

Jan. 9, 1945.

A. N. GOLDSMITH

2,367,116

WAVE CONTROL CIRCUIT

Filed Jan. 31, 1942

2 Sheets-Sheet 1

Fig. 1.

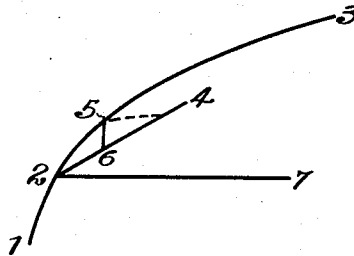


Fig. 2.

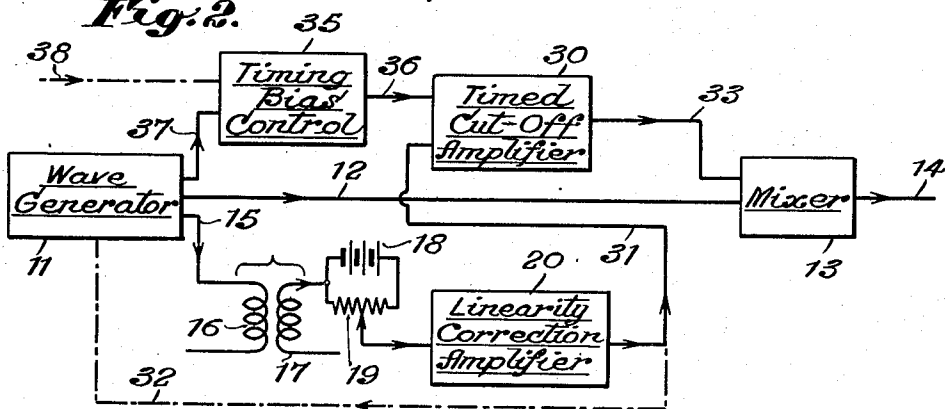


Fig. 3.

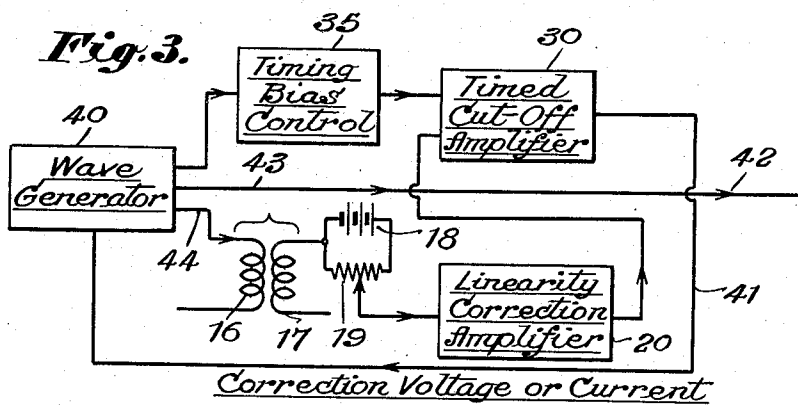
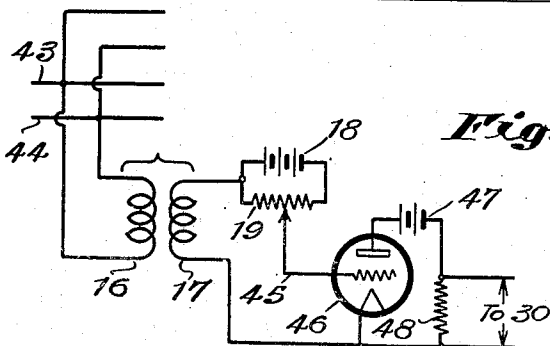


Fig. 4.



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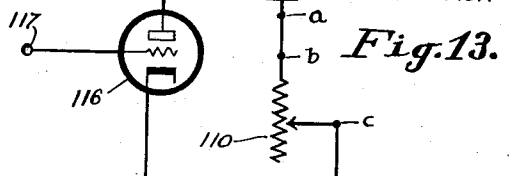
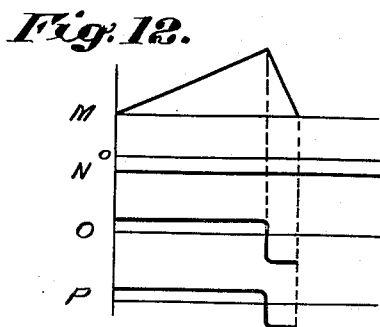
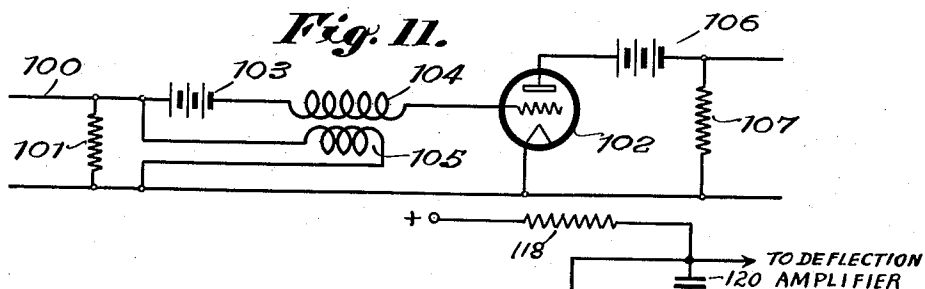
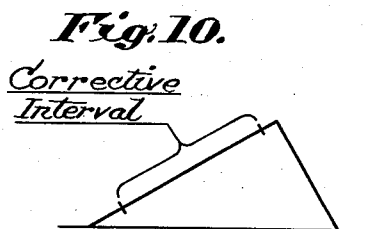
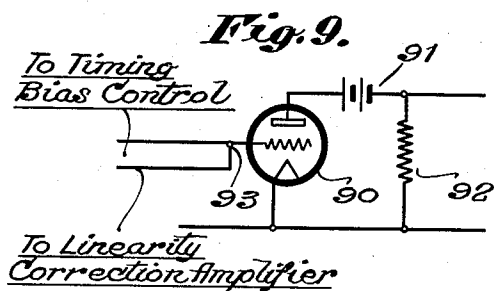
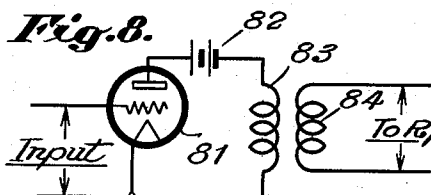
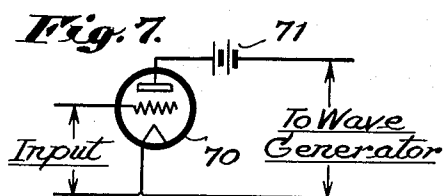
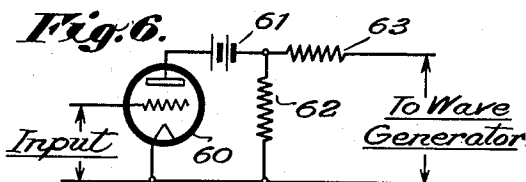
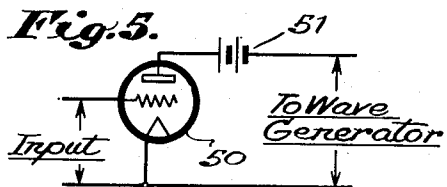
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,367,116

WAVE CONTROL CIRCUIT

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Application January 31, 1942, Serial No. 429,017

2 Claims. (Cl. 178-44)

My invention relates to apparatus for generating electrical wave forms, and more particularly to apparatus and methods for producing modified electrical wave forms.

In the electrical art, and particularly in the art of television transmission and reception, it is often both highly desirable and necessary to utilize wave forms which have been modified somewhat from the normally produced or producible wave formation. Particularly in the development of wave formation, for energizing and actuating deflection apparatus, wave forms which are modifications of a normally produced wave form are not only desirable, but necessary. Accordingly, it is one of the objects of my invention to provide methods and apparatus for producing wave forms which are modifications of normally produced wave forms.

In the television art, and particularly in the color television art, so-called linearity of the deflecting wave form is necessary. If the wave forms produced for deflection purposes vary from the linear, not only is there a distortion in the reproduced image which is proportional to this variation from linearity, but in the case of color television where several images have to be superimposed one on the other to give the color image, lack of registration of the component color images will result if the effective deflecting wave formation varies from the linear. Thus all the component color images may be caused to register at their edges, but if there are different nonlinearities in the horizontal or vertical deflection waves of these images, they will not be in registry in the central portions of the picture. Accordingly, it is another of the objects of my invention to provide methods and apparatus for improving the linearity of a produced sawtooth or serrated wave form.

Methods and means for improving the linearity of sawtooth wave formation have been disclosed heretofore. In order to obtain linearity the methods of some of these disclosures have gone so far as to attempt to produce an additional non-linear sawtooth wave whose non-linearity is the reverse of that of the original wave, and then these waves are combined in order to produce a theoretically linear sawtooth wave. The difficulties of such an arrangement are obvious and it should be apparent that a method which linear-

izes a non-linear wave in accordance with the instantaneous deviations from linearity is highly preferable, and accordingly it is another of the objects of my invention to provide a method and apparatus for modifying a non-linear sawtooth wave form in accordance with the instantaneous deviations from linearity of the wave form.

It will be appreciated that the aforementioned objects are only among the prime objects of my invention, and do not comprise the entire objects thereof, but have been set forth for purposes of illustration only.

My invention in general contemplates the utilization for linearity control purposes in a circuit of appropriate small time constant of voltages or currents derived from the wave form to be controlled. The derivation in question is of a type analogous to the mathematical process known as differentiation. That is, the derived wave form which is used for control or correction is based on the rate of change at each instant of the wave form which is to be controlled. The derived wave may then be used to correct for non-linearity in the wave form from which it is derived.

My invention will be understood best by reference to the drawings, in which:

Fig. 1 shows a wave form deviating from linearity.

Fig. 2 shows schematically an arrangement according to my invention.

Fig. 3 is a schematic arrangement of an embodiment of my invention.

Fig. 4 shows a linearity correction amplifier.

Figs. 5, 6, 7, and 8 show arrangements for utilizing the corrective wave forms with the sawtooth wave generator.

Fig. 9 is a timed cut-off amplifier.

Fig. 10 is a curve.

Fig. 11 is a time controlling apparatus.

Fig. 12 is a set of illustrative curves.

Fig. 13 shows schematically one way of applying the correction signals as developed by the circuits of Figs. 5 through 8, for instance.

Referring to Fig. 1, there is shown a wave form which deviates from linearity. The deviation of the wave, a section of which is indicated by the numerals 1, 2, 3, from a linear or straight line type of wave indicated as 2, 4 at the point 5 is shown by the line 5, 6. For simplicity in

analysis the point 2 is taken as the point of origin and the line 2, 7 as the abscissa axis.

As a valid simplification for the short lengths which are involved during the correction periods, the equation of the curve along the section 2, 5 may be taken as being:

$$y_1 = bx + cx^2 + \dots \quad (1)$$

The true linear portion 2, 4 may be represented by the equation:

$$y_2 = dx \quad (2)$$

Then,

$$y_1 - y_2 = (b - d)x + cx^2 + \dots \quad (3)$$

Equation 3 is expressive of the varying length of the line 5, 6 for various values of the abscissa x .

$$(y_1 - y_2) \text{ varies as } (b - d) \text{ for } x = 0 \quad (4)$$

Equation 4 indicates that as x approaches zero the line 5, 6 is proportionate to the difference of the slopes of 2, 5 and 2, 6 respectively. Equation 4 also indicates the amount of instantaneous correction necessary to change the curved wave form 1, 2, 5, 3 to the straight line 2, 6, 4, if such correction is applied at or close to the point 2.

As derivative currents or voltages are obtained from the curve form at 2 and from the straight line at 2, the magnitude of these derivative quantities may be given by Equation 5, and their difference by Equation 6.

$$\frac{dy_1}{dx} = b + 2cx + \dots \quad \frac{dy_2}{dx} = d \quad (5)$$

$$\frac{dy_1}{dx} - \frac{dy_2}{dx} = d \frac{(y_1 - y_2)}{dx} = (b - d) + 2cx + \dots \quad (6)$$

and

$$d \frac{(y_1 - y_2)}{dx} \doteq (b - d) \doteq (y_1 - y_2) \text{ for } x \doteq 0 \quad (7)$$

As indicated in Equation 7, the difference of the derivative quantities according to Equation 6 are again proportionate to the difference of slopes of the curved wave form and the linear wave form at point 2 as x approaches zero.

Referring to Fig. 2, there is shown schematically a circuit whereby a wave form can be brought to linearity or corrected to approach closely to linearity over any predetermined portion thereof. Generally, it will be assumed that the wave form to be corrected does not deviate too widely from linearity in any brief period. A wave form such as a sawtooth wave may be produced in the wave generator 11 and is passed by way of conducting means 12 to a mixer 13, and thence, after correction, to the output circuit through conducting means 14. A portion of the output of the sawtooth wave generator also will pass through conductor 15 to the primary 16 of a transformer. For purposes of simplicity the entire circuit has not been shown, but will be illustrated hereinafter in this application; and only the primary of the transformer is shown for the purpose of showing the means of obtaining a derivative wave. The secondary 17 of the transformer is connected through potentiometer biasing means consisting of potential source 18 and resistor 19, and is impressed on the input of a linearity correction amplifier 20. The output of the linearity correction amplifier is fed to the input of a timed cut-off amplifier 30 by means of conductor 31. For a small or short period of time in the neighborhood of the point 2 in Fig.

1, the voltage across 17 is equal or proportionate approximately to b . By means of the potentiometer arrangement consisting of 18 and 19 a second voltage equal or similarly proportionate to d is subtracted from the voltage generated in 17, and it is this difference voltage that is applied to the linearity correction amplifier 20. Since this amplifier has controllable amplification of any conventional type (not shown), its output can be made equal to the necessary voltage for correction of instantaneous non-linearity. Amplifier 20 has a brief time constant. That is, it responds up to high frequencies. This is necessary to prevent deviations from linearity in the resulting output wave form increasing beyond practically infinitesimal values. The output of amplifier 20 may be used in one of various ways to correct the wave form of generator 11. In one such method the output of amplifier 20 passes by the conductor 32 back to a point in the circuits of generator 11 where the linearity of the resulting wave may be controlled instantaneously. The conductor 32 is shown in a dashed and dotted form. Such linearity control points in the wave generators as arranged at present for manual operation of the said control are known and can be rearranged readily for automatic operation or control.

In another form the output of amplifier 20 passes through the conductor 31 and is impressed on the timed cut-off amplifier 30, and thence, after time-controlled amplification, through conductor 33 to the mixer 13.

The amplifier 30 has, as its purpose, the application of the linearity control means to the controlled wave form generator 11 only during such portions of an operating cycle as may be appropriate. In the case of the sawtooth wave it is obvious that only the major portion of the rising wave need be controlled as to linearity for practical purposes, although there is no objection to controlling the linearity of the major portion of the falling section of the sawtooth wave. Obviously, it is not possible nor desirable to attempt to control linearity at or close to the minimum and maximum values of a sawtooth wave where abrupt changes in slope are, in fact, called for by the nature of the wave. The cut-off in amplifier 30 is controlled by the timing bias control element 35. This latter element is joined to the timed cut-off amplifier 30 by conducting means 36. The timing bias control element 35 may be any combination of circuits and biases either controlled from the wave generator itself by impressing a part of the sawtooth wave through the conductor 37 and impressing it onto the element 35, or it may be independently controlled by an additional timing wave generated and impressed onto the timing bias control by means of the conductor 38, the latter being indicated in dashed and dotted form. If a control wave is generated and is impressed onto the timing biasing control by the conducting means 38, this may be derived from the same impulse generator which controls the wave generator 11, or any other suitably synchronized timing device correctly related to the wave generated in 11.

It will be noted that by changing the setting of the potentiometer comprising elements 18 and 19 the slope of the desired linear wave form may be modified slightly. In general, 18 should be set so that the determined slope corresponds to that of a straight line passing through the beginning and end of that portion of the wave generated by 11 which is to be controlled as to linearity. The method herein disclosed is then based on the con-

trol of linearity of a wave form by the utilization for corrective means of a voltage derived therefrom and proportionate to the instantaneous rate of change thereof, from which derivative voltage a determined or datum voltage is subtracted to set approximately the slope of the desired linear wave. The corrective energy may be obtained from a linear correction amplifier of appropriate time constant. The time constant may be brief.

Referring to Fig. 3, there is shown schematically another arrangement according to my invention. In this figure the wave generator has a portion of the output thereof impressed across the primary 16 of a transformer. For purposes of simplicity the remaining portions of the circuit are not shown, but this section represents a differentiating circuit. The secondary 17 of the transformer is connected through a potentiometer arrangement comprising a source of direct current energy 18 and resistor 19, and is impressed onto the linearity correction amplifier 20. The output of the linearity correction amplifier is impressed onto the input of the timed cut-off amplifier 30 and the output of the timed cut-off amplifier is returned to the wave generator 40 by means of conductor 41. As in Fig. 2, a portion of the output of the wave generator 40 is impressed onto a timing bias control 35. The output of the wave generator then is taken from the conductor 42. In this manner the corrective effect is applied directly to the wave generator itself.

The particular form of wave generator or sawtooth generator per se which has been illustrated herein is of a general and well known type, for instance, and in substantially a duplicate of that illustrated in the book entitled "Television" by Zworykin and Morton and published by John Wiley & Sons, New York, 1940. Linearity correction can be made by applying the corrective wave form in the output circuit of the generator, for instance, between the negative terminal of the plate supply battery or source and the charging resistor, or the correction may be made across the charging resistor contained in the output circuit of such an oscillator.

Referring to Fig. 4, there is shown a linearity correction amplifier which may be used with the schematic arrangement of my invention according to Fig. 3. In this arrangement the conductors represented by 43 and 44 in Fig. 3 are connected to the primary 16 of a transformer having secondary 17 and one side of the secondary is connected to the variable biasing arrangement comprising energy source 18 and potentiometer 19, and the variable bias is connected by conductor 45 to the grid of a thermionic tube 46 having anode, cathode and at least one grid or control electrode. The anode of the tube 46 is energized by a potential source 47 and the output may be taken from across resistor 48. This output is impressed onto the input circuit of the timed cut-off amplifier 30.

The control grid or grids of the first tube in timed cut-off amplifier 30 are thus subject to two independent but simultaneously active controls. One of these controls, emanating from the output of the linearity correction amplifier 20, serves to control the production in the output of amplifier 20 of the correction voltage or current which will cause the generated wave from 40 to become linear in the final output. The other of these controls, received from the output of the timing bias control 35, renders the ampli-

fier 30 active only during the desired portion of the sawtooth wave cycle.

There has been referred to hereinbefore the fact that the correction voltage or current may be impressed directly onto the wave generator or sawtooth wave oscillator. By way of example a suitable form of sawtooth wave oscillator is shown by Fig. 13 and in the more detailed explanation thereof to follow, it will be pointed out how the correcting voltage may be applied either in series or in parallel with the peaking or linearity control resistor 110.

Referring to Fig. 5, there is shown a simplified arrangement of how the voltage or current may be impressed onto the circuit of the sawtooth wave generator of the general character shown by the above mentioned figure of the Zworykin and Morton publication in parallel with the resistor R_1 there shown. The arrangement of Fig. 5 consists of a thermionic tube 50 having anode, cathode, and a single control electrode illustrated, the anode being energized by the plate supply source 51 and the output of the tube being connected to terminal points *a* and *b* so as to be capable of being connected directly in parallel with the resistor R_1 of Zworykin and Morton or the resistor 110 of Fig. 13 when the switch arms 112 and 114 are moved against the right side contacts. For purposes of simplicity the input circuits of this tube 50 have not been indicated since the tube input would correspond to the input circuit to the thermionic tube 46 of Fig. 4.

Referring to Fig. 6, there is shown another arrangement which might be used to impress the voltage or current in parallel relationship onto the resistor R_1 of the sawtooth wave generator hereinbefore referred to. Here again the input circuit of the tube has not been indicated, but would correspond to the input circuit of tube 46 of Fig. 4. The arrangement consists in a thermionic tube 60 having anode, cathode, and one control electrode, the anode being energized by a supply 61 and serially connected with the anode and the supply 61 is a resistor 62, the latter being connected back to the cathode of the tube 60. Also connected in series with the anode and the source of potential 61 is a second resistor 63 and the uncommon terminal of the latter resistor and the uncommon terminal of resistor 62 are connected in parallel with the resistor 110 of Fig. 13. In the arrangements according to Figs. 5 and 6 the amplifier tube acts substantially as a variable resistor connected across the resistor 110 of the wave generator.

Referring to Fig. 7, there is shown a simplified arrangement for impressing the corrective voltage or current wave onto the wave generator in series with the resistor 110. Here again the input circuit has been omitted for purposes of simplicity since it would correspond to input circuit of tube 46 of Fig. 4. In the arrangement according to this figure the anode of the tube 70 is energized by source of potential 71 and the output of the tube may be impressed onto the wave generator by opening the connection between the cathode of the tube and the peaking or linearizing resistor 110 (see Fig. 13), and inserting directly in series with said resistor and said cathode the output corrective wave, such as may be done by connecting the output points *a* and *b* to points *a* and *b* of Fig. 13 and then omitting the wire connection shown between the said points *a* and *b*.

Referring to Fig. 8, there is shown still another arrangement for inserting the linearizing or corrective wave form in the wave generator circuit

in parallel with the resistor 110 of Fig. 13. Again the input circuit of the tube 81 has been omitted for purposes of simplicity, since this input corresponds to the input circuit of tube 46 of Fig. 4. The tube 81 in this illustration comprises illustratively a triode having anode, cathode and one control electrode. The anode is energized by a source of potential 82 and connected serially with said source of potential and the cathode of the tube is the primary 83 of a transformer having secondary 84. The secondary winding 84 may be connected directly in parallel with the resistor 110. In this arrangement the tube of the amplifier is in effect connected across the series resistor of the wave generator through a transformer, the transformer preferably having a low leakage reactance so that the tube resistance is inserted effectively in parallel with the series resistor of the wave generator. In the several arrangements illustrated herein the illustrated tube could be replaced by a pair of tubes connected in push-pull relationship rather than a single tube so as to give full wave operation, if that be desired, and it will be appreciated that throughout this specification applicant is entitled to use obvious and well known equivalents.

Referring to Fig. 9, there is shown one embodiment of a timed cut-off amplifier such as illustrated in Figs. 2 and 3 as the element 30. The amplifier comprises a thermionic tube 90 having anode, cathode and control electrodes, the anode being energized by the energy source 91 and a resistor 92 being provided as an output load member for the amplifier. It will have been noted that in both of the arrangements of Figs. 2 and 3 there is a connector between the timing bias control and the timed cut-off amplifier, and there is another connector between the linearity correction amplifier and the timed cut-off amplifier. Each of these connections may be connected to the grid of the tube 90 and may be joined at the common terminal 93. Each of the connections shown in the drawings has been provided with a legend to show the connection between the elements 20 and 35 of Fig. 3 and the element 30 of the same figure. It will be appreciated that this amplifier may be provided with a fixed bias and it may be arranged to become operative when the variable wave impressed thereon exceeds the fixed bias by a value sufficient to bring the tube up to a conductive state, as is well known. On the other hand, the tube may be made to operate continuously and the variable bias may be applied in a negative sense thereto to block the action of the tube at various times. These two actions are well known in the communications art, and it will be apparent that any of such timed switching arrangements may be utilized which fits the particular problem, and applicant's illustration is merely a well known form of timed cut-off arrangement.

The timing bias control may be arranged to pass current approximately during a certain portion of the sawtooth wave, and thus to activate the timed cut-off amplifier only during the same portion of the wave, and hence in the arrangement according to Fig. 3 correction would take place only at such time that the timed cut-off amplifier is actuated to apply a corrective voltage or current. For sake of illustration, there is shown Fig. 10, in which a portion of the sawtooth wave is indicated, and a legend is inserted to illustrate the fact that correction may take place only at definite portions of the sawtooth wave.

A reference to Fig. 3 will show that the timing bias control may be connected to the wave generator 40 of that figure through conducting means. The timing bias control arrangement for inserting a corrective signal only at spaced intervals of time and on a definite portion of the sawtooth of the wave generator is illustrated by way of example in Fig. 11.

Referring to Fig. 11, the wave generator output is connected by conductor 100 to one terminal of a resistor 101, the other terminal of which is connected to the cathode of a thermionic tube 102, the latter having an anode, cathode and control electrode so that the resistor 101 is shunted across the control electrode-cathode path. Connected serially between the terminal of the resistor 101 which is connected to the conductor 100 and the control electrode of the thermionic tube 102 is a biasing source 103 and an inductance 104 connected serially with said biasing source and the said control electrode. Also shunted across the control electrode-cathode path is a second inductance 105 which is coupled to inductance 104. The output of the tube feeds through plate supply battery 106 and resistor 107. The negative grid bias 103 renders the tube non-conducting until a more than compensating positive bias appears across the secondary 104 of the transformer whose primary is 105. The primary 105 is effectively connected across the output of the wave generator. Accordingly, by proper selection of polarity a bias which does in effect exceed the blocking negative bias 103 by a sufficient amount to make the tube 102 conduct will be generated across the secondary 104 as soon as the steadily rising portion of the sawtooth wave is impressed onto the conductor 100 and the cathode of tube 102.

Referring to Fig. 12, there is shown a set of illustrative curves, the first of these being the curve M which illustrates a sawtooth wave; the curve N which shows the negative bias of the source 103; and O illustrates the differentiating or derived voltage appearing across secondary 104 of the transformer whose primary is 105, and which appears during the entire sawtooth cycle. The sum of the negative bias due to the battery 103 and the positive bias due to the voltage appearing in the secondary 104 is illustrated by the curve P, and it will be seen from this curve how the timed bias control is inactive during undesired portions of the sawtooth cycle.

The arrangement shown by Fig. 13 illustrates generally one form of system to which the invention is applicable. This figure illustrates one suitable form for the wave generators shown conventionally in Fig. 2 at 11 or in Fig. 3 at 40. In the showing of Fig. 13, operating voltages are applied from the terminal marked by the positive sign through the resistor 118 to charge the condenser 120. The tube 116 derives its operative voltages also from the source (not shown) connected to the positive terminal. When the operative voltages are applied to charge condenser 120 in the manner which was explained in the above-mentioned Zworykin and Morton publication, the peaking or linearity control is provided by means of the variable resistor 110 which is also shown in the Zworykin and Morton publication.

In order to apply corrections from the various forms of correcting circuits illustrated, for example, by all of Figs. 5, 6, and 8, provision has been made in the arrangement of Fig. 13 where-

by the output terminals of the said circuits may be

connected to the terminal points or tapping points indicated on Fig. 13 as the points *a* and *b* on the one hand, or terminal points *b* and *c* on the other hand. It will be appreciated that when the connection of the output of any of the circuits such as those of Fig. 5, 6, or 8, for example, are connected to the terminals *a* and *b*, the connection shown in Fig. 13 between these points will be broken, and the correcting circuit will be applied as a series connected correcting circuit with a series connection being made between the charged condenser 120 and the peaking resistor 110.

However, where it is desired to establish a parallel correction control, the connection of the correction circuits may be made to the terminal points marked *b* and *c* which places the correcting circuit in parallel with the peaking resistor 110 of the saw tooth wave generator tube 116. Control impulses are applied to the saw tooth wave generator tube 116 by way of the input terminal 117 or as indicated in the Zworykin and Morton text.

It will be appreciated from the foregoing description that there may be departures from the particular arrangements shown which will still fall within the spirit and scope of my invention, and accordingly I am entitled to all such equivalents as fall fairly within the terminology of the hereinafter appended claims.

What I claim is:

1. A system for producing saw-tooth form electrical waves having substantially a constant rate of change in one direction for one pre-determined finite time period and a relatively rapid change

in the opposite direction during a reduced finite time period which includes a wave generator for developing an electrical wave of approximately constant rate of change during the longer selected finite time period, means for differentiating the wave under development to obtain thereby a derivative wave representative of the rate of change, means for utilizing the developed derivative directly to modify the wave under development by directly influencing the wave generator so as to bring the actually developed wave to substantially precise linearity during the selected first named finite period, and means for limiting the control of linearity of the wave to the longer of the two time periods.

2. A method for producing saw-tooth form electrical waves having substantially a constant rate of change in one direction for predetermined finite time periods and being of rapidly changing form in the opposite direction during a reduced finite time period which includes generating an electrical wave of substantially constant rate of change during the longer selected time period, differentiating the generated wave to obtain thereby a derivative wave representative of the rate of change departures from linearity, directly utilizing the developed derivative to modify the generated wave by directly controlling the wave generation so as to bring the developed wave to substantially precise linearity during the selected finite time period, and limiting the control of linearity of the wave to the longer of the two time periods.

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