

May 10, 1938.

E. G. LINDER

2,117,098

SECONDARY EMISSIVE ELECTRONIC DISCHARGE DEVICE

Filed April 30, 1936

2 Sheets-Sheet 1

Fig. 1.

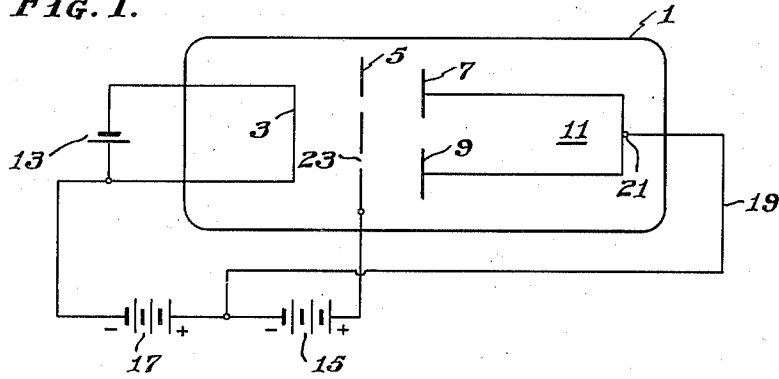


Fig. 2.

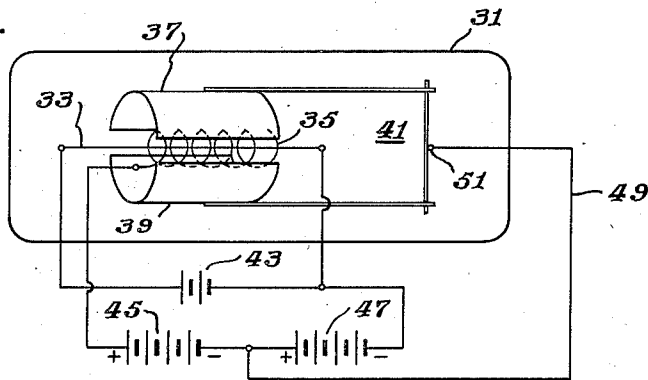
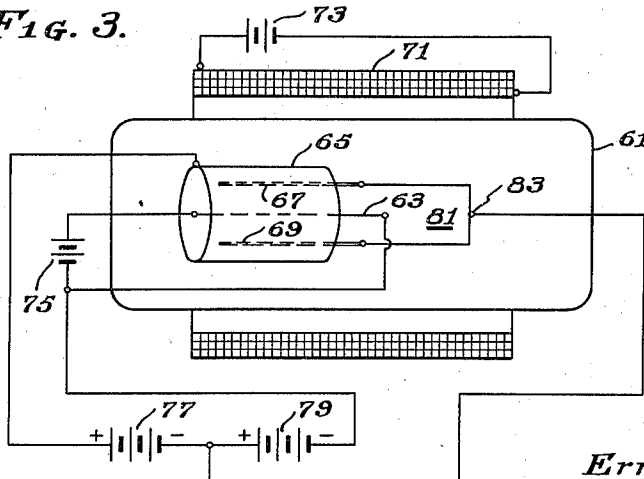


Fig. 3.



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FIG. 4.

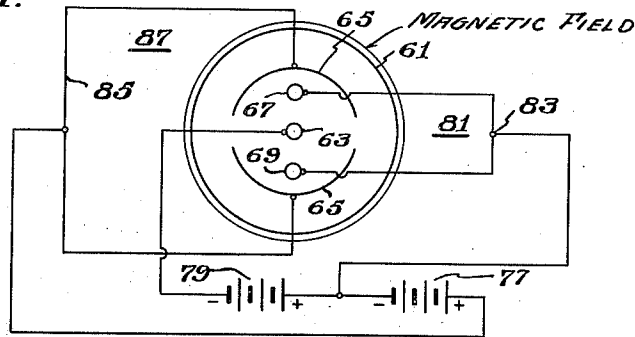


FIG. 5.

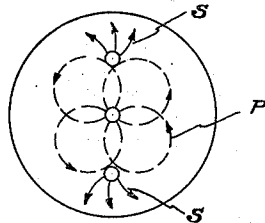
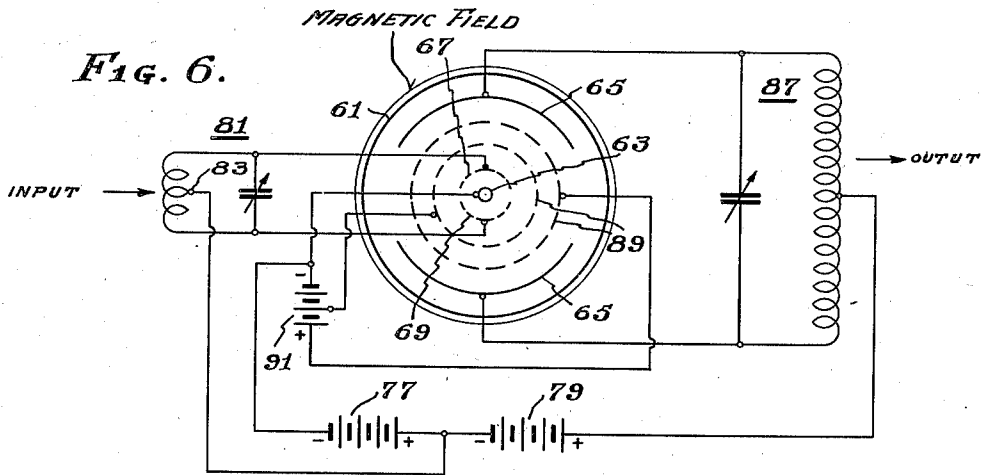


FIG. 6.



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SECONDARY EMISSIVE ELECTRONIC DIS-
CHARGE DEVICEErnest G. Linder, Philadelphia, Pa., assignor to
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Application April 30, 1936, Serial No. 77,144

8 Claims. (Cl. 250—36)

This invention relates to secondary emissive electronic discharge devices and particularly to push pull electronic oscillators in which the electrons have appreciable transit times as compared to their period of oscillation.

Ultra high frequency oscillators of the Barkhausen-Kurtz or magnetron type are well known to those skilled in the art. Such oscillators have depended primarily upon electron emission from a heated cathode. While the push pull electronic oscillator of this invention may employ a primary electron source, such as a heated cathode or a photoemissive electrode, the main source of electronic oscillatory current is derived by secondary emission of electrons.

My invention may be most easily understood by reference to the accompanying drawings, in which Fig. 1 is a schematic diagram of one form of secondary emissive electronic oscillator.

Fig. 2 represents a schematic illustration of a modified form of oscillator.

Fig. 3 is a schematic diagram of a magnetron oscillator in which the main oscillatory current depends upon secondary emission.

Fig. 4 is a schematic representation of a magnetron oscillator which is a modification of Fig. 3.

Fig. 5 is a sketch illustrating the electronic paths of an oscillator similar to the one illustrated in Fig. 3, and

Fig. 6 is a circuit diagram of an electronic device similar to Fig. 4 but including a plurality of secondary emissive electrodes for amplifying the electronic currents.

Referring to Fig. 1, within an evacuated envelope 1 are suitably supported a cathode 3, an apertured accelerating electrode 5 and a pair of secondary emissive electrodes 7, 9. This pair of electrodes 7, 9 are connected to a resonant circuit 11 which may or may not be included within the envelope.

The cathode 3 may be energized by a battery 13. A pair of batteries 15, 17 are serially connected between the accelerating electrode 5 and the cathode 3 to positively bias the former as shown. A lead 19 is connected between a point 21 intermediate the ends of the tuned circuit 11 and the junction of the serially connected batteries 15, 17.

The operation of the circuit of Fig. 1 is essentially as follows: electrons emitted from the energized cathode 3, under the influence of the positively charged accelerating electrode 5 start toward the accelerating electrode or anode. Some of these electrons strike the accelerating electrode, while others pass through the apertures 23.

The electrons passing through the apertures continue at high velocities and impinge upon the secondary emissive electrodes 7, 9. The primary electrons impinging on the emissive electrodes 7, 9 liberated increasing numbers of secondary electrons, which flow to the accelerating anode. This action gives rise to a negative resistance characteristic.

Since one of the pair of emissive electrodes will be naturally slightly more emissive than the other, one of the electrodes will become momentarily negative with respect to the other, thereby establishing transient currents in the oscillator circuit 11. The transient currents will have an oscillatory frequency equal to the resonant frequency or period of the tuned circuit, which is preferably adjusted to equal the time of transit of electrons moving from the accelerating electrode to the secondary emissive electrode.

In Fig. 2 the arrangement is as follows: Within an envelope 31 are suitably mounted a primary emissive electrode 33, a grid-like accelerating electrode 35 substantially coaxially arranged with respect to primary emission electrode, and a pair of secondary emissive electrodes 37, 39. The secondary emissive electrodes are preferably semi-cylindrical and are joined by an oscillatory circuit 41. The cathode 33 is energized by a battery 43. The accelerating electrode 35 is positively biased with respect to the cathode by a pair of serially connected batteries 45, 47. The emissive electrodes 37, 39 are positively biased by a connection 49 from the junction of the serially connected batteries 45, 47 and a point 51 intermediate the ends of the tuned circuit 41.

The operation of the circuit of Fig. 2 is essentially the same as Fig. 1. Some of the electrons leaving the cathode 33 pass through the meshes of the accelerating electrode 35, and impinge on the emissive electrodes 37, 39 thereby liberating secondary electrons, which flow to the accelerating electrode. A negative resistance characteristic starts the oscillatory currents which flow in the oscillatory circuit 41. The oscillatory frequency is preferably related to the electron transit time, as previously described.

In Fig. 3, a modified electrode arrangement and also a magnetic field are employed. Within the envelope 61 are mounted a cathode 63, a cylindrical accelerating anode 65 coaxially arranged with respect to said cathode, and a pair of secondary emissive electrodes 67, 69. The emissive electrodes may each consist of a single wire or a plurality of spaced wires arranged concentrically between the accelerating electrode and cathode.

A magnetic field whose lines of force are nearly parallel to and surround the cathode is established by a solenoid 71 (illustrated in cut away form) which may be energized by a battery 73, or any suitable arrangement may be used to establish the magnetic field. The cathode 63 is energized by a battery 75. The accelerating electrode 65 is biased positively by a pair of serially connected batteries 77, 79 which are connected between the accelerating electrode and the cathode.

The secondary emissive electrodes 67, 69 are connected to the terminals of a resonant circuit 81. The junction of the serially connected batteries 77, 79 is connected to a point 83 intermediate the terminals of the resonant circuit 81. The operation of the foregoing circuit differs slightly from the circuits illustrated in Figs. 1 and 2. In the present circuit, the magnetic field causes the primary electrons emitted from the cathode to take spiral paths from the cathode 63 toward the accelerating electrode 65. The field strength is adjusted to substantially cut-off with respect to the accelerating electrode.

Some of the electrons spiralling outwardly from the cathode will impinge upon the secondary emissive electrodes 67, 69 at high velocity. The impinging primary electrons will liberate secondary electrons which, in turn, spiral to the accelerating electrode. In Fig. 5 the paths of the primary electrons are illustrated by the reference character P; while the paths of the secondary electrons are represented by S. The magnetic field is perpendicular to the plane of the illustration.

Negative resistance characteristics are established by the secondary emission. By virtue of the negative resistance oscillatory currents are set up in the resonant circuit 81. For optimum operation the electron transit time between the cathode 63 and the secondary emissive electrodes 67, 69 should equal one oscillation period. The structure of the electronic tube of Fig. 3 contributes to low inter-electrode capacities and enables ultra high frequency oscillations to be established.

The circuit and elements of Fig. 4 being essentially the same as Fig. 3, similar reference characters will indicate similar elements in this and following figures. In the present circuit, an end view of the electron tube is shown. The solenoid is omitted but the magnetic field is represented by an appropriate legend. The accelerating anode 65 is split and the semi-cylindrical parts thereof are joined by a lead 85 to form a resonant circuit 87.

The split anode decreases the capacity between the emissive electrodes. The resonant circuit between the split anode or accelerating electrodes may be adjusted to favorably react upon the resonant circuit 81 connected to the emissive electrodes and thereby increase the efficiency of the oscillator.

The circuit of Fig. 6 is not unlike that of Figs. 3 and 4 with the addition of a plurality of accelerating electrodes. The emissive electrodes 67, 69 are concentrically arranged with respect to the cathode 63. A plurality of grid-like secondary emissive electrodes 89 are concentrically arranged about the cathode 63. These electrodes 89 are made more positive with respect to cathode as their spacing therefrom increases. A battery 91, or the like, may be used to bias the several emissive electrodes.

The magnetic field, represented by a circle

and appropriate legend, is of such strength that the electrons liberated from each emissive electrode must impinge upon the next outer electrode before it can reach the further removed electrodes. The several electrode potentials are each adjusted to emit secondary electrons. Each successive emissive electrode increases the electron current which is thus amplified.

In each of the several electronic tubes the oscillatory circuit is arranged to act in push-pull arrangement by the negative resistance characteristic established by the secondary emission. The secondary emissive electrodes have surfaces which are made secondary emissive by means of a silver surface which is first oxidized, and thereafter treated with caesium. It should be understood that other suitable materials and treatments may be used to make the several electrodes secondarily emissive. The input and output, or load circuits, may be connected to the electronic devices by any of the well known coupling means.

I claim as my invention:

1. In a device of the character described, a source of primary electrons, an accelerating electrode, means for biasing said accelerating electrode positively with respect to said source, a pair of electrodes having surfaces adapted to emit secondary electrons upon impingement of said primary electrons, a source of potential for biasing said pair of electrodes positively with respect to said source of primary electrons and less positive than said accelerating electrode, and a resonant circuit connected between said pair of electrodes.

2. In a push pull electronic oscillator, a cathode, a cylindrical shape accelerating anode substantially co-axially arranged with respect to said cathode, means for biasing said anode positively with respect to said cathode, a pair of secondary emitting electrodes interposed in the electron path between said cathode and anode, means for biasing said pair of electrodes positively with respect to said cathode, and a resonant circuit connecting said pair of electrodes and having a time period which is responsive to the transit time of secondary electrons moving between said pair of electrodes and said anode.

3. In a push pull electronic oscillator a cathode, a grid-like accelerating anode substantially coaxially arranged with respect to said cathode, and a pair of semi-cylindrically shaped electrodes, said pair of electrodes having surfaces so treated as to be highly secondarily electron emissive, means for biasing said anode positively with respect to said cathode, means for biasing said pair of electrodes positively with respect to said cathode and less positively than said anode, and a resonant circuit terminating in said pair of electrodes and energized almost entirely by high frequency currents generated by electrons emitted from said secondary emissive electrodes.

4. In a device of the character of claim 2 means for establishing a magnetic field whose lines of force surround and are substantially parallel to said cathode.

5. In a device of the character described, a cathode, a pair of semi-cylindrical shape accelerating anodes substantially coaxially arranged with respect to said cathode, means for biasing said anodes positively with respect to said cathode, a resonant circuit joining said anodes, a pair of secondary emissive electrodes interposed in the electron path between said cathode and anode, means for biasing said pair of electrodes

positively with respect to said cathode, and a second resonant circuit connecting said pair of emissive electrodes and having a time period which is of the order of the transit time of secondary electrons moving between said emissive electrodes and said anodes.

6. In a device of the character of claim 5, means for establishing a magnetic field whose lines of force are substantially parallel to said cathode.

7. In a device of the character described, a cathode, a pair of semi-cylindrical shape accelerating anodes, substantially coaxially arranged with respect to said cathode, a resonant circuit joining said anodes, means for biasing said anodes positively with respect to said cathode, a pair of secondary emissive electrodes interposed in the electron path between said cathode and anodes, means for biasing said pair of electrodes positively with respect to said cathode, a second resonant circuit connecting said pair of emissive electrodes and having a time period which is of the order

of the transit time of secondary electrons moving between said emissive electrodes and said anodes, a plurality of grid-like accelerating electrodes disposed between said accelerating anodes, and said emissive electrodes, and coaxially arranged with respect to said cathode, and means for biasing said plurality of grids positively with respect to said cathode.

8. In a device of the character described, a source of primary electrons, an accelerating electrode, means for biasing said accelerating electrode positively with respect to said source, a pair of electrodes having surfaces which have been so treated as to adapt them to emit secondary electrons upon impingement of said primary electrons, a source of potential for biasing said pair of electrodes positively with respect to said source of primary electrons and less positively than said accelerating electrode, and a resonant circuit connected between said pair of electrodes.

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