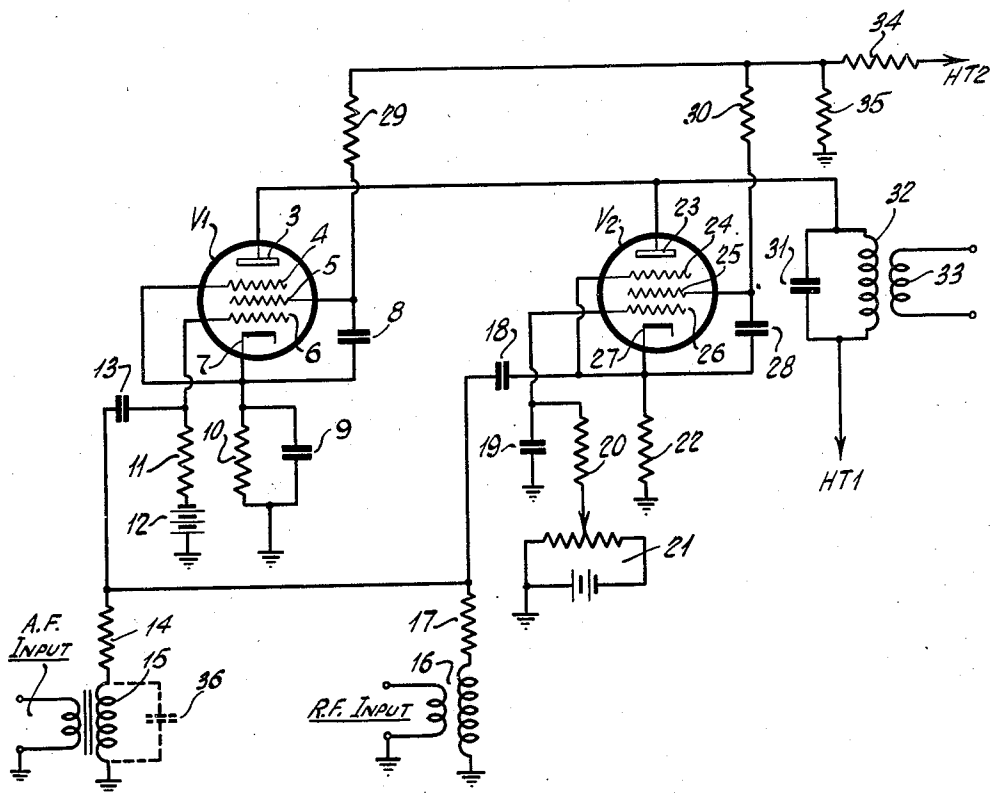


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MODULATOR ARRANGEMENTS FOR CARRIER
WAVE TELEGRAPHY AND TELEPHONY
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MODULATOR ARRANGEMENT FOR CARRIER
WAVE TELEGRAPHY AND TELEPHONY

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This invention relates to improvements in modulation arrangements for carrier wave telegraphy and telephony and is directed to the production of an improved modulator circuit which permits both carrier and modulating voltages to be suppressed in the output circuit.

In carrier wave telegraphy and telephony, and in privacy devices for telephony and in similar application, it is often necessary to modulate a carrier and to provide means for suppressing the transmission of each of the input waves and for producing in the output of the modulator only waves which represent the combination frequencies and the double frequency of the impressed waves.

In the past, in order to perform this function, it has been the practice to employ various arrangements of the well known balanced modulator circuit. All of these prior art modulator circuit arrangements require the use of balanced input and/or output transformers and their efficient operation depends on securing and maintaining a high degree of balance; a requirement that is not readily realizable in practice.

The object of the present invention is to provide a comparatively simple circuit utilizing two valves interconnected in such a way that both carrier and modulation can be suppressed, said circuit having the advantage that the use of balanced transformers is avoided and all transmission paths are earthed on one side, i. e., single-side. A further advantage arising out of performance of the present invention is that exact independent balance can be obtained by simple means for both carrier and modulation suppression.

The above objectives are achieved in accordance with the present invention by an improved modulator arrangement comprising a pair of similar thermionic valves each having at least a cathode, an anode and a control grid, an unbalanced input circuit for carrier frequency energy, and an unbalanced input circuit for modulation frequency energy, both said circuits being connected to said valves in such a manner as to produce, without the aid of a balancing transformer, instantaneous potentials of opposite phase relationship on the control grids of both valves, and means including an unbalanced output circuit for obtaining energy at a frequency equal to the sum and/or difference frequencies of the said carrier and modulating frequency energies.

In carrying out the invention one of said thermionic valves is provided with an unbypassed resistive impedance in its cathode circuit and has

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its control grid effectively earthed for all operating frequencies. Carrier frequency energy and modulating frequency energy from the unbalanced input circuits are applied simultaneously to the cathode of this valve and to the grid of the other valve. The resistive impedance in the cathode circuit referred to functions to invert the phase of the energy applied to its associated cathode and thus produce on the control grid of this valve input potentials of opposite phase relationship to those applied to the control grid of the other valve.

The anodes of the valves are connected together and to an unbalanced output circuit which is appropriately tuned to receive either the sum and/or difference frequencies of the said carrier and modulation frequency energy as desired.

For a more complete understanding of the invention and the manner in which it is to be carried out, attention is now directed to the following description in connection with the accompanying drawing, which illustrates one practical method of carrying the invention into effect.

Referring to the drawing, valve V1 is of the pentode type having its cathode 7 earthed through resistor 10 and condenser 9 in parallel. Control grid 6 is connected through resistor 11 to a source of fixed bias represented by battery 12. Screen grid 5 is bypassed for all signal frequencies by condenser 8 connected to cathode 7. Operating voltage is supplied to the screen 5 from a potentiometer 34, 35 across a source of high tension voltage HT2 through resistor 29. The suppressor grid 4 is connected to cathode 7. Valve V2 is identical to V1. Cathode resistor 22 is not bypassed. Control grid 26 is effectively earthed for all frequencies through condenser 19 and is connected through resistor 20 to a variable source of bias potential indicated by 21. Screen grid 25 is effectively shorted to cathode, at all frequencies through condenser 28 and is supplied with high tension operating voltage through resistor 30 and potentiometer 34, 35. Plates 3 and 23 are coupled together and to a tuned circuit 31, 32 which is resonant at the carrier frequency and plate operating voltage from source HT1 is supplied through coil 32. Modulating potentials are applied to the terminals A. F. input of low frequency transformer 15. Similarly, carrier frequency voltage is applied to terminals R. F. input of transformer 16. The secondaries of these transformers, in series with resistors 14 and 17 respectively, are connected in parallel. Audio frequency voltages developed across resistor 14 are fed through condenser 13 to grid 6 of valve V1

and, through condenser 18, to cathode 27 of valve V2. Similarly, radio frequency voltages across 17 are also fed to grid 6 and to cathode 27. Note that the secondary of transformer 15 is effectively shorted for radio frequencies by self-capacity as represented by condenser 36.

Valves V1 and V2 should be of the type having a square-law characteristic, i. e., the relation between instantaneous plate current (i) and instantaneous grid-cathode voltage (e) can be expressed for valve V1 by a relation

$$i_1 = a_0 + a_1 e + a_2 e^2$$

over a substantial portion of the characteristic. Type 6U7G valves have been found suitable.

It is preferable to use a valve having a screen grid so that inverse feedback effects, arising in the unbypassed cathode resistor 22, are substantially compensated by variations of screen voltage obtained by connecting screen to cathode.

In a particular circuit the following values were used:

Resistor:

10	ohms	100
11	do	100
20	do	100
22	do	100
29	do	1,000
30	do	1,000
14	do	500
17	do	500
13	Reactance less than 11 and 22 at lowest A. F., say 25 μ F.	
18		
8, 28	μ F	20
19	μ F	25
9	μ F	25

The two high tension sources, which may be the same source, were 250 v. D. C. Bias 12 was 6 volts, screen grid voltage 100 volts by making 34=32,000 ohms, 35=25,000 ohms. The tap on bias source 21 is adjusted so that the bias on the control grid of 26 is equal to that of valve V1. Note that in each valve the bias is the sum of a small self-bias developed across the bias resistor in the cathode circuit, and a fixed or adjustable bias. Since resistor 22 is not bypassed, and if the value of this resistance is considerably greater than the reactance of condenser 18, the voltage applied between grid and cathode of valve V2 is equal in value but opposite in sign to that applied to the grid-cathode of valve V1. This is true since grid 26 is effectively earthed through condenser 19.

Thus, if each valve is operating on an identical characteristic of square-law shape, the plate current of valve 2 is represented:

$$i_2 = a_0 + a_1(-e) + a_2(-e)^2 = a_0 - a_1 e + a_2 e^2$$

Thus, the total current flowing through circuit 31, 32 is the sum of the two plate currents and is given by $i_0 = i_1 + i_2 = 2a_0 + 2a_2 e^2$. If the R. F. voltage is of the form $E1 \cos \omega t$ and the A. F. voltage $E2 \cos pt$, then

$$e = E1 \cos \omega t + E2 \cos pt$$

(Phases are neglected to simplify the illustration.) The total plate current is therefore:

$$\begin{aligned} i_0 &= 2a_0 + 2a_2(E1 \cos \omega t + E2 \cos pt)^2 \\ &= 2a_0 + 2a_2 \left[\frac{E1^2}{2} \cos 2\omega t + \frac{E2^2}{2} \cos 2pt - \frac{E1^2 + E2^2}{2} + \right. \\ &\quad \left. E1E2 \cos (\omega + p)t + E1E2 \cos (\omega - p)t \right] \end{aligned}$$

Thus the output of the device contains terms representing steady direct currents, alternating currents twice the frequency of the signal and carrier respectively, and two radio frequency currents of the sum frequency and difference frequency respectively. It is seen that there are no terms present for the frequencies ω or p . Thus, if the tuned circuit 31, 32 resonates at frequency ω and is reasonably selective to reject frequencies 2 and 2p, the two sidebands only may be obtained by coupling to coil 33 as shown. If the two frequencies are nearly equal, then the output circuit may be tuned to reject all except one sideband. If voltages of frequency ω do appear at the output, then a slight adjustment of bias 21 will be sufficient to ensure that the valves are operating on identical characteristics. In effect, this adjustment is one which makes the constants a_1 equal in the two expressions for the characteristics.

Although for purposes of description the signal frequency has been shown as an audio frequency, it may be of any frequency.

What is claimed is:

1. In a current mixing system, two electron discharge devices each having electrodes including an anode, a cathode, and a control grid, two sources of currents to be intermodulated, an impedance between the cathode of one device and ground, means coupling said sources in parallel in shunt to said impedance, means coupling said sources in parallel between the grid and cathode of the other device, and an output circuit coupling the anodes of said devices in parallel.

2. A system as recited in claim 1 wherein said one device has a screen electrode coupled to its cathode by a capacitor of low impedance to voltages of the frequencies of said sources.

3. In a modulation system, a source of signals, a source of wave energy to be modulated, a pair of electron discharge devices, an unbalanced input circuit coupled to an electrode of one device, an unbalanced input circuit coupled to an electrode of the other device, an impeder in each input circuit, a coupling connecting said impeder in parallel, connections from the signal source to one impeder for applying signals to both input circuits, connections from the wave energy source to the other impeder for applying carrier wave energy to be modulated to said input circuits the arrangement being such that the signals and wave energy are applied in phase opposition to the devices and an output circuit coupling the anodes of said devices in parallel.

4. A system as recited in claim 3 including means to tune said output circuit to a side band frequency.

5. In a modulation system, a source of signals, a source of wave energy to be modulated, a pair of similar electron discharge devices each having an anode, a cathode and a control grid, an unbalanced input circuit including an impeder coupled between the control grid of one of said devices and ground, an unbalanced input circuit including an impeder coupled between the cathode of said other device and ground, a coupling connecting said impeder in parallel, connections from said signal source to one impeder for applying signals to said one impeder, connections from said wave energy source to the other impeder for applying carrier wave energy to be modulated to the other impeder and an output circuit coupling the anodes of said devices in parallel.

6. In a modulation system, a source of signals, a source of wave energy to be modulated, a pair of similar electron discharge devices each having

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an anode, a cathode and a control grid, an unbalanced input circuit including an impeder coupled between the control grid of one of said devices and ground, an unbalanced input circuit including an impeder coupled between the cathode of said other device and ground, a coupling connecting said impeder in parallel, connections from the signal source to one impeder for applying signals to said one impeder, connections from the wave energy source to the other impeder for applying wave energy to be modulated to the other impeder, a third impeder coupling the cathode of the other device to ground, a screen grid in said other device, a coupling of low impedance to voltages of signal and wave energy frequency cou-

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pling the screen grid of the other device to ground, and an output circuit coupling the anodes of said devices in parallel.

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