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(54) APPARATUS FOR GENERATING HIGH VOLTAGE FOR CATHODE-RAY TUBE

(71) We, HITACHI LTD., a Japanese Body Corporate 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 used for generating a DC high voltage for the cathode-ray tube, which is suitably applied to the television receiver.

Generally, the picture tube of the television receiver requires a DC high voltage of 7 to 25KV for accelerating charged particles.

A well known conventional device for producing such a high DC voltage includes a rectifier device comprising a flyback transformer and a rectifier element of high reverse breakdown voltage, or a voltage-multiplying rectifier device employing the Cockcroft-Walton accelerator circuit having a flyback transformer and a plurality of rectifier elements and capacitors.

In applying any of the above-described devices to the color television receiver, it is very important to maintain the produced high voltage as constant as possible or to hold the variations of the produced high voltage within a predetermined allowable range. This is in view of the fact that great variations in high voltage will cause color errors.

It is also well known that the variation in high voltage is smaller the higher the order of harmonics for resonance.

The first of the above-mentioned well known devices has the disadvantage that the great number of turns of the secondary winding results in a very large turns ratio, which in turn renders very high the value of the distributed capacity of the primary winding as converted from the secondary winding on the basis of the square of the turns ratio, thus limiting the high harmonic resonance up to the unsatisfactory third order.

The second of the above-mentioned conventional devices, on the other hand, is advantageous in that the greater the number by which the voltage is multiplied, the smaller the high voltage pulse generated may be, so that the turns ratio between the primary and secondary windings and hence the distributed capacity is reduced accordingly, thereby making possible a device capable of a harmonic resonance at a higher order with less variation in high voltage. In spite of this advantage, the number of capacitors needed for the rectification system of the device under consideration leads to the bulkiness and high cost of the device.

A well known fact about the flyback transformer is that in order to improve the characteristics thereof by reducing the leakage inductance and distributed capacity of the secondary winding, the secondary winding is divided into a multiplicity of sections by a dividing bobbin. The United States Patent No. 3,562,623 discloses a high voltage transformer in which the secondary winding arranged on a magnetic core together with the primary winding is divided into a plurality of winding units, which are connected alternatively in series with a plurality of rectifier elements for rectification of the voltage across the respective winding units.

An object of the present invention is to provide an improved high voltage generator.

According to the present invention, there is provided apparatus for generating a high voltage for a cathode-ray tube comprising: a primary winding and a secondary winding divided into a plurality of winding units by a plurality of diodes, said primary winding having a winding density which varies along its length and the winding units being arranged to have different numbers of turns from each other, whereby the individual winding units are tuned to harmonics of odd numbered orders equal to and higher than the 5th order of a predetermined signal to be

applied to the primary winding and said harmonics include the 5th order harmonic and another order harmonic higher than said 5th order.

The resonance order of high harmonics depends substantially on the product of the distributed capacity and the leakage inductance for a given pulse width, and therefore it is necessary to take into consideration the variation in leakage inductance of the secondary winding units in addition to the distributed capacity in order to determine the order of high harmonics with which they will resonate.

The distributed capacity of the high voltage generator for the television receiver can be adjusted by adjusting the winding width or height of the secondary winding, by dividing the secondary winding into a plurality of winding units and by changing the turns ratio between the primary and secondary windings. Further, as a method to adjust the leakage inductance, the distance between the primary and secondary winding units can be changed or alternatively the number of turns be changed while maintaining the turns ratio constant.

The present invention is based on ideas mentioned below.

First, since the secondary winding is divided into a plurality of winding units, the distributed capacity of the secondary winding can be so reduced that the winding units can resonate at the 5th or higher order harmonics of the signal applied to the primary winding with little variation in high voltage output.

Secondly, the leakage inductance can be adjusted as desired by changing not only the number of turns of each winding unit of the divided secondary winding but also the distribution of winding density along the primary winding.

In embodying the present invention by dividing the secondary winding into three winding units, for example, it should desirably be so constructed that two of the winding units be tuned to resonance at the 7th order harmonics and the remaining one winding unit at the 5th order harmonics.

The invention will become further apparent by the following exemplary detailed description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a circuit diagram showing a high voltage generator according to an embodiment of the present invention;

Fig. 1 is a winding arrangement in an example of the configuration of the circuit illustrated in Fig. 1;

Fig. 3 is a diagram showing the relation between beam current and high voltage;

Fig. 4 is a graph showing a curve representing the relation between the number of resonance orders of harmonics and regulation in high voltage;

Fig. 5 is a winding arrangement in another example of the circuit configuration similar to that of Fig. 2;

, Fig. 6 is a sectional diagram showing the construction of a high voltage generator having the circuit configuration of Fig. 1 and produced by the method shown in Fig. 2; and

Fig. 7 is a circuit diagram showing a high voltage generator according to another embodiment of the present invention.

In Fig. 1 showing the circuit arrangement of the high voltage generator according to the invention, reference numeral 1 shows a cathode-ray tube, a numeral 2 a transformer including a primary winding 3, a secondary winding 4 and in an appropriate magnetic core 5.

The secondary winding 4 is divided into three winding units or coils 41, 42 and 43. The winding unit 41 has an end thereof connected to earth 6 and the other end connected to a diode 7. The winding unit 42 has an end thereof connected to the cathode of the diode 7 and the other end thereof to the anode of the diode 8. The winding unit 43 has an end thereof connected with the cathode of the diode 8 and the other end connected to the anode of the diode 9. The cathode of the diode 9 is connected to the anode of the cathode-ray tube 1.

In the circuit arrangement thus constructed, assuming that the frequency of 15,734 KHz is involved, the three winding units 41, 42 and 43 are energized simultaneously only for several microseconds of the period of approximately 63.55 μs during which the diodes 7, 8 and 9 are energized, thereby producing a voltage three times higher than the high-voltage pulse produced by each winding unit. During the remaining period of approximately 69 μs, on the other hand, the winding coils 41, 42 and 43 are operatively separated from each other. For this reason, the turn ratio between the primary and secondary windings is very small due to the fact that the distributed capacity of the winding units 41, 42 and 43 takes the form of series connection, thereby remarkably reducing the effective distributed capacity of the secondary winding.

The circuit arrangement of Fig. 1 based on the aforementioned first and second ideas is such that the secondary winding is divided into three winding units to reduce the distributed capacity thereof, while at the same time having the three winding units at different distances from the primary winding, with the result that the winding units 41 and 42 are tuned to resonance at the 7th harmonic and the winding unit 43 at the 5th harmonic.

Description will be made below of an example of means for tuning to resonance the winding units 41 and 42 at the 7th-order harmonic and the winding unit 43 at the 5th-order harmonic, with reference to Fig. 2.

In the example under consideration, the total number of turns of the secondary winding is divided into the number of turns 908T of the winding 41, the number of turns 1064T of the winding unit 42 and the number of turns 1158T of the winding unit 43. The density of turns of the primary winding is greatest nearer the winding unit 41 which has the smallest number of turns of the different winding units and least near the winding unit 43 side which is the winding unit with the greatest number of turns. In other words, as illustrated the primary winding is provided in eight density sections of 15T, 26T, 15T, 15T, 15T, 10T, 10T and 10T as viewed from the winding unit 41 side so that the winding units are tuned to resonance at the harmonics of the above-mentioned orders respectively.

In the embodiment under consideration, even though the turns ratio between the primary winding and the whole secondary winding is constant, the fact that the number of turns is different for each of the winding units of the secondary winding causes the conversion ratio between the primary winding and the respective winding units of the secondary winding to be different from each other, resulting in different distributed capacities for different winding units. Further, in adjusting the leakage inductance between each of the winding units and the primary winding, in Fig. 1 the inductance is first measured between the terminals of the primary winding with the respective secondary winding units of 41, 42 and 43 short-circuited and, in this state, the winding density of the primary winding and the leakage inductance between the divided windings are adjusted to provide distributed capacity and leakage inductance whose product substantially meets the conditions for resonance with harmonics of the desired orders.

It is possible to tune to resonance the two winding units 41 and 42 at the 7th harmonic and the remaining winding unit 43 at the 5th harmonic by the use of the above-described means.

The high voltage generator which is capable of dual harmonics resonance of the 5th and 7th orders as mentioned above has the beam current — high voltage characteristics as shown in Fig. 3. It will be obvious from the diagram under consideration that a superior characteristic is obtained in which the high voltage generated undergoes little change with the increase or decrease in beam current.

Fig. 4 shows a curve representative of the value (or internal resistance) of high voltage regulation versus the resonance order of harmonics. The curve (A) represents the value of high-voltage regulation in the case where the secondary winding is composed of a single conventional winding unit. It appears from the curve that the resonance points *a, b, c, d,* and *e* which are respectively tuned to the respective harmonics of 3rd, 5th, 7th, 9th and 11th orders prove the value of good regulation (or internal resistance), and that the characteristic proves to become extremely unstable in detuning from the above resonance points. The curve (B) depicts a curve linking the values (or internal resistance) of the high voltage regulation versus the resonance order of harmonics. Namely, when the winding units 41, 42 are tuned to a harmonic of 7th order and the winding unit 43 is tuned to a harmonic of 5th order, the value (or internal resistance) of the high voltage regulation will be at a point C between the values corresponding to the harmonics of 5th and 7th orders.

Another example for achieving the objects of the invention is shown in Fig. 5, whereby the winding unit 41 is tuned to resonance at the 5th harmonic and the winding units 42 and 43 at the 7th harmonic.

In this embodiment, the number of turns of the winding units 41, 42 and 43 of the secondary winding is the same as that of the example shown in Fig. 2. The turn density distribution of the primary winding 3 is such that the density thereof is higher nearer the winding units 42 and 43 of the secondary winding thereby to render the leakage inductance of the winding unit 41 greater than that of the winding unit 43, the primary winding 3 being formed in seven different turn density sections.

This embodiment has the same characteristics shown in Fig. 3 and Fig. 4 as those of the embodiment shown in Fig. 2 and provides a superior device with little variations in high voltage.

The diagram of Fig. 6 illustrates an actual construction of the embodiments shown in Fig. 1 and Fig. 2, in which the primary winding 3 is arranged on the primary dividing bobbin 10 in different eight divisions, while the secondary winding is divided into three winding units on the secondary dividing bobbin 11. The winding units 41, 42 and 43 are connected by the diodes 7, 8 and 9 respectively thereby to make up a series circuit as a whole. The primary and secondary windings are connected by an appropriate magnetic core 12.

Unlike the above-described manner in which the secondary winding is divided and arranged, they may alternatively be divided and arranged in different layers with paper.

Also, each winding unit may be subdivided into smaller units.

The present invention enables the high voltage pulses to be reduced in amplitude, thereby facilitating insulation. Also, it is possible to obtain a low-cost, compact and superior device capable of high harmonic resonance with little high voltage variation due to a greatly reduced distributed capacity.

Furthermore, by varying the distance between the primary winding and each of the winding units of the secondary winding and by varying the number of turns of each winding units of the secondary winding, different resonance can be effected for different winding units, thus making it possible to obtain a superior device which is subjected to less variations in high voltage as a whole.

A further modification of the invention is shown in Fig. 7. By dividing the secondary winding into a plurality of winding units by means of a plurality of diodes, different voltages can be applied to the phosphor anode 12, mask anode 13, anode 14 and focus anode 15 of the cathode-ray tube 1.

WHAT WE CLAIM IS:—

1. Apparatus for generating a high voltage for a cathode-ray tube comprising: a primary winding and a secondary winding divided into a plurality of winding units by a plurality of diodes, said primary winding having a winding density which varies along its length and the winding units being arranged to have different numbers of turns from each other, whereby the individual winding units are tuned to harmonics of odd numbered orders equal to and higher than the 5th order of a predetermined signal to be applied to the primary winding and said harmonics include the 5th order harmonic and another order harmonic higher than said 5th order.

2. Apparatus according to claim 1, wherein the winding units of the secondary winding are wound on separate winding sections of a divided bobbin so that at least two of the winding units wound on respective winding sections have different numbers of turns.

3. Apparatus according to claim 1 or 2, wherein the primary winding is wound on different winding sections of a divided primary winding bobbin, the primary winding being so wound on said winding sections of the primary bobbin that portions wound on at least two of the winding sections of the primary dividing bobbin are different in number of turns so as to provide the variation in winding density distribution of the primary winding.

4. High voltage generating apparatus constructed and arranged to operate substantially as hereinbefore described with reference to and as shown by the accompanying drawings.

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