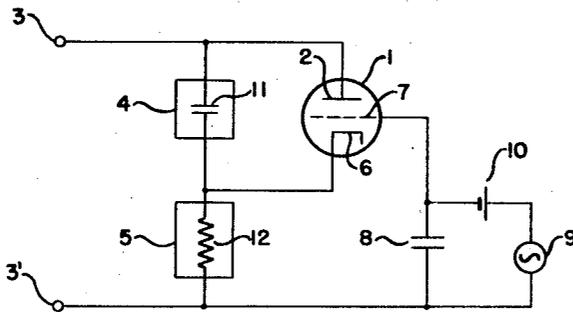


Oct. 25, 1949.

W. R. RAMBO
ELECTRICAL CIRCUIT
Filed Nov. 6, 1945

2,485,919



INVENTOR.

WILLIAM R. RAMBO

BY

William D. Hall

ATTORNEY

UNITED STATES PATENT OFFICE

2,485,919

ELECTRICAL CIRCUIT

William R. Rambo, Cambridge, Mass., assignor to
the United States of America as represented by
the Secretary of War

Application November 6, 1945, Serial No. 627,046

12 Claims. (Cl. 332-28)

1

This application relates to electrical circuits and particularly to reactance tube circuits.

As known in the art a reactance tube is an electronic device such as a vacuum tube in which current flows through the tube out of phase with an applied radio-frequency voltage. Thus, in a tube of this character, an applied plate R.-F. voltage may produce a plate current which is approximately 90° out of phase with the plate voltage, thereby causing the tube to simulate a reactance. Generally this effect is produced by utilizing a phase-splitting network which causes the voltage applied to the grid of the reactance tube to be in a desired out-of-phase relationship with the plate voltage. When such an arrangement is associated with an oscillator tank circuit, it affords a convenient means for controlling the oscillator frequency to produce frequency modulation as a function of a modulating voltage applied to the grid of the reactance tube.

In practical applications it is difficult to maintain the flow of current through the reactance tube circuit at exactly 90° in phase relative to the R.-F. voltage throughout the normal range of operating conditions. This may be attributed to the variation of the tube plate-cathode impedance with the amplitude of the modulating voltage. Such variation of impedance affects the functioning of the phase-splitting network, and as a result there is apt to be an in-phase component of plate current of variable magnitude which causes a varying amount of the power of the output of the oscillator to be dissipated in the reactance tube circuit. The loss of oscillator power as a function of modulating voltage constitutes a very undesirable form of parasitic amplitude modulation.

Heretofore a number of circuit modifications have been proposed for the purpose of eliminating the above described parasitic amplitude modulation. All of these are similar in that an endeavor is made to shift the R.-F. grid voltage more than 90° out of phase with the applied plate voltage so that, in effect, the reactance tube is capable of supplying energy to the system in the proper amount to compensate for its own variable internal losses. Fundamentally, this is a sound solution to the problem and the present invention utilizes such a method to accomplish the desired result. However, in prior arrangements, the internal plate-grid capacitance of the tube has had an undesirable effect at the higher frequencies. The use of pentode tubes remedies this situation within the range of frequencies for which pentodes are available, but at still higher

2

frequencies, where triodes must be employed, the plate-grid capacitance is a serious factor which renders these circuits unreliable.

A primary object of the present invention is to prevent parasitic amplitude modulation in a reactance tube circuit by the use of a common-grid reactance tube circuit in which a triode may be utilized without any detrimental effect due to plate-grid capacitance. A common-grid circuit, within the meaning of the present specification, is one in which a grid terminal is common to both the input and output circuits, in contradistinction to the conventional tube circuit in which the cathode terminal is common to both input and output circuits.

A further object is to provide a novel reactance tube circuit of general application at all radio frequencies for achieving the above described desired result.

Other objects, features and advantages of the present invention will suggest themselves to those skilled in the art and will become apparent from the following description of the invention taken in connection with the accompanying drawing which presents a schematic view of a reactance tube circuit according to the present invention.

Reference is now made to the accompanying drawing in which a basic common-grid circuit is illustrated. The reactance tube circuit, in the present instance, comprises a triode 1, although it should be understood that other tubes such as pentodes may be utilized equally well in those frequency ranges where such tube types are available. The plate 2 of the tube 1 is connected to one of the terminals 3 to which the radio-frequency voltage from the oscillator tank circuit (not shown) is applied. A phase-splitting network comprising the series combination of a reactive element 4 and an impedance 5 are connected across the R.-F. terminals 3 and 3'. The cathode 6 of tube 1 is connected to the junction of the element 4 and impedance 5. The grid 7 of tube 1 is connected through a capacitor 8, which presents substantially a short circuit at radio frequencies, to the end of the impedance 5 which is connected to the R.-F. terminal 3'.

A source 9 of modulating voltage in series with a bias supply 10 is connected across the capacitor 8, which constitutes substantially an open circuit at the modulating frequency.

The reactive element 4 may consist of a capacitor 11 while the impedance 5 is a resistor 12. At very high frequencies the capacitor 11 may be afforded solely by the plate-cathode capacitance of the tube 1. At these frequencies the reactance

55

3

of the grid-cathode capacitance in tube 1 may become low enough to influence the value of the impedance 5. Preferably, for high-frequency operation, an inductive element such as a high-frequency line is connected in parallel with the resistor 12 to offset the capacitive reactance of the grid-cathode capacitance so that impedance 5 is substantially a pure resistance. The phase-splitting network tends to displace the radio-frequency voltage applied to the grid 7 of the tube substantially 90 electrical degrees with respect to the plate voltage. This phase quadrature relationship is modified by the plate-cathode impedance of tube 1 which varies with the amplitude of the modulating voltage applied to grid 7. Because of the interchange of the grid and cathode connections, as contrasted with conventional circuits, the present arrangement causes the R. F. grid voltage to be displaced more than 90° from the R. F. plate voltage, rather than being less than 90° out of phase therewith as might otherwise be the case.

The plate current flowing throughout the tube 1 may be thought of as comprising two currents, one produced by application of the R. F. plate voltage irrespective of the grid voltage, with variable plate-cathode impedance, and the other being the current produced by the effect of the R. F. grid voltage. The real components of these two plate currents, that is, those components which are capable of producing power in conjunction with the applied R. F. voltage, are in phase opposition and tend to cancel each other. In other words, the reactance tube circuit tends to supply energy to the oscillator circuit in an amount which compensates for the dissipation of oscillator power in the reactance tube circuit.

Actual tests of the above described invention have shown that the loading of the oscillator by the reactance tube is maintained substantially constant over extremely wide modulated bandwidths. The general simplicity of the circuit and its applicability to triode reactance tubes are especially advantageous at high frequencies. The Q, i. e., the ratio of reactance to resistance, of the phase-splitting network can be made very low to minimize any tendency toward parasitic oscillations at possible resonant frequencies that may exist in the reactance tube circuit.

While there has been described what is at present considered to be the preferred embodiment of the present invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention.

The invention claimed is:

1. For use in combination with the tank circuit of a radio-frequency oscillator, a reactance tube circuit comprising a vacuum tube having a plate, a cathode and a control grid, said plate being directly connected to one side of said tank circuit, means of negligible impedance at said frequency for coupling said grid to the other side of said tank circuit, a reactor connected across said plate and said cathode, an impedance connecting said cathode to said other side of said tank circuit, said reactor and said impedance together comprising a phase-splitting network, and a source of modulating voltage connected across said grid coupling means.

2. A reactance tube circuit for use in combination with a radio-frequency oscillator, said circuit comprising a two-terminal phase-splitting network, a vacuum tube having a plate, a cathode and a control grid, said plate being connected

4

to a first terminal of said network, said grid being coupled to the second terminal of said network, said cathode being connected to an intermediate point of said network, and a source of modulating voltage having output terminals respectively connected to said grid and to said second terminal of said network.

3. A reactance network for a high frequency circuit, said network comprising an electron tube having cathode, anode, and grid electrodes, couplings from the grid and anode, respectively, to points of different potential on said circuit, said couplings having substantially like impedance at said frequency, means for applying a potential to the cathode which is phase displaced approximately 90° with respect to the potentials applied to said grid and anode, and means for varying the transconductance of said tube.

4. A reactance modulating network for the resonant circuit of a radio frequency oscillator, said network comprising an electron tube having cathode, anode, and grid electrodes, couplings from the grid and anode, respectively, to points of different potential on said resonant circuit, said couplings having negligible impedance to the oscillator currents, a phase-shifting circuit for applying a potential to the cathode which is phase displaced approximately 90° with respect to the potential at the anode, and modulating means connected between the grid and cathode for varying the transconductance of the tube in accordance with a signal potential.

5. A network as set forth in claim 4, wherein said phase-shifting circuit comprises reactive and resistive elements connected in series between said points, said cathode being connected to the junction of said elements.

6. A reactance modulating network for the resonant circuit of a radio frequency oscillator, said network comprising an electron tube having cathode, anode, and grid electrodes, a coupling of negligible impedance to oscillator currents from the anode to one point on said resonant circuit, a second coupling between the grid and another point on said circuit, a phase-shifting circuit for applying a potential from said circuit to the cathode which is phase displaced approximately 90° with respect to the potential applied to the anode, and modulating means connected between the grid and cathode for varying the transconductance of the tube in accordance with a signal frequency potential, the impedance of said second coupling being negligible to oscillator currents, but high to said signal frequency potential.

7. A network as set forth in claim 6, wherein said second coupling is a blocking condenser.

8. A network as set forth in claim 6, wherein said phase-shifting circuit comprises reactive and resistive elements connected in series between said points, said cathode being connected to the junction of said elements.

9. A network as set forth in claim 8, wherein said reactive element is connected between said anode and cathode, and said resistive element is connected between said cathode and grid.

10. A network as set forth in claim 6, wherein the Q of said phase-shifting circuit is low.

11. A network as set forth in claim 6, wherein said phase-shifting means comprises capacitive reactance between the anode and cathode, said reactance being the capacity between said anode and cathode electrodes.

12. A reactance network for a high frequency circuit, said network comprising an electron tube

2,485,919

5

having cathode, anode, and grid electrodes, couplings from the grid and anode, respectively, to points of different potential on said circuit, said couplings having substantially like impedance at said frequency, means for applying a potential to the cathode which is phase displaced with respect to the potentials applied to said grid and anode, said means including a phase shifter having a reactance and a resistance in series between said points of different potential, said reactance comprising the capacity between said anode and cathode electrodes, and means for varying the transconductance of said tube.

WILLIAM R. RAMBO.

6

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,144,541	Mayer -----	Jan. 17, 1939
2,216,829	Plebanski -----	Oct. 8, 1940
2,235,565	Roberts -----	Mar. 18, 1941
2,279,660	Crosby -----	Apr. 14, 1942
2,323,598	Hathaway -----	July 6, 1943
2,349,811	Crosby -----	May 30, 1944