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A. G. THOMAS
HIGH FREQUENCY TUBE
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2,305,646

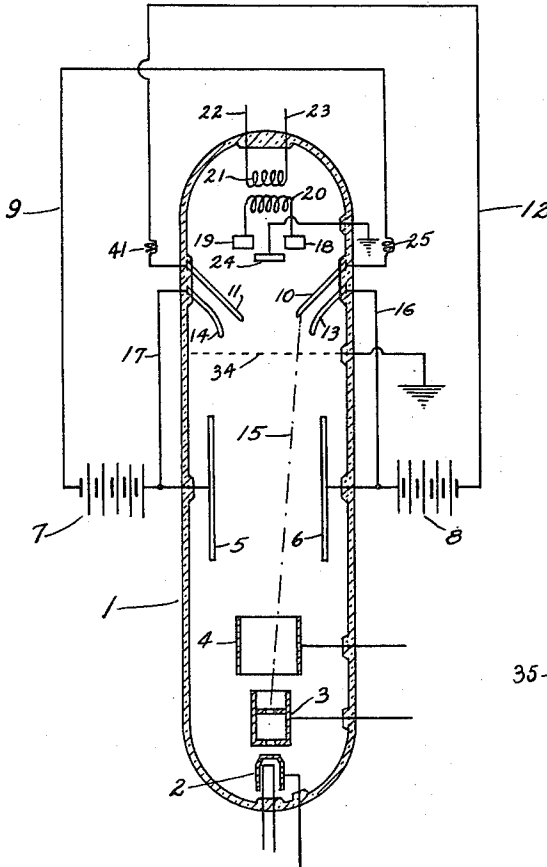


Fig. 1

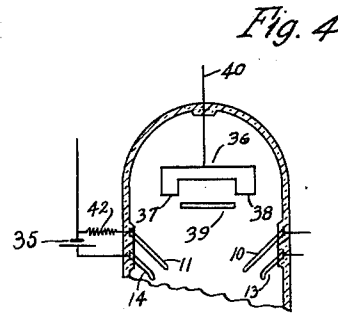


Fig. 4

Fig. 2

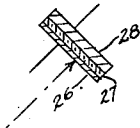
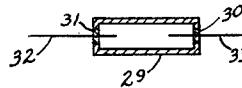


Fig. 3



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HIGH FREQUENCY TUBE

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8 Claims. (Cl. 250-27)

This invention relates to electronic tubes and is a continuation-in-part of the tube shown in Figure 10 of my copending application, Serial No. 282,733 filed July 3, 1939.

An object is to provide a tube capable of very high frequency oscillations.

Another object is the provision of a tube in which an electron beam is automatically shifted in position at high frequency.

Other objects will appear in the specification. In the drawing:

Figure 1 is an elevation, in part section, of a high frequency beam shifted type of tube.

Figure 2 is a side sectional elevation of an electronically operated contact device.

Figure 3 is a side sectional elevation of a gaseous type electronically operated contact.

Figure 4 is a fragmentary elevation, in part section, of a tube similar to that of Figure 1, but with a different anode.

In Figure 1 tube 1 has cathode 2, perforated accelerating beam forming anode 3, and second anode 4, forming an electron gun to direct a beam of electrons along the axis of the tube, normally. Electrostatic deflection plates 5 and 6 are provided and may be flared if desired. These plates may be charged to deflect the electron beam to one side or the other of normal position. The positive terminal of potential source 7, which may be a battery or otherwise, is connected to plate 5 and the positive terminal of potential source 8 is connected to plate 6. The negative terminal of source 7 is connected by means of wire 9, to inclined conducting element 10 sealed into position and the under surface of which is preferably coated with good secondary emitting material such as barium oxide or caesium. Similarly the inclined conducting element 11 is sealed into position and its under surface is coated with good secondary emitting substance. Element 11 is connected, by means of wire 12, to the negative terminal of potential source 8. Metal electron collecting element 13 is sealed into position, being placed so that it will receive electrons ejected from element 10 but will preferably not be struck by the bombarding electron beam 15. Element 13 is connected to deflector 6 by wire 16. Electron receiving element 14 is similarly placed relative to element 11 and is connected to deflecting plate 5 by wire 17. In fact the elements 13 and 14 may be integral with the deflectors.

Target electrodes 18 and 19 are placed as shown and are connected by inductance 20 which is coupled with output inductance 21 hav-

ing leads 22 and 23. Grounded target electrode 24 may be provided to cover the space between elements 18 and 19 if desired.

In operation, cathode 2 is heated and anodes 3 and 4 are made at progressively higher potentials relative to cathode 2 by means of a battery or other source, as usual. A beam of electrons will therefore be directed down the central axis of the tube to strike electrode 24 or one of electrodes 18 or 19 as desired.

If then the electron beam is shifted to the right, by means of a starting magnetic field to shift the beam to strike one of the secondary elements or by connecting wires 12 and 17 together momentarily to charge plate 6 positively, then beam 15 will strike the under surface of element 10 so that secondary electrons will be ejected across to receiving element 13. This will cause the electrical gap between the elements to become momentarily closed so that the negative terminal of potential source 7 will be connected to plate 6 and the positive terminal of the same source will be connected to plate 5. Therefore beam 15 will be shifted quickly toward positively charged plate 5 until it strikes the under surface of element 11. Secondary electrons will then be ejected upon receiving element 14 so that this electrical gap is momentarily closed and the negative terminal of potential source 8 will then be momentarily connected to plate 5 and the positive terminal of that source remains connected to plate 6. The beam will therefore be quickly attracted back toward plate 6 until it strikes element 10 again so that the cycle will be repeated over and over again at extremely high frequency.

The rapidly shifting beam of electrons will strike first electrode 18 then electrode 19, then electrode 18 again, etc. so that high frequency oscillatory currents will be developed in inductance 20 and accordingly also in output inductance 21. The capacitance between electrodes 18 and 19 may be employed to form a resonant circuit and this capacitance may of course be increased by placing the electrodes in close proximity.

The mid-point of inductance 20 could be positively charged with respect to cathode 2 if desired, and shielding element 24 could also be positively charged instead of being grounded. The rate of oscillation of beam 15 should be timed so that it will be in tune with the resonant circuit containing inductance 20 and the electrodes 18 and 19, so that oscillations in this circuit will be maintained. The rate of oscillation

of the electron beam can be changed by varying the potential of one or both of anodes 3 and 4 or of sources 7 and 8. If desired, inductances 20 and 21 can be eliminated and electrodes 18 and 19 can be connected by a non-inductive wire out of the path of the electrode beam. In that case an anode lead can be connected to the cross wire and brought out of the tube so that the beam current itself can be used. This current will be interrupted at high frequency as the beam is oscillated.

Magnetic beam shifting can be employed but the electrostatic method is preferable. It is also desirable to arrange elements 10 and 11 so that the beam remains on electrodes 18 or 19 respectively, until one of the first named elements is struck.

The momentary charging of a deflecting plate should ordinarily impart to the electron beam a sufficient impulse to shift it across, but if it is desired to have the deflecting plates establish a beam shifting field until the beam actually strikes one or the other of elements 10 or 11, this may be accomplished by inserting small inductances 41 and 25 in the circuits as shown so that these will tend to delay the peak driving potential until the beam has gone through its reversal of direction. The under surface of elements 10 and 11 could be coated with an electron emitting substance that would tend to glow or emit for a small time after the removal of the bombarding beam.

It is not essential that secondary electrons be emitted since the electron beam can merely bridge the gap between elements 10 and 13 and between elements 11 and 14 in order to make conductive connections. Likewise the connection may be made as shown in Figure 2 in which aluminum oxide insulating plate 27 is sandwiched between thin aluminum plate 26 and a metal back plate 28. Suitable leads are connected to the front and back plates and the aluminum oxide ordinarily insulates the two. If however, a high speed electron beam bombards the aluminum plate it penetrates it and temporarily breaks down the resistance of the oxide so that a conductive connection is established.

Another method of making a conductive connection by means of a beam of electrons is shown in Figure 3. Aluminum container 29 has insulating end portions 30 and 31 sealing the container. Electrodes 32 and 33 pass through these insulators and make contact with an ionizable gas such as helium, mercury vapor, or the like, sealed in container 29. Then if an electron beam bombards container 29 and passes through the aluminum wall it will ionize the gas and so will establish a conductive connection between electrodes 32 and 33. Furthermore the character and density of the gas can be so chosen that the ionization decay time will be just correct for maintaining the conductive connection until the beam has been shifted across to the other side of its path.

The above described tube can be operated at exceedingly high frequency and can produce large power output, using either the resonant circuit or the beam current itself. For the sake of clarity the connecting wires are shown outside of the tube, but it is preferable that these wires be placed inside the tube so that they will be as short as possible. Coil 20 can be grounded through a resistance to prevent the building up of excessive charges. If it is desired to bombard targets 18 and 19 to eject secondary electrons,

these secondaries can be collected by element 24 or similar elements grounded or positively charged.

Since there is an electrostatic field between plate 5 and element 10 and between plate 6 and element 11 grounded screen 34 placed as shown may be employed to remove the effects of these fields so that the electron beam will be affected largely by the field between plates 5 and 6. Shielding screen 34 may be placed in the position shown, or along the axis of the tube, or separate shields may be placed near elements 9 and 10. These elements or any other parts of the tube which tend to accumulate charges may be grounded through high resistances to allow electrons to flow to or away from them as the case may be.

As shown in Figure 4, extra potential may be applied between element 11 and electrode 14 by connecting the positive terminal of battery 35 to electrode 14 and the negative terminal to element 11, through high resistance or impedance 42. This furnishes an extra driving potential to carry electrons across the gap. A similar potential may be applied between element 10 and electrode 13.

The anode 36 for receiving electrons from the beam may have end arms 37 and 38 with grounded shield 39 between them so that a fluctuating contact of the beam with anode 36 will result as the beam vibrates back and forth. The high frequency current can then be taken off through lead 40, the other connection being made to the cathode not shown. Anode 36 will be positively charged, with respect to the cathode, by a suitable potential source.

The word "beam" as used in the specification and claims denotes a stream of electrons of any desired cross sectional shape and not necessarily a narrow pencil of electrons.

What I claim is:

1. An electronic tube comprising, a cathode, means for forming a beam of electrons from said cathode, a pair of electrostatic beam shifting elements one on either side of the normal path of said beam, an electronically operated circuit closing element on one side of the normal path of said beam, a second electronically operated circuit closing element on the opposite side of the normal path of said beam, said elements being adapted to be struck alternately by said beam to close normally open circuits energizing said beam shifting elements alternately so that said beam is automatically shifted back and forth between said circuit closing elements, and means for collecting electrical impulses from said beam.

2. An electronic tube comprising, a cathode, electron beam forming means, beam shifting means, means to receive electrons from said beam, a potential source one terminal of which is normally disconnected from said beam shifting means, and means adapted to be struck by said beam to apply potential difference from said source to said beam shifting means to cause reversal of direction of shift of said beam.

3. An electron tube comprising, a cathode, electron beam forming means, beam shifting means, means for collecting electrons from said beam, a potential circuit normally open to prevent application of potential difference from a potential source to said beam shifting means, and means adapted to be struck by said beam to apply potential difference from said source to said beam shifting means, said potential circuit being separate from said cathode.

4. An electron tube comprising, a cathode, elec-

tron beam forming means, electron collecting means, a pair of beam shifting elements one on either side of the normal axial path of said beam, a source of potential associated with but normally disconnected from one of said elements 5 another source of potential associated with but normally disconnected from the other said element, means adapted to be struck by said beam to close a circuit to apply potential from one of said sources to one of said beam shifting elements, and means adapted to be struck by said beam to close another circuit to apply potential from said other source to said other beam shifting element.

5. An electron tube comprising, a cathode, electron beam forming means, electron collecting means, a pair of electrostatic beam shifting elements one on either side of the axial path of said beam, a potential source normally disconnected from one of said elements, another potential source normally disconnected from said other element, means on one side of the axial path of said beam for closing the circuit of said one potential source to one said element when said circuit closing means is struck by said beam, and other means on the opposite side of the axial path of said beam for closing the circuit of said other potential source to said other beam shifting element when said other circuit closing means is struck by said beam.

6. An electron tube comprising, a cathode, electron beam forming means, electron collecting means, a beam shifting element on one side of said beam, another beam shifting element on the opposite side of said beam, a source of potential one terminal of which, of chosen polarity, is connected to one of said elements, another source of potential a terminal of which of similar polarity is connected to the other said element, the

other terminal of said first named source being connected with electronically operated means adapted to establish electrical connection with said other element when said electronically operated means is struck by said beam, and the other terminal of said other source being connected with other electronically operated means adapted to establish electrical connection with said first named element when said other electronically operated means is struck by said beam.

7. An electron tube comprising, a cathode, electron beam forming means, electron collecting means, a beam shifting element on one side of said beam, another beam shifting element on substantially the opposite side of said beam, said elements being normally electrically disconnected from each other, means for producing potential difference, and means adapted to be struck alternately by said beam to apply alternately opposite potential to said elements to cause alternately opposite shifting of said beam.

8. An electronic tube comprising, a cathode, electron beam forming means, electron collecting means, a pair of beam shifting elements one on either side of said beam, a pair of secondary emitting elements one on either side of the mid path of said beam, an electron collector for one of said secondary emitting elements, an electron collector for the other said secondary emitting element, a pair of potential sources, and means associating said potential sources with said secondary emitting elements, said electron collectors, and with said beam shifting elements so that alternately opposite potential is applied to said beam shifting elements as said beam automatically vibrates to strike said secondary emitting elements alternately.

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