

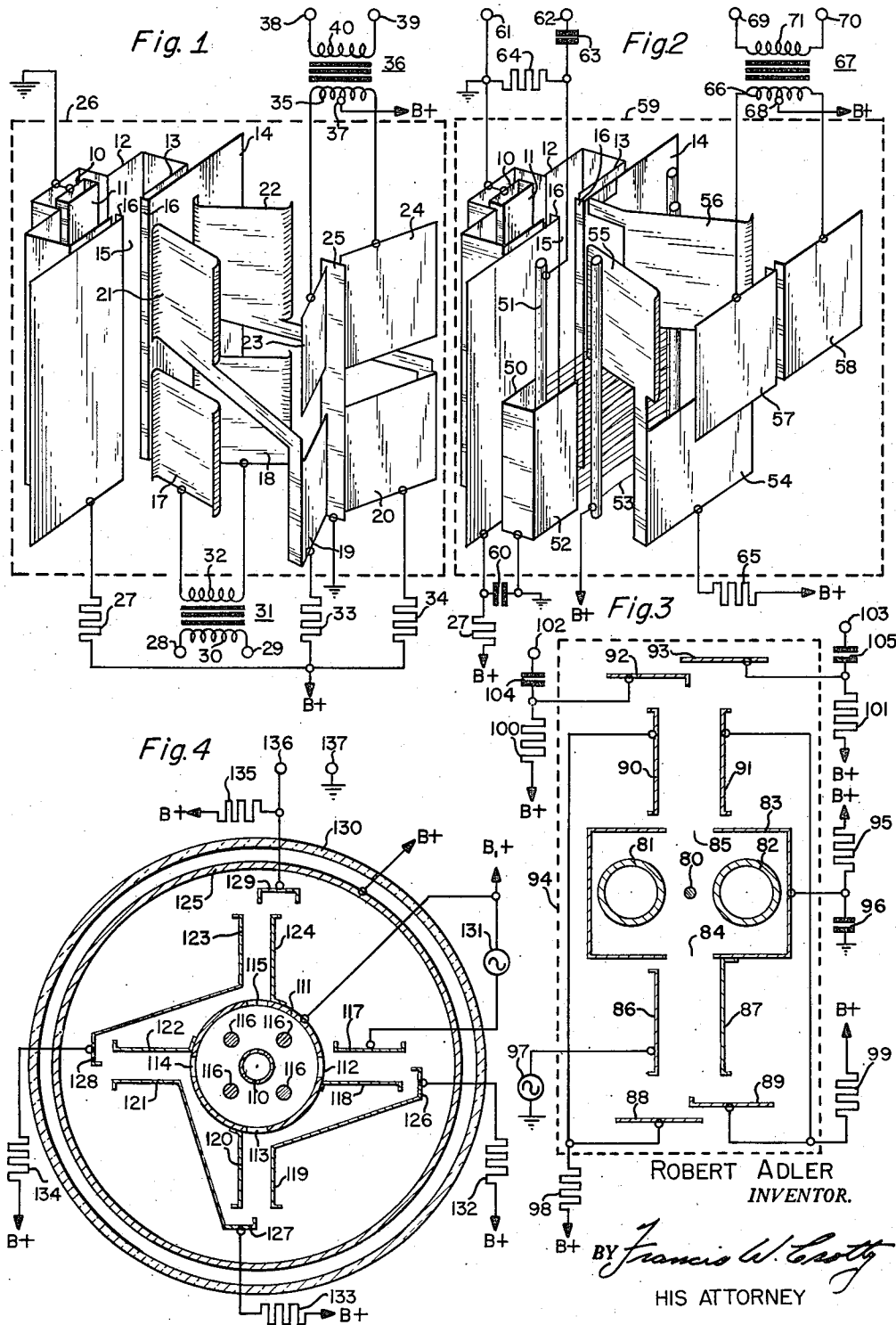
Oct. 21, 1952

R. ADLER

2,615,142

DEFLECTION CONTROL ELECTRON DISCHARGE DEVICE

Filed Jan. 19, 1950



## UNITED STATES PATENT OFFICE

2,615,142

DEFLECTION CONTROL ELECTRON  
DISCHARGE DEVICERobert Adler, Chicago, Ill., assignor to Zenith  
Radio Corporation, a corporation of Illinois

Application January 19, 1950, Serial No. 139,403

6 Claims. (Cl. 315-13)

1

This invention relates to electron-discharge devices and more particularly to such devices of the deflection-control type.

Deflection-control amplifiers as such are well known in the art, and it is conventional to provide amplification of an input signal by deflecting a formed electron beam between a pair of anodes in accordance with that signal. It is not generally possible to obtain with a deflection-control system amplification comparable to that obtainable with a control system comprising a conventional intensity-control grid, and for this reason, deflection-control is commonly utilized only in certain specialized applications. However, deflection-control affords certain well known advantages over intensity-control, as for example, in push-pull or balanced circuit arrangements.

In order to obtain the advantages of deflection-control while increasing the obtainable amplification, it is known to arrange a plurality of deflection-control systems in cascade along the path of a single formed electron beam and to connect the output electrodes of each system to the input electrodes of the succeeding system. This scheme may not be carried out indefinitely, however, due to the difficulty of collimating an electron beam over a long path.

It is, therefore, a primary object of the present invention to provide an improved multi-stage deflection-control electron-discharge device.

It is a further object of the invention to provide an improved deflection-control electron-discharge device which affords the advantages of prior-art arrangements while avoiding one or more of their disadvantages.

An electron-discharge device constructed in accordance with the present invention comprises an electron gun including a cathode and an accelerating electrode for projecting a plurality of formed electron beams. A first control system, comprising electrodes positioned along the path of one of the beams, includes an intensity-control grid followed by an anode, and a second control system, comprising electrodes positioned along the path of another of the beams, includes a deflection-control electrode which is electrically connected to the anode of the first system. Preferably, the anode of the first system is integrally constructed with the deflection-control electrode of the second system.

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood, however, by

2

reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals indicate like elements, and in which:

5 Figure 1 is a perspective view of the internal construction of an electron-discharge device, together with a schematic representation of its circuit connections;

10 Figure 2 is a similar view of another embodiment of the invention, and

Figures 3 and 4 are cross-sectional views of further embodiments of the invention together with schematic representations of their circuit connections.

15 In Figure 1, an electron-discharge device comprises an electron gun including an elongated cathode 10 having an emissive surface 11, an auxiliary electrode 12 electrically connected to cathode 10 and having portions substantially coplanar with emissive surface 11, a focussing electrode 13 having a slot opposite emissive surface 11, and an accelerating electrode 14 having a slot 15 bounded by a pair of opposed lips 16 extending into the slot of focussing electrode 13, substantially as disclosed and claimed in the copending application of Robert Adler, Serial Number 68,285, filed December 30, 1948, now U. S. Patent No. 2,559,037, issued July 3, 1951, for Electron-Discharge Devices of the Focussed-Beam Type, and assigned  
20  
25  
30 to the present assignee.

A first control system, comprising electrostatic-deflection electrodes 17 and 18 and a pair of anodes 19 and 20, is positioned along the path of the lower transverse portion of the electron  
35 beam emerging from slot 15 of accelerating electrode 14, anodes 19 and 20 having active portions on opposite sides of that path. A second similar control system, comprising electrostatic-deflection electrodes 21 and 22 and a pair of anodes  
40 23 and 24, is positioned along the path of the upper transverse portion of the beam projected through slot 15 of accelerating electrode 14. A suppressor electrode 25, which may conveniently be grounded, is disposed between the anodes of  
45 each system in order to suppress secondary electron emission in a manner well known to the art.

Anodes 19 and 20 of the first electrode system are electrically connected respectively to electrostatic-deflection electrodes 21 and 22 of the second system; preferably, this electrical connection is accomplished by integrally constructing anode  
50 19 and deflection electrode 21, and anode 20 and deflection electrode 22, as by forming each of these pairs of electrodes from a single sheet-metal stamping.

The entire electrode structure is supported within an evacuated envelope, indicated schematically at 26, which may be evacuated, gassed, and based in any convenient known manner.

Cathode 10, auxiliary electrode 12, focussing electrode 13 and suppressor electrode 25 are connected to ground. Accelerating electrode 14 is connected to a suitable source of positive unidirectional operating potential, conventionally designated B+, through a resistor 27. An input signal is applied from any suitable source (not shown) between a pair of input terminals 28 and 29 at opposite terminals of the primary winding 30 of an input transformer 31, and the secondary winding 32 of input transformer 31 is connected between electrostatic-deflection electrodes 17 and 18. Anodes 19 and 20 are connected to B+ through resistors 33 and 34 respectively, and anodes 23 and 24 are connected to opposite terminals of the primary winding 35 of an output transformer 36, a center tap 37 of primary winding 35 being connected to B+. A pair of output terminals 38 and 39 are provided across the secondary winding 40 of output transformer 36.

In operation, cathode 10, auxiliary electrode 12, focussing electrode 13 and accelerating electrode 14 cooperate to project a formed sheet-like electron beam of substantially rectangular cross-section in the manner described in detail in the above-identified Adler application. The lower portion of the beam is projected between electrostatic-deflection electrodes 17 and 18 and is transversely deflected in accordance with the input signal applied between terminals 28 and 29. An amplified signal is thereby produced between anodes 19 and 20 in a manner well known in the art.

Anodes 19 and 20 are electrically connected respectively to the electrostatic-deflection electrodes 21 and 22 associated with the upper portion of the beam. This portion of the beam is thereby deflected in accordance with the amplified signal appearing between anodes 19 and 20, and a further amplification is effected at anodes 23 and 24. The output signal appearing between output terminals 38 and 39 may be applied to further amplifying and/or utilizing means (not shown).

Thus, in effect, a pair of electron beams are projected from cathode 10 and are separately controlled by electrostatic-deflection electrodes 17, 18 and 21, 22 respectively. A first amplification of the input signal is effected in the lower electrode system, and the amplified signal is utilized as the input to the second or upper electrode system. Consequently, two stages of amplification are effected within a single device. The arrangement has the advantage, however, over known arrangements in which the deflection-control systems are arranged in cascade along the path of a single electron beam, that the amplified signal obtained at the output of the first system is utilized to control a separate and distinct portion of the electron emission with a result that detrimental defocussing effects are avoided.

In Figure 2, representing an embodiment of the invention, intensity-control is utilized in the first system and deflection-control in the second. The first control system comprises a second focussing electrode 50, an intensity-control grid 51, a third focussing electrode 52, a screen grid 53, and an anode 54. Preferably, in order

to obtain maximum transconductance of control grid 51, the distance between slot 15 of accelerating electrode 14 and control grid 51 is made greater than the width of slot 15, as disclosed and claimed in the copending application of Robert Adler, Serial No. 7,864 filed February 12, 1948, for Electron-Discharge Devices, now U. S. Patent 2,511,143 dated June 13, 1950, and assigned to the present assignee. Third focussing electrode 52 and screen grid 53 constitute a convergent electron lens for refocussing electrons passed by control grid 51 in the manner described in the first-mentioned copending Adler application.

The second electrode system, positioned along the path of the upper transverse portion of the beam projected through slot 15, comprises a pair of electrostatic-deflection electrodes 55 and 56 and a pair of anodes 57 and 58 which have active portions on opposite sides of, and are preferably positioned symmetrically with respect to, the path of the beam. In accordance with the invention, anode 54 is electrically connected to electrostatic-deflection electrode 55, and electrode 56 is electrically connected to accelerating electrode 14. Preferably, anode 54 and deflection electrode 55 are integrally formed from a single piece of sheet-metal to provide the desired electrical connection. The electrode structure is supported within an evacuated envelope schematically represented at 59.

Cathode 10, auxiliary electrode 12, and focusing electrodes 13, 50, and 52 are all connected to ground, and accelerating electrode 14 is connected to B+ through resistor 27 and to ground through a condenser 60. A pair of input terminals 61 and 62, respectively connected to ground and coupled to control grid 51 by means of a condenser 63, are provided, and control grid 51 is returned to ground through a resistor 64. Screen grid 53 is directly connected to B+ or alternatively to accelerating electrode 14, and anode 54 is connected to B+ through a resistor 65. Anodes 57 and 58 are connected to opposite terminals of the primary winding 66 of an output transformer 67, a center tap 68 on primary winding 66 being connected to B+. Output terminals 69 and 70 are provided across the secondary winding 71 of output transformer 67.

In operation, an input signal applied between terminals 62 and 61 from any suitable source (not shown) effects intensity-control of the lower transverse portion of the electron beam projected through slot 15 in the manner described in the above-identified Adler applications. An amplified signal is therefore produced at anode 54. This amplified signal is applied directly to electrostatic-deflection electrode 55 by virtue of the internal electrical connection between these electrodes, and resistors 27 and 65 are made equal to maintain the average potentials of electrostatic-deflection electrodes 55 and 56 at a common value. Consequently, the amplified signal produced at anode 54 effects a corresponding transverse deflection in the upper portion of the beam, and an amplified output signal appears between terminals 69 and 70.

In the embodiment of Figure 3, the electron gun comprises a straight filamentary cathode 80 flanked by a pair of substantially cylindrical beam-forming electrodes 81 and 82. An accelerating electrode 83 having apertures 84 and 85 is provided to produce a positive potential gradient adjacent cathode 80 (near but not directly at the surface of the cathode) in a direction substan-

tially perpendicular to a plane including the axes of beam-forming electrodes 81 and 82. Preferably, beam-forming electrodes 81 and 82 are individually constructed of a diameter of substantially 60% of their center-to-center spacing and are operated at a potential near that of cathode 80; for convenience, cathode 80 and beam-forming electrodes 81 and 82 may all be operated at substantially ground potential. The electron gun, comprising cathode 80, beam-forming electrodes 81 and 82, and accelerating electrode 83, functions to project a pair of oppositely directed electron beams through apertures 84 and 85 respectively.

A first control system, positioned along the path of the beam projected through aperture 84, comprises a pair of electrostatic-deflection electrodes 86 and 87, the latter being directly connected to accelerating electrode 83. A pair of anodes 88 and 89 are provided with active portions on opposite sides of the path of the beam in a manner well known in the art.

A second control system, comprising electrostatic-deflection electrodes 90 and 91 and anodes 92 and 93, is positioned along the path of the beam projected through aperture 85. In accordance with the invention, anodes 88 and 89 are electrically connected respectively to electrostatic-deflection electrodes 90 and 91. The entire electrode structure is supported within an evacuated envelope schematically represented at 94.

Cathode 80 and beam-forming electrodes 81 and 82 may conveniently be maintained at substantially ground potential, and accelerating electrode 83 is connected to B+ through a resistor 95 and to ground through a bypass condenser 96. An input signal source 97 is connected between electrostatic-deflection electrode 86 and ground, and anodes 88 and 89 are connected to B+ through resistors 98 and 99 respectively. Anodes 92 and 93 are coupled to B+ by means of resistors 100 and 101 respectively, and a pair of output terminals 102 and 103 are coupled to anodes 92 and 93 respectively by means of condensers 104 and 105.

In operation, the electron beam projected through aperture 84 is deflected in accordance with the input signal from source 97, and the amplified signal appearing between anodes 88 and 89 is applied between deflection electrodes 90 and 91, associated with the beam projected through aperture 85. An amplified output signal is therefore developed between anodes 92 and 93.

In the embodiment of Figure 4, the electron gun comprises a centrally located cathode 110, preferably cylindrical, and an accelerating electrode positioned substantially concentrically with respect to cathode 110. Accelerating electrode 111 is provided with four equally spaced similar slots 112, 113, 114, and 115, and focussing electrodes 116 are provided between slots 112-115 and cathode 110. Cathode 110 is provided with a heater element (not shown) and is preferably operated at a common potential with focussing electrodes 116. Accelerating electrode 111 may conveniently be formed as a solid cylinder from which material has been removed to provide the desired number of slots or apertures.

A pair of electrostatic-deflection electrodes 117 and 118 are disposed on opposite sides of the path of the beam projected through slot 112; similarly, electrostatic-deflection electrodes 119, 120, 121, 122; and 123, 124 are positioned on opposite sides of the paths of the respective

beams projected through slots 113, 114, and 115. A final anode 125, which may conveniently be of cylindrical configuration, is substantially concentrically disposed with respect to cathode 110, and intercepting anodes 126, 127, 128, and 129 are interposed between final anode 125 and the respective pairs of electrostatic-deflection electrodes to intercept the respective beams upon deflection thereof in one transverse direction. Deflection electrodes 118, 120, 122, and 124, constituting one of each pair, are electrically connected to accelerating electrode 111 for operation at a common potential therewith.

Deflection electrode 117, associated with the beam projected through slot 112, serves as an input electrode, while intercepting anode 129, associated with the beam projected through slot 115, constitutes a convenient output electrode. Each of the other intercepting anodes, in accordance with the present invention, is electrically connected to the remaining electrostatic-deflection electrode of the next system; in other words, intercepting anode 126 is electrically connected to deflection electrode 119, intercepting anode 127 to deflection electrode 121, and intercepting anode 128 to deflection electrode 123. Preferably, each of these electrical connections is effected by constructing the parts to be connected of a unitary piece of sheet metal.

The entire electrode structure is supported within an evacuated envelope 130 in any convenient manner.

Cathode 110 and focussing electrodes 116 are preferably operated at ground potential, and final anode 125 is connected to B+. Accelerating electrode 111 is connected to a source B1+ of a lower positive unidirectional operating potential than that of source B+. An input signal source 131 is connected between electrostatic-deflection electrode 117 and B1+, and intercepting anodes 126, 127, 128, and 129 are connected to B+ through resistors 132, 133, 134, and 135 respectively. Output terminals 136 and 137 are connected respectively to intercepting anode 129 and to ground.

In operation, resistors 132, 133, and 134 are equal in magnitude and of such size as to maintain deflection electrodes 119, 121, and 123 at an average potential equal to that of source B1+. The input signal from source 131, applied to deflection electrode 117, transversely deflects the electron beam projected through slot 112 so that an amplified signal appears at intercepting anode 126. This amplified signal is utilized as the input signal to the next system, and further amplification is progressively accomplished by means of the successive control of the electron beams projected through slots 113, 114, and 115. Thus, four stages of deflection-control amplification are accomplished within a single envelope, the final output signal appearing between terminals 136 and 147. Of course, a larger or smaller number of stages may be included within the structure as desired, and the arrangement may be adapted for push-pull operation at the expense of greater complexity of construction.

Thus, the invention provides a new and improved type of deflection-control electron-discharge device comprising at least two control systems, at least one of which is of the deflection-control type, which are arranged in cascade with respect to the signal to be amplified but in parallel with respect to a common electron source. Thus, each pair of deflection-control electrodes operates on a well-formed electron beam, and

the detrimental defocussing effects of prior-art arrangements are avoided.

While particular embodiments of the present invention have been shown and described, it is apparent that various changes and modifications may be made, and it is therefore contemplated in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. An electron-discharge device comprising: an electron gun including a cathode and an accelerating electrode for projecting a plurality of formed electron beams; a first control system comprising electrodes positioned along the path of one of said beams and including an intensity-control grid followed by an anode; and a second control system comprising electrodes positioned along the path of another of said beams and including a deflection-control electrode electrically connected to said anode.

2. An electron-discharge device comprising: an electron gun including a cathode and an accelerating electrode for projecting a plurality of formed electron beams; a first control system comprising electrodes positioned along the path of one of said beams and including an intensity-control grid followed by an anode; a second control system comprising a pair of electrostatic-deflection electrodes positioned on opposite sides of the path of another of said beams; and means electrically connecting one of said electrostatic-deflection electrodes with said anode.

3. An electron-discharge device comprising: an electron gun including a cathode and an accelerating electrode for projecting a plurality of formed electron beams; a first control system comprising electrodes positioned along the path of one of said beams and including an anode; a second control system comprising a pair of electrostatic-deflection electrodes positioned on opposite sides of the path of another of said beams; and means electrically connecting one of said electrostatic-deflection electrodes with said anode and the other of said electrostatic-deflection electrodes with said accelerating electrode.

4. An electron-discharge device comprising: an electron gun including a cathode and an accelerating electrode for projecting a plurality of formed electron beams; a first deflection-control system positioned along the path of one of said beams and including an anode and a pair of electrostatic-deflection electrodes; means for operating said accelerating electrode and one of

said electrostatic-deflection electrodes at a common potential; and a second deflection-control system positioned along the path of another of said beams and including a pair of electrostatic-deflection electrodes one of which is electrically connected to said anode and the other of which is electrically connected to said accelerating electrode.

5. An electron-discharge device comprising: an electron gun including a centrally located cathode and an accelerating electrode positioned substantially concentrically with respect to said cathode and having  $n$  slots for projecting  $n$  formed electron beams,  $n$  being an integer greater than unity;  $n$  pairs of electrostatic-deflection electrodes individually positioned on opposite sides of the paths of said respective beams;  $n$  intercepting anodes disposed between said final anode and said respective pairs of electrostatic-deflection electrodes for individually intercepting said respective beams upon deflection thereof in one transverse direction; means for operating one of each of said pairs of electrostatic-deflection electrodes at a common potential with said accelerating electrodes; and means electrically connecting one of said intercepting anodes with the other of the pair of electrostatic-deflection electrodes associated with a different beam.

6. In an electron-discharge device, an electron gun comprising: a rectilinear filamentary cathode; a pair of substantially cylindrical beam-forming electrodes flanking said cathode and individually having a diameter of substantially 60 per cent of the center-to-center spacing between said electrodes; and a slotted accelerating electrode for producing a positive potential gradient adjacent said cathode in a direction substantially perpendicular to a plane including the axes of said beam-forming electrodes.

ROBERT ADLER.

# REFERENCES CITED

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

## UNITED STATES PATENTS

| Number    | Name          | Date          |
|-----------|---------------|---------------|
| 2,171,490 | Dalpayrat     | Aug. 29, 1939 |
| 2,203,221 | Jonker et al. | June 4, 1940  |
| 2,254,096 | Thompson      | Aug. 26, 1941 |
| 2,332,977 | Skellett      | Oct. 26, 1943 |
| 2,456,654 | Soller        | Dec. 21, 1948 |
| 2,472,779 | Selgin        | June 7, 1949  |
| 2,516,752 | Carbrey       | July 25, 1950 |