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FREQUENCY MODULATOR

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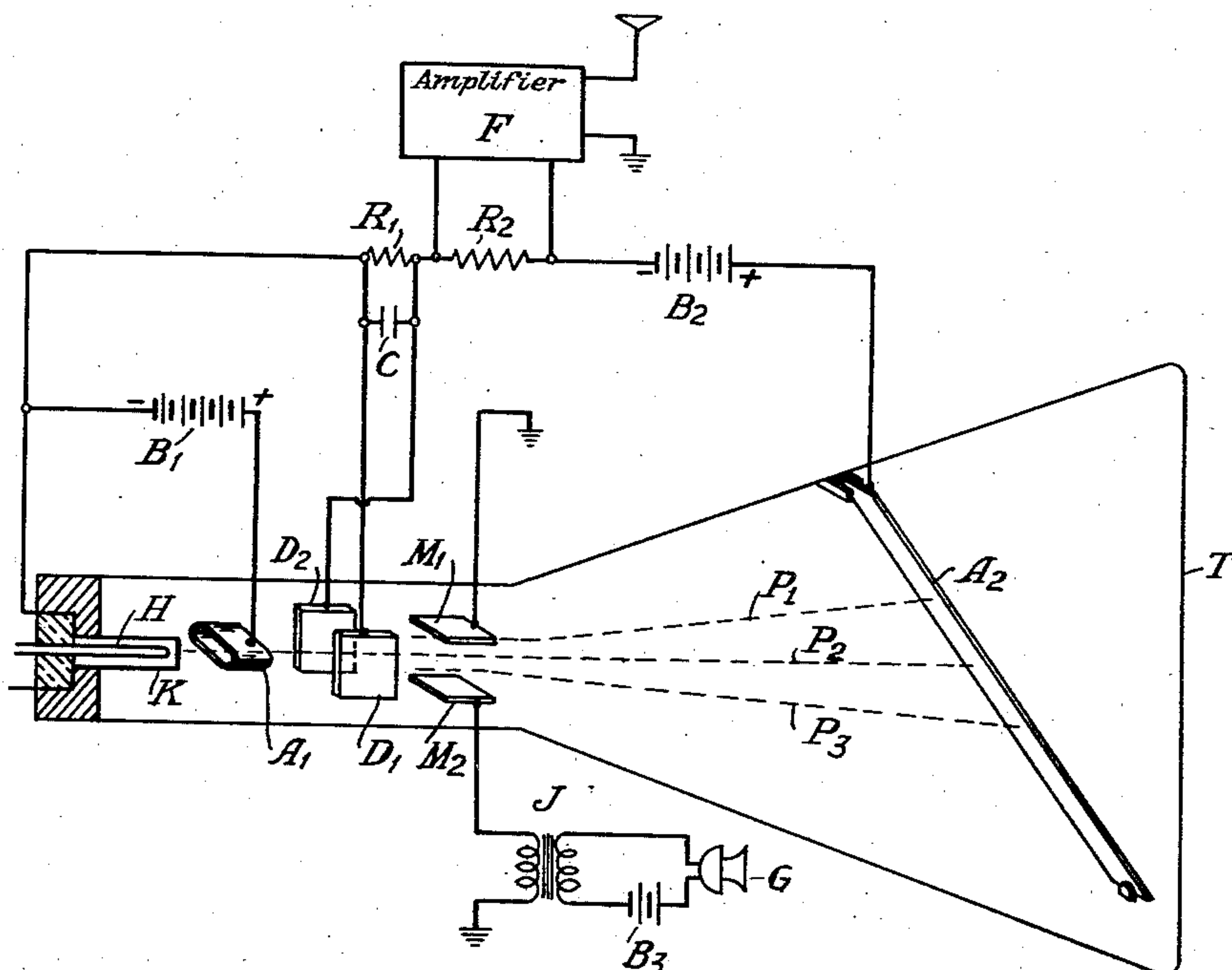


Fig. 1

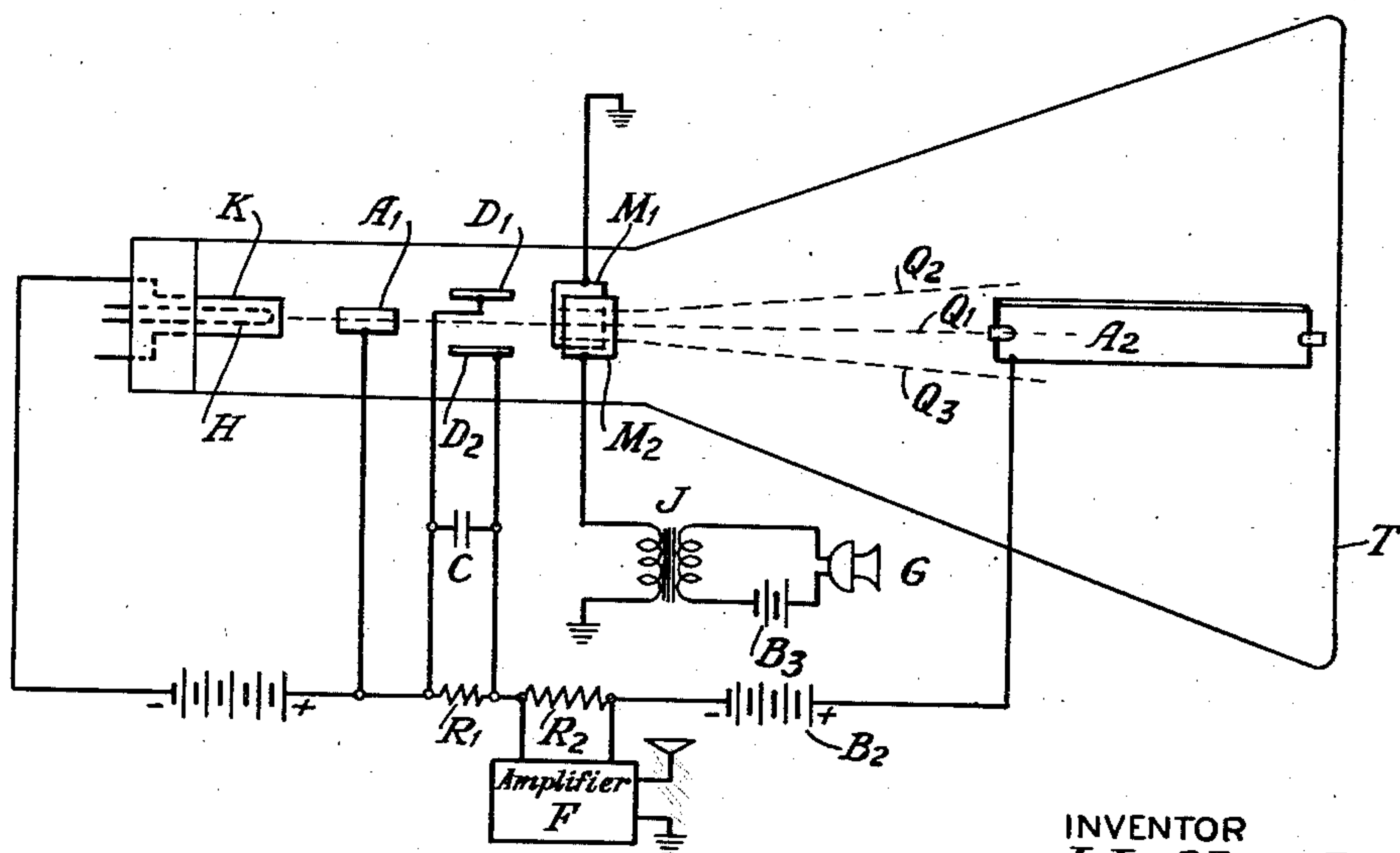


Fig. 2.

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FREQUENCY MODULATOR

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This invention relates to oscillation generators and to modulators. More particularly, this invention relates to oscillation generators of the electron beam type as well as to modulators for varying the frequency of the current generated by such oscillation generators.

Various forms of transmitters for producing high frequency waves and for modulating the frequency of such waves in accordance with signals have heretofore been proposed. These transmitters usually comprised a large number of vacuum tubes, one or more of which were used for generating oscillations and the other tubes for multiplying the frequency of the generated oscillations, as well as for modulating the frequency of the generated oscillations in accordance with signals. Because of the large number of tubes and other equipment going into the transmitters, the apparatus was very bulky and therefore quite unsuited for low power, short haul point-to-point, or mobile services as would be required, for example, in providing service for automobiles.

In order to overcome these difficulties a different form of oscillation generator and frequency modulator has been provided which, in accordance with this invention, comprises a tube of the electron beam type set up to generate high frequency oscillations, the tube and the circuit attached thereto including a simple arrangement for varying the frequency of the generated oscillations in accordance with signals or other effects. The electron beam tube comprises the usual electrodes of a cathode ray tube and, in addition, an anode which is positioned at a predetermined angle with respect to the mean path of the electron beam. The signals or other effects which are applied to the tube electrodes are employed to deflect the electron beam so that it will travel over a distance which will correspond to the signal or effect impressed upon the tube electrodes. As the electron beam traverses a shorter or longer path, a higher or lower frequency will be obtained from the system.

This invention will be better understood from the description hereinafter following, when read in connection with the accompanying drawing in which Figure 1 shows one form of arrangement for carrying out the principles of this invention, and Fig. 2 illustrates another view of the arrangement of Fig. 1, the tube of Fig. 1 having been rotated through 90 degrees along its main axis.

Referring to Figs. 1 and 2 of the drawing, the electron beam tube designated T includes a heater H, a cathode K for producing an electron

beam, an anode A₁ which is connected to the cathode K by means of a high voltage battery B₁ for accelerating the cathode ray beam, two deflecting plates D₁ and D₂ between which the electron beam is passed, two additional deflecting plates M₁ and M₂ between which the beam is subsequently passed, the latter plates being displaced at a 90-degree angle with respect to the plates D₁ and D₂, and a second anode A₂ which is inclined at some predetermined angle with respect to the normal or mean path of the electron beam. The inclined anode A₂—which is the only electrode other than those usually found in a cathode ray tube—is connected to the cathode K by a circuit which includes two resistors R₁ and R₂ and a battery B₂ which may be of lower voltage than the battery B₁. The resistor R₁ is shunted by a condenser C, the left terminal of the condenser C being connected to the plate D₁ and the right terminal of the condenser C to the plate D₂. The resistor R₂ may be connected to any apparatus or load circuit which may be supplied with the high frequency pulsating or alternating current generated by the circuit already described. This high frequency current may be amplified, if desired, by an amplifier such as F, and then transmitted through space over the usual form of antenna circuit suitable for such high frequency currents. The frequency of the generated current may be varied in accordance with signals or other effects by impressing those signals or other effects upon the plates M₁ and M₂ of the tube T. One form of modulating circuit is shown in the drawing, and this comprises a telephone transmitter G which is connected in series with the battery B₃ and the primary winding of a transformer J, the secondary of transformer J being connected between plate M₂ and ground, while the other plate M₁ is also grounded. The manner in which the arrangement shown in Figs. 1 and 2 generates high frequency oscillations will now be considered, and in this connection it will be assumed that no signals or other effects are impressed upon the modulating plates M₁ and M₂. Electrons emitted by the cathode K are directed toward the anode A₁ by the high voltage impressed between the anode A₁ and the cathode K. These electrons form a beam which may be rendered substantially flat by suitable design of the cathode K and the anode A₁. The anode A₁ may, for example, comprise a metallic device of elliptical or rectangular cross-section providing an aperture or opening through which the electrons may pass in a narrow beam. This beam of electrons will then pass

between the plates D_1 and D_2 and then between the plates M_1 and M_2 along the path P_2 of Fig. 1 and Q_1 of Fig. 2, and finally reach the anode A_2 which is also maintained at a sufficient positive potential with respect to the cathode K . The flow of these electrons causes a current to traverse a circuit including the battery B_2 , the resistor R_2 , and the resistor R_1 . The current traversing the resistor R_1 will build up a charge on the condenser C which will also be impressed upon the plates D_1 and D_2 , the potential on plate D_2 being negative with respect to the potential applied to plate D_1 . The potential difference impressed upon the plates D_1 and D_2 will deflect the cathode beam sidewise, that is, in the direction of Q_2 or in the direction of Q_3 (of Fig. 2). The electron beam will at times strike the anode A_2 and at other times may be deflected beyond the anode A_2 which is of limited breadth. As will be observed from the drawing, the anode A_2 is a long and narrow element, the breadth of which will be properly determined for the generation of the oscillations.

When the electron beam strikes the anode A_2 , however, current will flow from the battery B_2 over the anode circuit including anode A_2 , cathode K , and resistors R_1 and R_2 . When the beam is deflected beyond the anode A_2 by reason of the voltage built up on condenser C and applied to plates D_1 and D_2 , no current will then flow from battery B_2 over the anode circuit just described. In other words, current will flow from battery B_2 through resistor R_2 only at such times as the anode A_2 is struck by the electron beam. At other times no current will flow through resistor R_2 . This arrangement will hence generate a pulsating or alternating current to be amplified by amplifier F and then transmitted through space by antenna circuit shown in the drawing. This process will be repeated indefinitely.

During the interval when no current flows from the battery B_2 through resistors R_1 and R_2 , the charge on the condenser C will leak off through the resistor R_1 . When this charge has been sufficiently dissipated, the electron beam will then swing from any position such as Q_2 transversing an arc the other limit of which is illustrated by the line Q_1 . During the interim, that is, during the interval when the beam again strikes the anode A_2 , current will again flow from the battery B_2 through the resistors R_1 and R_2 . Thus the electron beam will move back and forth between its two limiting positions Q_2 and Q_1 of Fig. 2. If the connections to D_1 and D_2 should be interchanged the electron beam will move back and forth between limiting positions Q_3 and Q_1 .

It will be observed that the plates D_1 and D_2 within tube T are employed to deflect the beam in a horizontal direction to either side of the mean path Q_1 as shown in Fig. 2. If the time required for the beam to traverse the distance between the plates D_1 and D_2 and the anode A_2 is small, that is, below some predetermined interval, no pulsating current whatever will be generated. In other words, the distance between the plates D_1 and D_2 and the anode A_2 must exceed some minimum value. The travel time must be equal to one-quarter of the period of a complete cycle of the generated current, or longer, but not less than this interval. Thus the frequency characteristics of the oscillation generator will be determined by the spacing of the anode A_2 from the plates D_1 and D_2 , as well as by the size of the condenser C and of the resistance R_1 . By varying or adjusting these elements within limits, the frequency

of the normal oscillations may be changed to any desired value.

The amplifier F may, of course, be of any well-known type and may include, or have attached thereto, a filter or other device (not shown) for smoothing out the pulses of current obtained and for excluding undesired frequencies.

The plates M_1 and M_2 are supplied with a modulating voltage for varying the frequency of the generated oscillations in accordance with that applied voltage. The voltages obtained from speech signals impressed upon a telephone transmitter G , for example, will vary from time to time as is well understood in the telephone art, and hence this varying potential will deflect the electron beam by corresponding amounts in a vertical direction, the limits of which may be, for example, P_1 and P_3 of Fig. 1. As the applied modulating voltage reaches one of its extreme values, the electron beam will be moved vertically in the direction designated P_1 , for example. As the modulating voltage reaches its other extreme value, the beam will be deflected downwardly to the path designated P_3 . In other words, as the signals obtained from the telephone transmitter G vary from zero to successive positive and negative values, the electron beam will traverse the path P_2 of Fig. 1, then move upwardly to the path P_1 of Fig. 1, and later return to the path P_2 and move downwardly to reach the path P_3 . The paths traversed by the electron beam are of different lengths and hence cause the pulsating current to vary from one frequency to another in accordance with these different distances.

The range of frequencies obtainable with this system may be controlled by deflecting the anode A_2 to different angles. As the inclination of the anode A_2 approaches a vertical position, that is, a position perpendicular to path P_2 , the frequency swing will be reduced to a minimum. On the other hand, if anode A_2 should be inclined further toward the horizontal, the swing of the frequency of the generated oscillations will be increased to any desired extent.

There are thus two separate and distinct pairs of plates D_1 and D_2 , and M_1 and M_2 functioning in different ways in the arrangement of this invention. The plates D_1 and D_2 will deflect the beam in a horizontal direction only and thus determine the mean or normal frequency of the generated oscillations. The other plates M_1 and M_2 will deflect the beam in a vertical direction for varying or modulating the frequency of the generated oscillations in accordance with signals or other effects.

The frequency modulator shown and described in this application will produce a current of varying frequency, the instantaneous value of the frequency corresponding at any instant to the voltage of the signal or other effect used in modulation. The amplitude of the current will, however, remain constant and unaffected by the frequency changes resulting from modulation. Thus, no current limiter or other such device will be required in transmitting signals with the circuit of this invention.

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. An electron beam tube for generating oscil-

lations comprising an evacuated envelope, a heater, a cathode, an accelerating anode having a narrow opening through which the electrons pass in the form of a flat beam, two pairs of spaced parallel electrodes, one pair of electrodes being at right angles to the other pair, the spacing of the electrodes of each pair being such that the electron beam may freely pass therebetween, a second flat anode inclined at a predetermined angle with respect to the mean path of the electron beam and acting as a target for the electron beam, and a circuit interconnecting said flat anode and said cathode and including means for applying variable voltage to one of the pairs of spaced electrodes for generating oscillations.

2. An oscillating circuit comprising an electron tube including a cathode for producing a narrow beam of electrons, two parallel plates which are spaced from each other so that the electron beam may pass therebetween, and an anode inclined at a predetermined angle with respect to the normal path of the electron beam, said anode being of predetermined breadth, a circuit external of said tube and connecting the anode of the tube with its cathode, said circuit including first and second resistors and a source of potential connected in series with said resistors and with the said anode and cathode, a condenser connected across the first resistor and between the two plates of the tube, and a load circuit connected to the second resistor.

3. A system for producing oscillations comprising an electron beam tube including a cathode, an accelerating anode, a pair of parallel plates for deflecting the electron beam, and a second anode inclined at a predetermined angle with respect to the mean path of the electron beam, a resistor, a condenser connected across said resistor and between the two plates of the tube, and a source of potential connected in circuit with the cathode and the inclined anode of the tube as well as the resistor.

4. An oscillating system comprising a source of potential, a resistor, a condenser bridging said resistor, and an electron tube, said electron tube including means for producing a substantially flat beam of electrons, two parallel plates spaced from each other on opposite sides of said beam and connected to the terminals of said condenser, and an anode inclined at a predetermined angle with respect to the path of said electrons, said anode being connected in series with said resistor and said source of potential and to the electron beam producing means of said tube.

5. A frequency modulator comprising an electron tube in which a beam of electrons is produced, said tube including an anode inclined at a predetermined angle with respect to the path of said beam of electrons, said anode being flat and rectangular in shape, means for generating oscillations, said means including means for periodically deflecting the electron beam in a direction corresponding to one of the dimensions of said anode and over a distance greater than said dimensions, and means for deflecting the electron beam in a direction corresponding to the other dimension of said anode.

6. A frequency modulator comprising a tube in which a beam of electrons is produced, a rectangular anode having two dimensions and positioned so that its longer dimension is at a predetermined angle with respect to said beam, means for swinging said beam across and beyond the smaller dimension of said anode, and means

for deflecting said beam along the longer dimension of said anode.

7. A frequency modulator comprising an electron tube enclosing a cathode, an accelerating anode, two pairs of parallel plates at right angles to each other, and a second anode inclined at a predetermined angle with respect to the mean path of the electrons, the second anode of the tube being of predetermined width, two series-connected resistors, a first source of potential connected between the cathode and the accelerating anode, a second source of potential connected in circuit with the second anode, the resistors and the cathode of the tube, a condenser connected across one of the resistors and between two of the plates forming one of the pairs, a load circuit connected to the other resistor, and a source of modulating energy connected to the other plates of the other of the pairs, the charge on the condenser deflecting the electron beam in the direction of the width of the second anode, the modulating energy applied to the other pair of the plates deflecting the electron beam along the anode in a direction corresponding to the length of the second anode.

8. A frequency modulator comprising an electron beam tube including a cathode, an accelerating anode maintained at a suitable potential with respect to the cathode, and a second anode of predetermined length and width and inclined at an angle with respect to the mean path of the electrons, a resistor, a source of potential connected in series with said resistor and with the cathode and second anode of said tube, a condenser bridging part of said resistor, a load circuit connected to another part of said resistor, a pair of parallel plates spaced from each other within the tube and connected to the condenser for deflecting the beam of electrons in the direction of the width of the second anode, a second pair of spaced parallel plates at right angles to the first pair of plates, and means for applying potential to the second pair of plates for deflecting the electron beam in the direction of the length of the second anode.

9. A frequency modulator comprising an electron beam tube including a cathode, a first anode maintained at a fixed potential with respect to the cathode, a second anode in the form of a flat plate of predetermined horizontal and vertical directions and inclined at a predetermined angle with respect to the mean path of the electrons, and first and second pairs of spaced parallel plates at right angles to each other, means for applying potential to the first pair of plates for moving the electron beam in the horizontal direction of the second anode, and means for applying potential to the second pair of plates for moving the electron beam along the vertical direction of the second anode.

10. A frequency modulator comprising an electron beam tube including a cathode, an accelerating anode maintained at a fixed potential with respect to the cathode, a second anode of predetermined horizontal and vertical dimensions inclined at a predetermined angle with respect to the mean path of the electrons, and two pairs of spaced parallel plates at right angles to each other and interposed between the two anodes between which the electron beam passes, a resistor, a condenser in parallel with the resistor and connected between the plates of one of the pairs of said tube, a source of modulating energy connected in series with the plates of the other pair of said tube, a load circuit, and a

source of potential connected in series with the cathode and second anode of the tube, the resistor and the load circuit, the potential applied to the first pair of plates deflecting the electron beam in the direction of the horizontal dimension of the second anode, the potential applied

to the second pair of plates deflecting the electron beam along the vertical dimension of the second anode, the inclination of the second anode determining the swing of the frequency of the generated oscillations.

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