Dec. 12, 1939. K. W. JARVIS ET AL 2,182,870

OSCILLATION GENERATOR

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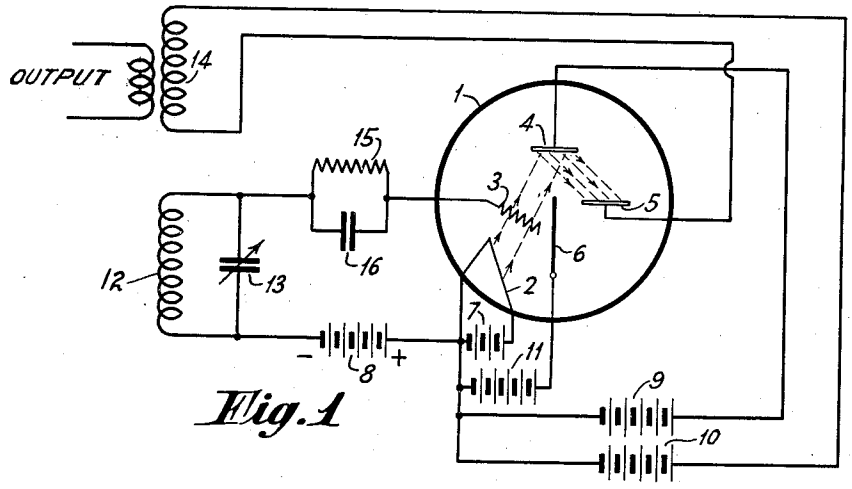
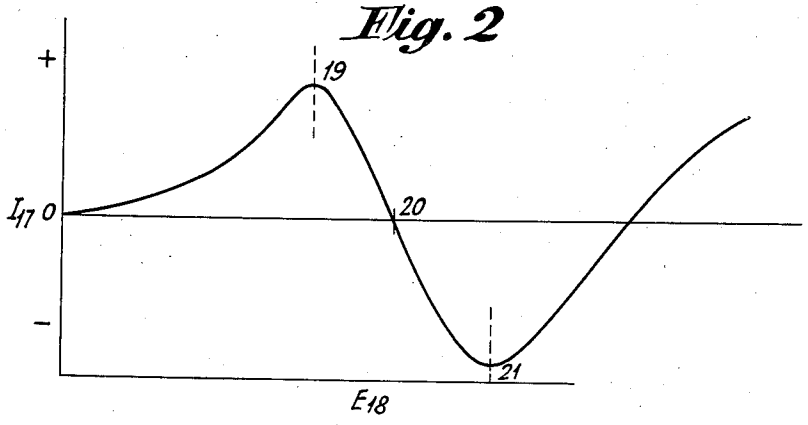


Fig. 1

Fig. 2



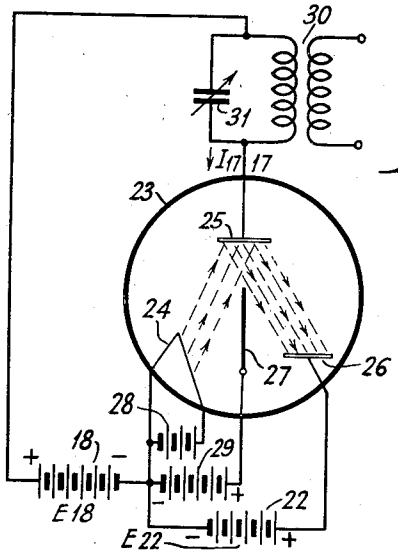


Fig. 3

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Fig. 4

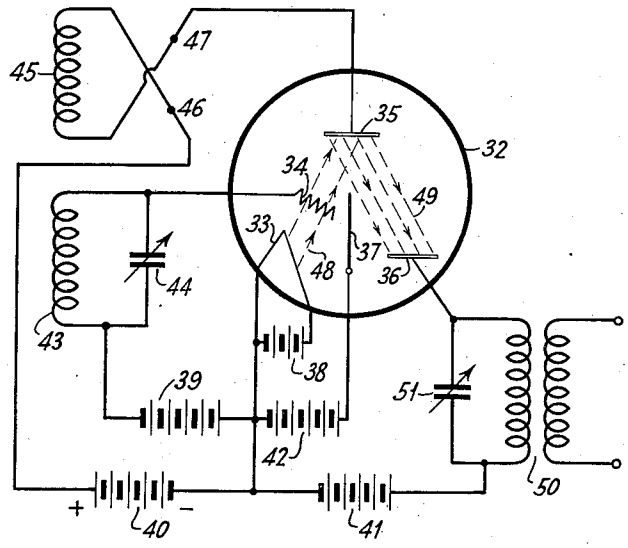
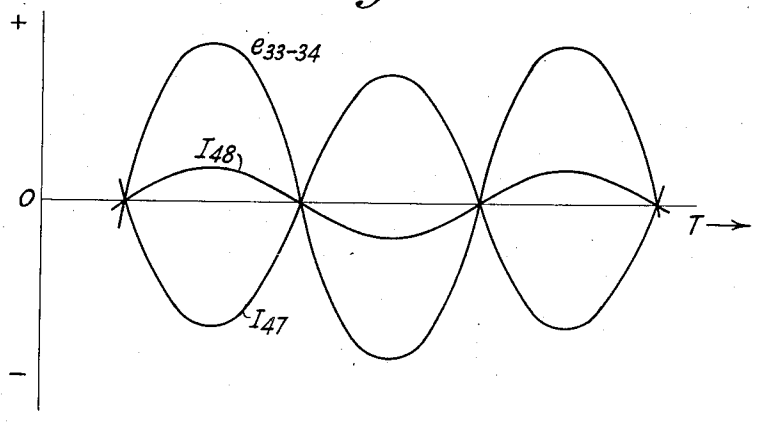


Fig. 5



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OSCILLATION GENERATOR

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Application December 24, 1936, Serial No. 117,659

3 Claims. (Cl. 250—36)

The present invention relates to oscillation generators and in particular, circuit arrangements adapted for use in connection with the operation of electron and vacuum tubes of the general type described in the U. S. Patent No. 1,903,569 issued April 11, 1933, to us and for which a reissue application Serial No. 16,108 has been filed on April 8, 1935. This reissue is No. 20,545, granted November 2, 1937. Still further, this 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.

In the prior art of generating oscillation utilizing electronic discharges, difficulties were encountered due to limitations of operating characteristics with respect to frequency, stability, efficiency, and control. Our present invention substantially overcomes these limitations by providing primary and secondary streams of electrons and ways and means for preventing the secondary stream from spuriously reacting upon the primary stream.

It is an object of this invention to provide a means for converting direct potentials into alternating potentials of any frequency, being limited only by transit time of the electrons.

A still further object of this invention is to provide a new type of oscillator.

Another object of this invention is to provide an oscillation system where no undesirable or uncontrollable coupling elements are introduced.

A further object of this invention is to produce a dynatron oscillator wherein higher efficiencies may be obtained.

Another object of our invention is to provide an electronic oscillator with relatively low plate power loss.

A still further object of our invention is to provide an electronic oscillator whose frequency characteristic is substantially independent of the oscillator's output.

An object of our invention is to provide an electronic oscillator whose frequency determining circuit is substantially isolated from its output circuit.

Other and further objects are disclosed in the following description and in the attached claims.

In the attached drawings,

Fig. 1 is a simple oscillator circuit corresponding in some respects to the well known three element grid controlled oscillator, but having some advantages over this known type;

Fig. 2 portrays the current in the collector plate of the tube structure referred to previously, with respect to the collector plate potential showing a negative resistance characteristic,

Fig. 3 shows an oscillation circuit making use of the negative resistance characteristic;

Fig. 4 shows the circuit of a new type of oscillator, and

Fig. 5 shows the current relationship in an oscillator as shown in Fig. 4.

In Fig. 1, the tube 1 comprises the emitter 2, the control grid 3, the collector plate 4, the output plate 5, and the shielding element 6. The sources of potential, 7, 8, 9, 10 and 11, serve to render the emitter thermionically emissive, and the other elements in the order named, properly operative. The oscillation circuit comprises the inductance 12 and the condenser 13, while the inductance 14 acts as a "tickler" to feed back energy to the oscillation circuit. The grid leak 15 and by-pass condenser 16 are used in the control electrode-cathode circuit as in conventional oscillators. As the principle of operation of such oscillators is well known, no additional description is added. However, in the usual oscillator, there is a capacity coupling between the output plate and the control grid. This often causes undesirable effects such as an uncontrollable feedback, parasitic oscillations, and other deleterious features well known in the art. In the circuit and tube arrangement shown, the only feedback is through the controllable element 14 and all the above disadvantages are avoided.

The potential of the source 10 is made sufficiently high to draw to the output plate 5 all the secondary charges emitted by the collector plate 4. In this case, the dynamic resistance of the output circuit of the tube is infinite, since further increase in the potential of the source 10 does not increase the flow of electrons to the output electrode 5. Accordingly, there is substantially no power loss equivalent to the plate power loss of conventional triode oscillators. This is an extremely important feature in this circuit arrangement, since most of the oscillators known to the art have a quite high power loss in the plate resistance which greatly reduces their efficiency of conversion of d. c. to a. c., compared to the arrangement of this invention.

Fig. 2 shows the variation in current flowing in the lead 17 of Fig. 3, with respect to the potential 18 applied thereto. The current starts from zero, increases in a positive direction as the potential is raised. As the potential is raised, the velocity of the striking electrons increases, and drives off secondary charges from the elec-

trode 25. These charges flow to an output plate 26 as previously described. At the point 19, the flow of secondary charges has increased to an amount to prevent further increase in I_{17}. A still further increase in E_{18} produces more secondary charges and I_{17} falls. At the point 20 in Fig. 2, the secondary charges leaving the collector plate equal the primary charges arriving, and give no current I_{17}. Further in the same positive direction with E_{18} gives more secondary charges, and the current I_{17} reverses as shown by the negative value. About the point 21 a new effect comes into play as the potential E_{17} approaches the output plate potential E_{22} of Fig. 3. The output plate potential no longer is relatively positive sufficient to draw over all the secondary charges, so the loss to I_{17} decreases, and I_{17} increases as shown. If E_{18} be made greater than E_{22}, I_{17} will reach in value the total primary emission as a limit. The region of I_{17} between the points 19 and 21 shows a decreasing current with an increasing voltage, which is in effect a negative resistance characteristic. If a tuned circuit having a positive resistance equal to the negative resistance (an average condition equalized by non-linear factors during oscillation) be connected in the negative resistance circuit, oscillation will result as is well known.

The complete circuit is shown as Fig. 3, where the tube structure is shown at 23. The emitter 24, the collector plate 25, the output plate 26 and the shielding element 27 are indicated. The source of potential 28 heats and renders thermionically emissive the emitter 24, and the sources of potentials 18, 22 and 29 serve to render the other elements operative in the order named. The potential 18 is preferably adjusted to a fixed value about the mid position of the values corresponding to points 19 and 21 of Fig. 2. The tuned circuit serving as the oscillator circuit includes the inductive impedance 30 and the tuning condenser 31. When the potentials are properly adjusted, the circuit oscillates as described and oscillating energy may be had from the secondary of 30. It will be appreciated that the element 30 may be a simple inductance and oscillating energy derived from the circuit electrostatically or by other electromagnetic means of coupling.

In the customary dynatron oscillators, the output element is in the form of a grid through which the primary charges flow, striking a secondary emitter further along in the direction of travel. Secondary charges travel in opposite direction, back to the higher positive potential grid. A similar negative resistance effect is produced at the secondary emitter in this system. However, in the devices known to the prior art, the output grid element interposed in the path of the primary stream absorbs much of the initial primary stream before it has a chance of producing secondary emission. This lowers the negative resistance effect (the negative resistance has a higher numerical value) and so the ability of the device to act as a power generator is likewise lowered. In the invention as shown, this defect is avoided, as all primary emission reaches the collector plate 25 and only the secondary emission reaches the output plate 26. This results in the high ratio of secondary to primary emission being completely usable. This makes for a very low negative resistance and an admirable oscillator under conditions which would spell failure for conventional dynatron devices.

Fig. 4 shows a novel and useful circuit arrangement which is a feature of our invention. The secondary emission tube structure 32 comprises elements as follows: emitter 33, control grid 34, collector plate 35, output plate 36 and shielding element 37. These elements are properly and respectively made operative by the sources of potentials indicated at 38, 39, 40, 41 and 42. In the input circuit of the control grid 34, is inserted the inductance 43 connected in parallel with the tuning condenser 44 forming an oscillatory circuit. In the collector plate 35 circuit is connected the inductance 45, inductively coupled to the inductance 43, serving as a tickler. In the output plate 36 circuit is connected the tuned circuit comprising the inductance 50 in shunt to the condenser 51. The internal tube currents are indicated at 48 and 49.

Referring now to Fig. 5, the action of the oscillator shown in Fig. 4 will be explained. Fig. 5 shows, neglecting certain slight phase shifts often present in an oscillator, the relationships between control grid 34 potential and several tube currents. Instantaneous values are shown against time. It will be observed that as the control grid potential gets more positive, the primary emission stream I_{48} also increases. This is exactly the same as in any normal triode. In the normal triode oscillator, this current I_{48} would flow out from the plate and through the tickler 45 and make the tube oscillate. In this case, however, the primary emission reaching the collector plate 35 dislodges a greater number of secondary charges which as I_{49} flow to the output plate 36. The current flowing out of the collector plate 35 is the difference between I_{48} and I_{49}, and due to the secondary emission ratio, I_{49} is the greatest and I_{47} is negative as shown. It follows the same phase as the primary emission I_{48} but is reversed in sign. As a result, in order to make the equivalent (emitter-control grid-collector plate) triode oscillate, the sign of the tickler mutual inductance must be reversed from that customarily necessary. This reversal is indicated in the crossed leads 46 and 47 in Fig. 4.

This novelty is not the only point of distinction of the circuit of Fig. 4. When this initial equivalent triode section is oscillating, a varying current will flow as I_{49}. If the tuned circuit 50—51 be tuned to this frequency of oscillation, it will absorb this a. c. power and may in turn supply it to other circuits as desired. If the potential 41 be maintained high enough so that the negative values of voltage across the tuned circuit 50—51 do not drop the sum of its voltage and the source 41 below the saturation potential, the impedance looking back into the output plate 36 will be infinite, using saturation in the same sense as the art does. This means that variations in the output circuit conditions cannot affect the tube conditions and so not change the oscillation frequency. This is a very important improvement, for in other tube oscillation circuits the load circuit and the frequency-determining circuit are one and the same. As a result, in the prior types of oscillators any change in load conditions affects the oscillation frequency, an effect generally most deleterious. In the circuit of this invention shown in Fig. 4, these two necessary frequency-determining and load circuits are completely independent, with the resulting attendant advantages of high frequency stability.

Having described our invention, what we claim is:

1. An electronic oscillator comprising a source of primary electrons, a secondary emissive elec-

trode, a feed-back inductance connected in series with a source of potential between said source of primary electrons and said electrode for controlling the number of primary electrons reaching said electrode, a control electrode interposed between said source and said emissive electrode, means connected between said control electrode and said cathode for receiving energy from said inductance, a secondary electron collecting electrode, an output circuit connected between said collecting electrode and said cathode and an electrostatic shield interposed between said source of primary electrons and said collecting electrode.

2. An electronic oscillator comprising a source of primary electrons, a secondary emissive electrode, a feed-back inductance connected in series with a source of potential between said source of primary electrons and said electrode for controlling the number of primary electrons reaching said electrode, a secondary electron collecting electrode, an electrostatic shield interposed between said source of primary electrons and said collecting electrode, a control electrode interposed between said source and said emissive electrode, and a tuned circuit connected between the control electrode and source, said tuned circuit being coupled to the feed-back inductance.

3. An electronic oscillator comprising a source of primary electrons, a secondary emissive electrode, a feed-back inductance connected in series with a source of potential between said source of primary electrons and said electrode for controlling the number of primary electrons reaching said electrode, a secondary electron collecting electrode, an electrostatic shield interposed between said source of primary electrons and said collecting electrode, a control electrode interposed between said source and said emissive electrode, a tuned circuit connected between the control electrode and source, said tuned circuit being coupled to the feed-back inductance, a tuned circuit connected between the collecting electrode and said source, and an output circuit coupled to said tuned circuit.

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