April 11, 1944. J. W. CONKLIN 2,346,557

DIRECT CURRENT RESTORING APPARATUS

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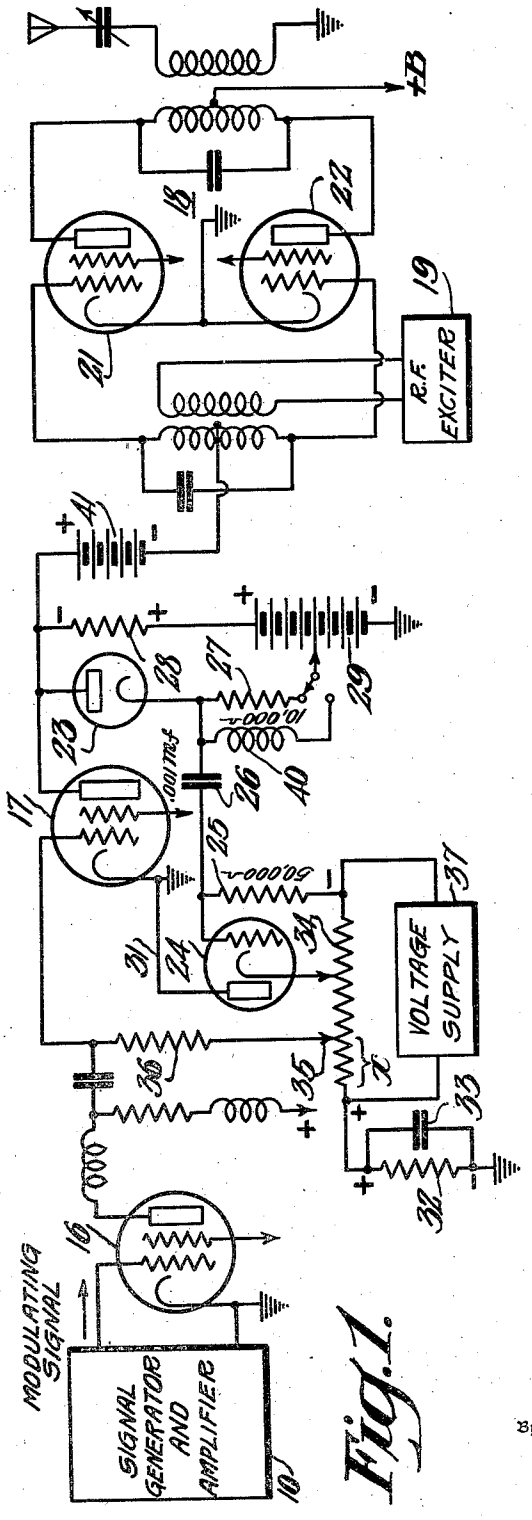


Fig. 1.

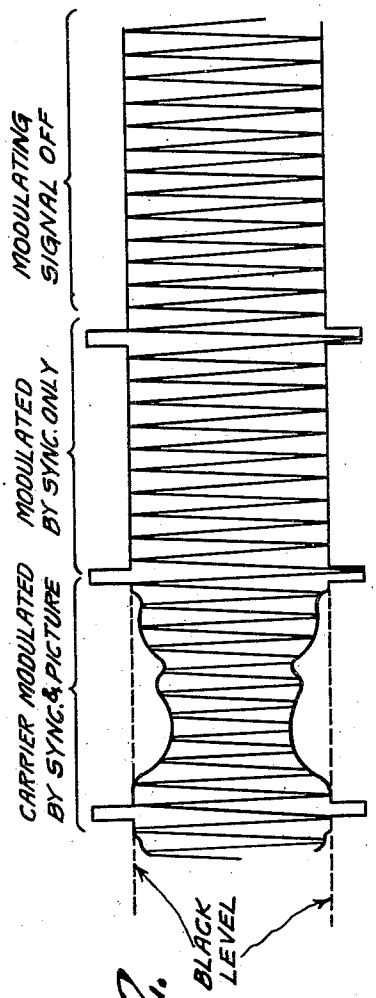


Fig. 2.

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Fig. 3.

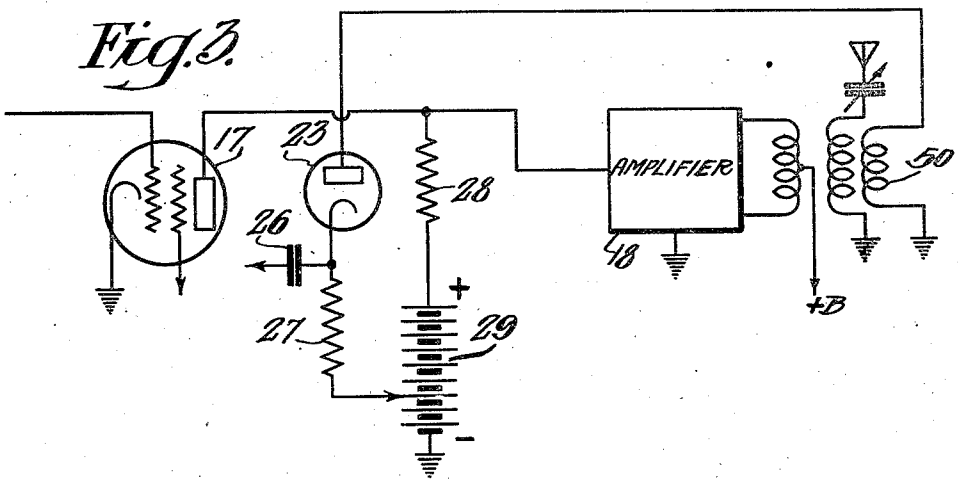
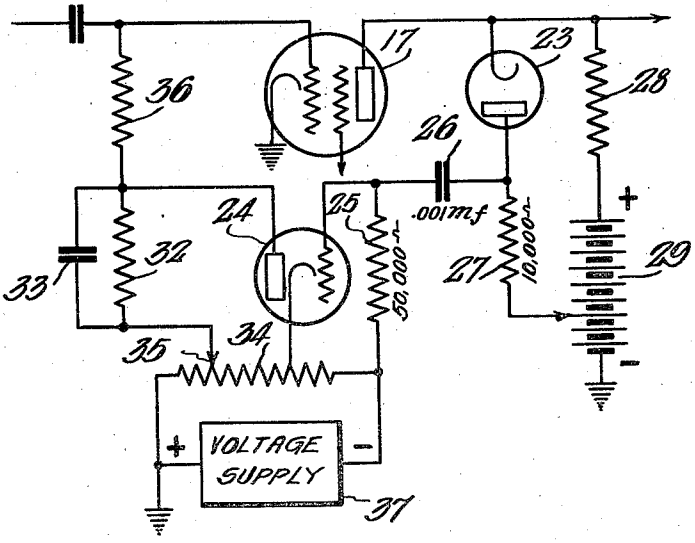


Fig. 4.



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DIRECT CURRENT RESTORING APPARATUS

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Application July 31, 1940, Serial No. 348,743

5 Claims. (Cl. 178—7.2)

My invention relates to circuits for reinserting or restoring the direct current component of a signal and, particularly, to such circuits as applied to television transmitters.

Various circuits have been proposed for reinserting the direct current component of a television signal by taking advantage of the fact that, after the D.-C. component is removed, the height of the synchronizing pulses as measured from the alternating current axis of the composite signal (picture signal plus synchronizing pulses) may be made to correspond to the missing D.-C. component. It has been found that in television transmitters, in particular, there are certain advantages in the use of the loop or feedback type of D.-C. inserting circuit disclosed in Patent 2,292,816, issued Aug. 11, 1942, in the name of A. V. Bedford, and assigned to the Radio Corporation of America. A circuit of this type is covered broadly in Vance Patent 2,124,044.

It is an object of my invention to provide an improved direct current reinsertion circuit of the above-mentioned type.

A further object of my invention is to provide a circuit of the above-mentioned type which may readily be applied to a transmitter.

A further object of my invention is to provide a circuit of the above-mentioned type in which the use of batteries or other power supply units above ground potential is avoided either entirely or in part.

A still further object of my invention is to provide an improved television transmitter circuit which is so designed that the transmitter cannot become damaged as a result of the modulating signal being removed.

In one of the preferred embodiments of my invention, the direct current component is reinserted at the modulator tube of a television transmitter. The synchronizing pulses appearing at the plate of the modulator tube are supplied to a diode which is biased to pass only their peaks. These peak pulses are supplied through a coupling condenser to an amplifier tube biased to pass only the synchronizing pulse peaks and having in its plate circuit an integrating or filtering circuit across which there appears a bias voltage. This bias voltage is applied to the grid of the modulator tube with the proper polarity to give a negative feedback effect. Specifically, this bias increases until an equilibrium condition is reached where the synchronizing pulse current passing through the diode is just sufficient to maintain the bias. Therefore the D.-C. component is reinserted and held at the proper value.

Since the modulator tube itself may be biased from a fixed voltage source to any level which will insure that the synchronizing pulses will pass current through the diode (biased to black level for example) the power amplifier can not be damaged as a result of interruption of the modulating signal.

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 of a preferred embodiment of my invention as applied to a television transmitter,

Figure 2 is a curve showing the modulated carrier wave output of the transmitter of Figure 1 under certain conditions, and

Figures 3 and 4 are circuit diagrams illustrating other embodiments of my invention.

Referring to Fig. 1, my invention is shown applied to a television transmitter of the type wherein the carrier wave is negatively modulated by a composite signal consisting of picture signal and synchronizing pulses.

By negative modulation is meant modulation in such direction that a decrease in light in the picture results in an increase in the carrier wave amplitude. Thus, in the usual case assumed in this application where synchronizing pulses are in the direction representing black in the signal, these pulses are represented by maximum carrier amplitude.

The transmitter comprises the necessary terminal equipment and amplifiers indicated by the block 10 for supplying the above-mentioned composite signal which is to modulate the transmitted carrier wave. It will be apparent from Fig. 2 that the modulating signal includes regularly recurring line synchronizing pulses, these pulses preferably being set on pedestals, the tops of which reach "black" level. The modulating signal also includes regularly recurring framing pulses not shown.

The terminal equipment 10 may be the same as that described in Patent 2,192,121, issued February 27, 1940, to A. V. Bedford, and assigned to the Radio Corporation of America. As indicated above, the pedestals appearing in the output of such terminal equipment are caused to go to a fixed level such as black in the picture, whereby the direct current component of the picture signal may be reinserted after the signal has passed through alternating current amplifiers.

The terminal equipment 10, if preferred, may be substantially the same as that shown in

Vance Patent 2,137,039, issued November 15, 1938, and assigned to the Radio Corporation of America. In the Vance patent, peaks of the synchronizing pulses go to black or to a fixed level beyond black.

The modulating signal is amplified by a suitable amplifier 16 and supplied to the control grid of a modulator tube 17 with the synchronizing pulses of negative polarity. The plate circuit of the modulator tube 17 is direct current-coupled to a push-pull power amplifier 18 for modulating the radio frequency carrier supplied from a suitable carrier wave source 19.

The power amplifier 18 comprises the amplifier tubes 21 and 22 which have a certain output rating determined by the plate dissipation.

Since the direct current component of the picture signal is to be transmitted, it is inserted in the example illustrated at the input of the modulator tube 17 by means of my improved D. C. inserting circuit, which comprises a diode 23 fed from the plate circuit of the modulator tube 17 and an amplifier tube 24 which is supplied through a coupling condenser 26 with the peaks of synchronizing pulses passing through the diode 23.

My improved D. C. inserting circuit resembles that described and claimed in the above-mentioned Bedford Patent 2,292,816 in that it is a negative feedback type of circuit, the peaks of the synchronizing pulses derived from the output circuit of the modulator tube 17 being utilized to control the bias applied to the control grid of the modulator tube.

The peaks of synchronizing pulses are obtained by connecting the diode 23 and a resistor 27 in series with each other and across the plate resistor 28 and the plate supply 29 of the modulator tube 17. The plate supply 29 in an actual transmitter preferably is the usual rectifier-filter supply unit rather than the battery illustrated.

It is desired to bias the diode so as to permit only the peaks of the synchronizing pulses to pass therethrough when they exceed a certain fixed amplitude level such as that representing "black" in the picture. Since the voltage drop across the plate resistor 28 is usually much larger than the desired bias voltage, the lower end of the diode output resistor 27 may be connected to a suitable point on the plate power supply 29 to oppose the said voltage drop and thereby adjust the bias voltage to the proper value. This bias or reference voltage, as indicated above, is adjusted to the value at which it is desired to maintain the peaks of the synchronizing pulses so that the diode will become conductive when the peaks just exceed this value.

The peaks of the synchronizing pulses when fed through the coupling condenser 26 to the grid of the amplifier tube 24, which is biased substantially to cut-off, causes pulses of current to flow through its plate circuit. This flow of curent may be traced from the plate of the amplifier tube 24 to its cathode, through the left-hand portion of a voltage divider 34, through the filtering or integrating circuit comprising a resistor 32 and a condenser 33 to ground, and through ground and a conductor 31 back to the plate of tube 24.

The relative resistance and capacitive values of the resistor 32 and capacitor 33 of the filter circuit are made such that the charge applied to the condenser 33 as a result of the peaks of the synchronizing pulses reaching the grid of the amplifier tube 24 will hold over for several successive line synchronizing pulses. In other words, the time constant of this circuit is similar to the time constant employed in other D. C. inserting circuits.

Since the filter 32—33 is in the grid-cathode circuit of the modulator tube 17, the bias on the grid of the modulator tube depends on the voltage drop across the resistor 32. This is made clear by tracing the grid circuit from the control grid of the modulator tube 17 through the grid resistor 36 to a variable tap 35, through the section X of the voltage divider 34, and through the filter resistor 32 to ground and to the grounded cathode of the modulator tube. It will be noted that an increase in voltage across resistor 32 makes the grid of the modulator tube 17 less negative whereby the plate end of the plate resistor 28 becomes more negative, the circuit approaching a condition where the diode 23 cannot pass current.

The voltage divider 34 is connected across a suitable voltage supply 37 such as a battery or the usual rectifier-filter supply unit. It will be noted that the voltage drop across the section X of the voltage divider applies a negative bias to the grid of the modulator tube 17. The voltage divider 34 also supplies the plate voltage and the grid bias voltage for the tube 24, the grid bias being supplied through a grid leak resistor 25 and preferably being sufficient to bias tube 24 substantially to cut-off.

The adjustable tap 35 on the voltage divider 34 is adjusted to a value which insures that the signal peaks (in this case the synchronizing pulse peaks), at least, will pass through the modulator tube 17 under all signal conditions so long as synchronizing pulses are being supplied from the generator 10 whereby the signal peaks in the modulator output will just exceed the reference voltage. At all times, therefore, a voltage will be fed back to establish the desired equilibrium condition. This bias adjustment, for example, may be such that, in the absence of a modulating signal, the modulator tube is biased to "black" level. The result of this bias adjustment for the condition where there is no applied modulating signal is illustrated in Fig. 2 at the end of the curve marked "Modulating signal off."

This illustrates an important feature of my invention, namely, that in case the modulating signal is interrupted, the output of the amplifier tubes 21 and 22 does not rise to the maximum output utilized during normal operation, that is, to the output representing the synchronizing pulses. Thus, my D. C. inserting circuit provides protection for the transmitter, there being no necessity for the use of a protective relay such as described in Patent 2,298,797, issued Oct. 13, 1942, in the name of Ray D. Kell, and assigned to the Radio Corporation of America.

It will be understood that, in the specific application of my invention described above, it is preferred to operate the television transmitter in the manner described in the above-mentioned Kell patent. Specifically, it is preferred to so operate the transmitter that the synchronizing pulses drive the power amplifier tubes 21 and 22 substantially beyond their normal rated continuous power output. It is possible to operate the power amplifier tubes in this manner be-

cause this maximum power output is not continuous. In fact, the amplifier tubes are operating at this power only a small percentage of the total time since the duration of the synchronizing pulses is only a small percentage of the total time. As pointed out in the Kell patent, with certain types of D. C. inserting circuits the power amplifier output will go to its maximum value and remain there in the event the modulating signal is interrupted unless certain precautions such as the use of a protective relay are taken. By the use of my invention, the necessity for such precautions is avoided.

The manner in which my D. C. inserting circuit operates will now be considered somewhat more in detail. Since the diode 23 is biased to a certain voltage with reference to ground, it will pass current upon the occurrence of each synchronizing pulse unless the bias applied to the control grid of the modulator tube 17 reduces the peak amplitude of the synchronizing pulses below a certain level, a condition that is never quite reached in operation. The peak amplitude just referred to is with reference to ground potential. The bias voltage which is derived from the pulses fed through the coupling condenser 26 and which appears across the filter resistor 32 tends to reduce the amplitude of the pulses below said level, but, as noted above, it can never quite accomplish this in operation because, if synchronizing pulses no longer pass through the diode 23, the bias applied to the modulator tube will drop back to its former value. Thus an equilibrium condition is reached where the modulator bias holds the peaks of the synchronizing pulses at the level corresponding to peak transmitter output.

It may be desirable to switch in an inductance coil 40 in place of the diode output resistor 27 in order to avoid any integrating action in the input circuit of the control tube 24 which would result in an incorrect bias on the grid of the tube 24. The use of the inductance coil 40 may be an improvement in this respect since its resistance may be made very low. In the average application the associated circuit constants are usually such that satisfactory performance is obtained with a resistor.

It will be apparent that, in addition to the protective feature of my improved circuit, there is also the advantage that no batteries or power supplies are required which must be operated above ground potential. It will be noted that the voltage supply 37 is connected to ground through the filter resistor 32 and that the plate supply 29, from which the diode bias voltage is obtained, has one terminal at ground potential.

It will be understood, of course, that the battery 41 is no portion of the D. C. inserting circuit and that this battery, which is above ground potential, has been shown merely for the purpose of simplifying the circuit by showing a conventional D. C. amplifier connection. In practice, suitable circuits are preferably employed to avoid the use of a battery, such as battery 41, above ground potential.

It may be noted that while I have shown the diode 23 connected to the output circuit of the modulator for setting the synchronizing pulses at a desired reference level, the important thing is that the diode 23 be connected at a point where the direct current component is to be restored. For example, it may be preferred to couple the biased diode 23 to the output circuit of the amplifier 18 whereby the peaks of the carrier wave pass through the diode as described and claimed in the above-mentioned Bedford application. This circuit arrangement is illustrated in Fig. 3.

Referring to Fig. 3 in which parts corresponding to those in Fig. 1 are indicated by like reference characters, the plate of the diode 23, instead of being connected to the plate circuit of the modulator tube 17, is connected to the output circuit of the radio frequency amplifier 18 by means of a coupling coil 50, for example. It will be apparent that the action of this circuit in restoring the direct current component is the same as that previously described in connection with Fig. 1.

Referring to Fig. 4, there is illustrated an embodiment of the invention in which the direct current restoring circuit is designed to operate under the condition where the synchronizing pulses are applied with positive polarity to the modulator tube or amplifier tube where the D. C. is being restored. Like parts in Figs. 1 and 4 are indicated by the same reference characters.

In Fig. 4 it is assumed that the synchronizing pulses are applied to the control grid of the tube 17 with positive polarity whereby the transmitted carrier wave is positively modulated by the picture and synchronizing signals. Under this condition of operation the D. C. restoring circuit differs from that shown in Fig. 1 in that the diode 23 is reversed, its cathode now being connected to the plate of the modulator tube 17. The other principal change in the circuit is that the integrating circuit 32—33 is so located in the circuit of the control tube 24 that an increase in the peaks of the synchronizing pulses passing through the diode 23 will cause the control grid of the tube 17 to become more negative. This will cause a decrease in the plate current of the modulator tube 17 whereby the cathode of the diode 23 is made more negative and the magnitude of the pulses fed to the control tube 24 is decreased.

The action of the control tube 24 in making the control grid of tube 17 more negative, as mentioned above, is as follows:

The periodically recurring pulse peaks appearing across the diode output resistor 27 are themselves of negative polarity but the portion of the signal between the narrow pulses is of positive polarity at the grid of the control tube 24 after passing through the A. C. coupling 26. This will be evident if it is kept in mind that an A. C. signal always has an A. C. axis, the signal on one side of the axis being positive and on the other side of the axis being negative. In the example illustrated and with the values indicated, merely by way of example, there is also a slight differentiating action which causes a small amplitude "kick" in the signal on the positive side.

Only the positive part of the signal affects the tube 24 since it is biased substantially at cut-off. Thus, any increase in signal across resistor 27 causes an increase in the plate current of the control tube 24 whereby the negative bias voltage across the integrating circuit 32—33 increases as is desired.

It may be desired to use the circuit shown in Fig. 1 in other cases than in the particular one for obtaining positive modulation. For example, considering the circuit of Fig. 1, it is sometimes found desirable to restore the direct current component in one or more of the amplifier stages preceding the modulator tube 17 even though this D. C. component is lost between stages because of the presence of a coupling condenser. In the case where my improved D. C. restoring circuit is

applied to successive amplifier stages, for example, it will be evident that the signal polarity at the control grids of successive amplifier tubes reverses whereby the connections shown in Fig. 1 will be employed for one amplifier stage while the connections shown in Fig. 4 will be employed for the amplifier stage immediately preceding.

From the foregoing, it will be apparent that various modifications may be made in my invention without departing from the spirit and scope thereof.

I claim as my invention:

1. Apparatus for reinserting the direct current component of a video frequency signal in which there are recurring pulses which, before said component was lost, had peaks reaching substantially a predetermined voltage level, said apparatus comprising an amplifier having an input circuit and an output circuit, means for passing said signal through said amplifier, means for controlling the bias of said amplifier, means coupled to said output circuit to pass the peaks of signal representative of said pulses only when they exceed a predetermined fixed voltage level, a control circuit having an input circuit and an output circuit, an alternating current connection between said last means and said last input circuit for passing said peaks whereby they appear in said last output circuit, said alternating current connection passing alternating current only, means for integrating said peaks to produce a bias voltage and for utilizing the resulting bias voltage to control the bias of said amplifier in such sense that an increase in the signal passed through said alternating current connection causes a decrease in the voltage level of the peak signal appearing in the output circuit of said amplifier.

2. Apparatus for reinserting the direct current component of a video frequency signal in which there are recurring pulses which, before said component was lost, had peaks reaching substantially a predetermined voltage level, said apparatus comprising an amplifier having an input circuit and an output circuit, means for passing said signal through said amplifier, means for controlling the bias of said amplifier, means connected in said output circuit to pass the peaks of said pulses only when they exceed a predetermined fixed voltage level, a control amplifier having an input circuit and an output circuit, an alternating current connection between said last means and said last input circuit for passing said peaks whereby amplified peaks appear in said last output circuit, said alternating current connection passing alternating current only, means for integrating said amplified peaks to produce a bias voltage and for utilizing the resulting bias voltage to control the bias of said amplifier in such sense that an increase in the signal passed through said alternating current connection causes a decrease in the voltage level of the signal pulses appearing in the output circuit of said first amplifier.

3. Apparatus for reinserting the direct current component of a video frequency signal in which there are recurring pulses which, before said component was lost, had peaks reaching substantially a predetermined voltage level, said apparatus comprising a vacuum tube having an input circuit and an output circuit and comprising a plurality of electrodes including a grid electrode, means for passing said signal through said tube, means connected to said output circuit to pass the peaks of said pulses only when they exceed a predetermined voltage level, a control tube having an input circuit and an output circuit, an alternating current connection between said last means and said last input circuit for passing said peaks whereby they appear in said last output circuit, said alternating current connection passing alternating current only, means for integrating said peaks and applying the resulting voltage to said grid electrode with such polarity that an increase in signal passed through said alternating current connection causes a decrease in the voltage level of the signal pulses appearing in the output circuit of the first amplifier tube whereby an equilibrium condition is established.

4. In a television transmitter, means for modulating a radio frequency carrier wave, said means comprising a radio frequency amplifier having an input circuit and a modulator tube having an output circuit which is direct current coupled to said input circuit, means for applying to the input circuit of said modulator tube a composite signal consisting of picture signal and periodically recurring synchronizing pulses of greater amplitude than the picture signal, said composite signal being applied to said modulator tube with such polarity that the maximum instantaneous output of said radio frequency amplifier is representative of said synchronizing pulses, and a direct current reinserting circuit comprising means connected in the output circuit of said modulator tube to pass the peaks of said synchronizing pulses only when they exceed a predetermined voltage level and to pass them substantially without integration, a control amplifier having an input circuit and an output circuit, means for supplying said peaks from said last means to the input circuit of said control amplifier through a connection that passes alternating current only, means for integrating the output of said control amplifier to produce a bias voltage, and means for applying said bias voltage to the input circuit of said modulator tube in such sense as to produce a degenerative feedback action.

5. In a television transmitter, means for modulating a radio frequency carrier wave, said means comprising a radio frequency amplifier having an input circuit and a modulator tube having an output circuit, means for so coupling said output circuit to said input circuit as to pass direct current, means for applying to the input circuit of said modulator tube a composite signal consisting of picture signal and periodically recurring synchronizing pulses of greater amplitude than the picture signal, said composite signal being applied to said modulator tube with such polarity that the maximum instantaneous output of said radio frequency amplifier is representative of said synchronizing pulses, and a direct current reinserting circuit comprising means coupled to a point succeeding said modulator tube to pass the peaks of said synchronizing pulses only when they exceed a predetermined voltage level and to pass them substantially without integration, a control amplifier having an input circuit and an output circuit, means for supplying said peaks from said last means to the input circuit of said control amplifier through a connection that passes alternating current only, means for integrating the output of said control amplifier to produce a bias voltage, and means for applying said bias voltage to the input circuit of said modulator tube in such sense as to produce a degenerative feedback action.

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