April 11, 1950 H. A. BROOS 2,503,996

CIRCUIT ARRANGEMENT FOR THE EXPANSION OF ELECTRICAL OSCILLATIONS

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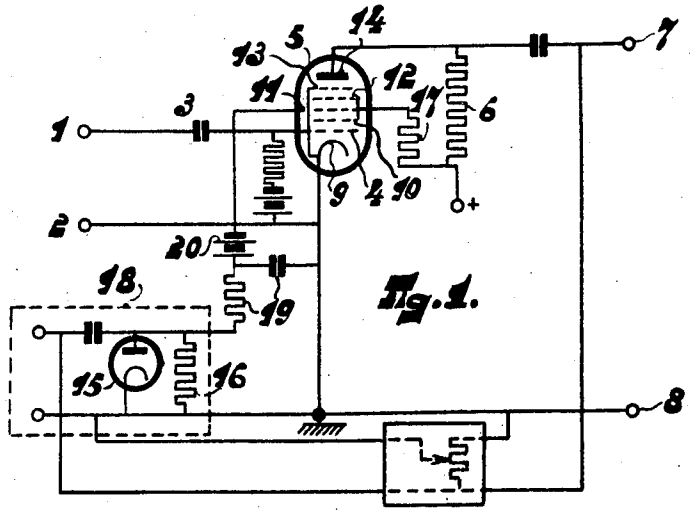


Fig. 1.

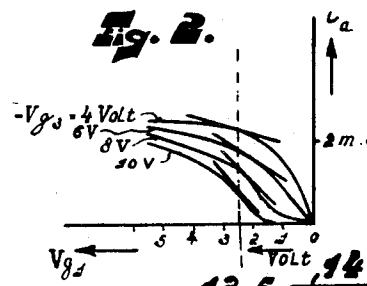


Fig. 2.

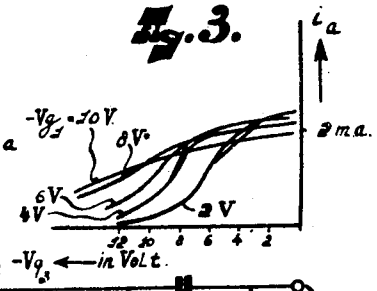


Fig. 3.

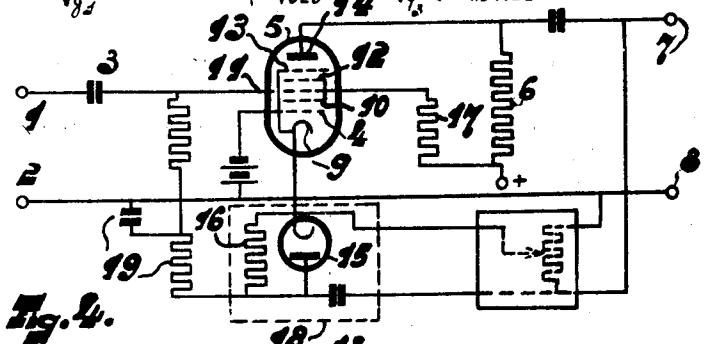


Fig. 4.

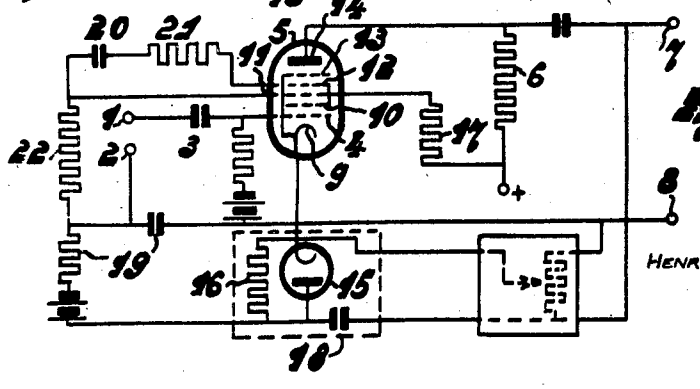


Fig. 5

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CIRCUIT ARRANGEMENT FOR THE EXPANSION OF ELECTRICAL OSCILLATIONS

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7 Claims. (Cl. 179—171)

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This invention relates to a circuit arrangement for expanding electrical oscillations. The expression "expand" is to be construed in the present case to mean the transmission of the electrical oscillations in such a manner that they are stronger transmitted according as their amplitude is larger.

For the expansion of electrical oscillations it is known to make use of a multi-grid tube, for instance a hexode comprising a cathode, a control-grid, a screen-grid, a second control-grid, a second screen-grid and an anode, the oscillations being supplied to the first control-grid and a control-voltage depending on the amplitude of the oscillations being fed to the second control-grid. When the control voltage is applied to the second control-grid with such a polarity that with an increase in amplitude this grid acquires a more positive voltage with respect to the cathode, the oscillations appearing in the anode circuit of the tube are expanded.

The control voltage is obtained by rectifying the oscillations by means of a control rectifier, thus obtaining a direct voltage which depends on the amplitude of the oscillations. When making use of a discharge tube, for instance, a diode, to constitute the control rectifier, and the rectified voltage is taken from a resistance connected between the anode and the cathode of the diode, the resistance-end connected to the cathode must be connected to the second control-grid of the controlled hexode to ensure that with an increase in amplitude of the oscillations to be expanded this grid acquires a more positive voltage. This results in that the cathode of the control rectifier and the cathode of the controlled hexode cannot have the same potential, which is often objectionable.

The invention has for its object to provide a circuit arrangement in which this evil is cured and, consequently, the cathode of the control-rectifier and the cathode of the controlled tube can be kept on the same potential and incorporated in one tube having a common anode.

When making use of a circuit arrangement comprising a plurality of discharge tubes the cathode of the control-rectifier need not be common to that of the hexode, since in this case it may equally well form part of the cathode of another discharge tube.

In a circuit arrangement for the expansion of electrical oscillations by means of discharge tubes comprising a cathode and, reckoned from the cathode onwards, successively at least one first control-grid, one screen-grid, a second control-grid, a second screen-grid and an anode, the oscillations being fed to one of the control-grids and a control-voltage, which depends on the amplitude of the oscillations, being fed to the second control-grid, a resistance is inserted, according to the invention, in a circuit common to the two screen-grids, which resistance has such a size that the mutual conductance of the characteristic curve representing the anode current as a function of the voltage set up at the control grid to which the oscillations are supplied increases with an increase in negative control-voltage.

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Figure 1 of the drawing represents one form of construction of the circuit according to the invention. The oscillations to be expanded are fed, through the intermediary of the input terminals 1, 2 of the circuit arrangement and a grid condenser 3, to the first control-grid 4 of a discharge tube 5. The expanded oscillations are set up across a resistance 6, which is inserted in the anode circuit of the tube, and are taken from the output terminal 7, 8. The tube 5 comprises the aforesaid first control-grid 4 and in addition a cathode 9, a first screen grid 10, a second control-grid 11, a second screen-grid 12, a suppressor grid 13 which is connected to the cathode 9, and an anode 14. The screen-grid circuit in common comprises a resistance 17 whose size and consequently the potential of the screen-grids is so chosen that the mutual conductance of the characteristic curve, which represents the anode-current as a function of the voltage set up at the control grid, to which the oscillations are supplied, increases with an increase in negative control-voltage. A voltage taken from the output terminals 7, 8 is added to the control detector 18. The control-detector consists of a diode 15 and a resistance 16, by which the anode is connected to the cathode of the diode and through which the control-voltage is taken. The cathode of the diode and the cathode of the discharge tube 5 have the same potential and the anode of the diode is connected through a smoothing filter 19 and a constant negative bias 20 to the second control grid 11 of the tube 5. In the arrangements hitherto known, in which the resistance 17 is missing, no expansion but compression of the electrical oscillations to be transmitted by the circuit is obtained i. e. oscillations having a large amplitude are amplified by the circuit to a lower degree than oscillations having a small amplitude. In fact, with a decrease in amplitude of the oscillations supplied to the output terminals 1 and 2 the control volt-

age derived from the oscillations taken from the output terminals 7 and 8 will decrease so that the voltage V_{g3} of the second control-grid 11 increases, and in the circuits hitherto known the mutual conductance of tube 5 increases at the same time, as a result of which the amplification increases. Hence, since the oscillations having a small amplitude are more amplified than oscillations having a large amplitude there occurs compression of the oscillations to be transmitted.

The screen-grid resistance 17 in common and the resistance 6 of the anode circuit of tube 5 is, according to the invention, given such a value that at definite values V_{g3} of the second control-grid voltage the relation illustrated in Figure 2 exists between the anode current i_a and the first control-grid voltage V_{g1}. From Figure 2 it appears that with a definite value of the first control grid voltage the mutual conductance

$$\frac{\Delta i_a}{\Delta V_{g1}}$$

of the tube 5 decreases as the voltage of the second control-grid V_{g3} becomes less negative. Consequently, in the circuit arrangement shown in Figure 1 the amplification of the circuit will increase with an increase in amplitude of the oscillations fed to the input terminals 1 and 2, since in this case the output voltage and at the same time the control voltage increases and the voltage of the second control-grid decreases, so that the mutual conductance

$$\frac{\Delta i_a}{\Delta V_{g1}}$$

and consequently the amplification increases. In this way expansion of the electrical oscillations to be transmitted by the circuit is obtained and notwithstanding that the cathode of the diode 15 and the discharge tube 5 can be kept at the same potential.

It is not necessary that the oscillations to be expanded are fed to the first control-grid, since they may equally well be fed to the second control-grid.

From Figure 3 illustrating the relation existing between the anode current and the second control-grid voltage for different values of the first control-grid voltage it appears that in the presence of a constant first control-grid voltage the mutual conductance

$$\frac{\Delta i_a}{\Delta V_{g3}}$$

becomes higher when the second control-grid voltage falls off. In this case, in order to secure expansion of the oscillations to be transmitted, the diode 15 of the control detector may be provided again similarly to Figure 1. The control voltage initiated across the resistance 16, jointly with the oscillations fed to the terminals 1 and 2 and to be expanded are supplied to the second control-grid, as shown in Figure 4. In this case the first control-grid must have a constant voltage E with respect to the cathode.

Finally Figure 5 represents another circuit arrangement according to the invention, in which expansion of the oscillations to be transmitted is obtained again, whilst the cathode of the diode and of the discharge tube 5 can be kept at the same potential.

This circuit arrangement yields a stronger amplification of the oscillations to be expanded. The discharge tube 5 may be considered as a combination of a triode part comprising the cathode 9, the first control grid 4 and the first

screen-grid 10, and a penthode part including a first screen-grid 10, which may be considered as an electron emitting virtual cathode, the second control-grid 11, the second screen-grid 12, the suppressor grid 13 and the anode 14. The control-voltage taken from the resistance 16 is supplied again to the second control-grid 11 and the oscillations to be expanded are supplied to the first control-grid 4. The electrical oscillations amplified by the triode part are taken from the first screen-grid 10 acting as an anode and are fed, through the intermediary of the second screen-grid 12, to the second control-grid 11 by means of a potentiometer consisting of a condenser 20, a resistance 21 and a resistance 22. The oscillations are finally amplified by the penthode part and can be taken again from the output terminals 7 and 8. The expansion of the oscillations to be transmitted is obtained by the control-voltage fed to the second control-grid in the same manner as set out with reference to Figure 1.

Since the relation between the control-grid voltages and the anode current of the discharge tube 5 is not linear the oscillations taken from the output terminals 7 and 8 will be distorted. This distortion can be decreased by making use of negative back coupling in a manner known per se. On account of the negative back coupling the expansion and amplification of the oscillations to be transmitted decreases, it is true, but this need not be objectionable in circuits where the amplification and expansion are considerable such as, for instance, in the circuit shown in Figure 5.

What I claim is:

1. An amplifier circuit arrangement for expanding the amplitude of an electrical oscillation, comprising an electron discharge tube having in the order named a cathode, a first control grid, a first screen grid, a second control grid, a second screen grid and an anode, said tube having a characteristic wherein for a predetermined value of operating potential on said first and second screen grids relative to the potentials on the other elements of said tube the mutual conductance of the tube as represented by the anode current-control grid voltage ratio increases with an arithmetic decrease of the control voltage, means including a resistor common to said first and said second screen grids to apply operating potentials to said electron discharge tube, means to apply said oscillation to one of said control grids, means to derive a control voltage proportional to the amplitude of said oscillation including a rectifying device having a cathode connected in common with the cathode of said tube and having an anode coupled to the anode of said tube, and means to apply said voltage to said second control grid, said resistor having a resistance value at which the potential applied to said first and second screen grids is substantially equal to said predetermined value of operating potential.

2. An amplifier circuit arrangement for expanding the amplitude of an electrical oscillation, comprising an electron discharge tube having in the order named a cathode, a first control grid, a first screen grid, a second control grid, a second screen grid and an anode, said tube having a characteristic wherein for a predetermined value of operating potential on said first and second screen grids relative to the potentials on the other elements of said tube the mutual conductance of the tube as represented by the anode

current-control grid voltage ratio increases with an arithmetic decrease of the control voltage, means including a resistor common to said first and said second screen grids to apply operating potentials to said electron discharge tube, means to apply said oscillation to said second control grid, means to derive a control voltage proportional to the amplitude of said oscillation including a rectifying device having a cathode connected in common with the cathode of said tube and having an anode coupled to the anode of said tube, and means to apply said voltage to said first control grid, said resistor having a resistance value at which the potential applied to said first and second screen grids is substantially equal to said predetermined value of operating potential.

3. An amplifier circuit arrangement for expanding the amplitude of an electrical oscillation, comprising a first electron discharge system having in the order named an electron-emitting cathode, a first control grid, a first screen grid, a second control grid, a second screen grid and an anode, said tube having a characteristic wherein for a predetermined value of operating potential on said first and second screen grids relative to the potentials on the remaining elements of said tube the mutual conductance of the tube as represented by the anode current-control grid ratio increases with an arithmetic decrease of said control voltage, means including a first resistor common to said first and said second screen grids to apply operating potentials to said electron discharge tube, means to apply said oscillation to one of said control grids, a second electron discharge system having a cathode connected to the cathode of said first electron discharge system and an anode coupled to the anode of said first electron discharge system, a second resistor coupled between the anode and cathode of said second electron discharge system to derive a direct control voltage proportional to the amplitude of said oscillation, and means to apply said voltage to said second control grid, said first resistor having a resistance value at which the potential applied to said first and second screen grids is substantially equal to said predetermined value of operating potential.

4. An amplifier circuit arrangement for expanding the amplitude of an electrical oscillation, comprising a first electron discharge tube having in the order named a cathode, a first control grid, a first screen grid, a second control grid, a second screen grid and an anode, said tube having a characteristic wherein for a predetermined value of operating potential on said first and second screen grids relative to the potentials on the remaining elements of said tube the mutual conductance of the tube as represented by the anode current-control grid ratio increases with an arithmetic decrease of said control voltage, a grid-leak resistor coupling said first control grid to said cathode, a load resistor coupled to said anode, a second resistor having one terminal connected to said first and said second screen grids, means to apply operating potentials to said load resistor and the other terminal of said second resistor, means to apply biasing potentials to said first and said second control grids, means comprising a capacitor to apply said oscillation to said first control grid, a second electron discharge tube having a cathode connected to the cathode of said first electron discharge tube and an anode, means coupling the anode of said first electron discharge tube to the anode of said

second electron discharge tube, a third resistor connected across the anode and cathode of said second electron discharge tube to derive a direct control voltage proportional to the amplitude of said oscillation, and means to apply said control voltage to said second control grid, said second resistor having a resistance value at which the potential applied to said first and second screen grids is substantially equal to said predetermined value of operating potential.

5. An amplifier circuit arrangement for expanding the amplitude of an electrical oscillation, comprising a first electron discharge tube having in the order named a cathode, a first control grid, a first screen grid, a second control grid, a second screen grid and an anode, said tube having a characteristic wherein for a predetermined value of operating potential on said first and second screen grids relative to the potentials on the remaining elements of said tube the mutual conductance of the tube as represented by the anode current-control grid ratio increases with an arithmetic decrease of said control voltage, means to maintain said first control grid at a fixed potential with respect to said cathode, a load resistor coupled to said anode, a second resistor having one terminal connected to said first and said second screen grids, means to apply operating potentials to said load resistor and the other terminal of said second resistor, means to apply biasing potential to said second control grid, means comprising a capacitor to apply said oscillation to said second control grid, a second electron discharge tube having a cathode connected to the cathode of said first electron discharge tube and an anode, means coupling the anode of said first electron discharge tube to the anode of said second electron discharge tube, a third resistor connected across the anode and cathode of said second electron discharge tube to derive a direct control voltage proportional to the amplitude of said oscillation, and means comprising a fourth resistor to apply said voltage to said second control grid, said second resistor having a resistance value at which the potential applied to said first and second screen grids is substantially equal to said predetermined value of operating potential.

6. An amplifier circuit arrangement for expanding the amplitude of an electrical oscillation, comprising a first electron discharge tube having in the order named a cathode, a first control grid, a first screen grid, a second control grid, a second screen grid and an anode, said tube having a characteristic wherein for a predetermined value of operating potential on said first and second screen grids relative to the potentials on the remaining elements of said tube the mutual conductance of the tube as represented by the anode current-control grid ratio increases with an arithmetic decrease of said control voltage, a grid-leak resistor coupling said first control grid to said cathode, a load resistor coupled to said anode, a second resistor having one terminal connected to said first and said second screen grids, means to apply operating potentials to said load resistor and the other terminal of said second resistor, means to apply biasing potentials to said first and said second control grids, means comprising a capacitor to apply said oscillation to said first control grid, a second electron discharge tube having a cathode connected to the cathode of said first electron discharge tube and an anode, means coupling the anode of said first

electron discharge tube to the anode of said second electron discharge tube, a third resistor connected across the anode and cathode of said second electron discharge tube to derive a direct control voltage proportional to the amplitude of said oscillation, and means comprising fourth and fifth resistors connected in series to apply said control voltage to said second control grid, the junction point of said fourth and fifth resistors being coupled to the cathode of said electron discharge tube, said second resistor having a resistance value at which the potential applied to said first and second screen grids is substantially equal to said predetermined value of operating potential.

7. An amplifier circuit arrangement for expanding the amplitude of an electrical oscillation, comprising a first electron discharge tube having in the order named a cathode, a first control grid, a first screen grid, a second control grid, a second screen grid and an anode, said tube having a characteristic wherein for a predetermined value of operating potential on said first and second screen grids relative to the potentials on the remaining elements of said tube the mutual conductance of the tube as represented by the anode current-control grid ratio increases with an arithmetic decrease of said control voltage, a grid-leak resistor coupling said first control grid to said cathode, a load resistor coupled to said anode, a second resistor having one terminal connected to said first and said second screen grids, means to apply operating potentials to said load resistor and the other terminal of said second resistor, means to apply biasing potentials to said first and said second control grids, means comprising a capacitor to apply said oscillation to said first control grid, a second electron discharge tube having a cathode connected to the cathode of said first electron discharge tube and an anode, means coupling

the anode of said first electron discharge tube to the anode of said second electron discharge tube, a third resistor connected across the anode and cathode of said second electron discharge tube to derive a direct control voltage proportional to the amplitude of said oscillation, a fourth resistor, a fifth resistor, a second capacitor and a sixth resistor connected in series between the anode of said second electron discharge device and said first and said second screen grids, a third capacitor coupling the junction of said fourth and fifth resistors to the cathodes of said electron discharge tubes and the junction of said fifth resistor and said second capacitor being connected to said second control grid to apply said control voltage to said second control grid and to apply the amplified oscillation derived from said second screen grid to said second control grid, said second resistor having a resistance value at which the potential applied to said first and second screen grids is substantially equal to said predetermined value of operating potential.

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