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2,421,312

DEFLECTION SIGNAL GENERATOR FOR POLAR SCANNING OF CATHODE RAY TUBES

Filed April 25, 1944

2 Sheets-Sheet 1

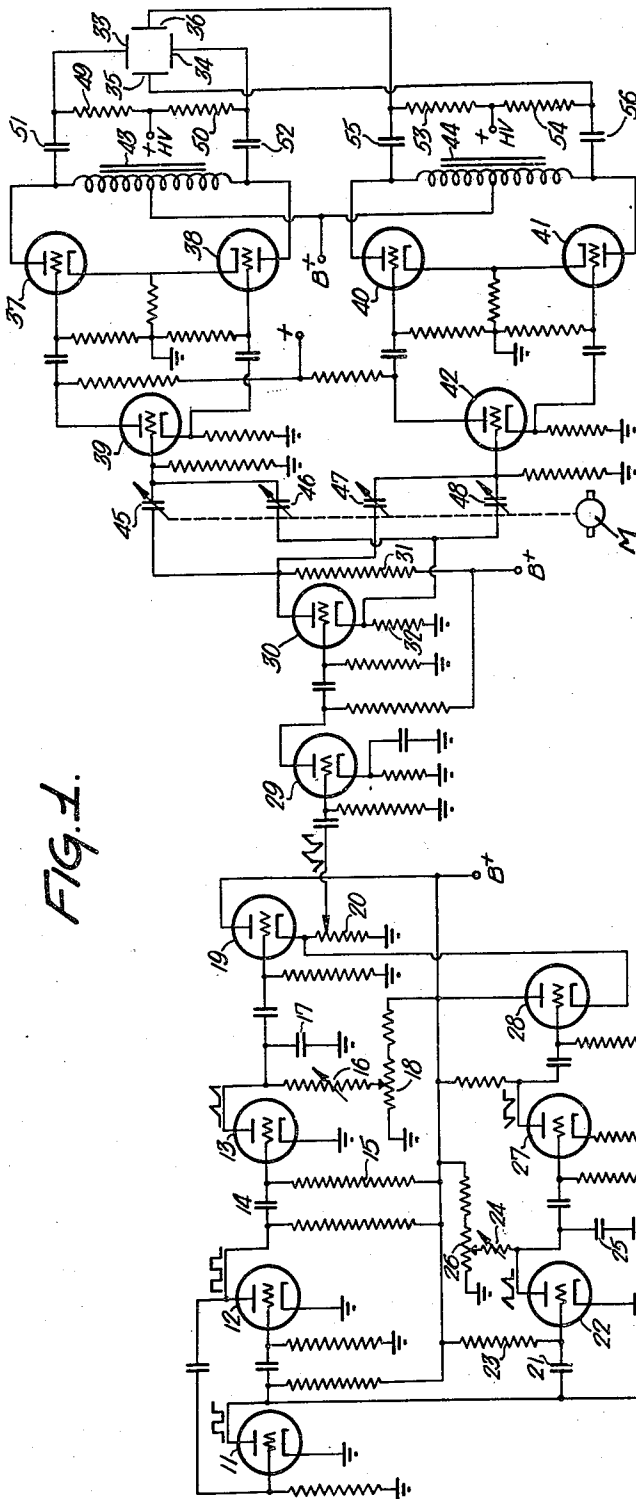


FIG. 1.

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2 Sheets-Sheet 2

FIG. 2.

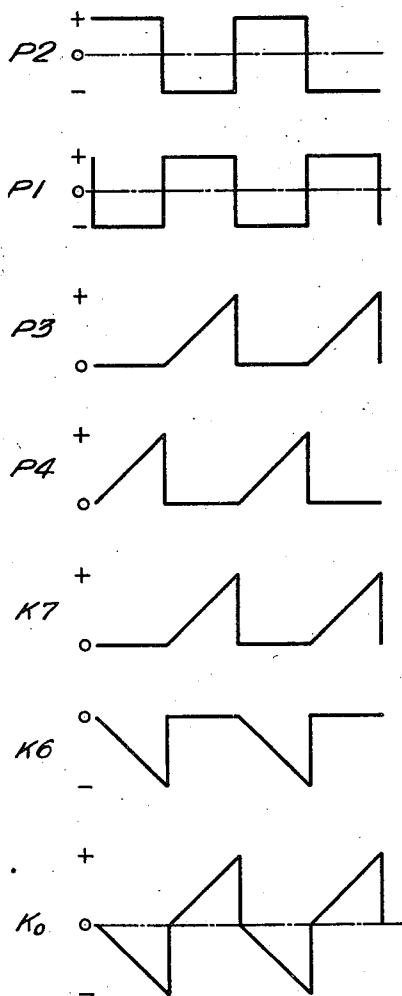


FIG. 3.

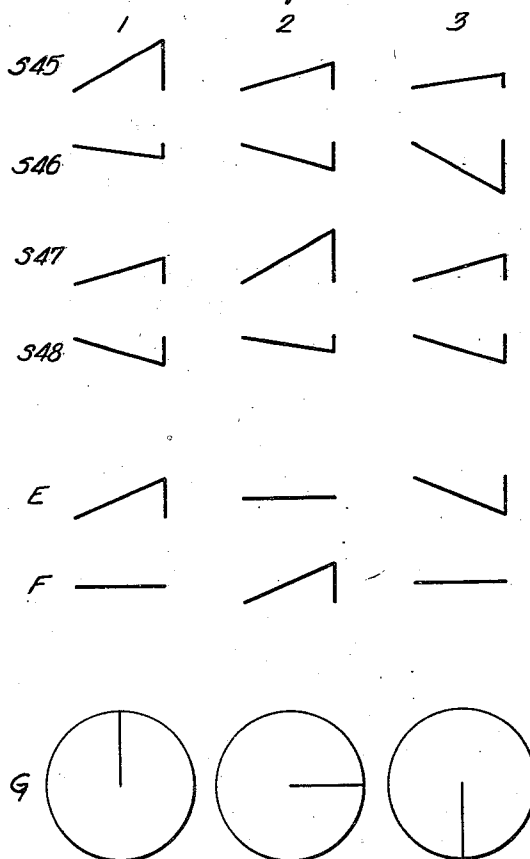
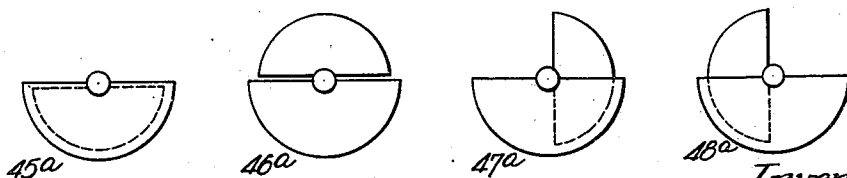


FIG. 4.



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UNITED STATES PATENT OFFICE

2,421,312

DEFLECTION SIGNAL GENERATOR FOR
POLAR SCANNING OF CATHODE-RAY
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assignments, to Philco Corporation, Philadel-
phia, Pa., a corporation of Pennsylvania

Application April 25, 1944, Serial No. 532,670

19 Claims. (Cl. 315-24)

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The present invention relates to signal generators for producing deflection voltages for cathode ray tubes, and more particularly to a deflection signal generator arranged to provide for the polar scanning of a cathode ray tube.

By "polar scanning" reference is had to that type of scanning wherein the electron beam traces successive radial lines on the screen of the cathode ray tube, the direction of the line being changed in successive radial scans, so that after a complete polar cycle the screen is completely scanned, as if by a rotating vector having its origin at the center of the screen.

The effect of polar scanning may be made to appear as an illuminated circular area, or as an illuminated line or vector revolving about the center of the screen, depending upon the speed with which the scanning line is made to rotate and upon the persistence of the fluorescent screen. In certain applications of cathode ray tubes, such as those wherein the tubes are used as indicating devices to provide an indication of the bearing, or azimuth, of a given object, it is frequently desirable to employ polar scanning in place of the more conventional rectangular scanning. In order to provide for such polar scanning the present invention provides, in a novel and simple manner, for the generation of a plurality of voltages which may be so controlled as to determine the rate of polar scanning.

It is, therefore, an object of the present invention to provide an improved circuit for effecting polar scanning of a cathode ray tube.

It is another object of the present invention to provide an improved and relatively simple scanning signal generator for effecting the polar scanning of a cathode ray tube, together with means for determining the rate at which the cathode ray beam is deflected radially on the one hand and circularly on the other.

Another object of the invention is to provide deflection voltages having symmetrical wave forms, thus eliminating the need for additional leveling circuits to center the pattern on the screen.

A further object of the invention is to effect polar scanning of a cathode ray tube by generating an alternating voltage wave having a rising wave front from a steep wave back in each half cycle, and by deriving voltages from said wave which are applied to the deflecting circuits of said tube and which are varied cyclically so as to produce the desired polar scanning.

Other and further objects of the present invention subsequently will become apparent by

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reference to the following description taken in conjunction with the accompanying drawings, wherein

Fig. 1 is a circuit diagram of a preferred embodiment of the invention;

Fig. 2 illustrates certain of the wave shapes produced by the circuit of Fig. 1;

Fig. 3 is an explanatory diagram which illustrates the manner in which various voltages are related to each other, and how they vary to produce polar scanning; and

Fig. 4 shows a preferred mechanical relationship of the variable condenser assembly.

The present invention may be practiced with cathode ray tubes having either magnetic or electrostatic deflection means. However, the power requirements for an electrostatic deflection system are much less than for a magnetic system (as is well known in the art) and consequently the electrostatic system is preferred where economy in cost and in weight is important. The circuit, as illustrated and described, is provided with an electrostatic deflection system, permitting the use of relatively small tubes throughout. Although the illustrated embodiment of the invention employs conventional triodes, it is to be understood that other types of tubes may be used, with appropriate circuit modifications.

Fig. 1 shows the schematic wiring diagram of one embodiment of the invention. For simplicity, plate load resistors, grid coupling condensers, grid resistors, cathode bias resistors, and by-pass condensers, where used in conventional manner, are unidentified. Circuit elements involved in the detailed description are given specific identification.

Vacuum tubes 11 and 12, with their respective circuit components, form a conventional multivibrator type of relaxation oscillator, producing square wave voltages in their plate circuits, of the frequency determined by the time constants of their grid resistors and grid coupling condensers, as is well known in the art. It is to be understood that other circuits or devices which produce the necessary voltages, for instance a mechanical chopper or vibrator, could be used in place of the multivibrator shown.

The alternating component of the output voltage of tube 12, of the wave form shown at P2 in Fig. 2, is applied to the grid of tube 13 through grid coupling condenser 14. Tube 13, with its adjustable plate load resistor 16 and with condenser 17 shunted across its output circuit, forms a conventional saw-tooth generator. This tube 13 is biased slightly positive by the plate voltage sup-

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ply B+, which is applied to the grid through a very high resistance grid resistor 15. The voltage drop through resistor 15 due to the small amount of grid current prevents an excessively positive voltage from being applied to the grid of tube 13. Potentiometer 18 is part of a voltage divider system connected across the plate voltage supply. The movable arm of potentiometer 18 is connected to one end of resistor 16. Resistor 16 and potentiometer 18 are so adjusted that the plate voltage on tube 13 is substantially zero during all positive half cycles of the alternating grid voltage. That is, during positive alternations of the grid voltage the internal cathode-to-plate circuit of the tube approximates a short circuit across the condenser 17. Conversely, during negative alternations of the grid voltage the tube 13 is driven to plate current cut-off and hence the shunting effect of the tube 13 across the condenser is eliminated. During the latter period the voltage across the condenser 17 increases linearly, the condenser being charged by virtue of its connection to B+ through the plate resistor 16. During the positive alternations the condenser 17 is effectively short circuited and hence the voltage thereacross is substantially zero. This mode of operation produces the linear sawtooth wave illustrated at P3 in Fig. 2.

The potentiometer 18 provides means of varying the voltage applied to plate of tube 13 so that either a linear or logarithmic saw-tooth wave may be generated in the output of this tube, as will be described later. The present description is based on a linear saw-tooth wave in which the voltage across condenser 17 builds up linearly with time, as indicated at P3 in Fig. 2.

The voltage developed across condenser 17 is fed conventionally to the grid of a resistance-capacitance coupled cathode follower amplifier tube 19. Since tube 19 is cathode loaded, its output is in phase with the input. The wave form of the output voltage developed across the cathode resistor 20 due to the plate current of tube 19 is shown at K7 in Fig. 2.

Returning now to tube 11 of the multivibrator, the output voltage of tube 11 is 180° out of phase with the output of tube 12 which is, of course, normal multivibrator action. The output voltage wave shape of tube 11 in relation to the output of 12 is shown at P1 in Fig. 2. The output voltage of tube 11 is applied through coupling condenser 21 to the grid of tube 22. This tube 22 is arranged for the same performance as tube 13, that is, it generates a saw-tooth wave form output but on the negative half cycles of tube 11. The circuit elements associated with tube 22, namely resistors 23 and 24, condenser 25, and potentiometer 26, perform the same functions in the circuit of tube 22, as resistors 15 and 16, condenser 17 and potentiometer 18, respectively, in the circuit of tube 13.

The outputs of tubes 13 and 22 are thus displaced by one-half cycle. The output of tube 22 is shown at P4 in Fig. 2, and is displaced by 180° from P3 of Fig. 2. The magnitude of the output potential of tube 22 is made equal to the potential developed in the output of the other saw-tooth generator tube 13.

The output of tube 22 is applied conventionally to the grid of a self-biased amplifier tube 27, which, being a resistance-capacitance coupled amplifier will invert the signal applied to its grid. The amplifier is adjusted for a gain of unity; thus the output potential is of the same magnitude as the output of the saw-tooth gen-

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erator tubes. The output of amplifier tube 27 then has the form shown at K6 in Fig. 2.

The output of tube 27 is applied to the grid of another resistance-capacitance coupled cathode follower amplifier tube 28. However, it will be noted that this latter tube uses the same cathode resistor that is in the cathode circuit of tube 19, namely resistor 20. Tube 19 therefore serves as a combining amplifier, since its cathode circuit combines its own output with that of tube 28.

The combining of the two outputs is accomplished as follows:

With no signal on the grid of either tube 19 or tube 28 the current through resistor 20 is the sum of the steady plate current of both tubes 19 and 28. When a negative signal is applied to the grid of tube 28 there will be no signal on the grid of tube 19, due to the half cycle displacement between the two signals, as previously explained. Similarly, when a positive signal is on the grid of tube 19, no signal is on the grid of tube 28.

The current through resistor 20 decreases in accordance with the negative signals on the grid of tube 28, and increases in accordance with the positive signals on the grid of tube 19. It will be remembered that only positive sawtooth signals are applied to the grid of tube 19 and only negative sawtooth signals to the grid of tube 28. The output voltage from resistor 20 then follows the wave form of the two voltages on the grids of tubes 19 and 28, and is represented at K6 in Fig. 2. Resistor 20 in Fig. 1 is shown as a potentiometer to provide means for varying the amplitude of its output voltage.

It is to be understood that while one circuit has been described which generates the voltage wave shape illustrated at K6 in Fig. 2, which wave shape may be described as a sawtooth wave form with the alternate cycles inverted, other circuits may be used to obtain the same wave shape.

This output voltage of wave shape K6 is applied directly, or through suitable amplifiers, if required, to the input of a conventional self-biased resistance-capacitance coupled amplifier tube 29. The amplified voltage of the wave form shown at K6 in Fig. 2 is applied by conventional means to the grid of a resistance-capacitance amplifier tube 30. This latter tube is both plate and cathode loaded. Its plate load resistor 31 is of the same value as cathode resistor 32, so that two signals of equal magnitude, but of opposite polarity are available from tube 30. Both of these signals are applied to a deflection voltage amplifier system for the vertical deflecting plates 33 and 34 of a cathode ray tube, and to a deflection voltage amplifier system for the horizontal deflecting plates 35 and 36.

The vertical deflection voltage amplifier consists of tubes 37 and 38 operating as a self-biased push-pull amplifier, and with their grids coupled by resistance-capacitance means to the phase inverter tube 39. The horizontal deflection voltage amplifier consists of tubes 40 and 41 similarly connected in push-pull and coupled to phase inverter tube 42. Inverter tubes 39 and 42 are both cathode and plate loaded with resistors of equal value, which method of phase inversion for use with push-pull amplifiers is well known. The grids of the inverter tubes 39 and 42 are returned to ground in a conventional manner through high resistance grid resistors.

The output voltage of tubes 37 and 38 for the vertical deflecting plates is developed across a high inductance center-tapped choke 43, one end

of which is connected to the plate of tube 37, the other end being connected to the plate of tube 38. The center tap is connected to the anode supply, marked B++, which may be of higher potential than the anode supply, marked B+, for the preceding tubes, as is well known in the art. The output voltage of tubes 40 and 41 for the horizontal deflecting plates is developed across a similarly connected inductance 44. The development of the necessary voltages across these two inductances for polar scanning will now be described.

Returning to tube 30 in Fig. 1, there are available from this tube two signals of the same magnitude, but of opposite polarity, and of the wave form shown at K₀ in Fig. 2. One of the signals is at the plate of tube 30, the other at the cathode. The signal voltage from the plate of tube 30 is applied to the grid of inverter tube 39 through variable condenser 45, and to the grid of inverter tube 42 through variable condenser 47. The signal voltage from the cathode of tube 30 is applied to the grid of tube 39 through variable condenser 46, and to the grid of tube 42 through variable condenser 48.

It is by means of the signals from tube 30, and the arrangement of the rotor plates of the four variable condensers, that the necessary horizontal and vertical deflecting plate voltages for polar scanning are formed. As indicated in Fig. 1, the variable condensers are ganged, the rotor plates being turned by a common shaft. The rotor plates of condensers 45 and 46 are insulated from the rotor plates of condensers 47 and 48, and all four rotor plates are insulated from ground. The rotors are driven by some suitable means, such as a motor M, and the speed of rotation of the rotor shaft determines the rate of the polar scanning of the cathode ray tube. The arrangement of the condenser rotor plates is illustrated in Fig. 4. Semi-circular plates are shown for the purpose of illustration, but other shapes may be used as required.

In Fig. 4, at the particular instant shown, the rotor plates of condenser 45a, representing condenser 45 of Fig. 1, are in full mesh or maximum capacity position. The rotor of condenser 45a, which represents condenser 46 in Fig. 1, is completely out of mesh or at minimum capacity, and the rotors of condensers 47a and 48a, representing condensers 47 and 48 of Fig. 1, are at one-half mesh or one-half maximum capacity position. It is by this 180° relation between condensers 45 and 46 and between condensers 47 and 48 and the 90° relation between each pair that the rotating field for polar scanning from the saw-tooth input signals is formed.

The generation of the necessary voltages for polar scanning may be understood by referring to Fig. 3, and the right-hand part of Fig. 1, bearing in mind that the deflection of the electron beam of a cathode ray tube depends upon the resultant field of two mutually perpendicular fields, which fields are proportional to the magnitudes and polarity of the differences of potential between the plates of each pair of mutually perpendicular deflecting plates. If the relative magnitudes or the polarity of these mutually perpendicular fields is changed then the direction of the resultant field will change.

Assume that the negative half cycle of the amplified saw-tooth signal is applied to the grid of tube 30 and that the positions of the variable condenser assembly rotors are as shown in Fig. 4, the signals applied to all four variable condensers will be of equal magnitude, since resistor 31

equals resistor 32, but the signals applied to variable condensers 45 and 47 will be positive while the signals applied to condensers 46 and 48 will be negative. Since the reactance of a condenser is inversely proportional to its capacity, the voltage drop across condenser 45 will be much less than the voltage drop across condenser 46. A large positive voltage and a small negative voltage will then be applied to the grid of tube 39, which tube is part of the vertical deflecting plate voltage amplifier.

The signal applied to the grid of tube 42, which tube is part of the horizontal deflecting plate voltage amplifier, is a positive voltage from the plate of tube 30 and an equal negative voltage from the cathode of tube 30, or a net zero signal voltage since condensers 47 and 48 are set at equal capacity positions.

The voltage relations are shown in Fig. 3, column 1, for the condition assumed above, i. e. with a negative signal on grid of tube 30, and with the condenser rotors as shown in Fig. 4. In Fig. 3, S45 is the signal from condenser 45, S46 the signal from condenser 46, S47 the signal from condenser 47, and S48 the signal from condenser 48.

The net voltage on the grid of each inverter tube 39 and 42 is the algebraic sum of the individual voltages from the condensers. Thus, E in Fig. 3, which represents the voltage on the grid of tube 39, is the algebraic sum of S45 and S46, a positive voltage which increases with time, then suddenly returns to zero, and F, which represents the voltage on the grid of tube 42, is the sum of S47 and S48 which is zero voltage.

For the period assumed, the signal, as amplified by the deflecting voltage amplifiers, will be such that the signal voltage developed across choke 43 for the vertical deflecting plates will be positive on the upper plate and negative on the lower plate, and the signal voltage developed across inductance 44 for the horizontal deflecting plates will be zero.

The signal voltage developed across inductance 43 is applied to the vertical deflecting plates 33 and 34 by means of coupling and blocking condensers 51 and 52, and the resistors 49 and 50 in the high voltage supply circuit +HV.

Likewise, any signal voltage developed across inductance 44 is applied to horizontal deflecting plates 35 and 36 by way of condensers 55 and 56 and resistors 53 and 54.

The supply voltage +HV shown in Fig. 1 represents the high voltage which, in practice, is generally applied to the second anode and also to the deflecting plates of a cathode ray tube. By such a connection the deflecting plates are at practically the same direct potential as the second anode, thus minimizing any retardation of the electron stream as it approaches the deflecting plates. This method of operation is well known in the art.

The pattern on the screen of the cathode ray tube will then, for conditions previously assumed, be as shown at G in Fig. 3, column 1, the spot moving uniformly from the center to the edge of the tube, then returning rapidly. With the condenser rotors in the position shown in Fig. 4, there will always be maximum percentage of the signal voltage on the grid of tube 39 and zero signal voltage on the grid of tube 42.

Assume now that the condenser shaft has rotated a quarter turn clockwise and that the negative half of the saw-tooth voltage is again on the grid of tube 30. Under these conditions there

will be equal positive and negative voltages applied to the grid of tube 39 since condensers 45 and 46 are both at $\frac{1}{2}$ maximum capacity, but on the grid of tube 42 there will be a large portion of the positive voltage from the plate to tube 30 as condenser 47 is now at maximum capacity, with minimum voltage drop across it, and a small negative voltage from the cathode of tube 30 since condenser 48 is at minimum capacity with maximum voltage drop across it. Thus the voltage relations will be as shown in column 2 of Fig. 3 where the letters S45 to S48, E and F represent the voltages at the points previously mentioned. For this assumed condition the voltages derived from the deflection voltage amplifiers and applied to the deflecting plates will be such as to sweep the electron beam across the screen from the center to the right in the pattern shown at G in Fig. 3, column 2.

With the negative half cycle of the input voltage and with the condenser shaft rotated another $\frac{1}{4}$ turn clockwise the voltages from the variable condensers and the net voltages on the grids of tubes 39 and 42 will be as shown under column 3 of Fig. 3, the resulting screen pattern being shown at G in the same column.

For positions of the condenser rotors other than the three assumed positions it is easily seen that as the condenser rotors are rotating, one deflecting voltage, either horizontal or vertical, is increasing while the other is decreasing. The resultant field due to these voltages is then changing its direction at the speed of rotation of the condenser rotor shaft. In general, the rotational speed of the condenser will be very low compared to the saw-tooth frequency. In other words, there will be a large number of radial scans for each complete revolution of the radius vector shown at G, column 1, Fig. 3.

The previous assumptions have been for negative portions of the sawtooth signal applied to tube 30 in Fig. 1, and the diagrams in Fig. 3 are for this signal. On the positive half cycles of the said sawtooth signal, the voltages represented in Fig. 3 will, of course, be of opposite polarity resulting in patterns, for each case shown at G, Fig. 3, extending in the opposite direction from the center of the screen. For an input of both positive and negative half cycles of the sawtooth signal, a line pattern will appear on the screen with its center at the center of the screen and which will rotate about its center at an angular velocity equal to the angular velocity of the condenser assembly shaft.

If it is desired to produce an effect similar to that shown at G, Fig. 3, namely a pattern extending from the center in one direction only but revolving about the center of the screen, a blanking circuit is provided by vacuum tube 57 in Fig. 1. This tube is cathode loaded and its grid is excited from the output of tube 11 through grid coupling condenser 59 and grid resistor 60. On the negative half cycles of the output of tube 11 a negative voltage is developed across its cathode load resistor 58 which voltage may be applied to the control grid of the cathode ray tube to prevent beam current from flowing during this half cycle of the multivibrator oscillation.

It may be desirable in some applications of polar scanning to vary the speed of the electron beam during its sweep across the fluorescent screen. For example a faster sweep may be desired near the center of the screen than in regions farther from the center. This may be accomplished by allowing the voltage on the condensers

17 and 25, in the sawtooth generator circuits associated with tubes 13 and 22, to build up logarithmically with time instead of linearly as illustrated and described with reference to tubes 13 and 22 of the invention.

Provision for affecting the linearity of the sawtooth wave fronts is incorporated in the invention through adjustment of potentiometer 18 for tube 13 and potentiometer 26 for tube 22 (Fig. 1).

It is well known in the art that the ratio of supply voltage to the potential to which a condenser is permitted to charge, in a resistance-capacitance circuit, determines the linearity of the charging voltage wave or of the wave front of a generated saw-tooth wave. If the supply voltage is much higher than the voltage to which a condenser is permitted to charge, in this type circuit, the charge or the potential will build up on the condenser at a linear rate. In practice the condenser in a saw-tooth generator is allowed to charge up to about 15% of the supply voltage for a linear wave front.

If, however, the condenser charges to nearly the same potential as the supply voltage, or conversely, if the supply voltage is low so that in the charging cycle of the condenser it is charged to a high percentage of the supply voltage, the potential on the condenser builds up logarithmically with time and the wave front of the saw-tooth wave is logarithmic instead of linear.

If the movable arms of the potentiometers 18 for tube 13 and 26 for tube 22, Fig. 1, are moved toward the grounded side of the potentiometer resistance a lower supply voltage will be applied to the plate circuits of tubes 13 and 22. If the voltage applied approximates the voltage to which the condensers 17 and 25 are permitted to charge during their charging cycle, a logarithmic sawtooth wave will be generated, resulting in a deflecting voltage which varies logarithmically with time being applied to the deflecting plates. Likewise, if the arms are moved toward the high potential side of the resistance and voltage conditions are favorable, a linear saw-tooth wave will be generated, resulting in a linear deflecting voltage being applied to the deflecting plates.

It is to be understood that the result obtained from the arrangement and operation of the four ganged variable condensers 45, 46, 47 and 48, Fig. 1, previously described, may be accomplished by other means. Each pair of condensers connected to each grid of the inverter tubes 39 and 42, acts as a capacitance potentiometer capable of varying the magnitude of the signal voltages applied to the grids of the inverter tubes and of cyclically selecting the voltage from the plate or cathode circuit of tube 30 which circuits are of opposite phase or polarity. Thus, for instance, it will be apparent to those skilled in the art that a suitable resistance potentiometer could be substituted for each pair of condensers 45—46 and 47—48. The arms of these potentiometers could be displaced 90° relative to each other and rotated by a suitable means to accomplish the same result as the variable condensers. However, the capacitive embodiment is the preferred arrangement since a smoother voltage change is accomplished by this method than is practical to obtain with a resistance potentiometer.

It is also to be understood that while the invention is illustrated and described for electrostatic deflection of the electron beam of a cathode ray tube, it is applicable to magnetic deflection. It will be apparent to those familiar with the art that by changing the wave form of the

voltage derived from the output of the combining amplifier 19, Fig. 1, illustrated at K₀ in Fig. 2, to a form suitable for magnetic deflection coils, and by using suitable deflection voltage amplifiers for the larger power requirements of magnetic deflection means, the invention may be applied to cathode ray tubes having magnetic deflecting coils.

In practicing this invention in accordance with the embodiment illustrated in Fig. 1 and the description related thereto, type 7N7 twin triode tubes were used in all circuits except the push-pull amplifier tubes 37, 38, 40, 41, which were type 6F8G twin triodes. The advantage of the twin type tubes is, of course, a more compact arrangement than is possible with single tubes.

The anode supply voltage marked B+ in the various locations in Fig. 1 was 200 volts, that marked B++ for the push-pull amplifier tubes was 250 volts, while the high voltage designated as +HV was 3000 volts D. C.

Other circuit values which are of special interest in the operation of the invention, as shown in Fig. 1, are as follows:

The multivibrator output frequency was 500 cycles per second.

All grid coupling condensers, other than those in the multivibrator circuit, were 0.1 μ f.

The maximum capacity of each of the four variable condensers 45, 46, 47 and 48 was 500 μ f.

All grid resistors, other than those in the multivibrator circuit, were of 5 megohms, except that the grid resistors for the two phase inverter tubes 39 and 42 had a value of 40 megohms. The purpose of the high value of grid leak resistance is to preserve the wave form of the generated saw-tooth wave in the various amplifying circuits for application to the deflecting plates.

Resistors 16 and 24 in the saw-tooth wave generators were variable 1 megohm resistances while the associated condensers 17 and 25 were 0.003 μ f.

Resistor 20 was a 5000 ohm potentiometer.

Inductances 43 and 44 each consisted of two 80 henry chokes connected in series.

Resistors 49, 50, 53, 54 were each 5 megohms.

Condensers 51, 52, 55, 56 were each 0.01 μ f.

Other circuit parameters were of such values for the type tubes and voltages used as would be used in conventional circuits.

While a particular circuit arrangement has been illustrated and described to disclose the invention, it is to be understood that it is not limited thereby, since variations and modifications in the circuit arrangements and in the instrumentalities employed are deemed to be within the scope of the invention as defined by the appended claims.

I claim:

1. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means responsive to said voltage wave for producing control voltages, means for cyclically varying said control voltages, and means operable by said control voltages to effect scanning movement of the electron beam within said tube.

2. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means responsive to said voltage wave for producing control voltages, means for cyclically varying said control voltages, means operable by said control voltages to produce resultant deflecting voltages,

and means for applying said deflecting voltages to the deflecting elements of said tube.

3. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means responsive to said voltage wave for producing control voltages, a pair of deflecting circuits connected to the deflecting elements of said tube, means for applying said control voltages to said deflecting circuits, and means for cyclically varying said control voltages in a manner to effect polar scanning movement of the electron beam within said tube.

4. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means responsive to said voltage wave for producing control voltages, a pair of push-pull deflecting circuits connected to the deflecting elements of said tube, means for applying said control voltages to said deflecting circuits, and means for cyclically varying said control voltages in a manner to effect polar scanning movement of the electron beam within said tube.

5. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means responsive to said voltage wave for producing control voltages, a pair of deflecting circuits connected to the deflecting elements of said tube, means for applying said control voltages to said deflecting circuits, and means including power-driven variable condensers operatively associated with said circuits for cyclically varying said control voltages in a manner to effect polar scanning movement of the electron beam within said tube.

6. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means responsive to said voltage wave for producing two control voltages of opposite phase, a pair of deflecting circuits having their outputs respectively connected to the deflecting elements of said tube, means for applying both of said control voltages to the input of each of said deflecting circuits, and means for cyclically varying the input voltages to said deflecting circuits in a manner to effect polar scanning movement of the electron beam within said tube.

7. In a system for effecting polar scanning of a cathode ray tube, means for producing a pair of saw-tooth control voltages of opposite phase, a pair of deflecting circuits having their outputs respectively connected to the deflecting elements of said tube, means for applying both of said control voltages to the input of each of said deflecting circuits, and means for cyclically varying the input voltages to said deflecting circuits in a manner to effect polar scanning movement of the electron beam within said tube.

8. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, a vacuum tube having cathode and anode load impedances, means for applying said voltage wave to the input of said vacuum tube, a pair of deflecting circuits having their outputs respectively connected to the deflecting elements of said cathode ray tube, connections between said im-

pedances and the inputs of said deflecting circuits for applying the output voltages of said vacuum tube to each deflecting circuit, and means for cyclically varying the input voltages to said deflecting circuits in a manner to effect polar scanning movement of the electron beam within said cathode ray tube.

9. In a system for effecting polar scanning of a cathode ray tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, a vacuum tube having cathode and anode load impedances, means for applying said voltage wave to the input of said vacuum tube, a pair of deflecting circuits having their outputs respectively connected to the deflecting elements of said cathode ray tube, connections between said impedances and the inputs of said deflecting circuits for applying the output voltages of said vacuum tube to each deflecting circuit, and power-driven variable condensers in said connections arranged to vary the input voltages to said deflecting circuits cyclically and relatively in a manner to effect polar scanning movement of the electron beam within said cathode ray tube.

10. In a system for effecting polar scanning of a cathode ray tube, a source of square wave voltage, means connected to said source for producing saw-tooth voltages which when combined are adapted to constitute an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means for combining said saw-tooth voltages to produce said voltage wave, means responsive to said voltage wave for producing control voltages, means operable by said control voltages to produce deflecting voltages, means for applying said deflecting voltages to the deflecting elements of said tube, and means for cyclically varying said control voltages in a manner to effect polar scanning movement of the electron beam within said tube.

11. In a system for effecting polar scanning of a cathode ray tube, a source of square wave voltage, means connected to said source for producing saw-tooth voltages which when combined are adapted to constitute an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means for combining said saw-tooth voltages to produce said voltage wave, means responsive to said voltage wave for producing control voltages, a pair of deflecting circuits connected to the deflecting elements of said tube, means for applying said control voltages to said deflecting circuits, and means for cyclically varying said control voltages in a manner to effect polar scanning movement of the electron beam within said tube.

12. In a system for effecting polar scanning of a cathode ray tube, a source of square wave voltage, means connected to said source for producing saw-tooth voltages which when combined are adapted to constitute an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means for combining said saw-tooth voltages to produce said voltage wave, means responsive to said voltage wave for producing control voltages, a pair of push-pull deflecting circuits connected to the deflecting elements of said tube, means for applying said control voltages to said deflecting circuits, and means for cyclically varying said control voltages in a manner to effect polar scanning movement of the electron beam within said tube.

13. In a system for effecting polar scanning of a cathode ray tube, a source of square wave voltage,

age, means connected to said source for producing saw-tooth voltages which when combined are adapted to constitute an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means for combining said saw-tooth voltages to produce said voltage wave, means responsive to said voltage wave for producing two control voltages of opposite phase, a pair of deflecting circuits having their outputs respectively connected to the deflecting elements of said tube, means for applying both of said control voltages to the input of each of said deflecting circuits, and means for cyclically varying the input voltages to said deflecting circuits in a manner to effect polar scanning movement of the electron beam within said tube.

14. In a system for effecting polar scanning of a cathode ray tube, a source of square wave voltage, means connected to said source for producing saw-tooth voltages which when combined are adapted to constitute an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means for combining said saw-tooth voltages to produce said voltage wave, a vacuum tube having cathode and anode load impedances, means for applying said voltage wave to the input of said vacuum tube, a pair of deflecting circuits having their outputs respectively connected to the deflecting elements of said cathode ray tube, connections between said impedances and the inputs of said deflecting circuits for applying the output voltages of said vacuum tube to each deflecting circuit, and means for cyclically varying the input voltages to said deflecting circuits in a manner to effect polar scanning movement of the electron beam within said cathode ray tube.

15. In a system for effecting polar scanning of a cathode ray tube, a source of square wave voltage, means connected to said source for producing saw-tooth voltages which when combined are adapted to constitute an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means for combining said saw-tooth voltages to produce said voltage wave, a vacuum tube having cathode and anode load impedances, means for applying said voltage wave to the input of said vacuum tube, a pair of deflecting circuits having their outputs respectively connected to the deflecting elements of said cathode ray tube, connections between said impedances and the inputs of said deflecting circuits for applying the output voltages of said vacuum tube to each deflecting circuit, and power-driven variable condensers in said connections arranged to vary the input voltages to said deflecting circuits cyclically and relatively in a manner to effect polar scanning movement of the electron beam within said cathode ray tube.

16. A method of effecting polar scanning of a cathode ray tube, which comprises generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, utilizing said voltage wave to produce control voltages for effecting the scanning operation, and cyclically varying said control voltages in a manner to effect polar scanning movement of the electron beam within said tube.

17. In a system for effecting polar scanning of a cathode ray tube, a pair of deflecting circuits connected to the deflecting elements of said tube, means for producing a first pair of saw-tooth voltages of opposite phase, means for adding said saw-tooth voltages algebraically to produce a resultant voltage, means for applying said resultant

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voltage to one of said deflecting circuits, means for cyclically varying the magnitude and phase of said resultant voltage, means for producing a second pair of saw-tooth voltages of opposite phase, means for adding said last-named saw-tooth voltages algebraically to produce a second resultant voltage, means for applying said second resultant voltage to the other of said deflecting circuits, and means for cyclically varying the magnitude and phase of said second resultant voltage.

18. A system for effecting polar scanning of a cathode ray tube as defined in claim 17, wherein the recited means for varying the resultant voltages comprise power-driven variable condensers.

19. In a system for effecting polar scanning of a cathode ray tube, a pair of deflecting circuits connected to the deflecting elements of said tube, means for generating an alternating voltage wave having a rising wave front and a steep wave back in each half cycle, means responsive to said wave for producing a first pair of saw-tooth voltages of opposite phase, means for adding said saw-tooth voltages algebraically to produce a resultant voltage, means for applying said resultant voltage to one of said deflecting circuits, means

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for cyclically varying the magnitude and phase of said resultant voltage, means responsive to said wave for producing a second pair of saw-tooth voltages of opposite phase, means for adding said last-named saw-tooth voltages algebraically to produce a second resultant voltage, means for applying said second resultant voltage to the other of said deflecting circuits, and means for cyclically varying the magnitude and phase of said second resultant voltage.

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Disclaimer

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Disclaimer filed Aug. 30, 1949, by the assignee, *Philco Corporation*.

Hereby enters this disclaimer to claim 7 of said patent.

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