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ELECTRON TUBE CIRCUIT

Filed July 30, 1926

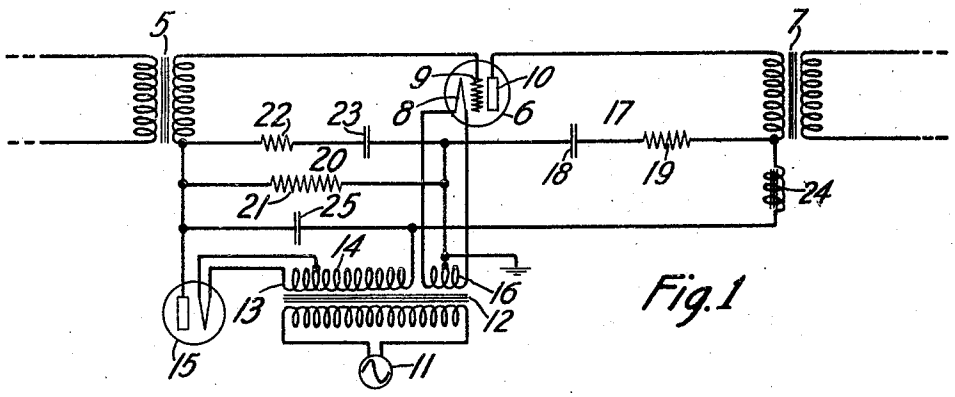

Fig. 1

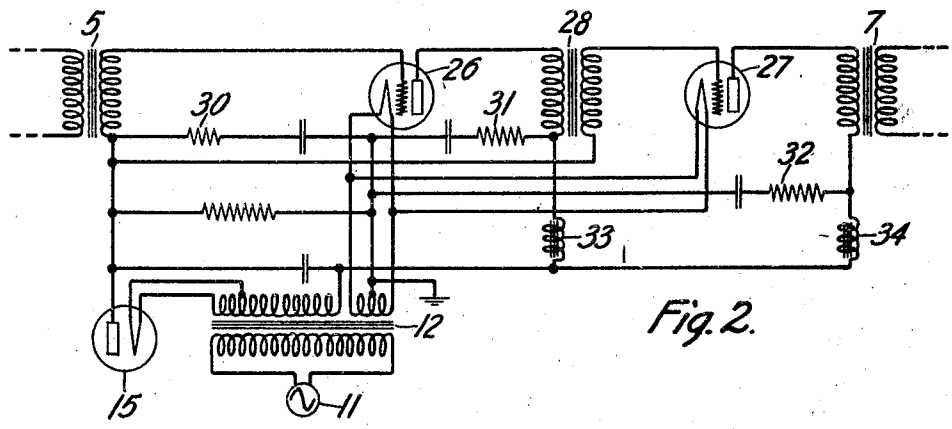

Fig. 2.

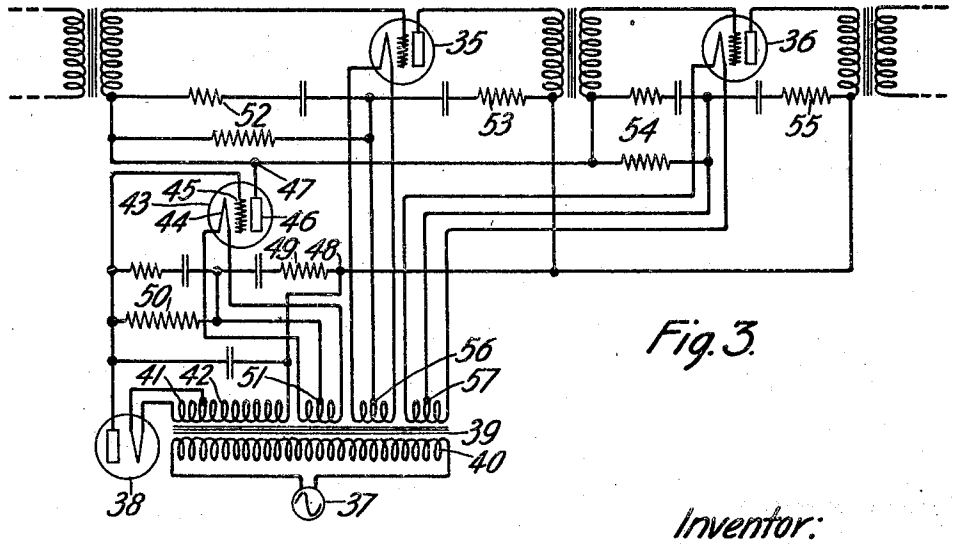

Fig. 3.

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UNITED STATES PATENT OFFICE

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ELECTRON-TUBE CIRCUIT

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This invention relates to electric wave apparatus and more particularly to circuits for controlling space discharge devices. An object of the invention is to stabilize the output of such devices when supplied with a source of fluctuating potential.

It has been suggested heretofore to energize space discharge devices with a source of fluctuating potential having a steady potential component or one from which a steady component is derived, and to prevent the presence of fluctuations in the output circuit by impressing upon the input circuit fluctuations from the same source in opposite phase. See U. S. patent to S. E. Anderson, No. 1,541,311, June 9, 1925. According to this patent input and output circuit networks are associated with the energizing source and so designed and arranged that potential applied by one of them to the input circuit acts to neutralize potential applied by the other to the output circuit; but in order to provide a normal flow of space current in the output circuit a separate source of biasing potential for the input circuit is necessary, as the networks cause neutralization of steady as well as variable potential components set up in the two circuits from the main energizing source.

The present invention eliminates the necessity for a separate source of biasing potential. This is accomplished by so designing the networks in the input and output circuits that the ratio of the fluctuating potential components in the two circuits is such as to prevent a fluctuating current in the output circuit, but the steady potential components are given a different ratio, whereby there is a normal flow of space current of desired amount in the output circuit.

In another aspect this invention comprises a space discharge device arranged as above described for smoothing out the output wave of a rectifier. The current from a rectifier thus controlled by space discharge device will be free of ripples and may be used directly for energizing other devices, such as other tubes, for example.

The invention pertains also to the elimination of fluctuations in the output circuit of a thermionic device resulting from the use of alternating current for heating the cathode. These fluctuations are particularly troublesome in a multi-stage amplifier in which fluctuations produced in an early stage are amplified in the subsequent stages. When a themionic discharge device used as described above for smoothing out the output of a rectifier is supplied with cathode heating current from an alternating current source there may be present in its output a small alternating current component caused by the action of the heating current. In using the output energy of this type of device for energizing a multi-stage amplifier this ripple may be balanced out in each stage by the use of the network arrangement above mentioned, so proportioned as to balance this ripple against the variations produced by alternating current used for heating the cathode of such stage.

These and other aspects and features of the invention will be more readily understood by reference to the following detailed description and claims in connection with the drawing in which: Fig. 1 shows one embodiment of the invention in a circuit for energizing a translating device in the form of a vacuum tube amplifier from an alternating current source; Fig. 2, another embodiment of the invention in a multi-stage amplifier energized from a alternating current source; and Fig. 3, an embodiment of the invention in a multi-stage amplifier, and employing a tube for smoothing out the output of the rectifier.

Fig. 1 shows a circuit adapted for amplifying or detecting signals which are received through an input transformer 5 and transmitted through a space discharge device 6 to an output transformer 7. The device 6 comprises the usual filamentary cathode 8, grid 9 and plate 10. Alternating current is supplied from a source 11 through a transformer 12 having secondary windings 13 and 14 connected to a rectifier 15 and a secondary winding 16 connected to the cathode 8 for supplying heating current thereto. Connected between the plate 10 and the cathode 8 is a network 17 comprising a condenser 18

and a resistance 19 in series while between the grid 9 and the cathode 8 is connected a network 20 comprising a resistance 21 in parallel with a resistance 22 and a condenser 23 in series. The positive terminal of the rectifier is connected through a retard coil 24 to the terminal of the network 17 adjacent the plate 10, and the negative terminal is connected to the terminal of the network 20 adjacent the grid 9. Connections to the cathode 8 are made at the mid-point of the secondary winding 16 so as to prevent undue disturbances in the output circuit due to the alternating current supplied to the filament. The space current circuit of the device 6 may be traced from the anode 10 through the primary winding of the output transformer 7, retard coil 24, the rectifier 15, resistance 21 to the cathode 8. The grid is maintained at a negative potential by the RI drop in resistance 21.

The values of the elements of the networks 17 and 20 are so proportioned that the impedance of the network 17 is μ times the impedance of network 20 and of the same phase characteristic, where μ is the amplification constant of the device 6. Any ripple in the output of the rectifier which impresses a voltage E between the anode and cathode of the device 6 simultaneously impresses a voltage

$$\frac{-E}{\mu}$$

between the grid and cathode so that no effect is produced in the output of the device 6.

The retard coil 24 is merely to prevent the signal output of the device from feeding back into the input through the condenser 25 and has no effect upon the noise level.

The condenser 18 makes the network 17 opaque to direct current so as not to balance out the direct current impressed upon the anode circuit. In order to prevent modulation of the signal by the alternating potential across the network 17 it is desirable that the impedance of this network be low compared to the plate impedance of the tube.

Fig. 2 shows a multi-stage circuit comprising devices 26 and 27 connected in tandem through an inter-stage transformer 28. The arrangement of this circuit is similar to that of Fig. 1 with modifications to adapt the circuit for two stage operations as noted below. One grid balancing network 30 is used for both stages, though separate plate networks 31 and 32 are used. The impedance of the network 31 is made μ times the impedance of the network 30 and the impedance of the network 32 is μ' times the impedance of the network 30 where μ and μ' are the amplification constants of the devices 26 and 27 respectively. If it is desired to use different grid biasing potentials for the two tubes separate grid circuit networks should be employed.

Separate retard coils 33 and 34 are provided in the plate circuits of the devices 26 and 27 respectively to prevent feed back not only from the output of one device to its input but also between stages.

Fig. 3 shows an amplifier comprising two space discharge devices 35 and 36 connected in tandem through an interstage transformer. Space current is derived by rectifying current from an alternating current source 37 in a rectifier tube 38. Current is supplied to the tube 38 through a transformer 39 having a primary winding 40 connected to the source 37 and secondary windings 41 and 42 connected to the tube 38.

A space discharge device 43 having a cathode 44, a grid 45 and an anode 46 is used for smoothing out the output of the rectifier. This device is arranged in a similar manner to the amplifier of Fig. 1 so that fluctuations in the space current supplied from the rectifier 38 are eliminated before the current reaches the output terminals 47, 48. Networks 49 and 50, similar to networks 17 and 20 of Fig. 1, are connected in the anode and grid circuits respectively. Network 50 is designed to have an impedance of the same phase angle characteristic but of a value one over the amplification constant of the tube 43 times the impedance of the network 49 so that the alternating current component of the output of the rectifier 38 is completely balanced out by the device 43. However, there may be an appreciable alternating current component in the anode circuit of the device 43 due to the effect of the alternating current supplied from the secondary winding 51 for heating the cathode 44.

The current at the output terminals 47, 48, which is constant except for this filament hum is supplied to the devices 35 and 36 across the two pairs of networks 52, 53, and 54, 55, respectively. These two pairs of networks function to balance this hum together with the hum produced in each device by the alternating current supplied from the secondaries 56 and 57 to the cathodes of said devices 35 and 36, respectively.

For example, in device 35 the hum in the output of device 43 is vectorially added, in the network 53, to the hum produced by the alternating current heating of the cathode to produce an alternating current electromotive force E. These two hums being produced in a similar manner by the action of the alternating current supplied to the filaments of the devices 43 and 35 are of the same frequency. Therefore their vector sum can be balanced out by the alternating electromotive force produced in the network 52 by the hum in the output of the device 43. This is accomplished by designing the network 52 so that the product of its impedance and the hum

current in the output of device 43 is equal to $1/\mu$ times the product of the impedance of network 53 and the vector sum of the hum current in the output of device 43 and that developed by device 35, where μ is the amplification factor of the device 35. The resulting current in the output circuit of device 35 will therefore be free of all hum.

Networks 54 and 55 are similarly designed to eliminate all hum from the output of device 36.

It is to be understood that the circuits described may be variously modified without departing from the spirit of the invention as defined in the appended claims; for example, the arrangement shown in Fig. 3 for smoothing out the output of a rectifier is not limited in its use to the circuits of space discharge devices.

What is claimed is:

1. In combination, a translating device having an anode, a cathode and a control element, a source of fluctuating potential for energizing said device, and means for supplying to said control element and said anode potentials proportional to the fluctuating component of said source and bearing a definite predetermined ratio to one another while supplying from said source to said anode and said control element direct current potentials having a ratio different than said first ratio.

2. In combination, a space discharge device having an anode, a cathode and a control electrode, a source of fluctuating potential for energizing said device, and means for applying potentials proportional to the fluctuating component of said source, of differing phase and having a ratio proportional to the amplification constant of said device to said control electrode and said anode, respectively, while supplying from said source to said anode a direct current potential and to said control electrode a second direct current potential, said last potentials having a ratio differing from said first ratio.

3. In combination, a space discharge device having an anode, a cathode and a control electrode, a source of fluctuating potential for energizing said device, an impedance network opaque to direct current connected between said anode and cathode, a second impedance network connected between said control electrode and cathode, the impedance of said second network being one over the amplification constant of said device times the impedance of the first network, and connections from the terminal of said first network adjacent said anode and the terminal of said second network adjacent the control electrode to said source, the direct current impedance of said second network being substantially less than infinity.

4. In combination, a space discharge device having a cathode, an anode and a control electrode, a source of fluctuating potential for energizing said device, an impedance path comprising a resistance and a condenser in series connected between said anode and cathode, a second impedance path, comprising a resistance and a condenser in series with each other and a resistance in shunt thereto connected between said control electrode and said cathode, the impedance of said second path being one over the amplification constant of said device times the impedance of said first impedance path, and connections from the terminal of said first impedance path adjacent the anode and the terminal of second impedance path adjacent the control electrode to said source.

5. In combination, a source of fluctuating potential, a utilization circuit, means for smoothing out the potential from said source, comprising a space discharge device having a cathode, a control electrode and an anode, and means for applying from said source potentials of opposite phase and having a ratio of one over the amplification constant of said device to said control electrode and said anode, respectively, whereby the space current of said device is maintained substantially constant, and connections from the output of said device for supplying a constant potential to said utilization circuit.

6. In combination, a source of fluctuating potential, a utilization circuit, means for smoothing out the potential of said source comprising a space discharge device having a cathode, a control electrode and an anode, and means including a resistance connected in series with said source between said anode and cathode for applying potentials of opposite phase, proportional to the fluctuating component of said source and having a ratio of one over the amplification constant of said device to said control electrode and anode, respectively, while applying to said anode a direct current potential and to said control electrode a second direct current potential proportional to the RI drop in said resistance and of a value less than one over the amplification constant of the tube times said direct current potential applied to the anode, and connections from the output of said device to said utilization circuit for supplying constant current thereto.

7. In combination, a source of fluctuating potential, a utilization circuit, means for smoothing out the output current of said source, said means comprising a space discharge device having a cathode, a control electrode and an anode, an impedance network opaque to direct current connected between said anode and cathode, a second impedance network having an impedance of one over the amplification constant of said device times the impedance of said first network connected between the control electrode and the cathode, connections from the terminal of said first network adjacent the anode and the terminal of said second network adjacent the control

electrode to said source, and connections from the output circuit of said device to said utilization circuit for supplying a constant current thereto.

8. A combination according to claim 7 in which said first network comprises a resistance and a condenser in series, and said second network a resistance and a condenser in series with each other and a resistance in shunt thereto.

9. In combination, a space discharge device having a thermionic cathode, a control electrode and an anode, a source of alternating current for energizing said device, connections for supplying heating current from said source to said cathode, a rectifier, connections for supplying current from said source to said rectifier, a second space discharge device having a thermionic cathode, a control electrode and an anode, connections for supplying heating current from said source to the cathode of said second device, means for supplying from the output of said rectifier potentials of differing phase and having a ratio of one over the amplification constant of said second device to said control electrode and anode, respectively, whereby the space current of said second device is maintained independent of the fluctuations in the output of said rectifier, an impedance network connected between the anode and cathode of said first device, a second impedance network connected between the control electrode and cathode of said first device, and connections from the output of said second device to the terminal of said first network adjacent the anode and to the terminal of said second network adjacent the control electrode for supplying space current to said first device, the impedances of said networks being so proportioned that the potential across said second network resulting from the electromotive force produced in said second device by the alternating current applied to the cathode is one over the amplification constant of said first device times the potential across the second network resulting from the combined action of the electromotive forces produced in both of said devices by the alternating current supplied to the cathodes thereof.

10. A combination according to claim 9 in which the means for supplying potentials from the rectifier to the second device comprises a network opaque to direct current connected between the anode and cathode of said second device, a second network connected between the control electrode and cathode of said second device and having an impedance one over the amplification constant of said second device times the impedance of said first network, and connections from said rectifier to the terminal of said first network adjacent the anode, and to the terminal of said second network adjacent the control electrode.

11. A combination according to claim 9 in which the first network comprises a resistance and a condenser in series, and the second network, a resistance and condenser in series with each other and a resistance in shunt thereto.

12. A combination according to claim 9 in which the means for supplying potentials from the rectifier to the second device comprises a resistance and condenser connected in series between the anode and cathode, a resistance and a condenser in series with each other and a resistance in shunt thereto connected between the control electrode and the cathode, and connections from said rectifier to the anode and control electrode of said second device, and the first network comprises a resistance and condenser in series and the second network, a resistance and condenser in series with each other and a resistance in shunt thereto.

13. In combination a space discharge device having an anode, a cathode and a control electrode, a source of fluctuating potential for energizing said device, an impedance path connected between the anode and cathode of said device, a second impedance path connected between the control electrode and cathode of said device, and connections from said source to the terminal of said first network adjacent the anode and to the terminal of said second network adjacent the control electrode, the impedances of said networks being so proportioned that potentials proportional to the alternating current component of said fluctuating potential and having a ratio of one over the amplification constant of said device are applied to the control electrode and the anode, respectively, and that the direct current potential applied to the control electrode is less than one over the amplification factor times the direct current potential applied to the anode.

In witness whereof, I hereunto subscribe my name this 27th day of July A. D., 1926.

FREDERICK B. LLEWELLYN.