Fig. 1.

Fig. 2.

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DIRECT CURRENT REINSERTING CIRCUIT

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My invention relates to the reinsertion of direct current and/or low frequency components of electrical signals, and particularly to the reinsertion of such components in a television system.

Various circuits have been proposed for the reinsertion of the above-mentioned components where the components have been suppressed during transmission, as, for example, where they are suppressed by transformers or by alternating current amplifiers. These circuits depend for their operation upon the transmission of periodically recurring control pulses which are caused to go to a fixed voltage level, such as “black,” in a picture, or a few volts beyond “black” before the said components have been suppressed. In television systems, these recurring pulses usually are the synchronizing pulses. A D.C. reinsertion circuit of this character is described and claimed in an application of Ralph S. Holmes, Serial No. 658,894, filed February 28, 1933, for “Television systems.”

Among the various proposed circuits are the so-called “keyed” circuits of the general type described in Brown, et al., Patent No. 2,190,753, issued February 20, 1940, and in the application of Henry R. Rice, Serial No. 295,270, filed May 27, 1939. In the circuits as described in the aforesaid patent and application, there is included a triode which is made conducting periodically (that is, it is “keyed”) by means of synchronizing pulses or the like to change the charge on a condenser in the grid circuit of the vacuum tube which is to have the reinserted D.C. in its output.

It is an object of my invention to provide improved direct current and/or low frequency component reinserting or correcting apparatus and, especially, to provide improved reinserting apparatus of the “keyed” type.

A further object of my invention is to provide an improved D.C. reinserting circuit which is both simple in design and effective in operation.

A further object of the invention is to provide an improved and simplified signal correction circuit of the type in which a condenser in the circuit is “keyed” for both charge and discharge.

A still further object of the invention is to provide an improved signal correction circuit of the keyed type in which the keying pulses are balanced out and prevented from mixing with the signal.

A still further object of the invention is to provide an improved signal correction circuit in which any sawtooth waves that may be produced in the keying circuit are balanced out.

Still another object of the invention is to provide an improved method of and means for obtaining a level setting voltage in keyed signal correction circuits.

In practicing a preferred embodiment of the invention, the charge of a condenser in the grid circuit of a vacuum tube is controlled by means of two diodes which are keyed by periodically recurring pulses, such as synchronizing pulses. Upon the occurrence of a synchronizing or keying pulse, one of the diodes is rendered conducting and the condenser will discharge therethrough a certain amount if its charge should be reduced to provide the correct D.C. reinsertion, or it will charge a certain amount through the other diode if its charge should be increased. Between keying pulses, both diodes are held nonconducting by means of a biasing voltage. Since both diodes are biased in this way, the reinserting circuit may be operated with an applied signal of either polarity. Preferably the diodes are provided with a level setting voltage which is produced automatically by the keying circuit.

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

Figure 1 is a circuit diagram showing one embodiment of my invention applied to television apparatus,

Figure 2 is a circuit diagram of another embodiment of my invention,

Figure 3 is a group of curves which are referred to in explaining the operation of the circuits of Figures 1 and 2, and

Figure 4 is a group of curves which are referred to in explaining the operation of the circuits of Figures 1 and 3 for the case where the polarity of the signal is reversed as compared with the polarity indicated in Figure 1.

Referring to Figure 1, the invention is shown applied to a television system in which there is produced a composite signal consisting of picture signals, periodically recurring line synchronizing pulses and periodically recurring framing pulses. As previously described, the peaks of the synchronizing pulses have been made to go to a fixed voltage level such as a fixed number of volts beyond “black” in the picture before the direct current and low frequency have been suppressed.

This may be accomplished in various ways, as by varying the clipping level of a vacuum tube in the way described in Patent No. 2,192,121, issued February 27, 1940, in the name of Alda V. Bedford, or by utilizing a suitable mask with a scan.
ning disc so that the signal goes to "black" at the end of each scanning line. It should be under-
stood, however, that in some applications of the "double keyed" circuits such as described herein the control pulses may be described as "control periods" during which the signal goes to zero or to ground potential, for example.

If the coupling means 28 may consist of two re-

semble a conventional al-

ermating current amplifier 18 which has the complete signal applied thereto with such polar-

ity that it appears in the output circuit with the synchronizing pulses of positive polarity as indi-
cated at 11. The pulses 11 are line synchro-

nizing pulses in a "black" or "blackter than black" level or pedestal indicated at 12. Picture signal is shown at 13.

It is desired to reinsert at the control grid of the next amplifier tube 16 any direct current and/or low frequency components that have been lost by transmission of the signal through the preceding portion of the signal channel. Also, it is desired to correct for 60-cycle hum, or the like, that has become mixed with the signal.

Stated differently, it is desired to have the tube 16 supply an output signal in which the pulses of all the synchronizing pulses go to a fixed voltage level. If this is done, correction is made for signal components that have been lost (i.e., they are reinserted) and correction is also made for undesirable effects which may have been in-

roduced, such, for example, as 60-cycle hum. It may be preferred to key the circuit only during the pedestal in which case the pedestals are set at the fixed level setting voltage.

The amplifier tubes 14 and 15, which may be conventional tetrodes or pentodes, are coupled by a coupling condenser C which, as will be explained hereinafter, has a suitable capacity value to per-

mit, first, the necessary initial charging and, later, the necessary additional charging or dis-

charging in cooperation with the complete cir-
bruit for the desired correction or reinsertion of low components.

In place of the usual grid leak resistor for the tube 16, there is the reinserting circuit comprising a pair of diodes 21 and 22.

The cathode of diode 21 and the plate of diode 22 are connected together and both connected through a condenser 24 to the control grid of amplifier tube 16. The other electrodes of diodes 21 and 22 are connected together through a re-

istor 27. They are also connected through con-
densers 28 and 29 to a keying circuit comprising an amplifier tube 31.

The purpose of the keying circuit is to apply positive pulses to the plate of diode 21 and negative pulses to the cathode of diode 22 as indicated at 32 and 33, respectively, whereby both diodes are rendered conducting for the duration of these keying pulses. As explained hereinafter, this permits the coupling condenser C either to charge through the diode 22 an additional amount or to discharge through the diode 21 a certain amount in order that the control grid of tube 16 may be driven periodically to a fixed potential determined by the level setting voltage.

The keying pulses may be supplied over a con-
ductor 36, through clipping tubes indicated at 35, through switches 37 and 38, and through a cou-

pling condenser 39 to the grid of tube 31. The tube 31 may be properly biased by means of a battery 41 to function as an amplifier.

In order to obtain both positive and negative keying pulses, the amplifier tube 31 is provided with both a plate resistor R1 and a cathode re-

istor R2. Pulses of positive polarity are sup-
plied from resistor R1 to the coupling condenser 28 while pulses of negative polarity are supplied from resistor R2 to the coupling condenser 29.

Preferably, the resistors R1 and R2 are of equal resistance so that the keying circuit is balanced to prevent the keying pulses from appearing on the grid of the tube 16.

The coupling means 38 may consist of two re-

semble coupled amplifier tubes, at least one of which is so biased as to pass only the synchro-
nizing pulses 11, as is well understood in the art.

In the specific keying amplifier arrangement shown in Figure 1, diodes 21 and 22 are so connected that they are made conducting by a negative pulse on the grid of tube 31.

Preferably the amplitude of these negative key-
ging pulses 11 at the grid of tube 31 is sufficient to drive the tube 31 beyond cut-off, whereby, during the keying period, there is no plate cur-

ent flowing through the cathode resistor R2, and the cathode of tube 31 is driven to ground potential. Otherwise, if it happens that there is a large current flow through diode 22, the fact that there is plate current flow through resistor R2 during a keying pulse will result in an un-

balance of the circuit whereby the amplitude of the pulse applied to the diode 22 is decreased and the amplitude of the pulse applied to the diode 21 is increased. This is caused by coupling through resistor R2 when the cathode of tube 31 is not driven to the ground potential. If an incoming signal causes a large current flow through diode 22, the cathode of tube 31 will go more positive with respect to its grid, the tube 31 will be driven towards cut-off, and the amplitude of the keying pulses at the plate of tube 31 will be increased in amplitude. The result of such an unbalance is to make the level setting voltage incorrect and the circuit will be slow in coming back to the correct level setting value.

During a keying pulse, the conductor 26 (and, therefore, the grid of tube 16) is driven to the potential of the alternating current mid-point of the resistor 27. For the case where resistors R1 and R2 are equal, this A.C. mid-point is at the middle of resistor 27. It follows that the grid of tube 18 is driven to a potential with respect to ground determined by the potential of the said A.C. mid-point with respect to ground. This potential is the previously mentioned level setting voltage.

The preferred method of obtaining the level setting voltage is the one employed in the circuit of Figure 1 where a resistor 45 is connected between ground and a point on the resistor 27 through a variable tap 47. The level setting voltage is then the voltage between the A. C. mid-

point and the tap 47 as indicated by the legend, "Level setting," this voltage resulting from cur-

rent flow through the resistor 27 which is pro-

duced as follows:

Each keying pulse causes current to flow through the coupling condensers 28 and 29 and the diodes 21 and 22 through a circuit that may be traced from the plate of tube 31 through the condenser 28, the diodes 21 and 22 through the coupling condenser 39 to the cathode of tube 31. Thus the condensers 28 and 29 receive a charge. At the end of the keying pulse, the condensers 28 and 29 discharge a certain amount through a path including the resistor 21, whereby, between keying pulses, there is always a current flow-

ning through resistor 27. This discharge path may be traced from the condenser 29, through
the resistor 27, the condenser 28, the resistor R1, the plate supply battery of tube 31, and through resistor R4 back to the condenser 28.

The across-resistor voltage across resistor 46, since it is not located in any path which includes a rectifier. The A. C. current which flows through resistor 46 is small and has negligible effect on the circuit; there being no current flow whatever through this resistor if the tap 47 is moved to the left midpoint of the resistor.

From the foregoing, it will be apparent that, during each keying pulse, the grid of amplifier tube 16 is brought to a certain fixed negative potential with respect to ground, as illustrated in Figure 3, this potential being the level setting voltage appearing between the tap 47 and the A. C. midpoint on resistor 27.

It will be understood that, in the process of causing the grid of tube 16 to be brought to the level setting potential, the condenser C acquires a slight additional charge through diode 22 if the synchronizing pulses 11 have increased in amplitude with respect to the A. C. axis of the signal, and that condenser C discharges a small amount through diode 21 if the said amplitude of pulses 11 has decreased.

Before referring to other features of the circuit of Figures 1 and 2, reference will be made to Figure 1, wherein parts corresponding to those in Figure 1 are indicated by the same reference characters.

The circuits of Figures 1 and 2 are the same except that in Figure 2 the level setting voltage is obtained from a biasing source such as a battery 51. Battery 51 is connected between ground and the A. C. midpoint on resistor 27. In the case of a symmetrical circuit arrangement such as shown in Figure 1, the A. C. midpoint is at the middle of resistor 21 and the battery 51 is connected to this point. Except for the method of providing the level setting voltage, the operation of the circuit in Figures 1 and 2 is the same.

Figure 1 has been described for the case where the pulses 11 are of positive polarity at the grid of amplifier 16. At first glance, it might appear that these pulses would cause grid current flow in the tube 16 and render the level setting voltage ineffective for the time that condenser C is to acquire a charge. This cannot happen, however, because the level setting voltage is negative and the pulses 11 never drive the grid of tube 16 positive, this being illustrated in Figure 3.

It will be apparent from the foregoing description that the keying circuit may be so balanced that the keying pulses will not apply to the conductor 26 any A. C. potentials with respect to ground. Therefore, the keying pulses will not mix with the output of tube 16. Likewise, any saw-tooth wave that may be produced in the keying circuit will be balanced out. Such a saw-tooth wave may be produced by the action of the comparatively long duration framing pulses, which, like the line pulses, cause the condensers 28 and 29 to charge suddenly, after which they discharge slowly through the resistor 27. Any saw-tooth voltage that may be produced by the line pulses 11 is usually of such small amplitude as to be negligible even if not balanced out.

The fact that the keying pulses do not feed back to the grid of tube 16 is of importance in the circuit shown in Figure 1, for the additional reason that there is no tendency for the circuit to oscillate. This is assuming a perfect balance. If, in practice, there is a slight unbalance, it may be found desirable to include some resistance in the conductor 26 to stop any tendency to oscillate caused by the feedback through the conductor 38.

The keying pulses may be supplied from points other than the output circuit of amplifier 16. For example, the switch 33 may be connected to a conductor 32 leading from the input circuit of the amplifier 10. With this connection, however, it may be desirable to provide additional amplification just preceding the tube 31.

Or the keying pulses may be supplied over a conductor 33 from a separate source, such as the synchronizing pulse generator of the television transmitter, by connecting the switch 32 to the conductor 33.

In some applications of the invention, it is desirable to have the reinserting circuit keyed only during the occurrence of the pedestals 12. This may be accomplished by properly delaying the keying pulses, as by means of a delay circuit 34 which is shown included in the circuit leading from the above-mentioned pulse generator (not shown).

The circuits of Figures 1 and 2 may be employed regardless of the polarity of the signal applied to the grid of tube 16. If the synchronizing pulses 11 are of negative polarity at this point, the clipper circuit 35 should be designed so that negative keying pulses still are applied to the grid of tube 31.

Also, as will be seen from an inspection of Figure 4, the level setting voltage must now be increased in value. Whereas a small level setting voltage, such as one volt for example, was satisfactory before (see Figure 3), it is necessary to have a level setting voltage sufficient to prevent picture signal peaks from driving the grid of tube 16 positive. In other words, the level setting voltage should now be greater than the signal voltage measured from the level setting point (which is peak of pulses 11 in Figure 4) to the peak of the picture signal 13.

In the operation as illustrated in either Figure 3 or Figure 4, the bias on the grid of tube 16 is the D. C. voltage across condenser C minus the plate voltage on the tube 15.

It should be understood that, in place of the keying amplifier 31 having both plate and cathode outputs, the keying pulses of opposite polarity may be applied to the diodes 21 and 22 through separate amplifier channels having outputs of opposite polarity, or they may be applied in any other suitable manner. In any case, the circuit should be balanced if the full capabilities of the correction circuit are to be utilized.

I claim as my invention:

1. In a circuit for correction of a signal supplied from a certain source and having recurring control periods, the combination of an amplifier tube having a control grid and a cathode, a condenser connected in series with said source and said control grid, and a charging and discharging circuit for said condenser which comprises a pair of diodes so connected that said condenser may charge through one of them and discharge through the other when the diodes are conducting, and keying means for matching said diodes conducting during portions of said control periods, and nonconducting between said control periods, said keying means comprising a circuit for applying keying pulses of opposite polarity to said diodes.

2. The invention according to claim 1 wherein said last means comprises a balanced circuit whereby said keying pulses do not appear on said control grid.

3. In a circuit for correction of a signal sup-
4. A certain source and having recurring control periods, an element to which it is desired to apply a corrected signal, a condenser connected in series with said source and said element, a pair of diodes each having a cathode and a plate, a direct current connection from the cathode of one diode and the plate of the other diode to said element, a resistor connected between the other cathode and other plate of said diodes, means for providing keying pulses during said control periods, and means for applying said keying pulses to one end of said resistor with a certain polarity and for applying said keying pulses to the other end of said resistor with the opposite polarity.

5. In combination, an amplifier tube having a control grid and a cathode, a coupling condenser connected to said control grid, means for feeding said composite signal through said coupling condenser to said control grid, and a charging and discharging circuit for said condenser which comprises a pair of diodes so connected that said condenser may charge through one of said diodes and discharge through the other of said diodes when said diodes are made conducting, means for so biasing said diodes that said condenser cannot discharge therethrough during certain signal intervals, means for producing keying pulses of opposite polarity, and means for applying between said intervals keying pulses of one polarity to one of said diodes to render it conducting and for simultaneously applying keying pulses of the opposite polarity to the other of said diodes to render it conducting.

6. In a circuit for correction of a signal supplied from a certain source and having recurring control periods, an element to which it is desired to apply a corrected signal, a condenser connected in series with said source and said element, a pair of diodes each having a cathode and a plate, a direct current connection from the cathode of one diode and the plate of the other diode to said element, a resistor connected between the other cathode and other plate of said diodes, means for providing keying pulses during said control periods, keying circuit condensers, and means for applying said keying pulses through one of said keying circuit condensers to one end of said resistor with a certain polarity and for applying said keying pulses through the other of said keying circuit condensers to the other end of said resistor with the opposite polarity.

7. The invention according to claim 5 wherein there is a resistor connected between a point on said first resistor and ground.

8. In a circuit for correction of a composite signal supplied from a certain source and consisting of signals and recurring control pulses, the combination of an amplifier tube having a control grid and a cathode, a condenser connected in series with said source and said control grid, a charging and discharging circuit for said condenser which comprises a pair of diodes so connected that said condenser may charge through one of them and discharge through the other one when the diodes are conducting, and keying means for making said diodes conducting between said signal intervals and nonconducting during said intervals, said keying means comprising a balanced circuit for applying keying pulses of opposite polarity to said diodes.

9. In a circuit for correction of a composite signal consisting of signals and recurring control pulses, the combination of an amplifier tube having a control grid and a cathode, a coupling condenser connected to said control grid, means for feeding said composite signal through said coupling condenser to said control grid, and a charging and discharging circuit for said condenser which comprises a pair of diodes each having a plate and a cathode, the plate of one diode and the cathode of the other diode being connected to said control grid, the other plate and cathode of said diodes being connected to each other through a resistor, means for providing a point on said resistor at a certain potential with respect to ground, said potential being of such polarity that the diodes are nonconducting during the signal intervals, and means for applying keying pulses of opposite polarity to the ends of said resistor for making said diodes conducting between said signal intervals.

10. In a circuit for correction of a composite signal consisting of signals and recurring control pulses, said pulses having an amplitude at least as great as said signals of like polarity, the combination of an amplifier tube having a control grid and a cathode, a coupling condenser connected to said control grid, means for feeding said composite signal through said coupling condenser to said control grid, and a charging and discharging circuit for said condenser which comprises a pair of diodes each having a plate and a cathode, the plate of one diode and the cathode of the other diode being connected to said control grid, the other plate and cathode of said diodes being connected to each other through a resistor having an alternating current midpoint, a second resistor connected between ground and a point on said first resistor which point is removed from said midpoint whereby said midpoint is held at a certain potential with respect to ground, said potential being of such polarity that the diodes are nonconducting during the signal intervals, and means for applying keying pulses of opposite polarity to the ends of said resistor for making said diodes conducting between said signal intervals.

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