

2,256,529

2 Sheets-Sheet 1

The graph shows the relationship between plate current and control grid voltage. The vertical axis is labeled "PLATE CURRENT" and the horizontal axis is labeled "CONTROL GRID VOLTAGE". A curve represents the plate current characteristic. A vertical dashed line marks the "MEAN VALUE OF COMPLETE WAVE", which is at a negative control grid voltage. The distance from the origin to this dashed line is labeled E . The distance from the origin to the point where the curve begins to rise is labeled E_0 . Below the graph, a complex periodic waveform is shown, with its mean value aligned with the dashed line at E . A label E_3 points to a specific part of this waveform.

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SYNCHRONIZING SIGNAL SEPARATOR CIRCUIT

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2 Sheets-Sheet 2

Fig. 3

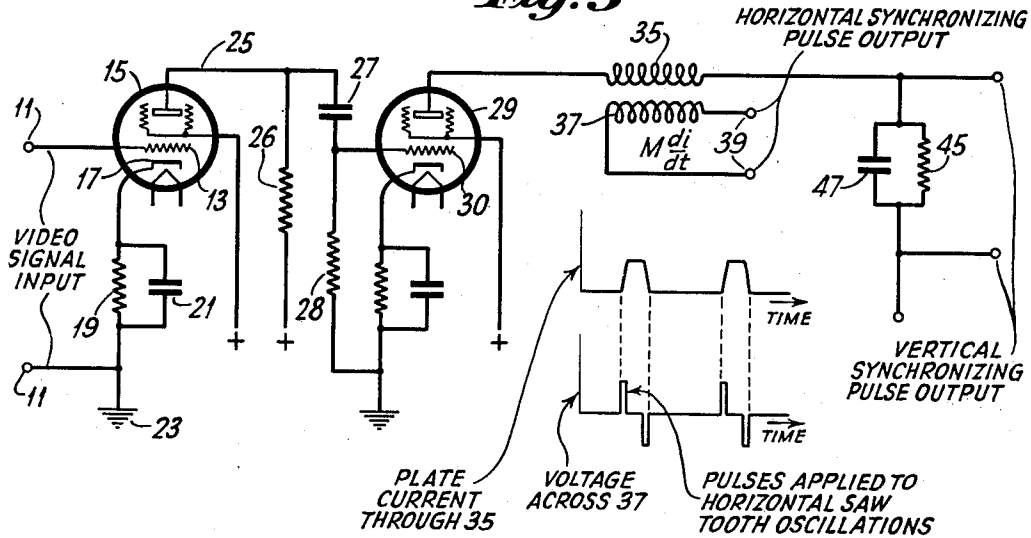
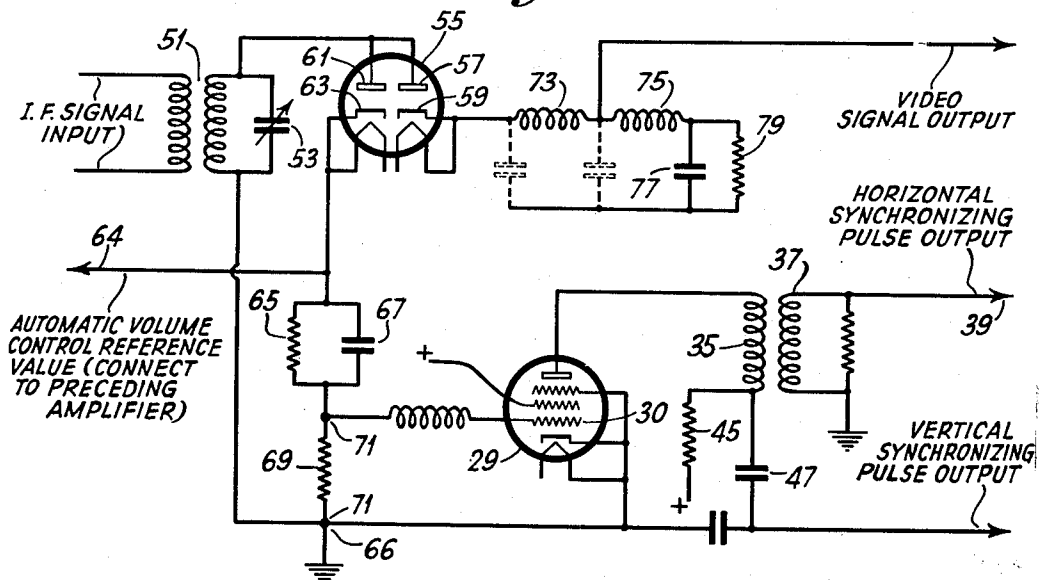


Fig. 4



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SYNCHRONIZING SIGNAL SEPARATOR
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Application October 6, 1938, Serial No. 233,552

5 Claims. (Cl. 178—69.5)

The present invention relates to television systems and is particularly directed to the receiving end of the television system and to means by which the synchronizing impulses are separated from the remaining portion of the signals transmitted from the point of signal origin in such a system.

It has already been explained and understood in the art that the television signals are transmitted from a transmitter in such a manner that following each line of image or video signal transmission there is sent out from the transmitter a signal impulse which is known as a blanking or pedestal signal and superimposed upon a portion of this blanking signal is an impulse which is the synchronizing signal. This form of transmission is adopted because of the fact that the video signal is interrupted for brief periods at the end of each scanning line and with the blanking signal representing "black" there will not be produced any visible pattern to view during these time periods of interruption when horizontal synchronizing signals or pulses are transmitted.

Still further at the end of each complete picture the video signal transmission is interrupted for a time period which is longer than the interruption period for each line interruption. During the long period of interruption at the end of transmission of each picture field vertical synchronizing and equalizing impulses are transmitted in addition to the continued horizontal synchronizing impulses. The interruptions of image point representations on the cathode ray tube target are accomplished by horizontal and vertical blanking signals respectively which are of the intensity of a black video signal and thus serve to cut-off the cathode ray beam in the image reproducing cathode ray tube by being impressed upon the control electrode thereof.

The horizontal pulses serve to start each scanning line at the receiver and the vertical pulses serve to start each new picture field at the proper time. The signal form which results from this type of transmission, as well as some of the proposed operating standards, has been described in the publication "Electronics" for July 1938 on pages 28, 29 and 55. At the bottom of page 29 of the aforesaid publication, there is pictured a diagram of the wave form of the video, the horizontal and vertical blanking signals as well as the superposed synchronizing signals.

The present invention is so constituted that it seeks to provide ways and means by which the synchronizing signals for controlling line and

frame synchronization in television apparatus may be separated from the remaining portions of the signal energy transmitted.

The type of signal transmitted is, of course, particularly adaptable for use in television systems wherein a cathode ray image reproducing tube is used to create an electro-optical replica of the image transmitted and wherein the envelope of the signal wave form controlling the cathode ray beam of this receiver tube is of the form above described. The function of blanking, of course, under such conditions, is performed directly upon the receiving tube by impressing the entire television signal upon the control electrode thereof. The synchronization of the cathode ray beam of the receiver tube with the transmitter tube and the control of the oscillators or impulse developing means for controlling the deflection of the cathode ray beam in the horizontal and vertical directions in order to reproduce these images, then is governed by the receipt of the synchronizing or short impulses appearing upon the pedestals or blanking signals. The blanking signals, it will be seen represent, in general, the absolute black level of the picture. Accordingly, when these signals are applied to the control electrode of the cathode ray image reproducing tube they serve to reduce to zero or to a black value the intensity of any possible light value resulting from the beam impinging upon the luminescent screen structure during its transverse thereof.

The synchronizing impulses, in order to become useful, must be separated from the composite television video and blanking signal. Accordingly, the present invention is particularly concerned with providing ways and means by which the synchronizing impulses may be separated from the blanking and video signals in the receiver.

It is thus apparent that the present invention, has as one of its main objects that of providing a form of arrangement for separating the synchronizing impulses from the composite television signal and further it is to provide suitable electrical networks for attaining this result. These results, for example, may be accomplished by a process which is known in the art as "clipping" or, in other words, they result from a process which limits the signals transmitted through a suitable form of energy separating network or networks only to those portions of the composite signal which exceed a predetermined amplitude in the direction of black but of greater

magnitude in that direction than an actual black signal.

In the case of the present form of apparatus, as disclosed, the invention is applied to television transmitting and receiving apparatus wherein the signal radiated from the transmission point is of the nature described in the above referred to "Electronics" publication and, therefore, is substantially the form now approved by the Television Committee of the Radio Manufacturers Association. With this form of transmission the synchronizing signals extend in the black level of the complete signal transmitted and are of a magnitude greater than that of the deepest black represented by either the video or the accompanying blanking signals. With this type of transmission the synchronizing signals exceed in percentage modulation either the video or blanking signals by substantial amounts of say not less than 20% of the maximum signals transmitted.

Accordingly, it is a still further object of the present invention to provide a system of an extremely simple nature by which the peak synchronizing impulses may be separated from the video signals and the accompanying blanking impulses.

Another object of the invention is to provide ways and means to produce automatic volume control potentials for controlling received operation, where the automatic volume control potential is developed in conjunction with the separation of synchronizing signals and, is therefore, related directly to the strength of the maximum signal received (assuming negative television modulation as is well understood in the art) which is the synchronizing impulse superimposed upon the black level pedestals.

Still other and further objects will become apparent and appreciated at once by anyone skilled in the art by a reading of the following specification and claims in connection with the accompanying drawings wherein

Fig. 1 illustrates schematically a form of signal transmitted and received in the transmitting equipment.

Fig. 2 schematically illustrates the relationship in the separating circles between the control grid voltage and the plate current flowing shows the general relationship between different portions of the signal with respect to the grid current flowing,

Fig. 3 schematically illustrates one form of circuit by which separation of the synchronizing signals from the remaining signal energy may be attained; and

Fig. 4 represents a modification of the circuit of Fig. 3.

Referring now to the drawings and first to Fig. 1 thereof, it will be seen that on each of the short blanking pedestals following each line of video signal pulses, a horizontal synchronizing signal pulse is represented and upon each of the long pedestals several pulses or groups of pulses are represented. The pulse on the short time duration pedestal serves the purpose of timing or controlling the time of operation of the deflection of the electron beam deflection system which is to control the line motion of the cathode ray beam to reproduce the electro-optical image while those pulses on the long time duration pedestals serve to time or synchronize both the horizontal and vertical deflection systems. In order that these pulses placed upon the blanking signals may serve to synchronize or to time both

the horizontal and the vertical deflection systems, it is necessary that they be separated from the composite signal. One means by which the separation may be effected is by virtue of the different amplitude of these several synchronizing pulses from the remaining portion of the signal (that is, the video and blanking signals). This form of separation is possible because of the fact that the video signal itself in the black direction never exceeds the height of the pedestal (or the so-called blanking impulse) because the pedestal height represents absolute black. Naturally, it is impossible to obtain negative light representations so that a light value cannot be represented by any signal of greater amplitude than that chosen for the blanking impulse.

Since the pedestals representing the blanking impulses are all of the same height, irrespective of whether or not the blanking signal is for the purpose of providing blanking following each line of transmission or for each frame of transmission and the synchronizing impulses (sometimes called "super synch" for this reason) are superimposed upon the blanking impulses, it is evident that separation of the synchronizing impulses from the remaining portion of the composite signal may be effected by a process known as "clipping" or, in other words, by magnitude discrimination and it is to this feature to which the invention herein to be described is in part directed.

Referring now more particularly to Fig. 2 of the drawings, after having appreciated the general nature of the signal which is being received and which has been above discussed in connection with Fig. 1, there has been shown by Fig. 2 diagrammatically the form of television signal which is delivered from the output of the video detector or amplifier, such, for example, as that detector described in the Carlson Reissue Patent #20,700 dated April 19, 1938, which is to be impressed upon the control electrode of a synchronizing signal separating tube 15 such, for example, as that shown and described more particularly in connection with the diagrammatic representation of Fig. 3. It will be seen by reference to Fig. 2 that if the tube of Fig. 3 is suitably biased to a point where plate current is cut-off except during the time of occurrence of the synchronizing signal impulse, it is possible to separate the synchronizing impulses from the remaining portions of the composite signal. This biasing, obviously, provides the effect of a so-called Class C amplifier. The composite picture and synchronizing signals are applied to the control electrode 13 of tube 15 with the synchronizing signals extending in a positive direction.

It has already been proposed, as above noted, to accomplish this separation by grid circuit detection as described, for example, in copending Tolson application, Serial No. 23,136 filed May 24, 1935 but in many instances the resistance value for providing this form of separation becomes unduly high for use in a grid circuit. It is a well known fact that current may flow from a negatively biased grid due to ionization of gas within the tube or due to actual grid emission. If an unduly large resistor is included in the grid circuit the current due to either cause, above stated, produces a positive direct current potential across the resistor which nullifies some of the negative bias allowing more plate current to flow than is desirable for most efficient tube operation. In some instances the conditions above described may be cumulative with increasing plate current so as to overload the separating tube to a sub-

stantial extent and cause it to operate in such a manner that replacement of the tube might require changes in circuit constants. Accordingly, the circuit arrangement disclosed by Fig. 3 of the drawings has dispensed with the high resistance grid-leak and employs a self-bias upon the separating tube which becomes effective due to plate current control in the synchronizing signal separating tube.

In the arrangement of Fig. 3 the output signal energy from a video detector, such as described in the above referred to Carlson patent, is applied across the terminal points 11 and supplied to the control electrode 13 of a signal separating tube 15 having its cathode element 17 connected through the parallel combination of resistance 19 and condenser 21 to ground at 23 or to any other suitable point of fixed potential. The output energy from the tube 15 is fed by way of the conductor 25 and coupling condenser 27 to any suitable form of utilization circuit such, for example, as the tube 29 and its associated circuits designed so that the line and frame synchronizing signals may be separated one from the other.

In the general form of arrangement which has been disclosed by Fig. 3 it is desirable, in general, to utilize a signal separating tube of the type known in the art as the RCA 6AC7 or a tube with generally similar characteristics. With the arrangement described in Fig. 3 it is apparent that in the absence of any signal impressed between the control electrode 13 and the cathode 17 of the tube 15 no greater bias than that indicated as E_0 that is, for example, cut-off bias, as shown by Fig. 2, can be obtained. Any greater bias E applied to the tube 15 is dependent upon the D. C. component of plate current from the tube 15 as appearing across the resistor 19 caused by the synchronizing impulses which alone swing over the plate-current grid-voltage characteristic of the tube as indicated by Fig. 2. This additional plate current is substantially independent of the value of the resistor 19 provided that the resistor is high enough for the purpose and, hence, the choice of size of the resistor 19 depends upon the magnitude of the D. C. component of plate current which can be developed by the synchronizing pulse without swinging the grid or control electrode 13 of the tube 15 positive.

From practical considerations and as a result of the form of signal which is to be transmitted, in accordance with the general characteristics shown by Fig. 1, it has been found that a resistance of the order of 12,500 ohms (although this may vary in value through wide limits) is suitable. The condenser 21, which is described as a by-pass across the resistor 19, must be large enough to maintain the grid bias on the tube 15 substantially constant during the vertical synchronizing period, during which time approximately 85% of maximum plate current flows for a very limited time (for example, $3/13230$ seconds in a 441 line transmission system) and yet the condenser 21 should be small enough so that the changes in the D. C. or background value of the composite signal can cause the necessary changes of bias in the cathode lead sufficiently rapidly to maintain the proper "clipping" level in the tube.

With the synchronizing signals having been separated from the video signals and the blanking impulses, it is now necessary to separate the vertical synchronizing impulses from the horizontal synchronizing impulses, since it is quite essential in order that the operation of the appa-

ratus shall be satisfactory, that the horizontal deflection timing or synchronizing control be uninterrupted. In order to accomplish this result the synchronizing impulses are impressed, by way of the condenser 27 upon electrode 30 of a further tube 29, with the synchronizing signals extending in a negative direction. The plate circuit load of tube 29 is small in comparison with the tube impedance, to warrant the assumption that the attenuating current in the plate circuit is independent of and uninfluenced by potentials appearing across the plate load impedance. In case the load is an inductive reactance, as indicated by the inductive load 35, the current through the inductance has the pulsating form of the synchronizing impulse which is impressed upon the blanking signal. Such a wave form has been schematically illustrated immediately below the inductive load 35. The application of a synchronizing impulse to the control electrode of tube 29 causes a decrease in the current flow in the anode circuit. However, the voltage which is developed across the coil 35 is represented by the value of the inductance multiplied by the rate of change in current with respect to time. Consequently, the steep sides of the current pulses cause the maximum change in voltage across the inductance element 35. Naturally, the signals transmitted have slopes of finite dimensions, as can be appreciated from a further consideration of Fig. 1, and the slope of the sides representing the differential change in current with respect to time is actually available in any practical case and, hence, the form of the voltage wave across the coil 35 is substantially that shown immediately below the pulses representing the synchronizing signals as applied through the coil 35.

It will be noted that there are two pulses of voltage per pulse of current since each sloping side of the current pulse yields a voltage pulse which is either positive or negative in sign across the inductance 35. Expressed in other terms the voltage across the inductance in this instance represents a derivative of the current with respect to time and hence there is obtained through the inductance 37 coupled to the inductance 35 at the output terminals 39 timing pulses which may be used to synchronize the horizontal beam deflection apparatus. Further, it will be seen that the voltage wave appearing across the inductance 37 which is coupled to the inductance 35 is such that the current flowing through the inductance 35 which yields in the secondary or coupled inductance 37 a voltage represented by the voltage across inductance 35 multiplied by the mutual inductance between the coils 35 and 37 is a voltage wave having peaks of both positive and negative polarity so that either the positive or negative pulse obtained at the terminals 39, 39 can be utilized for controlling the horizontal deflection of the cathode ray beam in the cathode ray image reproducing tube.

Similarly, in order to differentiate or separate the vertical synchronizing impulses, which occur at relatively low frequency, from the relatively high frequency horizontal synchronizing impulses, it is possible to utilize in series with the inductance 35, but also connected serially in the output circuit of the tube 29, an integrating circuit formed from a combination of a resistance element 45 and a condenser 47. In this instance, of course, it will be apparent that the capacitive reactance of condenser 47 at all important component frequencies of the pulse received is high

in comparison with the series resistance of the resistor 45. Therefore, it will be appreciated that the charging current for the condenser 47 always flows through the resistance 45. This charging current is proportional to the slope of the voltage wave at any instant when the synchronizing impulses are received. Therefore, the voltage impulses are of substantially the form indicated at the terminal points 49 where the voltage across condenser 47 builds up and is discharged rapidly while line synchronizing impulses are received. About 85% of maximum plate current normally flows in tube 29, except when the plate current is momentarily reduced by line synchronizing signals, but when the wider vertical impulses are received the flow of anode current is reduced for a material length of time and as a result the charge across condenser 47 builds up faster than resistor 45 can discharge the condenser until the voltage receives a maximum at which the resistor current is equal to the average value of the charging current.

A modified form of separating circuit which is adapted for use particularly with the so-called "negative modulation" systems has been shown by Fig. 4 which is particularly adaptable for connection to the intermediate frequency amplifier output, such for example, as the output of tube 22 of the above named Carlson Reissue Patent #20,700, where the coupling to the aforesaid intermediate frequency amplifier provided by way of the tuned circuit comprising the inductances 51 and condenser 53 tuned to the intermediate frequency. This timing circuit comprising the inductance and condenser is then connected to a suitable form of detector, such, for example, as a tube of the type known in the art as the 6H6 which is a double-diode and conventionally represented by the tube 55 in such a manner that one set of elements comprising the anode 57 and the cathode 59 is used for video signal detection and the other set of elements comprise the anode 61 and cathode 63 is used for synchronizing signal detection. This synchronizing signal detector portion of the diode, comprising the electrodes 61 and 63, has bias applied to it through the parallel combination of resistance 65 and capacity 67 which is connected in the cathode circuit of the tube. There is also connected in series with the parallel combination of the resistance 65 and the condenser 67 an additional resistance 69 which is of relatively small value compared to the resistance 65. In the preferred operation, the resistance 65 may be made of the order of two megohms with the capacity 67 varied between .05 and 0.5 micro-farad and the resistance 69 may then be of the order of 2000 to 5000 ohms.

It will thus be seen that suitable bias for the portion of the tube 55 which is to separate the synchronizing signals from the remaining video signals is applied and that the time constant of the network comprising the resistance 65 and the condenser 67 is sufficiently high so that only the synchronizing impulses which are superimposed upon the blanking impulses can cause current to flow through the diode. Of these pulses of current which do flow through the diode the D. C. component develops a steady voltage across the resistor 65 and thus biases the diode plate or anode element 61 sufficiently negative to prevent detection of any signal magnitude below a pedestal or black level. Naturally, current flows through this diode portion of the tube during receipt of signals representing synchronizing im-

pulses which are superimposed upon the blanking impulses and this current necessarily flows through the load resistor 69. Consequently, across the output terminals 71, 71, there appears a voltage which represents the synchronizing impulses which have been graphically illustrated in Fig. 1. The by-pass condenser 67 in connection with the arrangement of Fig. 4, unlike that of Fig. 3, is not called upon to change its potential with changes in the background level since the peak amplitude of the intermediate frequency carrier, as impressed upon the tuned circuit 51, 53, remains substantially constant during reception, assuming that a proper and adequate volume control is functioning in the system.

Since the video intermediate frequency amplifier output was connected to the tuned circuit 51, 53, the video signals and the blanking impulses may then be detected in that portion of the detector 55 formed from the anode 57 and cathode 59 and by way of the suitable filtering network comprising the inductance 73, 75 with the capacity 77 and the output resistor 79 may be applied to the control electrode of the final image reproducing tube. The details of the filter network and the feasibility of deriving a plurality of different character outputs from different junction points of the filter has been described in more detail and is claimed in my copending application for "Electrical circuits" filed June 17, 1938 as Serial No. 214,251.

This permits the output energy which appears at the terminal points 71 and representing voltage impulses corresponding to both to the vertical synchronizing signals and the horizontal synchronizing signals to be fed in parallel, preferably, to a differentiating circuit, such as that set forth by the inductance separator 35, 37 of Fig. 3, and to an integrating circuit, such as that described in connection with the elements 45, 47 of Fig. 3. In this way the controlling impulses for separating the line and frame signals one from the other are derived in a manner slightly modified from that of Fig. 4.

Naturally, tube 55 may be replaced by two separate diodes, or one or the other (or both) of the diodes may be replaced by triodes (or suitable multi-electrode tubes). If the separating diode is replaced by a multi-element tube its bias will be supplied according to the arrangement described by Fig. 3 but in this instance the control energy is impressed thereon in the form of intermediate frequency energy rather than detected video signals as explained in the detailed discussion of the circuit of Fig. 3.

From the above it is, of course, apparent also that the circuit of Fig. 4 is so constituted that the average direct current potential at point 64 (the point at which resistor 65 and cathode 63 connect) relative to that of the point 66 is in direct proportion to the peak carrier amplitude being received and is thus a correct reference potential for the operation of an automatic volume control of preceding amplifier stages. With connections shown by Fig. 4 potentials at terminal 64 are increasingly positive with increasing peak signal strength and thus must be fed through a reversing direct current amplifier to be used for amplifier bias control purposes. The proper polarity signal for automatic volume control can, however, be obtained at terminal 64 directly by a mere reversal of the connection points of electrodes 61 and 63. This change, however, may necessitate the use of a reversing amplifier con-

nected at terminals 71, 71 to obtain the proper polarity of synchronizing signal.

Of course, it will be appreciated that many other variances and changes in the control may be provided and, accordingly, various modifications may be made without departing from the spirit and scope of the invention provided such modifications and changes fall fairly within the spirit and scope of the claims hereinafter appended.

What I claim is:

1. A television synchronizing signal separating system comprising a thermionic electron discharge tube having a cathode, a control electrode and an anode, means for maintaining said anode positive with respect to a point of fixed potential, a resistance connecting said cathode to said point of fixed potential, a condenser connected in parallel with said cathode resistance to determine and control the rate of change of potential of said cathode with respect to said point of fixed potential, means for applying television picture and line and frame synchronizing signals between said control electrode and said point of fixed potential with the synchronizing signals extending in a positive direction, said line and frame synchronizing signals having approximately the same amplitude but having different time durations, whereby synchronizing signals only will appear in the anode circuit of said tube, a second electron discharge tube including a cathode, a control electrode and an anode, means for applying synchronizing signals present in the anode circuit of said first tube to the control electrode of said second tube, means including a serially connected resistance and inductance for maintaining the anode of said second tube positive with respect to its cathode, a second inductive member magnetically coupled with said first inductive member, a condenser connected in parallel with said last named resistance, whereby short differentiated impulses may be produced across said second inductive member in response to line synchronizing impulses and whereby integrated impulses may be developed across said last named resistance and condenser combination in response to frame synchronizing impulses.

2. A television synchronizing signal separating system comprising a thermionic electron discharge tube having a cathode, a control electrode and an anode, means for maintaining said anode positive with respect to a point of fixed potential, a resistance connecting said cathode to said point of fixed potential, a condenser connected in parallel with said cathode resistance to determine and control the rate of change of potential of said cathode with respect to said point of fixed potential, means for applying television picture and line and frame synchronizing signals between said control electrode and said point of fixed potential with the synchronizing signals extending in a positive direction, said line and frame synchronizing signals having approximately the same amplitude but having different time durations, whereby synchronizing signals only will appear in the anode circuit of said tube, means coupled to the anode of said discharge tube including an inductance and a resistance connected in series, a second inductance mutually coupled to said first inductance, a condenser connected in parallel with said last named resistance, whereby short differentiated impulses are produced across said second inductance in response to line synchronizing impulses and whereby integrated impulses are produced across said

last named condenser in resistance in response to frame synchronizing impulses.

3. A television synchronizing signal separating system including a source of line and frame synchronizing signals, said synchronizing signals being of substantially the same amplitude but with the frame synchronizing signals having a greater duration than the line synchronizing signals, a discharge tube having a cathode, a control electrode and an anode, means for applying the synchronizing signals between the control electrode and the cathode, means including a series connected resistance and inductance for maintaining the anode positive with respect to the cathode, a second inductance magnetically coupled to said first inductance, a condenser having one terminal connected to the junction of said series resistance and inductance, whereby short differentiated impulses are developed across said second inductance in response to line synchronizing impulses and whereby integrated impulses are produced across said last named condenser in response to frame synchronizing signals.

4. A television synchronizing signal separating system comprising a source of line and frame synchronizing signals, said signals being of substantially the same amplitude but the line synchronizing signals being of shorter duration than the frame synchronizing signals, an electron discharge tube including a cathode, a control electrode and an anode, means for applying the synchronizing signals between the control electrode and the cathode of said tube, means including a series connected resistance and inductance for maintaining the anode positive with respect to the cathode, a second inductance mutually coupled to said first inductance, a condenser connected in parallel with said resistance, whereby line synchronizing impulses are produced across said second inductance and frame synchronizing impulses are produced across said condenser in response to the receipt of line and frame synchronizing signals due to the differentiating and the integrating effects respectively of the inductances and the resistance-condenser network.

5. A television synchronizing signal separating system comprising a discharge tube having a cathode, a control electrode and an anode, means for applying a composite series of picture signals and line and frame synchronizing signals to the control electrode of said discharge tube, means for maintaining said anode positive with respect to a point of fixed potential, means including a resistance for connecting said cathode to said point of fixed potential, a condenser connected in parallel with said resistance for determining the rate of change of potential of the cathode with respect to the point of fixed potential, whereby the line and frame synchronizing signals are separated from the picture signals by amplitude selection so that only the line and frame synchronizing signals are present in the anode circuit of said tube, means coupled to the anode of said tube comprising a series connected resistance and inductance, a second inductance inductively coupled to said first inductance, and a condenser connected in parallel with said last named resistance, whereby short differentiated synchronizing impulses of line frequency are developed across said second inductance and whereby integrated frame synchronizing impulses are developed across said last named resistance and condenser in response to the presence of line and frame synchronizing signals respectively in said anode circuit.

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