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TELEVISION SIGNAL SEPARATOR

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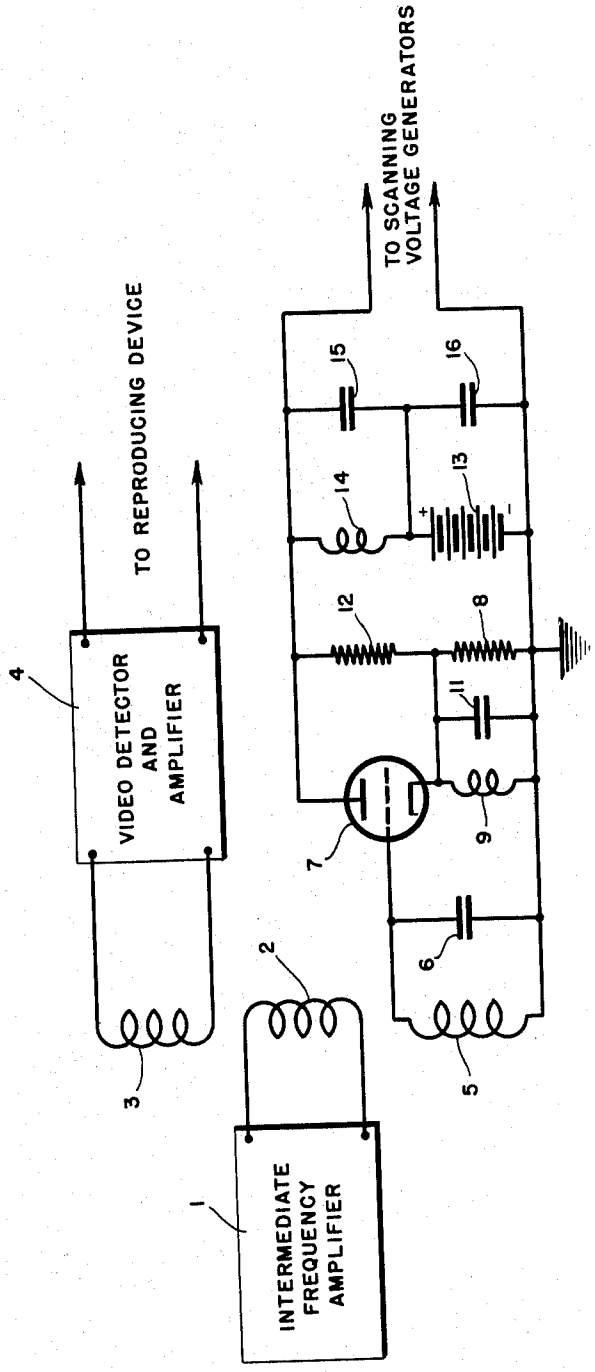

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TELEVISION SIGNAL SEPARATOR

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8 Claims. (Cl. 178—69.5)

This invention relates to electron discharge devices and particularly to amplitude discriminating devices of this character for recovering the synchronizing signal component from a carrier wave which is modulated in amplitude by a composite television signal.

According to conventional television practice, a carrier wave is amplitude modulated by both video and synchronizing signal components to form a composite television signal. In order to operate the receiving apparatus in synchronism with the transmitting apparatus, it is necessary to recover the synchronizing signal component from a carrier wave, either the wave which is radiated or one having an intermediate frequency. The separation of the synchronizing signal component from the video signal component ordinarily is accomplished by means of limiter tubes, biased by the signals themselves or otherwise to effect cutoff of space current in the amplitude range of the video signal component. Also, it is customary to demodulate the carrier frequency wave before the composite signal is applied to the signal separator.

Many types of circuits have been devised for the operation of the limiter tubes. Most of these circuits require the establishment of the direct current signal level of the picture which is to be reproduced to suitably bias the tube and/or the impression of the composite signal upon the limiter tube in considerable amplitude so that the tube may be self-biased. To meet either or both of these requirements necessitates the employment of additional apparatus.

A signal separator which is capable of functioning independently of the direct current signal level and of the signal strength is disclosed in a copending application for patent of Madison Cawein, Serial No. 480,978, filed March 29, 1943, for Television signal amplifier. Briefly, this apparatus comprises a single three-element vacuum tube which is provided with a directly coupled regenerative feed-back facility between the anode and cathode thereof, whereby there is effected a non-linear amplification of a composite television signal of such a character to discriminate sufficiently on the basis of signal amplitude to suppress a selected one of the television signal components. This apparatus, however, in common with the other prior art signal separators referred to, requires signal detection or demodulation of the carrier wave since it operates only under the control of the composite signal which is the envelope of the amplitude modulated carrier wave.

The object of the present invention, therefore, is to provide, in a television system, an improved signal separator, the operation of which is independent of the signal strength and of the direct current signal level, and in addition, does not require a prior demodulation of the carrier wave.

In accordance with the present invention there is provided an electron discharge device such as a three-element vacuum tube which comprises an anode, a cathode and a control grid. A carrier wave which is modulated in amplitude by a composite television signal including video and synchronizing signal components is impressed upon the input circuit of the electron discharge device which includes the control grid and the cathode. The output circuit of the electron discharge device which includes the anode and the cathode is coupled to the input circuit by a regenerative feed-back circuit, whereby there is effected an amplitude discrimination by the device in its output circuit. By reason of this discrimination only the synchronizing signal component is reproduced in the output circuit. There also is provided means including a circuit which has a maximum impedance at the frequency of the carrier wave, which is connected in parallel with the feed-back circuit and by means of which space current is supplied to the electron discharge device. Either the anode or the cathode of the tube may be connected to the utilization circuit, such as the scanning voltage generators.

For a better understanding of the invention, together with other and further objects thereof, reference is had to the following description, taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the accompanying drawing, the single figure is a circuit diagram of that portion of a superheterodyne television receiver which embodies the present invention.

Referring now to the drawing, there is shown an intermediate frequency amplifier 1 which comprises a source of carrier wave which is modulated in amplitude by a composite television signal, including the video and synchronizing signal components. The output of the intermediate frequency amplifier is connected to a coil 2. A second coil 3 is inductively coupled to the coil 2. The coupling between the coils 2 and 3 preferably is of such a character that there is passed a relatively wide band of frequencies of the order of 4 megacycles, for example. The coil 3 is connected to video detecting and amplifying apparatus 4. This apparatus is shown schematically

in the drawing for the reason that it does not form any part of the present invention and may comprise conventional apparatus of this type. The video detecting and amplifier apparatus is coupled to the appropriate electrodes of a cathode ray or other suitable reproducing device by means of which the light and shade values of the picture to be reproduced are controlled.

There also is provided a third coil 5 which is inductively coupled to the coil 2 in such a manner that a relatively narrow band of frequencies of the order of 1 megacycle is passed. The employment of relatively narrow band coupling enables the development in the coil 5 of the composite television signal at a substantial level. At the same time the band is sufficiently wide to develop the synchronizing signals in the coil 5 with enough fidelity of wave shape to secure satisfactory synchronization. A condenser 6 is connected in parallel with the coil 5 to provide a resonant circuit which may be tuned either slightly above or below the carrier frequency, depending upon the particular side band employed. It is assumed that single side band transmission of the television signal is employed in accordance with the standards at present set by the Federal Communications Commission. Hence, when operating under such standards, this circuit is tuned slightly above the carrier frequency since the upper side band is used.

The signal separator comprising the subject matter of the instant invention includes an electron space discharge device which may be a three-element vacuum tube 7. The resonant coupling network comprising the coil 5 and the condenser 6 is connected between the control grid of the tube 7 and ground. The cathode of the tube is connected to ground by means of an impedance device such as a resistor 8. The resistor 8 is shunted by a parallel network of a coil 9 and a condenser 11. The shunting network is sharply tuned for resonance at the frequency of the carrier wave. The anode of the tube 7 is connected to the cathode by a feed-back impedance device such as a resistor 12. Space current for the tube 7 is derived from a suitable source such as a battery 13. The circuit from the battery to the anode of the tube, by means of which the space current is supplied, includes the series connection of a resonant network comprising the parallel arrangement of a coil 14 and a condenser 15. This resonant network also is tuned to the carrier wave frequency. The battery 13 is by-passed by a condenser 16 which has a relatively low impedance at the carrier wave frequency.

As illustrated, the anode of the tube 7 is connected to a utilization circuit such as the scanning voltage generators. In this case the signals impressed upon the generators are of negative polarity. If it is desired to employ signals of positive polarity for impression upon the scanning voltage generators, the output circuit may be derived by means of a connection to the cathode of the tube as is well known in the art.

Referring now to the operation of the apparatus embodying the invention, consideration will be given only to the positive half cycles of the carrier wave, it being assumed that the negative half cycles will carry the input circuit of the tube 7 beyond the point of space current cutoff and so will not be reproduced in the output circuit. The average of the instantaneous values of the positive half cycles of a carrier wave modulated in amplitude by a composite television signal is a voltage which lies in the range of the video signal voltages and has a value which is less by only a small amount than the voltage representative of picture black. This average voltage will be called the datum potential and it will be assumed that it is the grid voltage at which cutoff of space current in the tube is effected. Thus, it is seen that for the major portion of the video signal component, even the peak values of the positive half cycles of the carrier wave are negative relative to the datum potential. For the remainder of the composite signal, including the synchronizing signal component, some portion of the positive half cycles of the carrier wave are positive relative to the datum potential. During these latter intervals there is effected an intermittent space current flow through the tube having instantaneous amplitudes corresponding to the instantaneous magnitudes of the carrier wave. As the potential of the control grid of the tube is increased in a positive sense relative to the datum potential, the space current conducted by the tube tends to increase.

This current traverses the resistor 8 and also the cathode connected resonant network comprising the coil 9 and the condenser 11. Inasmuch as this network is tuned to the frequency of the carrier wave and it is at this frequency that the current flow is effected, the network presents a maximum impedance to the current flow. Consequently, there is developed at the carrier wave frequency in the cathode connected network a voltage of considerable magnitude. Thus, by reason of the impedance represented in the cathode circuit, as the space current in the tube increases, the potential of the tube cathode tends to increase in a positive sense relative to the datum potential. Considering the effect of this circuit alone it is seen that it is a degenerative one.

However, at the same time, the flow of space current in the tube, in transversing the resonant network connected to the tube anode, also effects a voltage drop in this network. In this manner, as the space current increases, the voltage of the tube anode is decreased so that it is less positive with respect to the datum potential. A predetermined portion of the anode voltage is impressed upon the cathode by means of the resistor 12. It is seen, therefore, that considering the anode voltage fluctuations alone, the impression thereof upon the cathode tends to depress the cathode voltage relative to that of the control grid. The connection of the resistor 12, therefore, produces a regenerative effect upon the tube operation.

By suitable selection of the impedance values of the cathode and anode circuits, the ranges of variation of the degenerative and regenerative voltages impressed upon the cathode by means of these circuits may be made substantially different. For example, when using a tube of the 6J6 type and a battery 13 having a voltage of approximately 300 volts, satisfactory operation has been secured when, at the carrier wave frequency, the impedance of the cathode circuit is a few thousand ohms and the impedance of the anode circuit is approximately twenty-five times that of the cathode circuit. The proportion of the anode voltage which is fed back to the cathode may be suitably adjusted when the resistor 12 has an impedance of the order of 100,000 ohms.

The connection of the resistor 8 and the resonant network comprising the coil 9 and the condenser 11 to the cathode of the tube in series

with the space discharge path thereof enables the cathode voltage to be varied. In this manner there may be effected the desired non-linear operation of the tube 7, whereby it is made to discriminate between the two components of the composite television signal on the basis of their respective amplitudes. The fact that this cathode circuit has a degenerative effect upon the tube operation, and thereby exerts an influence which is the opposite of that desired, may be overcome by making the regenerative effects of the feed-back circuit including the resistor 12 predominately greater. This result is obtained by a circuit having the parameters described. Inasmuch as the regenative effect of the feed-back circuit including the resistor 12 is greater than the degenerative effect of the cathode circuit, with the two effects subject to variation through different ranges, it is seen that, as the signal impressed upon the control grid increases in amplitude to increase the conduction of space current in the tube, the net result of the degenerative and regenerative circuits is to depress the cathode potential. This, of course, still further increases the voltage of the control grid with respect to the cathode and, thereby, tends to increase still further the conduction of space current in the tube. Conversely, as the signal voltage which is impressed upon the control grid decreases in a positive sense or in other words, increases in a negative sense, the space current tends to be decreased, which causes an increase in the positive anode voltage which, when fed back to the cathode of the tube increases in a positive sense the potential of the cathode. The result is that the control grid-to-cathode voltage is decreased even further.

By a suitable selection of circuit components such as those indicated, the impression of a signal voltage upon the control grid of the tube 7 having a value representing picture black may be made to produce, by reason of the described feed-back circuit arrangements, an effective grid-to-cathode voltage which will completely cut off space current in the tube. Obviously, when the signal voltage impressed upon the control grid becomes more negative to represent the video signal component, the tube 7 will remain in a non-conducting state so that the video signal component will not be reproduced in the output circuit of the tube. Similarly, when the signal is more positive to represent the synchronizing signal component, the tube will conduct and the synchronizing signal component will be reproduced in the output circuit.

It also is seen that, by reason of the direct current coupling between the output and input circuits of the tube provided by the resistor 12, a portion of the positive potential of the battery 13 appears as a steady direct current voltage at the cathode. The effect of this arrangement is to shift the average bias of the tube further toward the point of space current cutoff.

As a result there is developed in the output circuit of the apparatus a series of time-spaced bursts of carrier wave. The envelope of these bursts represents the synchronizing signal component of the composite signal. These carrier wave bursts may be employed without detection or demodulation for the control of many types of scanning voltage generators. If, however, it is desired to derive the elementary synchronizing signals without the serrations of the carrier wave, a simple filter may be connected in a conventional manner in series with the output circuit to remove the ripple caused by the carrier wave. No additional amplification is necessary for the reason that the described apparatus over-emphasizes the amplification of the synchronizing signals by its non-linear mode of operation.

It is seen from the foregoing description of an illustrative embodiment of the invention that there is provided a single three-element tube which is capable of functioning independently of signal strength and/or the direct current signal level to simultaneously separate the video and synchronizing signal components of a composite television signal and to amplify the synchronizing signal component non-linearly without having first to demodulate the carrier wave upon which the composite signal is amplitude modulated.

While there has been described what, at present, is considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. Apparatus for recovering the synchronizing signal component from a carrier wave modulated in amplitude by a composite television signal comprising, an electron discharge device having an anode, a cathode and a control grid, an input circuit for said device including said control grid and said cathode, an output circuit for said device including said anode and said cathode, means for impressing said modulated carrier wave upon said input circuit, means including a regenerative feed-back circuit connected between said input and output circuits for effecting an amplitude discrimination by said device in said output circuit, and means including a circuit having a maximum impedance at the frequency of said carrier wave for supplying space current to said electron discharge device.

2. Apparatus for recovering the synchronizing signal component from a carrier wave modulated in amplitude by a composite television signal comprising, an electron discharge device having an anode, a cathode and a control grid, means for impressing said modulated carrier wave upon said control grid, an external circuit having a maximum impedance at the frequency of said carrier wave connected between said anode and said cathode, and means including a conductive circuit coupling said anode and said cathode for varying under the control of said carrier wave the voltage of said cathode oppositely in polarity to the voltage variations of said control grid.

3. Apparatus for recovering the synchronizing signal component from a carrier wave modulated in amplitude by a composite television signal comprising, an electron discharge device having an anode, a cathode and a control grid, means for impressing said modulated carrier wave upon said control grid, means including a conductive impedance device connected between said anode and said cathode for varying under the control of said carrier wave the voltage of said cathode oppositely in polarity to the voltage variations of said control grid, and means including a circuit having a maximum impedance at the frequency of said carrier wave connected in parallel with said impedance device for supplying space current to said electron discharge device.

4. Apparatus for recovering the synchronizing

signal component from a carrier wave modulated in amplitude by a composite television signal comprising, a vacuum tube having an anode, a cathode and a control grid, means for impressing said modulated carrier wave upon said control grid, a first conductive impedance device connected to said cathode in series with the space discharge path of said tube, a first circuit having a maximum impedance at the frequency of said carrier wave connected in parallel with said first impedance device, a second conductive impedance device connected between said anode and said cathode, and means including a second circuit having a maximum impedance at the frequency of said carrier wave for supplying space current to said tube.

5. Apparatus for recovering the synchronizing signal component from a carrier wave modulated in amplitude by a composite television signal comprising a vacuum tube having an anode, a cathode and a control grid, means for impressing said carrier wave upon said control grid, a conductive impedance device connected to said cathode in series with the space discharge path of said tube, a first circuit tuned to the frequency of said carrier wave and connected in shunt with said cathode connected impedance device, a feed-back resistor connected between said anode and said cathode, and a second circuit tuned to the frequency of said carrier wave connected in shunt with said feed-back resistor.

6. Apparatus for recovering the synchronizing signal component from a carrier wave modulated in amplitude by a composite television signal comprising a vacuum tube having an anode, a cathode and a control grid, means for impressing said carrier wave upon said control grid, a resistor connected to said cathode in series with the space discharge path of said tube, a first network tuned to the frequency of said carrier wave and connected in shunt with said cathode connected resistor, a feed-back resistor connected between said anode and said cathode, a source of space current for said tube, and a second network tuned to the frequency of said carrier wave connected to said anode in shunt with said resistors.

7. Apparatus for recovering the synchronizing signal component from a carrier wave modulated in amplitude by a composite television signal comprising a vacuum tube having an anode, a cathode and a control grid, means for impressing said carrier wave upon said control grid, a resistor connected to said cathode in series with the space discharge path of said tube, a first resonant network tuned to the frequency of said carrier wave and connected in shunt with said cathode connected resistor, a feed-back resistor connected between said anode and said cathode, a source of space current for said tube, a second resonant network tuned to the frequency of said carrier wave connected to said anode in series with said source of space current and in shunt with said resistors, and a utilization circuit coupled to one of said resonant networks.

8. Apparatus for recovering the synchronizing signal component from a carrier wave modulated in amplitude by a composite television signal comprising a vacuum tube having an anode, a cathode and a control grid, means for impressing said carrier wave upon said control grid, a resistor connected to said cathode in series with the space discharge path of said tube, a first parallel resonant network tuned to the frequency of said carrier wave and connected in shunt with said cathode connected resistor, a feed-back resistor connected between said anode and said cathode, a source of space current for said tube, a second parallel resonant network tuned to the frequency of said carrier wave connected to said anode in series with said source of space current and in shunt with said resistors, and a utilization circuit coupled to said anode.

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