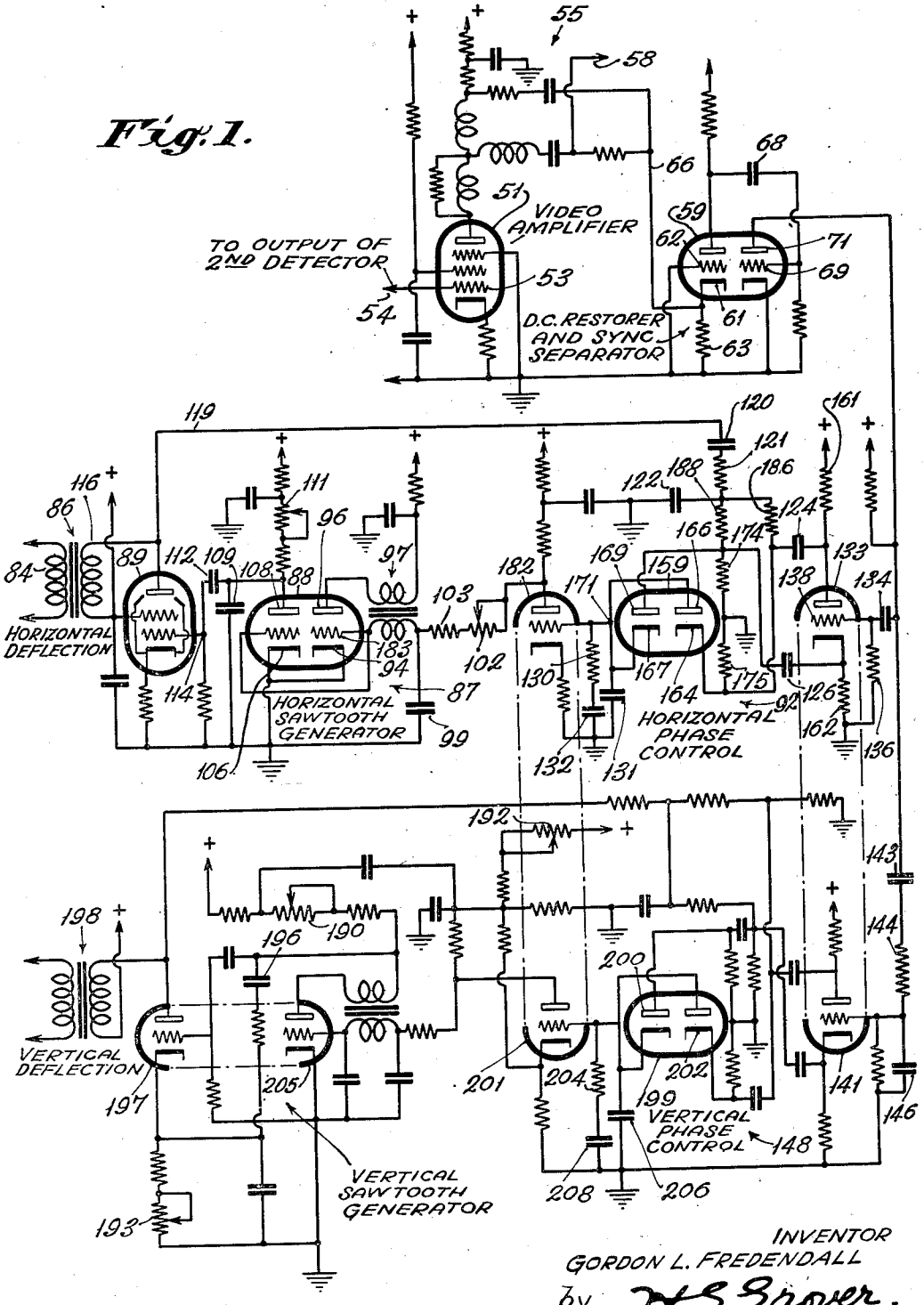
Jan. 4, 1949. G. L. FREDENDALL 2,458,156

AUTOMATIC FREQUENCY CONTROL SYSTEM

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Fig. 1.



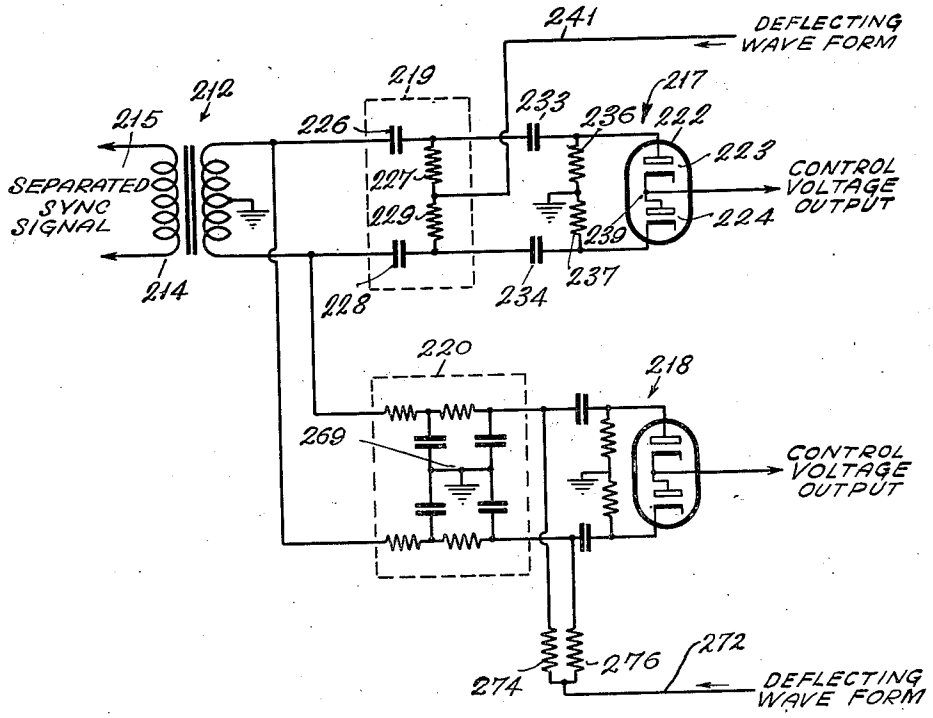
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Fig. 2.



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AUTOMATIC FREQUENCY CONTROL SYSTEM

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Application July 29, 1944, Serial No. 547,230

1 Claim. (Cl. 250—36)

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The present invention relates to automatic frequency control or phase control circuits and particularly to novel apparatus for the synchronization of cathode ray deflecting circuits in television receivers or the like.

In some locations, generally near the edges of the service area of a television station, local interference or weak signals, or perhaps both, impair the accuracy of synchronization in a television receiver to such an extent that the horizontal resolution is appreciably reduced. There may also be failure of interlace and even sporadic failure of synchronization. This invention aims to provide an improvement in synchronizing action that will improve performance in these marginal locations without introducing comprising factors. For signal conditions which are at all satisfactory for reception, substantially the maximum horizontal resolution permitted by the television channel may be realized in a receiver embodying the present invention when allowance is made for unavoidable noise effects seen in the image as beam modulation. Also, noise effects do cause "tearing" of the picture in horizontal strips. Appreciable improvements in vertical synchronization is shown.

In accordance with this invention, these and other desirable results are attained by providing improvements in previously known television receiving equipment in which synchronization of an oscillator is to be obtained by employing an automatic frequency control circuit responsive to any change in the time relationship of the synchronizing pulses with respect to saw-tooth waves used to control deflection.

A further object of the invention is to provide an improved means for synchronizing the deflecting circuit or circuits of an image producing device.

A still further object of the invention is to provide an improved television receiver.

In accordance with the invention, a phase detector is coupled in a novel manner to a signal source.

Other and more specific objects of the invention will become apparent and suggest themselves to those skilled in the art to which the invention is directed upon reading the following specification and claim in connection with the accompanying drawing in which:

Fig. 1 is a circuit diagram of substantially the entire deflecting arrangement of a television receiver embodying the invention; and

Fig. 2 is a schematic representation of a portion of a television receiver embodying a modification of the invention.

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Referring to Fig. 1 of the drawings, certain parts of a typical television receiver, modified to incorporate features of this invention, are shown diagrammatically. The video amplifier, D. C. restorer, sync separator, and the deflection generators are shown.

A tube 51 serves as a video amplifier, the video signals from the second detector of the receiver (not shown) being impressed on the control grid 53 of this tube by way of a connection 54. The output of the tube 51 includes a peaking arrangement indicated generally by reference character 55. Inasmuch as this arrangement has been employed in previously known television receivers, its functions and operation will not be described in detail. The output to the image producing device such as a Kinescope is indicated at 58. Usually, this connection will effectively terminate at the control grid of the Kinescope. A tube 59 of the duplex type serves as a D. C. restorer and also as a sync pulse separator and amplifier. The cathode 61 and the grid 62 together with the cathode resistor 63 serves as a diode rectifier with its load resistor to perform the function of a D. C. inserter since the control grid circuit of the image producing device is coupled through the resistor 63. The control grid 62 also causes the signals applied over a conductor 66 from the peaking circuits 55 to be repeated by way of a condenser 68 on the control grid 69 of the tube 59. The grid and cathode elements 61 and 62 rectify the peaks of the synchronizing pulses which are applied to the cathode with negative polarity, and only the sync signals are passed by the condenser 68 to the grid 69. The pulses appearing on the grid 69 are present in the plate circuit of the plate 71 which is coupled in a novel manner, hereinafter described, to the automatic frequency controlled horizontal or vertical deflection circuits.

The horizontal deflection circuit of the image producing device is fed in the usual manner from the secondary 84 of a transformer 86. A horizontal saw-tooth generator 87 including a tube 88 applies a saw-tooth voltage to a high impedance horizontal output tube 89. The plate circuit of this tube 89 is coupled to the horizontal deflecting means of the image producing device through the previously mentioned transformer 86.

The details of the horizontal saw-tooth generator 87 and the function and operation of the horizontal phase control 92 will now be described. The cathode 94 and anode 96 of the duplex type tube 88 are elements of the usual blocking oscillator tube. The blocking oscillator includes in

addition a feedback transformer 97, a condenser 99, which is charged and discharged, and a speed control resistor 102 which is in series with a resistor 103.

The blocking oscillator section of the tube 88 operates to produce pulses and is controlled from the phase control 92 in a manner to be described. The elements 106 and 108 of the tube 88 serve as a discharge tube to generate a saw-tooth of voltage by charging and discharging a condenser 109. The adjustable resistor 111 serves as a width control. The saw-tooth voltage across the condenser 109 is applied through a condenser 112 to the grid 114 of the high impedance horizontal output tube 89. The plate circuit of this tube includes the primary 116 of the transformer 86 which also serves as a coupling impedance for applying voltage pulses to a filter composed of a resistor 121 and a condenser 122 by way of a conductor 119 and a condenser 120. This resistor 121 and condenser 122, in combination, produce a wave of saw-tooth form from the pulses derived from the output of the tube 89, the latter being of such character that the saw-tooth current is produced in the horizontal deflecting coil of the Kinescope. The condensers 124 and 126 correspond to the condensers 24 and 26, respectively, of Fig. 1 of a co-pending application of the present applicant jointly with Alfred C. Schroeder, Serial No. 547,355 and filed July 31, 1944. Resistors 174 and 175 correspond to the resistors 34 and 36 respectively of Fig. 1 of said application. The filter constituted by the components 131, 132, and 130, corresponds to the filter 39 of Fig. 1 of the said application.

The filter-resistor 130 has a critical value, for each receiver of a given design in which it is used. When this resistor is too large, the sides of the image become scalloped, and when it is too small, the image as a whole vibrates in the horizontal direction. There is an intermediate range of values for which the image is correct.

A phase inverter tube 133 is coupled to the output from the plate 71 of the tube 59 through a coupling condenser 134. The coupling condenser 134 in conjunction with the grid resistor 136 of the tube 133 serves as a differentiating circuit to separate horizontal sync pulses from the output of the tube 59. The pulses which are applied to the grid 138 are of short time duration which is desirable for application to the phase control 92.

A phase inverter tube 141 is coupled to the output of the tube 59 through a coupling condenser 143 and a resistor 144. The resistor 144, in conjunction with a condenser 146, serves as an integrating circuit to obtain separation of the vertical sync pulses which are to be applied to the vertical phase control designated generally by a reference character 148. Inasmuch as the action of the vertical sync circuits is similar to the action of the horizontal sync circuits, a detailed description will be given in connection with tube 133, and it will be understood that this description applies equally to the tube 141.

Pulses appearing on the grid 138 of the tube 133 are applied in opposite phase by way of the previously mentioned condensers 124 and 126 to a phase detector comprising a pair of diodes or, as shown by way of example, a duplex diode 159. Coupling is effected in a manner to provide positive pulses on the plate and negative pulses substantially of equal amplitude on the cathode of the tube 133. Equality of amplitude is readily obtained by selecting a proper value for the plate resistor 161. As a consequence of capacitance effects in the tube 133, the resistors 161 and 162 are not necessarily of equal value.

The condenser 124 serves to couple the plate of the tube 133 to the cathode 164 of one of the diode sections. The corresponding anode 166 is joined to the cathode 167 of the other diode section, and this connection, indicated by reference character 171, serves as the output terminal of the phase detector 92. The D. C. return paths for the diode sections are provided by resistors 174 and 175, having a common terminal which is grounded as shown, thereby providing a balanced arrangement for the phase detector. The anode 169, corresponding to the last-named cathode, is coupled by the condenser 126 to the cathode of the tube 133.

The diode sections of the duplex diode 159 function as peak detectors by selecting values for the resistors 174 and 175. The discharge paths of the condensers 126 and 124 have a relatively long time constant.

A D. C. amplifier 182 amplifies the control signal from the phase detector which appears at the point 171. This amplified control signal is applied to the grid resistor 103 of the blocking oscillator triode section of the tube 88. This output is in the form of a signal which slowly varies when noise is present. The variation in this signal is added to or subtracted from the potential normally applied to the grid 183, this normal potential being variable at will within chosen limits by the speed control resistor 102.

The operation of the receiver of Fig. 1 with the horizontal deflecting circuit arrangement as shown, in accordance with the invention, will now be described. Sync signals of opposite polarity with respect to ground are provided by the phase inverter tube 133 by way of the condensers 124 and 126. These sync signals of opposite polarity are superimposed on the saw-tooth wave derived from the tube 89 through resistors 186 and 188. The sync signal which is applied through the condenser 126 to the plate 169 of the tube 159 is in the positive sense, while the sync signal applied by way of the condenser 124 to the cathode 164 is in the negative sense. The saw-tooth waves on the plate 169 and the cathode 164 are in phase and the time relation is such that the sync signals are positioned on the return or re-trace portion of the saw-tooth. In normal operation, assuming that disturbances such as noise are absent, and with a pre-determined normal setting of the control 102, the sync signals are substantially at the middle of the re-trace. Any change in the phase relation of the saw-tooth wave and sync pulses will cause an increase in the peak amplitude of one composite signal and a decrease in the peak amplitude of the other composite signal, these composite signals being the saw-tooth combined with one set of sync pulses extending either in a positive or negative sense.

The voltages across the resistors 174 and 175, that is to say, on the diode side of the condensers 124 and 126, include the D. C. voltage inserted by the peak rectifier action of the diode sections of the duplex diode 159. The peaks of the sync pulses are held at the same reference level, which may conveniently be zero.

In the signal appearing at the point 171, the sync pulses are effectively balanced out, leaving a signal containing only the saw-tooth wave components. The saw-tooth component is filtered out by the previously mentioned filter composed of the elements, 130 to 132, and a D. C. control

potential is obtained which is not a fluctuating saw-tooth wave but is a very slowly varying signal when noise is present. This control potential is amplified by the amplifier tube 182. In the illustrative example, the average potential existing between the saw-tooth waves with the peaks of the sync pulses at the same reference level is zero at the instant when the sync pulses occur. If a small phase displacement occurs between the sync pulses and the saw-tooth waves, the peaks of the sync pulses continue to be maintained at zero potential, for example, but the average potential at the point 171 is lowered or raised, depending on whether the pulse moves to an advanced or to a retarded position in time relative to the saw-tooth wave. The feedback action is such that the change in speed of the oscillator tends to reduce the magnitude of the phase discrepancy between a saw-tooth cycle and a pulse that gave rise to the increment in the control voltage.

The equilibrium position of the pulses is a function of the settings of the speed control, for example, speed control 102, but is constrained to lie somewhere on the return time of the saw-tooth. The suggested normal location given above was in the middle of the return time of the saw-tooth. When the amplitude of noise is sufficiently great, some noise peaks tend to be held at zero potential by the action of the diodes of the duplex diode tube 159. The potential at the point 171 tends to fluctuate about zero, if the distribution of the noise is random. Under such circumstances, the D. C. component is zero. It is important here to note that the wave forms of noise and saw-tooth do not appear at the junction of the diodes as distributing components of the control voltage. Variations in the difference between the "instantaneous A. C. axes" of the two saw-tooth waves would appear at the point 171 in the absence of the filter 130—132. The function of the filter is the removal of the higher frequency components of the control voltage and the transmission only of the very low frequency components. In the absence of noise, the latter are a true indication that a readjustment in the phase of the oscillator is necessary for the maintenance of accurate synchronism. Low frequency components are indications of a drift in circuit constants or small changes in the frequency of the transmitted sync pulses.

The vertical deflection circuit and vertical deflection control shown by Fig. 1 of the drawings are similar to and operate in the manner already discussed in connection with the horizontal deflection circuit. The adjustable resistor 190 serves as a size control and corresponds to the size control 111. The adjustable resistor 192 serves as a speed control and corresponds in function to the adjustable resistor 102. The adjustable resistor 193 serves as a vertical linearity control. A condenser 196 is charged and discharged to provide a voltage wave which controls the plate current of a tube 197. This plate current in the primary of transformer 198 serves to drive a saw-tooth wave of current through the vertical deflection coil (not shown).

Polarities relative to ground of the vertical sync pulses appearing at the vertical phase detector 199 should be such that positive pulses are applied to the plate 200 and negative pulses to the cathode 202. The limits of the value of resistor 204, which is the damping resistor in the filter combination 206, 208, and 204, in general need not be as restricted as the value limits of the corresponding resistance 130 in the horizontal

filter. If resistor 204 has too large a value, the image will tend to bounce in the vertical direction under the influence of severe noise. The lower limit of value of the resistor 204 will, in general, be fixed by the speed of pull-in considered desirable and the tightness of lock-in desired.

It is desirable in the operation of an automatic frequency controlled television received to maintain a reasonably constant plate voltage supply for the tubes 182 and 201 (or the two parts of a duplex tube, if one is used as shown) and the tubes 88, 205, and 197 when the gain control of the I. F. amplifier (not shown) is varied. An effective arrangement for insuring a reasonably constant plate voltage is shown in the application of Gordon L. Fredendall, Serial No. 526,287, filed March 13, 1944, now matured into Patent Number 2,454,150.

Referring to Fig. 2 of the drawings, a portion of a television receiver embodying the invention in modified form is disclosed. Reference character 212 denotes a transformer, the primary 214 of which is furnished with separated horizontal and vertical sync signals over a connection indicated at 215. This connection 215 may correspond with or be analogous to the circuit of the plate 71 of the tube 59 of Fig. 1. Push-pull horizontal and vertical sync pulses required by the horizontal and vertical phase detectors 217 and 218 are derived from the transformer 212 by means of high-pass R—C filter network 219 and a low-pass R—C filter network 220.

The horizontal sync control will first be described since, as was stated in connection with Fig. 1 of the drawings, the principal features of the vertical sync control are analogous and therefore a detailed description of it need not be given. The phase detector 217 comprises a pair of diodes or, in the interest of economy, a duplex diode 222 comprising independent diode sections 223 and 224. The high-pass filter 219 is designed in accordance with well-known principles and comprises two sections, each composed of a condenser and resistor. Condenser 226 and resistor 227 provides sync pulses in the positive sense to the diode section 223. Condenser 228 and resistor 229 provide a sync pulse in the negative sense to the diode section 224. Condenser 233 corresponds in function and location to the condensr 126 of Fig. 1. Condenser 234 corresponds in function and location to the condenser 124 of Fig. 1.

Resistors 236 and 237 are grounded at their point of connection to cause the diode sections to serve as peak detectors. In order that a control signal representing the phase difference between sync signals and the saw-tooth deflection wave may be developed at the point 239, the saw-tooth deflection wave is fed by way of a connection 241 to the zero ground potential point, provided at the junction of the resistors 229 and 227. The arrangement from the condensers 233 and 234 may be the same as the arrangement shown on Fig. 1 of the drawings from the condensers 124 and 126 through the horizontal deflection transformer 86 shown on Fig. 1 of the drawings. The connection 241 corresponds to the connection 119 of Fig. 1. Inasmuch as the arrangement of Fig. 1 may be used, it is not believed that further detailed illustration of these features is necessary. The saw-tooth wave is derived, for example, from a discharge tube under control of a blocking oscillator tube which functions in the manner explained in connection with tube 88 of Fig. 1 of the drawings. The output of the discharge tube appearing in its plate circuit is supplied through

the medium of a transformer to the horizontal deflecting coil (not shown). The output of the discharge tube may, it will be understood, be of a wave form which is suitable to provide a current wave of saw-tooth form in the horizontal deflecting winding.

The synchronizing peaks, applied in opposite sense by the connection 241 and the saw tooth wave voltage are combined in a manner previously explained in Fig. 1 of the drawings to provide a control signal at the point 239.

The principal difference between the vertical and horizontal control circuits in this modification lies in the design of the filter 220 which passes the vertical sync signals. Since the details of the filter 220 conform to normal practice, and the choice of constants of the filter can readily be made by those skilled in the art, a detailed description will not be given. It is to be noted that the capacity arms of the positive and negative portions of the filter are grounded at 269. The saw-tooth voltage from the vertical discharge tube is applied over a connection 272 to each half of the phase detector by resistors 274 and 276.

As a consequence of the balanced nature of both the horizontal and vertical control circuits in accordance with this modification of the invention, there are no troublesome reactions between horizontal and vertical circuits. Economy of design is also a feature of the invention in this form since only the single transformer 212 is required for both the horizontal and vertical circuits. This feature of economy is of considerable importance in television receivers designed for household use which, to be available generally to the public, must be sold at a modest price.

Various 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 alterations be considered within the purview of the present invention as defined by the hereinafter appended claim.

Having now described the invention, what is claimed and desired to be secured by Letters Patent is the following:

An automatic frequency control system comprising a pair of peak rectifiers, a source of signals of sawtooth wave form, a source of separated pulses providing high and low frequency pulses, a transformer connected to said source of separated pulses, means for applying sawtooth wave form signals to said rectifiers with like polarity at each rectifier, means including a high pass filter for applying pulses of high frequency to said rectifiers from said transformer with opposite polarity at each rectifier, means for utilizing the output of said pair of peak rectifiers for controlling said means for applying sawtooth wave form signals, a second pair of peak rectifiers, means for applying low frequency sawtooth wave form signals to said second pair of peak rectifiers with like polarity at each rectifier, means including a low pass filter for applying low frequency pulse signals to said second pair of rectifiers from said transformer with opposite polarity at each rectifier, and means for utilizing the output of said second pair of rectifiers for controlling said means for applying low frequency sawtooth wave form signals.

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