

Oct. 13, 1942.

H. E. RHEA

2,298,809

LOW FREQUENCY REINSERTING CIRCUIT

Filed May 27, 1939

4 Sheets-Sheet 1

FIG. 1.

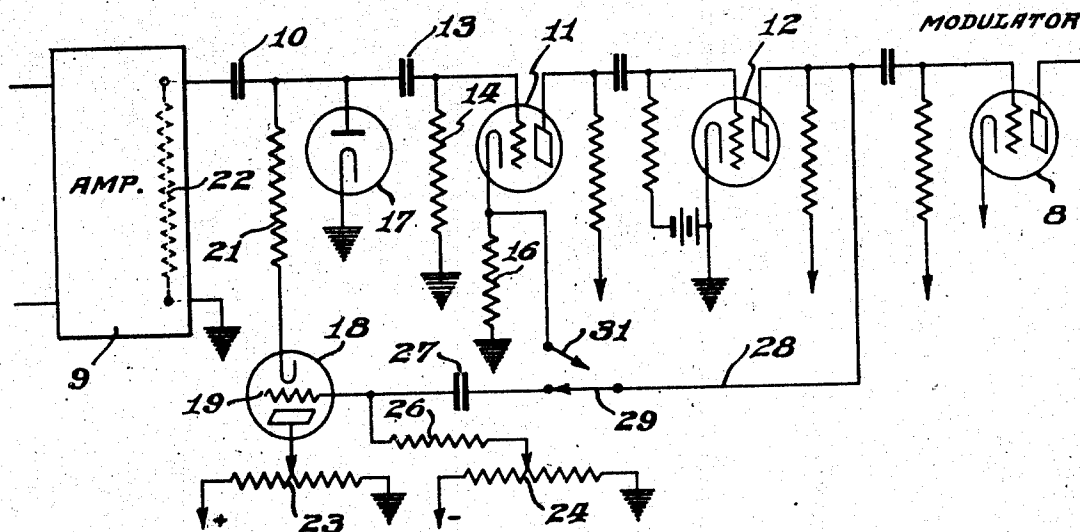


FIG. 2.

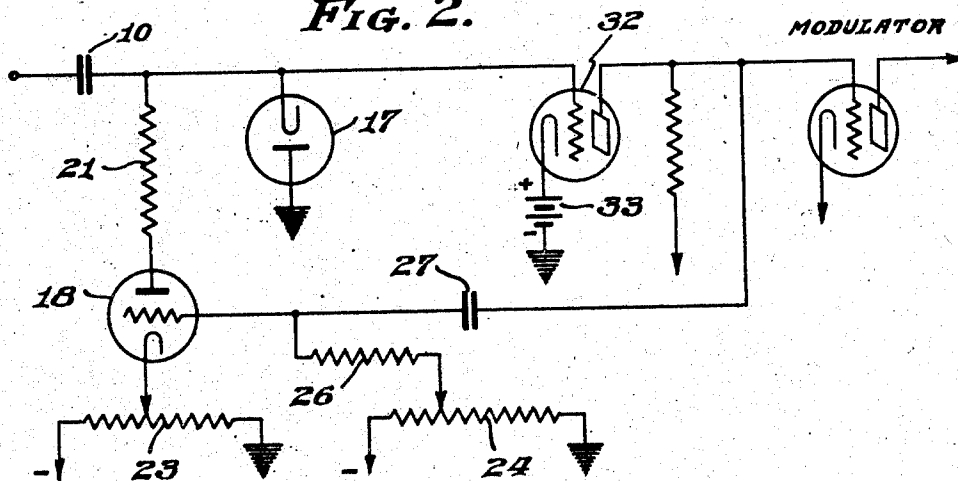
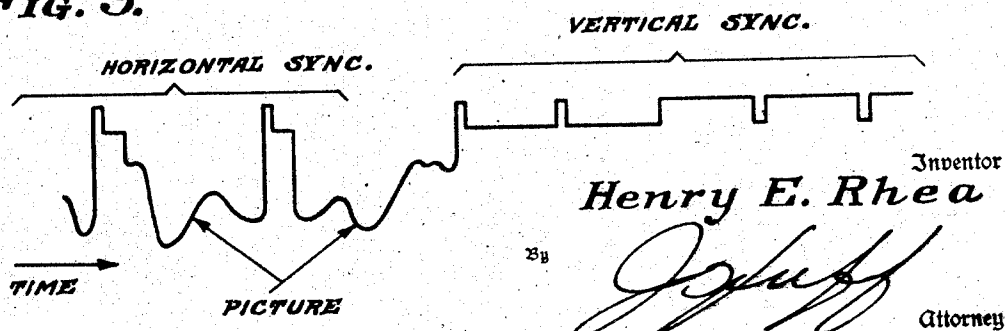


FIG. 3.



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FIG. 4.

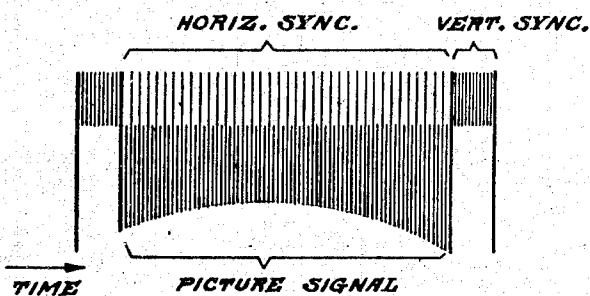


FIG. 5.

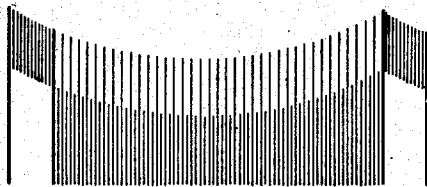
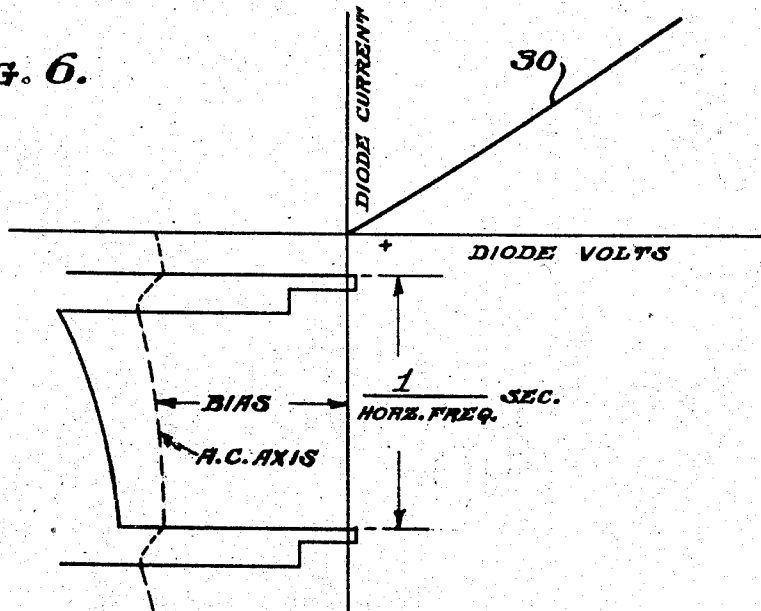


FIG. 6.



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FIG. 7.

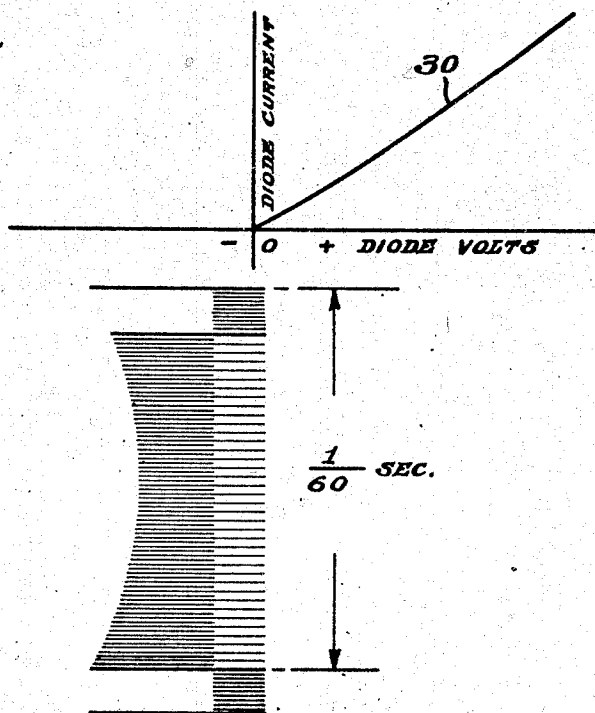
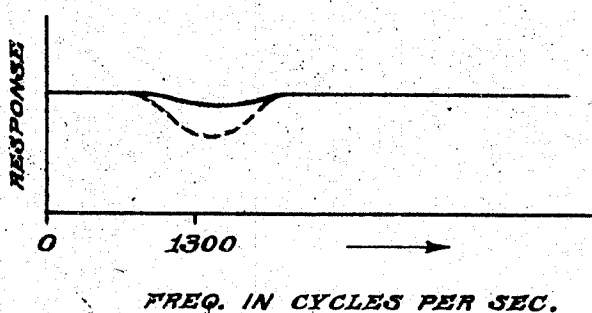


FIG. 8.



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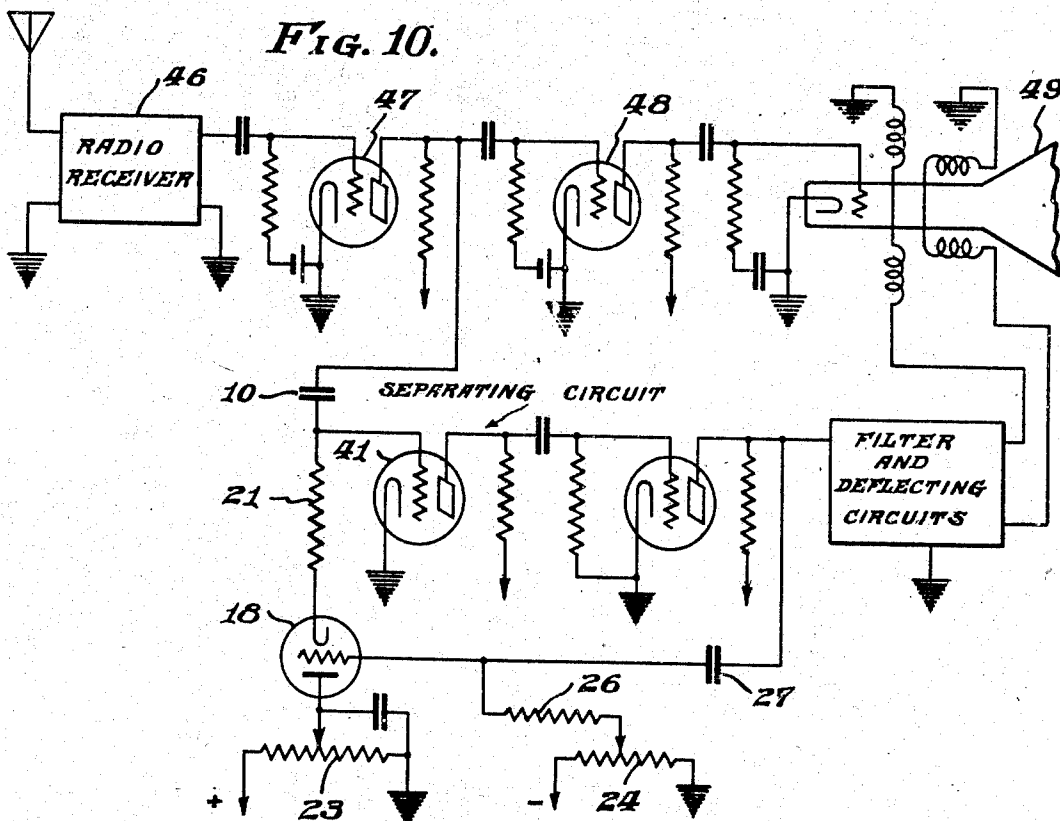
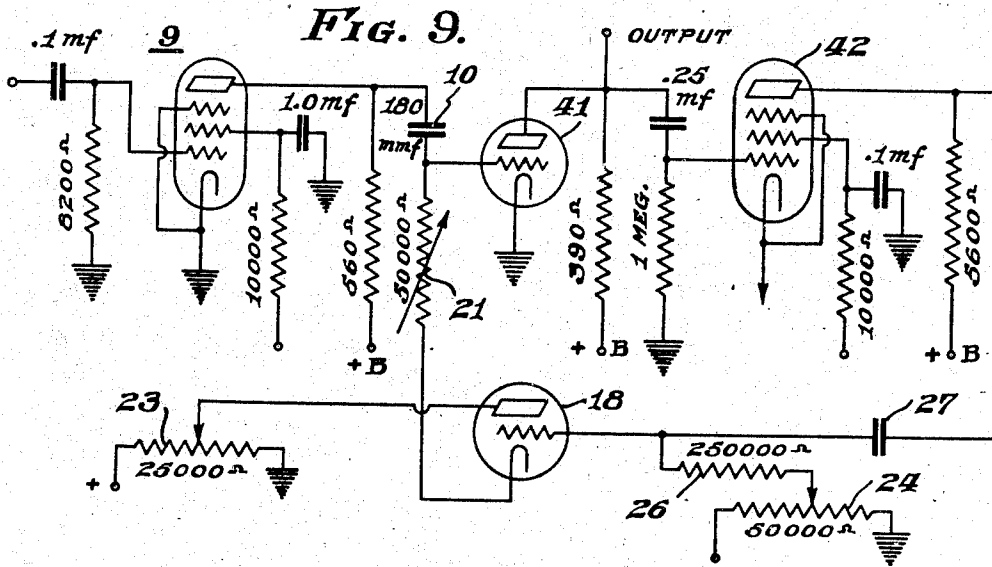
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## UNITED STATES PATENT OFFICE

2,298,809

## LOW FREQUENCY REINSERTING CIRCUIT

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Application May 27, 1939, Serial No. 276,082

6 Claims. (Cl. 178—7.3)

My invention relates to electrical circuits for reinserting low frequency and/or direct current components of a television signal or the like. More particularly, the invention relates to a circuit which may be employed to improve the low frequency response of an amplifier in either a television transmitter or a television receiver and which may also be employed to provide improved separation of synchronizing signals from picture signals.

It is well known that, in television systems of the type preferred at the present time, the direct current component and the low frequency components of a signal may be lost in an alternating current amplifier and reinserted at a later point in the system by utilizing the synchronizing impulses to operate the reinserting circuit. In such circuits, the synchronizing impulses have been made to go to a definite level, such as "black" in a picture before the above-mentioned alternating current amplifier has removed the direct current component. Such systems of the prior art are disclosed in Williams Patent 2,252,746, issued Aug. 19, 1941.

In systems of the above-mentioned character, it has been found that, at or in the origin of the line frequency or horizontal synchronizing frequency, there is a dip in the frequency response characteristic of the amplifier. From one viewpoint, it would appear that, with the designs formerly employed, any attempt to make the low frequency inserting circuit operate to reinsert frequencies extending farther toward the high frequency end of the amplifier range resulted in making the amplifier, considering it operating independent of the reinserting circuit, have a low frequency cut-off at a higher frequency than formerly. Thus, there appeared to be two conflicting requirements in the design of an amplifier of this type.

Referring to another aspect of the invention, it has become the usual practice in a television receiver to remove the picture signal from the synchronizing impulses before they are impressed upon the deflecting circuits. A separating circuit commonly employed for this purpose is the one described in Tolson Patent 2,207,839, issued July 16, 1940. While a separating circuit of this type is entirely satisfactory provided the low frequency content of the signal applied to the separating circuit is the same as in the original signal, it has been found that the presence of too much or too little of the low frequency components and that the presence of phase shift in the low frequency components may cause the

operation of the separating circuit to be unsatisfactory.

Accordingly, an object of my invention is to provide an improved method of and means for reinserting low frequency and/or direct current components in a television signal or the like. More specifically, one of the objects of my invention is to provide an amplifier to have a substantially flat frequency characteristic from zero frequency up to the highest frequency to be amplified.

A further object of my invention is to provide an improved separating circuit for separating picture signals from synchronizing impulses.

In the preferred embodiment of my invention, I impress the synchronizing impulses of a television signal upon either a diode or a triode through a condenser which is charged as a result of the current flow produced by the synchronizing impulses. A discharging circuit is provided for this condenser which, instead of consisting of a fixed resistor as in the case of similar circuits formerly employed, includes a variable impedance device such as a vacuum tube which has its impedance lowered for the duration of each synchronizing impulse.

Thus, at the termination of a synchronizing impulse, the charged condenser can discharge either at a very slow rate only or not at all. As will be pointed out hereinafter, this substantially eliminates a line frequency saw-tooth component which ordinarily is present in a reinserting circuit of this general type. When a properly adjusted circuit is operated in this manner, the dip in the frequency response curve formerly present is greatly reduced and, for all practical purposes, may be considered eliminated.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which—

Figures 1 and 2 are circuit diagrams of different embodiments of my invention for reinserting low frequency and/or D.-C. components;

Figure 3 is a curve showing the type of television signal which may be utilized in connection with my invention;

Figures 4 and 5 are curves or diagrams illustrating the effect of low frequency components on the television signal;

Figures 6 and 7 are diagrams which are referred to in explaining the invention;

Figure 8 is a frequency response curve of my improved amplifier;

Figure 9 is a circuit diagram of another em-

bodiment of my invention for reinserting low frequency and/or D.-C. components; and

Figure 10 is a circuit diagram showing my invention as applied to a separating circuit for removing picture signal from synchronizing impulses.

Referring to Fig. 1, I have shown my invention as it may be applied either to a television transmitter or a television receiver. It will be assumed, for the purpose of explanation, that it is located in a transmitter where its output is supplied directly to the transmitter modulator tube 8. The input signal which is fed through the condenser 10 may be a signal such as that shown in Fig. 3, which has passed through amplifiers indicated at 9 designed to have good gain and stability at the expense of their low frequency response. The particular circuit illustrated includes two amplifier tubes 11 and 12 which may be triodes, as illustrated, or screen grid tubes, such as those of the pentode type. The amplifier tubes 11 and 12 are resistance-coupled in the conventional manner, the tube 11 having in its input circuit the usual coupling condenser 13 and grid leak resistor 14. For the purpose of showing a variation of the circuit connections, a cathode resistor 16 is shown connected between the cathode of tube 11 and ground.

Referring to the low frequency inserting portion of the circuit, the diode 17 may be employed with its anode connected to one terminal of the condenser 10 and its cathode connected to ground, whereby a synchronizing impulse of positive polarity appearing at the input terminal will cause a flow of diode current into the condenser 10 to give it an additional charge. This is assuming, of course, that the relation of the synchronizing impulse amplitude and the charge of the condenser 10 is such that the synchronizing impulse can cause a further charge of the condenser. As will appear later, the relation may be such that the condenser 10 will discharge through its discharging circuit instead of receiving a charge.

The discharging circuit includes a variable impedance device which preferably is a vacuum tube 18 having a control grid 19. It is found in practice that it usually is preferable to include in series with the vacuum tube 18 a resistor 21. Its use is optional, however, and would serve no useful purpose if the tube 18 had suitable characteristics.

The tube 18 is connected in the discharging circuit in the proper direction so that the condenser 10, assuming that the tube 18 is not blocked by a high negative potential on its grid 19, can discharge through the resistance of the preceding amplifier circuit indicated at 22 and through the tube 18 and the resistor 21.

It generally will be found desirable to make the anode of the tube 18 positive a certain amount with respect to ground by means of a voltage divider 23 or the like, although, as will appear later, in some cases this anode may be connected directly to ground.

The tube 18 is normally biased beyond cut-off, a suitable negative voltage being applied to the grid 19 from a voltage divider 24 through a grid leak resistor 26. This tube is made conducting periodically by applying synchronizing impulses of positive polarity to the grid 19 through a coupling condenser 27. These synchronizing impulses may be obtained from the output circuit of the amplifier tube 12 and supplied through a conductor 28 and a switch 29 or, if preferred, they may be taken from across the cathode resistor 25

16 and supplied to the switch 31 with the switch 29 open. The latter method of obtaining synchronizing impulses to impress upon the grid 19 may be preferred if the particular transmitter design makes it desirable to omit the amplifier 12.

The operation of the circuit of Fig. 1 will now be described in connection with Figs. 4 to 7. Referring to Fig. 4, there is represented the television signal which occurs during a period of slightly more than one vertical deflection, where the signal includes a 60-cycle component, as indicated. This component may be one that has been introduced by the picture shading. It will be noted that the composite signal consists of picture signal, line frequency or horizontal synchronizing impulses and the vertical synchronizing impulses, as indicated by the legends. In Fig. 5, this same signal is shown after it has passed through the amplifier indicated in Fig. 1, which has removed the 60-cycle component. Obviously, the 60-cycle component will be reinserted if the synchronizing impulses are pulled up to the original horizontal level. In this respect, my improved circuit functions substantially the same as similar systems of prior art.

This action is indicated in Figs. 6 and 7, Fig. 7 indicating the action over one complete vertical deflection. In these figures, the diode characteristic is shown at 30. The operation is indicated somewhat more clearly in Fig. 6, where the A.-C. axis of the signal and the amount of bias produced by the reinserting circuit are indicated. It will be understood that, if the height of an impulse with respect to the A.-C. axis increases, the charging current for the condenser 10 through the diode 17 increases, whereby the bias or voltage from the diode to ground increases slightly. If the height of the synchronizing impulse with respect to the A.-C. axis decreases, a reverse action takes place, the condenser 10 discharging somewhat, whereby the next occurring impulse of lower amplitude may cause a flow of charging current through the diode.

The above general statement of the circuit operation is true for the operation of circuits previously employed, as well as for applicant's circuit. One of the main differences in operation, however, is that whereas, in the circuits previously employed, the condenser 10 discharged a certain amount between the occurrence of successive synchronizing impulses as indicated in Fig. 6, in applicant's circuit the condenser 10 discharges only a slight amount or not at all between successive synchronizing impulses. It will be apparent that this is true if it is remembered that the tube 18 is biased beyond cut-off and is conducting only for the duration of a synchronizing impulse. Therefore, my improved circuit has eliminated the line frequency sawtooth component with the result that, as indicated by the solid line curve in Fig. 8, the frequency response curve for the amplifier is substantially flat, rather than having a very substantial dip at or near the line frequency, as indicated by the dotted line.

It will be understood that, during the occurrence of a synchronizing impulse, the condenser 10 may either charge or discharge, depending upon whether the height of the synchronizing impulse with respect to the A.-C. axis has increased or decreased. If the height has decreased, the voltage as represented by the height of the impulse will not be sufficient to drive the anode of the diode 17 positive to charge the condenser 10 and, at the same time, if the

voltage across the condenser 10 is larger than the synchronizing impulse voltage, the condenser will discharge a certain amount through its discharging circuit 22, 18, 21, since the tube 18 is conducting at this time. It will be understood that 22 represents the output or plate circuit resistance of the amplifier tube preceding the diode 17.

In the example illustrated in Fig. 1, it is assumed that the amplifier 11, 12 is designed to pass much lower frequency components than is the preceding amplifier 9. Obviously, if it is desired to modulate with the D.-C. component in addition to the lower frequency components, the amplifier 11, 12 may be designed as a D.-C. amplifier, the coupling condenser 13 and the other coupling condenser between tubes 11 and 12 being omitted in such a redesign.

In Fig. 2 there is illustrated another embodiment of my invention which, in operation, is substantially the same as that shown in Fig. 1. However, it is designed to operate with negative synchronizing impulses applied to its input instead of positive impulses, as in the case of Fig. 1, and it is also designed to reinsert the D.-C. component, as well as the low frequency components. In the two figures, like parts are indicated with the same reference numerals. It will be noted that Fig. 2 differs mainly from Fig. 1 in that the connections of the diode electrodes have been reversed, the same being true of the tube 18. The other difference is that the amplifier tube 32 has a biasing battery 33 provided between its cathode and ground to provide suitable bias to the grid of the tube 32 through the D.-C. connection.

It will be understood that the output lead of the amplifier shown in Fig. 2 may be applied to the grid of a modulator tube, as indicated, or, where the reinserting circuit is employed in a television transmitter, this output lead may connect to the control electrode of the cathode ray tube. With the latter connection, the circuit functions to provide automatic background control for the receiver.

In Fig. 9, there is shown a low frequency and a D.-C. reinserting circuit which, except for slight differences in design, is the same as the circuit shown in Fig. 1. In Figs. 1 and 9, like parts are indicated by the same reference numerals. One of the changes in design is that, in place of a diode, there is employed a triode 41 in which the grid and cathode elements perform the function of the diode in the preceding circuit. It will be noted that the triode 41 of Fig. 9 takes the place of the diode 17 and the amplifier tube 11 in Fig. 1. Also, it will be noted that the reinserted D.-C. component is present at the plate of the triode 41, whereby the signal may be taken off at this point and supplied directly to the grid of the modulator tube; to the grid of the cathode ray tube, if the invention is being applied to a receiver; or to any other point in a circuit where the presence of the low frequency components or of the D.-C. component is desired. The amplifier tube 42 corresponds to the tube 12 of Fig. 1.

In Fig. 9, an amplifier stage corresponding to the last stage of the amplifier 9 indicated in Fig. 1 has been illustrated and the constants of the various circuit elements of this amplifier stage and of the rest of the circuit have been indicated on the drawings, by way of example, in ohms, microfarads, and micromicrofarads. These values were used where the horizontal and verti-

cal deflecting frequencies were 13,230 per second and 60 per second, respectively. Also, the tube type numbers have been indicated, by way of example. It will be understood, of course, that these circuit constants may be varied over a wide range. In particular, the value of the resistor 21 is not critical. It may be omitted entirely although it was found that under some operating conditions a value of from 50,000 ohms to 200,000 ohms seemed to make the circuit more stable. However, one point is to be noted with respect to the circuit constants, and that is that the series condenser 10 in the reinserting circuit has very small capacity, whereby its charging time constant is very fast.

Considering now the use of my invention in a separating circuit, this use is illustrated in Fig. 10. Referring to Fig. 10, there is illustrated a television receiver comprising a suitable radio receiver portion 46 which supplies to the amplifier tubes 47 and 48 and the cathode ray tube 49 the demodulated video signal of the type shown in Fig. 3, for example. This signal is also supplied from the output circuit of the amplifier tube 47 where the synchronizing impulses are of positive polarity to the separating circuit, which is the same as the low frequency reinserting circuit shown in Fig. 9. In the two figures, like parts are indicated by like reference numerals. In this circuit, the first tube 41 functions as the separator tube and it separates out the picture signal rather than passing it, as in the case of the circuits previously described, because the amplitude of the video signal at its grid is made so high that only the synchronizing impulses can pass through the tube 41, the picture signals being beyond the cut-off point of the tube. This result may be accomplished either by merely providing sufficient amplification ahead of the separator tube 41 or by applying a very low voltage to the plate of the separator tube 41 as compared with the rated plate voltage of the tube. In practice, of course, both additional amplification and lowering of the separator plate voltage may be utilized for obtaining good separation.

I claim as my invention:

1. In a circuit for reinserting lost frequency components of a composite signal comprising picture signal and regularly recurring control impulses of greater amplitude than the picture signals of like polarity, the combination of a condenser and rectifier means connected in series to form a charging circuit for said condenser, means for charging said condenser through said charging circuit in accordance with the height of said impulses as measured from the alternating current axis of said composite signal, a discharging circuit for said condenser, said discharging circuit including an electric discharge tube, and means for so applying said control impulses to said tube that the impedance thereof is lowered for the duration of said impulses.

2. In a circuit for reinserting lost frequency components of a composite signal comprising picture signal and regularly recurring control impulses of greater amplitude than the picture signals of like polarity, the peaks of said control impulses having been brought to a fixed predetermined level before said components were lost, the combination of a condenser and rectifier means connected to form a charging circuit for said condenser, means for so applying said composite signal to said charging circuit that said condenser may receive a charge in

accordance with the height of said control impulses as measured from the alternating current axis of said composite signal, a discharging circuit for said condenser, said discharging circuit including an electric discharge tube, and means for so applying said control impulses to said tube that the impedance thereof is lowered for substantially only the duration of said control impulses.

3. The invention according to claim 2 characterized in that the electric discharge tube through which said condenser may discharge has a control electrode which is driven more positive periodically by the application of said control pulse thereto.

4. In a circuit for reinserting lost frequency components of a composite signal comprising picture signal and regularly recurring control impulses of greater amplitude than the picture signals of like polarity, the combination of an amplifier tube having a control grid and a cathode, a condenser connected in series with the grid-cathode circuit of said tube, means for applying said composite signal across said series circuit with the control impulses of positive polarity at said control grid whereby said condenser may receive a charge through said grid-cathode circuit, and a discharging circuit for said condenser comprising a variable impedance device, and means for lowering the impedance of said device periodically in response to the application of said control impulses thereto.

5. In a circuit for reinserting lost frequency components of a composite signal comprising picture signal and regularly recurring control impulses of greater amplitude than the picture signals of like polarity, the combination of an amplifier tube having a control grid and a cath-

ode, a condenser connected in series with the grid-cathode circuit of said tube, means for applying said composite signal across said series circuit, a rectifier connected in series with said condenser with respect to the source of said composite signal, said rectifier being connected in such direction that the applied control impulses may cause said condenser to receive a charge, a discharging circuit for said condenser which circuit has a high impedance between the occurrence of said control impulses, said discharging circuit including an electric discharge tube, and means for applying said control impulses to said tube to reduce the impedance of said discharging circuit periodically to a comparatively low value at substantially the time of occurrence of said control impulses.

6. In a television receiver of the type having a picture signal channel and a separating circuit channel, the combination of a condenser in said separating circuit channel, means for charging said condenser in accordance with the height of synchronizing signals as measured from the alternating current axis of a composite signal containing them and for applying the voltage resulting from said charge to the control grid of a separating tube in said separating circuit, a discharging circuit for said condenser comprising a variable impedance device, means for lowering the impedance of said device periodically in response to the application of said synchronizing impulses thereto, and means for applying said composite signal to said separating tube with the proper amplitude and polarity to cause substantially only the synchronizing impulses to appear in the output circuit.

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