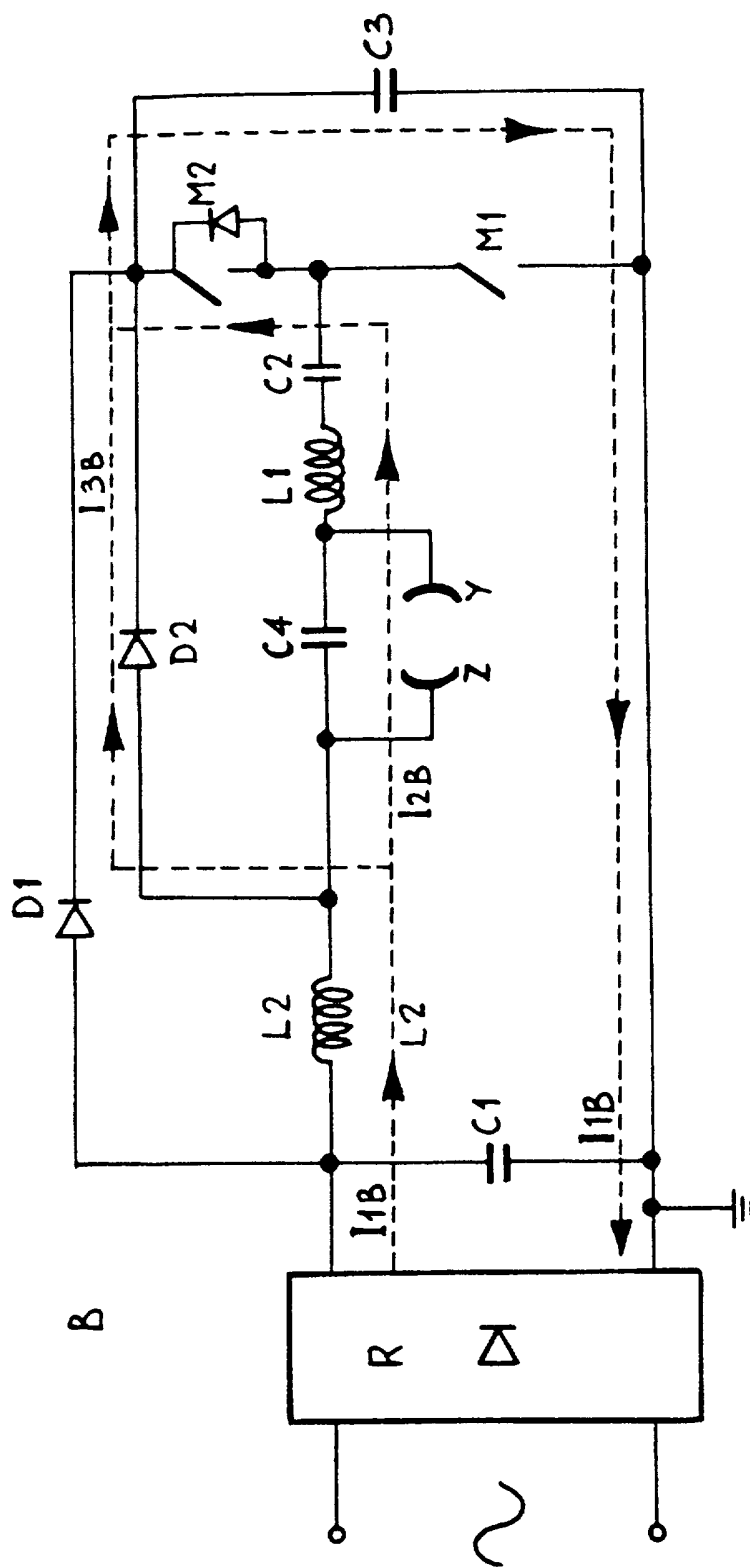


Fig. 3

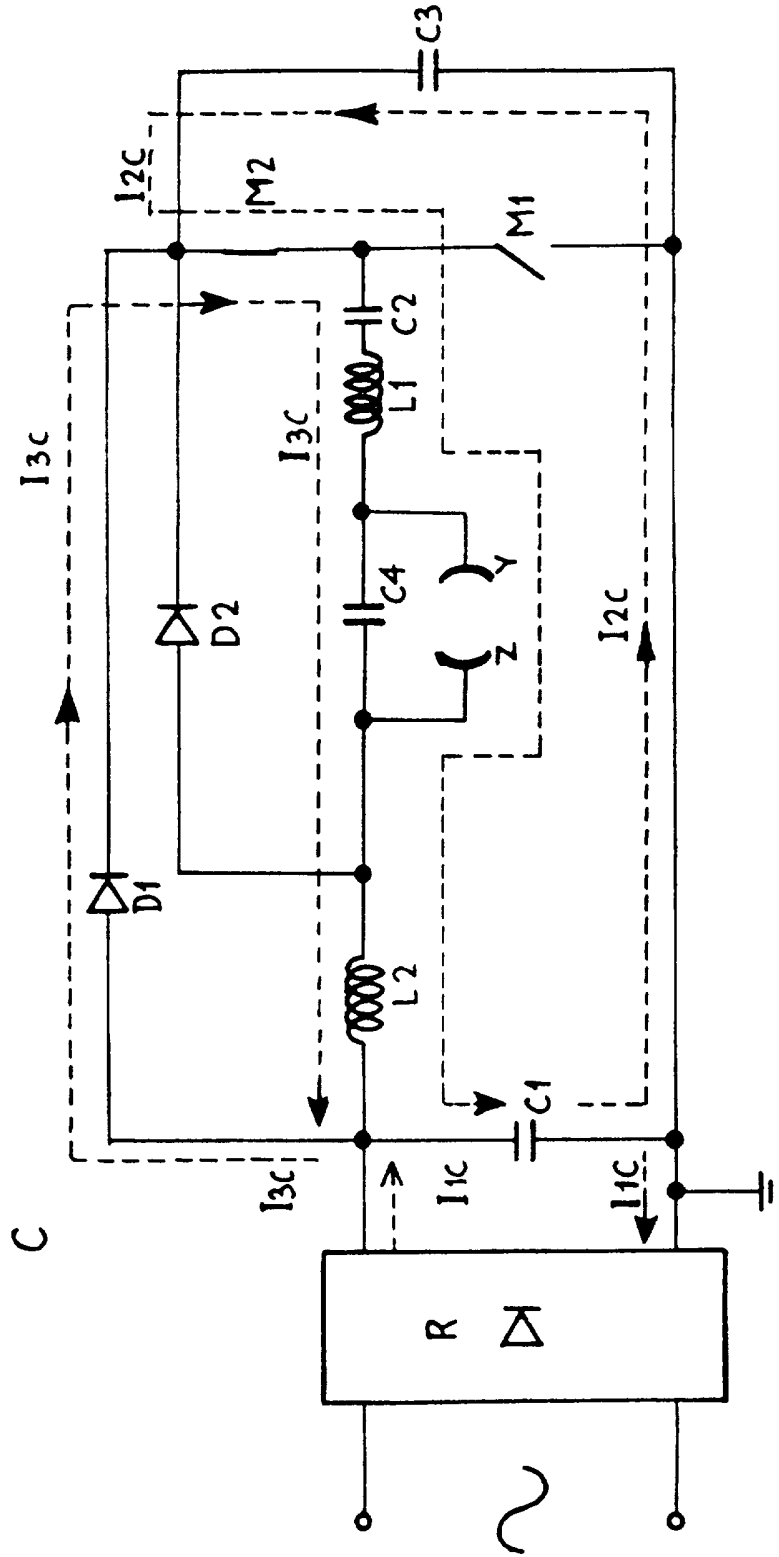


Fig.4

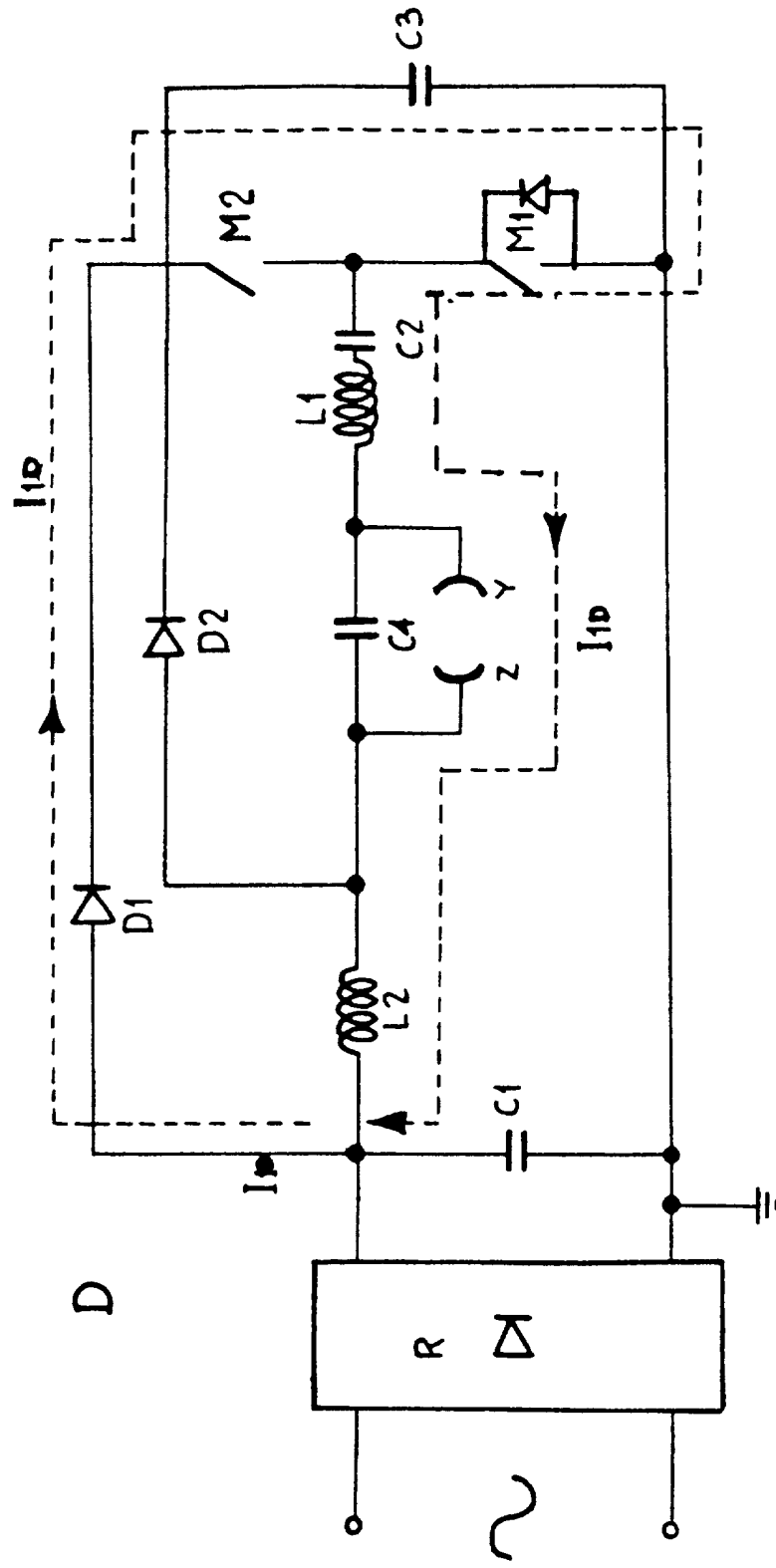
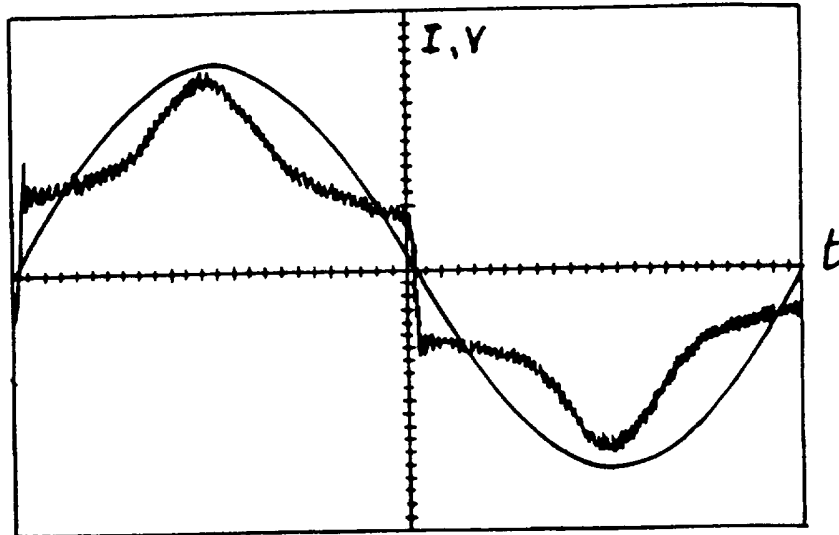
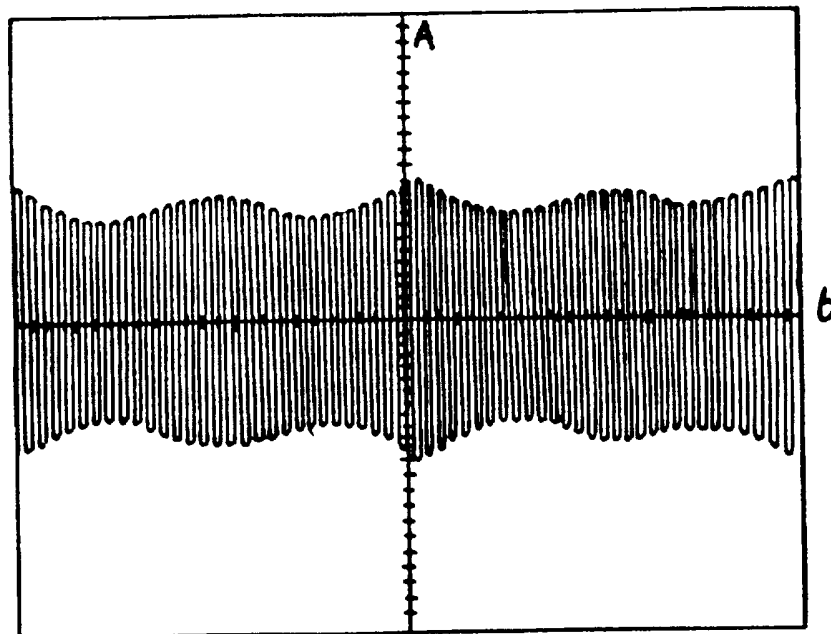


Fig. 5



(a) Ballast input current for sinusoidal input voltage



(b) Lamp current over a full line cycle

Fig.6

INTERNATIONAL SEARCH REPORT

Intern al Application No
PCT/IE 97/00016

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 H05B41/29

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 H05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR 2 527 889 A (CONTROL LOGIC PTY LTD) 2 December 1983 see page 13, line 29 - page 14, line 23; figures 8,9,17,18 ---	1-3
X	EP 0 395 776 A (SIEMENS AG) 7 November 1990 see column 4, line 31 - column 4, line 56; figures 2-7 ---	1-3,5-7
X	EP 0 621 743 A (PHILIPS NV) 26 October 1994 see page 5, line 3 - page 5, line 37 see page 7, line 27 - page 7, line 30; figure 5 ---	1,8,9
	-/--	

Further documents are listed in the continuation of box C.

Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

13 May 1997

Date of mailing of the international search report

30. 05. 97

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentaan 2
NL - 2280 HV Rijswijk
Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+ 31-70) 340-3016

Authorized officer

Speiser, P

INTERNATIONAL SEARCH REPORT

International Application No

PCT/IE 97/00016

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 44 00 436 A (MATSUSHITA ELECTRIC WORKS LTD) 25 August 1994 see figure 11 -----	1,10,11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/IE 97/00016

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
FR 2527889 A	02-12-83	AT 386103 B	11-07-88
		AU 555355 B	18-09-86
		AU 1522383 A	08-12-83
		BE 896912 A	03-10-83
		BR 8302928 A	07-02-84
		CA 1207830 A	15-07-86
		CH 671860 A	29-09-89
		DE 3319739 A	01-12-83
		GB 2124042 A, B	08-02-84
		JP 59078496 A	07-05-84
NL 8301951 A	02-01-84		
US 4511823 A	16-04-85		

EP 0395776 A	07-11-90	DE 58907116 D	07-04-94
		JP 2304896 A	18-12-90

EP 0621743 A	26-10-94	US 5404082 A	04-04-95
		US 5410221 A	25-04-95
		CA 2121726 A	24-10-94
		CN 1098242 A	01-02-95
		JP 7073988 A	17-03-95

DE 4400436 A	25-08-94	JP 6245530 A	02-09-94
		CA 2113031 A	24-08-94
		CN 1092913 A, B	28-09-94
		US 5517403 A	14-05-96
