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(54) **Electronic ballast for fluorescent lamp**

(57) An electronic ballast for a fluorescent lamp includes a rectifier circuit (11), a filter circuit (16), a high frequency generating and control circuit (17), a starting circuit (18) for the fluorescent tube and main (14) and auxiliary (13) circuits used to increase the power factor of the ballast and to suppress the harmonic current interference. Because of the introduction of the main and the auxiliary current-uninterrupted circuits, the input curent is continuous and follows the variation with the input voltage and the power factor of the ballast is increased while the post high frequency generating and control circuit tends to be stable in operation. Furthermore, the interference of the harmonic current for the ballast will be suppressed effectively, the contamination to power network will be reduced and the electrical security in operation will be enhanced.

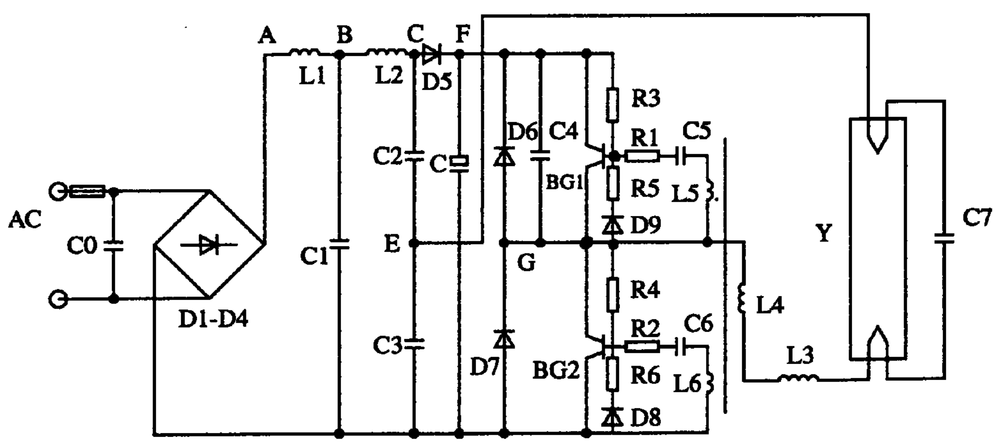

Fig. 5

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Description

Technical Field

This invention relates to an operating circuit for a fluorescent lamp, and especially to an electronic ballast for a fluorescent lamp.

Background Art

An AC-DC-AC transformation is adopted in all existing electronic ballasts for fluorescent lamps, which, through converting civil power supply into tens of kilohertz high frequency power, initiates the fluorescent lamp. This kind of electronic ballast usually includes a rectifier circuit, a filtering circuit, a high frequency generating and control circuit as well as a starting circuit for the fluorescent tube (see Fig. 1). However, since an electrolytic capacitor with a large capacitance is used in the filtering circuit (see Fig. 2), the conduction angle of the rectifier diode is very small. Its waveform appears as discrete pulses as shown in Fig. 3, hence its power factor is very low, and usually falls in the range between 0.5 and 0.6.

Furthermore, the harmonic of the current in this kind of ballast is large and may contaminate the electrical power network. If a large amount of this kind of ballast is used in three phase power supply lines, then a large neutral current will be caused in the power lines, so as to cause potential harm to the safety of the power network.

In addition, the operating method in this kind of ballast cannot protect the electronic ballast against shocking due to the surge current in the power network from switching on the fluorescent lamp. It is subject to the breakdown of the electronic elements of the ballast.

Summary of the Invention

The purpose of this invention is to provide an electronic ballast for a fluorescent lamp with a high power factor, the capability of reducing the harmonic interference to the power network and security of operation.

According to one aspect of the invention, an electronic ballast for a fluorescent lamp includes: a rectifier circuit and a filtering circuit used for converting a civil power supply into DC power, a high frequency generating and control circuit used for providing operating power to the fluorescent lamp by converting the DC power to a high frequency power source, a starting circuit used to initiate the fluorescent lamp as well as a main and an auxiliary current uninterrupted circuit connected between the rectifier circuit and the filtering circuit, used to increase the power factor of the ballast and to suppress the harmonic interference.

According to the electronic ballast for the fluorescent lamp in this invention, the addition of the main and the auxiliary current uninterrupted circuits between the rectifier circuit and the filtering circuit makes the input current continuous and follows the variation with the input voltage, hence the power factor of the ballast is increased while post high frequency generating and control circuit tends to be stable in operation.

Furthermore, the interference of the harmonic current in the ballast will be suppressed effectively, the contamination of the power network will be reduced and the electrical security of operation will be enhanced. In addition, due to the adoption of the main and the auxiliary current uninterrupted circuits in the electronic ballast of this invention, the conduction interference of the radiating frequency for the ballast is able to meet the standard stipulated by the IEC.

Brief Description of the Drawings

Fig. 1 is an electric circuit diagram of a prior art electronic ballast,
Fig. 2 is a simplified circuit diagram showing a rectifier circuit and a filtering circuit of the electronic ballast of Fig. 1,
Fig. 3 is a waveform diagram of the input current of the electronic ballast of the prior art,
Fig. 4 is a block diagram of an electronic ballast for a fluorescent lamp, according to one embodiment of this invention,
Fig. 5 is an electric circuit diagram of an electronic ballast for a fluorescent lamp, according to one embodiment of this invention,
Fig. 6 is a current/voltage waveform diagram for the electronic ballast for a fluorescent lamp shown in Fig. 5,
Fig. 7 is a conducting interference chart of the radiating frequency for the electronic ballast for a fluorescent lamp shown in Fig. 5, and
Figs. 8 to 10 are sketches to explain the principle of operating of the apparatus of Fig. 5.

Referring to Figs. 1 to 3, in the prior art circuit the current is rectified and filtered to produce a DC signal. This DC signal is used to drive the high frequency switching circuit, and also provides the power that is switched to drive the lamp. The effect of this is that current only flows when the magnitude of the input voltage is greater than the DC voltage, forward biasing the rectified diodes.

During this phase, current flows through the diodes and charges the capacitor C. During the remainder of the cycle, current flows from C to the switching circuit, and a lamp. Consequently all the current is drawn during a very narrow conduction angle, causing large harmonics and interference to the supply.

Fig. 4 and Fig. 5 show the block diagram and the electric circuit diagram respectively of a fluorescent lamp according to one embodiment of this invention. The electronic ballast for a fluorescent lamp includes a rectifier circuit 11, an auxiliary current-uninterrupted circuit 13, a main current-uninterrupted circuit 14, a filtering circuit 16, a high frequency generating and control circuit 17 and a starting circuit for initiating a fluorescent tube 18. The rectifier circuit 11, the filtering circuit 16, the high frequency generating and control circuit 17 and the starting circuit 18 can adopt the circuit of the prior art, i.e. they can be constituted as follows: the rectifier circuit 11 includes a bridge rectifier which is composed of diodes D1 to D4; the filtering circuit 16 includes an electrolytic capacitor C; the high frequency generating and control circuit 17 includes transistors BG1 and BG2, diodes D6 to D9, resistors R1 to R6, capacitors C4 to C6 and inductors L3 to L6. The diodes D6 and D7 are connected in parallel to the electrolytic capacitor C, i.e. between the point F and the ground as shown in the Figure. The capacitor C4 is connected between the point F and the joint point G of the diode D6 and D7. For the transistor BG1, the collector is connected to the point F, the emitter is connected to the point G, the base is connected to the point F via the resistor R3, and connected to the point G via the resistor R5 and the diode D9 connected in series and the resistor R1, the capacitor C5 and the inductor L5 connected in series respectively. For the transistor BG2, the collector is connected to the point G, the emitter is connected to the ground, the base is connected to the point G via the resistor R4, and connected to the ground via the resistor R6 and the diode D8 connected in series as well as the R2, the capacitor C6 and the inductor L6 connected in series respectively. The inductors L3 and L4 are connected in series between point G and one pin of the fluorescent tube Y. The starting circuit for the fluorescent tube 18 includes a capacitor C7 which is connected between two pins of the fluorescent tube Y.

As described above, this invention features the introduction of main and auxiliary current uninterrupted-circuits between the rectifier circuit 11 and the filtering circuit 16. The auxiliary current uninterrupted-circuit 13 includes an inductor L1 and a capacitor C1 connected in series. Its two ends A and D (i.e., the ground) are connected across the output of the rectifier circuit 11. The main current uninterrupted-circuit 14 includes an inductor L2 (its inductance $\leq$ 10mH, e.g., 5mH), capacitors C2, C3 (their capacitance $\leq 0.1\ \mu$ F, e.g., $0.01\ \mu$ F, proof voltage $\geq$ 400V) and a diode D5 (e.g. FR-104 fast recovery diode, the proof voltage $\geq$ 400V). One end of the inductor L2 is connected to the joint of the inductor L1 and the capacitor C1 (point B) and the other end is connected to the anode of the diode D5. The cathode of the diode D5 is connected to the point F. The capacitors C2 and C3 are connected in series between the joint of the inductor L2 and the diode D5 (point C) and the ground. The joint of the capacitors C2 and C3 (point E) is connected to a pin of the fluorescent tube Y.

The principle of operation is as follows:

Without the effect of the direct filter, by means of the great value of the capacitor the rectified voltage wave form (U_{BD}) is shown in Fig. 8.

In order to perform correction of power factor, input current and voltage should be identical in phase, i.e., the following means should be made:

(a) When switching transistor (BG_2) is on, (BG_1 is off), current is divided into two paths: as seen from Fig. 5:

$iL_2 \rightarrow C_2 \rightarrow lamp \rightarrow L_3 \rightarrow L_4 \rightarrow BG_2 \rightarrow$ point D
$iL_2 \rightarrow D_5 \rightarrow C$ (electrolytic capacitor) $\rightarrow$ point D

(b) When switching transistor (BG_1) is on (BG_2 is off), L_2 is in the energy stored state so that iL_2 is unable to become abrupt, while L_2 will induce voltage (UL_2, left - right + as shown in Fig. 5). $U_{CD} = U_{L2} + U_{BD}$ (rectified output voltage) is more than U_{CD} so as to enable D_5 to continue to be on;

one current path: $iL_2 \rightarrow D_5 \rightarrow BG_1 \rightarrow L_4 \rightarrow L_3 \rightarrow lam$ $p \rightarrow C_3 \rightarrow$ point D;

another one $ic \rightarrow BG_1 \rightarrow L_4 \rightarrow L_3 \rightarrow lamp \rightarrow C_3$ $\rightarrow$ point D.

As we can see from the above, during the switching of of BG_1 and BG_2, a continuous sawtooth waveform current iL_2 is induced, the phase of which is identical to U_{BD}.

As we can see from the waveform, the phase of the envelope wave of iL_2 is the same as that of U_{BD}, i.e. AC input voltage and current are the same phase.

The filtration of L1 and C1, which filtrates higher harmonics of U_2 makes the input voltage and current identical in phase, resulting in a high power factor and lower harmonics.

The addition of the current-uninterrupted circuit means that a signal is still available to drive the (low power) switching circuit, but that the switched signal is now the rectified but unfiltered sine wave. Consequently the only charge stored on the capacitor C is that which is required to power the switching circuit.

A circuit according to the embodiment of the invention described above enables the conduction angle of the diodes D1 to D4 in the rectifier circuit 11 to increase, so that the waveform of the input current tends to be continuous instead of the original waveform which is in discrete and sharp pulses, and close to sinusoidal waveform as shown in Fig. 6. Thus, on the one hand, it can protect the ballast from shocking due to surge current from switching on the fluorescent lamp, on the other hand, it can suppress the contamination to the power network due to the harmonic current of the ballast. According to the electronic ballast for the fluorescent lamp according to the above embodiment of this invention, its power factor can be 0.95 - 1 and its total harmonic distortion THD of the current is approximately 10%.

The percentage of each harmonic for the ballast is listed in Table 1.

Table 1

K01.100.00%	K20:000.63%
K02.002.00%	K21:000.37%
K03.008.94%	K22.001.63%
K04.001.30%	K23.000.32%
K05:004.84%	K24.001.23%
K06:000.75%	K25.001.80%
K07:002.85%	K26:000.35%
K08:000.48%	K27:000.60%
K09:001.52%	K28.000.96%
K10.000.50%	K29.000.26
K11.001.94%	K30.000.86%
K12.001.52%	K31.001.05%
K13.000.69%	K32.000.49%
K14.001.05%	K33.001.20%
K15.001.69%	K34.000.50%
K16.001.43%	K35.001.63%
K17.000.23%	K36.000.88%
K18.001.63%	K37.001.52%
K19.002.27%	K38.000.73%
	K39:001.04%
THD:012.72%	

Fig. 7 shows a conducting interference chart of the radiation frequency of the electronic ballast for a fluorescent lamp according to this invention, and the chart shows that it meets the standard stipulated by the IEC.

Of course, the above mentioned is only one preferred embodiment of the invention. According to the concept of this invention, various modifications and transformation can be made by those skilled persons. For example, the main and the auxiliary current-uninterrupted circuits of this invention can be also connected between the rectifier circuit and the high frequency generating and control circuit. Apart from that, the main and auxiliary current uninterrupted circuits of this invention can be also used for other various ordinary electronic ballast. Such modifications are all within the scope of this invention.

Claims

1. An electronic ballast for a fluorescent lamp, comprising:

   a rectifier circuit 11 and a filtering circuit 16 used for converting the civil power supply into direct current;

   a high frequency generating and control circuit 17 used for providing operating power to the fluorescent lamp by converting the DC power mentioned into a high frequency power source;
   a starting circuit 18 used to initiate the fluorescent lamp; and
   a main current-uninterrupted circuit 14 and an auxiliary current-uninterrupted circuit 13 connected between the rectifier circuit 11 and the filtering circuit 16, and used to increase the power factor of the ballast and to suppress the harmonic interference.

2. An electronic ballast for a fluorescent lamp as claimed in claim 1, wherein the auxiliary current-uninterrupted circuit 13 includes an inductor L1 and a capacitor C1 connected in series, and its two ends are connected across the output of the rectifier circuit 11.

3. An electronic ballast for a fluorescent lamp as claimed in claim 1 or claim 2, wherein the main current-uninterrupted circuit 14 includes an inductor L2, capacitors C2, C3 and a diode D5, wherein: one end of the inductor L2 is connected to the joint of the inductor L1 and the capacitor C1 and another end is connected to the anode of the diode D5; the cathode of the diode D5 is connected to the high frequency generating and control circuit 17; the capacitors C2 and C3 are connected in series between the joint of the inductor L2 and the diode D5 and the ground; and the joint of the capacitors C2 and C3 is connected to the one pin of the fluorescent tube Y.

4. An electronic ballast for a fluorescent lamp as claimed in claim 3, wherein the inductance of the inductor L2 is less than or equal to 10mH; the capacitance of the capacitors C2 and C3 is less than or equal to 0.1 μ F and the proof voltage is more than or equal to 400V; and the proof voltage of the diode D5 is more than or equal to 400V.

5. An electronic ballast for a fluorescent lamp as claimed in claim 4, wherein the diode D5 is a fast recovery diode.

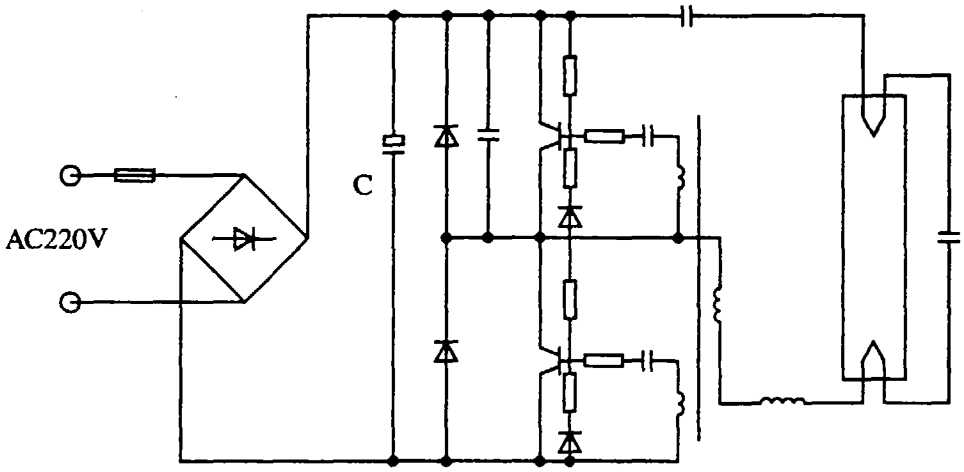

Fig. 1

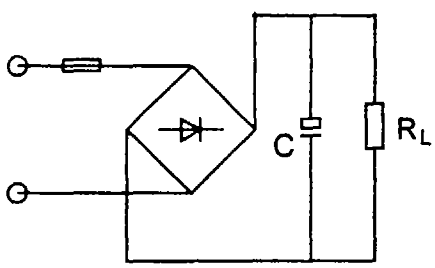

Fig. 2

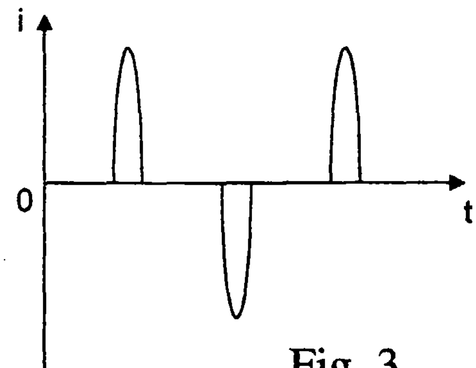

Fig. 3

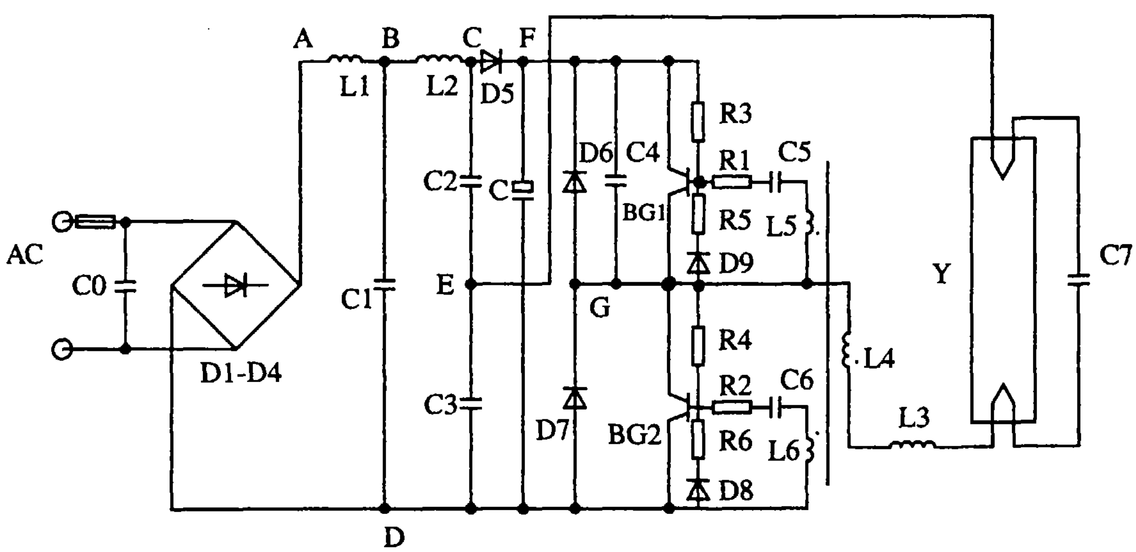

Fig. 5

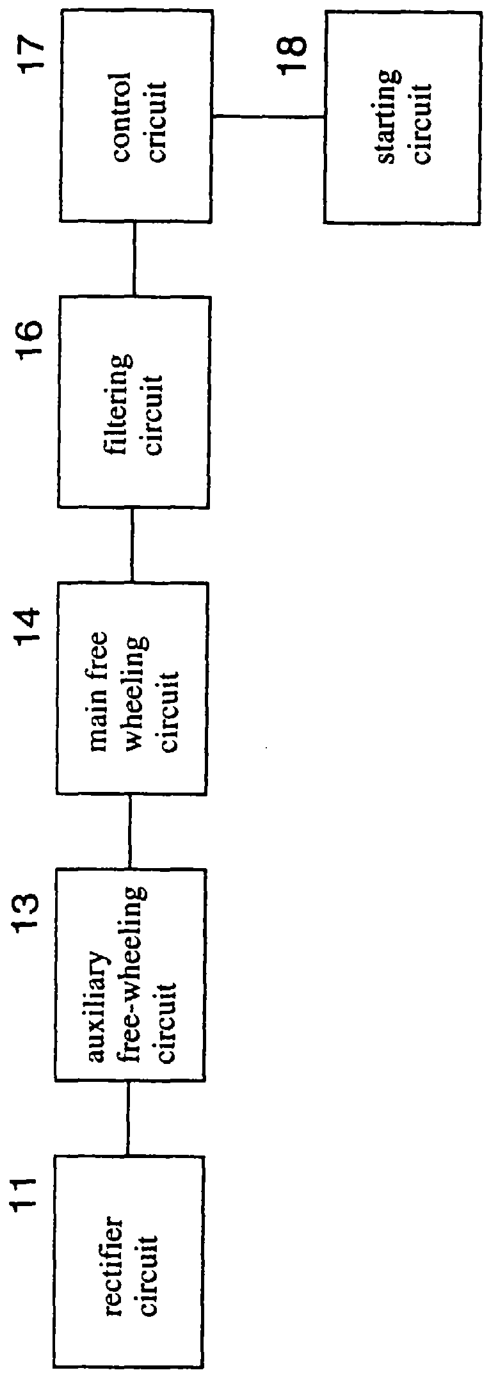
11
rectifier circuit
13
auxiliary free-wheeling circuit
14
main free wheeling circuit
16
filtering circuit
17
control cricuit
18
starting circuit

Fig. 4

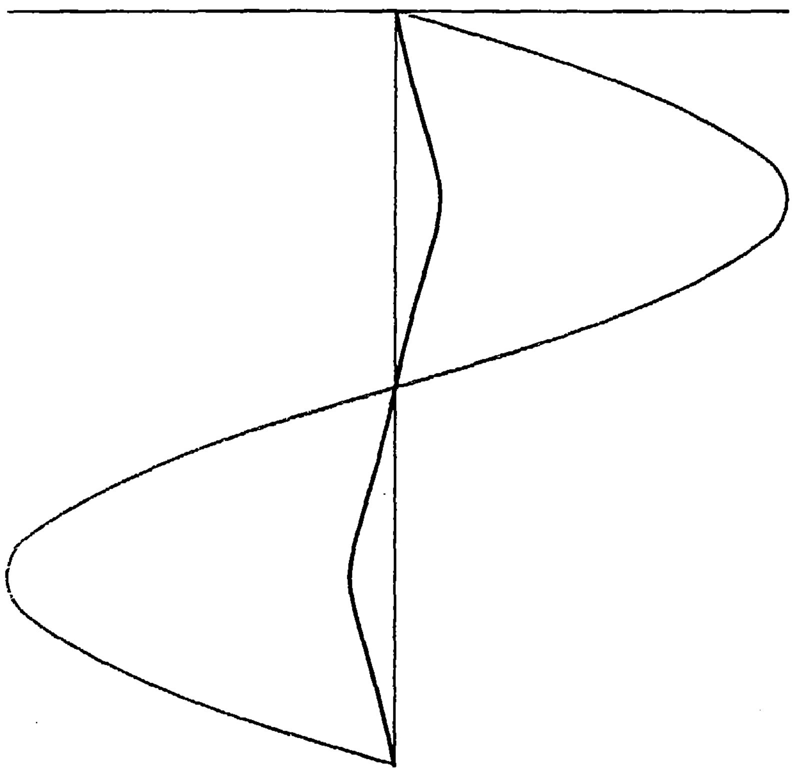

Fig. 6

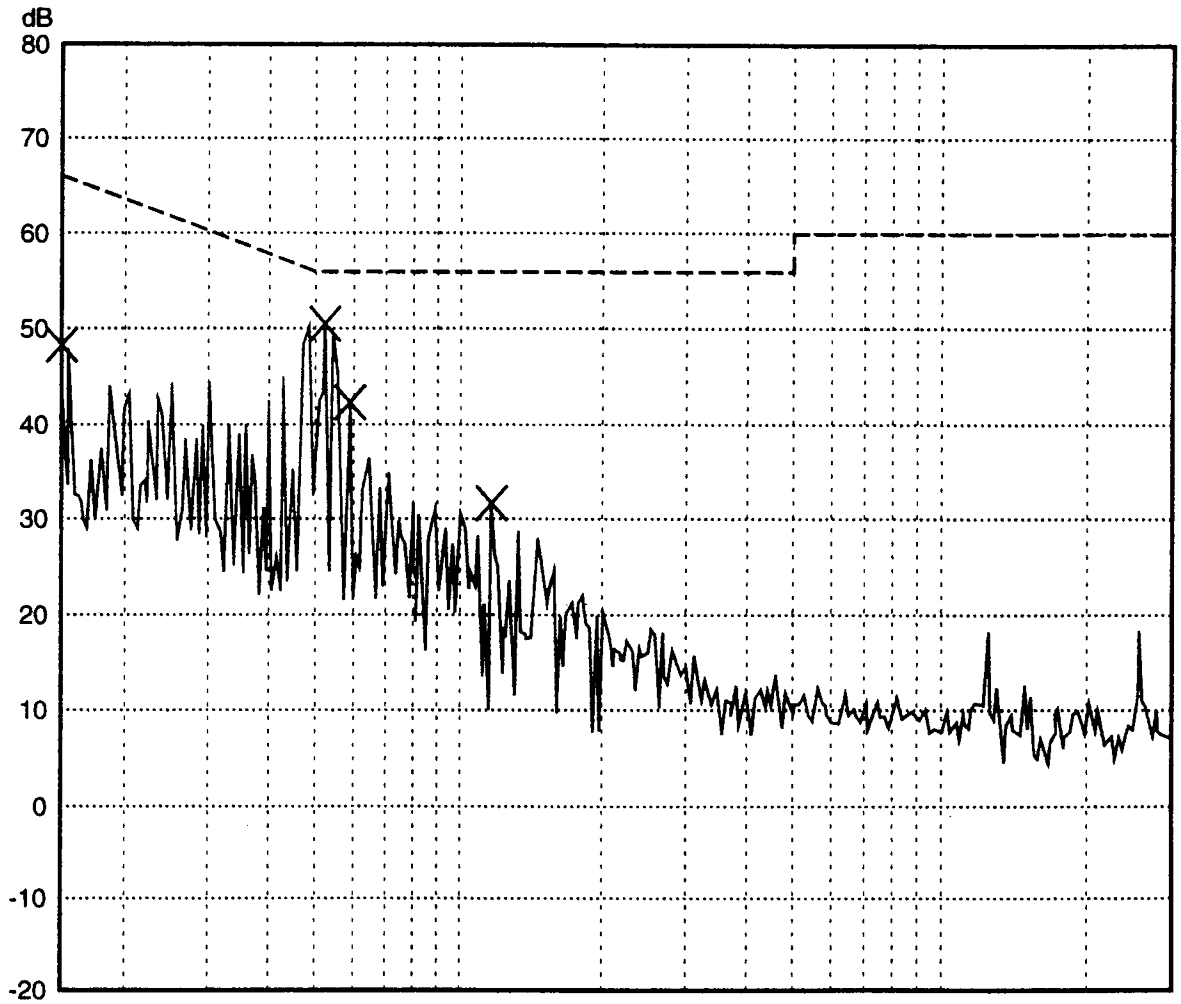

Fig. 7

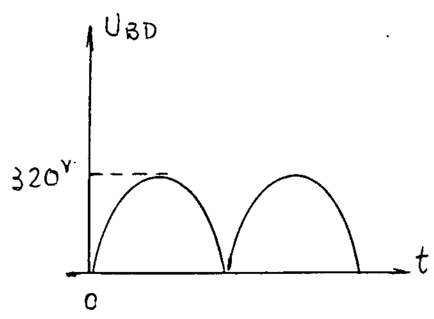

FIG 8

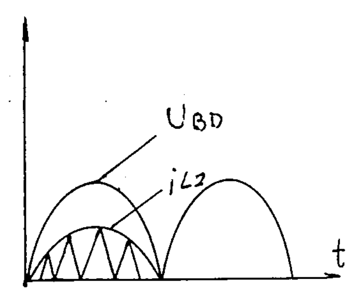

FIG 9

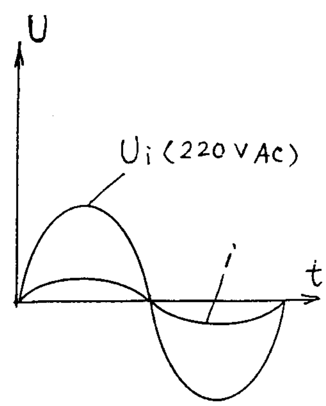

FIG 10