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Applicant: **THORN EMI plc**
4 Tenterden Street
London W1A 2AY(GB)

Inventor: **Green, Ian Macdonald**
Westwood, High Street
Buckie, Banffshire(GB)
Inventor: **Mascarenhas, Everard Joseph**
75, Pinewood Avenue
Hillingdon, Middlesex(GB)

Representative: **Hurst, Richard Arthur**
Alexander et al
THORN EMI Patents Limited The Quadrangle
Westmount Centre Uxbridge Road
Hayes Middlesex UB4 0HB(GB)

Supply circuits for discharge lamps.

A supply circuit for a discharge lamp powered by an A.C. supply is provided, the circuit including a variable impedance for connection in series with said lamp, means for monitoring the amplitude of the supply frequency component of the power driving

the lamp, and means for using the amplitude to control the variable impedance so as in use to reduce substantially the amplitude of the flicker of the lamp of the supply frequency.

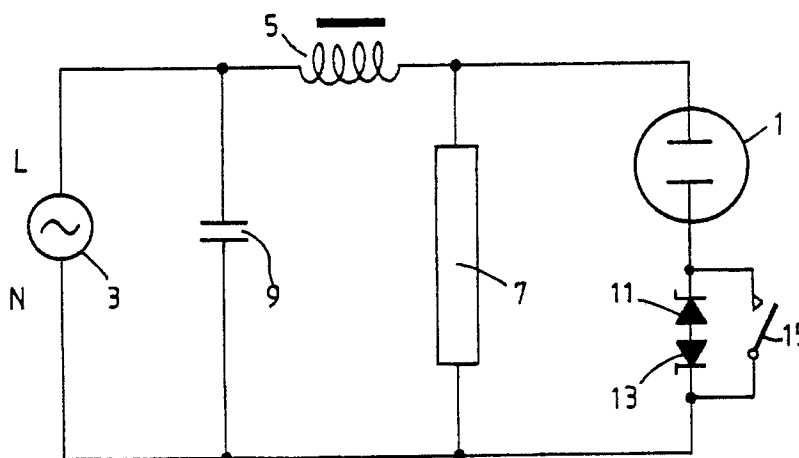


FIG. 3

SUPPLY CIRCUITS FOR DISCHARGE LAMPS

This invention relates to supply circuits for discharge lamps. In particular the invention relates to supply circuits which are powered by an A.C. supply, for example an A.C. mains supply. In such circuits lighting flicker at the frequency of the supply can cause considerable annoyance. Such flicker generally arises from asymmetries in either the supply waveform, the construction and operation of the lamp itself or in the associated circuitry.

One known method of alleviating the problem of flicker is to drive the lamp from a high frequency voltage derived from the A.C. supply via appropriate circuitry, for example power FETs. While such an arrangement has the advantage of considerable reduction in flicker together with increased efficiency the circuitry required is, at present, relatively expensive. Furthermore there are problems in controlling the high voltages needed to start the lamp and subsequently drive it using such high frequency voltages.

It is an object of the present invention to provide a supply circuit for a discharge lamp wherein the problems of flicker are at least alleviated, but does not involve the use of high frequency voltages.

According to the present invention there is provided a supply circuit for a discharge lamp powered by an A.C. supply, the circuit including a variable impedance for connection in series with said lamp, means for monitoring the amplitude of the supply frequency component of the power driving the lamp, and means for using the amplitude to control the variable impedance so as in use to reduce substantially the amplitude of the flicker of the lamp.

Preferably the amplitude of the supply frequency component of the power of the lamp is monitored optically.

Alternatively the amplitude of the supply frequency component of the power of the lamp is monitored by monitoring the D.C. current through the lamp.

Preferably the voltage across the variable impedance is used to power the circuitry which monitors the amplitude of the supply frequency component of the power through the lamp.

Thus no additional power supply will be needed.

Two supply circuits in accordance with the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of a conventional supply circuit for a discharge lamp;

Figure 2 illustrates the light output of the

discharge lamp incorporated in the circuit of Figure 1;

Figure 3 is a schematic illustration of a first circuit in accordance with the invention which illustrates the principle of the present invention;

Figure 4 shows the lamp voltage and lamp power of the lamp incorporated in the circuit of Figure 3;

Figure 5 illustrates the variation in the phase of the flicker as a function of the timing of the operation of the switch in Figure 3;

Figure 6 illustrates the variation of the magnitude of the flicker as a function of the timing of the operation of the switch in Figure 3;

Figure 7 is a schematic diagram of a second circuit in accordance with the invention;

Figure 8 shows part of the circuit of Figure 7 in more detail;

Figure 9 shows part of the circuit shown in Figure 8 in more detail;

Figure 10 shows a first waveform for use in a Fourier analysis technique used in a circuit in accordance with the invention;

Figure 11 shows a second waveform for use in the Fourier analysis technique; and

Figure 12 shows a third alternative waveform for use in the Fourier analysis technique

Referring firstly to Figure 1, the circuit shown is a typically conventional supply circuit for a high pressure discharge lamp. The circuit comprises the high pressure discharge lamp 1 connected across an A.C. supply 3, typically a 50 Hz 240 volt mains supply. A ballast inductor 5 is connected in series on the live supply rail between the supply 3 and the lamp 1, a starting circuit 7 being connected across the lamp 1. A power factor correction capacitor 9 is connected across the supply 3. In use of the circuit the starting circuit 7 causes the lamp 1 to strike by inducing high voltage spikes. The voltage across the lamp 1 then falls to the normal running voltage.

When lamps are operated on a.c. supplies there is a cyclic variation in light output of twice the fundamental supply frequency. On 50HZ supplies the effect is a 100Hz flicker which is not normally visible.

Referring now also to Figure 2 the lamp light output from such a circuit is of the general form shown in this figure although the magnitude of the flicker has been slightly exaggerated for the sake of clarity. It will be seen from this figure that the lamp light output reduces in magnitude at time intervals corresponding to every other half cycle of the supply voltage, resulting in a 50HZ flicker component which is highly visible, this being due to

asymmetries within the circuit or the lamp. The purpose of the instant invention is to substantially eliminate the supply frequency of flicker that is at 50HZ.

Referring now also to Figure 3, in a circuit in accordance with the invention additional circuitry is provided to the circuit shown in Figure 1 in order to alleviate the effect of flicker. Thus in the circuit shown in Figure 3 in which the corresponding components to those in Figure 1 are accordingly labelled, between the lamp 1 and the neutral rail there is provided a parallel arrangement of two back to back zener diodes 11, 13 and a switch 15. The switch, whose form will be described in more detail hereafter, is arranged to open at times within each mains cycle dependant on the flicker of the lamp 1. The effect of this is that the voltage on the lamp side of the inductor 5 changes from the arc voltage of typically 100 volts to a slightly greater voltage, typically 110 volts. This in turn changes the rate of change of current through the inductor 5 which changes the current waveform and hence the light output of the lamp 1. It will be seen that if the switch is opened for a period during each positive half cycle of current a 50 Hz component of power and therefore of light output is developed in the lamp. If however the switch is opened during negative half cycles only, an antiphase component is developed. Thus a component may be induced which reduces a component of any existing flicker enabling an equal lamp power to be developed over all cycles of the supply as shown in Figure 4.

Referring now also to Figures 5 and 6 it will be understood that the timing and duration of the opening of the switch 15 is critical in the reduction of flicker. As can be seen in Figure 5 in the particular example shown the phase of the flicker varies by 17 degrees dependent on when, within a half cycle of the mains waveform the switch 15 is operated across a half cycle of the mains. As can be seen in Figure 6, the magnitude of the flicker also varies slightly dependent on the timing of the opening of the switch 5 within the AC half cycle. In order to achieve the required cancellation of flicker two vectors are combined, one being approximately minimum phase and the other maximum phase. The maximum phase vector is generated by opening the switch 15 when the current is close to zero. The length of this vector is proportional to the length of time the switch 15 is left open. Similarly by opening the switch 15 when the current is close to maximum a second vector can be generated. It will be seen that because both positive and negative current cycles are produced these vectors can be controlled from positive through zero to negative. Thus by an appropriate combination of these two vectors with their relative phase of 17 degrees a vector representing the flicker can be cancelled.

Generally orthogonal vectors will be used, these orthogonal control vectors being generated from available vectors, 17 degrees out of phase by matrixing. Thus using an appropriate feed back control circuit the flicker can be reduced to substantially zero. It will be appreciated that ideally the switch when shut should have zero impedance so as to minimise power dissipation. In practice however this may not always be the case.

Referring now to Figure 7 the second circuit in accordance with the invention to be described operates on the same principle as the first circuit. The two zener diodes 11, 13 of the first circuit however are replaced by a single zener diode 17 connected across the output of a rectifier in the form of a diode bridge 19. The diode bridge 19 ensures that although the current through the lamp changes sign, the current across the zener 17 is always in one direction. Thus the voltage across the switch 15 is always of one polarity, making the control of this voltage easier.

Referring now to Figure 8 the switch 15 is suitably constituted by a VMOS FET 21 which is driven by a low power integrated circuit 23. The integrated circuit 23 controls the FET 21 to be open for at least a small part of each half cycle of the supply voltage. This ensures that some rectified 10 volt pulses appear across the zener diode 17 with these pulses powering the integrated circuit 23. The timing of these pulses suitably are arranged to be at current zero-crossing times since power consumed will then be a minimum, a trigger input to the integrated circuit 23 allowing mains synchronisation.

It will be noticed that the circuitry contained within the dotted box 24 indicated in Figure 8 has only two terminals and thus can be provided as a unit to be readily connected in series with a lamp in existing installations.

Referring now also to Figure 9 the integrated circuit 23 includes a series arrangement of a charge subtraction circuit 24 comprising four transistors 25, 27, 29, 31 and a photodiode 33 connected across the outputs of the rectifier 19 i.e. the voltage rails Vdd, Vss. The photodiode 33 is arranged such that it is responsive to light emitted by the lamp 1, a suitable viewing window being provided adjacent to the photodiode within the unit containing the circuitry contained within the box 24. A J-K flip-flop 35 is connected via a Schmidt trigger circuit 37 to the node between the photodiode 33 and transistor arrangement 25, 27, 29, 31. The flip-flop 35 has outputs Q and Q which are arranged to address the gates of the four transistors 25, 27, 29, 31, the flip-flop 35 being clocked by a system clock 38. The four FETs 25, 27, 29, 31 thus switch small capacitors 39, 41 between the photodiode 33 and the ground rail Vss alternately. Every time Q and Q

change, this being dependent on the value of the JK inputs to the flip-flop 35 one of the capacitors 39 or 41 is discharged to ground and the other capacitor 41 or 39 is charged up to the voltage of the photodiode 33. This then enables the discharge of the photodiode 33 towards ground by a known amount which depends on the relative capacitance of the small capacitor 41 or 39 and the photodiode 33. Light from the lamp 1 falling on the photodiode 33 results in a photo current which charges the photodiode 33 away from ground. When the photodiode voltage exceeds the threshold of the Schmidt trigger circuit 37, the JK inputs to the flip-flop 35 go high, thereby causing Q and Q to change on the next clock pulse edge. This in turn causes the grounded capacitor 39 or 41 to be connected in parallel with the photodiode 33 thus bringing the photodiode voltage back below the Schmidt threshold. As a result of this the output of the flip-flop 35 alternates at a frequency which is directly proportional to the intensity of the light falling on the photodiode 33. Thus a counter (not shown) connected to the integrated circuit 23 would display a count proportional to the light falling on the photodiode 33 integrated over a chosen counting period. A voltage derived from the flicker component in the output of the flip-flop 35 is used to control the conductance of the FET 21 to thereby reduce the 50 Hz flicker in the lamp 1.

Referring now to Figures 10, 11 and 12 in order to detect the flicker component in the repetitive waveform of the supply in the frequency output of the flip-flop 35 the waveform is multiplied by a sinusoidal function of the same frequency and phase as the supply waveform and the result integrated over the repetition period i.e. Fourier analysed. The ideal multiplication waveform is the sine wave shown in Figure 10. This may however be replaced by the approximation of the square wave shown in Figure 11. Thus the frequency count over one half of the supply cycle will be subtracted from the frequency count over the other half to give a flicker component. The disadvantage of such an arrangement however is the spurious response at odd harmonics of the supply frequency, for example 150 Hz and 250 Hz flicker might be responded to, the circuit thus generating a spurious 50 Hz pulse. In such an event waveforms of the type shown in Figure 12 may be used. This may be readily implemented by using a divide by two circuit to half the frequency output of the flip flop 35 at selected times within the supply waveform cycle. For example, if over half a cycle the times allocated for multiplications of 1 2, 1 and then 1 2 are in the ratio 1:1:1, the spurious 150 Hz response will be reduced to zero. If however these times are in the ratio 1:2:1, both the 150 Hz and 250 Hz responses will be reduced by a factor of

about 6. As, however, symmetric lamps will have flicker at only even harmonics of the supply frequency this is unlikely to be a major problem.

It will be appreciated that whilst the rate of change of the output of the flip-flop 35 will vary as the detected light intensity, this frequency output cannot be greater than the frequency of the system clock 38.

Thus the clock rate of the flip-flop 35 is determined by the necessity to measure flicker accurately. It is found however that the system clock rate can be kept down to around 1 MHz. Such a clock rate will allow a light count of a few thousand over a quarter of a mains cycle and will minimise the power consumption of the integrated circuit 23. In order to further reduce the necessary clock rate additional photodiodes (not shown) may be connected in parallel with the photodiode 33. Alternatively different values of small capacitors 39, 41 may be switched in. In order to accommodate a wide range of conditions such as widely different lamps, different light mountings or dirt on the sensing window to the photodiode it would be advantageous if this could be performed automatically dependent on the light count using an appropriate feedback circuit.

It will be appreciated that some means must be provided for enabling light from the lamp to fall on the light sensing means. This does not necessarily mean however, that a direct window between the lamp and the light sensing means will be necessary. One alternative which avoids the problem of the chip exposure to ultra violet radiation and heat radiation is to use a transparent fluorescent fibre to connect the lamp to the light sensing means. Most of the length of the fibre will be exposed to the lamp light causing it to fluoresce. The resultant light will be transmitted down the fibre, one end of which is coupled to the light detection means. This arrangement would be particularly convenient for sensing light from an extended source such as a compact fluorescent tube.

It will be appreciated that whilst in the particular circuits described herebefore the lamp is a high pressure discharge lamp, the invention is applicable to other types of gas discharge lamps as long as the flicker is not spacially variant over the lamp, or, where there is some spatial variation in flicker, if light from the part of the lamp giving rise to a different flicker component can be shielded from the light sensing means.

Whilst the invention finds particular application to supply circuits for discharge lamps which are connected to an A.C. supply via an inductive ballast, the invention is relevant to lamp circuits which do not contain inductive ballasts, for example a lamp circuit incorporating an electronic ballast which does not include correction for flicker in

itself.

It will also be appreciated that whilst it is particularly convenient to detect the flicker by means of the lamp light output there are alternative methods of detecting the flicker. One such method is to monitor the D.C. current through the lamp which will in itself be an indication of the flicker of the lamp. If the flicker is predominantly of one phase, an approximate correction can then readily be made to the current waveform through the lamp so as to reduce the DC current by varying an impedance in series with the lamp at an appropriate time within the mains half cycle.

It will also be appreciated that whilst the circuits for monitoring the amplitude of the supply frequency component of the power of the lamp described herebefore is a digital circuit, an analogue circuit may be used instead. It is however particularly advantageous to use a digital implementation as an analogue implementation is likely to require more components which can not be incorporated in an integrated circuit. Furthermore an analogue implementation will be more prone to outside interference.

Claims

1. A supply circuit for a discharge lamp powered by an A.C. supply, the circuit including a variable impedance for connection in series with a said lamp, means for monitoring the amplitude of the supply frequency component of the power driving the lamp, and means for using the amplitude to control the variable impedance so as to, when in use, reduce substantially the amplitude of the flicker of the lamp at the supply frequency.

2. A supply circuit according to claim 1 wherein the supply frequency component of the power driving the lamp is monitored optically.

3 A supply circuit according to claim 2 comprising a means for transferring light from the lamp, when in use, to fall onto a light sensing means.

4. A supply circuit according to claim 3 wherein said light sensing means comprises a photodiode.

5. A supply circuit according to claim 3 wherein said means for enabling light from the lamp, when in use, to fall onto a light sensing means comprises a transparent fluorescent fibre.

6. A supply circuit according to claim 1 wherein the supply frequency component of the power driving the lamp is monitored by monitoring the D.C. current through the lamp.

7. A supply circuit according to claim 1 wherein the voltage across the variable impedance is used to power the circuitry which monitors the amplitude of the supply frequency component of

the power through the lamp.

8. A supply circuit according to claim 1 wherein said variable impedance is provided by a parallel arrangement of two back to back Zener diodes and a switch.

9 A supply circuit according to claim 1 wherein said variable impedance is provided by a single Zener diode connected across the output of a rectifier in the form of a diode bridge and a switch.

10 A supply circuit according to claims 8 or 9 wherein the switch is constituted by a MOS FET.

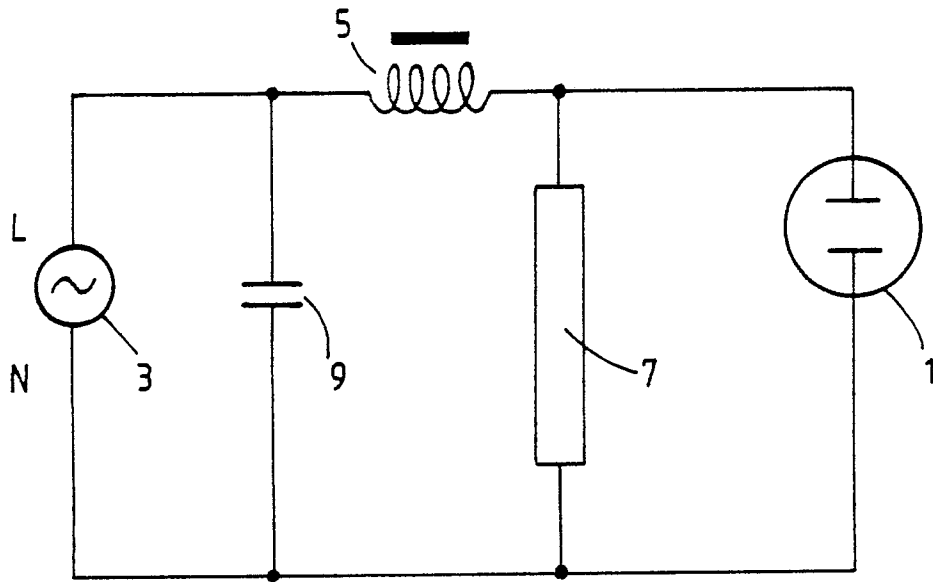


FIG. 1 PRIOR ART

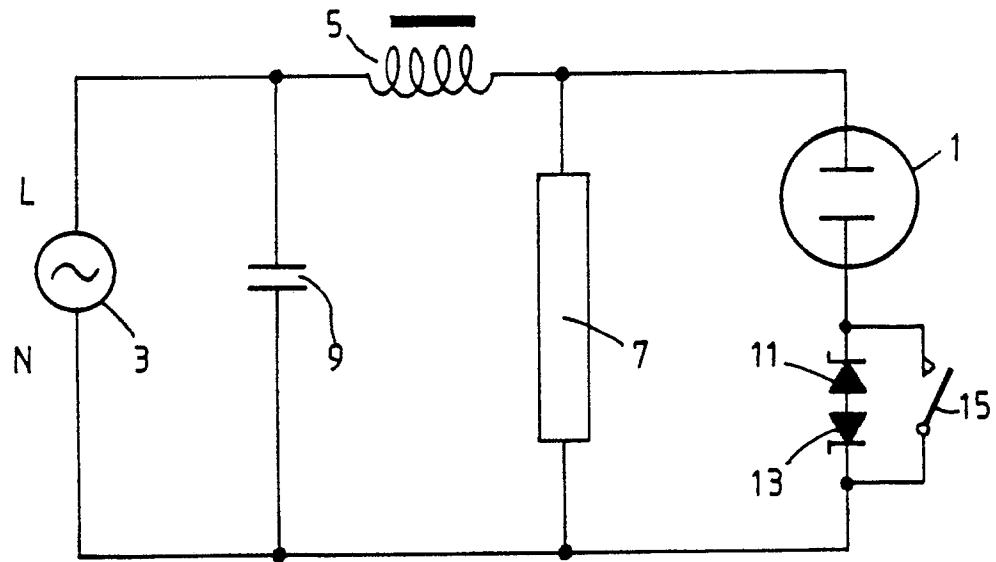


FIG. 3

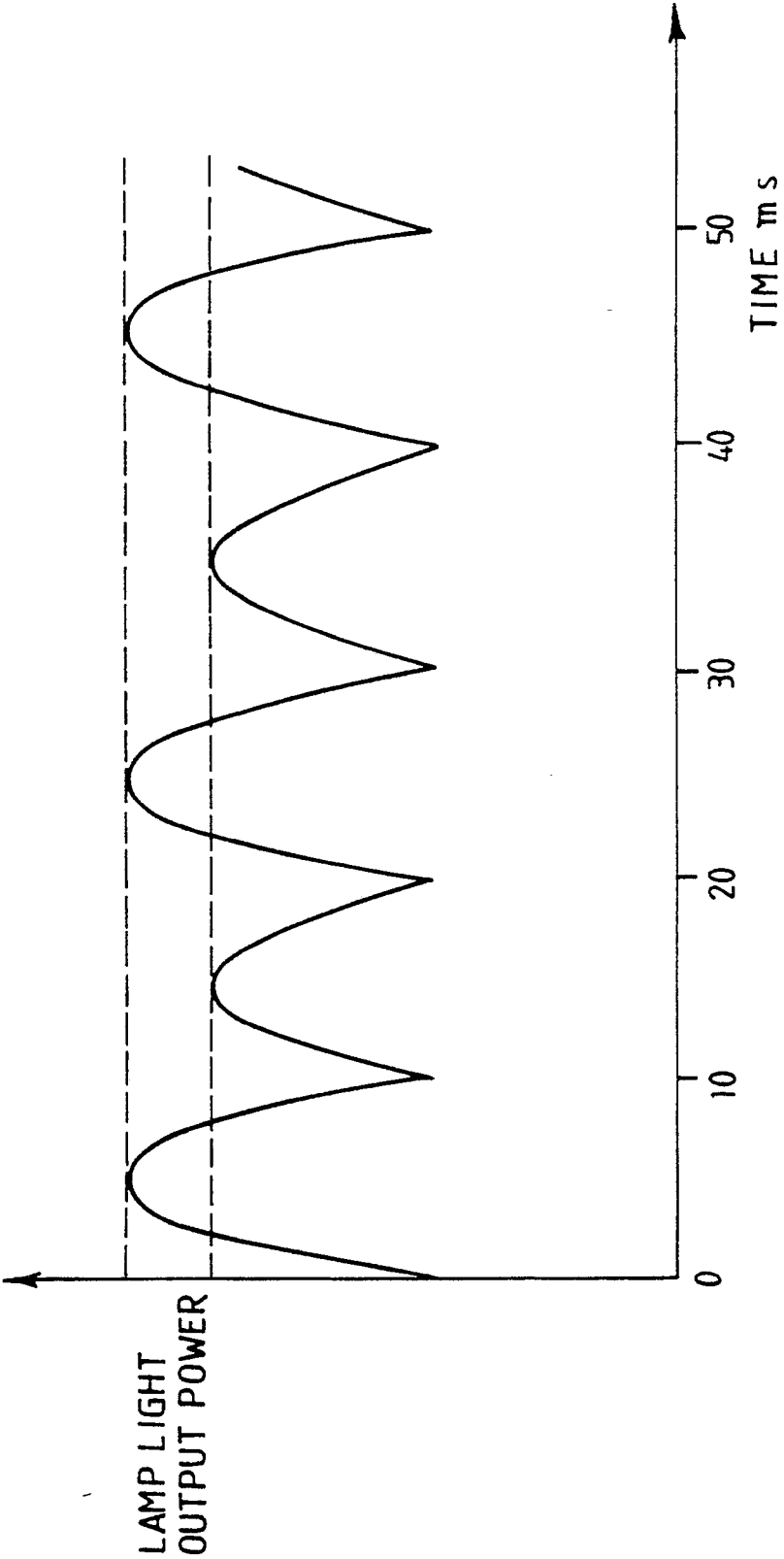
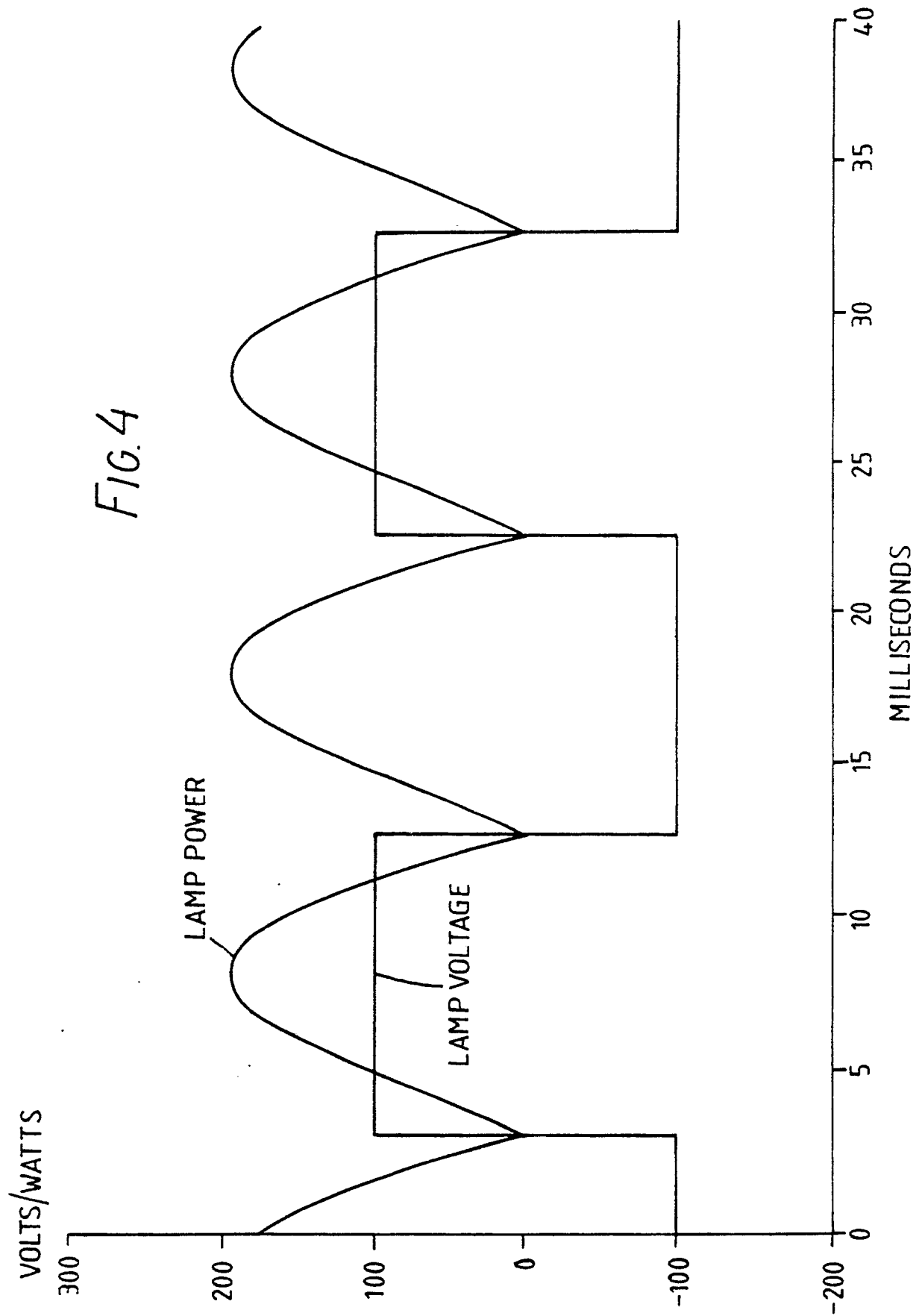


FIG. 2 PRIOR ART



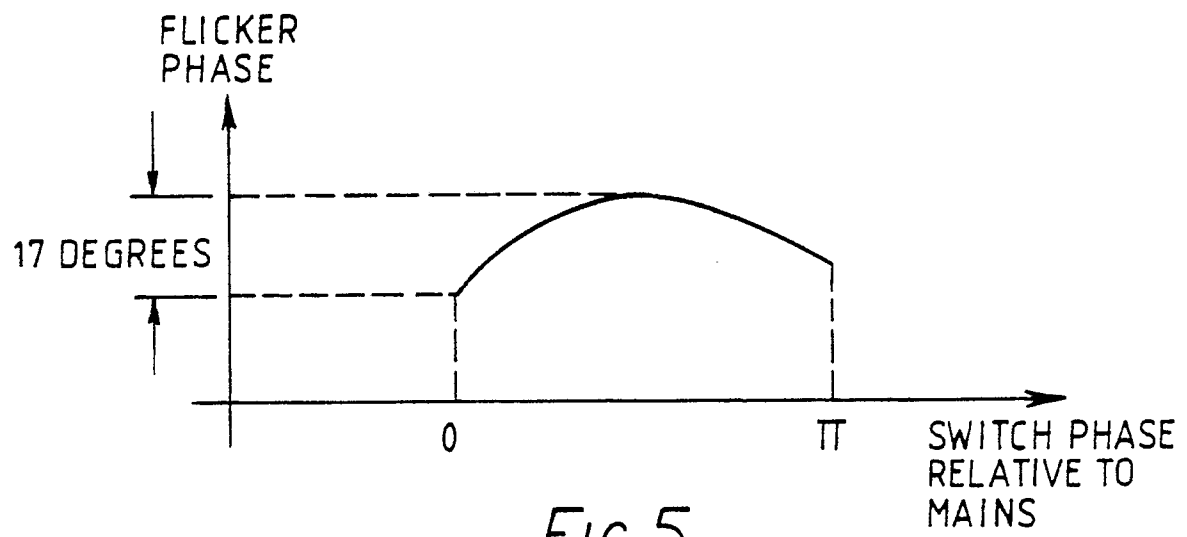


Fig. 5

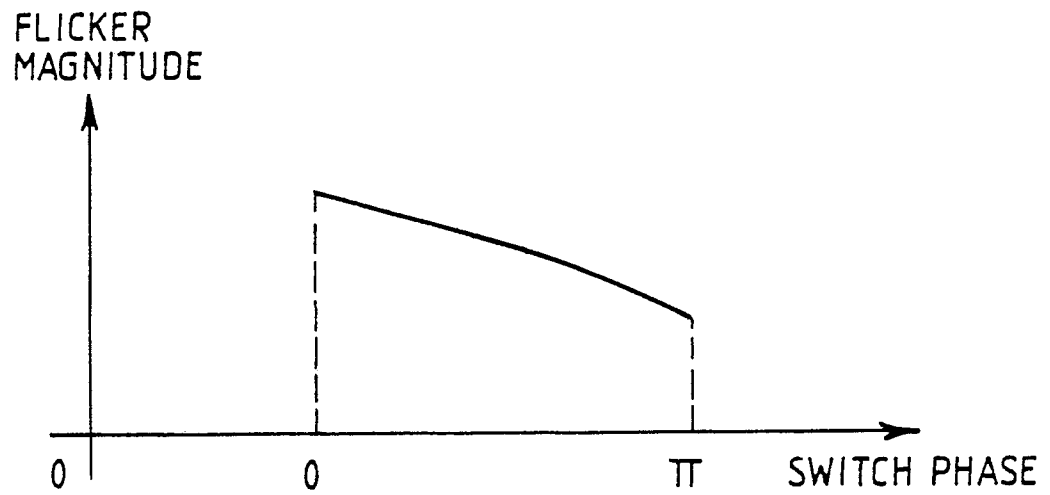


Fig. 6

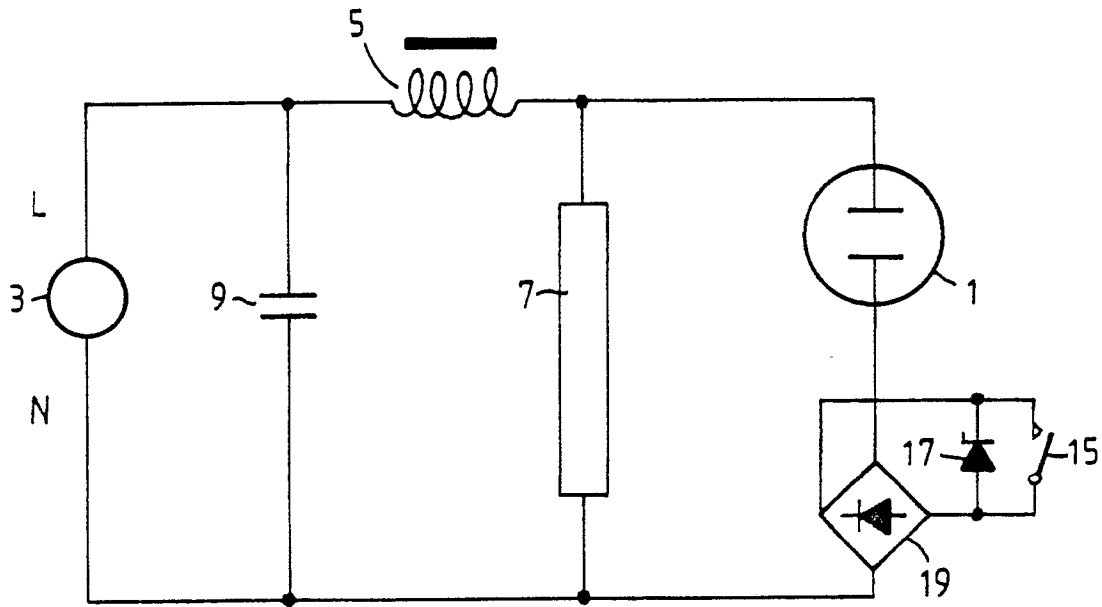


FIG. 7

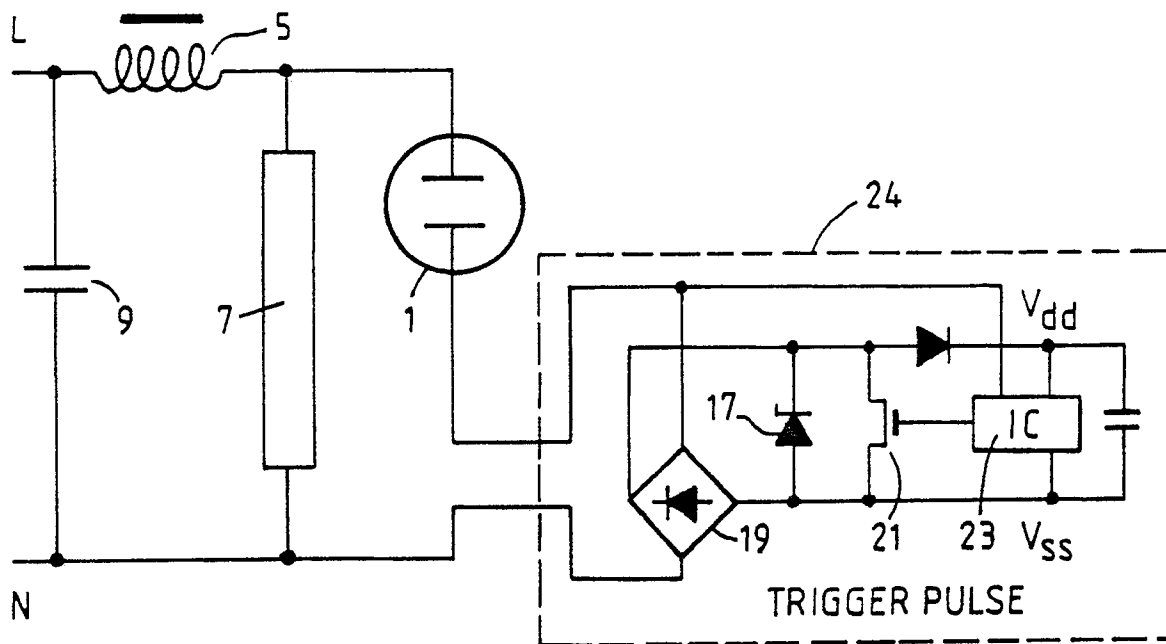
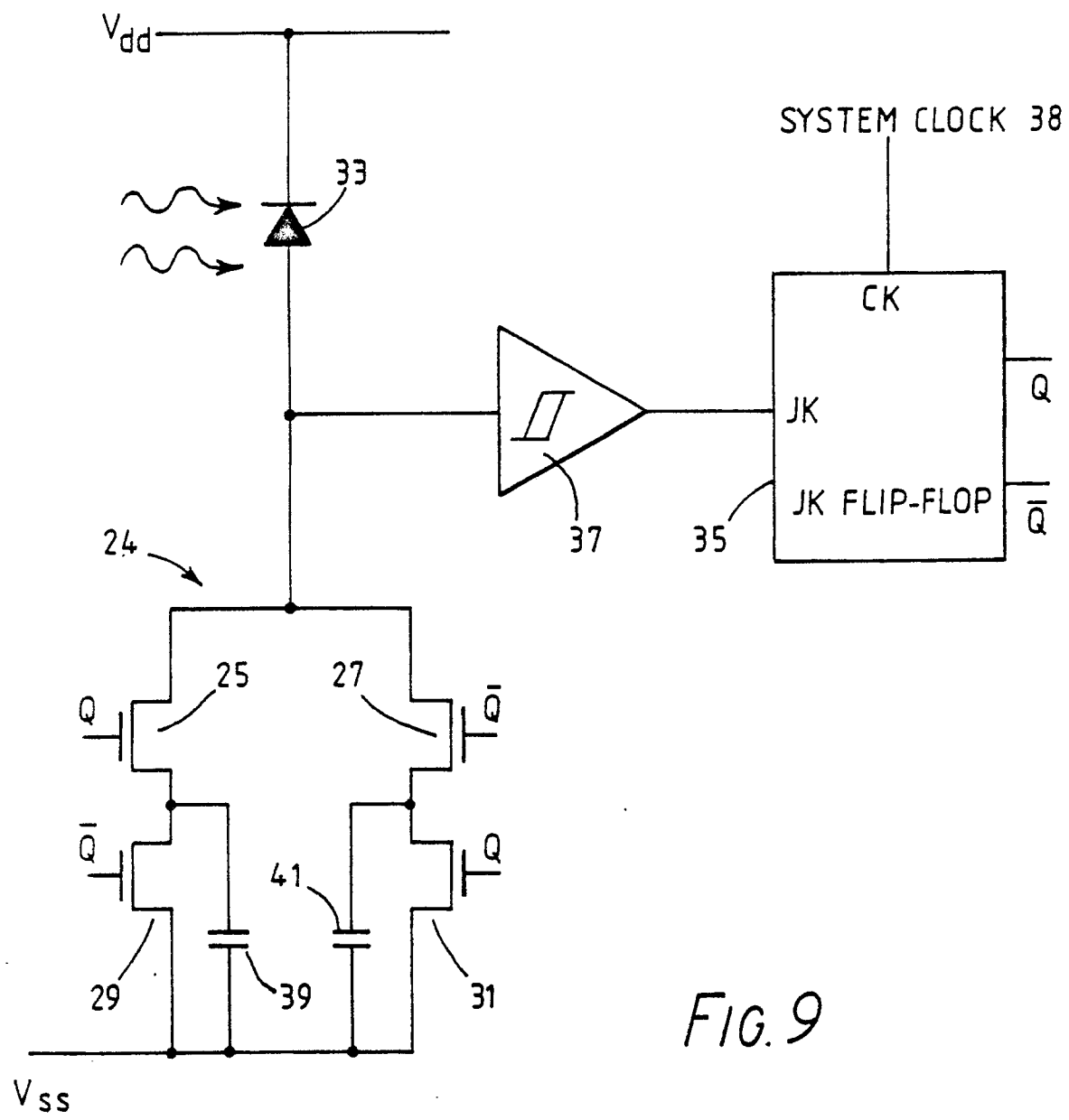


FIG. 8



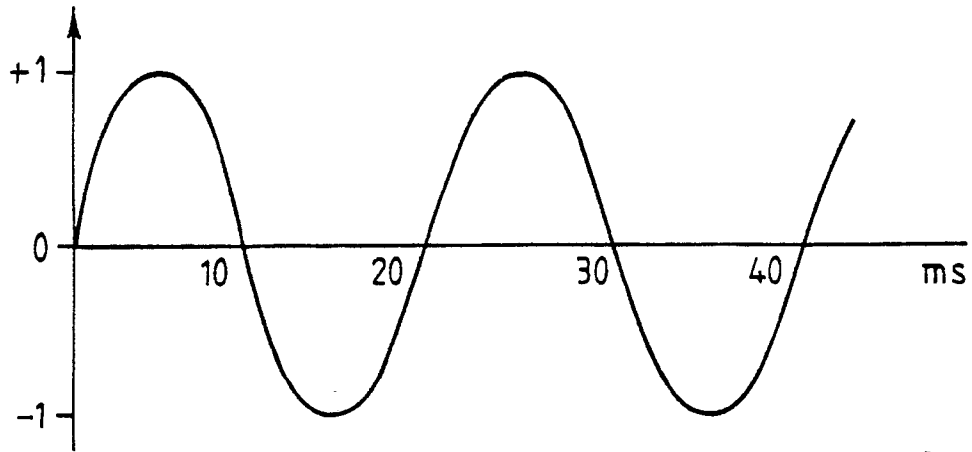


FIG.10

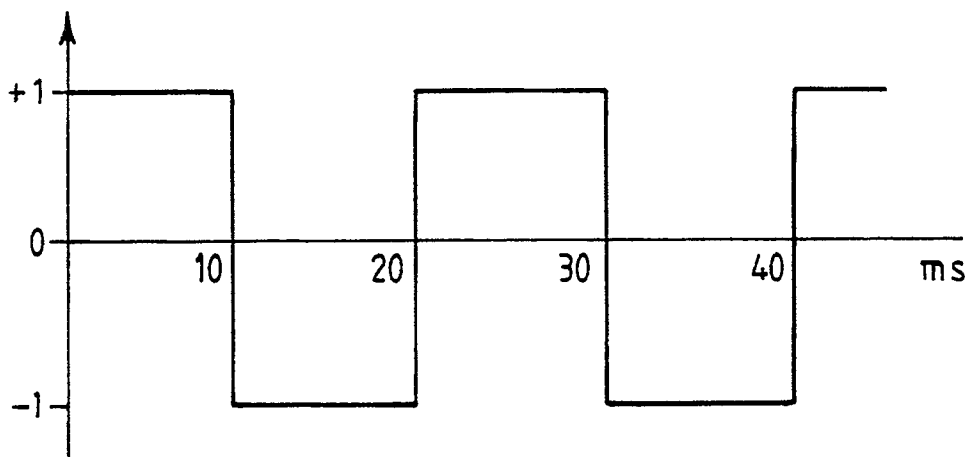


FIG.11

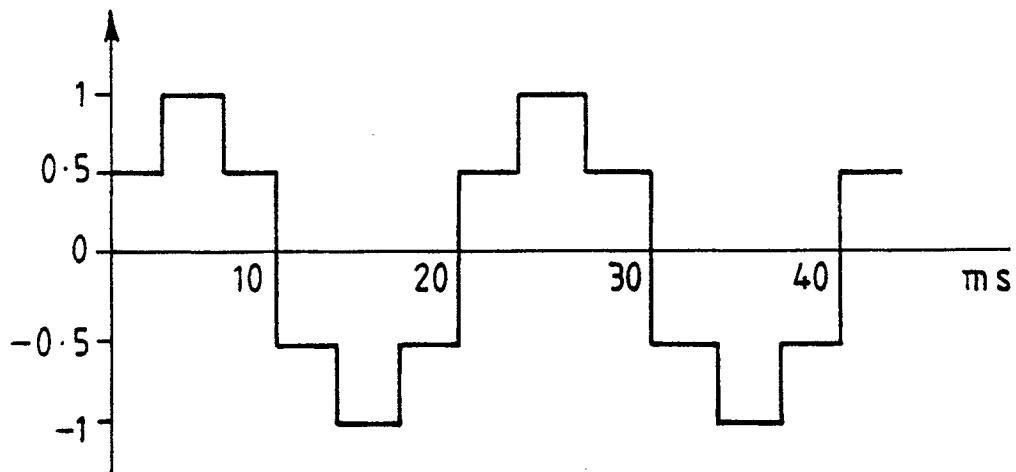


FIG.12



DOCUMENTS CONSIDERED TO BE RELEVANT			EP 90305695.0
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.')
A	<u>DE - A - 2 417 594</u> (MATSUSHITA) * Fig. 1,2,5,6; claims 1-5 * --	1	H 05 B 41/23
A	<u>DE - A1 - 3 723 971</u> (ULTRALIGHT) * Abstract; fig. * --	1	
A	<u>SU - A - 493 941</u> (KANN POLY) * Abstract; fig. * ----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.')
			H 05 B 41/00 H 05 B 37/00
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 11-09-1990	Examiner VAKIL
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	