Dec. 21, 1948. W. SOLLER 2,456,654

SECONDARY ELECTRON EMISSION TUBE

Original Filed Aug. 19, 1943 3 Sheets-Sheet 1

FIG. 1

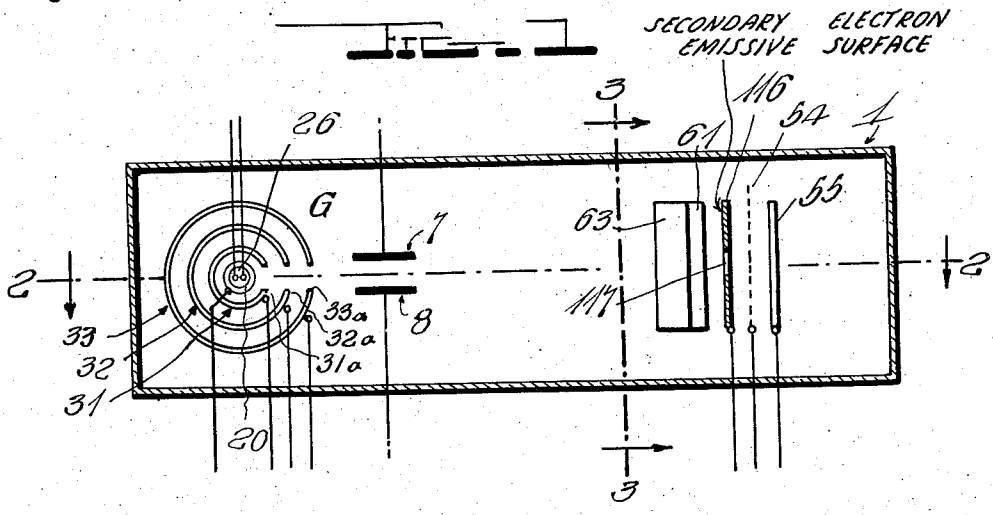
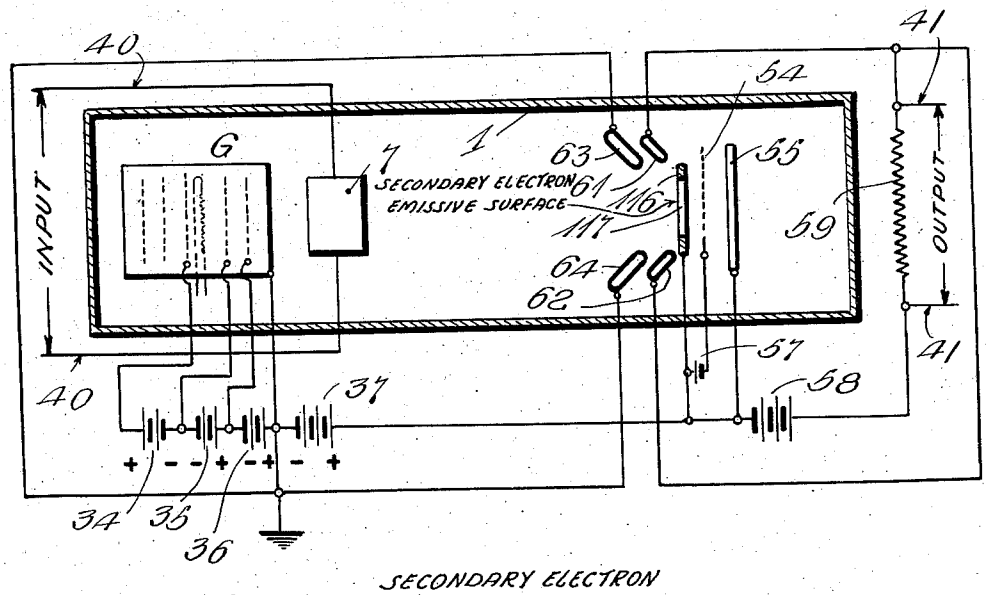


FIG. 2



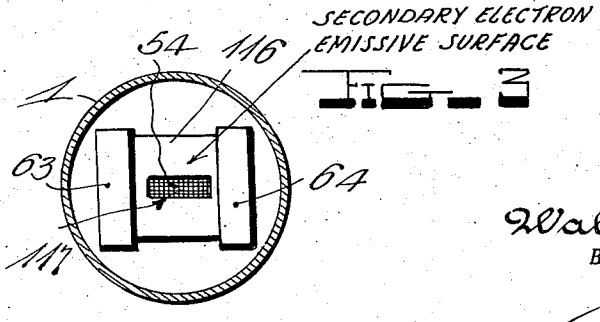


FIG. 3

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FIG. 4

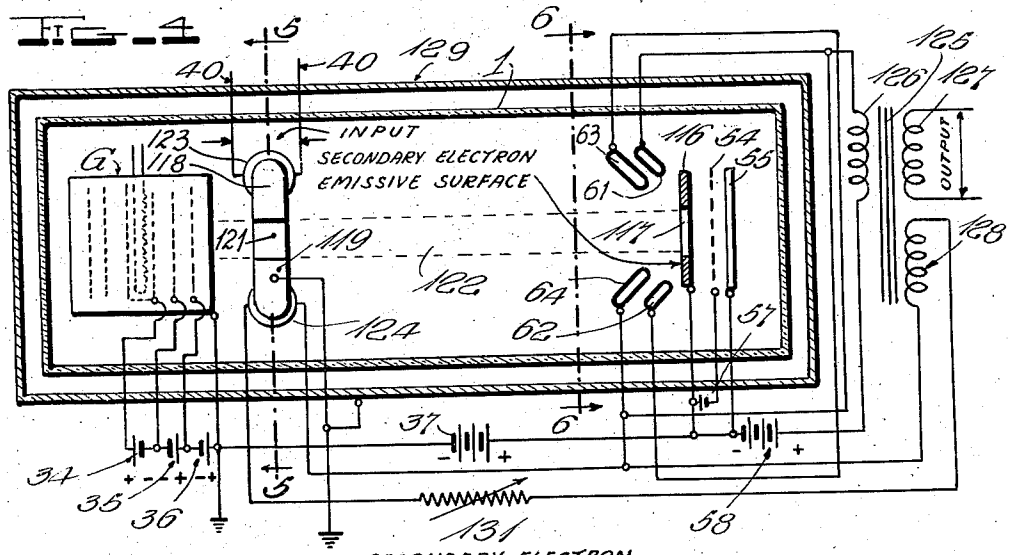


FIG. 5

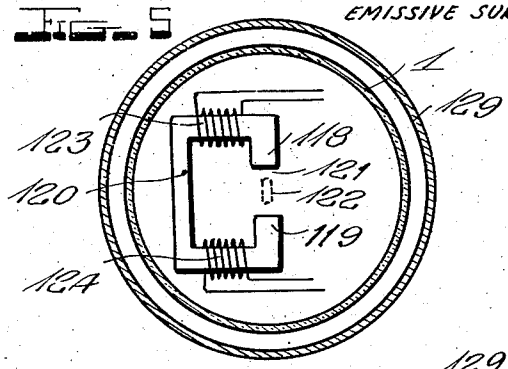
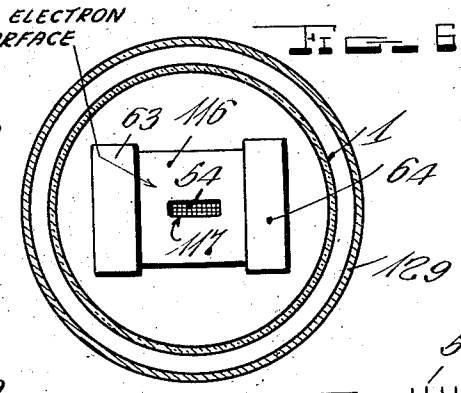


FIG. 6



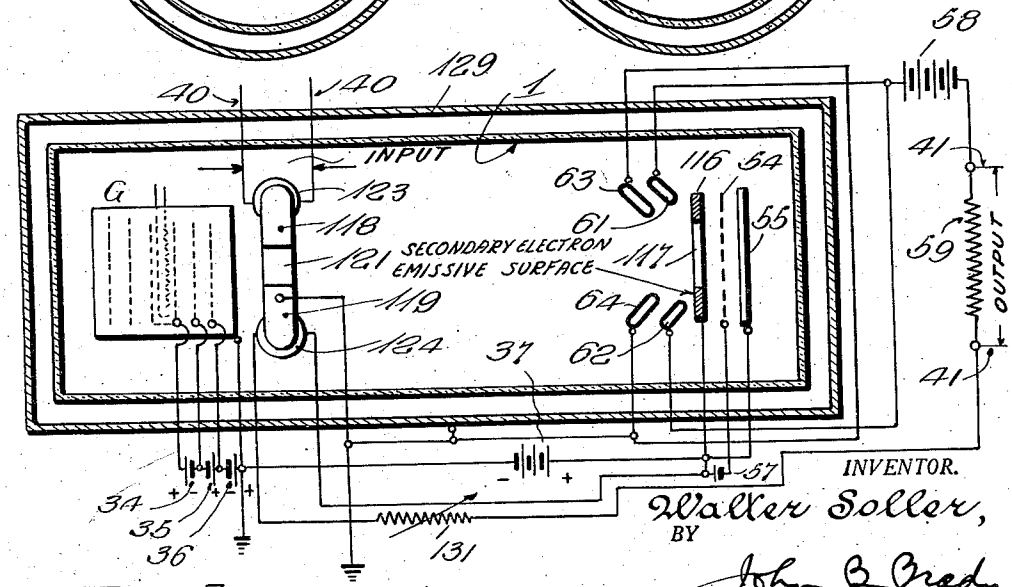


FIG. 7

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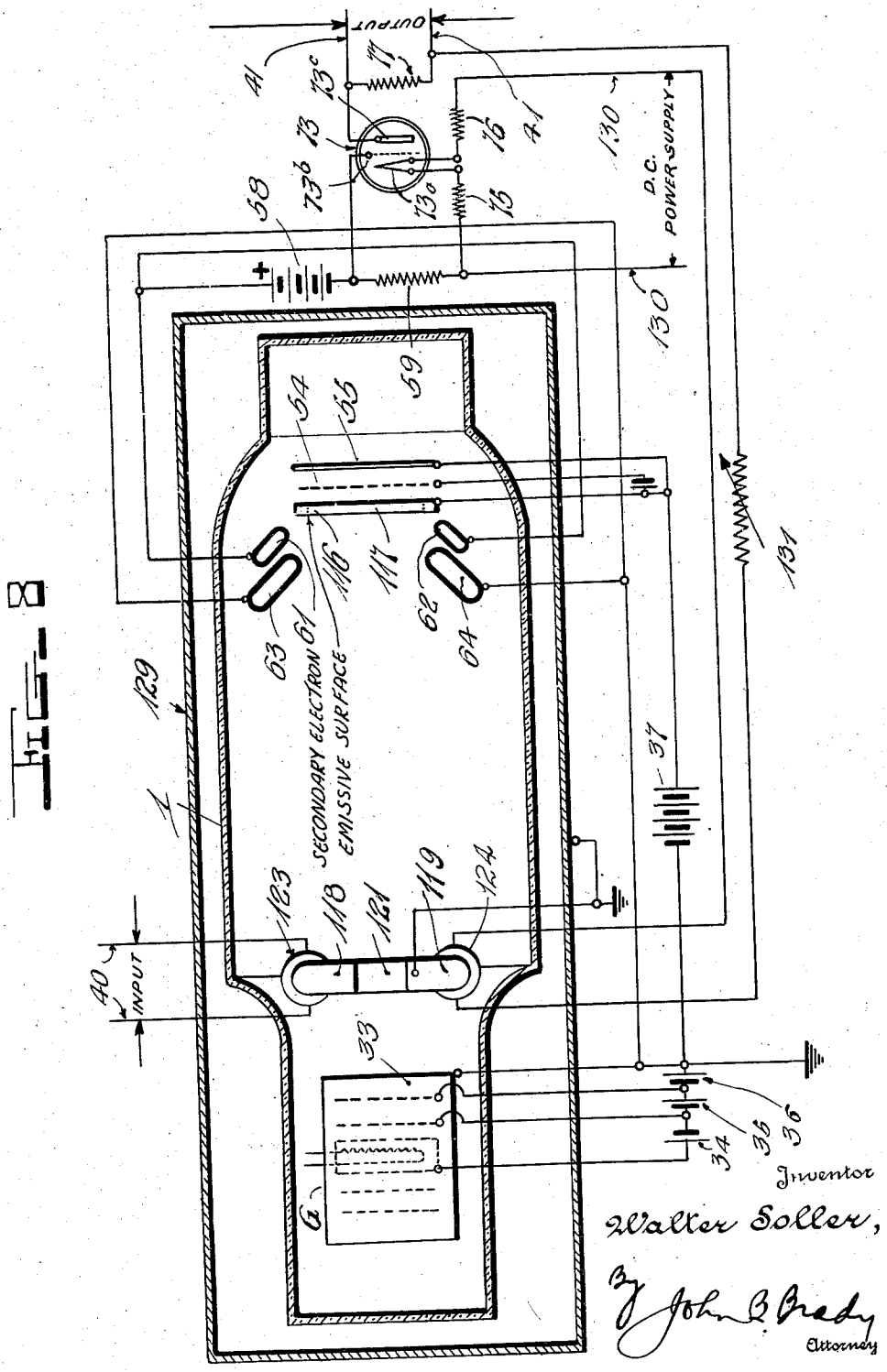


FIG. 8

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UNITED STATES PATENT OFFICE

2,456,654

SECONDARY ELECTRON EMISSION TUBE

Walter Soller, Cincinnati, Ohio, assignor of one-half to William H. Woodin, Jr., San Mateo, Calif.

Original application August 19, 1943, Serial No. 499,260. Divided and this application August 29, 1944, Serial No. 551,689

6 Claims. (Cl. 250—27)

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My invention relates broadly to electron tubes and more particularly to a deflection type of secondary electron emission tube for wide application in the electronic industry.

This application is a division of my application Serial No. 499,260, filed August 19, 1943, for Electron tube.

One of the objects of my invention is to provide a construction of deflection type secondary electron emission tube having associated input and output circuits wherein substantially complete isolation of the input from the output circuit is effected.

Another object of my invention is to provide a construction of secondary emission tube having means for directing a shaped beam of electrons against an electrode assembly of the secondary electron emission type.

Still another object of my invention is to provide an arrangement of magnetically controlled beam tube having means for directing a shaped beam of electrons against an electrode assembly of the secondary electron emission type.

A further object of my invention is to provide a magnetically controlled beam tube of the regenerative type for increasing the magnitude of the electron current through the beam tube.

Other and further objects of my invention reside in the construction and arrangement of the elements of deflection type secondary electron emission tubes as set forth more fully in the specification hereinafter following by reference to the accompanying drawings, in which:

Figure 1 is a schematic longitudinal sectional view of the secondary emission tube of my invention; Fig. 2 is a transverse sectional view of the tube taken substantially on line 2—2 of Fig. 1; Fig. 3 is a longitudinal sectional view taken on line 3—3 of Fig. 1; Fig. 4 is a schematic circuit arrangement of the magnetic control system for the secondary emission tube showing the regenerative circuit arrangement employed with the tube and the arrangement of secondary emission electrodes in transverse section; Fig. 5 is a sectional view taken substantially on line 5—5 of Fig. 4; Fig. 6 is a sectional view taken substantially on line 6—6 of Fig. 4; Fig. 7 is a schematic circuit arrangement of the beam tube of my invention connected in a direct current amplification circuit; and Fig. 8 is a schematic circuit arrangement showing the beam tube of my invention arranged in a magnetically controlled regenerative direct current amplification system.

In Figs. 1–3 I have illustrated an electron beam tube 1 of high sensitivity in which a flat electron beam of rectangular section normally passes directly through a rectangular aperture 117 in secondary electron emission plate 116 for zero input. The electron beam generator is illustrated as including the electron emitter represented generally at 20, the beam forming plates being shown at 31—32 and 33 entirely surrounding the emitter 20 with slots 31*a*, 32*a* and 33*a* in the beam forming plates registering one with the other for shaping the rectangular electronic beam. That is to say, the beam forming plates are shown at 31, 32 and 33, each including transversely extending slots indicated at 31*a*, 32*a* and 33*a*. A rectangular narrow beam is thus projected between the deflection plates 7 and 8 to bombard the secondary emission plate system.

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It will be observed that a steady potential is maintained between the cathode and the beam forming plate 31 as represented at 34 in Fig. 2. The positive terminal of the direct current source 34 connects to the cathode 20 while the negative terminal of direct current source 34 connects to beam forming plate 31. A direct current source 35 is provided with its negative terminal connected to beam forming plate 31 and its positive terminal connected to beam forming plate 32. A direct current source 36 is provided with its negative terminal connected to beam forming plate 32 and its positive terminal connected to beam forming plate 33. The circuit is completed from the positive terminal of direct current source 36 to the auxiliary plates 63 and 64 connected together and connected to the positive terminal of direct current source 36.

The auxiliary plate system is formed and shaped to eliminate sharp edges wherever a concentration of field strength exists. By shaping the auxiliary plates in elliptical section and providing coacting pairs of plates as represented at 61, 62, 63 and 64, the field strength around the plate system is rendered uniform and excessive concentrations of field strength are eliminated. As a further precautionary measure for reducing edge effects and erratic electron discharges, the plate member 55 is rounded at its edges. The auxiliary plates 63 and 64 also serve to shield the electron beam from any possible transverse field across collector plates 61 and 62. This form of tube is highly practical for use in all of the various circuit arrangements heretofore employing conventional control grid tubes with the added advantage that reactionary effects between the control system and the output circuit are substantially eliminated.

That part of the electron beam that does not strike the plate element 116 will pass through the grid electrode 54 and strike plate electrode 55 which is spacially related to grid electrode 54. The secondary electron emission from plate electrode 55 is prevented from reaching auxiliary plates 61, 62, 63 and 64 by the negative potential impressed upon grid electrode 54 from potential source 57. In order to further reduce the possibility of secondary electrons discharging from plate electrode 55 and being collected by auxiliary

electrodes 61, 62, 63 and 64, the plate 55 is constructed from a material which does not readily emit secondary electrons while plate member 116 is coated for the particular purpose of producing high secondary electron emission properties. A slight deflection of the beam produced by a small input between plates 7—8 with this construction will cause a relatively large portion of the beam to strike plate 116 causing a correspondingly large secondary emission from it. This greater sensitivity is caused by a large change in secondary emission produced by a slight change in the deflection of the beam. Potential source 37 is connected between the electron beam generator G and the secondary emission plate 116 and plate member 55 placing positive potential on the plate system and negative potential on the electron generator. A potential source 58 is connected between plate member 55 and auxiliary plates 61—62 through output resistor 59 leading to output circuit 41.

In Figs. 4, 5 and 6 I have shown a construction of tube in which a magnetic control system is employed for deflecting the beam. The magnetic control system is a coil structure 120 of magnetic alloy having pole pieces 118 and 119 terminating in a magnetic gap 121 through which an electron beam from electron beam generator G of the type heretofore explained is propagated. The magnetic control system operates to control the displacement of the electron beam. The magnetic alloy core concentrates the magnetic field to substantially the thickness of the electron beam irrespective of the size of the control windings at the gap where the magnetic circuit passes through the beam as shown more clearly in Fig. 5. The magnetic control system includes an input winding 123 connected to input circuit terminals 40 and a regenerative winding 124 which connects to the anode system as shown.

With the construction of core 120 as shown, several coils can be caused to affect the magnetic field and so better facilitate feedback and balancing arrangements with deflection beam tubes. In this circuit alternating current signal energy is employed. The output transformer 125 is arranged so that the current produced in an additional secondary coil 128 can be fed back into the independent coil 124 from that through which the input current passes. Winding 124 is wound on the core 120 of the magnetic deflecting unit. By this means an entirely independent positive or negative feedback can be obtained. The positive feedback will give greater amplification than can be produced without the feedback, while the negative feedback will produce stability of operation of the tube and circuit. Resistance 131 is provided in circuit between control winding 124 and secondary coil 128 to adjust the phase of the feedback to synchronize with the deflection of the beam. The output from the cathode system 61—62 and plate electrodes 51—55 is supplied to primary winding 126 by transformer 125 by which a portion of the energy is transferred through winding 128 to the magnetic control winding 124. Secondary winding 127 leads to the output circuit designated at 41.

Fig. 7 shows a tube that is similar to the tube of Figs. 4–6 except that it allows the feedback feature to be accomplished for D. C. current. The current in the output circuit is fed directly back through the second coil 124 of the magnetic deflecting unit through phase resistor 131. By using suitable connections and by the relative direction of the winding of the two coils 123—124 on the core either positive or negative feedback, even on D. C. operation, is obtained. Very small D. C. voltages can be amplified with this arrangement and the higher sensitivity and stability of positive and negative feedback systems can be obtained There is a decided advantage in this independence of feedback in these deflection amplifying tube systems. This circuit is adapted to thermocouple and thermopile voltage amplification as it is a voltage sensitive D. C. amplifier.

The shield 129 around the tube 1 is of high permeability material so that external electric and magnetic fields will not disturb the operation of the tube. As both shield 129 and core 120 are of high permeability material and the core 120 is entirely inside and away from the shield, the magnetic field will remain in the core 120 and thereby go through the electron beam rather than into the shield. The shield 129 and core 120 are both grounded as shown. All other forms of tubes shown in the several figures can be shielded similarly where high sensitivity is required and protection against external fields is needed.

In Fig. 8 I have shown the arrangement of the tube system of Fig. 7 with an additional direct current amplifier of the conventional type. The direct current amplifier 73 has the grid cathode circuit thereof connected to the resistance 59 in the output circuit 41 of the anode system of the deflection tube. Tube 73 includes cathode 73*a*, control grid 73*b* and anode 73*c* arranged as shown. The cathode is supplied with power from power source 130 through resistors 75 and 76. The output resistance 59 in series with potential source 58 in the output circuit of the electron beam tube connects to control grid 73*b* and cathode 73*a* through resistance 75. The output circuit of tube 73 connects from anode 73*c* through resistance 77 and to the potential source 130 as shown.

The output current of this amplifier is fed back into the second coil 124 on the magnetic deflection core 120 through phase adjusting resistor 131. The operation of the tube of Fig. 8 is similar to that shown in Fig. 7, and when negative feedback is used, even greater stability is accomplished than with that of circuit in Fig. 7. Fig. 8 is not restricted to the application of the invention to one amplifier stage but any number of stages of amplifiers and the current in the last stage is fed back into the second coil 124 of the magnetic core. The larger the amplification, the greater will be the stability. Also if it is positive feedback, this arrangement will give even greater amplification. The tube of Fig. 8 employes the principle of controlled emission in the output part of the tube in which feedback is employed.

While I have described my invention in certain preferred embodiments, I realize that modifications may be made in the arrangement and method employed and I desire that it be understood that no limitations upon my invention are intended other than may be imposed by the scope of the appended claims.

What I claim and desire and desire to secure by Letters Patent of the United States is as follows:

1. An electron discharge system comprising an electron discharge device for propagating an electron beam, means for shaping said beam into substantially rectangular section, means for controlling the angular sweep of said electron beam, a plate system disposed in the path of said electron beam comprising a plate electrode containing

a substantially rectangular slot for the passage of said electron beam in central position a secondary electron emitting coating carried by said plate electrode throughout the area surrounding the slot therein, a grid electrode disposed rearwardly of said plate electrode and maintained at negative potential with respect to the aforesaid plate electrode, a plate electrode disposed behind the aforesaid grid electrode and maintained at positive potential with respect to said grid electrode, secondary electron collecting plates disposed adjacent said first mentioned plate electrode, an output circuit including said secondary electron collecting plates and said plate system and activated whenever said electron beam is diverted from a central position passing through the slot in said plate electrode.

2. An electron tube system comprising an electron generator for generating and propagating a beam of electrons, means for shaping said beam into a narrow substantially rectangular section a plate system disposed in the path of said beam of electrons, said plate system including a secondary electron emitting plate member and an associated secondary electron collecting plate member, said plate member being centrally slotted in substantially rectangular section corresponding to the section of said beam and having a secondary electron emitting coating surrounding the central slot therein, a grid electrode disposed between said plate members and charged negatively with respect thereto, an output circuit interconnecting said plate members, a magnetic control device including a magnetic core terminating in a magnetic gap on opposite sides of the normal path of said beam of electrons, an input winding on said magnetic core for electro-magnetically controlling the magnetic circuit through the magnetic gap in said magnetic core, and an auxiliary winding on said magnetic core connected with said output circuit for regeneratively controlling the current therein for effecting angular displacement of said beam from the slot in said plate member to the secondary electron emitting coating thereon.

3. An electron tube system comprising an electron beam generator for generating and propagating an electron beam, means for shaping said beam into a substantially rectangular section a plate system disposed in the path of said electron beam, said plate system including a secondary electron emitting element and a secondary electron collecting element, said secondary electron emitting element having a central substantially rectangular slot therein conforming in shape to the section of said beam, a grid electrode disposed between said elements and charged negatively with respect thereto, an output circuit interconnecting said elements, input means for controlling the scanning of said plate system by said electron beam, and means regeneratively coupling said output circuit with said input means for regeneratively acting upon current delivered to said input means.

4. An electron tube system comprising an electron beam generator for generating and propagating an electron beam, means for shaping said beam into a substantially rectangular section a plate system including a secondary electron emitting element disposed in the path of said electron beam and a secondary electron collecting element, said secondary electron emitting element having a central substantially rectangular slot therein conforming in shape to the section of said beam, a grid electrode disposed between said elements

and charged negatively with respect thereto, an output circuit interconnecting said elements, a three electrode tube system including grid, cathode and anode electrodes, connections between said output circuit and said grid and cathode electrodes, an output circuit interconnecting said anode and cathode electrodes, and means for shifting said electron beam for scanning said secondary electron emitting element in the area surrounding the central slot therein for producing current changes in the circuits associated with said grid, cathode and plate electrodes proportional to current changes impressed upon said means.

5. An electron beam tube comprising an electron generator, means for shaping propagated electrons into a substantially rectangular beam, a plate electrode disposed in the path of said beam and having a substantially rectangular slot therein for the normal passage of said beam, a secondary electron emitting coating formed on said plate electrode surrounding the slot therein, an electron collecting plate electrode disposed behind the slot in the aforesaid plate electrode, a grid electrode disposed between said plate electrodes and charged negatively with respect thereto, secondary electron collecting plates adjacent said first mentioned plate electrode, and means for angularly displacing said substantially rectangular beam from a substantially central position passing through the rectangular slot in said first mentioned plate electrode to a position striking the secondary electron emitting coating on said first mentioned plate electrode throughout the area surrounding said substantially rectangular slot for liberating electrons for collection by said secondary electron collecting plates.

6. An electron tube system comprising an electron discharge device for propagating an electron beam, means for shaping said beam in substantially rectangular section, means for controlling the angular sweep of the electron beam, a plate system disposed in the path of said electron beam comprising a pair of spacially disposed plates, one of said plates having a substantially rectangular plot disposed centrally therein conforming in shape with the shape of said electron beam, a secondary electron emitting coating on said plate system surrounding the central slot therein and the other of said plates being disposed behind the slot in the aforesaid plate, a grid electrode arrangement between said plates and charged negatively with respect thereto, and a plurality of secondary electron collecting plates disposed adjacent said plate system and out of the path of sweep of said electron beam, said secondary electron collecting plates each being elliptical in section and coextensive with the length of said plate system.

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