May 9, 1939. P. DREWELL ET AL 2,157,529

RELAXATION OSCILLATOR

Filed July 20, 1937 2 Sheets-Sheet 1

Fig. 1

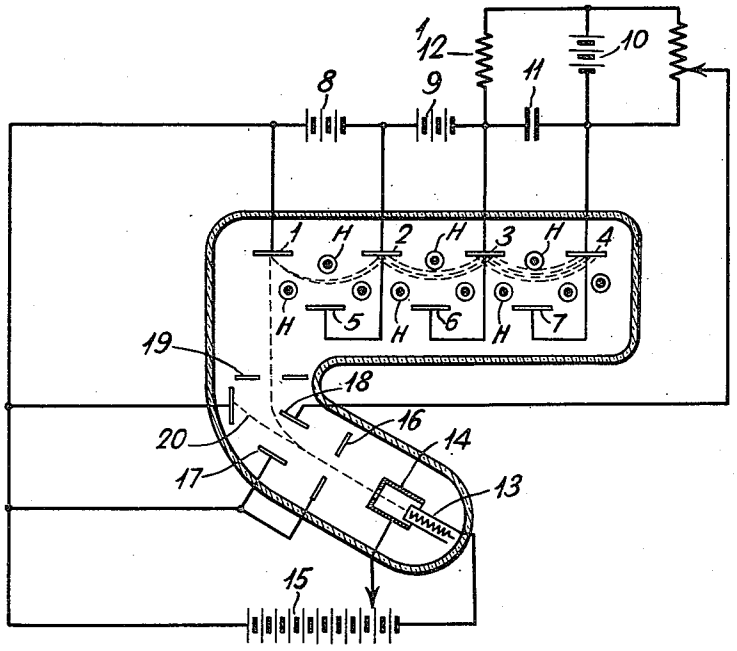
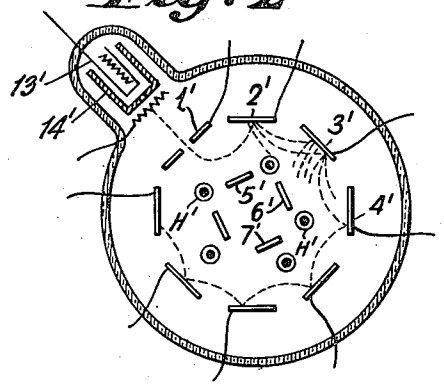


Fig. 2



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Filed July 20, 1937 2 Sheets-Sheet 2

Fig. 3

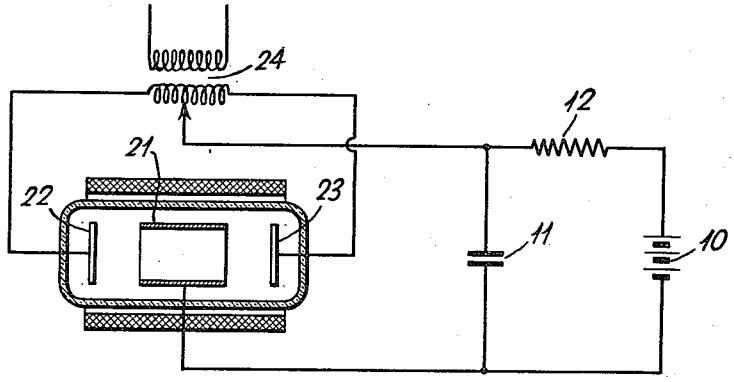
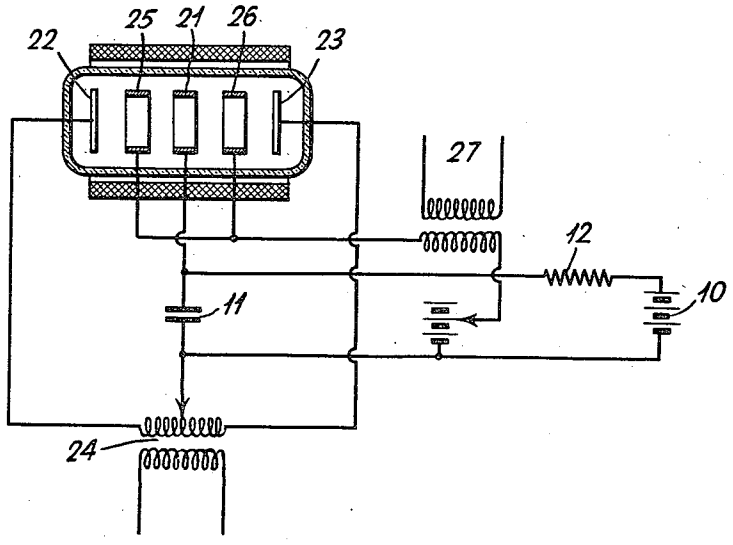


Fig. 4



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RELAXATION OSCILLATOR

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Application July 20, 1937, Serial No. 154,540
In Germany July 24, 1936

6 Claims. (Cl. 250—36)

The production of saw-tooth or relaxation waves of the kind required, for instance, for causing a time-proportional deflection of the electron-ray pencil, recourse has in the past been had to gas discharge tubes connected in a thyratron circuit scheme or else high-vacuum electron tubes in a dynatron circuit organization. Where gaseous discharge tubes are used, the highest attainable frequency of the oscillations is around 100 kc. The frequency is, in the main, limited on account of the fact that the deionization process, that is, the period required for the tube to become non-conducting, amounts to some considerable length of time. In the case of high-vacuum tubes, considerably higher oscillation frequencies are obtainable, though in their case the attempt to attain a sufficiently high oscillation amplitude is attended with difficulties. In practical cases it proves mostly necessary to amplify the relaxation or saw-tooth waves generated in high-vacuum tubes, and this scheme involves a comparatively great number of tubes and other circuit elements.

The present invention is concerned with an arrangement in which the advantages of the gas-discharge tube organization (high amplitude of oscillations) are combined with the particular merits inherent in high-vacuum circuit organizations, namely, high frequencies of the oscillations.

The invention is predicated upon the well known fact that a current or stream of electrons may be considerably amplified inside a high-vacuum tube when the primary electrons are made to bombard an electrode so that on the latter a great number of secondary electrons are released. The ensuing secondary electrons may be made to impact another plate so that they may again be multiplied by virtue of secondary emission of electrons. If arrangements are made so that this process is repeated several times, it is possible to obtain very great amplifications of the primary or input current. This scheme and arrangement is known in the art as an electron multiplier, in fact, the same has been employed in quite a number of different ways, for instance, for the amplification of the photo-cell currents.

According to the invention, a secondary electron multiplier is employed for the object to discharge a condenser, and to exactly control the incipiency or initiation of such discharge.

The idea underlying the invention shall be described in more detail in what follows by reference to the attached drawings wherein Figure 1 shows schematically one embodiment of the present invention as applied to an electron multiplier of the static type.

Figure 2 shows a modification of Figure 1, and Figures 3 and 4 show further forms of the present invention as applied to an electron multiplier of the dynamic type.

Referring now to Figure 1, elements 1, 2, 3 and 4 are the electrons contained within a secondary electron multiplier of the so-called "electrostatic" type, the said electrodes consisting of a substance, or being coated with a substance which, upon being bombarded by electrons, releases a great number of secondary electrons. By the electrodes 5, 6, 7, which may be in electrical connection with the electrodes 2, 3 and 4, respectively, as well as by magnetic fields H whose lines of force are at right angles to the plane of, and emerge from the drawings, such electrons as are released by electrode 1 will be so deflected that they will be made to bombard electrode 2. In turn, the electrons given off from 2 are made to impinge upon electrode 3, and the secondary electrons released on 3 will strike 4, as indicated by the broken lines. Between the plates 1, 2, 3, 4 as known in the prior art, are provided sources of direct current voltage as indicated at 8, 9, 10. But these direct current voltages may also be derived from one and the same source with the intermediary of a voltage divider.

Now according to the invention a condenser 11 is interposed between plates 3 and 4 which is charged by way of a resistance 12 from a source of direct current 10. In order that the rise of the condenser potential may occur in direct time proportion, the said resistance 12, as also known in the prior art, may be replaced by an electron tube whose plate current stays independent of the size of the plate potential inside wide limits. During the condenser charge, a minimum amount of current only should be allowed to flow between the electrodes 3 and 4. However, as soon as the condenser has attained a certain potential, a large current must suddenly arise so that the condenser will be discharged rapidly. The said discharge action could be controlled, for instance, by the primary electron pencil impacting the electrode 1, in fact, according to the invention this is to be accomplished, for instance, by that the electron pencil is first generated by the aid of an indirectly heated cathode 13 and then focused by the agency of a Wehnelt cylinder 14 or some other electron lens arrangement, the pencil being accelerated towards the anode 16 by the aid of a plate potential derived from a d. c. source 15. By the aid of an opening in the anode the pencil is diaphragmed and, if no potential acts upon the deflector plates 17

and 18, along the line (marked broken) 20 it reaches a collector chamber 19. If, then, between the deflector plates 17 and 18 a potential is applied the electron-ray pencil will be correspondingly deflected. If the said potentials is derived from the charge circuit of the condenser 4, then, choosing by correct dimensions for the deflector plates and by suitable choice of the operating voltages, conditions can be made so that the electron ray pencil will just fall through the aperture or the slit of chamber 19 onto the electrode 1 when the condenser has attained the desired maximum voltage. By the action of the electron pencil, secondary electrons will then be splashed out of electrode 1 which thereupon by way of electrodes 2 and 3, will cause the release of a multiplied or amplified current between 3 and 4, by which the condenser 11 may be discharged inside a comparatively short length of time. Simultaneously with the condenser voltage will decrease also the voltage acting upon the deflector plates 17 and 18, with the result that the electron pencil will be less markedly deflected and will fall back into the collector chamber. As soon as no more electrons impact upon electrode 1, also the flow of current between electrodes 3 and 4 will cease, and the charging of the condenser be resumed. In other words, the condenser potential becomes of the typical form known in the art as a relaxation or saw-tooth wave.

Fig. 1 illustrates only one exemplified embodiment of the scheme designed to insure a control action upon the secondary-electron current serving for the generation of saw-tooth waves. Another chance to accomplish the same end would be, for instance, to make the plate 1 to act as the anode of an electronic tube having three or more electrodes in which the electronic current issuing from a hot cathode is subject to a control action of one or more grids. This control action may be insured also in dependence upon the condenser voltage in such a way that the grid or grids block the flow of the electron current until the condenser has built up its potential to the desired value. In such a scheme, by the adoption of means and ways known in the art, care must be taken so that, upon the desired condenser voltage being attained, the electron current will abruptly rise to its full amplitude. This circuit organization offers the merit that one works with a comparatively large number of primary electrons so that the number of multiplier stages may be reduced.

The arrangement of the multiplier plates also is not restricted to the exemplified embodiment shown in Fig. 1. For instance, the plates could be arranged also in a manner as indicated in Fig. 2 so that they result in a regular polygon. This scheme offers the advantage over that in Fig. 1 that a great number of plates may be accommodated within a small space, and that, in addition, a single magnetic field H will suffice for insuring deflection of the electrons, the axis of the magnetic field coinciding with that of the polygon. In the case of Fig. 2 the said magnetic field H must again be conceived to be at right angles to the plane of, and emerge from, the drawings. Moreover, in this arrangement the number of the co-operating electrodes 5', 6', 7' etc., may be smaller than the number of interspaces between electrodes 1', 2', 3', 4', etc. The control of this multiplier may again be accomplished in a way as hereinbefore indicated. For example, a controlled electron pencil, as known in the art, may be caused to enter the multiplier across an aperture or slit in plate 1 from a cathode 13', for instance.

A modification of the basic idea of this invention would consist in the use of the secondary electron multiplier for the generation of relaxation or saw tooth waves. It results directly from the theory of the multiplier that the multiplication process will actually take place when to the multiplier is applied an alternating voltage of a definite amplitude and frequency, and a definite anode potential. There are quite a number of such triplets of numerical values for which resonance exists, i. e., where multiplication is brought about. If the frequency and the amplitude of the alternating voltage are fixed, there exists a very definite critical anode voltage value at which multiplication takes place, with the result that the anode current will suddenly leap from zero to a considerable crest value. However, such sudden rise does not occur in the presence of all such triplets of values at which the occurrence of resonance may be anticipated. Still the points where such leaps happen are quite readily reproducible. If the multiplication has been initiated in the presence of a resonance value of the said three quantities, then the anode voltage, for instance, must be still further reduced beyond the critical point until the anode current becomes again zero. The difference between the voltages at which the multiplication action is started and caused to be discontinued again is a function of the resonance point to which adjustment has just been made; it may be over 50 volts, though for other triplets of resonance values it may be hardly appreciable.

It will be seen from this behavior that such a multiplier exhibits all of the properties of a gaseous discharge tube so that it is feasible to produce relaxation waves therewith.

A circuit organization which flows from an application of the exemplified embodiment Fig. 1 to a dynamic multiplier is illustrated in Fig. 3. The condenser 11 which, similarly as in the arrangement Fig. 1, is charged from a battery 10 by way of a resistance 12 is in this instance discharged by the plate cylinder 21 of an electron multiplier whose multiplier plates 22 and 23 are kept at alternating potential by a transformer 24.

In order to insure synchronization of the relaxation wave with an alternating potential, it would also be feasible to mount another electrode which will insure a corresponding control of the multiplication process. It will be advantageous in this connection to choose the mounting symmetric, say, to build the multiplier in a form as shown by way of example in Fig. 4. Between the plate cylinder 21 and the multiplier plates 22 and 23, there are here provided also control electrodes 25 and 26 which are connected with the source of synchronizing alternating voltage 27.

One great advantage of the multiplier as compared with gas discharge vessels is that inertia or lags which are inevitable in the latter because of their gas content and which are extremely annoying and troublesome are here obviated. As a result it is possible to insure with an arrangement as here disclosed far higher relaxation frequencies than what has in the past been possible with gas discharge tubes, without the entire arrangement being made more complicated. This factor is particularly important since Braun tubes are adapted to do oscillographic work with higher frequencies.

A special use of the present arrangement designed to generate relaxation or saw-tooth

waves will be found in connection with Braun tubes whose electron source consists of a secondary electron multiplier. In such a case it will be suitable to use one and the same generator for the purpose of starting the multiplier for the relaxation waves and the multiplier which serves as the electron source.

What we claim is:—

1. A system for producing oscillations of sawtooth wave form comprising a condenser, a resistance and a source of current connected in a series circuit whereby the condenser is charged linearly by the source of current through the resistance, and means including a secondary electron emissive device for substantially instantaneously discharging said condenser.

2. A system for producing oscillations of sawtooth wave form comprising a condenser, a resistance and a source of current connected in a series circuit whereby the condenser is charged linearly by the source of current through the resistance, means including a secondary electron emissive device for substantially instantaneously discharging said condenser, and means for controlling said device to determine the instant of discharge.

3. A system for producing oscillations of sawtooth wave form comprising a condenser, a resistance and a source of current connected in a series circuit whereby the condenser is charged linearly by the source of current through the resistance, means including a secondary electron emissive device for substantially instantaneously discharging said condenser, and means responsive to the charge on said condenser for determining the instant of discharge.

4. A system for producing oscillations of sawtooth wave form comprising a condenser, means for linearly charging said condenser, and means including a secondary electron emissive device for substantially instantaneously discharging said condenser.

5. A system for producing oscillations of sawtooth wave form comprising an electron multiplier tube having a plurality of secondary emissive anodes, means for maintaining said anodes at progressively increasing positive potentials, said means including a source of current and a current limiting device connected between two of said anodes, a condenser connected between said two anodes, and means for causing intermittent operation of said multiplier tube whereby the said condenser is charged linearly by said source of current through said current limiting device and is discharged substantially instantaneously by said multiplier tube.

6. A system for producing oscillations of sawtooth wave form comprising an electron multiplier tube having a primary electron emitter and a plurality of secondary emissive anodes, means for maintaining said anodes at progressively increasing positive potentials with respect to said emitter, said means including a source of current and a resistance connected across two of said anodes, a condenser connected across said source of current and resistance, and means for causing an intermittent electron discharge between said anodes whereby said condenser is charged linearly by said source of current through said resistance and discharged substantially instantaneously by the electron discharge between said two anodes.

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