

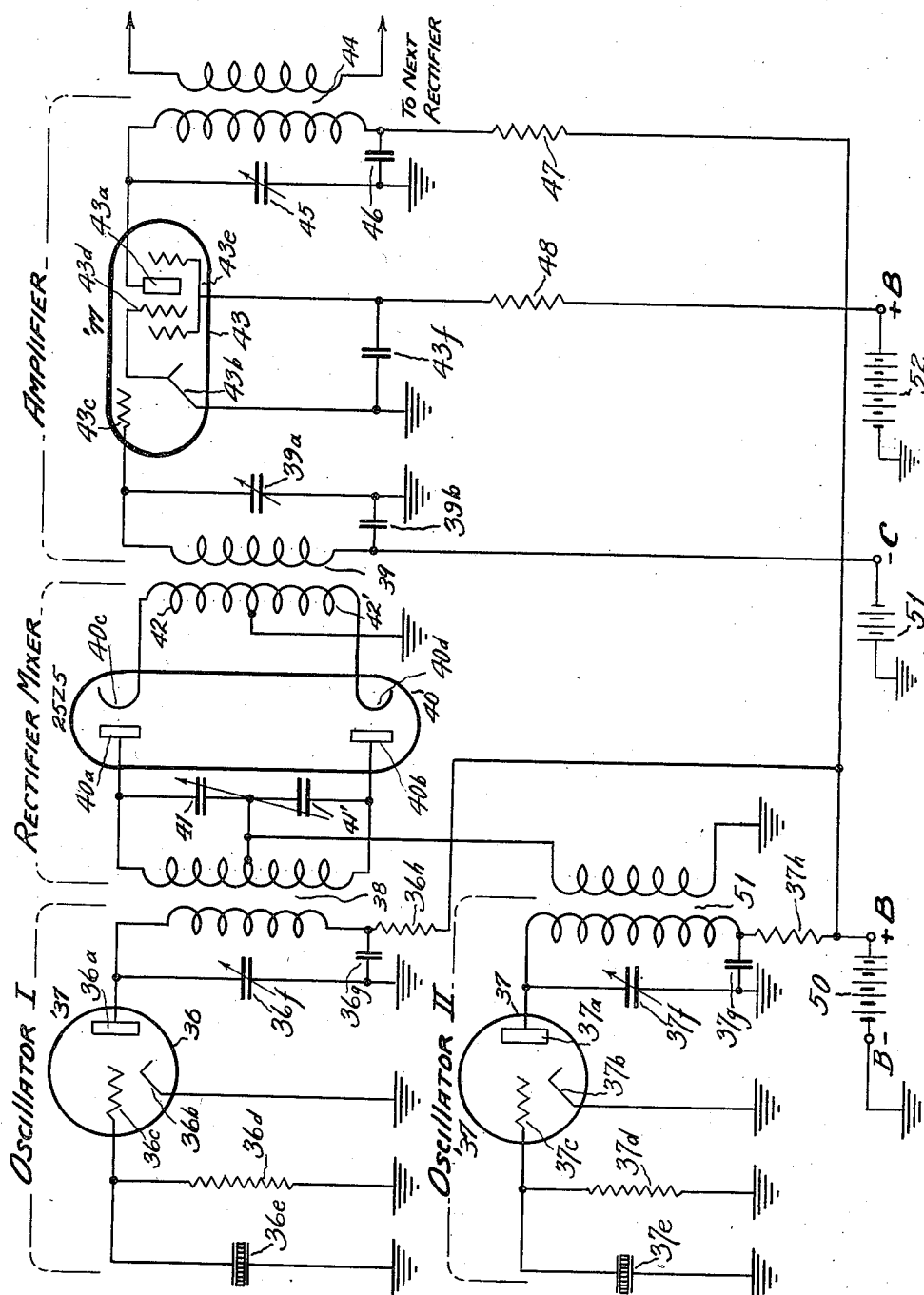
March 1, 1938.

H. GRANGER

2,110,082

ELECTRICAL OSCILLATION MIXING CIRCUIT

Original Filed July 27, 1934



INVENTOR
Harold GRANGER
BY Ben J. Chasney
ATTORNEY

UNITED STATES PATENT OFFICE

2,110,082

ELECTRICAL OSCILLATION MIXING CIRCUIT

Harold Granger, Alexandria, Va., assignor, by mesne assignments, to Bendix Radio Corporation, New York, N. Y., a corporation of Delaware

Original application July 27, 1934, Serial No. 737,309. Divided and this application January 18, 1936, Serial No. 59,770

8 Claims. (Cl. 250—36)

This invention relates to electrical circuits generally. More particularly this invention relates to modulation circuits adapted for use in signaling apparatus.

5 This application is a division of my application, Serial No. 737,309, filed July 27, 1934, for Frequency control and measuring system.

An object of my invention is to provide a balanced mixer circuit for combining two frequencies wherein undesired components of one of the frequencies are opposed and canceled in the output thereof.

Another object of this invention is to provide a modulator or mixer circuit for combining the effects of two or more varying electric currents or electric potentials without introducing the effects of undesired frequencies of one or both of the currents or potentials upon the other.

Another object of this invention is to provide an electrical circuit arrangement adapted to be balanced electrically, for mixing or modulating electric currents and/or potentials in accordance with another electric current and/or potential without introducing the effects of undesired frequencies which may be present in the circuit of the mixing or modulating current and/or potential.

Other and further objects of this invention will be apparent to those skilled in the art to which it relates from the following specification and the claims.

In accordance with this invention I provide a balanced mixer or modulator circuit arrangement employing a pair of rectifier elements or units connected between coupling units such as transformers, for the purpose of utilizing a plurality of electrical oscillations of different frequencies for deriving a predetermined frequency or frequencies therefrom. A source of electrical oscillations adapted to produce one or more predetermined frequencies is coupled to one of the coupling units and the other unit is arranged to impress the oscillations not neutralized or balanced out in the mixer circuit, on the input circuit of an amplifier or on a load circuit.

Another source of oscillations is connected to the mixer circuit between the coupling units in such a way that the oscillations therefrom are impressed across the rectifier units and between the coupling units. Electrical energy from this source of oscillations flows through the rectifiers during the portion of the cycle when the proper polarity is impressed thereon. However, an electric current from the source of oscillations coupled to one of the aforesaid coupling units flows

through the rectifiers alternately, depending on the polarity thereof, and also flows through the circuit of the second source of oscillations.

Further details of my invention will be apparent from the following specification and the drawing in which, briefly, the sole figure illustrates an embodiment of my invention.

Referring to the drawing in detail, oscillator I includes one electric discharge device 36 having anode, cathode, and grid electrodes 36a, 36b, and 36c, respectively. Grid resistor 36d and piezoelectric crystal 36e are connected between the grid 36c and the cathode 36b. An oscillatory circuit, including the primary of transformer 38, variable condenser 36f and fixed condenser 36g, is connected to the anode 36a and cathode 36b. A series resistor 36h is connected to the condenser 36g and the primary of transformer 38 and to the source of anode current supply 50, for the purpose of reducing the voltage of this supply. A similar resistor 37h is connected to the primary of transformer 51.

Oscillator II includes an electric discharge device 37 having anode, cathode, and grid electrodes 37a, 37b, and 37c, respectively, connected to the grid resistor 37d and crystal 37e and to the oscillatory circuit, including the primary of transformer 51, variable condenser 37f and fixed condenser 37g, in substantially the same manner as electric discharge device 36 is connected to corresponding elements and units.

The secondary of transformer 38 is connected to the anodes 40a and 40b of the rectifier 40. Variable condensers 41 and 41', adapted to be adjusted as a single unit, if desired, are connected across the secondary of transformer 38 and the connection between these condensers is connected substantially to the mid-point of the secondary. The secondary of transformer 51 is also connected to condensers 41 and 41' and to the midpoint of the secondary of transformer 38, aforesaid.

Transformer 39 is provided with a primary divided into two sections 42 and 42'. One of the sections 42 is connected to the cathode 40c of rectifier 40 and the other section 42' is connected to cathode 40d of this rectifier unit. The common connection of the sections 42 and 42', corresponding substantially to the midpoint, is connected to ground, that is, the metal chassis on which the apparatus is mounted. The secondary of transformer 51 is also connected to the ground, aforesaid; thus the primary sections 42 and 42' are connected to this secondary.

Pentode electric discharge device 43, having

anode 43a, cathode 43b and three grid-like electrodes 43c, 43d, and 43e, respectively, is employed as an amplifier. The oscillatory circuit including the secondary of transformer 39, variable condenser 39a and fixed condenser 39b is connected to the grid 43c and cathode 43b of device 43. A "C" battery 51 or similar source of current supply, is connected to the secondary of transformer 39 to furnish a bias potential for the grid 43c with respect to the cathode 43b.

The primary and secondary of the transformer 39 are closely coupled so that the tuning of one, for example, the secondary, has the effect of tuning the other, for example, the primary, also.

An oscillatory circuit, including the primary of transformer 44, variable condenser 45 and fixed condenser 46, is connected between the anode 43a and cathode 43b of device 43. A bypass condenser 43f is provided between the electrode 43a and cathode 43b. A voltage reducing resistor 47 is provided to the anode circuit of the device 43a and a similar resistor 48, which may be of a different value, however, is provided to the circuit of the grid-like electrode 43e. These resistors 47 and 48 and resistors 36h and 37h may be dispensed with if the current supply sources 50 and 52 are of the proper potential for the electric discharge devices energized. The current supply sources 50, 51, and 52 may be combined into one unit, if desired, and where available a source of direct current or rectified alternating current obtained from a suitable generator or generators, may be used.

The balanced rectifier circuit of my invention operates as follows: Oscillator I is adjusted to produce oscillations of a certain frequency and impress those oscillations on the secondary of transformer 38. Thus alternately the anodes 40a and 40b of the rectifier have impressed thereon positive and negative potentials through the action of the oscillator I. The secondary of transformer 51, being coupled to oscillator II, impresses oscillations from this oscillator between the midpoint of the secondary of transformer 38 and the midpoint of the primary of transformer 39. Thus oscillator II alternately impresses a positive potential and a negative potential on both of the anodes 40a and 40b.

Since the anodes 40a and 40b are connected to opposite terminals of the secondary of transformer 38, it is apparent that a circulating current due to the potential produced by oscillator I cannot be obtained through both of the rectifier paths, the primary of transformer 39 and secondary of transformer 38, other than through the secondary of the transformer 51.

One half of the potential impressed across the secondary of transformer 38 is thus employed to transmit a current through the rectifier sections alternately depending on whether anode 40a or 40b is positive. The secondary of transformer 51 is employed as a return circuit and when the terminal of this secondary connected to the midpoint of the secondary of transformer 38, is positive, the potential developed in the secondary of transformer 51 adds to the potential of either half of the secondary of transformer 38, depending upon which half of the latter secondary is transmitting current through the rectifier 40. This condition prevails even if the frequency of oscillator II is lower than the frequency of oscillator I except that when the frequency of oscillator II is lower than that of oscillator I, the potential developed in the secondary of transformer 51, during the half cycle when this secondary im-

presses a positive potential on the midpoint of the secondary of transformer 38, may add consecutively to the potentials developed in the two halves of the latter secondary.

Under certain conditions when the circuits of the rectifiers are perfectly symmetrical with respect to secondary of the transformer 51 the effects of oscillations impressed on the rectifiers from this transformer may be neutralized in the primary of the output transformer 39, when no oscillations are fed to the rectifiers from oscillator I. When oscillations are fed to the rectifiers from oscillator I the total effects of these oscillations and those derived from oscillator II are not neutralized in the transformer 39, inasmuch as the rectifiers are not operated simultaneously under equal load conditions. The rectifiers, having non-linear input-output characteristics, cause currents of substantially different magnitudes to flow in the primary sections 42 and 42', the effects of which are not neutralized, when both oscillators I and II are energizing the rectifiers. In this manner the sum and difference frequencies of the oscillators I and II may be derived from the output transformer of the rectifiers, to the exclusion of the fundamental frequencies of these oscillators.

While I have described this invention in detail in a preferred embodiment, it will be observed that modifications therein may be made without departing from the spirit and scope thereof and therefore I do not desire to limit this invention to the details set forth except insofar as those details may be defined by the claims.

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

1. In an oscillation mixing circuit the combination of a pair of devices having non-linear resistance characteristics, input and output poles thereon, an input circuit connected between like poles of said devices, an output circuit connected between the other like poles of said devices, one of said devices and half of said input and said output circuits being symmetrical to the other of said devices and the other half of said input and said output circuits, an oscillation generator coupled to said input circuit for impressing potentials of unlike polarities upon corresponding parts of each of said symmetrical circuits, a second oscillation generator for impressing potentials of like polarities across each of said symmetrical devices, and a load circuit coupled to said output circuit.

2. In an oscillation mixing circuit the combination of a pair of electric discharge device rectifiers each having an anode and a cathode, an input circuit connected between the anodes of said rectifiers, an output circuit connected between the cathodes of said rectifiers, a source of electrical oscillations coupled to said input circuit, a second source of electrical oscillations, means for connecting said second source of oscillations to said output circuit and to said input circuit for impressing similar electrical potentials across said rectifiers simultaneously, and a load circuit coupled to said output circuit.

3. In an oscillation mixing circuit the combination of a pair of rectifiers, each of said rectifiers having a pair of terminals, one of each of said pair of terminals being positive in polarity and the other negative, an input transformer having a secondary connected between terminals of like polarities of said rectifiers, an output transformer having a primary connected between the other terminals of like polarities of said

rectifiers, a source of electrical oscillations coupled to the primary of said input transformer, a second source of electrical oscillations, means for connecting said second source of electrical oscillations between the electrical midpoints of said input transformer secondary and said output transformer primary and a load circuit coupled to said output circuit.

4. In an oscillation mixing circuit the combination of a pair of rectifier units, an input transformer having a secondary connected between like poles of said rectifiers, an output transformer having a primary connected between the other like poles of said rectifiers, one of said rectifiers and half of said input transformer secondary and said output transformer primary being symmetrical to the other of said rectifiers and the other half of said input transformer secondary and said output transformer primary, an oscillation generator coupled to said input transformer for impressing potentials of unlike polarities upon said symmetrical rectifier units, a second oscillation generator for impressing potentials of like polarities across said symmetrical rectifier units, and a load circuit coupled to said output circuit.

5. In an oscillation mixing circuit the combination of a pair of electric discharge device rectifiers each having an anode and a cathode, an input transformer having a secondary connected between the anodes of said rectifiers, an output transformer having a primary connected between the cathodes of said rectifiers, a source of electrical oscillations coupled to said input transformer, a second source of electrical oscillations, means for connecting said second source of oscillations to the secondary of said input transformer and to the primary of said output transformer for impressing similar electrical potentials across said rectifiers simultaneously, and a load circuit coupled to said output circuit.

6. In an oscillation mixing circuit the combination of a pair of electric discharge device

rectifiers each having an anode and a cathode, an input circuit connected between the anodes of said rectifiers, an output circuit connected between the cathodes of said rectifiers, one of said rectifiers and half of said input and said output circuits being symmetrical to the other of said rectifiers and the other half of said input and said output circuits, an oscillation generator coupled to said input circuit for impressing potentials of unlike polarities upon said symmetrical rectifier units, a second oscillation generator for impressing potentials of like polarities across said symmetrical rectifier units, and a load circuit coupled to said output circuit.

7. In an oscillation mixing circuit the combination of a pair of rectifiers having input and output poles, each of said rectifiers having non-linear output characteristics, an input circuit connected between like poles of said rectifiers, an output circuit connected between the other like poles of said rectifiers, a source of electrical oscillations coupled to said input circuit, a second source of electrical oscillations, means for connecting said second source of electrical oscillations between the electrical midpoints of said input and said output circuits, and a load circuit coupled to said output circuit, said rectifiers and said input and output circuits being adjusted substantially to neutralize the effects of individual ones of said oscillation sources and to transmit only the effect of the combined efforts of said oscillation sources to said load circuit.

8. In an oscillation mixing circuit, rectifying elements having anodes and cathodes, an input circuit connecting said anodes in phase opposition, a first oscillator connected with said input circuit, an output circuit connecting said cathodes in phase opposition, a second oscillator connected to said anodes in parallel relationship, said second oscillator being symmetrically connected in circuit to said input and said output, and a load circuit coupled to said output circuit.

HAROLD GRANGER.