

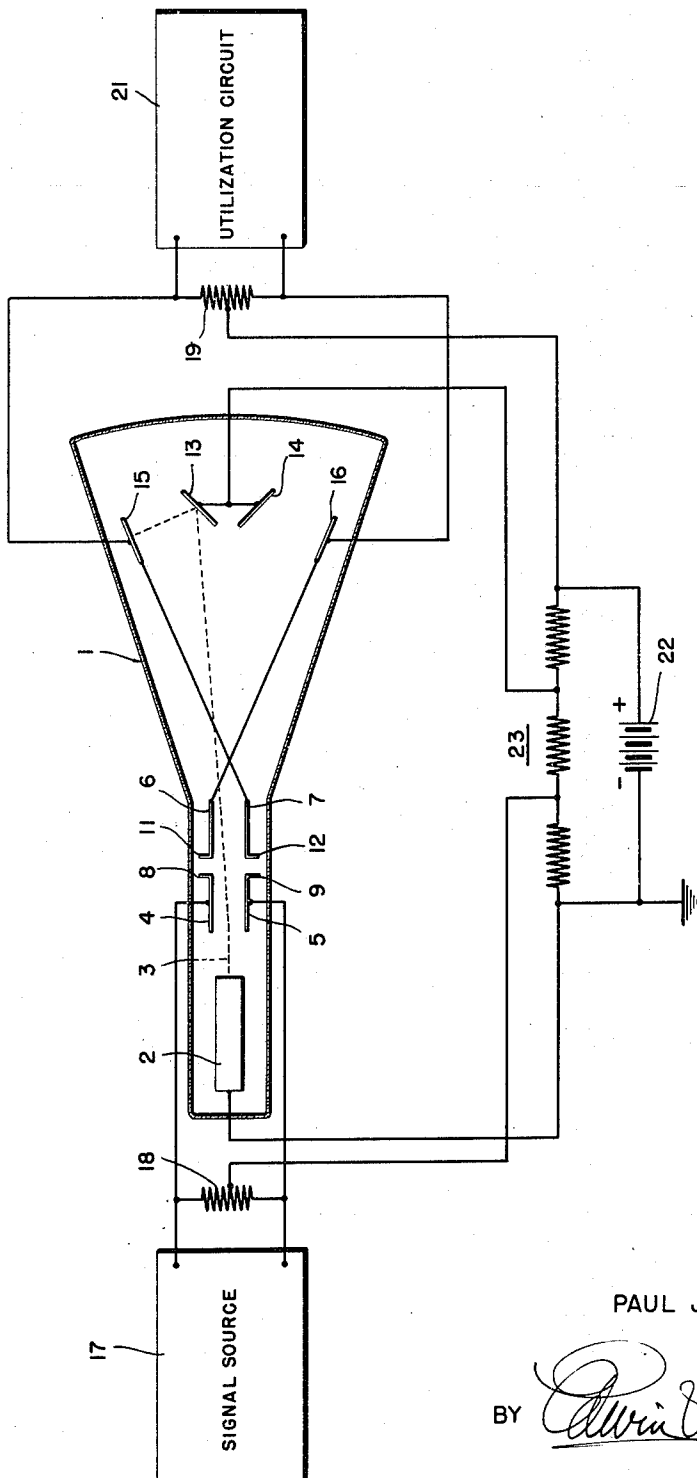
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DEFLECTION MODULATION TUBE

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## DEFLECTION MODULATION TUBE

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This invention relates to cathode ray tubes and particularly to such tubes for use as signal modulators, amplifiers and the like wherein one or more electron beams are deflected over a target electrode structure.

One use which has been made of cathode ray tubes is that of deflecting an electron beam over a target electrode structure for the purpose of modulating and/or amplifying signal effects. Usually the target electrode structure is coupled to an output circuit wherein signals are developed in accordance with the direction and magnitude of the electron beam deflection over the target electrode structure. The use of such a tube as a signal amplifier for example, frequently entails the deflection of an electron beam under the control of signals of relatively small magnitudes. In order to effect the desired signal amplification, it is desirable to produce as great a deflection of the beam relative to the target electrode structure, as possible. It is well known that, in order to develop an electron beam which will have a suitably small cross-sectional area in the plane of the target electrode to minimize signal distortion, it is necessary that the beam have what is known as relatively high order of stiffness. In other words, the beam is required to travel at a relatively high velocity. It is relatively difficult to deflect such a beam, particularly when the deflecting voltages are derived from relatively weak signals. It is desirable, therefore, to provide means for increasing the beam deflection over the target electrode structure.

A type of cathode ray tube, which is in somewhat general use, is one in which the electron beam is deflected by means of an electrostatic field produced between a pair of plate electrodes. It is well known that there exists an inherent capacitance between a pair of deflection electrodes. This capacitance produces a relatively small reactance at high signal frequencies. Consequently, when it is desired to use such a device for response to signal effects either having a relatively high frequency in themselves or by reason of the signals being modulated on a carrier wave of high frequency, the capacitive reactance of the deflecting electrodes upon which the signal effects are impressed provides a relatively low impedance shunt across the signal source. It, therefore, is desirable to compensate for, or to neutralize, the inherent input capacitance of the deflecting system used in a device of this character.

It is an object of the present invention, there-

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fore, to provide a cathode ray tube having a novel electrode structure and arrangement, whereby to increase the magnitude of the electron beam deflection over a target electrode structure.

Another object of the invention is to provide a cathode ray tube having an electrode structure so arranged and interconnected electrically to effect a substantial neutralization of the input circuit capacitance.

A further object of the invention is to provide a cathode ray tube having an electrode structure of such a character that increased beam deflection may be accomplished, and at the same time, the inherent input circuit capacitance may be effectively neutralized.

In accordance with this invention, there is provided a cathode ray tube having a means, such as an electron gun, for developing a beam of electrons and directing it toward a target electrode. The tube also is provided with at least two deflecting electrodes located respectively on opposite sides of the beam. One of these electrodes may be coupled to a signal source. A target electrode structure also is provided in the tube and is mounted in the path of the undeflected beam. The target electrode structure is coupled to the other deflecting electrode in a manner whereby the electron impingement upon the target electrode energizes the second deflecting electrode in such polarity to aid the first electrode in effecting deflection of the beam. In this manner an increased beam deflection may be produced.

Two pairs of deflecting electrodes located in series along the path of the beam may be used. In this case the signal source may be coupled to the first pair of electrodes and the target electrode structure may be coupled to the second pair of deflecting electrodes in suitable polarity. By locating the two pairs of deflecting electrodes closely enough adjacent to one another, there may be produced a capacitance between corresponding ones of the two pairs of electrodes. By coupling the second pair of deflecting electrodes to the target electrode in a manner to effect a positive feed back, whereby to increase the magnitude of the beam deflection, the capacitance between corresponding ones of the two pairs of deflecting electrodes is of a character tending to neutralize the inherent capacitance between the two electrodes of the pair upon which the signal effects are impressed.

In a specific embodiment of the invention, the cathode ray tube may also be provided with one or more sets of secondary electron emissive elec-

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trodes, as part of the target electrode structure. Also, the feed back connections to the second pair of deflecting plates may be made from either the secondary electron collecting electrodes or from any pair of secondary electron emissive electrodes. By properly polarizing these feed back connections, the second pair of deflecting plates may be made to have either a regenerative or a degenerative effect upon the deflection of the electron beam. Furthermore, the plates of the two pairs of deflecting electrodes may be shaped suitably to increase the interelectrode capacitance by the corresponding plates, sufficiently to produce the desired amount of neutralization of the input circuit capacitance.

For a better understanding of the invention, together with other and further objects thereof, reference is made to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the drawing, the single figure is a diagrammatic illustration of a cathode ray tube embodying the invention, and typical essential circuit connections of the tube electrodes to a power source and to the input and output circuits.

Referring now particularly to the drawing, the tube is provided with an evacuated envelope 1. At one end of the envelope there is provided a conventional electron gun 2 shown only diagrammatically in the drawing. The electron gun is capable of developing an electron beam 3 and directing it generally toward the opposite end of the tube envelope in which is mounted a target electrode structure. Adjacent to the electron gun along the path of the beam, there is mounted a first pair of deflecting plates 4 and 5 on either side of the beam. In addition, there is provided a second pair of deflecting plates 6 and 7 located on either side of the beam and further along the beam path toward the target electrode structure. It may be desirable to provide each of the deflecting plates with an additional facility whereby to produce a greater capacitance between corresponding ones of the plates. This facility may, for example, be embodied in a suitable flange formed on the deflecting plates. The plates 4 and 5 are shown having respective flanges 8 and 9 extending perpendicularly relative to the field producing portions of the plates. As shown, these flanges are formed on the edges of the plates 4 and 5 which are adjacent to edges of the corresponding plates 6 and 7. In like manner, these latter plates are provided with flanges 11 and 12 facing the flanges on the other pair of plates.

Finally, at the other end of the tube envelope there is provided a target electrode structure for the electron beam. In the particular embodiment of the invention shown herein, the target electrode structure comprises a pair of secondary electron emissive electrodes or dynodes 13 and 14. In this case the dynodes are in the form of substantially flat plates mounted so as to be inclined to one another and also to the undeflected path of the electron beam. The target electrode structure also includes a pair of electron collecting electrodes 15 and 16 for cooperating respectively with the dynodes 13 and 14. The collector electrodes also are shown as substantially flat plates.

The primary electron beam deflection is effected under the control of signals derived from a signal source 17. The signal source is connected across an input resistor 18, the terminals of which are connected to the primary beam deflecting electrodes 8 and 9. The electron collecting elec-

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trodes 15 and 16 are connected to the terminals of an output resistor 19, to which also is connected a utilization circuit 21. The collector electrodes also are back-coupled to the secondary beam deflecting plates in a manner to effect positive or regenerative feed back. Specifically, the collector plate 15 is connected to the deflecting plate 12 and the collector 16 is connected to the deflecting plate 11.

The signaling system including the cathode ray tube is energized for operation by suitable connection to a source of unidirectional voltage such as a battery 22. The terminals of this battery are connected to the terminals of a voltage divider 23, whereby suitable potentials may be impressed upon the various circuits for operation. The negative terminal of the voltage divider is grounded and connected to the electron emitting facility of the electron gun 2 in a conventional manner. The other electrodes of the electron gun may be energized from the battery 22 by suitable conventional connections to the voltage divider. In order to avoid complicating the drawing, these electrodes and connections have not been shown. A center tap on the input resistor 18 is connected to a more positive point on the voltage divider, whereby a positive potential of suitable magnitude may be impressed upon the primary deflecting electrodes 4 and 5. The dynodes 13 and 14 are connected together and to a still more positive point on the voltage divider. Finally, the center point of the output resistor 19 is coupled to the positive terminal of the voltage divider.

Reference now will be made to the operation of the cathode ray tube embodying the present invention. Signals are impressed upon the input circuit of the device including the primary beam deflecting plates 4 and 5 in a push-pull manner. Signal voltage developed in the input resistor 18 varies both in polarity and magnitude. The field produced by the primary deflecting electrodes 4 and 5 varies both in magnitude and in direction in a manner to cause the beam 3 to be deflected vertically over the dynodes 13 and 14. As a consequence, the electron collection by the electrodes 15 and 16 varies correspondingly to develop signal voltages in the output resistor 19.

When the beam is undeflected, substantially equal numbers of electrons impinge upon the dynodes 13 and 14. Consequently the electron collection by the electrodes 15 and 16 is about equal. If now the signal voltage which is developed in the input resistor 18 is such to deflect the beam 3 upwardly, then more electrons impinge upon the dynode 13 than upon the dynode 14. A greater collection of electrons is effected by the collector 15 than by the collector 16 so that there is developed a signal voltage in the output resistor 19 which corresponds to that impressed upon the input resistor 18. In order to effect such a beam deflection, the potential of the primary deflecting plate 4 must have a greater positive magnitude than that of the primary deflecting plate 5. Also, since fewer electrons are collected by the collecting electrode 16 than by the collecting electrode 15 as a result of the deflection of the electron beam, the collector 16 is at a higher positive potential than the collector 15. By the described connection of the collector 16 to the secondary deflecting plate 6 and a corresponding connection of the collector 15 to the secondary deflecting plate 7, it is seen that the polarity relationship between the collector electrodes is impressed also upon the secondary

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deflecting plates in a manner to increase the upward deflection of the electron beam. Hence, by reason of this positive or regenerative feed back connection, a greater beam deflection may be secured.

Obviously, when the electron beam deflection under the control of the impressed signals is in a downward direction, the regenerative feed back arrangement also increases this deflection. As a consequence, still greater signal voltages may be developed in the output circuit resistor 19 for impression upon the utilization circuit 21.

An important feature of this invention is the facility provided for effectively neutralizing, or at least, minimizing the input capacitance of the device. This capacitance is produced by the primary deflecting plates 4 and 5. In order to more clearly understand the operation of the device in effecting the input capacitance neutralization, assume that, under the control of a signal derived from the source 17, the primary deflecting plate 4 is at a positive potential relative to the primary deflecting plate 5. In this case there is produced an electrostatic field between these two plates.

The lines of force of this extend from the plate 4 to the plate 5. At relatively high signal frequencies, therefore, there is required a flow of charging current to the condenser represented by these plates. Thus, the condenser acts as a shunt across the input circuit thereby draining current from the signal source which otherwise could be used for deflecting purposes. However, by reason of the described feed back connections to the secondary deflecting plates 6 and 7, the flange 11 is maintained at a higher positive potential than the adjacent flange 8. One electrostatic field is produced between the flanges 8 and 11 of such a character that the lines of force extend from the flange 11 to the flange 8. Charging current flows to the condenser formed by the flanges 8 and 11, and is supplied from the collector electrode 16. Simultaneously, the connection of the deflecting plate 7 to the collector 15 maintains the flange 12 at a lower positive potential than the adjacent flange 9. Another electrostatic field is produced between these two flanges of such a character that the lines of forces extend from the flange 9 to the flange 12. It is seen, therefore, that the lines of force produced between the various described portions of the deflecting electrodes extend from the electrode 6 to the electrode 4 to the electrode 5 and finally to the electrode 7. As a consequence, the current flow between the flanges 8—11 and 9—12 is in proper direction to supply charging current to the condenser formed by the deflecting plates 4 and 5. Hence, the current drain required to charge the condenser formed by the plates 4 and 5 is decreased so far as the signal source 17 is concerned. By properly locating the deflecting electrodes relative to one another, the current drain upon the source 17 may be completely eliminated. In other words, the described electrode structure completely neutralized the input capacitance of the tube.

A device in accordance with this invention may be employed, therefore, for control by a source of signals which need have practically no power output available. For example, it may be coupled directly to a resonant circuit energized from an antenna system, without adding a capacitive load to the resonant circuit and thereby enabling the achievement of increased gain and selectivity. The feed back circuit arrangements provided by such a device will enable the production of a sufficient deflection of the beam to amplify the

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signal effects in the output circuit and, at the same time, provide an input circuit for coupling to the antenna system which has substantially no input capacitance.

It should be obvious to those skilled in the art that a device embodying the principles of the present invention may be provided with a greater number of electron multiplying stages, whereby to further amplify the signal effects. Also, it should be evident that it is not necessary, in every case, to provide the back coupling to the secondary beam deflecting system from the electron collecting electrodes. For example, in the present illustrative form of the invention, the dynodes 13 and 14 may be coupled to a load resistor much in the same manner as the collectors 15 and 16 are coupled to the output resistor 19. In such a case the dynodes may be utilized as the source of feed back potentials for the secondary deflecting electrodes. Of course, since a dynode develops a voltage of opposite phase to that developed by an electron collector, the connections to the deflecting system will have to be reversed to those shown. In other words, the dynode 13 should be coupled to the deflecting electrode 6 and the dynode 14 to the deflecting electrode 7. Also, it is not always necessary, in practicing this invention, to provide any electron multiplication in the tube. The electrodes impinged by the primary electron beam could just as well be utilized as the electron collectors by suitable connections of these electrodes to the output circuit.

Furthermore, the employment of the inter-electrode capacitance between the two pairs of deflecting electrodes provides a convenient means of utilizing the feed back feature of the invention to neutralize the input circuit capacitance of the electrodes 4 and 5. However, instead of or in addition to the electrode flanges, external condensers may be provided between corresponding electrodes to effect capacitance neutralization by means of the feed back couplings to the electrodes 6 and 7. Obviously, it is not necessary in all cases to utilize the full voltage developed by the collector electrodes 15 and 16 across the output resistor 19 for feed back purposes. If desired, suitable tapping points on this resistor may be back-coupled to the electrodes 6 and 7. In such a case the couplings will be made outside of the tube and may also include impedance devices for phasing and other purposes in a manner well known in the art.

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it, therefore, is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A cathode ray tube comprising, means for developing an electron beam and directing it toward a target electrode structure, a first pair of deflecting electrodes located on opposite sides of said beam to effect a first deflection of said beam, a second pair of deflecting electrodes located on opposite sides of said beam adjacent to said first pair of deflecting electrodes, a pair of target electrodes located on opposite sides of the undeflected beam path, whereby to intercept respectively electrons in proportion to said beam deflections, couplings between said target electrodes and respective ones of said second pair of deflecting

electrodes, whereby to effect a second deflection of said beam, and condensers connected between corresponding electrodes of said first and second pairs of deflecting electrodes for neutralizing the capacitance between the electrodes of said first pair of deflecting electrodes.

2. A cathode ray tube comprising, means for developing an electron beam and directing it toward a target electrode structure, a first pair of deflecting electrodes located on opposite sides of said beam to effect a first deflection of said beam, a second pair of deflecting electrodes located on opposite sides of said beam adjacent to said first pair of deflecting electrodes, a target electrode structure including a pair of electron collecting electrodes located on opposite sides of the undeflected beam path whereby to intercept respectively electrons in proportion to said beam deflections, and couplings between said target electrode structure and respective ones of said second pair of deflecting electrodes, whereby to effect a second deflection of said beam in the same direction as said first beam deflection, the capacitance between corresponding electrodes of said first and second pairs of deflecting electrodes serving to neutralize the capacitance between the electrodes of said first pair of deflecting electrodes.

3. A cathode ray tube comprising, means for developing an electron beam and directing it toward a target electrode structure, a first pair of deflecting electrodes located on opposite sides of said beam adjacent to said beam developing means to effect a first deflection of said beam, a second pair of deflecting electrodes located on opposite sides of said beam adjacent to said first pair of deflecting electrodes, a target electrode structure including a pair of secondary electron emissive electrodes and a pair of electron collecting electrodes, said secondary electron emissive electrodes being located in the path of said beam on opposite sides of the undeflected beam path, whereby to be impinged respectively by said beam proportionately to said beam deflections, said collecting electrodes being located respectively adjacent to said secondary electron emissive electrodes, whereby to intercept respectively secondary electrons in proportion to said beam deflections, and couplings between said secondary electron emissive electrodes and respective ones of said second pair of deflecting electrodes, whereby to effect a second deflection of said beam in the same direction as said first beam deflection, the capacitance between corresponding electrodes of said first and second pairs of deflecting electrodes serving to neutralize the capacitance between the electrodes of said first pair of deflecting electrodes.

4. A cathode ray tube comprising, means for developing an electron beam and directing it toward a target electrode structure, a first pair of deflecting electrodes located on opposite sides of said beam adjacent to said beam developing means to effect a first deflection of said beam, a second pair of deflecting electrodes located on opposite sides of said beam adjacent to said first pair of deflecting electrodes, a target electrode structure including a pair of secondary electron emissive electrodes and a pair of electron collecting electrodes, said secondary electron emissive electrodes being located in the path of said beam equally displaced from and on opposite sides of the undeflected beam path, whereby to be impinged respectively by said beam proportionately to said beam deflections, said collecting electrodes

being located respectively adjacent to said secondary electron emissive electrodes, whereby to intercept respectively secondary electrons in proportion to said beam deflections, and connections between said collecting electrodes and respective ones of said second pair of deflecting electrodes, whereby to effect a second deflection of said beam in the same direction as said first beam deflection, the capacitance between corresponding electrodes of said first and second pairs of deflecting electrodes serving to neutralize the capacitance between the electrodes of said first pair of deflecting electrodes.

5. A cathode ray tube comprising, means for developing an electron beam and directing it toward a target electrode structure, a first pair of deflecting plates located on opposite sides of said beam adjacent to said beam developing means and responsive to signal voltages to effect a first deflection of said beam, a second pair of deflecting plates located on opposite sides of said beam adjacent to said first pair of deflecting plates, a target electrode structure including a pair of secondary electron emissive electrodes and a pair of electron collecting electrodes, said secondary electron emissive electrodes being located in the path of said beam equally displaced from and on opposite sides of the undeflected beam path, whereby to be impinged respectively by said beam proportionately to said beam deflections, said collecting electrodes being located respectively adjacent to said secondary electron emissive electrodes, whereby to intercept respectively secondary electrons in proportion to said beam deflections, and connections between said collecting electrodes and respective ones of said second pair of deflecting plates located on the opposite side of said electron beam, whereby to effect a second deflection of said beam in the same direction as said first beam deflection, the capacitance between corresponding plates of said first and second pairs of deflecting plates thereby neutralizing the capacitance between the plates of said first pair of deflecting plates.

6. A cathode ray tube comprising, means for developing an electron beam and directing it toward a target electrode structure, a first pair of deflecting plates located on opposite sides of said beam adjacent to said beam developing means and responsive to signal voltages to effect a first deflection of said beam, a second pair of deflecting plates located on opposite sides of said beam adjacent to said first pair of deflecting plates, a target electrode structure including a pair of secondary electron emissive electrodes and a pair of electron collecting electrodes, said secondary electron emissive electrodes being located in the path of said beam equally displaced from and on opposite sides of the undeflected beam path, whereby to be impinged respectively by said beam proportionately to said beam deflections, said collecting electrodes being located respectively adjacent to said secondary electron emissive electrodes, whereby to intercept respectively secondary electrons in proportion to said beam deflections, connections between said collecting electrodes and respective ones of said second pair of deflecting plates located on the opposite side of said electron beam, whereby to effect a second deflection of said beam in the same direction as said first beam deflection, and flanges formed on adjacent edges of corresponding plates of said first and second pairs of deflection plates to provide capacitance for neutralizing the capacitance between the plates of said first pair of deflecting plates.

7. A signaling system comprising, a source of

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signals, a utilization circuit, a cathode ray tube having an evacuated envelope, an electron gun located adjacent one end of said envelope, an input circuit for said tube including a first pair of deflecting electrodes located adjacent said electron gun and constituting a major portion of the capacitance of said input circuit, means for coupling said signal source of said first pair of deflecting electrodes, an output circuit for said tube including a pair of target electrodes located adjacent the other end of said envelope on either side of the undeflected path of an electron beam developed by said electron gun, means for coupling said target electrodes to said utilization circuit, a second pair of deflecting electrodes located between said first pair of deflecting electrodes and said target electrodes, couplings between said target electrodes and respective ones of said second pair of deflecting electrodes to effect a magnified de-

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flection of said electron beam, and condensers coupled between corresponding ones of said first and second pairs of deflecting electrodes to neutralize the input circuit capacitance of said first pair of deflecting electrodes.

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