Feb. 2, 1943. O. H. SCHADE 2,309,672

CATHODE RAY BEAM DEFLECTING CIRCUIT

Filed March 21, 1940 2 Sheets-Sheet 1

Fig. 1

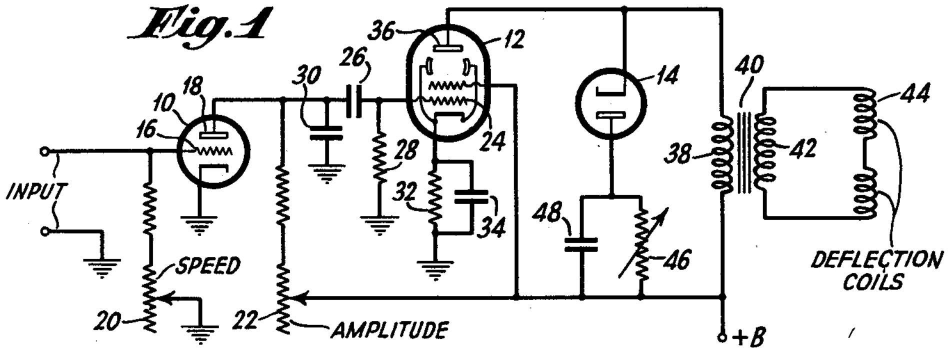


Fig. 2

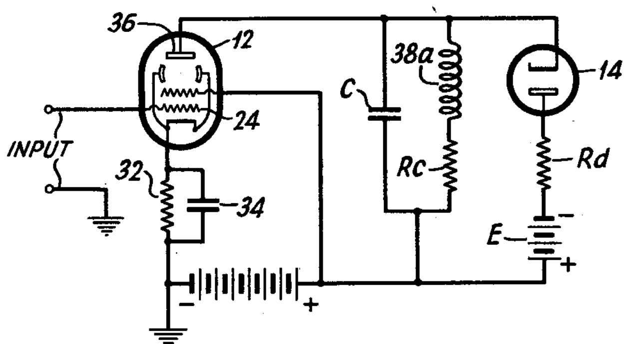
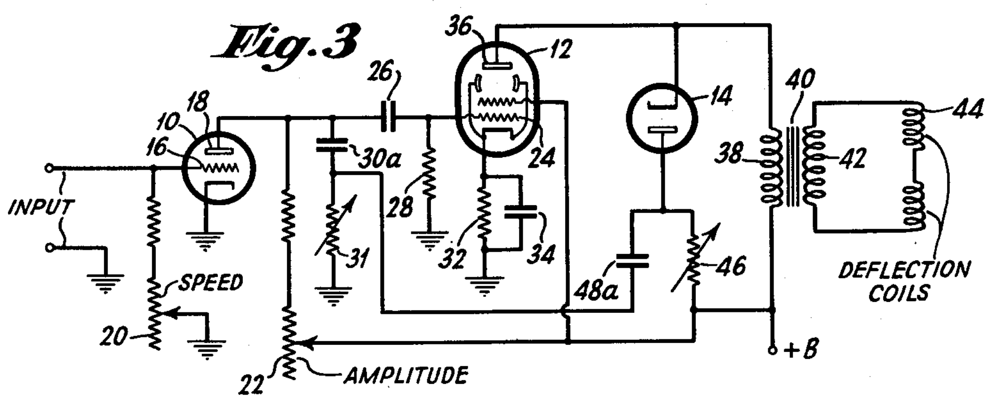


Fig. 3



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Filed March 21, 1940 2 Sheets-Sheet 2

Fig. 4

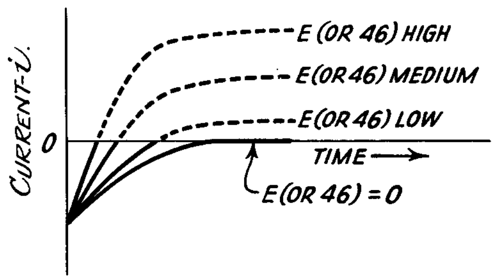


Fig. 5

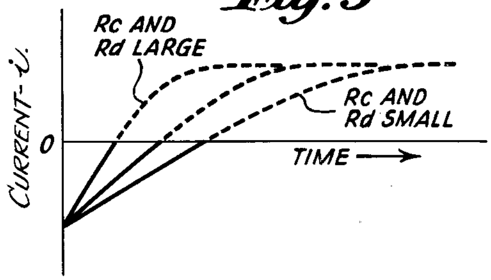


Fig. 7

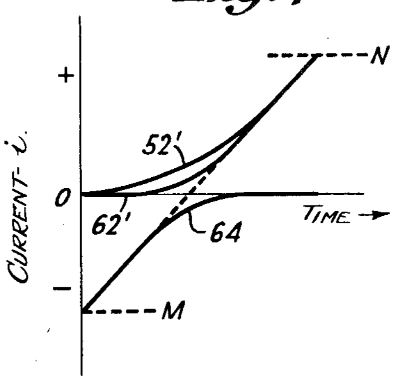
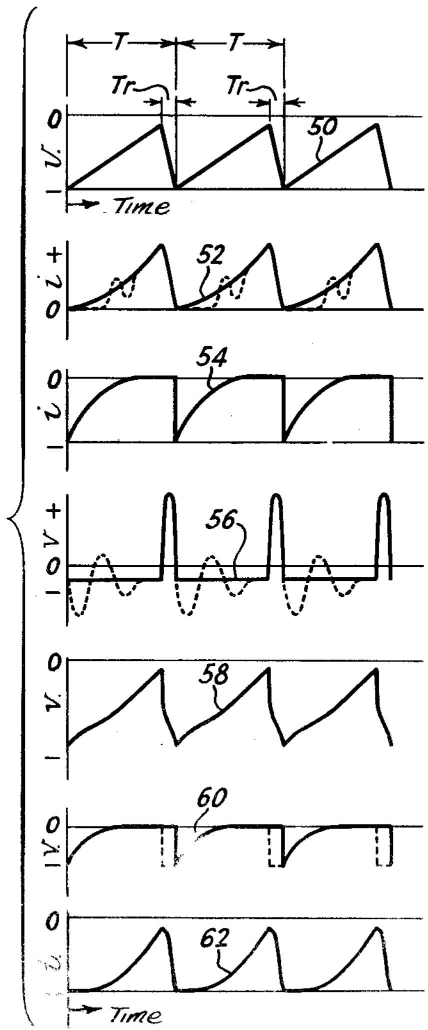


Fig. 6



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UNITED STATES PATENT OFFICE

2,309,672

CATHODE RAY BEAM DEFLECTING CIRCUIT

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Application March 21, 1940, Serial No. 325,207

3 Claims. (Cl. 250—27)

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 deflected horizontally at a relatively high rate. Since cathode ray beams in television receivers are preferably deflected by electromagnetic 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 or 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 receiving systems the cathode ray beam which is produced in the receiving tube is deflected vertically at the rate of 60 deflections per second, $\frac{9}{10}$ (or more) of the time for each cycle being used for deflecting the beam in one direction vertically, and the remaining $\frac{1}{10}$ (or less) of the cycle being used for returning the beam to its initial starting point. Simultaneously the cathode ray beam is deflected horizontally at the rate of 13,230 cycles per second, $\frac{9}{10}$ (or more) of the time for each cycle being required to deflect the beam in one direction horizontally, and the remaining portion of the cycle being used to return the beam to its initial starting point. Actually it is desirable that the return time be less than $\frac{1}{600}$ of a second for the vertical deflections, and less than $\frac{1}{132300}$ of a second for horizontal deflections, if possible. In presently used television circuits, the high voltage variations for deflecting the beam are produced by a powerful amplifier tube of the beam power type working in conjunction with a diode for assisting in producing a more linear change in the voltage variation. Such circuits require rather delicate adjustments, and at best do not produce an absolutely linear voltage variation. Furthermore, such systems are not as efficient as would be desired, and considerable power is required to produce voltage variations in the amount necessary to produce the desired horizontal deflection of the cathode ray beam.

It is therefore one purpose of the present invention to provide a cathode ray beam deflecting circuit which will be more efficient in operation than the systems heretofore used.

Another purpose of the present invention resides in the provision of a cathode ray beam deflecting circuit which will produce substantially linear voltage variations over the desired portion of the deflection cycle.

Still another advantage of the present invention resides in the provision of a simple arrangement whereby a certain portion of the voltage developed by a rectifier tube or diode is superimposed upon the control electrode of the power amplifier tube in opposition to the voltage normally applied to this electrode so that an increased efficiency will be obtained from the power amplifier tube.

A still further purpose of the present invention resides in the provision of means whereby the distribution or linearity of the voltage variation may be readily controlled so that the circuit may be easily adjusted after the receiver has been completed.

Various other advantages and purposes of the present invention will become more apparent to those skilled in the art from a reading of the following specification and claims, particularly when considered with the drawings, wherein like reference characters represent like parts, and wherein:

Figure 1 represents a deflection circuit similar to those now in use;

Figure 2 shows a schematic representation of the circuit shown in Figure 1;

Figure 3 shows a cathode ray beam deflection circuit constructed in accordance with the purposes of the present invention;

Figure 4 shows a series of curves representing the current decay time of the diode as a function of the potential opposing such change;

Figure 5 shows a family of curves representing the current decay time of the rectifier or diode as a function of the ohmic resistance of the circuit;

Figure 6 shows a series of curves representing the current and voltage variations at various points in the circuits shown in Figures 1 and 3; and,

Figure 7 shows graphically the results which are accomplished by using the circuit shown in Figure 3.

Referring now to the drawings and particularly to Figure 1 thereof, a cathode ray beam deflecting circuit is shown, the circuit being identical or similar to the circuits which are now in conventional use. The circuit includes a discharge tube **10**, a power amplifier tube **12**, and a damping tube **14**. The discharge tube includes a cathode, a control electrode **16**, and an anode **18**. the cathode of the discharge tube **10** is preferably connected to ground, and the control electrode **16** of the tube is connected to ground through an adjustable resistance or potentiometer **20**. The anode **18** is connected to a source of positive potential through an adjustable resistance or potentiometer **22**. The control electrode of the discharge tube **10** is supplied with controlling or synchronizing impulses which are impressed between the control electrode and the cathode, and these controlling or synchronizing impulses, in the case of a television receiving apparatus, are generally transmitted from the transmitting station along with the picture signals. The exact circuit used in connection with the discharge tube **10** is not vital to the present invention, since any type of a deflection or saw-tooth voltage wave form generator may be used. Various forms of relaxing oscillators, blocking oscillators and multivibrators have successfully been used for producing the desired saw-tooth wave forms of low voltage variations. It is desirable, however, that the oscillator or saw-tooth wave form generator be controllable as to its speed of operation and a variation in the amount of the resistance **20** will normally afford the necessary frequency control. Furthermore, the amplitude of the voltage variation as derived from the anode of the tube **10** should be controllable in order to vary the amount of horizontal deflection of the cathode ray beam, and by adjusting the value of the resistance **22**, the amplitude of the voltage variation at the anode **18** of the tube **10** may be controlled.

The voltage variations which exist at the anode **18** of the tube **10** are impressed upon the control electrode **24** of the amplifier tube **12** by means of a coupling condenser **26**. The control electrode is connected to ground by way of the grid resistance **28**. There is also a condenser **30** connected between the anode **18** of the discharge tube **10** and ground.

The cathode of the amplifier tube **12** is connected to ground by way of resistance **32** which is by-passed by condenser **34**. This resistance is used in order that proper voltage relationships may exist between the control electrode and the cathode of tube **12**. The tube **12**, as stated above, is generally of the beam power type, and may be a tube such as the 6L6 or the 6V6 type. The screen grid of the power tube is connected to a source of positive potential, and the beam forming electrodes are, of course, connected to the cathode as is conventional in beam type tubes. The anode **36** of the tube **12** is connected to one end of the primary winding **38** of the output transformer **40**, while the other end of the primary winding is connected to a source of positive potential. The secondary winding **42** of the output transformer **40** is connected to the deflecting coils **44** which surround the neck of the cathode ray tube in order that the cathode ray beam may be deflected by the electro-magnetic flux which is produced thereby.

Connected in parallel with the primary winding **38** of the output transformer **40**, is a diode or damping tube **14** and a resistance and condenser combination. The cathode of the damping tube is connected to the anode of the power amplifier tube **12** while the anode of the damping tube **14** is connected to the source of positive potential by means of a variable resistance **46**, the resistance being shunted by a condenser **48**.

When the circuit described above and shown in Figure 1 is placed in operation, voltage variations of saw-tooth wave form are supplied by the discharge tube **10** and are impressed upon the control electrode of the power amplifier tube **12**. The power amplifier tube amplifies the intensity of the saw-tooth wave form voltage variations sufficiently to produce the desired deflection of the cathode ray beam, and in order to approach the desired linearity the damping tube **14** is placed in parallel with the primary of the output transformer or placed across the output terminals of the power amplifier tube **12**. In some instances the damping tube may be placed across the secondary winding **42** of the output transformer **40**.

The portion of the circuit shown in Figure 1, including the power amplifier tube **12**, the damping tube **14** and the primary of the output transformer **38** may be resolved into a simplified schematic showing such as disclosed in Figure 2 of the drawings. In this figure, the power amplifier tube **12** is shown substantially identically as it is shown in Figure 1, as is also the damping tube **14**. The inductance of the deflection coils as reflected into the anode circuit of tube **12** is shown at **38*a***, while the reflected resistance component is represented by the resistance R_c. The condenser C shown in Figure 2 represents the total reflected and shunt capacity in the anode circuit of tube **12**. The resistance R_d of Figure 2 represents the effective resistance of the diode or damping tube **14**, while the source of potential E represents the voltage which is developed across the resistance **46** during the operation of the circuit shown in Figure 1. The polarity of this source of potential, as well as the polarity of the anode potential for the tube **12** are shown in the figure.

The voltage variations of saw-tooth wave form which are applied to the input electrode **24** of the power amplifier tube **12** are shown by the curve **50** in Figure 6. These voltage variations, of course, alter the intensity of the electron stream through the tube, and accordingly, vary the plate current present in the tube in a manner indicated by the curve **52** of Figure 6. In the absence of the damping tube **14**, the anode current of the power amplifier tube **12** is represented by the dotted line shown in curve **52** while the voltage variation at the anode is represented by the dotted line shown in curve **56** of Figure 6. The dotted line curves coincide partially with the solid line curves shown at **52** and **56** and Figure 6, the dotted portion showing only the deviation and the oscillations obtained due to the tuned circuit connected to the anode of power tube **12**. By using the damping tube **14**, these oscillations are prevented and the damping tube or diode, in view of its connection in the circuit and the effect of the potential E, operates as a switch which closes at the end of the return time, i. e., at the beginning of the initial horizontal deflection cycle. One cycle of operation is represented by the time T shown in Figure 6, while the return period is indicated by the time T_r in Figure 6. The switching operation of the diode or damping tube **15** causes transient currents to flow in the circuit **38*a***, R_c, R_d and **14** of Figure 2. This transient current if of correct magnitude and wave form assists the tube **12** in causing the desired current changes in the primary of the output transformer, and assists to a large extent in improving the efficiency of the circuit.

The length of time that the current persists in damping tube **14**, as well as the value of the current, are determined by certain of the parameters of the circuit. The current which is induced to flow through the damping tube **14** will decay exponentially as indicated in Figures 4 and 5, which show curves of the current passed by the damping tube 14, and in Figure 4, the decay of the current approaches certain predetermined values as an asymptote, these values being determined by the value of the potential source E in Figure 2, or in other words, the value of the resistance 46 in Figure 1. If the potential source E is high, then the value of the current approached will be high, whereas on the other hand, if the value of the potential source E is low, or zero, the current flow through the damping tube will approach a low value or zero as an asymptote. This condition would exist if the diode remained permanently conducting, and had a resistance R_d of a fixed value. The current in the diode circuit cannot in actual practice reverse direction, however, and therefore, the current ceases to flow when the zero axis is reached, as indicated by the solid portion of the curves shown in Figure 4.

The effects of different values of the resistances R_c and R_d on the shape of the transient current which is passed by the damping tube 14 are shown in Figure 5. If the value of the potential E remains fixed, then the current will decay to a predetermined fixed value, but the rate at which such decay takes place is a function of the values of the resistances R_c and R_d. If these resistances are large, then the decay of the current will be relatively rapid, whereas if the resistances are small, the decay of the current will be extended over a considerable period of time. Here again, the current ceases entirely when reaching the zero axis, since the direction of flow of current cannot reverse in the damping tube 14. For the purpose of clarity, however, the extensions of the current variation in Figures 4 and 5 are indicated by dotted lines. In order to produce the desired decay of current in the damping tube 14, the values of the resistances R_c and R_d may be changed, or if these are relatively fixed, then the value of the potential source E, that is, the value of the resistance 46, may be reduced in order to extend the flow of the current through the damping tube over a longer period of time before it is permitted to reach the zero axis. This extension of time is often necessary in practical commercial circuits in order to avoid distortion of the current variation of saw-tooth wave form in the deflecting coils 44 or in the primary output of transformer 38, the effective current being the sum of the current passed by the power tube and the current passed by the damping tube or diode 14. The wave form of the current passed by the diode under predetermined adjusted conditions is indicated by the curve 54 shown in Figure 6.

In using a circuit such as shown in Figure 1, the damping tube current wave form must be given such a shape and the power tube bias must be so adjusted that the geometric sum of the plate current of the power tube 12 and the diode current of the tube 14, is a straight line. Unless this condition does exist, very undesirable distortions may result in the picture as a result of non-linear deflection of the cathode ray beam in the horizontal direction. Normally, in circuits such as shown in Figure 1, it is desirable that the diode current be stretched over substantially the full time occupied by the horizontal deflection cycle because a sufficiently slow diode cutoff is difficult to obtain due to the value of resistance R_c. In circuits where the resistances R_c and R_d are high, it is sometimes necessary to so decrease the value of potential E or the value of resistance 46 to cause a relatively slow decay of the current in the damping tube 14 so that a certain amount of current is permitted to flow even at the end of the deflection cycle. If, however, the resistances R_c and R_d are too large, a proper matching of the damping tube 14 to the power amplifier tube 12 cannot be obtained. The summation of the current passed by the power amplifier tube 12 and the damping tube 14 is greatest, and the circuit operates with best efficiency, when the current of the damping tube is reduced to zero near the middle of the horizontal deflection cycle as shown at 64 in Figure 7, matched by a power tube current having a wave form as shown at 62′ in Figure 7.

The above described circuit may be improved in operation and efficiency, and the linearity of the deflection may be improved, if a certain amount of feedback is permitted from the damping tube 14 to the input electrode of the power amplifier tube 12. Such a circuit is shown in Figure 3 of the drawings. This circuit is similar in many respects to the circuit shown in Figure 1, except that the condenser 30, which is connected between the anode 18 of tube 10 and ground in Figure 1, is replaced by condenser 30a and a variable resistance 31. Furthermore, in Figure 1, the anode of the damping tube 14 is connected to the source of positive potential by means of condenser 48 and adjustable resistance 46, whereas in Figure 3, the condenser connection is omitted and the junction of the condenser 30a and resistance 31 is connected to the anode of the damping tube 14 by means of condenser 48a. During normal operation of the circuit shown in Figure 3, it is clear that a potential variation having a wave form similar to the damping current in the anode circuit of the damping tube 14 is superimposed upon the input electrode 24 of the power amplifier tube 12 through the condenser 30a and 26. By means of such connection, any non-linear characteristics because of poor matching in the circuits shown in Figure 1, especially where the resistances R_c and R_d are not too large, are completely overcome, and accordingly the efficiency of the system is materially increased. A resultant linear characteristic and improved efficiency could be obtained by modifying the shape of the current wave form of the damping tube 14 or of the power tube 12 to supplement the other. If these two wave forms can be so adjusted, then a true linear characteristic may result, but in the system shown in Figure 1, such a matching is not always possible. Since changing the wave form of the current which is passed by the damping tube 14 is not directly and readily possible, the present invention relates to a change in the wave form of the current passed by the power tube 12. Furthermore, in the system shown in Figure 1, especially where the circuit is to be used in a television transmitting station for causing deflection of the cathode ray beam in the television transmitting tube, the resistance of the deflection circuit alone, particularly when the deflection coils of the television transmitting tube are supplied with energy over relatively long cables, causes a fast decay of the diode current, that is, the current passed by the damping tube 14, and hence, poor distribution, or at least, reduced scanning efficiency results. Such drawbacks are completely overcome by using a system such as shown in Figure 3, since, in view of the feedback arrangement, values of the resistances R_c and R_d may be greatly increased without affecting the linearity of the deflection or the efficiency of the system. Accordingly, the deflection circuit may be positioned quite remotely with respect to the television camera and the associated deflecting coils.

The principle of operation of the circuit shown in Figure 3 is relatively easily understood, since, as stated above, a voltage variation produced by the current passed by the damping tube, is superimposed upon the input electrode of the power amplifier tube 12. This voltage as produced at the resistance 31 is negative in polarity, and is in opposition and superimposed upon the saw-tooth voltage applied to the input electrode 24 of the power amplifier tube 12 by tube 10. Accordingly, the wave form of the voltage impressed upon the input electrode of the power amplifier tube 12 is altered by the superimposed voltage which is derived from the damping tube 14. One form of the voltage variation which is applied to the control electrode of the power amplifier tube 12 from the damping tube 14 is shown by the solid curve 60 in Figure 6, and this voltage variation, when combined with the saw-tooth wave form voltage variation shown by the curve 50 and present at the output electrode of the discharge tube 10, will produce a wave form such as indicated at 58 in Figure 6. Accordingly, the input electrode of the power amplifier 12 is subjected to a voltage variation similar to that shown by the curve 58 in Figure 6. From this wave form it may be seen that the control electrode of the power amplifier tube is subjected to a relatively high negative value during the initial portion of the deflection cycle, the polarity increasing in a positive direction shortly thereafter, as determined by the voltage derived from the discharge tube 10. Since the control electrode of the power amplifier tube is initially supplied with a relatively high negative potential, the plate current of the power amplifier tube 12 will be initially reduced so that a wave form of the plate current of the power amplifier tube will resemble the curve shown at 62 in Figure 6, which is somewhat different from the wave form shown at 52 in the same figure. By a comparison of the curves 52 and 62, the effect of the feedback from the damping tube will become clearly apparent.

In order to make a clear comparison of the current supplied by the power amplifier tube 12 under the conditions both with and without feedback, attention is directed to Figure 7 where the two current waves are adjacent each other. The curve 52′ in Figure 7 indicates the current passed by the power amplifier tube 12 without any feedback from the damping tube, as in a circuit such as shown in Figure 1. The curve 62′, however, indicates the shape of the current wave supplied by the power amplifier tube 12 when the feedback arrangement shown in Figure 3 is utilized. The curve 64 shows the current passed by the damping tube 14 in Figure 3 which is necessary to produce a proper matching of the damping tube to the power amplifier tube when the feedback arrangement is used.

Since the current which is applied to the primary winding 38 of the output transformer 40 is the algebraic sum of the currents passed by the power amplifier tube 12 and the damping tube 14, it will be seen that the wave form of this current is a straight line extending from M to N of Figure 7. A portion of this line is shown in dotted form. By inspecting Figure 7 it may be clearly seen that the current variation for one complete horizontal deflection of the cathode ray beam is linear, and accordingly, the cathode ray beam will be deflected at a uniform rate across the mosaic electrode in a television transmitting tube or across the screen in a television receiving tube. Furthermore, by inspecting Figure 7 it may be seen that a considerable portion of the straight line extending from M to N extends below the zero axis of the figure, and accordingly, the efficiency of the system has been greatly improved. Through such an arrangement considerable of the work imposed upon the power amplifier tube is relieved, and is accordingly assumed by the operation of the damping tube 14. Through the use of such a system, the power output of the power amplifier tube 12 need not be so high, and the cathode ray beam may be deflected by a greater amount and at an assumed constant rate throughout the complete deflection cycle.

The resistance 31 which is preferably made adjustable, causes a certain amount of "peaking" of the voltage applied to the control electrode of the power amplifier tube 12. This peaking effect is not deleterious, but on the contrary, improves the scanning efficiency of the system. The presence of the resistance 31 causes the feedback component shown in curve 60 of Figure 6 to follow the dotted line portion of the curve during the return time. The resistance 31 may be called a distribution control, since an adjustment of the value of the resistance 31 permits an adjustment of the saw-tooth wave shape. Actual tests have shown that good distribution and even over-compensation can be obtained in a deflection circuit by using the feedback shown in Figure 3 in which otherwise a correction could not be obtained without serious loss of linearity of deflection.

Although the present invention, as shown in Figure 3, indicates an application of the feedback voltage to the control electrode of the power amplifier tube, such an application is not the only method of accomplishing the same results, since the inverse feedback voltage could also be applied to the screen grid electrode of the power amplifier tube 12. Furthermore, although the damping tube 14 is shown as connected across the primary winding of the output transformer 40, the damping tube 14 could as well be connected across the secondary winding 42 of the output transformer 40, to produce the same desired results.

Although the present invention is described as applicable primarily to a television receiving system, it is to be understood that such a deflection circuit may also be applied to a television transmitting circuit and in fact, the use of the system shown in Figure 3 is highly desirable in a television transmitting circuit in order to compensate for the resistance of the leads between the deflection generator and the deflecting coils.

In view of the foregoing, it may be seen that a new and improved deflection system has been devised which will permit the production of current variations of linear wave form so that a cathode ray beam may be deflected at a uniform rate throughout the entire deflection cycle. Furthermore, the system as shown and described herein is simple in operation, and results in a material increase in the efficiency of operation of previously used deflection circuits.

Various other modifications and alterations 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.

I claim:

1. A deflection generator comprising means for producing voltage variations of substantially saw-tooth wave form, an amplifier tube including a cathode, a control electrode and an anode, means for impressing the voltage variations upon the control electrode of said amplifier tube, a load circuit including cathode ray beam deflection coils coupled to the anode of said amplifier tube, an asymmetric unit including two electrodes, means for connecting one electrode of said asymmetric unit to the amplifier anode end of the load circuit, means including an adjustable impedance for connecting the other electrode of said asymmetric unit to the other end of the load circuit whereby the current passed by said asymmetric unit will produce potential variations across said impedance, a condenser and a resistance connected in series between the said other electrode of said asymmetric unit and a point of fixed potential, and means including a condenser for coupling the control electrode of said amplifier tube to the junction of said condenser and resistance whereby the potential variations produced across said impedance will be superimposed upon the voltage variations of saw-tooth wave form.

2. A cathode ray beam deflection generator comprising means for producing voltage variations of substantially saw-tooth wave form, an amplifier tube including a cathode, a control electrode and an anode, means for impressing the voltage variations of saw-tooth wave form upon the control electrode of said amplifier tube, a load circuit including cathode ray beam deflection coils coupled to the anode of said amplifier tube, a diode including a cathode and an anode, means for connecting the cathode of the diode to one end of the load circuit, means including an impedance for connecting the anode of the diode to the other end of the load circuit whereby the current passed by the diode will produce potential variations across said impedance, a condenser and resistance connected in series between the anode of said diode and a point of fixed potential, and means including a condenser for coupling the control electrode of said amplifier tube to the junction of said series connected condenser and resistance whereby the potential variations produced across said impedance will be applied to the control electrode of said amplifier tube along with the voltage variations of saw-tooth wave form.

3. A cathode ray beam deflection generator comprising means for producing voltage variations of substantially saw-tooth wave form, an amplifier tube including a cathode, a control electrode and an anode, means for impressing the voltage variations of saw-tooth wave form upon the control electrode of said amplifier tube, a load circuit including cathode ray beam deflection coils coupled to the anode of said amplifier tube, a diode including a cathode and an anode, means for connecting the cathode of the diode to the amplifier anode end of the load circuit, means including a resistance for connecting the anode of the diode to the other end of the load circuit whereby the current passed by the diode will produce potential variations across said resistance, a condenser and a second resistance connected in series between the anode of said diode and point of fixed potential, and means including a second condenser for connecting the control electrode of said amplifier tube to the junction of said condenser and said second resistance whereby the potential variations produced across said first resistance will be impressed upon the control electrode of said amplifier tube along with the voltage variations of saw-tooth wave form.

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