Dec. 30, 1952 J. J. Z. VAN ZELST 2,623,955

CIRCUIT FOR AMPLIFYING ELECTRICAL OSCILLATIONS WITH A CONSTANT AMPLIFICATION FACTOR

Filed Aug. 2, 1948

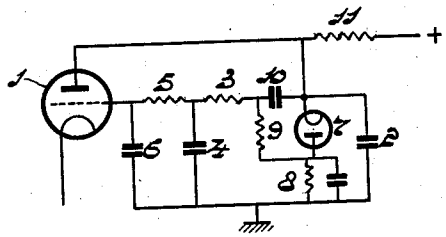


Fig. 1

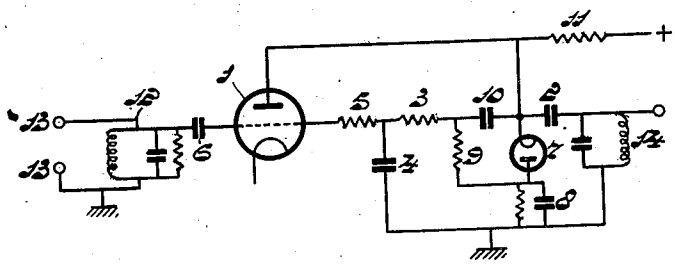


Fig. 2

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Patented Dec. 30, 1952 2,623,955

UNITED STATES PATENT OFFICE

2,623,955

CIRCUIT FOR AMPLIFYING ELECTRICAL OSCILLATIONS WITH A CONSTANT AMPLIFICATION FACTOR

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Application August 2, 1948, Serial No. 41,926
In the Netherlands August 25, 1947

5 Claims. (Cl. 179—171)

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This invention relates to an improvement in or modification of the invention described and claimed in my copending application Serial Number 684,071, filed July 16, 1946, now issued as Patent No. 2,544,132, May 22, 1951. In said copending application a circuit-arrangement is described for amplifying electrical oscillations with the use of electric discharge tubes, the ratio between the output and the input voltages of the amplifier (amplification factor) having a constant or substantially constant value.

The above-identified copending application describes, inter alia a circuit-arrangement which self oscillates at an auxiliary frequency lying without the frequency range of the oscillations to be amplified, said auxiliary frequency having derived from it, by detection a control voltage, with the use of which the amplification factor of the amplifier is controlled.

In this case the amplification factor of the circuit arrangement is found to vary only with the value of the impedances included in the feedback circuit for the auxiliary frequency and of the impedances included in the amplification channel of the frequency to be amplified.

The invention relates to a circuit-arrangement in which the influence of variations or divergence of these impedances at given amplification is cut down to a minimum value.

According to the invention the feedback circuit for the auxiliary frequency is constituted by a phase-shifting network which is built up from resistances and reactances and which in addition to the anode resistance of the discharge tube comprises at least one further resistance these resistances and reactances being proportioned to be such that the quotient of the transfer impedance of the network in the proximity of the auxiliary frequency and the output resistance may be represented approximately by a whole negative power of a linear form in the frequency. A more detailed discussion of the theory underlying the present invention, as well as a full mathematical treatment thereof may be found in the article appearing in the Philips Technical Review, vol. 9, No. 9, pages 309 to 315, published March 1948 and entitled "Constant amplification in spite of changeability of the circuit elements."

In order that the invention may be more clearly understood and readily carried into effect, it will now be described more fully with reference to the accompanying drawing, in which Fig. 1 shows an oscillator circuit known per se which comprises a discharge tube 1, represented, for

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the sake of simplicity by a triode, the anode circuit of which is connected through a phase-shifting network to the grid circuit. This phase-shifting network has several, say 3, sections comprising the output resistance 11 and a capacity 2, a resistance 3 and a capacity 4, a resistance 5 and a capacity 6. This circuit will self-oscillate at a frequency such that the total phase-shift effected by this network for this frequency is equal to 180°. In order to reduce conductance variations of the tube 1, the oscillations produced are detected with the use of, for example, a diode 7 and its output filter 8 and the voltage produced across this output filter 8 is then fed, through a grid leak 9, to the grid of the discharge tube 1. A blocking condenser for the direct anode voltage is designated 10.

Owing to this measure the mutual conductance of the discharge tube 1 varies only with the value of the impedances included in the phase-shifting network, since for self oscillation the condition applies that the mutual conductance S of the tube is adjusted to be such that $SZ=1$, in which Z designates the transfer impedance (i. e. the ratio between the ouput voltage and the input current) of the feedback network. A variation of the impedances included in the feedback circuit or a divergence between the relative values of these impedances with various identical amplifiers will be responsible for the fact that in spite of the control of the mutual conductance as a function of the amplitude of the oscillations produced, the amplification factor Sr of the circuit arrangement (in which r designates the value of the output resistance 11) is not adjusted to the same value.

According to the invention, the phase-shifting network is built up in such manner that the quotient Z/r of the transfer impedances Z and the output resistance r in the proximity of the auxiliary frequency produced may approximately be denoted by $Z/r=(c_1+jc_2w)^{-n}$, in which c_1 and c_2 are constants, n a constant whole number and w denotes frequency.

The transfer impedance Z of an electric quadripole may generally be represented by the quotient of two higher-power functions of the frequency the coefficients of which are functions of the impedances included in the quadripole. If in adidtion to the output resistance r of the discharge tube such a quadripole comprises at least one further resistance, as explained in the above-identified publication calculation reveals that, if in the proximity of the auxiliary frequency Z/r may be represented approximate-

ly by $(c_1+jc_2w)^{-n}$ a small variation of one of the impedances of the phase-shifting network results in that for this auxiliary frequency (at which the network consequently has to perform a phase-shift equal to a whole multiple of 180°) the amplification factor Sr of the circuit-arrangement has remained substantially unaltered.

The phase-shifting network may be built up more particularly from sections as shown in the figures. In this case, the above feature, to the neglect of the relative load, is apparent from that in the proximity of the auxiliary frequency each section produces an equal phase shift of this frequency. It is consequently found that in this case the quotient Z/r of the phase-shifting network varies least with small variations of divergence of the value of these impedances.

Fig. 2 shows, by way of example, one form of circuit-arrangement according to the invention, the capacity 6 of the phase-shifting network being connected in series with an oscillatory circuit 12, to which the oscillations to be amplified are fed by way of input terminals 13, and the capacity 2 of the phase-shifting network being connected in series with a circuit 14, from which the output oscillations are taken. Since the circuits 12 and 14, which are tuned to the frequency of the oscillations to be amplified, exhibit substantially no impedance for the auxiliary frequency, this impedance will scarcely influence the auxiliary frequency.

In a circuit-arrangement comprising a discharge tube and a phase-shifting network built up from three sections, as shown in Fig. 2, the phase-shift per section is, if the sections load one another to a small extent, equal to 60° and Z/r equal to ⅛. The amplification realized with such a circuit-arrangement is thus equal to 8. If the sections load one another any value of the amplification factor between 4 and 10 is obtainable in the case of suitable proportioning. Provision must be made by suitable proportioning of the impedances, for example of the resistance 9 and the capacity 10, to see that the circuit-arrangement does not self oscillate at a frequency lower than the desired auxiliary frequency.

What I claim is:

1. A circuit arrangement for amplifying signals lying within a predetermined frequency range with constant gain comprising an oscillating and amplifying system for said signals provided with means to control the amplification thereof and including an electron discharge tube having a cathode, a grid and an anode and an output resistance connected to said anode, feedback means for sustaining said system in oscillation at an auxiliary frequency lying outside said predetermined range and including an aperiodic phase-shifting network coupled between said anode and said grid and formed by resistance-reactance sections connected in cascade relation, said output resistance constituting the resistance in one of said sections, means to detect the auxiliary frequency oscillations generated by said system to produce a control voltage, and means to apply said voltage to the amplification control means of said system to maintain constant gain.

2. A circuit arrangement for amplifying signals lying within a predetermined frequency range with constant gain comprising an oscillating and amplifying system for said signals provided with

means to control the amplification thereof and including an electron discharge tube having a cathode, a grid and an anode and an output resistance connected to said anode, feedback means for sustaining said system in oscillation at an auxiliary frequency lying outside said predetermined range and including a phase-shifting network coupled between said anode and said grid and formed by resistance-reactance sections connected in cascade relation, said output resistance constituting the resistance in one of said sections, said network being characterized in the vicinity of said auxiliary frequency by a value of transfer impedance which when divided by the value of said output resistance may be represented approximately by $(c_1+jc_2w)^{-n}$ where c_1 and c_2 are constants, n is a constant whole number and w denotes frequency, means to detect the auxiliary frequency oscillations generated by said system to produce a control voltage, and means to apply said voltage to the amplification control means of said system to maintain constant gain.

3. An arrangement, as set forth in claim 2, in which the reactances in said sections of said phase-shifting network are constituted by capacitances and wherein said sections have resistance-capacitance values producing a phase-shift for the auxiliary frequency which is substantially equal for all sections.

4. An arrangement, as set forth in claim 2, wherein said network is constituted by three resistance-capacitance sections each producing a 60 degree phase-shift.

5. A circuit arrangement for amplifying signals lying within a predetermined frequency range with constant gain comprising an oscillating and amplifying system for said signals including an electron discharge tube having a cathode, a grid and an anode, a resonant input circuit connected to said grid for applying the signals thereto and an output resistance connected to said anode, feedback means for sustaining said system in oscillation at an auxiliary frequency lying outside said predetermined range and including a phase-shifting network coupled between said anode and said grid and formed by resistance-capacitance sections connected in cascade relation, one of said sections being constituted by said output resistance, said network being characterized by a value of transfer impedance which when divided by the value of said output resistance may be represented approximately by $(c_1+jc_2w)^{-n}$, where c_1 and c_2 are constants, n is a constant whole number and w denotes frequency, a detector coupled to said output resistance to rectify the auxiliary frequency oscillations developed thereacross, means to filter the rectified oscillations to produce a control voltage, and means to apply said control voltage to said grid to maintain constant gain.

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