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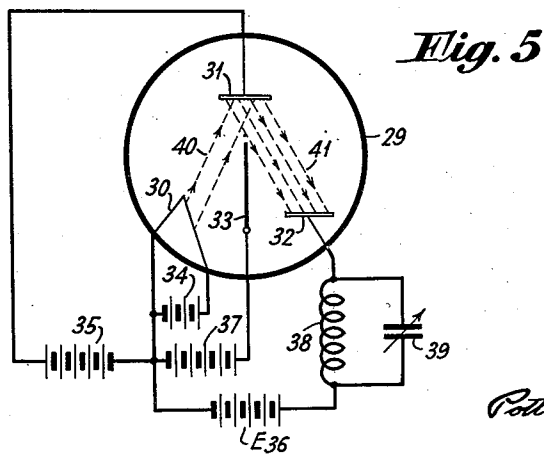
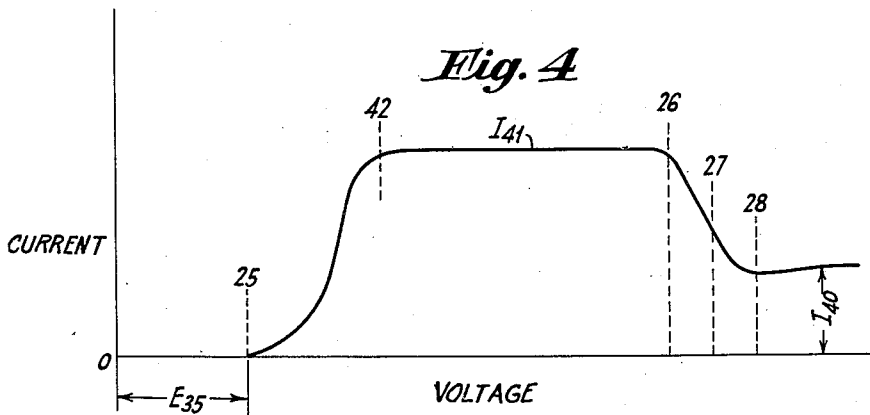
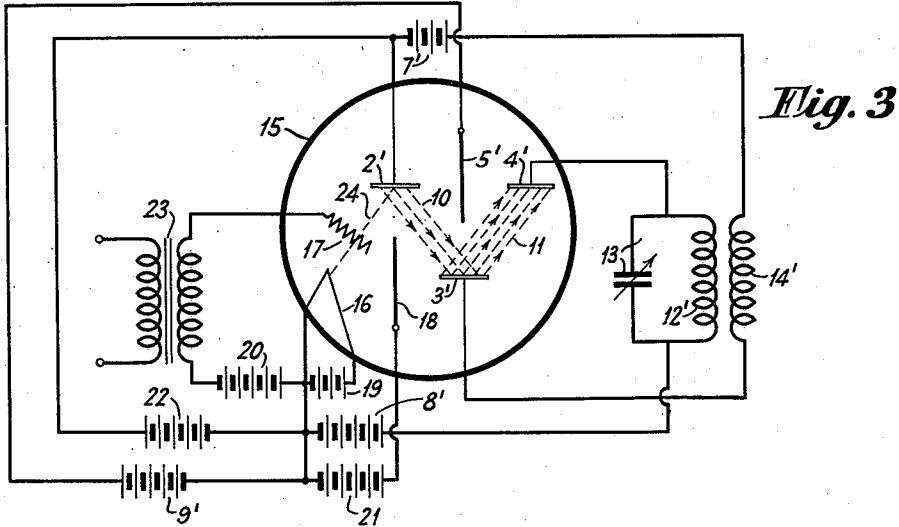
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2,220,452

ELECTRONIC DEVICE

Filed Dec. 24, 1936

2 Sheets-Sheet 2



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2,220,452

ELECTRONIC DEVICE

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Application December 24, 1936, Serial No. 117,660

18 Claims. (Cl. 179—171.5)

The present invention relates to oscillation circuits and in particular to circuit arrangements adapted for use in connection with the operation of secondary emission electron and vacuum tubes of the general types described in our U. S. Patent No. 1,903,569 issued April 11, 1933 to Russell M. Blair and Kenneth W. Jarvis, and for which a reissue application Serial No. 16,108 has been filed, on April 8, 1935. This has matured into Reissue Patent No. 20,545 granted November 2, 1937.

In the conventional grid-controlled thermionic amplifier, amplifying action is obtained by virtue of the grid or control electrode being spaced closer to the electron emitter than the anode or output electrodes, and the ratio of amplification is to a first degree of approximation equal to the ratio of the electrostatic fields set up between the emitter-grid and the emitter-anode. Since these electrostatic fields depend almost solely upon the geometric configurations of the various electrodes, the amplifying characteristic of the tube, in turn, is determined by the size and positioning of the electrodes. By suitable energy feeding back such amplifiers can be made to oscillate.

In contra-distinction, our invention provides an amplifying system whose gain characteristic is not so dependent but is dependent upon secondary emission effect. The amplifying characteristic which we provide is largely fixed by the ratio of secondary electron emission to the primary electrons initiating the emission of the secondary electrons. By suitably feeding back energy to a control circuit, oscillations can be generated and sustained.

A further feature of our invention lies in the manner of producing a negative resistance characteristic which can be combined with a suitable electrical network to generate and maintain oscillations. In previous types of secondary emission discharge devices, negative resistance occurs because the secondary emission current leaving a reference electrode is greater than the primary emission current reaching the electrode. Secondary emission from the reference electrode is a necessity for operation. In our invention, however, the negative resistance characteristic is obtained in an entirely new and novel manner, as there is no secondary emission from the reference electrode. The negative resistance characteristic is derived from a decrease in output current, due to a decrease in secondary emission augmentation of the output current, as the output voltage is increased. This effect is different from previous types of oscillators and

has many useful advantages that result from the isolation of the secondary electrons emitted from the primary stream of electrons.

Thus our invention relates to the use of primary and secondary electron streams and associated tube and circuit elements and operating potentials for producing systems capable of oscillation. It is an object of this invention to provide a means for converting direct potentials into alternating potentials covering the extreme range of frequencies.

A still further object of this invention is to provide a new and improved type of oscillator, substantially different from known previous types.

Still another and further object is to provide for a new type of negative resistance oscillator, wherein the negative resistance is obtained in an entirely new and novel manner.

Turning now to the drawings, in which Fig. 1 shows the circuit of a new type of oscillator,

Fig. 2 shows graphically the current-voltage relationship of tubes used in our invention as an aid in explaining the operation of Fig. 1,

Fig. 3 is another embodiment of our invention showing a method for modulating the type of oscillator shown in Fig. 1;

Fig. 4 is another current chart of output voltage against output current of a negative resistance characteristic, and

Fig. 5 shows an embodiment of our invention having a characteristic shown in Fig. 4; our invention will be described in detail.

Fig. 1 shows our new oscillator arrangement made possible by the effective power amplification released through the phenomena of secondary emission. The tube structure 1 includes an emitter 2, a collector plate 3 adapted for the emission of secondary emission on the impact of primary emission, an output plate 4 and a shielding element 5. The source of potential 6 activates the emitter 2, while the source of potential 7 maintains the collector plate 3 at the proper average potential. As here shown, the source of potential 8 is added to that of 7 to furnish plate supply for the output plate 4. Separate potentials can be used if preferred, or any other dual potential arrangement, if desired. The source of potential 9 is used to polarize the shielding element 5. The primary charge stream is indicated at 10, and the resulting secondary charge stream at 11. The electrical network connected to the output plate 4 includes the inductance 12 connected in parallel with the condenser 13. The inductance 14 is electromagnetically coupled to

the inductance 12, and is connected in the external circuit between the collector plate 3 and the emitter 2.

In order to explain the resulting action, attention is directed to Fig. 2. Here is shown the magnitudes of the currents I_{10} and I_{11} with respect to voltage E_7 in Fig. 1. Starting from zero current I_{10} increases to a saturation value as indicated by the upper bend of the characteristic curve. The current I_{11} is substantially directly proportional to I_{10} , the proportionality factor being the secondary emission ratio. This ratio varies near the extremes of the curves but this variation is very small when the tube is operated over the linear portion of the characteristic. It is obvious that a small change in voltage E_7 will produce a small change in I_{10} and a very large change in I_{11} in the linear regions of current voltage, but that in the saturation region, no substantial change takes place.

In the circuit of Fig. 1, the ratio of the secondary emission current to the primary electron current is utilized to make the device act as a power amplifier, and so under proper conditions, to oscillate. As this type of oscillator is essentially new in action, a rather detailed description is necessary. Assume that the total potential between the emitter 2 and the collector plate 3 is increasing. This will increase the currents I_{10} and I_{11} . The current I_{11} flowing through the inductance 12 will induce a voltage in the inductance 14. If the proper polarity of connections is observed, this induced voltage will add to that of the source of potential 7. This addition raises the total potential between the emitter 2 and the collector plate 3, which in turn increases the currents. If the supplied potential is suitably chosen, this action is cumulative and the current I_{11} builds up to substantially the saturation value. At this point, increasing the total control potential will not increase I_{11} and therefore the induced potential in the inductance 14 disappears. The total control potential is therefore only that due to the source E_7 and is not sufficient to maintain I_{11} at saturation value. I_{11} therefore decreases, and in so doing introduces in the inductance 14 a potential of opposite sign to the source E_7 . This reduces the net control voltage to a value still lower than the source E_7 , and the current I_{11} continues to fall. After reaching substantially zero I_{11} cannot decrease further and therefore the induced negative voltage in the inductance again becomes zero. The net control potential now approaches that of the source E_7 , the current I_{11} increases, the induced voltage in the inductance 14 adds to that of the source E_7 and the cycle repeats itself. In view of the high secondary emission ratio possible, provided by the conditioning of the collector plate 3, far more power is liberated by the output plate circuit than is required to maintain the needed control potentials. Accordingly, useful power may be obtained from the output current without stopping the oscillation.

It is important to note that while the effective resistance looking into the control plate 3 circuit is negative, that this negative resistance effect is unimportant except that it is one of the necessary accompanying conditions under which power is released by secondary emission. If the resistance loss at high frequencies be increased in the external circuit of a conventional negative resistance dynatron to a value greater than the negative resistance will nullify, the dynatron will stop oscillating. On the contrary, in our inven-

tion, if such losses be introduced into the external collector plate 3 circuit of Fig. 1, the circuit will not stop oscillating since these losses can be supplied by the output plate 4 circuit of Fig. 1. In general, with the secondary emission ratio now obtainable, this is easily accomplished. The circuit arrangement is therefore totally unlike the conventional dynatron-type of oscillator.

The circuit of Fig. 3 shows a widely useful adaptation of the type of oscillator described in Fig. 1. The oscillator of Fig. 3 is substantially like that of Fig. 1, but certain additions are to be noted. In Fig. 3 the prime numbers indicate those elements which perform similar functions to the functions of the elements in Fig. 1. The tube structure is denoted by 15, while the emitter 16 is heated by the battery 19. A control grid 17 is interposed between the emitter 16 and the first collector plate 2'. As this collector plate 2' also serves as the source of emission for the rest of the tube which acts as the oscillator, the old number 2' is retained. The shield 18 and source of potential 21 is shown, as well as an input transformer 23 connected in series with a polarizing potential 20. The battery 22 supplies potential for the collector plate 2'. As the amplitude of oscillation is largely dependent on the emission from the collector plate 2', so is it also dependent on the primary emission 24. This in turn is controlled by the potential on the grid 17, and so modulation potentials impressed on the grid 17 serve to control the amplitude of oscillation. This combination therefore serves very well as a modulated oscillator. One important advantage of this type of modulated oscillator over other types is that no translating impedances need be included between the modulation frequency source (grid 17) and the succeeding oscillator. It can thus be modulated by D. C. or potentials of any frequency alike. Accordingly, the modulation of the oscillations does not introduce any frequency distortion or phase-shift of the modulating potentials. This feature is of the greatest importance where the band width of frequencies of the modulating potentials is great, as for example, in television transmission. In such transmissions, the video signal band-width is on the order of millions of cycles and it has been practically impossible to avoid frequency discrimination and phase shift of the modulating potentials. To overcome this deleterious feature, complicated correction networks are employed which in general reduce the overall efficiency of the system. Our invention overcomes these deleterious effects without resorting to complicated networks so that a further improvement in efficiency results.

It should also be noted that instead of a constant emission source and variable grid control, that a variable source of emission such as in a phototube may be similarly directed against the collector plate 2' and serve to modulate the oscillator portion.

The elimination of the translating or coupling impedance permits substantially uniform modulation of the entire frequency band, a feature lacking in modulator-oscillator systems of the past.

Still another different type of oscillation is shown schematically in Fig. 5. As an aid to understanding the operation of the circuit shown in Fig. 5, attention is arrested to Fig. 4. This plot shows the relationship between the output plate 32 current I_{11} and the output plate voltage E_{32} , as this latter voltage is increased. The other volt-

ages are assumed to be at suitable operating values. This curve shows that while secondary electrons are emitted out of the plate 31, Fig. 5, they will not go to the output plate 32 until the output potential E_{32} is greater than the collector plate potential E_{35} . Beyond this point, I_{41} increases, I_{40} remaining constant. This point of increase in current is shown in Fig. 4 at the point 25. Due to the constant primary current I_{40} , the secondary emission current I_{41} can be no greater than this primary current times the secondary emission ratio at the collector plate 31. This limit is reached about the potential indicated at 42, Fig. 4. As the potential E_{32} is further increased, changes in the electrostatic field occur, but due to structural design little change in current I_{41} takes place until the point 26 is reached. At this point, the high potential E_{32} acts around the edge of the shielding element 33 and begins to draw the primary emission directly to the output plate 32 without producing secondary emission. As a result, the ratio between primary and secondary electrons is reduced, and the output plate current I_{41} decreases. This decrease continues to the point 28 where all the primary emission is drawn around and no secondary emission increase is present. If the emission from the emitter 30 is saturated, the final current I_{41} will equal I_{40} for all subsequent increases in E_{32} . If not saturated, I_{41} will gradually climb beyond the point 28 to the saturation current. The curve between the points 26 and 28 exhibits a negative resistance characteristic. This may be used as any other negative resistance, and in conjunction with a tuned circuit of equal positive resistance, will oscillate. Such a tuned circuit is included in the output plate 32 circuit of Fig. 5 as the inductance 38 and tuning condenser 39. For normal operation the potential E_{32} is adjusted to a point on the linear portion of the negative slope of the voltage current characteristic, as for example point 27 of Fig. 4, which is about centered in the negative resistance region. The circuit and system will then oscillate, the potential swinging approximately between the points 26 and 28. The oscillation cycle of our invention is substantially that followed by so-called negative resistance discharges, and since these are well known in the art, it is believed to be unnecessary to discuss them further at this point.

Other changes and modifications may suggest themselves to those skilled in the art without departing from the scope and spirit of our invention.

What we claim is:

1. The method of operating an electronic device wherein is provided a secondary electron emissive electrode comprising the steps of producing a supply of primary electrons, producing a constant electron accelerating field between the produced supply of electrons and the emissive electrode to direct the primary electrons thereon, emitting secondary electrons from the emissive electrode under the control of the primary electrons arriving on the emissive electrode, segregating the emitted secondary electrons from the primary electrons, collecting the segregated secondary electrons, and varying the produced accelerating field only in proportion to the variation in the number of electrons collected per unit of time.

2. An electronic device comprising a secondary electron emissive electrode, means for producing

a supply of primary electrons, means for producing a constant electron accelerating field between the electron producing means and the emissive electrode to direct the primary electrons thereon, means for emitting secondary electrons from the emissive electrode under the control of the primary electrons arriving at said electrode, means for segregating the emitted secondary electrons from the primary electrons, means for collecting the segregated secondary electrons, and means for varying the produced accelerating field in proportion to only the variation of the number of electrons collected per unit of time.

3. An electronic device comprising a source of primary electrons, a secondary electron emissive electrode, means for electrostatically directing primary electrons at a constant rate toward said electrode to impact thereon and feedback means between the source of primary electrons and the secondary electron emissive electrode for varying the emission of secondary electrons from the said electrode from zero to substantially saturation value under the control of primary electrons.

4. An electronic device comprising a source of primary electrons, a secondary electron emissive electrode, means for electrostatically directing primary electrons at a constant rate toward said electrode to impact thereon and feedback means between the source of primary electrons and the secondary electron emissive electrode for cyclically and periodically varying the emission of secondary electrons from the said electrode from zero to substantially saturation value and back to zero under the control of primary electrons.

5. The method of operating an electronic device which comprises the steps of producing a stream of primary electrons, accelerating the produced stream of electrons toward a secondary electron emissive surface at a constant rate, releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons arriving at said emissive surface, segregating the released secondary electrons from the accelerating electrons, collecting the segregated secondary electrons, and producing a potential difference between the source of primary electrons and said emissive surface only in proportion to the variation of the number of secondary electrons collected per unit of time, whereby the ratio of released secondary electrons to primary electrons arriving at the emissive surface is varied.

6. In an electronic device wherein is provided a source of primary electrons and an electrode for emitting secondary electrons under the impact of primary electrons, the method of operating which includes the steps of electrostatically only accelerating primary electrons from the source to said electrode at a constant rate and varying the ratio of secondary electrons emitted per unit of time to the primary electrons impacting the said electrode per unit of time from zero up to a predetermined maximum value.

7. In an electronic device wherein is provided a source of primary electrons and an electrode for emitting secondary electrons under the impact of primary electrons, the method of operating which includes the steps of electrostatically only accelerating the primary electrons from the source to said electrode at a constant rate, and cyclically and periodically varying the ratio of the secondary electrons emitted per unit of time to the primary electrons impacting said electrode per unit of time from zero up to a predetermined maximum value and back to zero.

8. The method of operating an electronic device which comprises the steps of producing a stream of primary electrons, accelerating the produced stream of electrons toward a secondary emissive surface at a constant rate, releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons arriving at said emissive surface, segregating the released secondary electrons from the accelerated electrons, collecting the segregated secondary electrons and producing a potential difference between the source of primary electrons and said emissive surface only in proportion to increases and decreases of the number of secondary electrons collected per unit of time, whereby the ratio of the released secondary electrons per unit of time to the primary electrons arriving at the emissive surface per unit of time is varied.

9. The method of operating an electronic device wherein is provided a secondary electron emissive electrode comprising the steps of producing a supply of primary electrons, producing a constant electron accelerating field between the produced supply of electrons and the emissive electrode to direct the primary electrons thereon, emitting secondary electrons from the emissive electrode under the direct control of the primary electrons arriving at said electrode, segregating the emitted secondary electrons from the primary electrons, collecting the segregated secondary electrons, and varying the produced accelerating field only in proportion to increases and decreases of the number of electrons collected per unit of time, whereby the ratio of the released secondary electrons per unit of time to the primary electrons arriving at the emissive surface per unit of time is varied.

10. The method of operating an electronic device comprising the steps of producing a stream of primary electrons, electrostatically only accelerating the produced stream of electrons toward a secondary electron emissive surface at a constant rate, releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons arriving at said surface, segregating the released secondary electrons from the accelerated electrons, varying the ratio of the released secondary electrons per unit of time to primary electrons arriving at said surface per unit of time from zero up to a predetermined saturation value, and collecting the segregated secondary electrons.

11. The method of operating an electronic device comprising the steps of producing a stream of primary electrons, electrostatically only accelerating the produced stream of electrons toward a secondary electron emissive surface at a constant rate, releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons arriving at said surface segregating the released secondary electrons from the accelerated electrons, cyclically and periodically varying the ratio of the released secondary electrons per unit of time to the primary electrons arriving at said surface per unit of time from zero to a predetermined saturation value and back to zero, and collecting the segregated electrons.

12. The method of operating an electronic device comprising the steps of producing a stream of primary electrons, electrostatically only accelerating the produced stream of electrons toward a secondary electron emissive surface at a constant rate, releasing secondary electrons from said emissive surface under the direct control of

the number of accelerated electrons arriving at said surface, segregating the released secondary electrons from the accelerated electrons, collecting the segregated secondary electrons, producing a potential difference between the source of primary electrons and said emissive surface only in proportion to the variation of the number of secondary electrons collected per unit of time, and varying the number of secondary electrons from zero to a predetermined saturation value under the control of the produced potential difference.

13. The method of operating an electronic device comprising the steps of producing a stream of primary electrons, electrostatically only accelerating the produced stream of electrons toward a secondary electron emissive surface at a constant rate, releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons arriving at said surface, segregating the released secondary electrons from the accelerated electrons, collecting the segregated secondary electrons, producing a potential difference between the source of primary electrons and said emissive surface only in proportion to the variation of the number of secondary electrons collected per unit of time, and cyclically and periodically varying the number of secondary electrons from zero to a predetermined saturation value and back to zero.

14. In an electronic device wherein is provided a secondary electron emissive electrode, the method of operation which comprises the steps of producing a stream of primary electrons, electrostatically only directing the produced stream of electrons toward the emissive electrode at a constant rate, bombarding the emissive electrode by the directed stream of electrons to produce secondary electrons, segregating the produced secondary electrons from the primary electrons, continuously collecting the segregated secondary electrons, and periodically only at predetermined time intervals, collecting primary electrons directly from the produced stream in addition to the secondary electrons.

15. An electronic device comprising means for producing a stream of primary electrons, means for accelerating the produced stream of electrons toward a secondary electron emissive surface at a constant rate, means for releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons reaching said surface, means for segregating the released secondary electrons from the accelerated electrons, means for collecting the segregated secondary electrons, and means for producing a potential difference between the source of the primary electrons and said emissive surface in proportion to only the variation in the number of secondary electrons collected per unit of time whereby the ratio of the secondary electrons released per unit of time to accelerated electrons reaching said surface per unit of time is varied.

16. In an electronic device a secondary emissive electrode, means for producing a stream of primary electrons having constant acceleration means for only electrostatically bombarding the emissive electrode by the produced stream of electrons to produce secondary electrons, means for segregating the produced secondary electrons from the primary electrons, means for continuously collecting the segregated secondary electrons, and means for only periodically at predetermined time intervals collecting primary elec-

trons directly from the produced stream in addition to the secondary electrons.

17. The method of operating an electronic device which comprises the steps of producing a stream of primary electrons, producing a constant electron accelerating field to direct the primary electrons toward a secondary emissive surface, releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons arriving at said surface, segregating the released secondary electrons from the accelerated electrons, and superimposing upon the produced field another accelerating field whose value is in proportion to only the variation of the number of electrons collected per unit of time.

18. In an electronic device, means for producing a stream of primary electrons, means for producing a constant electron accelerating field to direct the primary electrons toward a secondary emissive surface, means for releasing secondary electrons from said emissive surface under the direct control of the number of accelerated electrons arriving at said surface, means for segregating the released secondary electrons from the accelerated electrons, and means for superimposing upon the produced field another accelerating field whose value is in proportion to only the variation of the number of electrons collected per unit of time.

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