

Sept. 29, 1942.

G. ZANARINI

2,297,522

GENERATION OF SAW-TOOTH SYNCHRONIZED VOLTAGES

Filed June 14, 1940

4 Sheets-Sheet 1

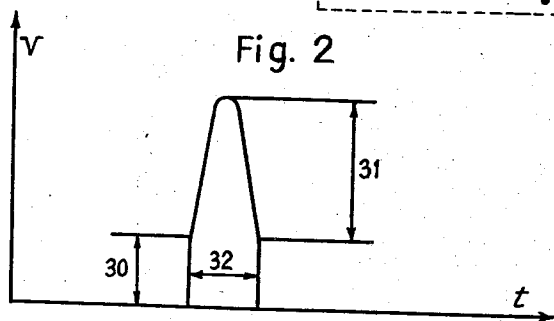
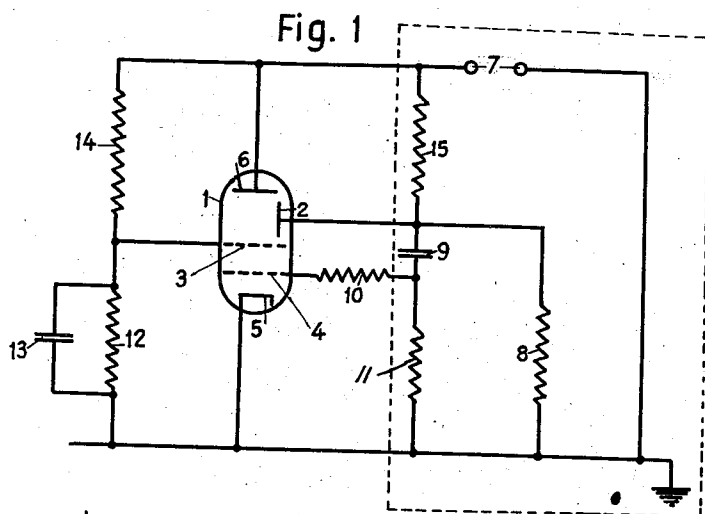
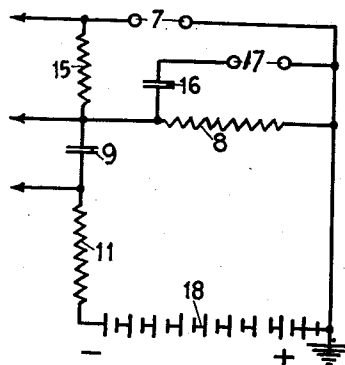


Fig. 3



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Fig. 4

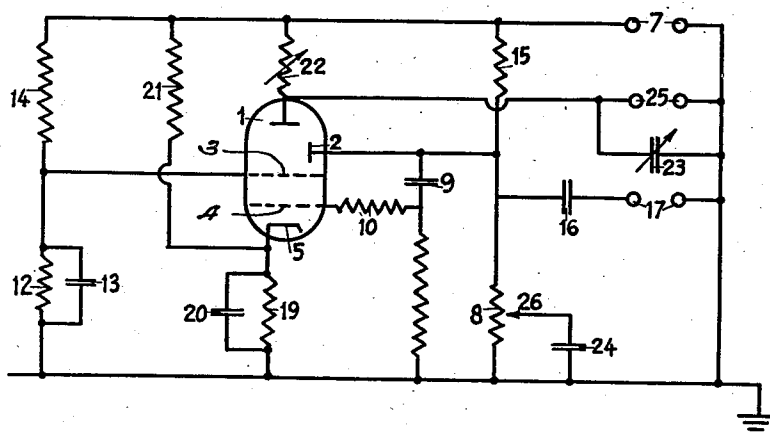
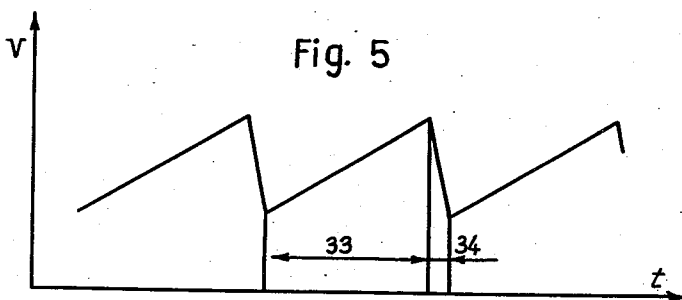


Fig. 5



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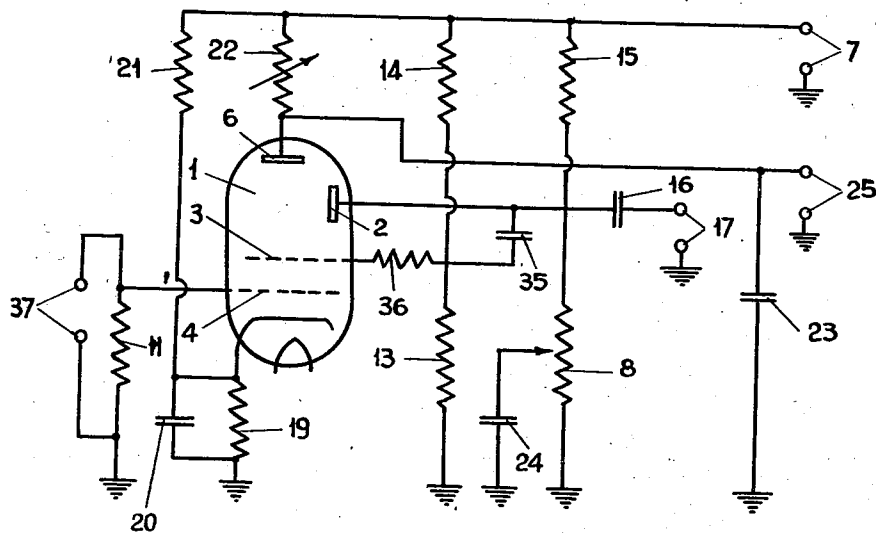
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Fig. 6.



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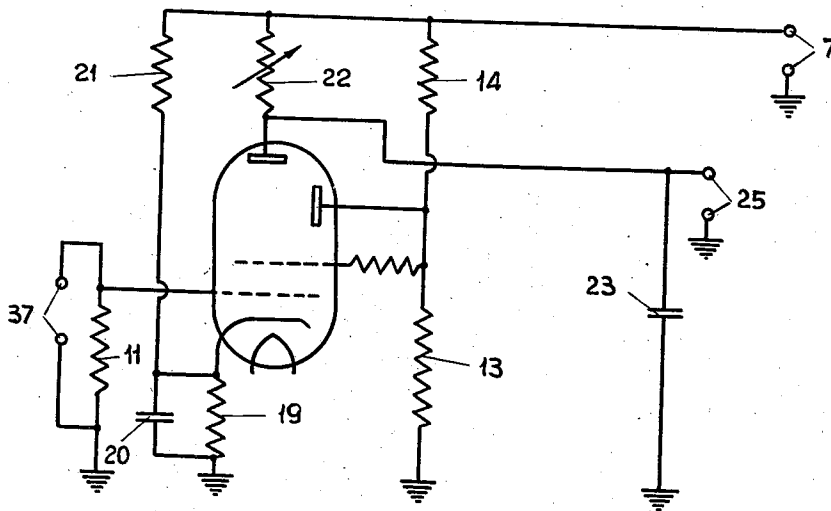
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Fig. 7.



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UNITED STATES PATENT OFFICE

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GENERATION OF SAW-TOOTH SYN-
CHRONIZED VOLTAGESGiuseppe Zanarini, Turin, Italy; vested in the
Alien Property CustodianApplication June 14, 1940, Serial No. 340,617
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3 Claims. (Cl. 250—36)

This invention relates to a system for the generation of saw-tooth synchronized voltages based on the particular features of secondary emission tubes. This invention has for its object the generation of said voltages of adjustable shape and magnitude, the frequency being controlled by external impulses by means of a single tube of the secondary emission type and an electronic coupling being employed between the secondary cathode and anode of the same tube.

The systems commonly used for obtaining synchronized saw-tooth voltages employ two tubes which separately accomplish two different functions. The first tube is used in a pulse generating circuit which may be synchronized by external impulses; the second tube, which is actuated by the pulses generated by the first one, is employed in a saw-tooth voltage generating circuit. The magnitude and shape of the signals may be properly adjusted. According to this invention a simple and efficient system has been developed which by uniting the two functions in one secondary emission tube affords the generation of saw-tooth voltages of great linearity and of adjustable magnitude.

As is well known, secondary emission tubes, have an active surface (secondary cathode) which, when struck by electronic bombardment, emits additional electrons in a larger number named secondary electrons. The bombarding or primary electrons, which are emitted by the primary cathode and controlled by the grid, reach through the screen grid the secondary cathode which thus emits further electrons (secondary electrons) in a larger number, that are then attracted by the plate to which a proper voltage is applied. Consequently, the current flowing through the secondary cathode has a negative direction and the secondary cathode-primary cathode path may be considered as a negative resistance. Moreover, it is known that by placing a positive resistance in parallel with a negative resistance a current will be set up, the value of such current being steady or unsteady; more particularly, the current is unsteady where the positive resistance has an actual value higher than that of the negative resistance. In this case, theoretically, an indefinite increase in current and voltage at the terminals of the set of resistances in parallel will take place. In practice, such increase in current will reach the limits afforded by the shape of the negative resistance characteristic curve, which is never perfectly linear and of indefinite length. In the case of a secondary emission tube, as said above,

the negative resistance is represented by the secondary cathode-primary cathode path and its value may vary from a minimum, determined by the tube characteristic, to a maximum coinciding with the infinite value as a function of the potential difference existing between the control grid and the primary cathode; the minimum value of the negative resistance corresponds to the zero value of said potential difference, while the maximum value will obviously correspond to cut-off. Therefore, by placing between primary cathode and secondary cathode an ohmic resistance having an actual value higher than the minimum value of the secondary cathode negative resistance, it is possible to go over from a steady to an unsteady condition, or vice versa, by simply adjusting in the proper way the control grid voltage. When set for stability, the voltage appearing on the secondary-cathode will be the product of the current by the positive resistance. When set for instability, said voltage will increase, the velocity depending upon the time constant of the circuit, until it reaches the maximum limit of the current supplied by the cathode under these particular conditions of operation. It is clear that this instability is not due to the coupling between the secondary cathode and control grid. By introducing this coupling, for instance by means of a capacity, the instability phenomenon is emphasized since, owing to this coupling, the value of the negative resistance of the secondary cathode-primary cathode path is actually decreased.

In this case it follows that, owing to the decreased value of the negative resistance during the dynamic condition, the instability phenomenon may also be obtained with positive parallel resistances of a relatively small value, in any case smaller than that of the negative resistance in a static condition which would not take place unless said coupling is resorted to. The invention is based on this condition in order to accomplish the first operation, that is, the generation of synchronized impulses. Current impulses may also be generated by virtue of either capacity or inductive coupling between the secondary cathode and the control-grid while the synchronizing signals may be applied through a capacity either to the secondary-cathode or the control grid.

Current impulses may also be generated by virtue of either capacity or inductive coupling between the secondary cathode and screen grid; in this way, the control grid remains free and

may be used for synchronization by means of external signals.

Therefore, the grid impedance of the secondary emission tube is not bound to the characteristics of the impulse generating circuit and may be of any value. Moreover, through the strong controlling action of the control grid on the emission of the tube, synchronization may be effected with synchronizing signals having considerably small voltage and current parameters.

Synchronization may also be effected by operating on either the secondary cathode or the screen grid.

Consequently, the circuit lends itself to a double synchronization, firstly, a synchronization which I call "main" synchronization may be made through the control grid and, secondly, a synchronization which I call "driven" synchronization, may be made through either the secondary cathode or the screen grid. If the two synchronizing signals are of a different frequency, the impulses may be generated by the secondary cathode on superposition of both actions of the synchronizing signals.

Finally, in the case of regeneration between the secondary cathode and screen grid the coupling may be obtained through direct connection.

The accompanying drawings show, by way of example only, some embodiments of the invention.

Figure 1 shows the diagram of a self-excited impulse generator synchronized by external positive impulses;

Figure 2 is a diagram showing the shape of the voltage on the secondary cathode of the synchronized impulse generator, of which Figure 1 shows the diagram.

Figure 3 shows a diagram of a blocked impulse generator operating under the action of synchronizing impulses only being a modification of the circuits included within the dash-line rectangle of Fig. 1 and may be substituted for the circuits included within said rectangle.

Figure 4 shows the diagram of a saw-tooth impulse generator by means of a condenser discharge.

Figure 5 shows a method of adjusting the tooth shape.

Figure 6 shows the diagram of a double-synchronization impulse generator with a capacitative coupling between the secondary cathode and screen grid.

Figure 7 shows a further modification, in which the reactive coupling is obtained through direct connection.

Referring to Fig. 1 which considers only the first operation, that is, the generation of synchronized impulses having certain characteristics, no use is made of the anode tube.

The tube adopted for this purpose may be a Philips 4696 type or any other tube having similar characteristics in which 2 is the secondary cathode, 3 the screen grid, 4 the control grid, 5 the cathode and 6 the anode. 7 are the anodic supply terminals.

In this case, the control grid 4 is not biased, but is directly connected to ground and, therefore, to the primary cathode through resistors 10 and 11, the purpose of which will be explained hereinafter. Consequently, according to what we have detailed above, the negative resistance of the secondary cathode-primary cathode path reaches its maximum value. The resistor 15 connected between the secondary cathode and high voltage supply supplies to the secondary cathode an

initial positive voltage, so that at the start the primary electrons can reach the cathode. Its value is such that the cathode is biased with 30 or 40 volts. The screen grid voltage is taken from the voltage divider 12, 14: the voltage is free from any variable component owing to the filtering action of the condenser 13.

A resistor 8 is connected between the secondary cathode and primary cathode and its value is such that the set of resistors 8 and 15 considered in parallel have an actual value higher than that of the primary cathode-secondary cathode path. In accordance with the statements made above, the circuit is in an unsteady condition and as a consequence, the secondary cathode voltage increases independently per se. At this point it should be noted that, on account of the capacitive coupling existing between the secondary cathode and control grid, the instability phenomenon might arise even for values considerably smaller than that of the resistor 8.

The design of the circuit could therefore be based on this circumstance, that is on the actual value taken by the negative resistance in a dynamic condition.

However, the operation of the circuit is the same and the instability is caused by an excess positive resistance as compared with the amount of negative resistance, considering the phenomenon in either a static or dynamic condition. In this example, however, for the sake of simplicity, I consider the first case only. The condenser 9 is connected to the secondary cathode and is in series with resistor 10 which is connected to the control grid; its charge increases by effect of the grid current of the tube and the current flowing through resistor 11. The grid then takes a slight positive potential, that lasts all the time during which the secondary cathode voltage increases. As soon as this increase ceases, owing to characteristic limitation, the positive grid voltage begins to decrease effecting a further charge of condenser 9.

The result is a decrease in the secondary current and corresponding voltage. At a certain point the grid current ceases and the condenser 9 then tends to maintain its charge owing to the relatively high value of resistor 11. Consequently, the control grid voltage becomes negative causing a further decrease in the secondary cathode voltage. It is clear that the phenomenon goes through a second phase, reverses to the first one with increasing velocity, until the secondary cathode has reached the bias voltage supplied by the voltage divider 8, 15. Under such condition, however, owing to the large charge of condenser 9, the tube is blocked and the condition lasts until the condenser has discharged itself (through resistor 11) to such an extent as to restore the unsteady condition. Thereupon another cycle, equal to the one just described, takes place. The generation of a series of impulses is thus obtained, said impulses being of a relatively small duration, separated by short intervals of time which depend upon the time constant of the network 9, 11 and the anode supply condition.

The duration of each impulse depends instead upon the time constant 9, 10 since resistor 10 affects the time needed for charging up condenser 9 during the unsteady phase. The voltage impulse on the secondary cathode is positive and its shape is of the type shown in Fig. 2. The voltages V are plotted on the ordinates and the times t on the abscissae. The voltage 30 designates the impulse magnitude and its value is

determined by the tube characteristic and operating conditions. Time 32 depends upon the value of capacity 9 and resistor 10 and the larger these values the greater the time will be.

The slope of the ascending and descending portions depends greatly upon the value of resistor 8 and the tube internal capacity. By suitably adjusting the elements of the circuit it is possible to vary all the characteristics of the impulse.

The impulse generator just described is self-excited and may be synchronized by external positive impulses fed on the secondary cathode. For certain uses, however, it is preferable for the generator to be normally blocked and operate only under the action of the synchronizing impulses. As shown in Fig. 3 which shows a modification of the circuits included in the dash-line rectangle in Fig. 1, this is obtained by simply supplying to the control grid a negative bias voltage 18 such as to keep the tube in a steady condition. A positive impulse of sufficient magnitude applied through the terminals 17 and a coupling condenser 16 to the secondary cathode reaches the control grid through condenser 9 causing an unsteady condition and therefore generating an impulse in the manner explained above. The second operation which is the generation of saw-tooth synchronized voltages, is effected by employing the plate of the tube which remained out of use when performing the first operation. In fact, during generation of the impulse, the anode resistance of the tube, starting from an infinite value corresponding to cut-off reaches a minimum value, corresponding to the maximum magnitude of the impulse and depending upon the characteristics of the tube and supply operating conditions, resuming the infinite value when the impulse ceases. This variation in resistance is employed according to the invention for the generation of the saw-tooth voltage by means of the discharge of a condenser. In Fig. 4, a practical arrangement of this system is shown. At each impulse capacity 23 is partially discharged and charges up again during the intervals between the various impulses with a velocity depending upon the value of resistor 22 or by varying the value of capacity 23 and the larger the value of these elements the smaller the magnitude will be. In order to obtain an efficient discharge of condenser 23, its capacity should not exceed certain limits, which depend upon the value of the anode resistance of the tube. In the example of Fig. 4, in which the capacity is assumed to be of a fixed value, the magnitude adjustment is obtained by means of resistor 22 and the variation in the saw-tooth slope, that is (referring to Fig. 5) the setting of time 33 and 34, is obtained by adjusting the duration of the impulse according to the circumstances previously set forth; the time 34 being substantially equal to the duration of the impulse producing the discharge of condenser 23.

In the circuit diagram given in Fig. 4, it is possible to go over from an almost steady condition (blocked impulse generator) to an unsteady condition (self-excited generator) by simply adjusting the bias voltage of the tube by varying resistor 22. The capacity 20 should be of a low reactance for the frequencies concerned and always much lower than the value of resistor 19. The condenser 24 (the reactance of which should be much lower than the value of resistor 8) permits by varying the tap 26 the adjustment of the regeneration effect and the slope of the ascending and descending portions of the impulses.

The saw-tooth synchronized voltage generator

just described is particularly suited for the synchronization in television receivers or the actuation of the time axis in cathode ray oscilloscopes and the like.

In Fig. 6 the reactive coupling is again between the secondary cathode and screen grid through capacity 35, but there is a double synchronization, namely a "main" synchronization applied to terminals 37 and a "driven" synchronization applied to terminals 17.

The considerations set forth above also apply to this embodiment as regards the degree of regeneration, instability condition, generation of the saw-tooth voltage operated by the anode circuit, etc.

In Fig. 7 the reactive coupling between the screen grid and secondary cathode is obtained by means of direct connection.

What I claim is:

1. In a saw-tooth synchronized wave generator, in combination a secondary emission high-vacuum thermionic tube including a primary cathode, a control grid, a screen grid, a secondary cathode emitting secondary electrons, and an anode, in the order named, means for conveying the electrons emitted by the primary cathode through the control grid and screen grid and means for conveying the secondary electrons to the anode; a reactive circuit generating impulse waves of a constant magnitude and considerable energy, in which the reactive effect is obtained by utilizing the negative resistance offered under certain feed conditions by the secondary cathode-primary cathode path in said secondary emission tube, said circuit being connected to the electrodes of the secondary emission tube comprised between the primary cathode and the secondary cathode both included; means for synchronizing said impulses by external impulses containing less energy and actuating said electrodes; a saw-tooth generating circuit formed by the internal anode resistance of the secondary emission tube, its value being controlled by the impulses generated by the reactive circuit through the electronic coupling existing between the secondary cathode and the anode of said tube and by a capacity connected between the anode and primary cathode in said tube, said capacity being periodically charged by the current flowing through a resistance connected to said capacity and to a source of direct voltage, and discharged by said internal anode resistance of the secondary emission tube, the discharge effect prevailing during said synchronized impulses and the charge effect prevailing during the time intervals between two successive impulses.

2. In a saw-tooth synchronized wave generator, in combination a secondary emission high-vacuum thermionic tube including a primary cathode, a control grid, a screen grid, a secondary cathode emitting secondary electrons, and an anode, in the order named, means for conveying the electrons emitted by the primary cathode to the secondary cathode through the control grid and screen grid and means for conveying the secondary electrons to the anode; a direct current anode supply source, means for applying to the screen grid and the secondary cathode in said secondary emission tube two positive biasing voltages with respect to the primary cathode, the values of said voltages being lower than the total voltage supplied by said current source, means for applying a positive biasing voltage to the primary cathode with respect to the bias voltage existing on the control grid of said tube; a cir-

cuit generating impulse waves of considerable energy, including a resistor having one terminal connected to the control grid of said tube and the other terminal connected to an impedance connected to the negative terminal of the direct current source, means for coupling in phase the secondary cathode to the junction point comprised between said resistor and said impedance in order to reduce the negative differential resistance offered by the primary cathode-secondary cathode path under certain feed conditions in the secondary emission tube, an impedance connected between the primary cathode and secondary cathode, the ohmic value of said impedance being larger for the operating frequencies than the minimum value of said negative differential resistance, said circuit generating impulses owing to the instability phenomena which happen whenever the instantaneous value of the control grid negative voltage with respect to the primary cathode is lower than a certain limit value, this value depending upon the characteristics of the tube and the value of said impedances; means for applying to said impulse wave generating circuit positive synchronizing impulses of lower energy, which, affecting said instantaneous grid voltage may produce, if of sufficient magnitude, said instability conditions which cause the circuit to generate an impulse the duration of which, in a certain degree, depends upon the value of said resistor connected to the control grid of said secondary emission tube, the magnitude of said impulse depending upon the characteristics of said tube, the supply voltages and the characteristics of the anode circuit of said tube; a saw-tooth wave generating circuit including a capacitor connected between the anode of said secondary emission tube and negative terminal of the direct current source and a resistor connected between said anode and the positive terminal of said source, said condenser being discharged at each impulse generated by the impulse wave generator by the anode current of the secondary emission tube, the value of said current being controlled by said impulse generator through the electronic coupling existing between the secondary cathode and anode inside said tube, said condenser being instead charged by the current flowing in the resistor connected to said anode during the time intervals which happen between two successive impulses, setting up at the terminals of said condenser a voltage variable with time according to a saw-tooth shape, said voltage being in synchronism with the external impulses applied to the impulse generating circuit and its magnitude depending greatly upon the values of said capacitor and resistors.

3. In a saw-tooth synchronized wave generator, in combination a secondary emission high-vacuum thermionic tube including a primary cathode, a control grid, a screen grid, a secondary cathode emitting secondary electrons, and an anode, in the order named, means for conveying the electrons emitted by the primary cathode to the secondary cathode through the control grid and screen grid and means for conveying the secondary electrons to the anode; a direct current anode supply source, means for applying

to the secondary cathode in said secondary emission tube two positive biasing voltages with respect to the primary cathode, the values of said voltages being lower than the total voltage supplied by said current source, means for applying a positive biasing voltage to the primary cathode with respect to the bias voltage existing on the control grid of said tube; a circuit generating impulses of considerable energy, including a resistor connected between the secondary emission tube control grid and the negative terminal of the direct current source, a resistor one terminal of which is connected to the screen grid of said secondary emission tube, while the other terminal is connected to an impedance connected to the positive terminal of the direct current source, means for coupling in phase the secondary cathode to the junction point comprised between said resistor and said impedance in order to reduce the negative differential resistance offered by the primary cathode-secondary cathode path under certain feed conditions in the secondary emission tube, an impedance connected between the primary cathode and secondary cathode, the ohmic value of said impedance being larger for the operating frequencies than the minimum value of said negative differential resistance, said circuit generating impulses owing to the instability phenomena which happen whenever the instantaneous value of the control grid negative voltage with respect to the primary cathode is lower than a certain limit value, this value depending upon the characteristics of the tube and the value of said impedances; means for applying to said impulse wave generating circuit positive synchronizing impulses of lower energy, which, affecting said instantaneous grid voltage may produce, if of sufficient magnitude, said instability conditions which cause the circuit to generate an impulse the duration of which partly depends upon the value of said resistor connected to the screen grid of said secondary emission tube, the magnitude of said impulse depending upon the characteristics of said tube, the supply voltages and the characteristics of the anode circuit of said tubes; a saw-tooth wave generating circuit including a capacitor connected between the anode of said secondary emission tube and negative terminal of the direct current source and a resistor connected between said anode and the positive terminal of said source, said condenser being discharged at each impulse generated by the impulse wave generator by the anode current of the secondary emission tube, the value of said current being controlled by said impulse generator through the electronic coupling existing between the secondary cathode and anode inside said tube, said condenser being instead charged by the current flowing in the resistor connected to said anode during the time intervals which happen between two successive impulses, setting up at the terminals of said condenser a voltage variable with time according to a saw-tooth shape, said voltage being in synchronism with the external impulses applied to the impulse generating circuit and its magnitude depending greatly upon the values of said capacitor and resistors.

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