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DEFLECTION CIRCUIT

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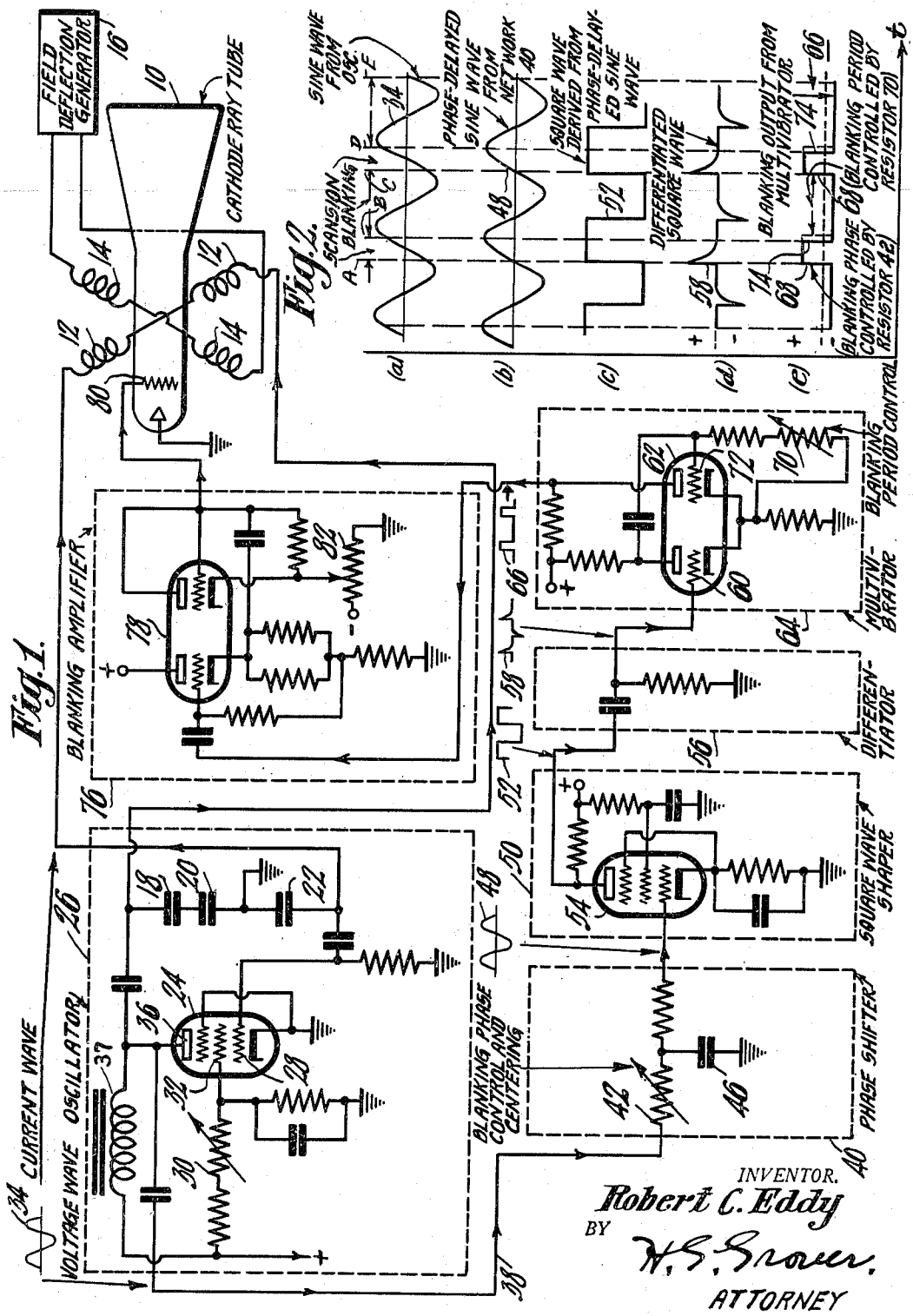


Fig. 1.

Fig. 2.

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DEFLECTION CIRCUIT

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The present invention relates to cathode ray beam deflection systems. In one embodiment, it relates to a low-power circuit for deflecting the cathode ray beam of an image-reproducing tube at line-scanning, or sweep, frequency, and with a sufficiently high degree of linearity to produce a raster which is suitable for checking certain of the operating characteristics of the tube.

When a cathode ray image-reproducing tube, or "Kinescope," is employed in connection with television receiving circuits, it is customary to bring about the desired deflection of the cathode ray scanning beam of the tube in each of its two mutually perpendicular directions by causing a sawtooth wave of current to flow through the electro-magnetic deflection unit associated with the tube, in the case of electro-magnetically deflected tubes, or by causing a sawtooth wave of voltage to be applied to a pair of deflection plates, in the case of electrostatically deflected tubes. If this sawtooth wave of current (or voltage) is of proper configuration, then the image reproduced on the face of the cathode ray tube will not be subject to crowding at its edges, or other distortion resulting from non-linearity of scan. In order to produce in electromagnetically deflected "Kinescopes" a suitable sawtooth current wave having sufficient amplitude for full beam deflection, it is customary to employ several power output tubes connected in parallel relation, especially in the case of "Kinescopes" which are operated at relatively high second anode potentials.

Due to the nature of the cathode ray tube itself, and due to the multiplicity of steps involved in its manufacture, it is necessary to thoroughly and accurately check the various operating characteristics of the tube before it is put into use. In order that this checking be done on the large scale necessary in mass production, well-designed test equipment is required.

One piece of test apparatus extensively used in connection with the manufacture of television image-reproducing tubes is the so-called life-test rack. This rack is adapted to hold several cathode ray tubes, and to operate these tubes under predetermined conditions for given periods of time. At the end of this test, the tubes are inspected in order to determine their response to the conditions imposed, and whether or not this response falls within prescribed standards.

The operating conditions for cathode ray tubes being tested in a life rack, such as mentioned above, are not necessarily the same as the conditions under which the tubes are operated in television applications, for example. Although it is

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essential that a raster of suitable area be produced upon the screen of the cathode ray tube during its life-testing, nonetheless the lines of this raster need not be as closely spaced as is the case for image reproduction, since the principal reason for producing such a raster during the testing operation is to establish an area on the tube face which is illuminated in a substantially uniform manner. This permits certain response characteristics of the tube to be determined for conditions under which the tube would normally be operated in practice, such, for example, as the life of various phosphors. Furthermore, from this illuminated area the light output of the cathode ray tube may be read directly in foot-lamberts upon a calibrated microammeter, or galvanometer, by applying a photocell directly to the tube face over the illuminated area.

In order to produce a uniformly illuminated raster, such as above set forth, it is not necessary to deflect the cathode ray scanning beam at a line frequency of 15.75 kilocycles, as is the case in presently-standard black and white television systems. Instead, the line or sweep frequency employed for the above-mentioned life test may be in the order of 3000 cycles per second, for example. Furthermore, since no modulation is applied to the grid of the cathode ray tube in the sense that modulation is applied to reproduce an image in television systems, it is therefore unnecessary that the linearity of line deflection be of as high a degree as in television circuits. Of course, if the linearity falls below a minimum standard, then the illumination of the tube face will not be sufficiently uniform for checking purposes. However, a reasonable degree of non-linearity can be tolerated without affecting to an appreciable degree the test results obtained.

It has been customary to deflect the cathode ray beam of magnetically deflected tubes being tested in a life rack by means of currents of sawtooth waveform. As previously stated, these sawtooth currents usually require several power output tubes in the deflection circuit, and the use of such power output tubes tends to keep the cost of such test equipment at a relatively high level.

Various attempts have been made to utilize other types of scanning generators in connection with apparatus of the type described. These attempts have included the use of a sine wave oscillator to deflect the cathode ray scanning beam of the tubes under test at line-scanning frequency. These attempts have not been successful, however, due to the fact that the deflection of the

beam produced by a sine wave deflection voltage is linear only over a portion of each cycle, resulting in a crowding of the lines at each side of the raster. The intensity of illumination at the raster edges, therefore, was so much higher than the intensity of illumination over the remainder of the raster that the results obtained from the life test and other calibrating procedures were unsatisfactory.

In accordance with the present invention, a vacuum tube sine wave oscillator is employed for deflecting the cathode ray scanning beam of a cathode ray tube at line-scanning frequency. However, the output of this oscillator is caused to produce a substantially linear trace on the face of the cathode ray tube through the utilization of only one substantially linear portion of each cycle of the oscillator sine wave output. During the remainder of each cycle, a portion of the output of the oscillator is utilized to produce a negative bias voltage which is applied to the control grid of the cathode ray tube in order to cut off, or blank, the cathode ray scanning beam.

Since only a single electron discharge device of standard construction (such, for example, as a tube of the 6L6 type) is utilized in the oscillator circuit itself, the cost of a deflection system designed in accordance with the present invention compares very favorably with the cost of formerly-used deflection circuits in which several power output tubes were employed in order to develop substantially linear sawtooth currents, or voltages, for deflecting the cathode ray beam.

The power requirements of a deflection circuit constructed in accordance with the present invention are reduced to a point where such a single oscillator tube may be utilized by employing the line deflection coils as part of a resonant circuit which is connected to receive the current output of the oscillator. This is achieved by connecting one or more condensers in parallel with the line deflection coils, the total capacity of these condensers being chosen so that the coil-condenser circuit will resonate substantially at the line-scanning frequency desired. Furthermore, such a mode of operation eliminates the necessity for employing special types of yokes for the cathode ray tubes under test, and also reduces insulation problems in connection therewith.

The means for blanking the scanning beam of the cathode ray tube during all except a selected substantially linear portion of each sine wave cycle of oscillator output is so designed that the duration of this blanking period may be manually controlled. This permits the selection of that portion of one direction of current flow through the line deflection coils which varies in a substantially linear manner with respect to time. Hence, by such a variation of the blanking period, the portion of such linearly varying current which is utilized for producing the image raster may be selected at will. Furthermore, since the initiation of the scanning period is controlled by phase-delaying the sine wave output of the oscillator, it is possible by varying the amount of this phase delay to control the centering of the raster on the face of the cathode ray tube.

One object of the present invention, therefore, is to provide a circuit for deflecting the scanning beam of a cathode ray tube at line-scanning frequency, and to further provide means whereby the line deflection coils associated with the cathode ray tube may form part of a resonant circuit connected to receive the current output of a sine wave oscillator.

A further object of the present invention is to provide a cathode ray beam deflection circuit for producing a raster area on the face of the cathode ray tube, the linearity of deflection of the cathode ray beam producing this raster being sufficiently high so that the raster area is illuminated in a substantially uniform manner.

A further object of the present invention is to provide means for causing a sine wave of current to flow through the line deflection coils which are associated with a cathode ray tube, and to further provide means whereby the scanning beam of the cathode ray tube is cut off, or blanked, during all but at least one selected substantially linear portion of each sine wave cycle.

Other objects will be apparent from the following description of a preferred form of the invention and from the drawings, in which:

Fig. 1 is a schematic representation of a preferred form of cathode ray beam deflection circuit in accordance with the present invention; and

Fig. 2 is a set of voltage waveforms which are referred to in explaining the operation of the circuit of Fig. 1.

Referring now to the drawings, there is shown in Fig. 1 a circuit for deflecting in substantially mutually perpendicular directions the electron beam of a cathode ray tube **10**. This mutually perpendicular deflection of the scanning beam of tube **10** will produce on the face of the tube an image raster in a manner well known in the art.

The cathode ray tube **10** has associated therewith a pair of horizontal, or line, deflection coils **12** and a pair of vertical, or field, deflection coils **14**. These coils **12** and **14** may constitute a yoke assembly encircling the neck of the cathode ray tube **10**, as well known in the art. The field deflection coils **14** are energized by current, preferably of sawtooth waveform and varying at field-scanning frequency, from a field deflection generator **16**. The generator **16** may be of any suitable type, and hence the details thereof have not been illustrated in order to simplify the drawing.

The horizontal, or line, deflection coils **12** are connected in parallel with three series condensers **18**, **20** and **22**, and hence the capacity of these condensers **18**, **20** and **22**, together with the inductance of the deflection coils **12**, forms a resonant, or tuned, circuit. The values of capacitance and inductance, respectively, of these elements are so chosen that the circuit will resonate at approximately the line-scanning or sweep frequency desired. For the purpose of the present invention, this frequency may be in the order of three kilocycles, although obviously any frequency of resonance within wide limits may be selected.

The tuned circuit including the condensers **18**, **20** and **22** and the line deflection coils **12** is supplied with cyclically varying current of sine wave configuration from an oscillator tube **24**. The oscillator tube **24** forms part of an oscillator circuit, generally indicated by the reference numeral **26**, and may be of any type which will operate to furnish to the deflection coils **12** a sine wave of current at the desired line-scanning frequency. Tube **24** is maintained in oscillating condition by feeding back a portion of its output with proper

polarity to one of its control grids, designated as 28.

Control over the amplitude of the sine wave output of tube 24 is obtainable by varying a potentiometer 30 connected in the voltage supply lead to the screen grid 32.

The current output of the oscillator circuit 26 which flows through the coils 12 will have a sine waveform such as indicated in the drawing by the reference numeral 34. A cyclically varying voltage having the same waveform 34 will appear on the anode 36 of tube 24 (or across the load inductance 37), and this voltage variation having the waveform 34 is applied over a conductor 38 to a phase-shifting network generally shown by the reference numeral 40.

Referring now to the sine wave 34 (which is shown in detail in Fig. 2a), it will be seen that this wave 34 has portions which vary in a substantially linear manner with respect to time. Each cycle of the sine wave 34 has two such portions, one in which the current is increasing from a negative to a positive value, and the other in which the current is decreasing from this positive value to a negative condition. In accordance with the present invention, preferably the former of these two mentioned portions is utilized—that is, that portion of each cycle in which the current is increasing in a positive direction. This portion is represented in Fig. 2 between the broken lines A and B, for one cycle, and between the broken lines C and D, for a second cycle. In other words, between the time intervals A and B and C and D, the voltage wave 34 varies in a substantially linear manner with respect to time.

As previously stated, the voltage wave 34 appearing on the plate 36 of tube 24 is applied over a conductor 39 to the phase-shifting network 40. This network includes a series resistor 42 and an intermediate shunt condenser 46. Network 40 acts to delay the phase of the sine wave 34 in such a manner that the output from the network 40 will be a sine wave 48 the phase of which is delayed with respect to the sine wave 34 in the manner illustrated by curve b of Fig. 2. The resistor 42 of the network 40 is adjustable in order to control the amount of phase delay.

The output of the phase-shifting network 40, represented by the phase-delayed sine wave 48, is applied to a wave-shaping network 50, which acts to produce in the output circuit thereof a substantially square wave having the waveform 52 (see Figs. 1 and 2). The details of the square wave-shaping circuit 50 may be of any suitable nature to produce the desired results, and since many such circuits are well known in the art, it will merely be said that the circuit 50 may include an electron discharge device 54 arranged to be driven alternately to saturation and cut-off, thereby producing an output wave the leading and trailing edges of each cycle of which are substantially vertical and the base portions thereof substantially flat. However, it may be necessary in some instances to provide one or more clipping stages in connection with the wave-shaping network 50 so as to produce an output wave 52 the leading edges of which are substantially vertical. The necessity for such an addition, however, depends in part upon the values of the components used for the network 50, and hence in many cases additional clipping elements may not be required.

The output of the wave-shaping network 50, consisting of the square wave 52, is differentiated by a capacity-resistance combination 56. The time constant of the R. C. combination 56 is relatively short, so that the output wave will be somewhat as shown by the reference numeral 58 in Figs. 1 and 2. This wave 58 consists of relatively sharp pulses of alternate positive and negative polarity, the leading edges of these pulses being substantially vertical and the trailing edges falling off rather rapidly in an exponential manner.

The differentiated square wave 58 is applied to the control grid 60 on one section of a twin triode 62 forming part of a multi-vibrator 64. This multi-vibrator 64 may be of known construction, and acts to furnish in the output circuit thereof a substantially rectangular wave which is indicated in the drawing by the reference numeral 66. Each cycle of the rectangular output wave 66 from the multi-vibrator 64 is initiated by the reception of one of the positive pulses of wave 58 on the control grid 60 of tube 62. The initial portion of each cycle of the output from multi-vibrator 64 may be represented by the substantially vertical leading edge 68 of wave 66 as shown in the curve e of Fig. 2. This substantially vertical leading edge 68 of each cycle of wave 66 coincides in time with the beginning of the substantially linear portion of rising current flow in the sine wave 34 of curve a, as represented by the broken line A (or C).

The output wave 66 of multi-vibrator 64 remains positive (from its initiation point on the broken line A) for a period of time determined by the adjustment of a potentiometer 70 which controls the rate of discharge from the control grid 72 of the second triode portion of tube 62 to ground. When this discharge from grid 72 reduces the potential on the grid to a predetermined value, the multi-vibrator triggers to produce the substantially vertical trailing edge 74 of wave 66. This trailing edge 74 occurs at the instant of time represented by the broken line B (or D). The output of the multi-vibrator then remains negative until the reception by grid 60 of tube 62 of a positive pulse 58 at the instant of time represented by the broken line C (or E). Another cycle now follows in the same manner as previously described—that is, the output wave 66 remains positive until the second half of tube 62 conducts, when it becomes negative until time E, etc. It will now be appreciated that the voltage wave 66, representing the output of multi-vibrator 64, alternates between periods of positive and negative polarity, the wave being positive during the scanning periods represented by A—B and C—D in the drawing, and negative during the blanking periods represented by the time intervals B—C and D—E. These intervals A—B and C—D, moreover, correspond to intervals during which the sine wave 34 varies in a substantially linear manner with respect to time—that is, they correspond to that portion of each sine wave cycle during which the wave varies linearly in a positive direction. The remainder of each oscillatory cycle of the sine wave 34 is covered by the blanking periods B—C and D—E.

The voltage wave 66 is amplified, if necessary or desirable, by a blanking amplifier 76, which may be of any suitable design. It may, for example, include a twin triode 78. The voltage wave 66 is applied to the first half of the twin triode 78, and the output is taken from the cathode of the tube so as to maintain the polarity of the wave 66. This output variation is applied to the control grid 80 of the cathode ray tube 10. Thus the cathode ray tube grid 80 is provided with a positive voltage from the cathode of

the first triode section of tube 78 during scanning intervals, and is correspondingly provided with a negative voltage during blanking intervals, this negative voltage being of sufficient amplitude to cut off the cathode ray scanning beam of tube 10 and prevent it from causing a visible trace on the luminescent screen of the tube.

Control grid 80 of the cathode ray tube 10 is normally provided with a suitable operating bias from an adjustable tap on a potentiometer 82 one end of which is grounded and the other end of which is connected to a suitable source of negative potential. By varying the position of this tap, the intensity of the cathode ray beam during scansion is readily controlled independently of the blanking voltage applied to grid 80 in the manner above described.

It will be recognized, however, that a variation in either or both the phase control resistor 42 and the blanking period resistor 70 would normally vary the amplitude as well as the duration of both the maximum and minimum control voltages applied to the grid 80 of the "Kinescope" 10. In other words, the blanking voltage wave 66 would normally drive the "Kinescope" 10 both positive and negative from a level which would be the average value of the wave 66.

To overcome this condition, the second half of tube 78 is arranged to "restore" the "Kinescope" grid 80 to the reference voltage established by the setting of potentiometer 82, or, in other words, the entire blanking wave 66 is caused to drive the grid 80 positive (or less negative) from the level selected by the adjustment of potentiometer 82.

Accordingly, potentiometer 82 provides for a selection of the maximum negative (bias) voltage on the grid 80, resistor 30 provides for a selection of the minimum negative voltage during the trace or scanning period (cathode-ray tube bias above the cut-off level), and potentiometers 42 and 70 provide for the initiation and duration, respectively, of this minimum negative voltage.

It will be obvious that a variation in the amount of phase shift provided by the network 40 as a result of a selected adjustment of resistor 42 will vary the instant at which the initiation of each cycle of the multi-vibrator 64 occurs, thus controlling the position of one edge of the image raster on the face of the cathode ray tube 10. The same resistor 42 additionally acts as a linearity control by permitting a choice of how great a portion of the rising edge of each cycle of the sine wave 34 is utilized. In other words, by narrowing the time interval A—B or C—D, a scanning output may be obtained which closely approximates linearity. On the other hand, by widening the periods A—B and C—D, more of the curved top and bottom portions of the sine wave 34 are utilized, and this introduces a greater degree of non-linearity.

As above stated, a variation of the potentiometer 70 of the multi-vibrator 64 varies the instant at which the trailing edge 74 of each multi-vibrator cycle occurs. This is equivalent, as shown by the dotted lines of curve *e*, to varying the instant B (or D at which scansion is terminated. Delaying this instant B increases non-linearity through the utilization of more of the curve top portion of each cycle of the sine wave 34. Conversely, advancing this instant B improves linearity by utilizing less of this curved portion.

While the present invention has been described in connection with apparatus suitable for testing the characteristics of cathode-ray tubes, it will be apparent that the disclosure in its broader aspects is readily adaptable to a television system in which actual reproduction of an image is desired. This is particularly true, for example, in a television system designed for industrial or educational use, and where high definition and resolution in the reproduced image are not required. If a sine wave scanning system such as herein described is employed at the transmitter as well as at the receiver, and if these scanning systems are accurately synchronized, then the resulting image should present acceptable characteristics, even though the deflection of the cathode ray scanning beams in both the camera tube and reproducing tube is not precisely linear with respect to time.

When the present invention is utilized for image reproduction in the manner above set forth, it is possible to double the number of scanning lines normally obtained through the expedient of blanking the scanning beam of tube 10 only at the extreme upper and lower portions of each sine-wave cycle—that is, only during the time periods when the wave is extremely non-linear. This would permit use of two substantially linear sections for each cycle, one section when the wave extends in a direction of one polarity, and the other section when the wave extends in the direction of opposite polarity. Such a result is obtainable merely by altering the constants of the illustrated circuit so as to obtain twice the number of blanking periods in the wave 66 (and hence double the number of scanning intervals). The basic feature of the invention would be unchanged—that is, the scanning beam of the cathode ray tube 10 is cut off, or blanked, except during at least one portion of each cycle of the sine wave current flowing through coils 12 when this current varies in a substantially linear manner with respect to time.

I claim:

1. In a system for deflecting the cathode ray scanning beam of an image-reproducing cathode ray tube, the combination of a pair of deflection coils, a sine wave oscillator, said deflection coils being connected to form part of the resonant circuit of said oscillator in such a manner that the flow of current through said coils is of substantially sine wave configuration, a phase-shifting network, means for applying a portion of the sine wave voltage output of said oscillator to said phase-shifting network, means for deriving a voltage variation of substantially square waveform from the output of said phase-shifting network, means for differentiating said square wave voltage, a multi-vibrator producing an output voltage variation of substantially rectangular waveform, means for applying said differentiated square wave voltage to control the initiation of each cycle of operation of said multi-vibrator, and means for applying the rectangular wave output of said multi-vibrator to said image-reproducing cathode ray tube so as to cut off the cathode ray scanning beam of said tube during periods when said rectangular wave extends in a direction of one polarity.

2. A deflection system according to claim 1, further comprising means for controlling the period during each cycle of operation of said multi-vibrator when the rectangular wave output thereof extends in a direction of one polarity.

3. A deflection system according to claim 1, in which said phase-shifting network is adjust-

able to vary the amount of phase shift and hence the instant of initiation of each cycle of operation of said multi-vibrator.

4. In a cathode ray beam deflection circuit of the type in which an image-reproducing cathode ray tube is provided with at least one cathode ray beam deflection coil associated therewith, the combination of a sine wave oscillator, means for supplying current of sine wave configuration to said deflection coil from said oscillator, a blanking pulse generator, means for synchronizing the operation of said blanking pulse generator with the operation of said oscillator, and means for applying the output of said blanking pulse generator to said cathode ray tube to blank the cathode ray scanning beam of said tube for all except at least one portion of each oscillatory cycle during which the sine wave current supplied to said deflection coil varies substantially linearly with respect to time.

5. A cathode ray beam deflection circuit according to claim 4, in which said cathode ray beam deflection coil forms part of the resonant circuit of said sine wave oscillator.

6. A cathode ray beam deflection circuit according to claim 4, further including means for controlling the width of the blanking pulses applied to said cathode ray tube from the said blanking pulse generator.

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