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E. Y. ROBINSON

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CIRCUITS FOR RELAYING OR AMPLIFYING DIRECT OR ALTERNATING CURRENT ENERGY

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Fig. 1.

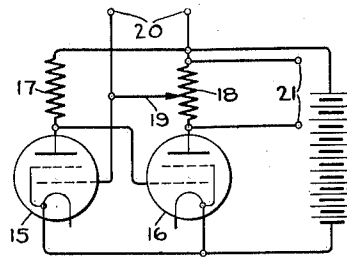


Fig. 2.

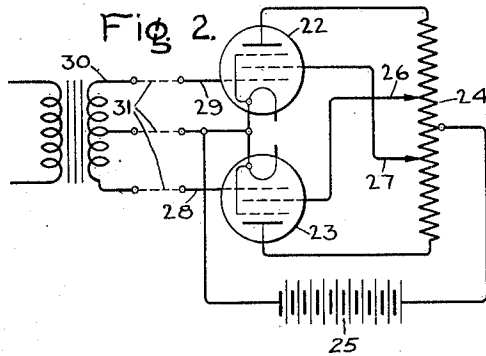
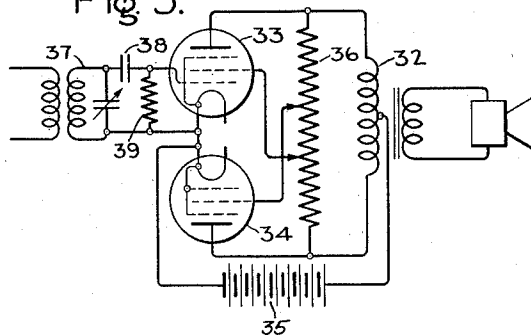


Fig. 3.



Inventor:
Ernest Y. Robinson,
by *Charles E. Tuller*
His Attorney.

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CIRCUITS FOR RELAYING OR AMPLIFYING
DIRECT OR ALTERNATING CURRENT
ENERGYErnest Yeoman Robinson, Enfield, England, as-
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5 Claims. (Cl. 179—171)

This invention relates to circuits for relaying or amplifying direct or alternating current energy by means of vacuum tube devices. In the case of alternating current, the invention relates especially, but not exclusively, to circuits designed to give a periodic amplification, that is, amplification which is independent of the frequency of the applied signal and which circuits can be employed for the amplification of slowly varying potentials if desired.

The invention also relates to means whereby the control grid of a vacuum electric tube may be operated at a highly positive potential even greater than that of the anode.

It is ordinarily necessary for the control grids of vacuum tubes to be operated at a negative potential with respect to the cathode. They may in some cases be operated at a slight positive potential but in any event at a potential which does not approach that of the anode, with the result that when two or more tubes are operated in cascade it is necessary to use inductive or capacitative coupling from the anode of one device to the grid of the succeeding device, or alternatively to provide biasing means between one tube and the next, either by a bias battery, for example, between the anode of one tube and the grid of the next, or by a bias battery between the cathode of one tube and the cathode of the succeeding tube. Circuits employing capacitative or inductive coupling means are not suitable for the amplification of slowly varying signals or of direct current, while circuits employing biasing means are difficult to adjust and maintain in adjustment.

According to the present invention the improved tube comprises a cathode, a control grid to which the signal to be amplified is applied, an anode and an additional grid disposed between said control grid and the anode, said additional grid being connected to a fixed source of potential, preferably zero or negative. Preferably such additional grid is connected to the cathode.

In one known tube construction three grids are interposed between the cathode and the anode, and the grid adjacent to the anode is connected to the cathode. In certain applications of the present invention, a tube of this known type may be employed, in which case the intermediate grid is employed as the control grid and the grid

adjacent to the cathode may be employed for other purposes, for example, as a space charge grid or as an additional grid for detection of modulated radio frequency signals.

The invention also comprises an amplifying circuit of the kind specified comprising two or more cascade coupled thermionic devices in which the output circuit of one tube is in direct electrical connection with the control grid of the succeeding tube wherein a further grid is disposed between said control grid and the anode and connected to a source of low or zero or negative potential and preferably to the cathode. In such a circuit, a resistance may be provided in the anode circuit of the output tube with a connection therefrom to the control grid of the preceding tube for providing regeneration.

The invention also comprises an amplifying circuit of the kind specified having two tubes arranged in push-pull relation, wherein each tube contains at least two grids of which the grid adjacent the anode is connected to a source of low or zero or negative potential, while means are provided for supplying the grids adjacent the first-mentioned grids with positive potential and a varying potential having a phase opposite to that of the respective anodes and preferably equal to each other so as to provide regeneration. Said varying potentials may be obtained from the potential drops across a resistance. In this circuit tubes containing five electrodes may be employed and the input or signal voltage may be applied to the grid of one tube which grid is adjacent the cathode or the signal may be bisected and applied to the grids adjacent the respective cathodes of both tubes. The circuit just above set forth may embody means for applying a modulated radio-frequency to the grids and means for demodulating said frequency.

To enable the invention to be clearly understood it will now be described with reference to the accompanying drawing, the figures of which show amplifying circuits embodying the present invention.

In one application of the invention as shown in Fig. 1, two 4-electrode tubes 15 and 16 are employed, the outer grids of which are connected to the cathodes as hereinbefore described and the coupling impedances consist of anode resistances 17 and 18. Regeneration or feed-back is intro-

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duced by connecting the grid of the first tube 15 to a tap 19 on the anode resistance of the second tube 16. As the tap is moved nearer to the anode of the second tube, the regeneration and amplification may be increased until the system becomes unstable. When regeneration is so great as to cause instability, the circuit may be employed as a negative resistance device for producing oscillations or for compensating for the resistance in other circuits coupled thereto. When the circuit is employed as a negative resistance device, the negative resistance effect is obtained across the terminals 20. The circuit may be employed in a variety of ways. For example, a tuned circuit comprising a condenser and inductance in parallel may be connected across the terminal points just mentioned whereby oscillation will be generated in said tuned circuit. When the device is to be used as an amplifier the signals to be amplified may be applied to the terminal points and the resulting amplified signals taken from the terminals 21. A disadvantage of the arrangement just described is that the device has a low input resistance. This may be overcome by using 5-electrode (pentode) tubes employed as shown in Fig. 2.

The anodes of the two tubes 22 and 23 are connected to the extremities of a centre tapped resistance 24, the centre point of this resistance being joined to the cathode through a battery or other high tension source 25. The intermediate grids of the tubes are connected to sliders 26 and 27 which are preferably adjusted to be equidistant from the centre tap of the aforesaid resistance. Such taps provide regeneration in the circuit and as they are moved away from the centre the regeneration in the circuit is increased until instability ensues. The applied signals may be introduced across the two innermost grids 28 and 29 of the two tubes by means of a centre tapped impedance such as the transformer secondary 30 connected to such grids and to the cathodes. When it is inconvenient to connect a centre tapped impedance across the grids as above described, as for example, when the impedance is resistive and the circuit is employed for amplifying slowly varying signals, the signals may be applied between the innermost grid 29 of one of the tubes and the cathode. In this case, the innermost grid 28 of the other tube can either be connected to the cathode or to the negative terminal of any biasing battery employed at 31 between the impedance connected between said input grid and the cathode.

In a further example shown in Fig. 3, using two 5-electrode tubes in which the circuit is used for the detection and amplification of modulated radio frequency signals, the anodes of the tubes 33 and 34 are connected to the extremities of the primary winding 32 of an output transformer, the winding 32 having a centre tap connected to the cathode through the high tension source 35 while the secondary winding of such transformer may be connected to a loud speaker. A resistance 36 is also connected across the two anodes and the two intermediate grids of the tubes are connected to taps on this resistance, equally spaced from the electrical centre but on opposite sides. Radio frequency signals are received in a tuned circuit 37 one end of which is connected to the cathodes and the other through a condenser 38 and a leak resistance 39 to the grid adjacent to the cathode of the tube 33, thus providing an arrangement which gives cumulative grid detection. The grid adjacent to the cathode of the other tube 34 is

connected to the cathode. When "anode-bend" detection is used the return lead from the tuned circuit 37 is connected to a negative bias battery in which case the grid adjacent to the cathode of the other tube is connected to the same bias to provide symmetry. In order to provide as much regeneration as possible without producing an audio frequency resonance or without producing instability, the loud speaker should be so chosen that as far as possible the load is resistive. It is obvious that the resistance 36 may be dispensed with and the intermediate grids of the two tubes be connected to equally spaced taps on the centre tapped primary 32 of the output transformer.

In 4-electrode tubes improved in accordance with this invention the grid adjacent to the anode may be connected to a negative potential if desired, but in the preferred method it is connected to the cathode by means of a connection inside the envelope or inside the cap of the tube.

It is obvious that two or more complete sets of electrodes with or without the coupling resistances may be mounted within one envelope, and this invention facilitates the manufacture of such multi-stage tubes since the necessity for coupling condensers between the anode of one electrode system and the grid of a succeeding electrode system is eliminated.

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

1. An amplifying system comprising a plurality of coupled amplifiers, each containing an anode, a cathode, and a control member, the coupling consisting of an equipotential conductor connected between the anode of one tube and the control member of a succeeding tube, and means for energizing the system, said means comprising a source of electromotive force connected to each of the anodes respectively through resistances, and a connection between one of said resistances and the control member of a preceding amplifier.

2. An amplifying system comprising a plurality of coupled amplifiers, each of which includes a cathode, an anode, a control grid and a second grid interposed between the control grid and the anode and connected to the said cathode, the coupling between amplifiers consisting of an equipotential conductor connected between the anode of one amplifier and the control member of the succeeding amplifier, said amplifiers being energized by a common source of electromotive force through resistances connected respectively to each of the anodes, and a connection between one of said resistances and the control grid of a preceding amplifier.

3. An amplifying system comprising a plurality of thermionic devices arranged in push-pull relation, each of said devices including a cathode, an anode, a control grid, and two grids between the control grid and the anode, the grid nearest the anode being connected directly to the cathode, means for energizing the system and for supplying the grid adjacent to the control grid with positive potential and also with a varying potential having a phase opposite to that of its respective anode whereby regeneration is produced in the system.

4. An amplifying system comprising a pair of thermionic devices, each of said devices including a cathode, an anode, a control grid and two grids between the control grid and the anode, the grid nearest the anode in both tubes being connected directly to the respective cathodes, the control grid of one of said tubes being also con-

5 nected to the cathode, means for energizing the system and for supplying the grids adjacent the respective control grids with a varying potential having a phase opposite to that of its respective anode whereby regeneration is produced in the system.

10 5. An amplifying system comprising a pair of thermionic devices, each of said devices including a cathode, an anode, a control grid and two grids between the control grid and the anode, the

grid nearest the anode in both tubes being connected directly to the respective cathodes, the control grid of one of said tubes being also connected to the cathode, means for energizing the system, and a connection between the anode of one tube and the grid adjacent the control grid of the other tube, said connection including an impedance.

ERNEST YEOMAN ROBINSON.

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