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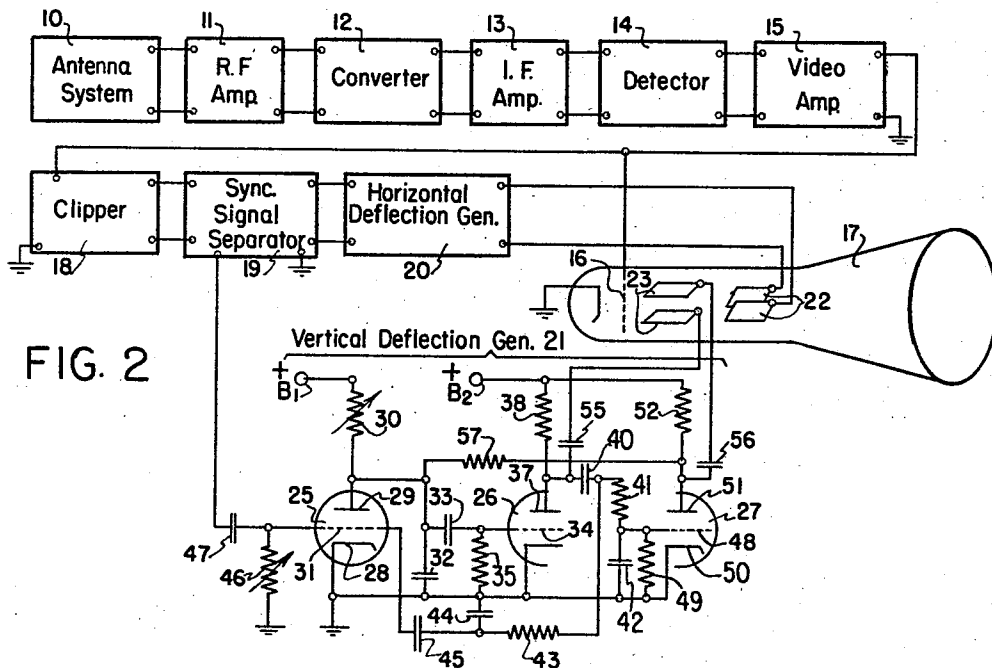
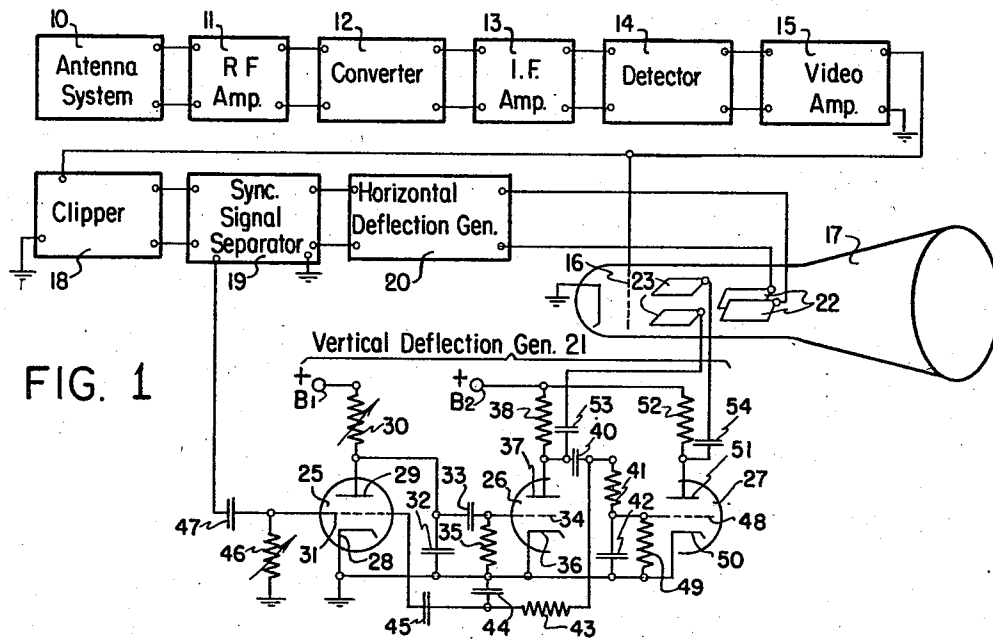
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2,458,367

SAWTOOTH VOLTAGE GENERATOR

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2 Sheets-Sheet 1



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FIG. 3

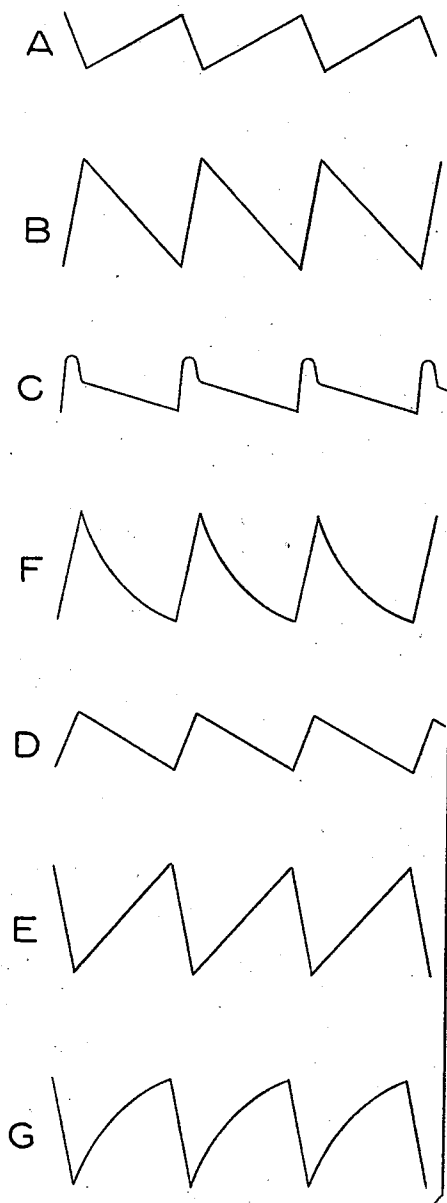
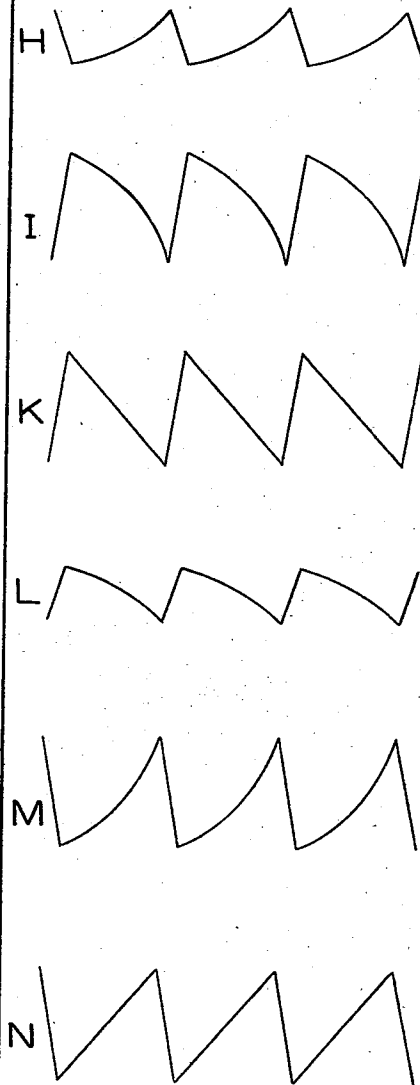


FIG. 4



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SAW-TOOTH VOLTAGE GENERATOR

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11 Claims. (Cl. 315—29)

1.

This invention relates generally to sawtooth voltage generators and more particularly to a multivibrator having a push-pull output circuit for producing sawtooth voltage waves for energizing the vertical deflection electrodes in a television receiver.

In an electrostatic television receiver, balanced sawtooth voltage waves are required for energizing the deflection plates or electrodes for providing an electrostatic field for deflecting the cathode ray beam. Such voltage waves have been provided in the prior art by the use of blocking oscillators for producing a sawtooth wave and suitable amplifying means for providing the required balanced or push-pull output. At the low frequencies involved in vertical deflection systems in a television system, very large condensers are required for applying the voltage waves from the amplifier to the deflecting electrodes in order to prevent distortion. Resulting systems have, therefore, been relatively expensive both because of the requirement for a transformer in the blocking oscillator and the relatively large condensers for coupling the deflection plates. Although it is known that a multivibrator can be substituted for the blocking oscillator and the blocking oscillator transformer can thereby be eliminated, this arrangement requires an extra tube which substantially offsets the advantage gained.

It is, therefore, an object of the present invention to provide a simplified sawtooth voltage generator.

It is a further object of this invention to provide an improved sawtooth voltage generator having a push-pull output including compensating means for overcoming distortion arising from coupling of the generator to the deflection plates.

A feature of this invention is the provision of a voltage generator including a condenser having a switch tube thereacross for producing a sawtooth voltage wave and a second tube serving as a sawtooth amplifier in which the two tubes function as a multivibrator to form a free running system.

A further feature of this invention is the provision of a multivibrator which provides a sawtooth voltage wave of large amplitude, a portion of which is used to excite an additional tube to produce a push-pull sawtooth output.

A still further feature of this invention is the provision of a push-pull sawtooth voltage generator for providing sawtooth voltage waves for the vertical deflection plates of a television

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receiver having a feed-back circuit for compensating for the loss in low frequency response caused by improper coupling of the generator to the deflection plates.

Further objects, features and advantages will be apparent from a consideration of the following description taken in connection with the accompanying drawings in which:

Fig. 1 illustrates the vertical deflection generator in accordance with the invention;

Fig. 2 illustrates a modified system in accordance with the invention; and

Figs. 3 and 4 are curve charts illustrating voltages at various points in the deflection generators of Figs. 1 and 2.

In practicing the invention there is provided a vertical deflection generator including a condenser across which a sawtooth voltage wave is produced. An electron discharge valve is connected across the condenser and functions as a switch to periodically short the condenser. The sawtooth voltage wave is applied to a second valve which inverts and amplifies the voltage wave. The first and second valves are connected in a multivibrator circuit so that the first tube operates automatically to periodically short the condenser. The output of the second valve is applied to a voltage divider system for providing a reduced voltage. The reduced voltage is used to drive a third valve which also inverts and amplifies the voltage wave applied thereto. The outputs of the second and third valves, therefore, provide relatively high amplitude balanced sawtooth voltage waves which may be applied to the deflection plates of a cathode ray tube. When used for providing vertical deflection at 60 cycles, very large condensers are required for applying the voltage waves to the deflection plates in order to prevent distortion. Smaller condensers, however, can be used with an attenuation of the low frequency response. This may be compensated for by providing feedback from the third valve to the charging condenser so that increased low-frequency components are provided in the original sawtooth voltage wave.

Referring now more particularly to the drawings, Fig. 1 illustrates a television system incorporating the sawtooth voltage generator in accordance with the invention for providing sawtooth voltage waves for vertical deflection of the cathode ray beam. The television receiver includes an antenna system 10 for intercepting and selecting a video modulated wave and a radio frequency amplifier 11 for further selecting and

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amplifying the wave. A converter 12 is provided for reducing the frequency of the wave, with the intermediate frequency wave being amplified in amplifier 13. The video signal is derived from the intermediate frequency wave by detector 14 and amplified in video amplifier 15. The resulting video signal is then applied to the control electrode 16 of the cathode ray tube 17 and also to synchronization signal clipper 18. The signal applied to the control electrode of the cathode ray tube controls the intensity of the cathode ray beam of the tube in accordance with the video signal in a well known manner and this action will not be described in detail. A suitable audio system also may be provided in the television receiver but such a system will not be described as it is not a part of this invention and any suitable known system may be used.

The synchronization signal clipper 18 derives the synchronization signals from the composite signal and applies the synchronization signals to the synchronization signal separator 19. Here the horizontal and vertical synchronization signals are separated and the horizontal synchronization signals are applied to horizontal deflection generator 20 and the vertical synchronization signals are applied to the vertical deflection generator 21. The deflection generators 20 and 21 are coupled to horizontal and vertical deflection plates 22 and 23, respectively, for providing balanced sawtooth voltages thereto. As the various components of the receiver other than the vertical deflection generator 21 are not a part of this invention they will not be described in detail and may be of any standard construction.

The vertical deflection generator 21 includes three electron discharge valves 25, 26 and 27. Each of these valves are simple triode tubes and a plurality of triode sections may be included in the same envelope as indicated by 25 and 27 which would normally be provided as a single tube such as a tube type 6SL7. Tube 25 functions merely as a switch tube to produce a sawtooth voltage wave and a medium high-mu tube such as type 6J5 is suitable. Tubes 26 and 27 function as sawtooth amplifiers to provide a balanced or push-pull sawtooth voltage output of relatively large amplitude and high-mu tubes such as type 6SL7 are required. The valves 25 and 26 are also connected in a multivibrator circuit so that the system is free running independent of the synchronization pulses.

Referring now more specifically to the components, the tube 25 includes a cathode 28 which is connected to ground, a plate 29 which is connected to a source of positive potential indicated as plus B1 through variable resistor 30, and a grid 31. The output electrodes 28 and 29 of the tubes 25 are connected to the terminals of condenser 32 across which a sawtooth voltage wave is produced. This, of course, results from charging of the condenser 32 from the source of potential through resistor 30 and then discharge of the condenser through the tube 25 when the tube conducts. The sawtooth voltage wave across condenser 32 is applied through coupling condenser 33 to the grid 34 of tube 26, the grid 34 being biased by resistor 35. The cathode 36 of the tube 26 is connected to ground, and the plate 37 is connected to a source of positive potential indicated as plus B2 through resistor 38. The potential plus B2 will normally be a much higher potential than plus B1, but both potentials may be obtained from the same source by suitable dropping means. It will be apparent, therefore,

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that as the sawtooth voltage is applied to the grid 34 of the tube 26, a sawtooth voltage wave of increased amplitude will be produced at the plate 37 of the tube which is in opposite phase to the applied voltage wave. Condenser 40, resistor 41 and condenser 42 are connected across the output circuit of the tube 26 and form a voltage divider and differentiating circuit as will be described more in detail. In order to provide a multivibrator action between the valves 25 and 26, coupling is provided between the plate 37 of the tube 26 and the grid 31 of the tube 25 including resistor 43 and condensers 44 and 45. Resistor 43 and condenser 44 form a low pass filter which eliminates any components of the high frequency horizontal deflection system which may be present. In practice this filter may be designed to pass frequencies below 2 kilocycles.

In order to provide a push-pull output, the electron discharge valve 27 is provided including a grid 48 to which the voltage across condenser 42 is applied, the grid 48 being biased by resistor 49. The cathode 50 of the valve 27 is connected to ground and the plate 51 is connected through resistor 52 to the positive potential plus B2. Therefore, the portion of the output voltage of the tube 26 appearing across condenser 42 is applied to the tube 27 which amplifies this voltage and inverts the same so that the voltage appearing on the plates 37 and 51 of the tubes 26 and 27, respectively, are at substantially equal amplitude and opposite phase. This balanced or push-pull voltage is applied through condensers 53 and 54 to the vertical deflection plates 23 of the cathode ray tube 17.

Considering now the operation of the vertical deflection generator 21, application of potential across the condenser 32 causes the condenser to be charged at a substantially uniform rate resulting in a linearly rising voltage on the plate 29 of tube 25 and on the grid 34 of tube 26. This causes linearly increasing current to flow in the tube 26 with the result that a voltage drop is produced across the resistor 38 and the potential of the plate 37 of the tube falls. This condition continues until the voltage on plate 29 of tube 25 increases and the negative bias on the grid 31 of the tube decreases to allow the tube 25 to conduct. When the tube 25 conducts, the condenser 32 is shorted as previously described to produce the retrace portion of the sawtooth wave. During this portion of the operation the condenser 45 charges to provide a negative bias on the grid 31 to cut off tube 25. This action is accelerated by the pulse produced by the differentiating circuit including condenser 40 and resistor 41. After the tube 25 is cut off, the condenser 32 again charges to provide the trace portion of the sawtooth voltage wave. This again provides a rising voltage on the plate 29 of tube 25. During the trace portion of the cycle the condenser 45 discharges through resistor 46 so that the negative bias on the grid 31 is gradually reduced. The rate of discharge of the condenser 45 may be controlled by varying the resistance of resistor 46. The increasing plate potential and reduction of the grid bias at a particular point results in the tube 25 again becoming conducting and a further cycle to take place. In Fig. 3, curve A indicates the voltage across condenser 32, curve B indicates the voltage across the plate 37, and curve C indicates the voltage applied to the grid 31.

It will be noted that the load on the tube 37 is principally a resistance 38, and the coupling to

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the deflection plates, the capacity of the plates and tube, and the stray capacity of the leads makes the load somewhat capacitive. It is well known that under such conditions the development of a pulse component on the sawtooth wave, as shown in the curve c of Fig. 3, is very difficult. In the present system the pulse is obtained by very careful differentiation. This is provided by the differentiating circuit including condenser 40 and resistor 41 and also by the time constant circuit composed of condenser 45 and resistor 46, the values of which are selected to provide further differentiation. Such sharp differentiation produces a great loss of amplitude and in order to provide sufficient pulse amplitude for making the tube 25 conduct very rapidly, high gain amplifier tubes must be used. This was achieved by using a type 6J5 tube as the discharge tube and a type 6SL7 tube as the amplifier tube. As previously stated, resistor 43 and condenser 44 provide a low pass or integration circuit to eliminate components of the horizontal deflecting voltage which may be present so that the vertical generator is not affected thereby.

The sawtooth generator, although arranged to be free running, is also adapted to be triggered by synchronization pulses. These pulses are applied from the synchronization signal separator 19 through condenser 47 to the grid 31 of tube 25. These pulses cause the tube 25 to conduct. The frequency of the multivibrator is adjusted by resistor 46 so that the natural frequency is slightly slower than the rate of synchronization pulses so that the generator will actually be triggered by the pulses. As the multivibrator is about ready to trip itself, small synchronization pulses are sufficient for triggering. The amplitude of the voltage waves and, therefore, the picture size can be controlled by variable resistor 30.

As previously stated, a portion of the output voltage of the tube 26 is used for driving the tube 27. This portion is made to have an amplitude substantially equal to the amplitude of the wave applied to the grid 34 of the tube 26 so that the output voltages of the tubes 26 and 27 will be substantially identical. The condensers 40 and 42 provide the required voltage division so that a voltage wave of proper amplitude for driving the tube 27 appears across condenser 42. This voltage wave is indicated by curve D in Fig. 3. The voltage appearing in plate 51 of the tube 27 is of opposite phase to the voltage appearing on the grid 47 and of increased amplitude. The voltage wave on plate 51 is indicated by curve E in Fig. 3. With reference to Fig. 3 it is pointed out that the curves are merely illustrative and do not indicate the relative amplitude between the various voltages developed in the system. The curves, however, are believed to be of help for a complete understanding of the operation of the system. It is apparent that the voltages 37 and 51 are of substantially equal amplitude and opposite phase so that a push-pull or balanced output is provided.

In standard television receivers, the frequency of the vertical deflection generator is 60 cycles per second. It is obvious that sawtooth waves having such a frequency include components of various frequencies from 60 cycles up. In order to apply such voltage waves to the deflection plates, very large coupling condensers are required. The use of smaller coupling condensers will attenuate the low-frequency components of the wave with the result that the voltages appearing on the deflection plates will be distorted

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as illustrated by curves F and G. Curve F illustrates the voltage wave which would be provided on the plate 23 connected to condenser 53, and curve G illustrates the voltage wave on the plate 23 connected to condenser 54. It is obvious that the provision of such deflection voltages will produce an electrostatic field for deflecting the beam which will be non-linear and this will obviously cause distortion of the reproduced television picture. However, as the use of very large condensers for coupling the voltages of the deflection plates is relatively expensive, it may be desirable to use smaller coupling condensers which are relatively inexpensive and provide means for compensating for the low frequency attenuation produced thereby.

A simple arrangement for compensating for the low frequency response which is lost in coupling the sawtooth generator to the deflection plates is illustrated in Fig. 2. As the system of Fig. 2 is generally similar to the system of Fig. 1, the same reference characters are used for corresponding elements and a complete description of the operation of the system is not repeated. The coupling condensers in Fig. 2 are designated 55 and 56, and these condensers may be much smaller than the condensers 53 and 54 of Fig. 1. A feed-back path is provided between the plate 51 of the tube 27 and the high potential side of the condenser 32. This feed-back path includes a very large resistor 57 which in systems constructed has been of the order of 30 megohms. The feed-back applied from the plate 51 to the condenser 32 provides for increase of the low-frequency components of the sawtooth voltage wave produced across the condenser 32. It is noted that the voltage wave E of Fig. 3 which appears on the plate 51 is in phase with the voltage wave across the condenser 32. Application of this voltage to the condenser 32 causes the charging rate to be non-linear, increasing rapidly at the end of the cycle due to the increasing voltage on the plate 51. Therefore, the voltage across 32 instead of having a linear rate of rise, increases exponentially as shown by curve H in Fig. 4. This voltage when applied to the grid 34 of tube 26 causes a voltage wave on the plate 37 thereof which is of the same shape but in opposite phase as illustrated in curve I. Application of this voltage to a deflection plate through a relatively small condenser results in flattening the wave as shown at K in which the trace portion of the voltage wave is substantially linear. Similarly the operation of the tube 27 will be modified as the voltage wave applied to the grid 48 thereof is of the same shape as the voltage on the plate 37 of tube 26. This is illustrated by curve L which is similar to curve I but of reduced amplitude. The voltage wave on plate 51 of tube 27 will be of inversed phase to the voltage L as illustrated by curve M. Application of this voltage wave to the other deflection plate through a small condenser will cause the wave to be straightened to provide a linear trace as illustrated by curve N. The voltage waves on the two deflection plates will then be the waves illustrated by K and N in Fig. 4 which include linear trace portions which are completely balanced to provide the required push-pull voltage. It will be apparent from a consideration of the foregoing description that the vertical deflection generator disclosed is of simple and inexpensive construction. A sawtooth voltage wave is provided without the use of a blocking oscillator thereby resulting in elimination of the blocking

oscillator transformer which is a relatively expensive component. The sawtooth voltage generating means is combined with a sawtooth voltage amplifier in a multivibrator circuit so that the system is free running. The specific combination of elements disclosed eliminates the second tube normally required in a multivibrator used for producing a sawtooth voltage wave or, considering the two tubes as a multivibrator, the second tube also functions as a voltage amplifier to eliminate the requirements of a separate amplifier. This results in the elimination of one tube from standard multivibrator and amplifier circuits.

The system for compensating for the distortion introduced by the use of small coupling condensers also results in a great saving in cost. As is noted from a consideration of Fig. 2, the only added component required is resistor 57 which is a relatively inexpensive item compared to the saving in cost by the use of small condensers (.005 microfarad) instead of the relatively large coupling condensers (.03 microfarad) which would normally be required to prevent objectionable distortion. This is particularly true as these condensers operate at relatively high voltage of the order of 6 kilowatts and must be hermetically sealed to prevent absorption of moisture with resulting leaking currents. In addition to providing a minimum of components and a reduction in cost, the compensating circuit is also advantageous in that it is not critical and no linearity control is required. Shaping is produced in the condenser which forms the original sawtooth voltage so that an additional component is not required for this operation. As the shaping is produced in the original voltage wave, there is no loss of driving voltage and the full output voltage can be obtained.

Systems in accordance with the invention have been tested and found to operate satisfactorily. In such systems the following components were used in the systems illustrated in Figs. 1 and 2:

Tube 25	6J5
Tube 26	6SL7
Tube 27	
Plus B1	volts-- 250
Plus B2	do-- 800
Resistor 30	megohms (variable)-- 8
Condenser 32	microfarad-- .1
Condenser 33	do-- .05
Resistor 35	megohms-- 10
Resistor 38	do-- 4.7
Condenser 40	micromicrofarads-- 100
Resistor 41	ohms-- 220,000
Condenser 42	microfarads-- .004
Resistor 43	ohms-- 150,000
Condenser 44	micromicrofarads-- 500
Condenser 45	do-- 1,000
Resistor 46	megohms (variable)-- 8
Resistor 49	megohms-- 10
Resistor 52	do-- 4.7
Condenser 53	microfarads 6 kv-- .03
Condenser 54	do-- .03
Condenser 55	microfarads-- .005
Condenser 56	do-- .005
Resistor 57	megohms-- 30

It is apparent that when working under different conditions various tubes and circuits may be required and different values will be required. The values listed above are merely one set of values which have been found to be satisfactory.

While there are described certain embodiments

of our invention which are illustrative thereof, it is apparent that various changes and modifications can be made therein without departing from the intended scope of the invention as defined in the appended claims.

We claim:

1. A sawtooth voltage generator adapted to produce a sawtooth voltage wave for a deflection plate of a cathode ray tube for deflecting the beam of said tube comprising, condenser means, means for charging said condenser means at a substantially uniform rate, an electron discharge valve having input and output electrodes, said output electrodes being connected across said condenser means to discharge the same when said valve conducts, a second electron discharge valve of the high-mu type having input and output electrodes, a load circuit including said deflection plate connected to said output electrodes of said second valve, said load circuit being principally resistive with a capacitive component, said input electrodes of said second valve being connected across said condenser means so that an amplified and inverted voltage is produced across said output electrodes, and a feedback circuit coupling said output electrodes of said second valve to said input electrodes of said first valve comprising a differentiating circuit including two differentiating sections connected in series for producing sharp voltage pulses at said input electrodes of said first valve.

2. In a television receiver including a cathode ray tube having means for producing an electron beam, horizontal deflection plates for producing high frequency deflection of said beam, and vertical deflection plates for producing low frequency deflection of said beam, a sawtooth voltage generator for producing a voltage wave for said vertical deflection plates comprising, condenser means, means for charging said condenser means at a substantially uniform rate, an electron discharge valve having input and output electrodes, said input electrodes being connected across said condenser means to discharge the same when said valve conducts, a second electron discharge valve of the high-mu type having input and output electrodes, a load circuit including said deflection plates connected to said output electrodes of said second valve, said load circuit being principally resistive with a capacitive component, said input electrodes of said valve being connected across said condenser means so that an amplified and inverted voltage is produced across said output electrodes, and a feedback circuit coupling said output electrodes of said second valve to said input electrodes of said first valve including a differentiating circuit for producing voltage pulses and a low pass filter for removing high frequency components picked up from said horizontal deflection plates.

3. A sawtooth voltage generator adapted to produce balance potentials on a pair of conducting plates comprising, condenser means, means for producing a sawtooth voltage wave across said condenser means including an electron discharge valve for discharging said condenser means when said valve conducts, a second electron discharge valve including input electrodes connected to said condenser means and an output circuit in which an inverted amplified sawtooth voltage wave is produced, a third electron discharge valve including input and output electrodes, means for applying a portion of said output voltage wave produced by said second valve to said input circuit of said third valve so that a

sawtooth output voltage wave is produced by said third valve which is equal and opposite to said output wave of said second valve, said output circuits including said conducting plates and providing a load for said second and third valves which is principally resistive with a capacitive component, and a feedback circuit coupling said output circuit of said second valve to said first valve including a differentiating circuit having two sections in cascade each of which includes a series condenser and a shunt resistor, said differentiating circuit producing sharp voltage pulses for rendering said first valve conductive.

4. A push-pull sawtooth voltage generator adapted to produce balanced potentials on a pair of conducting plates comprising, condenser means, a charging circuit for producing a sawtooth voltage wave on said condenser means including means for varying the charging rate, first and second electron discharge valves having output electrodes coupled to said plates, means for applying the voltage on said condenser means to said first valve, means for applying a portion of the output voltage wave from said first valve to said second valve, and means for compensating for the attenuation of low frequency components of the sawtooth waves on said plates including a feedback circuit from said output electrodes of said second valve to said condenser to charge the same at an increasing rate to thereby increase the low frequency components of the sawtooth voltage wave across said condenser means, said feedback circuit being independent of said charging circuit so that the amplitude of said sawtooth voltage wave can be changed by said means for varying the charging rate independently of said means for correcting for the low frequency attenuation.

5. A push-pull sawtooth voltage generator adapted to produce balanced potentials on a pair of conducting plates comprising, a main condenser, charging means for producing a sawtooth voltage wave on said main condenser including a variable resistor connected in series with said main condenser across a source of potential, first and second electron discharge valves having output electrodes, means for applying the voltage on said main condenser to said first valve, means for applying a portion of the output voltage wave from said first valve to said second valve, means for applying the voltage waves from said output electrodes to said plates including coupling condensers which distort said waves, and means for shaping the voltage wave on said main condenser to compensate for distortion produced by said coupling condensers including a feedback circuit from said output electrodes of said second valve to said condenser to charge the same at an increasing rate, said feedback circuit being independent of said charging means so the amplitude of said sawtooth voltage wave can be changed by said variable resistor independently of said means for correcting for the low frequency attenuation.

6. A push-pull sawtooth voltage generator comprising, condenser means, a charging circuit for producing a sawtooth voltage wave across said condenser means including a resistor connected in series with said condenser means to a source of potential, said resistor being variable to control the amplitude of the voltage wave produced across said condenser means, a first electron discharge valve adapted to invert and amplify said sawtooth voltage wave, a second electron discharge valve arranged to invert and amplify a

portion of the voltage wave produced by said first valve so that a pair of balanced output voltage waves are produced, and means for accentuating the low frequency response of said generator comprising a feedback path from the output circuit of said second valve to the juncture of said resistor and said condenser means so that said feedback path is independent of said charging circuit, the voltage in said output circuit of said second valve being in phase with the voltage across said condenser produced by said charging means and increasing substantially linearly with time so that an increasingly greater voltage is applied to said condenser and the voltage developed thereacross builds up at a rate which increases with time.

7. In a push-pull sawtooth voltage generator adapted to produce potentials for the deflection plates of a cathode ray tube for deflecting the beam of the tube, and including condenser means across which a sawtooth voltage valve is developed, a first electron discharge valve adapted to invert and amplify said sawtooth voltage wave, and a second electron discharge valve arranged to invert and amplify a portion of the voltage wave produced by said first valve whereby the output voltage wave produced by said second valve is in phase with the voltage wave developed across said condenser; means for applying said output voltage waves produced by said valves to said deflection plates, said means being effective to attenuate the low-frequency components of said waves, a first charging circuit including a variable resistor connected in series with said condenser means across a source of potential, a second charging circuit for said condenser including a feedback path for applying at least a portion of the output sawtooth voltage wave of said second valve to said condenser means, said feedback path including a resistor connecting said output circuit to the juncture of said variable resistor and said condenser means so that while said condenser means is charging through said variable resistor an increasingly greater voltage is applied thereto by said second charging circuit and the voltage developed thereacross builds up at a rate which increases with time.

8. In a push-pull sawtooth voltage generator adapted to produce potentials for the deflection plates of a cathode ray tube for deflecting the beam of the tube, and including a main condenser across which a sawtooth voltage wave is developed, a first electron discharge valve adapted to invert and amplify said sawtooth voltage wave, and a second electron discharge valve arranged to invert and amplify a portion of the voltage wave produced by said first valve so that the output voltage wave produced by said second valve is in phase with the voltage wave developed across said condenser, means for applying said output voltage waves produced by said valves to said deflection plates including condensers which are effective to attenuate the low-frequency components of said waves, a charging circuit including a variable resistor connected in series with said main condenser across a source of potential for charging said main condenser substantially linearly, and means for accentuating the low frequency response of said generator comprising a feedback path for applying the output sawtooth voltage wave from said second valve to said main condenser, said feedback path including a resistor connecting said output circuit of said second valve to the juncture of said variable resistor and said main condenser so that during a portion of the cycle of each wave an increasingly greater

voltage is applied to said condenser by said feedback circuit and the voltage developed thereacross builds up at a rate which increases with time.

9. A sawtooth voltage generator adapted to produce balanced potentials for the deflection plates of a cathode ray tube for deflecting the beam of said tube, comprising a condenser, charging means including a variable resistor for connecting said condenser to a source of potential for charging said condenser at a variable rate, a first electron discharge valve connected across said condenser for discharging said condenser so that a sawtooth voltage wave is developed thereacross, means including a second electron discharge valve for inverting and amplifying said sawtooth wave developed across said condenser, means including a third electron discharge valve for inverting and amplifying a portion of the output voltage wave produced by said valve so that a pair of balanced output voltage waves are produced, means for applying said output voltage waves to said deflection plates including a pair of small condensers which attenuate the low-frequency components thereof, and means for accentuating the low frequency response of said generator comprising a feedback path from the output circuit of said third valve to the juncture of said variable resistor and said condenser so that said feedback path is independent of said charging means, the sawtooth voltage wave in said output circuit of said third valve being in phase with the voltage across said condenser so that an increasingly greater voltage is applied to said condenser and the voltage developed thereacross builds up at a rate which increases with time.

10. A sawtooth voltage generator adapted to produce balanced potentials for the deflection plates of a cathode ray tube for deflecting the beam of said tube, comprising a condenser, means including a source of potential for charging said condenser at a variable rate, a first electron discharge valve connected across said condenser for discharging the same so that a sawtooth voltage wave is developed thereacross, a second electron discharge valve including input electrodes connected to said condenser and an output circuit in which an inverted and amplified sawtooth wave is produced, a differentiating circuit coupling said output electrode of said second valve to said input electrodes of said first valve, said differentiating circuit producing pulses from the sawtooth voltage wave in the output circuit of said second valve for rendering said first valve conductive to discharge said condenser, a third electron discharge valve including input and output circuits, means for applying a portion of the output voltage wave produced by said second valve to said input circuit of said third valve so that a pair of balanced voltage waves are produced in said output circuits, means for applying said output voltage waves to said deflection plates including a pair of small condensers which attenuate the low-frequency components thereof, and means for accentuating the low frequency re-

sponse of said generator comprising a feedback path from the output circuit of said third valve to said condenser which is independent of said charging means so that the amplitude of said sawtooth voltage wave developed across said condenser can be varied by said charging means independently of said means for accentuating said low frequency response, the sawtooth voltage in said output circuit of said third valve being in phase with the voltage across said condenser so that an increasingly greater voltage is applied to said condenser and the voltage developed thereacross builds up at a rate which increases with time.

11. A sawtooth voltage generator adapted to produce balanced potentials for the deflection plates of a cathode ray tube for deflecting the beam of said tube, comprising a condenser, means including a variable resistor and a source of potential connected in series to said condenser for charging the same at a variable rate, a first electron discharge valve connected across said condenser for discharging the same so that a sawtooth voltage wave is developed thereacross, a second electron discharge valve including input electrodes connected to said condenser and an output circuit in which an inverted and amplified sawtooth wave is produced, a differentiating circuit coupling said output electrodes of said second valve to said input electrodes of said first valve so that said valves alternatively conduct, a third electron discharge valve including input and output circuits, means for applying a portion of the output voltage wave produced by said second valve to said input circuit of said third valve so that a pair of balanced output voltage waves are produced by said second and third valves, means for applying said output voltage waves to said deflection plates with the low-frequency components of said waves being attenuated, and means for accentuating the low frequency response of said generator comprising a feedback path from the output circuit of said third valve to the juncture of said variable resistor and said condenser, said sawtooth voltage wave in said output circuit of said third valve being in phase with said voltage wave developed across said condenser so that during the rising portion of said waves an increasingly greater voltage is applied to said condenser.

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GARTH J. HEISIG.

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