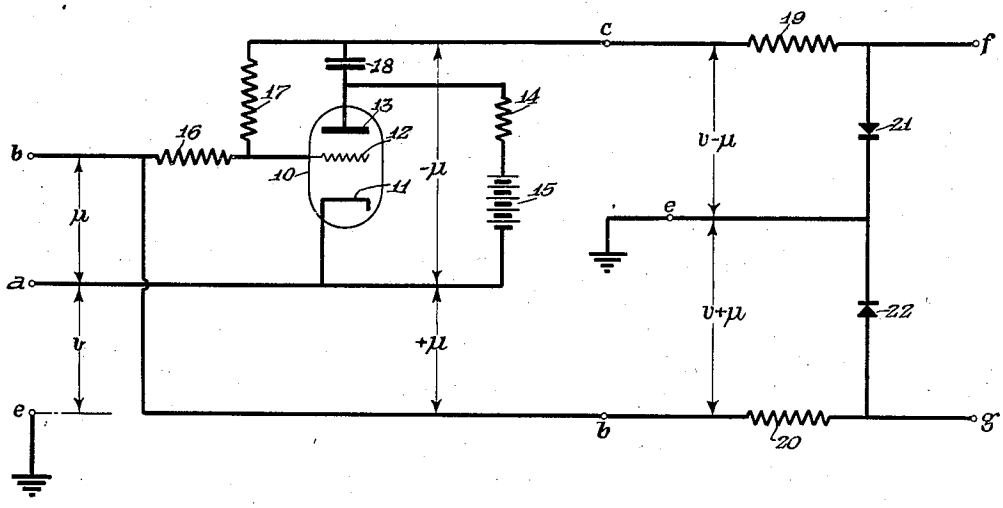
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MODULATING CIRCUIT

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MODULATING CIRCUIT

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This application is a continuation in part carved out from Serial No. 190,940 filed February 17, 1938, Patent No. 2,164,402, issued July 4, 1939, entitled "Electrical circuits."

In the above mentioned application there is shown and described an electrical network embodying a vacuum tube of standard construction having at least a cathode, a grid and an anode and serving as a phase inverting element to change the phase of an alternating potential by substantially 180°, such as required in the driver stage of a resistance coupled push-pull amplifier or for any other use.

The object of the present invention is to utilize a phase inverting system of the type described in the parent application or of a similar construction embodying a vacuum tube as a phase inverting element and comprising substantially non-reactive impedance elements only for the purpose of combining two alternating currents or potentials of like or different frequencies by mutual inter-modulation or production of a resultant current or potential being a product function of the currents or potentials being combined.

According to the invention, the phase inverting circuit is employed to produce sum and difference potentials from a pair of alternating potentials or signals such as a potential of higher (carrier) frequency and a potential of lower (modulating) frequency. The obtained sum and difference potentials are separately rectified and the rectified potentials added in series in opposed polarity relation to obtain a resultant output potential which is a product function of the instantaneous magnitudes of the input potentials being combined. When using a carrier and modulating potential as pointed out, the resultant output will be a modulated carrier similar as obtained by means of other known modulating arrangements in the art. A characteristic of the invention compared with the prior art devices and arrangements is the fact that substantially no reactive elements are required in the modulating system, resulting in an elimination of distortions and other advantageous effects desirable in many instances.

A special application of the invention relates to the combination or mutual inter-modulation of alternating potentials of like frequency in which case the resultant output potential contains a uni-lateral or direct current component which varies directly in proportion to the relative phase angle between the potentials being combined. Accordingly, the invention is well suited for phase indication or comparison having the advantage over similar arrangements that substantially no reactive impedance elements are required in the circuit, thereby avoiding spurious and other undesirable phase shifts interfering with the accuracy and stability of the phase indication and/or translation.

Further objects and advantages of the invention will become more apparent from the following description taken in reference to the accompanying drawing illustrating a circuit diagram of an arrangement for carrying out the invention.

Referring to the drawing, a first input potential u, which may be a carrier potential of relatively high frequency, is applied to the circuit by way of input terminals a, b. Similarly, a second input potential v which may be a modulating potential of relatively low frequency is applied to the circuit by way of input terminals a, e, the latter in the example shown being connected to ground or any other reference or datum potential point of the system.

There is shown at 10 a vacuum tube of known construction comprising at least a cathode 11, grid 12 and anode or plate 13. The anode-cathode path of the tube is shunted by a high potential source 15 which may be a battery or the like in series with an alternating current impedance 14 to supply anode operating potential to the tube in a manner well understood. The input terminal b is connected to an output terminal c through a voltage divider arrangement comprising in the example a pair of resistances 16 and 17 connected in series. The grid 12 of the tube 10 is connected to an intermediate point of the voltage divider, in the example shown to the common junction point between the resistances 16 and 17, while the anode is connected to the output terminal, preferably by way of an electric condenser 18.

A vacuum tube circuit of the aforedescribed type constitutes a highly stabilized phase inverter adapted to produce a negative potential $-u$ between the output terminal c and the cathode (terminal a) from the applied input potential $+u$ impressed by way of input terminals a, b. As explained in the parent application, a negative feedback effect from the anode 13 to the grid 12 through the condenser 18 and resistance 17 causes the phase inverted potential to be of substantially constant and invariant amplitude and substantially independent of variations of the tube characteristics. In other words, the inverse feedback may be such as to cause the amplification by the tube to be considerably

reduced or practically to be suppressed, thereby greatly stabilizing the operation, it being only desired to obtain potentials $-u$ and $+u$ of the same amplitude.

From the arrangement shown, it is seen that there are produced in the above described manner sum and difference potentials $(v+u)$ and $(v-u)$, respectively, between the datum point e and the terminal b on the one hand and between the datum point e and the terminal c on the other hand. These sum and difference potentials which may be utilized for any desired purpose are, in the example shown, separately rectified by means of rectifiers 21 and 22 having smoothing impedances 19 and 20 connected in series therewith and arranged in opposition to each other. The rectifiers 21 and 22 are directly connected in series with their common junction point connected to the datum point e, while the outer ends of the rectifiers are connected to the terminals b and c through resistors 19 and 20, respectively. Further smoothing elements such as resistors and condensers may be provided if desirable to obtain a filtered output current of desired characteristics.

With an arrangement as aforedescribed there is obtained between the output terminals g and f a potential or current being a product function of the instantaneous values of the impressed input potentials u and v. If one of these potentials is a carrier of relatively high frequency and the other potential has a relatively low (modulating) frequency, a modulated carrier current is obtained at the terminals g and f which may be used for signaling or any other purpose.

If the potentials u and v are of the same frequency the intermodulation product obtained at terminals g and f will contain a uni-directional or direct current component varying directly in proportion to the relative phase angle between the applied potentials. This phase responsive current may be extracted by adequate filtering from the output product and serve to indicate the phase angle between two potentials one of which may have a fixed standard phase while the other is of variable phase. In this manner the invention may advantageously serve as a phase demodulator for receiving frequency and/or phase modulated signals.

Another use of the invention relates to the production of a tuning discriminating potential in a radio receiver embodying an automatic tuning arrangement of known construction wherein deviations from the exact tuning of the receiver are manifested by a varying phase of a portion of the signal energy extracted from a suitable part of the receiver such as the intermediate section in a superheterodyne system. This signal current of varying phase characteristic of the amount of receiver detuning is converted into a direct current by means of an arrangement according to the invention which direct current serves as a tuning control (AFC) current to adjust an electric tuning correcting device in the local oscillator circuit such as a vacuum tube arranged to form a variable reactance (condenser or inductance) operatively associated with the oscillatory circuit of the local oscillator.

The invention has many other uses wherever it is desired to translate variations of the relative phase angle between two alternating currents or potentials into corresponding variations of a uni-lateral current especially for indicating and controlling purposes.

As will be evident from the above, the invention is not limited to the specific circuit arrangement and details disclosed and shown herein for illustration, but that the underlying thought and principle of the invention are subject to numerous modifications and variations coming within the broad scope and spirit of the invention as defined in the appended claims. The specification and drawing are accordingly to be regarded in an illustrative rather than a limiting sense.

I claim:

1. In an electrical system, a pair of input circuits with means for impressing thereon separate alternating potentials, a vacuum tube phase inverter for producing a phase inverted potential from the first alternating potential, means for combining both said first alternating potential and said phase inverted potential with the second alternating potential to form sum and difference potentials, means for rectifying the sum and difference potentials, and means for differentially combining the rectified potentials.

2. In an electrical network comprising three input terminals, means to impress a first alternating potential between the first and second input terminal, further means to impress a second alternating potential between the first and third input terminal, a vacuum tube having at least a cathode gride and an anode, said cathode being connected to the first input terminal, a potential divider connected between said second input terminal and said anode, and a connection from an intermediate point of said potential divider to said grid thereby to produce the sum and difference of said alternating potentials between said third input terminal and said second input terminal on the one hand and between said third input terminal and said anode on the other hand.

3. In an electrical network comprising three input terminals, means to impress a first alternating potential between the first and second input terminal, further means to impress a second alternating potential between the first and third input terminal, a vacuum tube having at least a cathode grid and an anode, said cathode being connected to said first input terminal, an output terminal coupled with said anode, a potential divider connected between said second input terminal and said output terminal, a connection from an intermediate point of said potential divider to said grid thereby to produce the sum and difference of said alternating potentials between said third input terminal and said second input terminal on the one hand and between said third input terminal and said output terminal on the other hand, means for separately rectifying the sum and difference potentials, and means for differentially combining the rectified potentials.

4. In an electrical network comprising three input terminals, means to impress a first alternating potential between the first and second input terminal, further means to impress a second alternating potential between the first and third input terminal, a vacuum tube having at least a cathode grid and an anode, said cathode being connected to said first input terminal, a first output terminal coupled to said anode and a second output terminal connected to said second input terminal, potential divider connected between said second input terminal and said first output terminal, a connection from an intermediate point of said potential divider to said grid thereby to produce the sum and difference of said alternating potentials between said third input terminal and said second output ter-

minal on the one hand and between said third input terminal and said first output terminal on the other hand, a pair of rectifiers connected in series between said output terminals with their current passing directions opposed to each other, and a connection from the common junction of said rectifiers to said third input terminal.

5. In an arrangement as claimed in claim 4 including an impedance inserted between each of said output terminals and said rectifiers.

6. In an arrangement as claimed in claim 4 including a condenser coupling said first output terminal with said anode, and a source of space current connected between said anode and cathode.

7. An electrical system for mutually inter-modulating a pair of alternating potentials comprising an electron tube circuit for producing a phase inverted potential from the first of said alternating potentials, negative feedback means to substantially suppress the amplifying gain of said tube, means for serially combining both said first alternating potential and its corresponding inverted potential with said second alternating potential to produce sum and difference potentials of said alternating potentials, means for rectifying said sum and difference potentials, and further means for differentially combining the rectified potentials.

8. An electric current system for mutually inter-modulating a first and second alternating potential comprising a vacuum tube circuit for producing a phase inverted potential from the first of said alternating potentials, inverse feedback means for substantially suppressing the amplifying gain of said tube, means for serially combining both said first alternating potential and its corresponding inverted potential with said second alternating potential to produce sum and difference potentials of said first and second alternating potentials, means for separately rectifying said sum and difference potentials, and further means for differentially combining the rectified potentials.

9. An electrical system comprising three input terminals, means to impress a first alternating potential upon the first and second input terminals, further means to impress a second alternating potential upon the first and third input terminals, an electron tube having at least a cathode, a grid and an anode, said cathode being connected to the first input terminal, a potential divider connected between the second input terminal in said anode, a connection from an intermediate point of said potential divider to said grid thereby to produce the sum and difference of said alternating potentials between said third input terminal and said second input terminal on the one hand and between said third input terminal and said anode on the other hand, a first branch circuit including a rectifier and an impedance in series connected between the anode and said third input terminal, a second branch circuit comprising a rectifier and an impedance in series connected between said second and third input terminals, said rectifiers being arranged in opposite polarity relation with respect to said third input terminal, and means for deriving an output voltage from points of said branch circuits being electrically symmetrical with respect to said third input terminal.

10. In an electrical system, a first and second source of alternating potential, an electron tube having a cathode, an anode and at least one grid, an input circuit connected to said grid and an output circuit connected to said anode, means for coupling said first source to said input circuit to produce a phase inverted potential in said output circuit, inverse feedback means for substantially suppressing the amplifying gain of said tube, means including circuit connections between said first and second source and said tube for additively combining both said first alternating potential and said phase inverted potential with said second alternating potential to produce sum and difference potentials of said first and second alternating potentials, means for separately rectifying said sum and difference potentials, and means for producing a differential potential from the rectified potentials.

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