Jan. 16, 1951 F. COETERIER 2,538,669

ELECTRON TUBE SYSTEM OF THE VELOCITY MODULATION TYPE

Filed Sept. 20, 1946

Fig. 1.

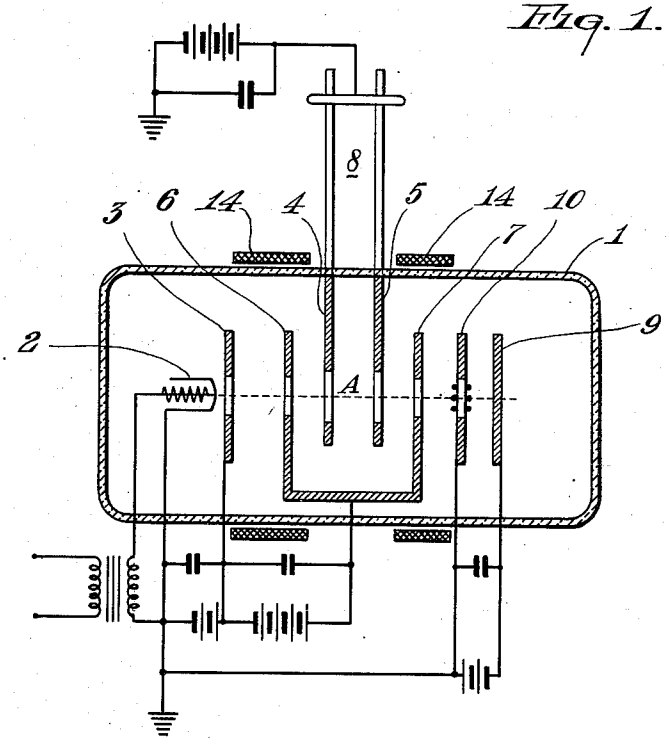
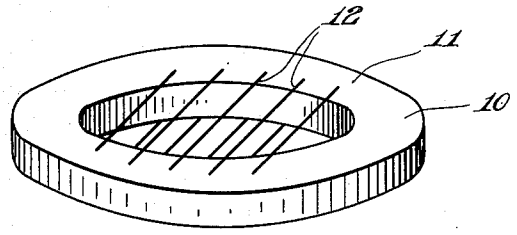


Fig. 2.



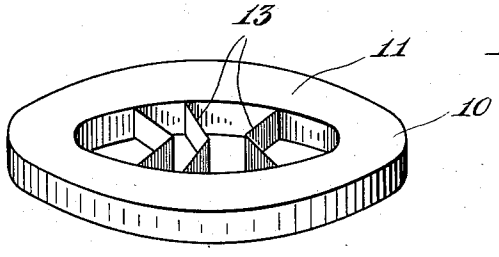


Fig. 3.

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Patented Jan. 16, 1951 2,538,669

UNITED STATES PATENT OFFICE

2,538,669

ELECTRON TUBE SYSTEM OF THE VELOCITY MODULATION TYPE

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Application September 20, 1946, Serial No. 698,352
In the Netherlands April 12, 1943

Section 1, Public Law 690, August 8, 1946
Patent expires April 12, 1963

1 Claim. (Cl. 315—16)

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This invention relates to an improvement in or modification of the invention described and claimed in application Serial No. 662,968, filed April 18, 1946.

In the said specification a device comprising a discharge tube is described in which a beam of electrons is generated, the velocity of the electrons in the beam being controlled by an ultra-high frequency control oscillation by means of an electrode system, the variations in velocity being then converted into variations in intensity by means of a repelling electrode which causes the movement of the velocity-varied electrons to reverse its direction during the conversion of variations in velocity into variations in intensity, so that the electrons pass a second time through the control electrode system and induce an oscillation in this system.

In the devices of this kind, as suggested before, the velocity control by the beam of electrons is effected by passing the beam of electrons through a control space which is circumscribed by two electrodes and contains one or more electrodes (cylinders or recessed strips) which enclose the course of electrons and have an ultra-high frequency control oscillation fed to them. The velocity variations of the electrons are then converted into variations in intensity by means of a repelling electrode or retarding electrode system arranged on the side of the control electrode system remote from the electrode system generating the beam of electrons (cathode). The electrons emerging from the control space, which in this space have been accelerated under the influence of a control oscillation and which get into the field of repulsion, will penetrate farther into this field than the electrons retarded in the control space, with the result that the electrons accelerated remain in this field for a longer time than the electrons retarded and are consequently overtaken by the latter. This means that in the beam of electrons leaving this field successive concentrations and dilutions of electrons occur or in other words that the variations in velocity of the beam of electrons have been converted into variations in intensity.

The variations in intensity caused by the repelling field are intensified according as the velocity modulation is greater and the electron flight time in this field is increased. On passing a second time through the control space the beam of electrons modulated in density in the manner above-described induces an alternating voltage in the control electrode system, said alternating voltage being capable of amplifying or

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maintaining oscillations in the control system. After passing through the control space a second time, but now in the opposite direction, the beam of electrons enters the space on the side of the control electrode system adjacent the cathode. In the device according to the prior specification, the returning electrons are preferably also repelled in this space and returned into the control electrode system through which they may thus pass a third time. Repeatedly passing through the control system that modulates the velocity and repeatedly being subjected to the grouping effect of the repelling fields will generally result in a blurring of the effect aimed at, either due to the fact that the electrons after being reflected several times obtain such a divergence from the mean oscillation time that they no longer pass through the control system in the desired phase or due to the fact that the grouping effect exceeds a given maximum and the transmission of energy to the control system consequently becomes less effective.

The invention has for its object to provide a device in which the phase of the reciprocating electrons as well as the relation of the electron groups that have once been formed is established in a critical manner and this permits of all of the electrons that pass several times through the control system, always transmitting, in doing so, a maximum quantity of energy to the control system, this having a favourable effect on the efficiency of the device.

According to the invention, this object is achieved in a device of the kind to which the invention refers by utilizing a double grid enclosing an equipotential space arranged in the repelling field space located on the side of the control electrode system remote from the cathode, the potential of said grid being approximately equal to the cathode potential.

In order that the invention may be clearly understood and readily carried into effect it will now be described more fully with reference to the accompanying drawing, in which

Figure 1 shows one form of construction of the device according to the invention.

Figures 2 and 3 show two forms of construction of a double grid for use in the device according to the invention.

In the embodiment shown in Figure 1, an exhausted vessel 1 contains a cathode 2 and a diaphragm electrode or first repelling electrode 3 which is connected to the cathode so far as high frequency currents are concerned, for generating a beam of electrons; the electrode 3 has supplied

to it a direct voltage positive with respect to the cathode. The velocity of the electrons in the beam of electrons issuing from the cathode and sharply circumscribed by the diaphragm electrode is controlled by means of a control system comprising two control electrodes 4 and 5 and two circumscribing electrodes 6 and 7. The control electrodes 4 and 5 have interconnected between them an oscillatory circuit 8 which is tuned to the frequency of the oscillations to be generated. The control electrodes 4 and 5 and the circumscribing electrodes 6, 7 have supplied to them a voltage which is positive with respect to the cathode and which materially exceeds the voltage of the electrode 3 with respect to the cathode. The source of voltage by which the said voltage is supplied is shunted for the oscillations to be generated, by a condenser. On the side of the control electrode system remote from the cathode 2 is arranged a second repelling electrode 9 having a voltage slightly negative with respect to the cathode. According to the invention, the control electrode system and the second repelling electrode have arranged between them a double grid 10 surrounding an equipotential space to form a drift space electrode having a potential which is approximately equal to that of the cathode so that electrons having a mean velocity reverse their direction at the area of the double grid 10.

The electrons retarded by the control system under the influence of the control voltage occurring between the electrodes 4 and 5 pass through the space between the circumscribing electrodes 6 and 7 in a longer time, and through the repelling field between the circumscribing electrode 7 and the double grid 10, in a shorter time, than is required for the electrons at a mean velocity. The choice of the spacing of the circumscribing electrodes 6, 7 in relation to the spacing between the circumscribing electrode 7 and the double grid or drift space electrode 10 ensures that the two extremes from the time in which the electrons at a mean velocity traverse the distance concerned compensate each other with sufficient approximation for any values of the velocity retardation occurring in practice. The transit time of all the retarded electrons for a reciprocating movement from the centre A of the control electrode system to the decelerating electrode 9 and back is consequently identical for all the retarded electrons and is equal to that of the electrons at a mean velocity so that overtaking effects do not occur among the retarded electrons mutually.

In contradistinction to this, the electrons accelerated in the control space traverse the control space as well as the spacing between the electrodes 7 and 10 at a greater velocity than the electrons at a mean velocity. Owing, however, to their kinetic energy they get through the field-free space of the double grid 10 into the portion of the field behind grid 10 and between grid 10 and electrode 9, the latter being negative with respect to the grid 10 which grid is a drift space electrode. The choice of the voltage drop between the electrodes 10 and 9 and the length of the field-free space within the electrode 10 in connection with the other electrode spacings and the voltages supplied is chosen to ensure with sufficient approximation that the time during which all the accelerated electrons are enclosed within the space 7—9 exceeds the time during which an electron not modulated in velocity and having a mean velocity is contained in this space by a constant amount which preferably equals half the oscillation time of the control oscillation or an odd multiple of half the oscillation time.

As with the retarded electrons, which leave the control electrode system near the electrode 7, returning to it, after reflection, in the form of a continuous current, so with the accelerated electrons, on the understanding, however, that they have been subjected to a common time delay of half an oscillation time.

This results in the retarded and accelerated electrons returning into the control electrode system at the same time so that the returning beam exhibits a periodical intensity jump of twice the initial intensity towards zero and vice versa. Apart from the fact that such a density-modulated electron beam has a comparatively favourable efficiency it is also obvious that in the case of a second reversal of the direction of movement in the space between the electrodes 3 and 6, which is preferably of the same size as the space between the electrodes 7 and 10, grouping effects no longer occur since by now half of the electrons are doubly retarded and the other half are accelerated once and retarded once so that it has recovered its orginal velocity. And so long as there are no accelerated electrons in the beam the transit time for a reciprocating movement, viewed from the point A, is identical for all the electrons. Hence, the transmission of energy to the control electrode system will always take place in the correct phase irrespective of the number of times the electrons pass through the control electrode system.

In order to increase the number of times the electrons pass through the control electrode system before being retained by a positive electrode means are provided preferably for the focussing of the electrons, for example a powerful axially directed magnet field provided, for example, by coils 14.

Figure 2 shows one embodiment of a double grid 10 which is the drift space electrode for use in the device shown in Figure 1. In this form of construction, the double grid is constituted by a bored disc 11, the bore being circumscribed on either side by grid rods 12.

In the embodiment shown in Figure 3 the disc 11 is provided with a bore subdivided by partitions 13.

What I claim is:

A high frequency electron discharge device system of the velocity modulation type, comprising a vessel, and, within the vessel, a cathode, means to generate a beam of electrons from said cathode, a system of electrodes through which said beam passes and comprising two electrodes having substantially the same D. C. potential positive with respect to said cathode and being respectively more remote from and closer to said cathode than other electrodes of said system and means to apply to said electron beam an alternating high frequency field having electric vectors parallel to said beam thereby velocity modulating said beam of electrons, an apertured electrode having substantially the same D. C. potential as that of said cathode to provide a field-free drift space in the aperture thereof and being more distant from said cathode than said electrode system to provide a field between said more remote system electrode and said apertured electrode to return to said electrode system substantially all electrons decelerated by said velocity modulating field and to pass through said aper-

tured electrode substantially all electrons accelerated by said velocity modulating field, and a repelling electrode having a negative D. C. potential with respect to said cathode and being more remote therefrom than said apertured electrode to provide a field between said apertured electrode and said repelling electrode to return said accelerated electrons toward and through said apertured electrode, and an electrode having a negative D. C. potential with respect to said system electrodes and having a positive D. C. potential with respect to said cathode and interposed between said beam generating means and said electrode system and provided with an opening through which said beam passes to provide a field between said closer system electrode

and said interposed electrode to return to said electrode system electrons leaving said system toward said cathode.

FREDERIK COETERIER.

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