

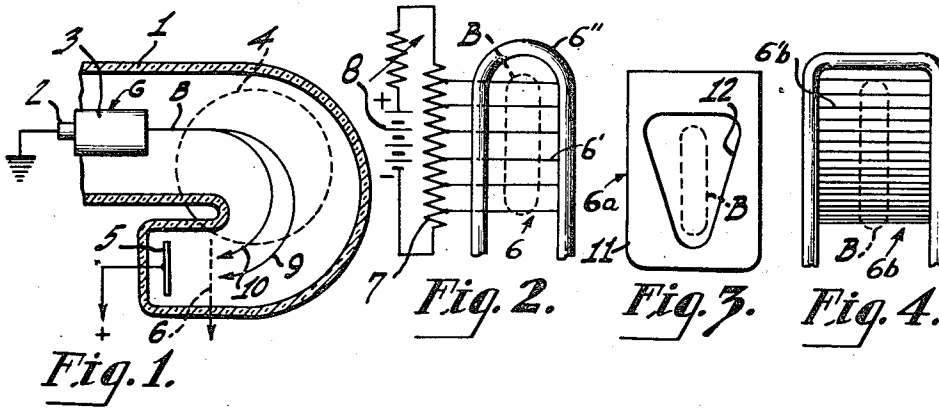
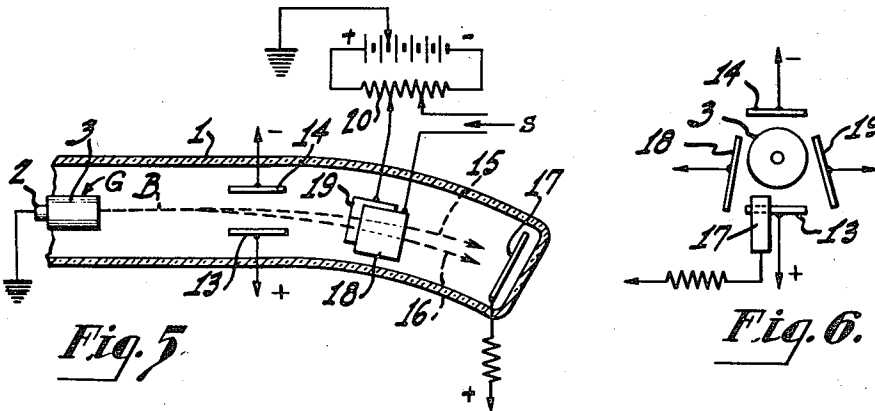
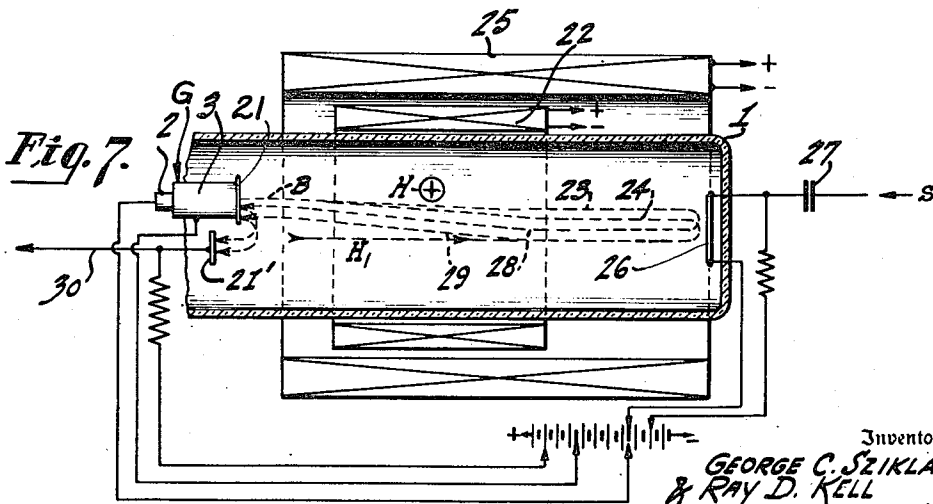
Aug. 7, 1951

G. C. SZIKLAI ET AL

2,563,197

TUBE WITH ELECTRON VELOCITY COMPENSATION

Filed Sept. 19, 1946



Inventors
 GEORGE C. SZIKLAI
 & RAY D. KELL
 By William A. Zaluski
 Attorney

UNITED STATES PATENT OFFICE

2,563,197

TUBE WITH ELECTRON VELOCITY
COMPENSATIONGeorge C. Sziklai and Ray D. Kell, Princeton,
N. J., assignors to Radio Corporation of Amer-
ica, a corporation of Delaware

Application September 19, 1946, Serial No. 697,994

1 Claim. (Cl. 313-75)

1

This invention relates to electron tubes in which the emission velocities have finite distribution. In a triode, or other tube having one or more control electrodes, the transconductance is limited, due to the finite velocity distribution of the electrons produced by the cathode inherently emitting electrons at a range of velocities so that the high and low velocity electrons require different grid voltages to bar or identically control their passage to the anode or other electrode. In Hartley, 1,542,386, an attempt was made to control all electrons emitted from a filamentary cathode uniformly in spite of the different potentials of the filament but this will not work with a unipotential cathode which is now almost universally used in amplifier tubes, and even in filament type tubes it compensates for the filament voltage drop only and not for the Maxwellian distribution of velocities.

It is an object of this invention to sort the electrons of a tube according to their velocities and apply compensating controls to increase the transconductance.

Another object of the invention is to velocity sort electrons by means of magnetic or electrostatic fields and apply compensating controls thereto for utilization of electrons of all velocities.

Other objects will appear in the following description, reference being had to the drawings, in which:

Fig. 1 is a diagrammatic illustration of one form of our invention utilizing magnetic velocity sorting means;

Figs. 2, 3 and 4 illustrate different forms of compensating controls;

Fig. 5 is a modified form of the invention employing electrostatic velocity sorting means;

Fig. 6 is an end view of the electrodes of the tube of Fig. 5; and

Fig. 7 is another form of the invention employing magnetic velocity sorting means with an electron mirror control.

Referring to Fig. 1 of the drawings, the tube shown comprises an evacuated envelope 1 containing a gun G consisting of cathode 2, first anode 3 and a control grid (not shown). Because of its well known construction the details of the gun are not shown herein but an illustration and description of the gun may be found in the application of Paul K. Weimer, filed September 16, 1944, Serial No. 554,494, now United States Patent No. 2,433,941, dated January 6, 1948.

2

The tube envelope is bent so as to provide a curved path for the electrons of beam B. A magnet 4 is positioned to produce a magnetic field at right angles to the path of the electrons and of such strength relative to the electron velocities as to cause the electrons to follow around the curved envelope with the highest velocity electrons at the outside and the lowest on the inside of the bent tube. At the end of the bent envelope is placed the plate or anode 5 for collecting the electrons. Adjacent the anode is placed a velocity compensating control electrode or grid 6 that may take various forms, the one illustrated being shown more clearly in Fig. 2. This grid has equally spaced equipotential wires 6' in a glass frame 6'' the wires being connected to a potentiometer resistance 7 fed by a potential source such as a battery 8. The grid may have a suitable negative bias, not shown, in respect to the cathode of the gun G.

In Fig. 1 the electrons are inherently emitted from the cathode at a range of velocities and they are deflected in circular paths by the magnetic lines of the field produced by magnet 4, the diameters of the circles varying with the electron velocities, the highest velocity electrons taking path 9 of greatest diameter and those of lowest velocity taking the path 10 of least diameter. Those of intermediate velocity take paths in between paths 9 and 10. The wires of the grid 6 in the path of the electrons of lowest velocity such as 10 have the highest potential (less negative) and the wires in the path of the highest velocity electrons have the lowest potential (most negative). These potentials are adjusted so that all electrons pass the grid and strike the anode 5. Thus, with my improved tube all electrons emitted by the cathode are velocity sorted by the magnetic field and utilized by the compensating means 6.

Instead of using the grid shown in Fig. 2, one may use other forms such as shown in Figs. 3 and 4. In Fig. 3 the compensation is produced by control electrode 6a in the form of a plate 11 having a triangular slot 12 so that the negative field at the base of the slot has least, and that at the apex has greatest, repelling action due to the field distribution.

In Fig. 4 the field of grid 6a is less negative in the path of the lowest velocity electrons and most negative in the path of the highest velocity electrons due to the difference in spacing of the grid wires 6'b.

In the modification of Fig. 5, the gun G pro-

jects the beam into an electrostatic field produced by plates 13 and 14 which are connected to a direct current power supply. The highest velocity electrons emitted from the cathode of the gun are deflected least as indicated by path 15 and those of lowest velocity are deflected the most as at path 16. The electrons of the beam, thus velocity sorted, are caused to land on the anode or plate 17 in accordance with the signal voltage S applied across the deflecting plates 18 and 19. To provide equal deflection of all the velocity sorted electrons the plates 18 and 19 are tilted toward each other at the proper angle (Fig. 6) which may be found by calculation of the velocities and electric field strengths. This produces the strongest deflecting field for the highest velocity electrons and the weakest for the lowest velocity electrons with proportionate fields for the electrons of intermediate velocities, thus providing uniform angular deflection. The plate 17 may be positioned with one side approximately in the vertical plane (as shown in Fig. 6) of the beam B and the bias resistor 20 in the signal circuit so adjusted that the beam just fails to land on the plate with no signal present. When the signal comes in, the electrons land on the plate and are utilized regardless of their difference in velocity because they are velocity sorted and have applied signal fields of proper value, the fastest electrons having greatest applied deflecting force and the slowest electrons having the least applied deflecting force. Since the beam has material thickness the number of electrons landing on the anode is proportional to the deflection. The output of the tube therefore may be made to vary with the deflection.

In Fig. 7, the envelope 1 is broken away as in the other figures at one end, and at this end a multiplier dynode 21 is shown on the end of the first anode 3. This is illustrative only and a multiplier of several stages would be used in practice. Around the envelope 1 is placed a deflecting unit 22 providing a magnetic field H perpendicular to the beam projected from the gun G and also perpendicular to the plane of the drawing. This field sorts the fast and slow electrons of the beam at 23 and 24 respectively with electrons of intermediate velocity in between. The beam electrons before entering and after leaving the transverse field H are caused to move parallel to the tube axis, or in other desired direction, by the magnetic field H₁ of coil 25 having the magnetic flux lines preferably parallel to the beam B as it leaves the gun G. At the end of the envelope 1 opposite the gun is placed an elongated resistive electron mirror 26 made to have a drop in potential from the bottom to the top, as shown in Fig. 7, so that the electrons of the beam all land on the mirror when no signal voltage is impressed there-

on. Those electrons emitted from the cathode 2 of the gun G with lowest velocity land on the points of the mirror having cathode potential and those of higher emission velocity land at points of the mirror having correspondingly lower potentials. This drop in potential along the mirror length may be obtained by giving it a suitable resistance and connecting it to the source of supply as indicated in Fig. 7. When the signals S come in through condenser 27 the potential gradient in the mirror is altered and more or less of the beam electrons are reflected as at 28 and 29 and accelerated to the dynode 21 of the electron multiplier. The secondary electrons are collected at 21' and passed by conductor 30 to amplifiers or other utilization circuits. As stated the single stage multiplier is intended to be symbolic only and a multi-stage multiplier would be used in practice, for example, like that shown in said Weimer application.

In the drawings cathode ray beam guns have been shown for producing the electrons but this is by way of example only. The electrons may be produced by cathodes such as used in triode or multi-grid amplifiers and velocity sorted and controlled as herein disclosed. Various other modifications may be made without departing from the spirit of the invention.

What we claim as new is:

An electron tube comprising means for producing a beam of electrons having an inherent range of velocities, means for producing a magnetic field transverse to the beam for sorting the electrons into positions according to their velocities, and electrode means comprising a series of transversely-disposed, equally-spaced, equipotential, grid wires extending across said beam in the plane of sorting and means connected to said wires for establishing a potential gradient along said series for applying different electrostatic forces to the sorted electrons to produce the same effect on all the electrons irrespective of their differences in velocities.

GEORGE C. SZIKLAI.
RAY D. KELL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,349,011	Smith	May 16, 1944
2,442,848	Gardner	June 8, 1948

OTHER REFERENCES

"Orbital-Beam U-H-F Tubes" by R. M. Smith from "Electronics" of May 1945, pages 103, 104, 105.