1 573 808

PATENT SPECIFICATION

(11) 1 573 808

(21) Application No. 51005/76 (22) Filed 7 Dec. 1976
(31) Convention Application Nos. 50/145 060 and 50/145 059
(32) Filed 8 Dec. 1975 in
(33) Japan (JP)
(44) Complete Specification published 28 Aug. 1980
(51) INT CL[3] H04N 3/18; H03K 4/62
(52) Index at acceptance
H2F 23E2R 23E2T1
H3T 2B9 2RX 2W2 2W3 31 3X 40 LCL

(19)

(54) HIGH VOLTAGE GENERATOR

(71) We, HITACHI LIMITED, a Corporation organized under the laws of Japan, of 5—1, 1-chome, Marunouchi, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a high voltage generator, for use in a CRT or a television receiver set or other CRT display apparatus, and more particularly to a high voltage generator in which a regulation for a high voltage to be supplied to a CRT of the television receiver set is enhanced.

It is generally desirable that the high voltage for the television receiver set or other CRT display apparatus, that is a D.C. high voltage obtained by rectifying an output pulse voltage of a flyback transformer, exhibits a small variation to the change in brightness of a picture image on the CRT or the change in a high voltage load current. Particularly in a color television receiver set, the regulation of the high voltage is highly desirable because the high voltage load current is large.

Heretofore, in the color television receiver set, as the brightness of the picture image on the CRT changes, the high voltage applied to the CRT also changes. When the variation of the high voltage is large, the change in the size of the picture image is also large resulting in a distortion in the picture image. It is well known that the closer to a square wave is the waveform of the output pulse of the flyback transformer, the more the variation of the high voltage is reduced.

The present invention will now be described in more detail with reference to the accompanying drawings, in which:

Fig. 1 shows a circuit configuration of a conventional high voltage generator.

Fig. 2 shows an equivalent circuit thereof.

Figs. 3 and 4 show waveforms for explaining the operation of the circuit of Fig. 1.

Fig. 5 shows a circuit configuration of a prior art high voltage generator using a bleeder resistor.

Fig. 6 shows characteristic curves for explaining the operation of the circuit of Fig. 5.

Fig. 7 shows waveforms for explaining the present invention.

Fig. 8 shows a circuit configuration of a high voltage generator in accordance with the present invention.

Fig. 9 shows a circuit configuration of a high voltage generator in one embodiment of the present invention.

Fig. 10 shows an impedance characteristic curve for explaining the present invention.

Figs. 11, 12, 13 and 14 show circuit configurations of other embodiments.

Fig. 15 is a high voltage generator in another embodiment of the present invention.

Fig. 16 shows an impedance characteristic curve thereof.

Figs. 17 and 18 show circuit configurations of modifications of Fig. 15.

Figs. 19 and 20 show waveforms for explaining the effect of the present invention.

Referring now to Fig. 1 which shows a circuit configuration of a conventional high voltage generator, numeral 1 denotes a horizontal output transistor, 2 a damper diode, 3 a resonance capacitor, 4 a deflection yoke 5 an S-shaped distortion compensating and D.C. blocking capacitor, 6 a flyback transformer, 7 a primary winding of the flyback transformer, 8 a secondary winding, and 9 a high voltage rectifying diode.

Fig. 2 shows an equivalent circuit of Fig. 1, in which SW corresponds to the horizontal output transistor 1 and the damper diode 2, L_1 is an equivalent inductance of the parallel circuit of the inductance of the deflection yoke 4 and the inductance of the primary winding 7 of the flyback transformer 6, C_1 corresponds to the resonance capacitor 3, L_2 is a leakage inductance between the primary winding 7 and the secondary winding 8, and C_2 is a grounding capacitance of the secondary winding 8. In the equivalent circuit of Fig. 2, a voltage V_{c2} developed across the grounding capacitor C_2 when SW is open is given by the following formula (1);

$$V_{C2} = \frac{E_B T_s}{2} \cdot \frac{1}{\alpha} \cdot \frac{\alpha^2\beta^2}{(\beta^2-\alpha^2)} [\sin(\alpha t - \phi_1) - \frac{\alpha}{\beta} \sin(\beta t - \phi_2)] \quad (1)$$

where

T_s : scan period

$$\phi_1 \doteqdot \tan^{-1} \frac{2}{\alpha T_s}$$

$$\phi_2 \doteqdot \tan^{-1} \frac{2}{\beta T_s}$$

$$\alpha^2+\beta^2 = \frac{1}{L_1C_1} + \frac{1}{L_2C_2} + \frac{1}{L_2C_1}$$

$$\alpha^2\beta^2 = \frac{1}{L_1C_1L_2C_2}$$

and where α and β are resonance angular frequencies of the resonance circuit with α representing a fundamental angular frequency and β representing a harmonic angular frequency. It is well known by a harmonic tuning theory that when β/α satisfies the following formula (2) where N is an odd number, no ringing voltage appears during the scan period.

$$\frac{\beta}{\alpha} = N \cdot \frac{1+\sqrt{1+\frac{16Tr}{N^2 T_s \pi^2}}}{1+\sqrt{1+\frac{16Tr}{T_s \pi^2}}} \quad (2)$$

where Tr: flyback period

N: 2k + 1, where k = 1, 2, 3, . . .

In the formula (2), when N = 3, it is referred to as a third-order tuning, and when N = 5, it is referred to as a fifth-order tuning. Similarly, it is referred to as an Nth-order tuning depending on the number of N. For each order, the magnitude of β/α changes depending on a ratio of T_r/T_s. For example, when $T_r = 12\ \mu s$ and $14\ \mu s$, (it is assumed that a horizontal repetition period is 63.5 μs), the magnitudes of β/α for the respective orders are shown in Table 1 below.

TABLE 1

Number of order N	β/α	
	$T_r = 12\ \mu s$	$T_r = 14\ \mu s$
3	2.79	2.75
5	4.62	4.56
7	6.45	6.35
9	8.28	8.16
11	10.20	9.97
13	11.97	11.78

It is seen from the formula (1) that a ratio of the fundamental component to the harmonic component of the output V_{C2} is equal to α/β, and has a substantially constant value determined depending on the number of order of tuning as seen from the Table 1. As for the output waveform, for the 3rd, 7th and 11th order tunings, the V_{C2} waveforms include central convexes as shown in Fig. 3(a) (which shows the 3rd order tuning), while for the 5th, 9th and 13th order tunings, the waveforms include central concaves as shown in Fig. 3(b) (which shows the 5th order tuning). Now taking the 3rd and 5th order tunings as examples, the comparison therebetween and the relation to the regulation are explained. Fig. 3(a) shows output waveforms for the 3rd order tuning and Fig. 3(b) shows output waveforms for the 5th order tuning. As is apparent from the comparison of the waveforms, the 5th order tuning waveform is broader than the 3rd order tuning waveform. As a result, it is apparent that when loaded the 5th order tuning present wider diode conduction angle than the 3rd order tuning and hence better high voltage regulation. Thus, the 5th or 9th order tuning has been frequently adopted to improve the regulation.

However, as seen from Fig. 3(b), since the waveform involves double peaks, a large voltage variation is observed in a small current region until the double peaks are clipped off as shown in Fig. 4.

Since the circuit configuration of Fig. 1 has a drawback of large high voltage variation as described above, many approaches to reduce the high voltage variation have been proposed. Those include a method of stabilizing a high voltage by changing the width of a pulse in accordance with the variation in high voltage load, using a saturable reactor, a method for changing a D.C. power supply in accordance with the variation in the high voltage load, and a method of connecting a bleeder resistor following a high voltage rectifier.

Fig. 5 shows a circuit configuration which reduces the high voltage variation by inserting a bleeder resistor 10 following to a high voltage diode. In this circuit, a satisfactory result is obtained only when a constant current is always passed through the bleeder resistor 10 to clip off the double peaks. Referring to Fig. 6, a curve A shows a regulation characteristic when no bleeder resistor is inserted and a curve B shows a regulation characteristic when the bleeder resistor 10 is inserted. However, when the bleeder resistor 10 is inserted as shown in Figure 5, an additional current other than a CRT current flows through the bleeder resistor 10 resulting in a power loss of $E_{HT}2/R$ where R is a resistance of the bleeder resistor 10 and E_{HT} is the magnitude of the high voltage. In addition, because the resistor is connected between the high voltage source and the ground, it must withstand the high voltage and a sufficient care must be paid for the insulation. As a result, the apparatus is naturally more expensive and less reliable.

It is an object of the present invention to provide a high voltage generator which is simple in circuit configuration and facilitates the improvement of the high voltage regulation of a television receiver set or CRT display apparatus.

It is another object of the present invention to provide a high voltage generator which suppresses spurious oscillation generated during the scan period of a television receiver set or CRT display apparatus.

The present invention provides a high voltage generator for a CRT comprising: a horizontal output circuit including a switching device for generating a flyback pulse during a retrace period of horizontal scan; a flyback transformer having primary and secondary windings for stepping up said flyback pulse; a voltage sound comprising said primary winding; a rectifying circuit for rectifying the stepped-up flyback pulse so that a D.C. high voltage is generated and supplied to a CRT; and a frequency dependent attenuation circuit connected in a series connection circuit of the primary winding of said flyback transformer, the switching device and the voltage source of the flyback transformer, said attenuation circuit being designed to attenuate only the harmonic component of the high voltage stepped-up flyback pulse so as to flatten a top of the retrace pulse waveform of the high voltage stepped-up pulse output.

The present invention also provides a high voltage generator for a CRT comprising: a horizontal output circuit including a switching device for generating a flyback pulse during a retrace period of a horizontal scan; a flyback transformer having primary and secondary windings for stepping up said flyback pulse, the primary winding having at least two parts connected in series; a voltage source energising said primary winding; a rectifying circuit for rectifying the stepped-up voltage for supplying a D.C. voltage to a CRT; and a frequency dependent attenuation circuit connected in series with said voltage source and the switching device and intermediate said parts of said primary winding of said flyback transformer, said attenuation circuit attenuating the harmonic component in a high voltage output waveform of said flyback transformer to flatten the top of the retrace pulse waveform of the high voltage output.

Preferred embodiments of the present invention are now described in conjunction with the drawings.

Fig. 7 shows curves illustrating the relation between the fundamental wave and the harmonic waves for explaining the feature of the present invention. For the (4k + 1)th order tuning such as 5th, 9th or 13th order tuning, the phase of the fundamental wave is opposite to that of the harmonic wave at the center of the output waveform and the output waveform has double peaks with a center concave, the depth of which changes with the magnitude of the harmonic wave. Fig. 7 shows such relation for the 5th order tuning. In Fig. 7, P represents a ratio of the fundamental component to the harmonic component. As seen from the formula (1) described above and β/α given in the Table 1, P is approximately 0.22 and a deep concave is observed.

Fig 8 shows a basic circuit configuration to a high voltage generator of the present invention, in which a frequency dependent attenuation circuit 10 is connected in series between a primary winding 7 of a flyback transformer 6 and a B power supply to attenuate harmonic components for relieving the concave characteristic in the output waveform shown in Fig. 7, whereby the high voltage regulation is improved.

Fig 9 shows a circuit configuration of a specific embodiment of the attenuation circuit 10 shown in Fig. 8.

The difference between the embodiment of Fig. 9 and the prior art circuit of Fig. 1 lies in that the attenuation circuit 10, that is, an LCR parallel circuit comprising an LC parallel resonance circuit including an inductor 11 and a capacitor 12, and a resistor 13 connected in parallel thereto, is connected in series between the primary winding 7 of the flyback transformer 6 and the B power supply. The remaining portions of the circuit of Fig. 9 is identical to those of Fig. 1 and designated by the same reference numerals.

In Fig. 9, assuming that the inductance of the inductor 11 is L_0, the capacitance of the capacitor 12 is Co, and the resistance of the resistor 13 is Ro, the circuit parameters are selected such that a resonance angular frequency LoCo is approximately equal to a harmonic angular frequency β. Fig. 10 shows impedance characteristics of the attenuation circuit 10, in which a curve *c* shows an impedance characteristic of the LC resonance circuit comprising the inductor 11 and the capacitor 12 and a curve *d* shows an impedance characteristic of the resistor 13. A principle of operation of the present invention is now explained with reference to Fig. 10. Major portion of the fundamental angular frequency current (α component) flows through the low impedance LC circuit comprising the inductor 11 and the capacitor 12 (mostly through the inductor 11) and minor portion of the current flows through the resistor 13. Therefore a resistive loss is small. Conversely, a major portion of the harmonic current (β component) flows through the low impedance resistor 13 resulting in a large resistive loss. Because of this resistive loss, the harmonic component in the output voltage V_{C2} is largely attenuated to compare with the fundamental component. As a result, the depth of the concave in the output waveform is reduced as shown in Fig. 7 so that the voltage variation in the small current region is effectively suppressed.

Fig. 11 shows a circuit configuration of another embodiment of the present invention similar to Fig. 9. In Fig. 11, an LCR circuit comprising the LC parallel resonance circuit including the inductor 11 and the capacitor 12 and having a resonance frequency approximately equal to the harmonic frequency, and the resistor 13 connected in series with the capacitor 12, is connected in series between the primary winding 7 of the flyback transformer 6 and the B power supply terminal E_B. In this embodiment, since the resonance frequency of the LCR circuit is approximately equal to the harmonic frequency, the harmonic circuit (β component) resonances in the LCR circuit, which then exhibits a high impedance and largely attenuates the harmonic current by the resistor 13. On the other hand, the fundamental current (α component) flows through the low impedance inductor L and hence it is not substantially attenuated. As a result, the harmonic component β of the high voltage output waveform from the flyback transformer 6 is largely attenuated compared with the fundamental component α so that the output waveform is flattened and the voltage variation in the small current region is reduced.

Fig. 12 shows other embodiment of the present invention similar to Fig. 9. In Fig. 12, numeral 14 denotes a filter comprising a mechanical filter, crystal filter or the like, an attenuation band of which is selected to be approximately equal to the harmonic frequency. In the present embodiment, like in the embodiment of Fig. 9, the harmonic component is effectively attenuated to improve the regulation.

As described in connection with the embodiments of Figs. 9, 11 and 12, by connecting the LCR resonance circuit in series between the primary winding of the flyback transformer and the B power supply terminal E_B, the harmonic component β of the high voltage output waveform is effectively attenuated whereby the output waveform from the flyback transformer is flattened and hence the high voltage regulation is improved. This is accomplished by adjusting the impedance characteristic shown in Fig. 10 by properly selecting the resonance frequency of the resonance circuit, Q of the circuit and the resistance of the additionally inserted resistor or inductance L of the LC circuit to provide an optimum amount of attenuation for the harmonic component β.

While the LCR parallel circuit is connected to the lower voltage terminal of the primary winding 7 of the flyback transformer 6, it should be understood that the same effect is obtained when the LCR parallel circuit is inserted intermediate of the primary winding 7 as shown in Fig. 13. Although not shown, the LCR parallel circuit may be connected even to a higher voltage terminal of the primary winding.

While the advantage of the present invention has been explained in conjunction with the output waveform with double peaks such as those for 5th and 9th order tuning ((4k + 1)th order tuning), the present invention is also useful in reducing the concave characteristic in the output waveform which appears in the 7th and 11th order tuning ((4k + 1)th order tuning).

Fig. 14 shows other embodiment of the present invention, in which the secondary winding is divided into *n* sections 8_1, 8_2, . . . 8_{n-1}, 8n by high voltage rectifying diodes 9. In this embodiment, each of the *n* secondary sub-windings may be tuned to any number of order. When the circuit is arranged for multiple tuning, one set of LCR circuits for a particular number of order may be inserted or a plurality of sets of LCR circuits each corresponding to respective ones of the orders may be connected in series.

Fig. 15 shows still other embodiment of the present invention, which differs from the embodiment of Fig. 9 in that an LR parallel circuit 10 comprising the inductor 15 and the resistor 16 is connected between the lower voltage terminal of the primary winding 7 of the flyback transformer and the B power supply. Fig. 16 shows impedance-frequency characteristics of the inductor 15 (L) and the resistor 16 (R), in which curves *e* and *f* show the impedance curves for L and R, respectively.

As seen from the LR impedance characteristics of Fig. 16, a major part of the fundamental component (α component) flows through the low impedance inductor 15 (L) and minor portion thereof flows through the resistor 16 (R). Therefore, resistive loss is small and no substantial damping occurs. On the other hand, major part of the harmonic component (β component) flows through the low impedance resistor 16 (R) and hence suffers a large resistive loss. Because of this resistive loss, the harmonic component β of the output waveform of the flyback transformer 6 is damped and largely attenuated to compare with the fundamental component α. As a result, the depth of the concave in the output waveform (for the (4k + 1)th order tuning) is reduced so that the waveform is flattened and the voltage variation in the small current region is suppressed. The amount of attenuation of the harmonic component can be adjusted by properly selecting the constants of the inductor and the resistor. In order to make the LR damping more effective and reduce the resistive loss as much as possible, it is desirable that the constants of the inductor (L) and the resistor (R) satisfy the relation of $\alpha L < R < \beta L$.

While the LR parallel circuit is connected in the embodiment of Fig. 15 to a lower voltage terminal of the primary winding 7 of the transformer 6, it should be understood that the LR parallel circuit may be connected intermediate of the primary circuit 7 as shown in Fig. 17.

Fig. 18 shows other embodiment in which the secondary winding 8 of the flyback transformer 6 is divided into n sections 8_1, 8_2, . . . 8_{n-1}, 8n by high voltage rectifying diodes 9. In this embodiment, each of the n secondary sub-windings may be tuned to any order of harmonics. It should be noted that the improvement of the regulation is attained by properly selecting the constants of the inductor and the resistor even for a multiple tuning circit arrangement. If desired, a plurality of LR circuits may be connected in series.

As described hereinabove, the present invention does not necessitate a number of expensive components which were required in the prior art apparatus but uses only inexpensive inductors, capacitors and resistors. Accordingly, a significant cost reduction is attained and the reliability is enhanced. Because high Q resonance is attenuated, power dissipation is considerably reduced. Furthermore, a spurious ringing generated during the scan period is suppressed so that the loss due to the ringing, the disturbance to other circuits and the increase in a collector current of a horizontal output transistor can be prevented. This is explained with reference to Figs. 19 and 20. Fig. 19 shows voltage output waveforms of a secondary winding of the flyback transformer 6 for one horizontal period, in which (c) shows a waveform when the attenuation circuit of the present invention is not inserted and (d) shows waveform when the present attenuation circuit is inserted. Where the attenuation circuit is not inserted, a spurious ringing voltage 20 generated during the scan period remains without substantial attenuation over the scan period. Since an angular frequency γ of the ringing voltage is approximately equal to β, the insertion of the attenuation circuit not only flattens the output waveform during the retrace period but alow attenuates the ringing voltage 20 during the scan period, as shown in Fig. 19 (d).

Fig. 20 illustrates the adverse affect of the ringing during the scan period and the effect of the present invention, taking the collector current of the horizontal output transistor as an example. Fig. 20 (e) shows a collector current waveform where no attenuation circuit is inserted, and Fig. 20 (f) shows that where the attenuation circuit is inserted. When the ringing current is superimposed during the scan period, a maximum collector current I_{cp} may increase as shown by I_{cp2} in Fig. 20 (e) depending on the phase of the ringing current. Since the phase of the ringing current is very unstable and varies with the variation in the high voltage load or the variation of the circuit parameters, it is necessary to keep the ringing current small. According to the present invention, the ringing current can be attenuated to substantially zero at the end of the scan period as shown in Fig. 20 (f) so that the increase of I_{cp} is suppressed.

WHAT WE CLAIM IS:—

1. A high voltage generator for a CRT comprising: a horizontal output circuit including a switching device for generating a flyback pulse during a retrace period of horizontal scan; a flyback transformer having primary and secondary windings for stepping up said flyback pulse; a voltage source energising said primary winding; a rectifying circuit for rectifying the stepped-up flyback pulse so that a D.C. high voltage is generated and supplied to a CRT; and

a frequency dependent attenuation circuit connected in a series connection circuit of the primary winding of said flyback transformer, the switching device and the voltage source for the flyback tranformer, said attenuation circuit being designed to attenuate only the harmonic component of the high voltage stepped-up flyback pulse so as to flatten a top of the retrace pulse waveform of the high voltage stepped-up pulse output.

2. A high voltage generator according to claim 1, wherein said attenuation circuit is connected between the primary winding of said flyback transformer and the voltage source.

3. A high voltage generator for a CRT comprising: a horizontal output circuit including a switching device for generating a flyback pulse during a retrace period of a horizontal scan; a flyback transformer having primary and secondary windings for stepping up said flyback pulse, the primary winding having at least two parts connected in series; a rectifying circuit for rectifying the stepped-up voltage for supplying a D.C. voltage to a CRT; and a frequency dependent attenuation circuit connected in series with said voltage source and the switching device and intermediate said parts of said primary winding of said flyback transformer, said attenuation circuit attenuating the harmonic component in a high voltage output waveform of said flyback transformer to flatten the top of the retrace pulse waveform of the high voltage output.

4. A high voltage generator according to claim 3, wherein said primary winding of said flyback transformer is divided into two sections and said attenuation circuit is connected between the two sections of said primary winding of the flyback transformer.

5. A high voltage generator according to any one of Claims 1 to 4, wherein said attenuation circuit comprises a parallel circuit of an inductor, a capacitor and a resistor.

6. A high voltage generator according to any one of Claims 1 to 4, wherein said attenuation circuit comprises an LC parallel resonance circuit of an inductor and a capacitor, and a resistor connected in series with said capacitor.

7. A high voltage generator according to any one of Claims 1 to 4, wherein said attenuation circuit comprises a parallel circuit of an inductor and a resistor.

8. A high voltage generator constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in Figures 7 to 20 of the accompanying drawings.

9. A television receiver incorporating a high voltage generator according to any one of the preceding claims.

J. A. KEMP & CO.,
Chartered Patent Agents,
14 South Square,
Gray's Inn, London WC1R 5EU.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1980.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

FIG. 1 PRIOR ART

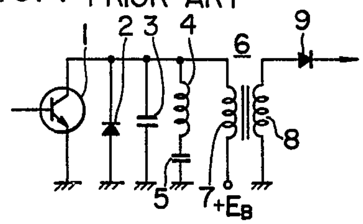

FIG. 2 PRIOR ART

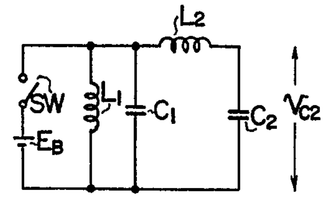

FIG. 3 PRIOR ART

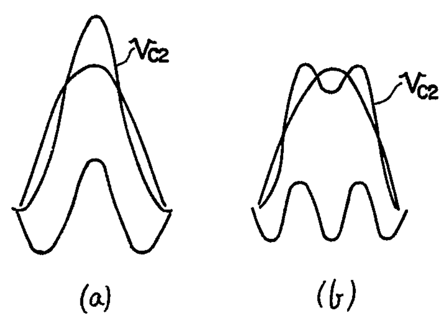

FIG. 4 PRIOR ART

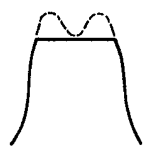

FIG. 5 PRIOR ART

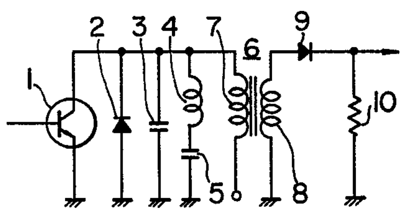

FIG. 6 PRIOR ART

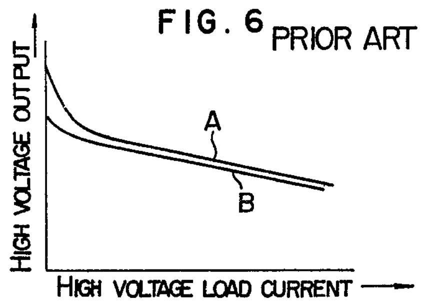

FIG. 7

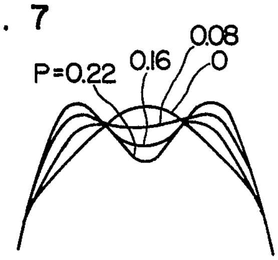

FIG. 8

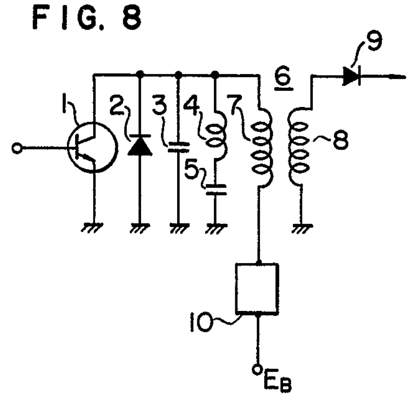

FIG. 9

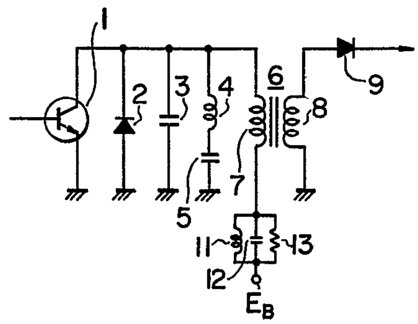

FIG. 10

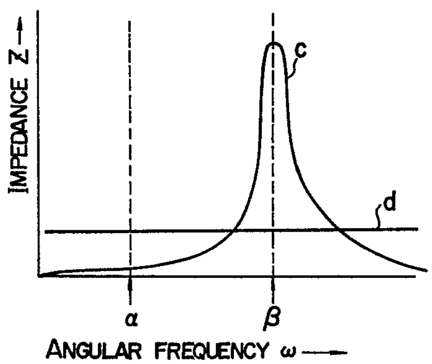

FIG. 11

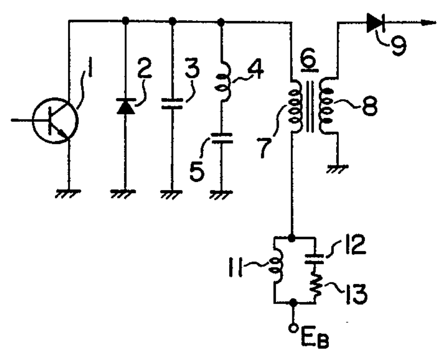

FIG. 12

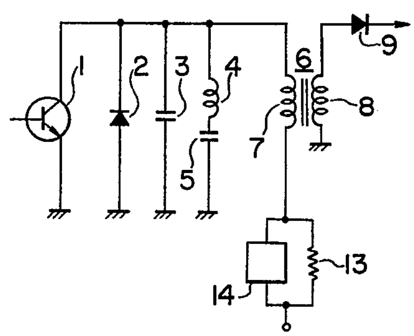

FIG. 13

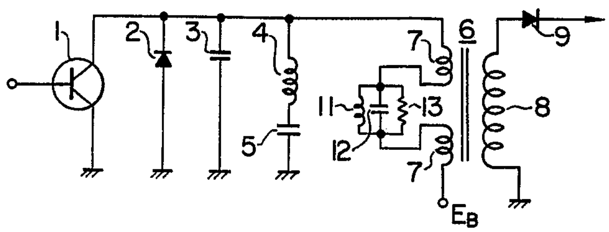
1
2
3
4
5
6
7
7
8
9
11
12
13
EB

FIG. 14

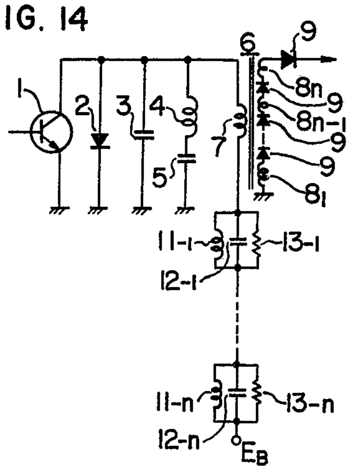
1
2
3
4
5
6
7
9
8n
9
8n-1
9
9
81
11-1
13-1
12-1
11-n
13-n
12-n
EB

FIG. 15

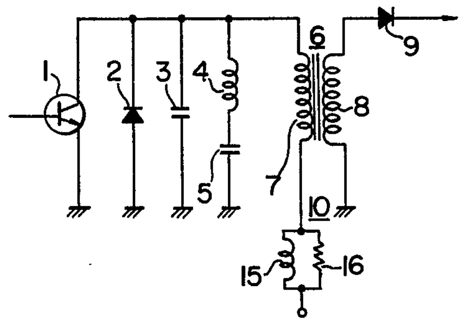

FIG. 16

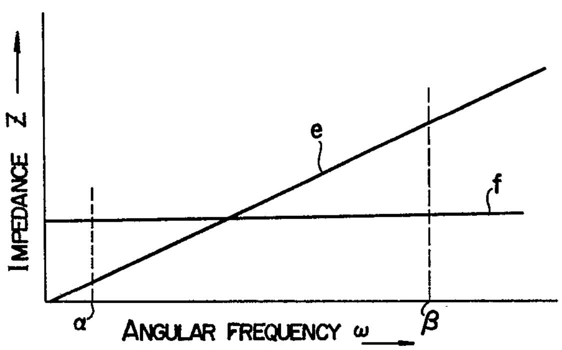

FIG. 17

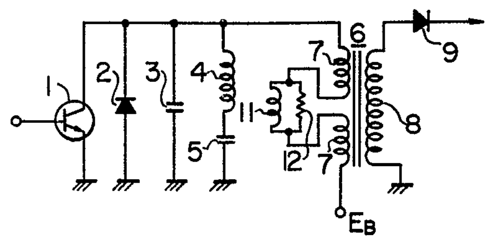

FIG. 18

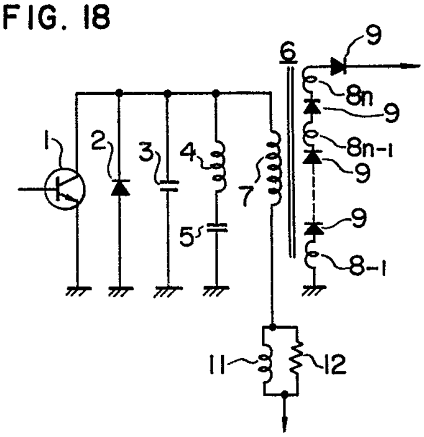

FIG. 19

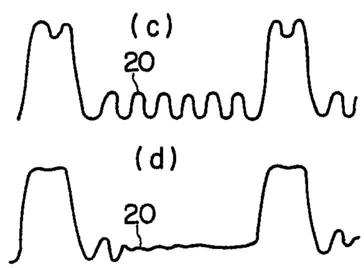

FIG. 20