

April 29, 1941.

R. B. J. BRUNN

2,239,776

BALANCED MODULATOR CIRCUIT

Filed March 3, 1939

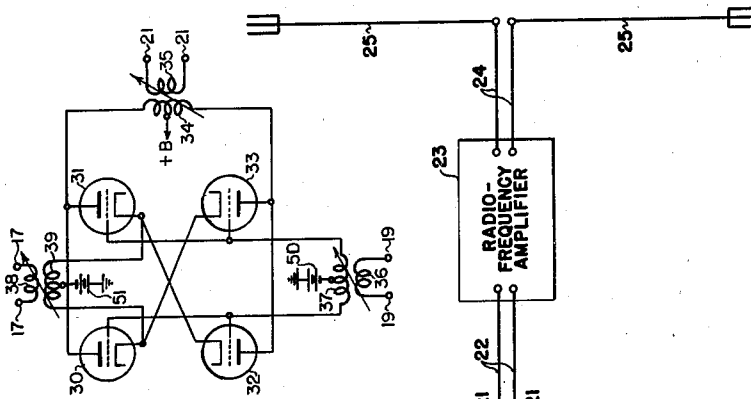


FIG. 2.

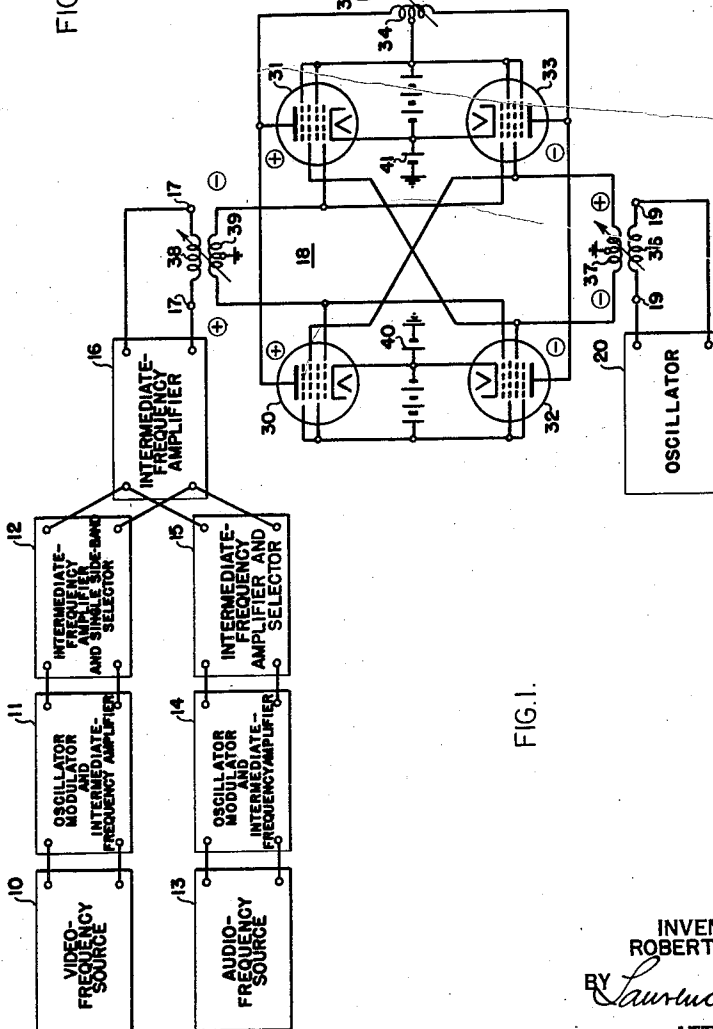


FIG. 1.

INVENTOR
ROBERT B. J. BRUNN
BY *Lawrence B. Odds*
ATTORNEY

UNITED STATES PATENT OFFICE

2,239,776

BALANCED MODULATOR CIRCUIT

Robert B. J. Brunn, New York, N. Y., assignor to
Hazeltine Corporation, a corporation of Delaware

Application March 3, 1939, Serial No. 259,546

5 Claims. (Cl. 179—171.5)

This invention relates generally to balanced modulator circuits and particularly to balanced modulator circuits from which it is desired to derive only heterodyne-frequency signals of two signal-input sources. While the invention is of general application, it is of particular utility in television signal-translating apparatus.

Balanced or push-pull modulators have been utilized in prior art arrangements to derive heterodyne-frequency signals from two signal-input sources. In push-pull modulators of the prior art, it has been possible to balance the arrangement from one of the sets of input terminals to the output terminals, whereby signals of the frequency of the input to said one of said sets of input terminals do not appear at the output terminals of the modulator. If only the heterodyne-frequency signals are desired, however, it is necessary to provide some other means for eliminating signals of the frequency of the other input signal from the output of the modulator. Selective circuits or filters have commonly been utilized for this purpose. However, in order that the desired signals of heterodyne frequencies may be selected in this manner, it is necessary that they differ substantially in frequency from the signals of input frequency which are to be rejected by the selective circuit. This relationship is sometimes difficult or impossible to procure. Furthermore, the selector circuits required in such arrangements add to the cost and complexity of the modulator and associated circuits.

It is, therefore, an object of the invention to provide a balanced modulator circuit which is not subject to the above-mentioned disadvantages of the arrangements of the prior art.

It is a further object of the invention to provide a balanced modulator in which only signals of heterodyne frequencies of two signal inputs thereto appear at the output terminals thereof.

It is still another object of the invention to provide a modulator circuit in which signals of the frequencies of each of two input sources are balanced with respect to the output circuit of the modulator.

In accordance with the invention, a balanced modulator comprises two sets of input terminals adapted to have signals applied thereto, a set of output terminals, and means for developing signals of heterodyne frequencies across the output terminals and balancing out at the output terminals the signals applied to both of the sets of input terminals. The modulator includes two pairs of vacuum tubes each tube having input and output sets of electrodes together with means

for coupling the output electrodes to the output terminals, the output electrodes of one pair of tubes being coupled to the output terminals with a polarity opposite to those of the other pair. The modulator also includes means for connecting one of the sets of input terminals in push-pull relation to input electrodes of both of the pairs of tubes, the push-pull connections to the pairs of tubes being of like polarity with respect to corresponding tubes of each pair. The modulator additionally includes means for connecting the other of the sets of input terminals in push-pull relation to input electrodes of both of the pairs of tubes, the push-pull connections of such other set of input terminals to the pairs of tubes being of opposite polarities with respect to corresponding tubes of each pair. Further, in accordance with a preferred embodiment of the invention, the modulator is incorporated in a modulated-carrier signal transmitter including an output circuit, a source of high-frequency oscillations, and a source of modulated-carrier frequency signals. In this embodiment of the invention, one of the sets of input terminals of the modulator is coupled to the source of high-frequency oscillations, the other of the sets of input terminals is coupled to the source of modulated-carrier signals, and the output terminals of the modulator are coupled to the antenna circuit. Preferably, the input terminals, the output terminals, and the above-referred-to pairs of vacuum tubes have a common neutral which is grounded.

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

Fig. 1 of the drawing is a circuit diagram, partly schematic, of an embodiment of the invention incorporated as a modulator in a modulated-carrier television signal transmitter, while Fig. 2 is a circuit diagram of a modulator similar to that of Fig. 1 utilizing vacuum tubes having a single control electrode.

Referring now to Fig. 1 of the drawing and neglecting for the moment the operation of the modulator circuit of the invention presently to be described, there is illustrated a circuit diagram of a modulated-carrier television signal transmitter in which the conventional portions are indicated schematically since, per se, they form no part of the invention. This transmitter comprises in one signal-translating channel thereof, cou-

pled in cascade in the order named, a source of video-frequency signals 10, an oscillator-modulator and intermediate-frequency amplifier 11, and an intermediate-frequency amplifier and single-sideband selector 12. The transmitter includes in another signal-translating channel thereof, coupled in cascade in the order named, an audio-frequency source 13, an oscillator-modulator and intermediate-frequency amplifier 14, and an intermediate-frequency amplifier and selector 15. The output signals of amplifier and single-sideband selector 12 and amplifier and selector 15 are coupled to an intermediate-frequency combining amplifier 16 wherein they are further amplified, the two above-mentioned channels comprising common units in the remaining portions of the transmitter. The signal output of intermediate-frequency amplifier 16 is coupled to input terminals 17 of the modulator circuit 18 of the invention, presently to be described. There is also coupled to the set of input terminals 19 of modulator circuit 18 a source of locally-generated oscillations 20. Connected to the output terminals 21 of modulator 18, in the order named, are a balanced transmission line 22, a radio-frequency amplifier 23, a second balanced transmission line 24, and a doublet antenna 25, 25.

Neglecting the moment the portions of the system comprising the present invention, the operation of the circuit just described is well understood in the art and a detailed description thereof is believed to be unnecessary. In brief, however, video-frequency signals, provided by source 10, are utilized to modulate a source of locally-generated oscillations and amplified in oscillator-modulator and intermediate-frequency amplifier 11. The intermediate-frequency output of unit 11 is further amplified and the carrier wave and a single sideband thereof are selected in amplifier and single-sideband selector 12. Audio-frequency signals, provided by source 13, are utilized to modulate a source of locally-generated oscillations in oscillator-modulator and intermediate-frequency amplifier 14 to provide an audio-modulated intermediate-frequency signal which is further amplified in amplifier-selector 15. The outputs of units 12 and 15 are further amplified and combined in intermediate-frequency combining amplifier 16 and applied to modulator 18 wherein the heterodyne-frequency signals of the output of unit 16 and oscillator 20 are provided at output terminals 21. The video- and audio-modulated carrier-frequency signals so provided are transmitted over balanced transmission line 22 to radio-frequency amplifier 23, wherein they are further amplified, and transmitted over balanced transmission line 24 to doublet antenna 25, 25 for radiation in a manner well understood in the art.

Coming now to the portion of the system comprising the present invention, there is shown a modulator circuit including means for developing signals of heterodyne frequencies across the output terminals 21, 21 and balancing out at the output terminals the signals applied to both of the sets of input terminals 17, 17 and 19, 19, this means comprising four vacuum tubes 30, 31, 32, and 33 each having two sets of input electrodes and one set of output electrodes. Means is provided for coupling the output electrodes of the pair of tubes 30 and 31 with one polarity to output terminals 21 and the output electrodes of tubes 32 and 33 to output terminals 21 with the opposite polarity comprising an attenuator including a mid-tapped inductance 34 variably in-

ductively coupled to inductance 35. A set of input electrodes of the tubes of each of the pairs 30, 31 and 32, 33 is coupled to input terminals 17 with opposite polarity for balanced operation with respect to the output terminals 21, and the remaining set of input electrodes of the tubes of one pair 30, 31 is coupled to input terminals 19 with opposite polarity to the input electrodes of tubes 32, 33 of the other pair, also for balanced operation with respect to output terminals 21. An attenuator comprising an inductance 36 variably inductively coupled to a mid-tapped inductance 37 is provided for coupling input terminals 19 to one set of input electrodes of each of tubes 30—33, while an attenuator comprising an inductance 38 variably inductively coupled to a mid-tapped inductance 39 is provided for coupling input terminals 17 to the others of the sets of input electrodes of tubes 30—33. The mid-points of inductances 34, 37, and 39 are grounded, the cathodes of tubes 30 and 32 are grounded through a common source of grid bias 40, and the cathodes of tubes 31 and 33 are grounded through a common source of grid bias 41. Thus, the attenuator 36, 37 comprises balanced means including the common grounded neutral for connecting the set of input terminals 19, 19 in push-pull relation to one set of input electrodes of both of the pairs of tubes 30—33, inclusive, the push-pull connections to the pairs of tubes being of like polarity with respect to corresponding tubes of each pair. Likewise, the attenuator 38, 39 comprises balanced means including the common grounded neutral for connecting the set of input terminals 17, 17 in push-pull relation to the other set of input electrodes of both of the pairs of tubes 30—33, inclusive, the push-pull connections of the latter set of input terminals to the pairs of tubes being of opposite polarities with respect to corresponding tubes of each pair.

In considering the operation of modulator circuit 18, it will be assumed that a signal is applied at terminals 19 to provide a radio-frequency voltage across inductance 37 of the instantaneous polarity shown and that modulated intermediate-frequency signals are applied at input terminals 17 to provide a voltage across inductance 39 of the instantaneous polarity shown. It will be seen that a negative voltage from inductance 37 is applied to an input electrode of tube 31 and to an input electrode of tube 32 and, as the output electrodes of these two tubes are connected to output terminals 21 with opposite polarity, that substantially no resultant signal voltage of the frequency of the signal applied to terminals 19 is developed at the output terminals 21 by the two tubes. Similarly, a positive potential from inductance 37 is applied to an input electrode of tube 30 and to an input electrode of tube 33 and, as these two tubes are coupled to output terminals 21 with opposite polarity, substantially no resultant signal voltage of the frequency of the signal input to terminals 19 appears at the output terminals 21 under these conditions. Similarly, signals of the frequency of the input to terminals 17 are substantially balanced with respect to output terminals 21 and substantially do not appear at the output terminals 21 of modulator 18.

However, with respect to signals of heterodyne frequencies of the sources applied at input terminals 19 and input terminals 17, it will be seen that the components developed by the several tubes are additive with respect to the output terminals 21. Thus, under the conditions assumed,

a negative potential is applied from inductance 37 to an input electrode of tube 31 and a negative potential is also applied from inductance 39 to another input electrode of tube 31. Therefore, the sign of the heterodyne-signal component is positive as indicated adjacent the anode of tube 31. Similarly, the sign of the heterodyne-signal output of tube 30 is positive for the reason that a positive potential is applied to one of its input electrodes from inductance 37 and a positive potential is applied to another input electrode from inductance 39. Upon consideration, it will also be seen that, under the conditions assumed, the sign of the heterodyne signals provided by tubes 32 and 33 are negative as indicated adjacent the anodes thereof. It is, therefore, apparent that signals of heterodyne frequencies of the two signal sources applied, respectively, at terminals 17 and 19 are additive in the output circuit of modulator 18 and appear at the output terminals 21 of the modulator.

It will be seen that the action of the transmitter illustrated is, with respect to either the video-frequency channel or the audio-frequency channel, simply the reverse of that of a conventional superheterodyne receiver. Furthermore, it is apparent that, under these conditions, oscillator 20 and radio-frequency amplifier 23 may be tunable and uncontrolled to provide a tunable transmitter for transmission at any selected carrier frequency within a predetermined range of frequencies.

While it is not intended to limit the several units of the invention to operation at any particular frequency or within any particular frequency range, there follow two groups of recommended frequencies or frequency ranges for each of the units which are particularly suitable for a modulated-carrier television signal transmitter:

	Group I	Group II
Source of video-frequency signals 10 megacycles.....	0-4	0-4
Oscillator-modulator and intermediate-frequency amplifier 11..... mcs.	9.75	6.25
Amplifier and single-sideband selector 12..... mcs.	5.75 to 9.75	6.25 to 10.25
Audio-frequency source 13..... kcs.	0-10	0-10
Oscillator-modulator and intermediate-frequency amplifier 14..... mcs.	5.25	10.75
Amplifier and selector 15..... mcs.	5.15-5.35	10.65-10.85
Intermediate-frequency amplifier 16..... mcs.	5-11	5-11
Oscillator 20..... mcs.	55-113	39-97
Radio-frequency amplifier 23 (six megacycles band width)..... mcs.	44-50	102-108

In Fig. 2 there is illustrated a modification of the circuit of Fig. 1 in which the modulator tubes 30-33, inclusive, comprise a single control electrode; that is, each tube has only one set of input electrodes. Similar circuit elements in the two figures have identical reference numerals. In Fig. 2 the voltage supplied from transformer 36, 37 is applied directly to the control electrode of the vacuum tubes 30-33, inclusive, and secondary winding 37 has coupled between its mid-tap and ground a source of bias potential 50. The input voltage supplied through transformer 38, 39 is connected in the cathode circuit of each of the tubes and a source of bias potential 51 is provided between the mid-tap of winding 39 and ground. The operation of the circuit of Fig. 2 is very similar to that of Fig. 1 and no further description thereof is deemed to be necessary.

While there have been described what are at present considered to be the preferred embodiments of this invention, it will be obvious to

those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What is claimed is:

1. A balanced modulator comprising, two sets of input terminals adapted to have signals applied thereto, a set of output terminals, and means for developing signals of heterodyne frequencies across said output terminals and balancing out at said output terminals the signals applied to both of said sets of input terminals, said means including two pairs of vacuum tubes each tube having input and output sets of electrodes, means for coupling said output electrodes to said output terminals, the output electrodes of one pair of said tubes being coupled to said output terminals with a polarity opposite to those of the other pair, means for connecting one of said sets of input terminals in push-pull relation to input electrodes of both of said pairs of tubes, the push-pull connections to said pairs of tubes being of like polarity with respect to corresponding tubes of each pair, and means for connecting the other of said sets of input terminals in push-pull relation to input electrodes of both of said pairs of tubes, the push-pull connections of said other set of input terminals to said pairs of tubes being of opposite polarities with respect to corresponding tubes of each pair.

2. A balanced modulator comprising, two sets of input terminals adapted to have signals applied thereto, a set of output terminals, and means for developing signals of heterodyne frequencies across said output terminals and balancing out at said output terminals the signals applied to both of said sets of input terminals, said means including two pairs of vacuum tubes, each tube having two sets of input electrodes and a set of output electrodes, means for coupling said output electrodes to said output terminals, the output electrodes of one pair of said tubes being coupled to said output terminals with a polarity opposite to those of the other pair, means for connecting one of said sets of input terminals in push-pull relation to one of said sets of input electrodes of both of said pairs of tubes, the push-pull connections to said pairs of tubes being of like polarity with respect to corresponding tubes of each pair, and means for connecting the other of said sets of input terminals in push-pull relation to the other of said sets of input electrodes of both of said pairs of tubes, the push-pull connections of said other set of input terminals to said pairs of tubes being of opposite polarities with respect to corresponding tubes of each pair.

3. A balanced modulator comprising, two sets of input terminals adapted to have signals applied thereto and having a common neutral, output terminals having the same common neutral, and means for developing signals of heterodyne frequencies across said output terminals and balancing out at said output terminals the signals applied to both of said sets of input terminals, said means including two pairs of vacuum tubes each tube having input and output sets of electrodes, means for coupling said output electrodes to said output terminals, the output electrodes of one pair of said tubes being coupled to said output terminals with a polarity opposite to those of the other pair, means comprising said common neutral for connecting one of said

sets of input terminals in push-pull relation to input electrodes of both of said pairs of tubes, the push-pull connections to said pairs of tubes being of like polarity with respect to corresponding tubes of each pair, and means comprising said common neutral for connecting the other of said sets of input terminals in push-pull relation to input electrodes of both of said pairs of tubes, the push-pull connections of said other set of input terminals to said pairs of tubes being of opposite polarities with respect to corresponding tubes of each pair.

4. In a modulated-carrier signal transmitter including an output circuit, a source of high-frequency oscillations and a source of modulated carrier-frequency signals, balanced modulator means for developing heterodyne frequencies across said output circuit and balancing out at said output circuit said modulated signals and signals of the frequency of said high-frequency source, said means comprising, two pairs of vacuum tubes each pair having input and output electrodes, means for coupling said output electrodes to said output circuit, the output electrodes of one pair of said tubes being coupled to said output circuit with a polarity opposite to those of the other pair, means for connecting said source of high-frequency oscillations in push-pull relation to input electrodes of both of said pairs of tubes, the push-pull connections to said pairs of tubes being of like polarity with respect to corresponding tubes of each pair, and means for connecting said source of modulated-carrier frequency signals in push-pull relation

to input electrodes of both of said pairs of tubes, the push-pull connections of said last-mentioned source to said pairs of tubes being of opposite polarities with respect to corresponding tubes of each pair.

5. In a carrier-frequency signal transmitter including a balanced output circuit, a balanced source of high-frequency oscillations, and a balanced source of modulating signals, balanced modulator means for developing heterodyne frequencies across said output circuit and balancing out at said output circuit said modulated signals and signals of the frequency of said high-frequency source, said means comprising two pairs of vacuum tubes each tube having input and output electrodes, balanced means for coupling said output electrodes to said output circuit, the output electrodes of one pair of said tubes being coupled to said output circuit with a polarity opposite to those of the other pair, balanced means for connecting said source of high-frequency oscillations in push-pull relation to input electrodes of both of said pairs of tubes, the push-pull connections to said pairs of tubes being of like polarity with respect to corresponding tubes of each pair, and balanced means for connecting said source of modulating signals in push-pull relation to input electrodes of both of said pairs of tubes, the push-pull connections of said source of modulating signals to said pairs of tubes being of opposite polarities with respect to corresponding tubes of each pair.

ROBERT B. J. BRUNN.