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2,205,243

AMPLIFIER

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Fig. 1.

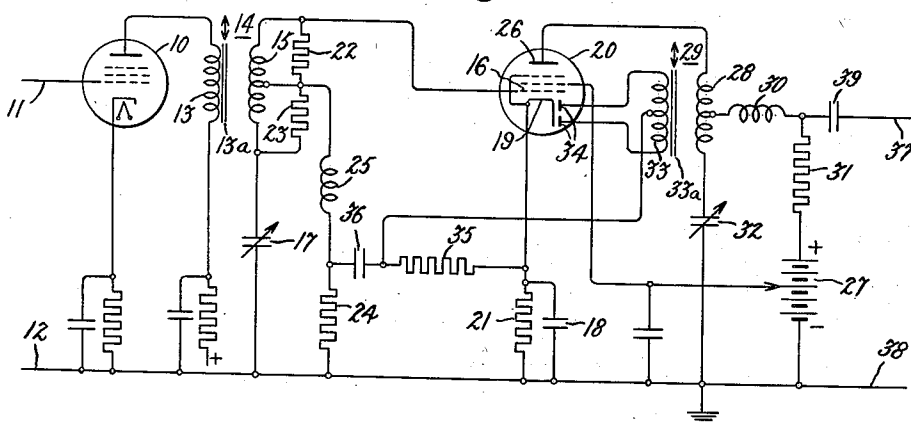
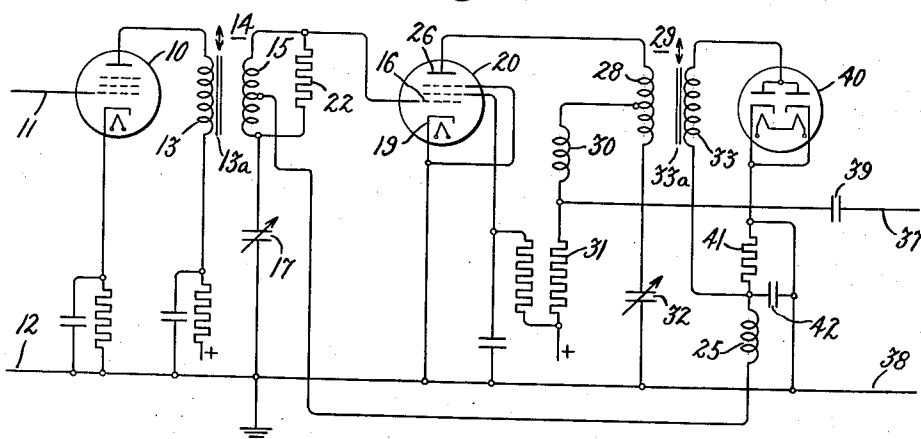


Fig. 2.



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## UNITED STATES PATENT OFFICE

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## AMPLIFIER

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Application December 15, 1938, Serial No. 245,879

7 Claims. (Cl. 250—20)

My invention relates to an improved signal amplifier and more particularly to amplifiers which operate simultaneously to amplify independent signal currents of different frequencies. While not limited thereto, my invention is particularly suited for use in an amplifier operating in accordance with the reflex principle wherein modulated signal currents are first amplified at a relatively high frequency, are demodulated, and are then re-amplified by the same amplifier at a lower frequency.

An object of my invention is to provide a signal amplifier having its input and output circuits arranged in the form of balanced Wheatstone bridges whereby signals of different frequencies may be simultaneously amplified in the amplifier free from interaction one with the other.

A further object of my invention is to provide in a reflex amplifier an arrangement which dispenses with the need for filters hereinbefore necessary to prevent the return with the demodulated signal of high frequency modulated currents from the output to the input circuit of the amplifier and one which, therefore, insures a more uniform amplification response for the modulation components of the signal.

An additional object of my invention is to provide a greatly simplified and improved reflex amplifier suited especially for use in a television receiver to amplify the picture modulated signal currents.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 illustrates an embodiment of my invention and Fig. 2 illustrates a modification thereof.

Referring more particularly to Fig. 1 of the drawing, my invention is illustrated as embodied in the picture intermediate frequency channel of a television receiver. In present day practice, a transmitted television carrier wave modulated with the picture signals is received, suitably amplified, and converted to a modulated intermediate frequency by apparatus, not shown, which precedes the amplifier stage 10 of Fig. 1. The modulated intermediate frequency picture signals (hereinafter to be referred to as the "video" intermediate frequency signals) are supplied to the input circuit 11, 12 of the amplifier 10, are here amplified, and are supplied to the primary winding 13 of an intermediate frequency transformer 14. The primary winding 13 is tuned to the intermediate frequency by an adjustable iron core 13a.

The transformer 14 has a secondary winding 15 which is connected to a control electrode 16 and, through a condenser 17 and a condenser 18, to a cathode 19 provided in an electron discharge device 20. The condenser 18 has a capacity only sufficiently large to bypass the relatively high video intermediate frequency currents around a cathode biasing resistor 21 which provides the control electrode 16 with a suitable operating bias. The secondary winding 15 is tuned by the condenser 17 and by the inherent capacity existing between the control electrode 16 and the other electron discharge device elements to resonance with the video intermediate frequency.

A resistor 22 is connected in series with a resistor 23 across the terminals of the secondary winding 15 to provide the broad frequency response which is necessary to pass the broad range of frequencies encountered in a video intermediate frequency amplifier system. The bias potential appearing across the resistor 21 is supplied to the control electrode 16 through a resistor 24 and a radio frequency choke coil 25. The resistor 24 in practice has a resistance of several megohms and is many times larger than the resistor 21.

The discharge device 20 is provided with an anode 26 which is connected to the positive terminal of a source of anode potential 27 through a primary winding 28, provided in an output transformer 29, and through a radio frequency choke coil 30 and a resistor 31. The output circuit of the discharge device 20 includes, in addition to the transformer primary winding 28, a variable condenser 32. The primary winding 28 is tuned to resonance with the intermediate frequency signal currents by the variable condenser 32 and by the inherent capacity existing between the anode 26 and the other elements of the device 20.

The output of the discharge device 20 is supplied through the secondary winding 33 of the transformer 29 to the diode rectifier elements 34 and the diode load resistor 35. The secondary winding 33 is tuned to resonance with the video intermediate frequency signal by an adjustable iron core 33a. The intermediate frequency signal oscillations are rectified by the diode elements 34 and the modulation components (hereinafter referred to as the "video" frequencies) appear as a potential across the resistor 35.

These potentials are returned to the input circuit of the device 20 through a condenser 36 and through the radio frequency choke coil 25 to a center tap provided on the secondary winding 15 of the input transformer 14. The capacity of the condenser 17 is made substantially equal to the inherent capacity existing between control electrode 16 and the other elements of discharge device 20. Each half of the transformer sec-

ondary winding 15 thus forms an arm of a balanced alternating current Wheatstone bridge whose other arms are the control electrode-ground capacity of the device 20 and the capacity of the condenser 17. Since the potential across the resistor 35 is supplied to opposite points on the input circuit bridge thus formed, and since these points have substantially zero potential between them with respect to the video intermediate frequency currents appearing across the entire transformer secondary winding 15, the return of the video frequency potentials to the input circuit of the amplifier 20 in this manner is not accompanied by any tendency of the video intermediate frequency currents to flow from the input circuit to the output circuit around the device 20. What little intermediate frequency current tends to flow, by virtue of a slight unbalance of the input circuit bridge, is effectively rendered negligible in magnitude by the radio frequency choke coil 25 through which any video intermediate frequency currents would have to pass in passing around the device 20. The choke coil 25 additionally serves as an element of an L-type low pass filter for the video frequencies. This filter is comprised by the choke 25, the condenser 17, and the input capacity of the device 20 and the stray capacity to ground of the transformer winding 15. The filter passes the relatively low video frequencies but effectively prevents the return from the output to the input circuit of the device 20 of the video intermediate frequencies and there is, consequently, no tendency of the circuit to break into uncontrolled oscillation.

The use of push-pull or full wave rectification by the diode rectifier elements 34 of the video intermediate frequencies further reduces the tendency of the video intermediate frequency currents to feed-back from the output to the input circuit of the device 20. With full wave rectification, no fundamental intermediate frequency currents can flow through the resistor 35 but only even order harmonics of the fundamental frequency.

A balanced alternating current Wheatstone bridge is likewise provided in the output circuit of the device 20 by a center tap on the primary winding 28 of the transformer 29 to which one side 37 of the output circuit 37, 38 is connected through a condenser 39 and the radio frequency choke 30. The output bridge is comprised by the two halves of a primary winding 28, which form two arms of the bridge, and by the condenser 32 and the anode-ground capacity of the device 20. The bridge is balanced by so choosing the value of the condenser 32 as to make the capacity of this condenser substantially equal to the anode-ground capacity of the device 20 when the output circuit is tuned to resonance with the video intermediate frequency signal currents. The output circuit 37, 38 is connected across opposite points on the output bridge and, since the potential between these points for video intermediate frequency signal currents is substantially zero, there is little or no tendency of the video intermediate frequency currents to flow in the output circuit 37, 38. The radio frequency choke 30, included in one side 37 of the output, effectively reduces to a minimum the video intermediate frequency currents in the output circuit.

It will thus be evident from the above description of my invention that the video intermediate frequency currents are supplied to the input circuit of the device 20, are amplified, and appear

in amplified form in the output circuit of the device 20 with little or no tendency for these currents to pass unamplified directly from the input to the output circuit through the interconnection of these circuits by the video frequency return circuit. It will further be evident that the video frequency potentials are returned from the output to the input circuit of the device 20 for amplification simultaneously with, though independently of, the video intermediate frequency oscillations and that the amplified video frequencies are supplied quite free of the video intermediate frequency currents from the output circuit of the device 20 to the output circuit 37, 38 suitably to operate an appropriate translating device, not shown.

Fig. 2 illustrates a modification of my invention in which elements corresponding to like elements of Fig. 1 are designated by like reference characters. In this modification a separate diode rectifier 40 is employed in place of the rectifier elements 34 which are included as elements of the discharge device 20 in the Fig. 1 arrangement. A normal operating bias for the control electrode 16 of the device 20 is provided in this modification by the potential which is generated across a resistor 41 as a result of the rectification of the video intermediate frequency signal currents by the diode rectifier 40. A condenser 42 is connected across the terminals of the resistor 41. This condenser has a relatively small capacity, only sufficiently large to maintain the lower terminal of the resistor 41 substantially at ground potential for the relatively high video intermediate frequency signal currents, and forms with the radio frequency choke coil 25, the condenser 17, and the input capacitance of device 20 and stray capacity of transformer winding 15 to ground a pi-type low pass filter for video frequencies. The capacity of the condenser 42 may thus be as large as 20 mmfd. or so without detrimentally affecting the video frequency response of the amplifier. The pi-type filter of which the condenser 42 and choke 25 are components effectively prevents the return of video intermediate frequency currents to the grid circuit of the device 20. This will be evident when it is considered that the middle of the video intermediate frequency band is about four times the cut-off frequency of this pi-type filter. It can be shown in this case that the ratio of output voltage to input voltage is:

$$\frac{e_0}{e_1} = \frac{f_c^2}{2f^2} = \frac{1^3}{2M^4} = \frac{1}{128}$$

where

$e_0$  = output voltage  
 $e_1$  = input voltage  
 $f_c$  = cut-off frequency of filter  
 $f$  = video intermediate frequency

Since the gain of the device 20 is about 15, no tendency to oscillate is experienced due to the fact that the feedback voltage is only about one eighth of that required to cause oscillation.

My circuit arrangement has the advantage that the simultaneous amplification of the video intermediate frequency and the video frequencies is accomplished free from interaction one with the other and with a minimum of circuit elements. In this regard, it may be noted that the condensers 17 and 32 not only tune the respective input and output circuits of the device 20 but additionally serve to balance the input circuit and the output circuit bridges whereby the potential at the center point of the transformer wind-

ing 15 and that at the center point of the transformer winding 23 is substantially zero for currents of video intermediate frequency when considered with respect to ground. The establishment of zero potentials at these points has the additional advantage that no shunt capacity is needed in the video frequency circuits for the purpose of filtering from these circuits the video intermediate frequency currents. This minimizes the shunt capacity across the video frequency circuits and assures maximum gain over the wide frequency band required. The fact that the resistor 21 in Fig. 1 is considerably smaller than the resistor 24 enables the condenser 18 to have a value only sufficiently large to bypass around the resistor 21 the intermediate frequency currents. This has the advantage that the Fig. 1 circuit arrangement is not degenerative to the video frequencies which must be amplified, along with the video intermediate frequency currents, by the discharge device 20.

While I have illustrated specific embodiments of my invention, it will, of course, be understood that I do not wish to be limited thereto since many modifications may be made in the circuit arrangement and in the circuit elements employed, and I contemplate by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In combination, an electron discharge amplifier having a cathode and a control electrode, a source of modulated oscillations connected between said cathode and control electrode, whereby said oscillations are amplified by said amplifier, means to demodulate said oscillations after amplification by said amplifier and to supply the demodulation products between said cathode and an intermediate point on said source, and means connected between said cathode and the terminal of said source opposite said control electrode to form with said source and the space between said grid and cathode a bridge having said means as a diagonal thereof, the electromotive force of said source being applied across the opposite diagonal of said bridge.

2. In combination, an electron discharge amplifier having a control electrode and a cathode, a high frequency input circuit connected between said control electrode and cathode, a low frequency input circuit connected between said control electrode and cathode, said low frequency input circuit being connected in balanced relation with respect to high frequency currents in said high frequency input circuit, whereby high frequency oscillations in said high frequency input circuit are not supplied to said low frequency input circuit, and means to demodulate high frequency oscillations amplified by said amplifier and to supply the demodulation products to said low frequency input circuit.

3. An electron discharge amplifier having a control electrode, an output electrode, and a cathode, a high frequency input circuit between said control electrode and cathode, a high frequency output circuit between said output electrode and cathode, an impedance, means to demodulate the high frequency oscillations in said output circuit and to supply the products of said demodulation across said impedance, said impedance being connected between said control electrode and cathode and in balanced relation with respect to high frequency oscillations appearing either on said input circuit or on the out-

put of said demodulating means, whereby said high frequency oscillations are not supplied from either said input circuit or said output to said impedance.

4. In combination, an electron discharge amplifier having a control electrode, and a cathode, a high frequency impedance having thereacross oscillations to be amplified connected between said control electrode and cathode, a balancing impedance substantially equal to the impedance between said control electrode and cathode connected between said cathode and the adjacent terminal of said first impedance whereby a point appears on said first impedance having substantially zero potential with respect to said cathode, and means to demodulate the oscillations amplified by said amplifier and to supply the demodulation products between said point and said cathode.

5. In combination, an electron discharge amplifier having a control electrode, and a cathode, a high frequency impedance having thereacross oscillations to be amplified connected between said control electrode and cathode, a balancing impedance substantially equal to the impedance between said control electrode and cathode connected between said cathode and the adjacent terminal of said first impedance whereby a point appears on said first impedance having substantially zero potential with respect to said cathode, means to demodulate the high frequency oscillations amplified by said amplifier, said means having an output balanced with respect to said cathode for said high frequency currents amplifier by said amplifier, said output being connected between said point and said cathode.

6. In combination, an electron discharge amplifier having a cathode and second electrode, a high frequency impedance having thereacross oscillations of a frequency at which said amplifier operates connected between said cathode and second electrode, a balancing impedance substantially equal to the impedance between said cathode and second electrode connected between said cathode and the adjacent terminal of said one impedance whereby a point appears on said one impedance having substantially zero potential at said frequency with respect to said cathode, and a circuit for currents of frequency other than said frequency connected between said point and cathode, whereby currents of said frequency are prevented from being supplied to said circuit.

7. In combination, an electron discharge amplifier having a cathode and second electrode, a high frequency impedance having thereacross oscillations of a frequency at which said amplifier operates connected between said cathode and second electrode, a balancing impedance substantially equal to the impedance between said cathode and second electrode connected between said cathode and the adjacent terminal of said one impedance whereby a point appears on said one impedance having substantially zero potential at said frequency with respect to said cathode, a circuit for currents of frequency other than said frequency connected between said point and cathode, whereby currents of said frequency are prevented from being supplied to said circuit, a balanced demodulator coupled to said one impedance to demodulate the oscillations thereacross, and means to supply the output from said demodulator to said amplifier to be amplified thereby and supplied to said circuit.

**Certificate of Correction**

Patent No. 2,205,243

June 18, 1940.

ROBERT B. DOME

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Page 2, first column, line 11, for "transsformer" read *transformer*; second column, line 53, in the formula, for " $\frac{1^3}{2M4^3}$ " read  $\frac{1^3}{2 \times 4^3}$ ; page 3, second column, line 12, claim 4, for "betwen" read *between*; line 34, claim 5, for "amplifier" read *amplified*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 6th day of August, A. D. 1940.

[SEAL]

HENRY VAN ARSDALE,  
*Acting Commissioner of Patents.*