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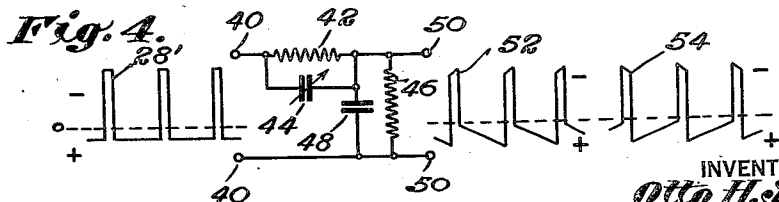
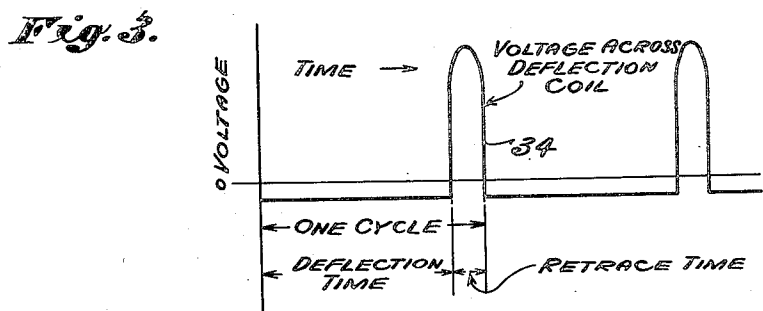
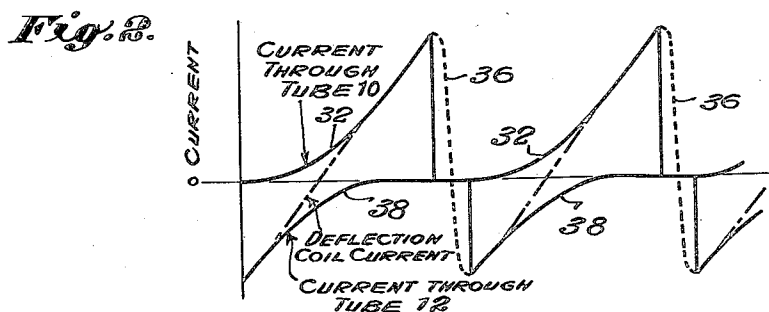
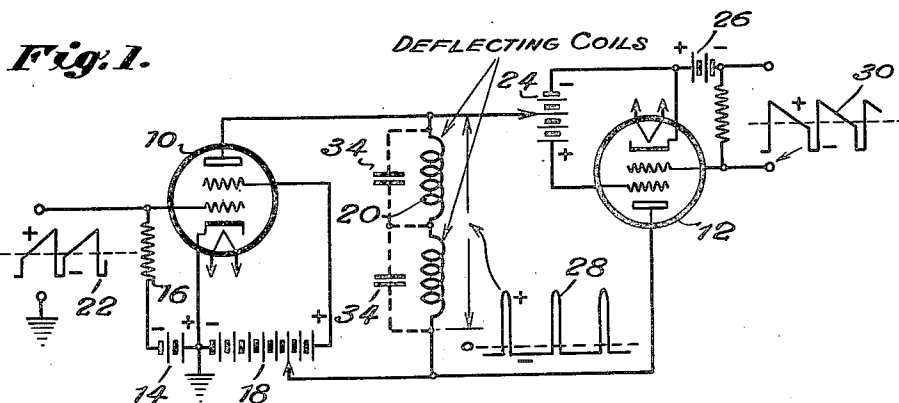
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2,382,822

CATHODE RAY BEAM DEFLECTING CIRCUIT

Filed June 30, 1942

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

Fig. 5.

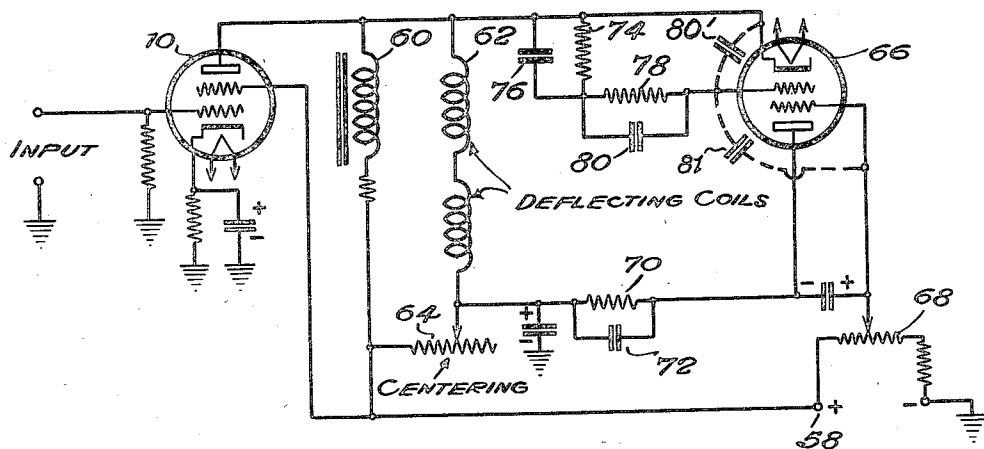
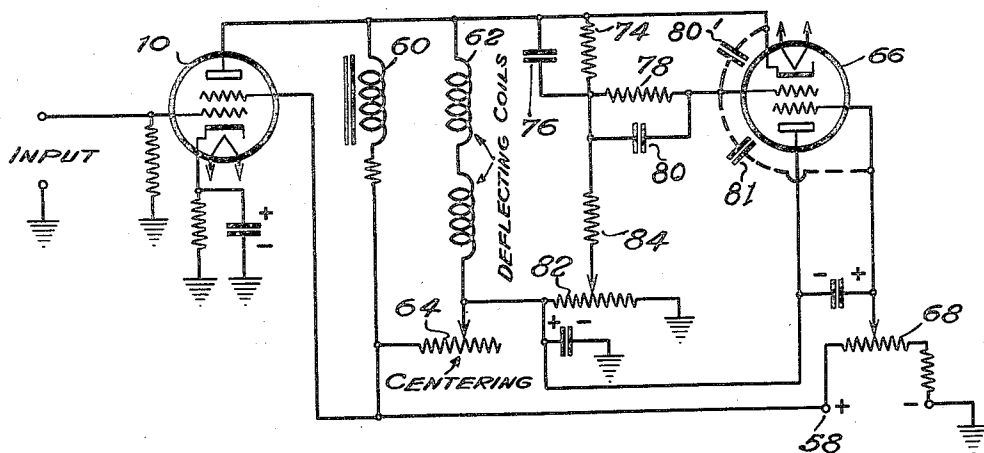


Fig. 6.



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3 Sheets-Sheet 3

Fig. 7.

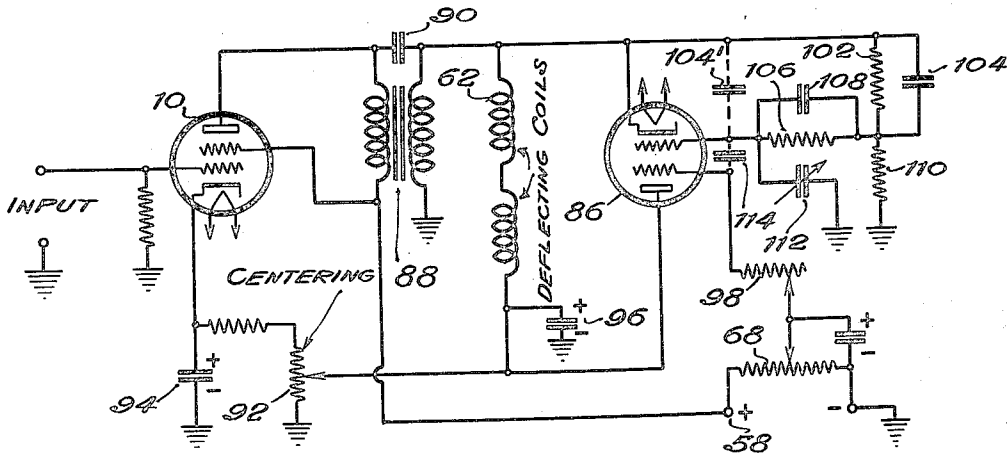
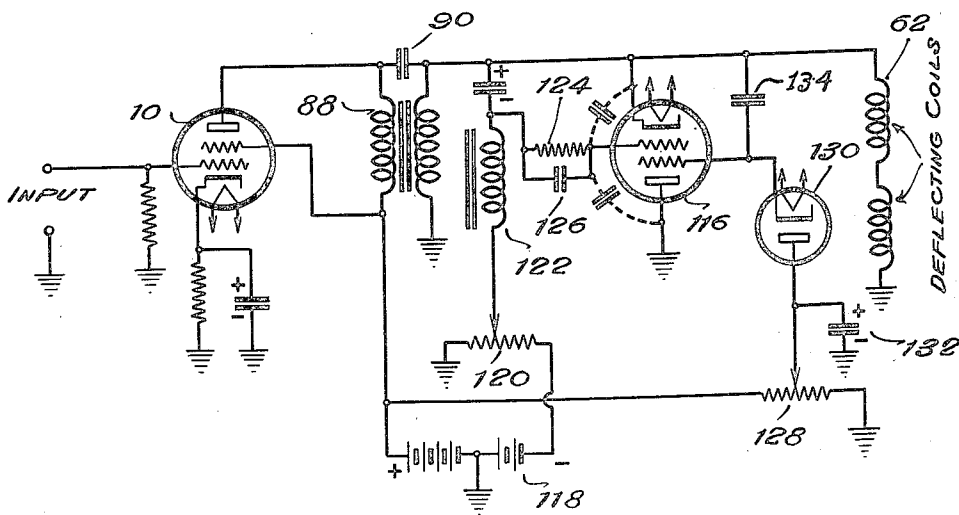


Fig. 8.



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CATHODE RAY BEAM DEFLECTING
CIRCUITSOtto H. Schade, West Caldwell, N. J., assignor to
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Application June 30, 1942, Serial No. 449,076

16 Claims. (Cl. 175—335)

This invention relates to an improvement in circuits for producing voltage variations for causing deflection of the cathode ray beam produced in a cathode ray tube.

More particularly, the invention is concerned with circuits to be used in television transmitting or receiving systems wherein the electron beam of a cathode ray tube is electromagnetically deflected in bi-lateral directions, the horizontal deflection being at a relatively high rate.

Since cathode ray beams in television receivers and transmitters are preferably deflected by electro-magnetic means, a large deflecting voltage variation is required in order to produce the necessary current changes in the deflecting coil for producing the required change of electro-magnetic flux for deflecting the cathode ray beam, and particularly for returning the cathode ray beam in a relatively short space of time.

In present television transmitting systems the cathode ray beam is deflected in a horizontal direction at a rate of about 15,750 cycles per second, nine-tenths or more of the time for each cycle being required to deflect the beam in one direction horizontally, and the remaining portion of each cycle being used to return the beam horizontally to its initial starting point. In view of the fact that the cathode ray beam is deflected at a relatively rapid rate, and particularly in view of the fact that the return deflection of the cathode ray beam is very rapid, voltages of considerable magnitude are developed across the deflecting coils of the cathode ray tube, and across the coupling transformer between the deflection power tube and the magnetic deflecting coils.

In conventional cathode ray beam deflecting circuits it is the usual practice to include a so-called damping tube, which in conventional circuits comprises an inverted diode connected in series with a resistance element, the diode and resistance element being connected across the primary of the coupling transformer or across the electro-magnetic beam deflecting coils (i. e. across the secondary of the coupling transformer).

The purpose for using the inverted diode, as is the conventional practice in the prior art, is basically for two reasons: the first being to eliminate high frequency oscillations which would otherwise be set up in the deflecting coils, and the second being to assist in the deflection of the cathode ray beam during its useful deflection cycle to thereby relieve or reduce the power demand upon the deflection power tube.

In the production of high quality television images, it is necessary that the cathode ray beam in both the transmitter and the receiver be deflected at as near a constant rate as is possible. When such linearity of deflection exists, distortion in the reproduced image is naturally materially reduced.

When a conventional deflection power tube and inverted diode are used, it has been found that the linearity of deflection of the cathode ray beam is not perfect and, by reason of the non-linearity of the deflection, certain imperfections and distortions occur in the reproduced image.

As stated above, the inverted diode serves as an aperiod-discharge path for the electro-magnetic energy stored in the coupling transformer or in the deflecting coils at the end of the deflection cycle. In the absence of the diode this stored energy would normally produce a relatively high frequency oscillation in the system, with the result that the deflection of the cathode ray beam during the initial part of its deflection cycle would be far from linear. When the diode is used as a damping tube, only one-half cycle of free oscillations is permitted to take place, and thereafter, the energy contained in the coupling transformer or in the deflecting coils is used for the initial part of the next useful deflection cycle.

In order to improve linearity of deflection, certain arrangements have heretofore been proposed, one of which is the use of a feedback circuit, in conjunction with an inverted diode, for modifying the characteristics of the deflection power tube. When proper feedback voltages are applied to the control electrode of the power tube, substantially linear deflection forces may be produced. A circuit employing the use of feedback voltage variations is shown and described in Schade Patent No. 2,309,672, issued on February 2, 1943.

It has been discovered that a linear summation characteristic is obtainable by modifying the characteristics of the inverted diode or suppressor tube, and in order to vary the characteristics of the diode, the diode is replaced by a triode or multi-grid electron discharge tube so that voltage variations of a particular wave form may be applied to the control electrode of the discharge tube to alter its conduction characteristics.

When the characteristics of the damping tube are varied during each deflection cycle, linearity of deflection may then be produced without resorting to the use of feedback voltage variations

applied to the deflection power tube, or to stages preceding the deflection power tube.

It has also been found that the control voltage variations which should be applied to the control electrode of the damping tube may be derived by differentiation of the deflection coil voltage rather than by integration of a voltage variation. Furthermore, by controlling the characteristics of the damping tube by voltage differentiation, it is not necessary to include additional inductances or capacitances in the circuit, with the result that the normal linearity and retrace time may be less disturbed than would be the case with the addition of these elements.

It is, therefore, one purpose of the present invention to provide a circuit for electro-magnetically deflecting a cathode ray beam in which linearity of deflection may be ensured through the use of a controlled suppressor (inverted) tube.

Another purpose of the present invention resides in the provision of a circuit arrangement for electro-magnetically deflecting a cathode ray beam in which a controlled suppressor tube is used, and in which the characteristics of the suppressor tube are determined by differentiation of the voltage variations appearing across the deflection coil or appearing across the coupling transformer between the deflecting power tube and the deflecting coils.

Still another purpose of the present invention resides in the provision of a circuit arrangement for electromagnetically deflecting a cathode ray beam in which linearity of deflection may be assured without resorting to a feedback arrangement and solely through the use of a controlled suppressor tube associated with the output circuit of the deflection system.

A still further purpose of the present invention resides in the provision of a system for electromagnetically deflecting a cathode ray beam in which circuits are provided for using auxiliary voltages and elements in the suppressor tube to permit the use of various types of tubes and to obtain low power control circuits at direct current or ground potential ensuring stability and flexibility of the circuit at widely different amplitudes and operating frequencies.

Another purpose of the present invention resides in the provision of a controlled suppressor tube in a circuit arrangement for electro-magnetically deflecting a cathode ray beam and so controlling the suppressor tube that the summation of the current flow through the suppressor tube and through the deflection power tube during each cycle will produce substantially linear deflections of the controlled cathode ray beam.

Various other purposes and advantages of the present invention will become more apparent to those skilled in the art from the following detailed description, particularly when considered in connection with the drawings, wherein

Figure 1 shows schematically a circuit arrangement for illustrating the principle involved in the present invention;

Figures 2 and 3 show current and voltage variations occurring at various parts of the system shown in Figure 1;

Figure 4 shows a circuit arrangement for producing the desired voltages by differentiation for controlling the characteristics of the suppressor tube, and

Figures 5, 6, 7 and 8 show various forms of the present invention based on the principle illustrated in the circuit diagram of Figure 1.

Referring now to Figure 1, there is shown a deflection power tube 10 and a suppressor tube 12. Both of these tubes are preferably beam power tubes and each includes a cathode, a control electrode, a screen electrode and an anode. The cathode of the deflection power tube 10 is connected to ground, and the control electrode is maintained at proper operating potential with respect to the cathode by means of the battery 14. A control electrode resistance 16 is also included between the control electrode and the negative terminal of the source of potential 14. The screen electrode is maintained at a positive potential by means of the battery 18, and the deflecting coils 20 represent the load circuit connected between the source of potential 18 and the anode of tube 10.

When voltage variations of a wave form such as represented at 22 are applied between control electrode and cathode of tube 10, voltage variations will be produced across the deflecting coils 20.

The suppressor tube 12 is inverted with respect to the power tube 10 and is effectively connected across the deflecting coils.

The screen electrode of tube 12 is maintained at its proper positive potential with respect to its associated cathode by means of battery 24, whereas the control electrode of the suppressor tube 12 is maintained at its proper negative operating potential by means of the battery 26. The anode of the suppressor tube 12 is connected to the potential end of the deflecting coils, whereas the anode of the power tube 10 is connected to a point along the potential source 24.

The voltage variations appearing across the deflecting coils is represented by the curve 28, whereas one example of the voltage variations to be applied to the control electrode of the damping tube 12 is represented by the curve 30.

As stated above, both of the tubes are preferably beam power tubes. However, triodes or similar tubes may be used, but such tubes normally require high negative peaking voltages to maintain absolute cut-off during the beam retrace time. The voltage variations applied to the control electrode of the power deflection tube 10 is a rising saw-tooth voltage as represented at 22, and the bias potential applied to the control electrode of tube 10 is such as to produce a current in tube 10 such as represented by the curve 32 in Figure 2.

The required power is supplied by the potential source 18, and the voltage of the source must be sufficient to overcome the potential drop in the tube plus the negative voltage developed across the deflecting coils. The voltage applied to the control electrode of the power deflection tube 10 cuts off plate current in tube 10 at the beginning of the retrace time as represented by the solid line in Figure 2. The current in the deflecting coils, however, does not disappear instantaneously because of the inherent distributed capacity across the deflecting coils, represented by the condensers 34. This distributed capacity across the deflecting coils is, at the instant of the beginning of the retrace, charged to a relatively low voltage.

The inductance of the coils, per se, together with the distributed capacity across the coils, forms a tuned circuit in which high frequency oscillations will be produced in the absence of the controlled inverted tube 12. The oscillations begin with the start of the retrace time, and one-half cycle of the natural period oscillation is represented by the dotted curve 36 shown in Figure 2. After one-quarter cycle, the current in the de-

deflecting coils is reversed and the oscillation is stopped after one-half cycle near the negative current peak by reason of the inverted tube 12. During the retrace time, that is, during the half-cycle of the natural period of oscillation of the deflecting coils, the current in both tubes 10 and 12 is completely blocked, the voltage as represented at curve 28 rising to a high peak value at one-quarter cycle, when the current passes through zero.

A new deflection cycle starts after the one-half cycle of free oscillation, at which time the voltage appearing across the deflecting coils is maintained substantially uniform, as represented by the curve 28 in Figure 1, and as also represented by the curve 34 in Figure 3.

In order that linear deflection may be produced, it is necessary that the rate of change of the current in the deflecting coils be maintained constant during the deflection cycle, and so long as the rate of change of current is constant, the voltage across the deflecting coils will remain constant at a predetermined value, as represented by the curve 34 shown in Figure 3. The voltage is negative with respect to the power tube 10, but is positive by the same amount with respect to the cathode of the inverted suppressor tube 12.

The grid voltage of the power tube 10 and the bias potential 14 of that tube maintains tube 10 at a cut-off for a predetermined length of time after the beginning of the deflection cycle. The voltage variations applied to the control electrode tube 12 together with the potentials of the source 24 and 26, however, are so adjusted that the suppressor tube 12 begins to conduct immediately following the retrace time.

The current through the inverted suppressor tube, as well as the corresponding power delivered thereby are supplied by stored energy in the deflecting coils and may be supplemented by the energy from the battery or source of potential 24 in case the suppressor tube 12 requires a higher anode voltage for operation to produce the amount of current required to be passed by the tube. This latter instance may be the case when the suppressor tube 12 is a triode or a higher gain tube. The use of a beam power tube with a screen grid, however, permits operation of the tube at plate voltages lower than the screen voltage, and eliminates therefore the need for a supplementing anode voltage source 24. The voltage applied to the screen electrode of the inverted tube 12 may, if necessary, be quite high without appreciable loss of circuit efficiency because of the small amount of power required to be handled by the screen electrode.

The inverted tube 12 or the suppressor tube operates, as stated above, with a plate current such as represented at 38 in Figure 2. This current begins at a definite value, determined by the maximum plate current of the deflection power tube 10 and by the Q of the deflection coil in the tuned circuit including the deflection coil and its distributed capacity. In practice, this current is from 50% to 75% of the peak current of the deflection power tube. The screen voltage applied to this suppressor tube must therefore have such a value as to obtain the prescribed amount of current at the most positive condition of the control electrode of the suppressor tube.

The saw-tooth part of the voltage variations applied to the control electrode of the suppressor tube 12 and the normal bias of the control electrode must have, therefore, about equal peak voltages and are so adjusted as to give the de-

sired wave form to the anode current permitted to flow through the suppressor tube.

When the wave form of the current represented at 38 in Figure 2 is properly matched with the wave form of the current represented by the curve 32 in Figure 2, the summation of these currents will therefore be a straight line (as shown by the dash-dot curve in Figure 2) and represents the current actually flowing through the deflecting coils during each deflection cycle. The wave form of the voltage variation applied to the control electrode of the suppressor tube 12, as represented by the curve 30, is saw-tooth in wave form, the most positive part of the wave form occurring immediately following the retrace time with negative peak impulses occurring concurrently with the retrace time.

After the initiation of current in the suppressor tube 12, the potential of the control electrode is gradually changed in a negative direction, according to a predetermined wave form, in order to gradually reduce the current flow through the suppressor tube 12 to result in a wave form such as represented by the curve 38 in Figure 2. Actually, the current through the power tube (curve 32) and the current through the suppressor tube 12 (curve 38) need not be identical to those shown in Figure 2, since various modifications and wave forms of both of the curves are naturally possible to still produce a summation current that is linear and that will produce linear deflection of the cathode ray beam.

It is apparent that a higher voltage applied to the screen electrode of the suppressor tube 12 and a correspondingly more negative grid bias potential 26 may be used to obtain the same peak current through the suppressor tube 12 immediately following the retrace time. High operating efficiency requires that one tube remain at or near cut-off during the portion of the cycle where the higher currents are supplied by the other tube. In other words, it is preferable that the power tube 10 be maintained at cut-off during the initial part of the conduction cycle of the suppressor tube, and, conversely, that the suppressor tube be maintained at cut-off during the final part of the deflection cycle, at which time the power tube 10 is supplying maximum current. Both of the tubes, as stated above, must be maintained at complete cut-off during the retrace interval.

In a circuit arrangement such as shown in Figure 1, the voltage variations applied between the cathode and the control electrode of the suppressor tube must be at considerable voltage variance with respect to ground. In practical arrangements this is difficult to attain, and furthermore it is impractical to have the biasing potentials or batteries operating at high potential with respect to ground. Aside from the mechanical difficulties associated with such an arrangement, certain electrical difficulties may appear in the form of distributed capacity between the potential sources and ground.

The circuits shown in Figures 5, 6, 7 and 8, therefore, show circuit arrangements which are practical and which may be used in conjunction with a television transmitting or receiving system in which it is possible to obtain a controllable positive saw-tooth voltage with negative cut-off impulses (such as shown at curve 30 in Figure 1) by differentiation of the inductive voltage appearing across the deflecting coils.

A network for differentiating the voltage across the deflection coils is shown in Figure 4 of the drawings. This circuit includes resistance

42 and parallel condenser 44, as well as resistance 46 and parallel condenser 48. The resistance-condenser combination 42—44 forms a time constant circuit that is connected in series, insofar as the direction of travel of the voltage variations is concerned, whereas the resistance-condenser combination 46—48 forms a time constant circuit that is connected in shunt with the voltage variations.

When a wave form, such as shown at 28' is applied to the terminals 40, a differentiated voltage variation may be derived from the terminals 50. It will be noticed that the wave form 28' corresponds substantially to the wave form 28 shown associated with the deflecting coils in Figure 1, the polarity being reversed.

When the time constant of 42—44 equals the time constant of 46—48, then the divider or differentiation circuit does not discriminate against any frequencies. When, however, the time constant 42—44 is less than the time constant 46—48, a differentiated wave form will be produced, such as that shown at 52 in Figure 4. In this instance, the differentiation circuit discriminates against higher frequencies and a rising saw-tooth component (with respect to the zero axis) is obtained from a square wave with a negative surge voltage, as shown by the curve 52. If, however, the time constant 42—44 is greater than the time constant 46—48, the wave form will be tilted in the opposite direction and a falling saw-tooth component (with respect to the zero axis) will be obtained, as represented by the curve 54 in Figure 4.

The approximate time constant (RC 46—48) of the differentiating circuit shown in Figure 4 should be of the order of one-half to two times the scanning time for highly efficient practical circuits, depending upon the operating time for tube 12 in Figure 1 which is usually not less than one-half of the deflection time. The relationship of the two time constants of the series time constant circuits may be adjusted in order to produce the desired wave form at the output terminals 50.

It will be noticed that the condition where the time constant of 42—44 exceeds the time constant of 46—48, a voltage variation will be produced similar to that required for the controlling voltage variation applied to the damping tube for the deflection circuit. Similarity between the voltage variation 54 in Figure 4 and the voltage variation 30 in Figure 1 will be apparent by an examination of the drawings.

For good linearity of the control voltage, the time constant of the resistance 46 and the condenser 48 should equal approximately the scanning time, and the value of condenser 44 should be equal to or slightly less than the value of condenser 48. The resistance 42 can often be omitted in practical circuits. The saw-tooth voltage component available at terminals 50 is a function of the value of condenser 44 because of its divider action. The voltage component reaches a maximum when the two condensers 44 and 48 are approximately equal. An increase in the time constant of the resistance 46 and the condenser 48 causes a larger deviation from linearity and proportionally decreased maximum voltage output. A decrease of the time constant of these elements, however, causes an opposite deviation from linearity and a proportionally increased maximum output. Adjustment of the ratio of condenser 44 to condenser 48 controls the saw-tooth voltage output for a predetermined wave form.

In order that the wave form available at the terminals 50 may be controlled, one of the elements must naturally be made adjustable, and it is preferable that the condenser 44 be varied to produce the desired wave form.

Figures 5, 6, 7 and 8 of this application show, as stated above, commercially practical circuits for producing linear deflection of a magnetically deflected cathode ray beam. All of the circuits include one form or another of the differentiating circuits shown in Figure 4. In some instances, the inter-electrode capacitances of the inverted tube materially contribute to the condenser component of the time constants and, in some instances, it is possible that the inter-electrode capacitances may be sufficient in themselves to produce the desired time constants when associated with a predetermined resistance.

Figure 5, for example, shows one form of a preferred deflection circuit in which linearity of deflection is accomplished by controlling an inverted (suppression) tube. In Figure 5 is shown a deflection power tube 10 which includes a cathode, a control electrode and an anode. Voltage variations similar to those shown at curve 22 in Figure 1 are applied between the control electrode and the cathode of the deflection tube. The screen grid electrode is connected directly to the positive terminal 58, whereas the anode of the deflection tube 10 is connected to terminal 58 through choke coil 60, the deflecting coils 62 and a portion of the resistance element of a centering resistance 64.

In the normal operation of the deflection tube 10, a deflecting voltage variation will be produced across the deflecting coils in a manner similar to the method of operation of the corresponding portion of the circuit shown in Figure 1.

The inverted tube 66 includes preferably a cathode, a control electrode and an anode, and it is also preferable that this tube be of the beam power type.

A potentiometer 68 is connected between the positive terminal 58 and a point of fixed potential, and the screen electrode of the inverted tube 66 is connected to an adjustable point along this potentiometer. The cathode of the inverted tube 66 is connected to the anode of the power deflection tube, and since the cathode operates at a positive potential, it is necessary that the heater energizing transformer winding be insulated with respect to ground, and further, it is preferable that the secondary winding supplying the heater energizing voltage have relatively low distributed capacity to ground.

The anode of the suppressor tube 66 is connected to the lower end of the deflecting coils by a condenser 72 which is shunted by a resistance 70. The resistance 70 and associated bypass condenser 72 is used when the voltage available across the deflecting coils during the trace (or deflection) period is excessive. A proper choice of the size of the resistance 70 will determine the voltage applied to the suppressor tube 66 during the trace period.

Two time constant circuits are connected between the cathode and the control electrode of the suppressor tube 66. These circuits include resistance 74 and parallel capacitance 76, as well as resistance 78 and parallel capacitance 80. The resistance 74 and condenser 76 are used to produce a steady negative bias by grid current. The condenser 80 may be omitted if the distributed capacity 80' between cathode and control electrode of the suppressor tube 66 is suffi-

cient. Likewise, a similar distributed capacity 81 appears between the control electrode and the screen grid of the suppressor tube 66.

The time constant circuit 78—80 and the capacity 81 correspond to the time constant circuit 46—48 and condenser 44 of the differentiation circuit shown in Figure 4 and described above. When the relationship of the circuit elements is properly chosen, a voltage variation may be applied to the control electrode of the suppressor tube 66 such that the current through the suppressor tube 66 (corresponding to the curve 38 in Figure 2), when added to the current supplied by the deflection tube 10 (corresponding to the curve 32 in Figure 2), will produce a linear current variation in the deflecting coils 62.

Centering of the cathode ray beam may be readily accomplished by adjusting the amount of the resistance element 64 included between the deflecting coils and the positive terminal 58, since this adjustment permits more or less direct current component to flow through the deflecting coils to thereby produce an adjustable permanent deflection force on the cathode ray beam.

By properly proportioning the time constant of the resistance 78 and the condenser 80, with relation to the inter-electrode tube capacitance 81, a voltage variation may be produced on the control electrode of the suppressor tube 66 which will eliminate non-linearities in the deflection of the cathode ray beam. Furthermore, the time during which the suppressor tube is rendered conductive may also be controlled by an adjustment of the potentiometer 68 which controls the voltage applied to the screen electrode of the suppressor tube.

Through the use of such a circuit arrangement, it is possible to accomplish linear deflection of a cathode ray beam without the necessity for exercising a feedback control on the deflection power tube 10.

A somewhat similar circuit arrangement is shown in Figure 6, wherein elements, corresponding to those found in Figure 5, have the same reference numerals applied thereto. This circuit differs from the circuit shown in Figure 5 in that a bleeder arrangement is connected between the lower end of the deflecting coils and the junction of the two time constant circuits. For this connection, a potentiometer 82 is used, the resistance element of which is connected between the lower end of the deflecting coils and a point of fixed potential. The movable contact of the potentiometer is connected to the junction of the two time constant circuits by a resistance 84. The direct current from the anode end of the deflecting coils 62 through resistances 74 and 84 and the resistance element of potentiometer 82 develops an adjustable bias voltage for the control grid of tube 66 by voltage drop across resistance 74 and condenser 76.

The anode of the suppressor tube 66 in Figure 6 is connected directly to the lower end of the deflecting coils, since the intensity of the voltage applied to the anode of the suppressor tube is sufficient and not critical, in view of the fact that the direct current grid voltage applied to the control electrode of the suppressor or inverted tube may be controlled by an adjustment of the potentiometer 82, and the screen voltage may be adjusted by potentiometer 68. In operation, the system shown in Figure 6 is quite similar to that of the system shown in Figure 5.

A somewhat more flexible circuit arrangement is shown in Figure 7, wherein the cathode of the

suppressor tube 86 is isolated, insofar as direct currents are concerned, from the anode of the deflection tube 10. In this circuit, the anode of the deflection tube is connected to the positive terminal 58 by the primary of transformer 88 (with a 1 to 1 ratio), and the secondary of the transformer is connected between the cathode of the suppressor tube 86 and a point of fixed potential, preferably ground.

The relatively low frequency components of the deflection voltages are transmitted by way of the transformer 88, whereas the higher frequency components are transmitted to the deflecting coils and the suppressor electrode over a coupling condenser 90 thus eliminating leakage reactance effects. The deflecting coils 62 are connected across the secondary of transformer 88, but include a portion of the centering resistance 92.

A potentiometer 92 is provided in the cathode circuit of the deflection power tube, and since the entire cathode resistance is by-passed by a relatively large condenser 94, a relatively fixed potential may be derived across the cathode load resistance. By varying the position of the movable contact along the potentiometer 92, varying degrees of a substantially constant direct current component may be caused to flow through the deflecting coils and through the secondary of the output transformer 88 in order to center the cathode ray beam on the screen of the target.

The suppressor tube 86 is preferably a beam power tube and the tube is connected directly across the cathode ray beam deflecting coils 62. The anode of the inverted suppressor tube 86 is connected to the lower end of the deflecting coils and to the movable contact on the centering potentiometer 92. A connection is also made to ground by way of a relatively high capacity electrolytic condenser 96 to substantially fix the potential of the anode of tube 86 with respect to ground.

The screen grid electrode is connected to the movable contact of potentiometer 68 by way of an adjustable resistance element 98. The control electrode of the suppressor tube 86 is connected to its associated cathode by way of two time constant circuits, the circuit 106—108 corresponding to the time constant circuit 46—48 shown in Figure 4. The resistance 102 and parallel condenser 104 function to produce a negative grid bias for tube 86 by grid current and bleeder potential division when considered in conjunction with resistance 110.

The control electrode of the damping tube 86 may also be connected to ground by way of an adjustable condenser 112 which is in parallel with a certain amount of inter-electrode capacity represented at 114 and present between the control electrode and the screen electrode of the inverted suppressor tube 86. These correspond to the differentiating condenser 44 in Figure 4.

In this circuit arrangement shown in Figure 7, all of the operating potentials for the suppressor tube 86 are derived from the voltage generated across the deflecting coils 62. The grid signal is obtained by differentiation where the inter-electrode capacitances form condensers 104' and 114. These inter-electrode capacitances may be increased and may be made adjustable by additional external capacitances (i. e. condensers 108 and 112) to obtain the desired signal voltage in combination with the resistance 106.

The direct current grid voltage, as stated above, is obtained on the self-biasing network in the grid to cathode connection by means of

grid rectification operating in conjunction with the grid resistance 110. The screen grid voltage, during conduction time, is substantially the positive voltage appearing across the deflecting coils during deflection interval, and would correspond to that portion of the voltage represented below the dotted line associated with curve 28' in Figure 4. This voltage may be increased by a direct current voltage through an adjustment of the potentiometer 68 in order to make proper adjustments for the particular tube used and the scanning conditions of the circuit.

Should tube 86 be replaced by a tube of higher perveance (i. e., the current change through the tube when one volt differential change is made in the potential of the control electrode), the required screen voltage becomes smaller and may, in some instances, be less than the voltage produced across the deflecting coils. When such is the case, the proper screen grid voltage may be obtained by inserting by-passed dropping resistance in series with the anode of the inverted suppressor tube, and by connecting the adjustable terminal of the potentiometer 68 to the anode of the damping tube.

By means of the circuit arrangement shown in Figure 7, linear deflections of the cathode ray beam may be produced and the current passed by the inverted suppressor tube 86 may be exactly matched with the current permitted to flow through the deflection power tube 10. When exact matching is obtained, a linear current change may be produced through the deflecting coils during the deflection interval with the result that the first derivative of the current in the deflecting coils is linear and may be represented by a constant inductive voltage.

The circuit shown in Figure 7 has the advantage that the inverted suppressor tube 86 and its associated circuit elements are isolated with respect to the deflection power tube 10, insofar as direct current components are concerned, and furthermore the circuit is largely self-adjusting with respect to amplitude changes and is easily adjusted for relatively large frequency changes, so that the circuit may be used where different rates of beam deflection are desired. Furthermore, a high screen grid voltage may be applied to tube 86 by means of potentiometer 68 by reason of the fact that the cathode of tube 86 is not connected to the anode potential source 58 but instead to ground through the deflecting coils 62. This permits the use of lower perveance tubes.

A further circuit arrangement for producing substantially linear deflections of the cathode ray beam is shown in Figure 8, and in this circuit, as in the circuit shown in Figure 7, the inverted suppressor tube 116 is isolated from the deflection power tube, insofar as the direct current component is concerned. A coupling transformer 88, having a 1 to 1 ratio, and condenser 90 are used, as in Figure 7, and the deflecting coils 62 are connected directly across the secondary of the transformer 88.

The cathode of the suppressor tube 116 is connected to the high voltage end of the deflecting coils, and likewise to the ungrounded end of secondary of transformer 88. Since the opposite end of the deflecting coils and of the secondary of the transformer are connected to ground, the control electrode for the inverted suppressor tube 116 may have a bias control potential applied thereto by providing a potential source 118, the positive terminal of which is connected to

ground. The potential source has connected in parallel therewith a potentiometer 120. The movable contact of the potentiometer is connected to the control electrode of the suppressor tube 116 by a choke 122 and a series resistance 124. The resistance has connected in parallel therewith a condenser 126 so that a time constant circuit 124—126 is formed.

The screen grid electrode of the suppressor tube 116 is connected to the movable contact of potentiometer 128 by means of a diode 130. The cathode of the diode is connected directly to the screen grid electrode of the suppressor tube, whereas the anode is connected to the movable contact of potentiometer 128. The anode of the diode is maintained at substantially constant direct current potential by means of the relatively large electrolytic condenser 132.

In the circuit shown in Figure 8, the average cathode potential of the inverted suppressor tube is substantially zero. The diode 130 operates to open the screen grid circuit during the retrace of beam return interval to prevent the production of a negative screen grid voltage with respect to the cathode. The small condenser 134 forces the cathode of diode 130 to follow the potential variations of the cathode of tube 116. This operation definitely guards against screen grid emission currents which might otherwise flow to the control electrode, and, in circuits where high currents are involved, the screen grid emission current and resulting control grid bombardment might be excessive in the absence of the diode and make the control voltage of tube 116 ineffective because of secondary electron emission currents from the control grid.

A partially fixed bias is necessary for stable operation when the average gain of the suppressor tube 116 over one complete deflection cycle approaches unity. In the absence of a partially fixed bias, the circuit might inherently operate as a relaxation oscillator because the grid signal is derived from the plate voltage for energizing the tube. Self-oscillation would be particularly apt to occur for class A operation of the suppressor tube 116. The bleeder resistances 84 in Figure 6 and 110 in Figure 7 are effective to present self-oscillation of the inverted tubes in those figures.

By means of any one of the various circuit arrangements shown in Figures 5, 6, 7 or 8, it is possible to produce substantially linear deflections of a cathode ray beam even though the beam is deflected electro-magnetically. Furthermore, such linear deflections may be produced without the necessity of providing a feedback voltage to the power deflection tube or to some tube preceding the power deflection tube. Also, by properly adjusting the various parameters of the circuits, it is possible to obtain relatively high efficiency in operation and to derive a relatively large percentage of the deflection current from the inverted suppressor tube.

When the current wave form of the inverted suppressor tube is properly matched with respect to the current wave form supplied by the power deflection tube 10, the sum of these currents can be made linear, so that the deflections of the cathode ray beam may be linear.

Various alterations and modifications may be made in the present invention without departing from the spirit and scope thereof, and it is desired that any and all such modifications be considered within the purview of the present invention, except as limited by the hereinafter appended claims.

What I claim is:

1. A system for deflecting a cathode ray beam comprising a deflection power tube having a cathode, a control electrode and an anode, a cathode ray beam deflecting coil coupled in the anode-cathode circuit of said tube, means for applying voltage variations of a predetermined wave form between the control electrode and cathode of said power tube to produce current variations in said deflecting coil, an inverted tube having a cathode, a control electrode and an anode, means to connect the electron path of said inverted tube across said deflecting coil to produce a current flow through said deflecting coil in opposition to the current flow produced by said power tube, a differentiating network responsive to the potential variation produced across the deflecting coil for generating a voltage variation of a predetermined wave form, and means to apply the generated voltage variation of predetermined wave form between the cathode and control electrode of said inverted tube.

2. A system for deflecting a cathode ray beam comprising an electron tube having a cathode, a control electrode and an anode, a cathode ray beam deflecting coil coupled in the anode-cathode circuit of said tube, means for applying a cyclically varying voltage of a predetermined wave form between the control electrode and cathode of said tube to produce a cyclically varying current in said deflecting coil, an inverted tube having a cathode, a control electrode and an anode, means to connect the cathode and anode of said inverted tube to opposite ends of said deflecting coil so as to produce a current flow through said deflecting coil in a direction opposite to the current flow produced by said first named tube, and means including a differentiating network responsive to the voltage across the deflecting coil for applying a cyclically varying voltage of a predetermined wave form between the cathode and control electrode of said inverted tube.

3. A system for deflecting a cathode ray beam comprising a deflection power tube having a cathode, a control electrode and an anode, a cathode ray beam deflecting coil coupled between the anode and cathode of said tube, means for applying a cyclically varying voltage of a substantially saw-tooth wave form between the control electrode and cathode of said power tube to produce a corresponding cyclically varying current in said deflecting coil, an inverted electron tube having a cathode, a control electrode and an anode, means to connect the electron path of said inverted tube across said deflecting coil so as to produce a current flow through said deflecting coil in a direction opposite to the direction of current flow produced by said power tube, means including a resistance-capacitance network responsive to the potential across the deflecting coil to generate a cyclically varying voltage of a substantially saw-tooth wave form, and means to apply the generated voltage between the cathode and control electrode of said inverted tube to control the intensity of the current in the electron path thereof.

4. A cathode ray beam deflection circuit for deflecting a cathode ray beam comprising an electron tube having at least a cathode, a control electrode and an anode, a cathode ray beam deflecting coil, means for connecting one end of the deflecting coil to the anode of said tube, means including a source of potential for connecting the other end of the deflecting coil to the cathode of said tube, means to apply a cyclically varying

voltage of a predetermined wave form between the control electrode and cathode of said tube to produce a cyclically varying current in said deflecting coil, an inverted tube having at least a cathode, a control electrode and an anode, means to connect the anode of said inverted tube to the said other end of the deflecting coil, means to connect the cathode of said inverted tube to the said one end of the deflecting coil, means including a time constant circuit responsive to the potential across the deflecting coil to produce a cyclically varying voltage of a predetermined wave form, and means to apply the produced voltage between the cathode and control electrode of said inverted tube.

5. A cathode ray beam deflection circuit for deflecting a cathode ray beam comprising a deflection power tube having at least a cathode, a control electrode and an anode, a cathode ray beam deflecting coil, means for coupling one end of the deflecting coil to the anode of said power tube, means for coupling the other end of the deflecting coil to the cathode of said power tube, means to apply a cyclically varying voltage between the control electrode and cathode of said power tube to produce an intermittent and cyclically varying current in said deflecting coil, an inverted tube having at least a cathode, a control electrode and an anode, means to connect the cathode of said inverted tube to the said one end of the deflecting coil, means to connect the anode of said inverted tube to the said other end of the deflecting coil so that electronic current passed by said inverted tube through said deflecting coil will be in opposition to the current produced in said deflecting coil by said power tube, and capacitive differentiating means responsive to the potential drop across said deflecting coil for applying a cyclically varying voltage of a predetermined wave form between the cathode and control electrode of said inverted tube to cyclically alter the impedance of said tube.

6. A cathode ray beam deflection circuit for deflecting a cathode ray beam comprising a deflection power tube having at least a cathode, a control electrode and an anode, means to maintain the anode positive with respect to the cathode, a cathode ray beam deflecting coil, means for coupling one end of the deflecting coil to the anode of said power tube, means for coupling the other end of the deflecting coil to the cathode of said power tube, means to apply cyclically varying voltage variations of a predetermined wave form between the control electrode and cathode of said power tube to produce cyclically varying current variations in said deflecting coil between the limits of zero and a finite value, an inverted tube having at least a cathode, a control electrode and an anode, means to connect the said inverted tube across said deflecting coil so that current passed by said inverted tube through said deflecting coil will be in opposition to the current produced in said deflecting coil by said power tube, and differentiating means including a resistance and capacitance responsive to the potential across the deflecting coil for applying cyclically varying voltage variations of a predetermined wave form between the cathode and control electrode of said inverted tube to produce cyclically varying current variations in said inverted tube between the limits of zero and a finite value.

7. A system for electromagnetically deflecting a cathode ray beam comprising a deflection power tube having a cathode, a control electrode

and an anode, a cathode ray beam deflecting coil, means including a load circuit for maintaining the anode positive with respect to the cathode, means for coupling the deflecting coil across said load circuit, means for applying a cyclically varying voltage between the control electrode and cathode of said power tube to produce a corresponding cyclically varying current in said deflection coil, an inverted electron tube having a cathode, a control electrode and an anode, means to connect said inverted tube across said deflecting coil in a manner such that current passed by said inverted tube through said deflecting coil will be in opposition to the current produced therein by said power tube, and means including a differentiating network comprising resistance and capacitance elements responsive to the potential across the deflecting coil for applying a cyclically varying voltage between the cathode and control electrode of said inverted tube.

8. A system for electromagnetically deflecting a cathode ray beam comprising a deflection power tube having a cathode, a control electrode and an anode, a cathode ray beam deflecting coil, means including a load circuit and a source of potential for maintaining the anode positive with respect to the cathode, means for coupling the deflecting coil across said load circuit, means for applying a cyclically varying voltage between the control electrode and cathode of said power tube to produce a corresponding cyclically varying current in said deflection coil, an inverted electron tube having a cathode, a control electrode and an anode, means to connect said inverted tube across said deflecting coil in a manner such that current passed by said inverted tube through said deflecting coil will oppose the current produced therein by said power tube, and means for applying a cyclically varying voltage between the cathode and control electrode of said inverted tube, said means including an electrostatic differentiating network responsive to the voltage variation produced across said deflecting coil by the cyclically varying current produced therein.

9. A cathode ray beam deflecting system for electromagnetically deflecting a cathode ray beam comprising a source of cyclically varying voltage, an electromagnetic cathode ray beam deflecting coil, means for applying the cyclically varying voltage to said deflection coil to produce a cyclically varying current therein, an inverted electron tube having a cathode, a control electrode and an anode, means for connecting the cathode and anode of said inverted tube to opposite ends of said deflecting coil so that current passed by said inverted tube through said deflection coil will be in opposition to the current produced therein by application of the cyclically varying voltage, an electrostatic differentiating network responsive to the potential drop across said deflecting coil for producing a cyclically varying potential, and means for applying the produced cyclically varying potential across the cathode and control electrode of said inverted tube.

10. A cathode ray beam deflecting system for electromagnetically deflecting a cathode ray beam comprising a source of cyclically varying current, an electromagnetic cathode ray beam deflecting coil, means for passing the cyclically varying current through said deflection coil, an inverted electron tube having a cathode, a control electrode and an anode, means for connecting the cathode and anode of said inverted tube to opposite ends of said deflecting coil so that the

electronic current passed by said inverted tube through said deflection coil will be in a direction opposite to the direction in which the cyclically varying current is passed therethrough, a differentiating network comprising two series connected parallel resistance and condenser combinations responsive to the potential drop developed across said deflecting coil for producing a cyclically varying potential, and means for applying the produced cyclically varying potential between the cathode and control electrode of said inverted tube.

11. A system for electromagnetically deflecting a cathode ray beam comprising a deflection power tube having a cathode, a control electrode and an anode, means including a load circuit for maintaining said anode positive with respect to said cathode, an electromagnetic cathode ray beam deflecting coil, means for coupling said electromagnetic deflecting coil across said load circuit, means for applying cyclically varying voltage variations of a predetermined wave form between the control electrode and cathode of said power tube to produce cyclically varying current variations in said deflecting coil, an inverted suppressor tube having a cathode, a control electrode and an anode, means for connecting said inverted tube across said deflecting coil with the cathode of the inverted tube connected to the power tube anode end of the deflecting coil, a resistance-capacitance differentiating network responsive to the potential developed across said deflecting coil for producing a cyclically varying potential of a predetermined wave form, and means for applying said produced potential across the cathode and control electrode of said inverted suppressor tube.

12. A system for electromagnetically deflecting a cathode ray beam comprising a deflection power tube having a cathode, a control electrode and an anode, means including a load circuit for maintaining said anode positive with respect to said cathode, an electromagnetic cathode ray beam deflecting coil, means for coupling said electromagnetic deflecting coil across said load circuit, means for applying cyclically varying voltage variations of a predetermined wave form between the control electrode and cathode of said power tube to produce cyclically varying current variations in said deflecting coil, an inverted suppressor tube having a cathode, a control electrode and an anode, means for connecting said inverted tube across said deflecting coil with the anode of the inverted tube connected to the fixed potential end of the deflecting coil, a differentiating network comprising a parallel connected condenser and resistance combination and a series connected condenser responsive to the potential developed across said deflecting coil by the current variations for producing a cyclically varying potential of a predetermined wave form, and means for applying said produced potential variation between the cathode and control electrode of said inverted suppressor tube to cyclically vary the impedance thereof.

13. A system for electromagnetically deflecting a cathode ray beam comprising a deflection power tube having a cathode, a control electrode and an anode, means including a load circuit for maintaining said anode positive with respect to said cathode, an electromagnetic cathode ray beam deflecting coil, means for coupling said electromagnetic deflecting coil across said load circuit, means for applying cyclically varying voltage variations of a predetermined wave form

between the control electrode and cathode of said power tube to produce cyclically varying current variations in said deflecting coil, an inverted suppressor tube having a cathode, a control electrode and an anode, means for connecting said inverted tube across said deflecting coil with the cathode of the inverted tube connected to the power tube anode end of the deflecting coil, a differentiating network comprising two series connected parallel condenser and resistance combinations responsive to the potential developed across said deflecting coil due to the current variations therein for producing a cyclically varying potential of a predetermined wave form, and means for applying said produced potential variation between the cathode and control electrode of said inverted suppressor tube to produce a second cyclically varying current therein.

14. A system for electromagnetically deflecting a cathode ray beam as described in claim 10 wherein the capacity elements of said differentiation network include at least in part the inter-electrode capacitances of said inverted tube.

15. A system for electromagnetically deflecting a cathode ray beam as described in claim 12 wherein the capacity elements of said differentiation network include at least in part the inter-electrode capacitances of said inverted tube.

16. A system for electromagnetically deflecting a cathode ray beam as described in claim 13 wherein the capacity elements of said differentiation network include at least in part the inter-electrode capacitances of said inverted tube.

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