

Oct. 26, 1937.

A. S. RIGGS

2,096,861

RECTIFICATION SYSTEM

Filed March 2, 1927

2 Sheets-Sheet 1

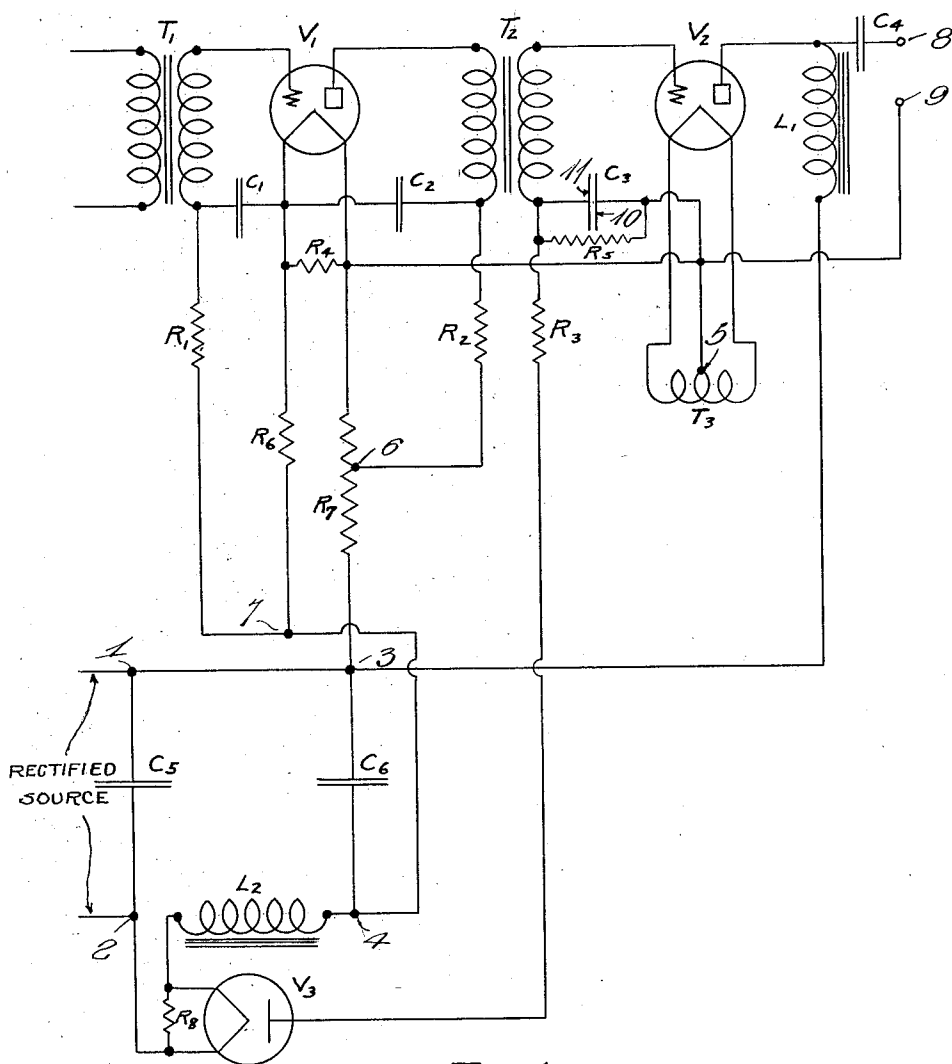


FIG 1.

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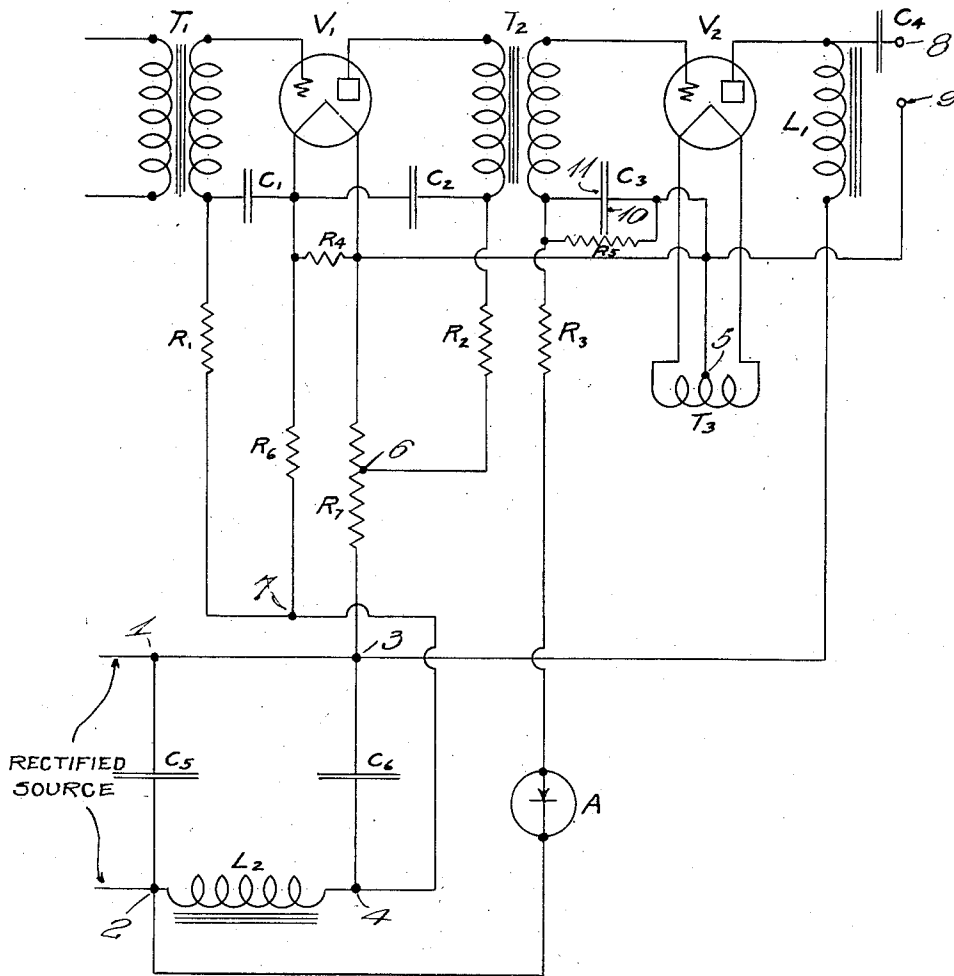


FIG. 2.

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UNITED STATES PATENT OFFICE

2,096,861

RECTIFICATION SYSTEM

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Application March 2, 1927, Serial No. 172,094

31 Claims. (Cl. 250—27)

My present invention relates to the rectification and filtering of alternating current for use in amplifier circuits using electron discharge devices, and more especially to such circuits when a large power tube is employed in conjunction with a smaller tube for the purpose of providing power amplification.

An object of my invention is to provide a filter for resolving the pulsating direct current from a rectifier into a substantially pure direct current.

A further object of my invention is to provide means whereby the filament or cathode of a small amplifier tube is heated by the space current of a power tube used in conjunction therewith.

A further object of my invention is to provide a system whereby appropriate negative potential for the grid of the power tube is obtained from the filter circuit, thereby obviating the necessity of securing such potential by the use of a resistor in series with the direct current circuit of the power amplifier tube.

A still further object of my present invention is to utilize the otherwise unused voltage drop which exists in an inductance forming a portion of a filter circuit.

With reference to the drawings of which Figure 1 is a diagrammatic view of an amplifier together with filter circuit incorporating the principal features of my invention and utilizing a supplementary rectifier tube; and Fig. 2 is a similar amplifier circuit in which a crystal, or other form of rectifier, is used as a supplementary rectifier.

With reference to the drawings and more especially to Fig. 1, inductance L_2 and condensers C_3 and C_6 form a filter through which rectified alternating current is supplied to amplifier tubes V_1 and V_2 which together with their attendant apparatus constitute an amplifier circuit.

Rectified current is introduced from the rectifier at points 1 and 2 and is passed to the amplifier circuit from points 3 and 4. It will be seen that electrons flow from point 4 of the filter through the following path: Point 4, through R_6 , through the cathode of V_1 (which is shunted by resistor R_4) thence to the point 5 on the transformer T_3 , which supplies the filament or cathode of tube V_2 , through the tube V_2 , inductance L_1 and thence to the filter at point 3. Part of the total electron flow, however, is through the resistor R_7 , which is in parallel with the plate filament circuit of V_2 .

A tap on R_7 at point 6 serves to supply plate potential to tube V_1 .

The resistor R_8 is of such value as to supply

appropriate negative potential for tube V_1 , the same being obtained by tapping at point 7.

Negative potential for the power tube V_2 is secured through the rectifier V_3 by the following process:

It will be seen that the cathode of tube V_3 is connected in series with the inductance L_2 on the rectifier, or power supply side. I contemplate using this method of supplying the filament or cathode of the tube V_3 . The resistor R_8 is provided across the cathode of V_3 for the purpose of by passing that portion of the total current which is not required to maintain the cathode, or filament of V_3 at proper temperature. The tube V_3 may consist of a three electrode tube with its plate and grid connected together.

It is manifestly evident that when current flows through the inductance L_2 that a potential is established across the terminals of the inductance. This potential is not pure direct current, but consists of pulsating current furnished from the rectifier (not shown) and has a frequency corresponding to that of the supply. It is obvious that this potential cannot readily be utilized for negative potential of the power tube, inasmuch as the "ripple" or pulsation of such potential would be transmitted to the tube V_2 and delivered in amplified form to the loud speaker or other translating device connected to points 8—9.

By the insertion of the auxiliary rectifier V_3 the condenser C_3 and the resistance R_5 , however, I readily utilize the otherwise unused potential drop across the inductance.

The method by which I utilize this potential will be evident from the following:

The plate 10 of the condenser C_3 is connected through the cathode of V_1 and R_6 to point 4 of the inductance L_2 , and the plate 11 of condenser C_3 is connected through the resistance R_3 and rectifier tube V_3 to point 2 or the other terminal of inductance L_2 . Now, when current flows through the circuit it is evident that a potential difference exists between plates 10 and 11 of condenser C_3 , due to the pulsating current in L_2 .

This pulsation would otherwise be transmitted to the grid of tube V_2 were it not for the fact that the rectifier V_3 allows an electron current to travel only in one direction (point 2 to plate 11). By the action of the rectifier V_3 , therefore, the condenser C_3 charges until its charge is equal to the "peak" or maximum value of the pulsating potential across the inductance L_2 , after which practically no current flows through the rectifier V_3 .

The charge on condenser C₃ therefore maintains the grid of tube V₂ at a substantially uniform negative potential. The resistance R₅, usually of high value, is inserted across the condenser C₃ to allow its charge to "leak off" when the system is not operating.

The condensers C₁, C₂ and C₃ together with resistors R₁, R₂ and R₃ serve the purpose of providing resistance capacity filters which prevent pulsating currents from the filter system (L₂, C₅ and C₆) from entering the amplifier and also prevent alternating currents generated in the amplifier from entering the filter and current supply system. The condenser C₃, therefore serves a threefold purpose.

Fig. 2 represents a similar system to Fig. 1, except for the tube V₃, which is in this case substituted by the crystal (or other form of rectifier) A.

In the drawings like parts are represented by similar reference numbers and figures.

It is understood that the system constituting my present invention represents an extremely stable amplifier circuit together with an efficient filtering means for eliminating "hum" in the loud speaker or other translating device used therewith.

While I have described my invention in certain of its preferred embodiments, I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than those imposed by the scope of the appended claims.

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

1. A power amplifier system comprising a plurality of electron tubes, a cathode circuit for each of said electron tubes, input and output circuits therefor, a power source of alternating current, connections for supplying alternating current from said source for energizing the cathode circuit of at least one of said electron tubes, a rectifier connected with said source for supply direct current for energizing the cathode circuit of another of said electron tubes, and independent rectifying means connected in series between said rectifier and a circuit of one of said electron tubes for supplying biasing potential thereto.

2. A power amplifier system comprising a plurality of electron tubes having their individual cathodes supplied at least one with alternating current and at least another with direct current, input and output circuits for each of said tubes and a rectifier device connected in series between the direct current supply to the cathode of one of the aforesaid electron tubes and with the input circuit of one of said electron tubes for supplying biasing potential thereto.

3. A power amplifier system comprising a plurality of electron tubes each having independent cathode circuits, input and output circuits for each of said tubes, a rectification circuit for supplying power from an alternating current source to at least one of said cathode circuits, means for energizing at least one of said cathode circuits from said alternating current power source, and an independent rectifier connected in series between one side of said rectification circuit and an input circuit of one of said tubes for supplying biasing potential to one of said electron tubes.

4. A power amplifier system comprising a plurality of electron tubes, independent cathode circuits for said electron tubes, a power source of alternating current, a rectification system inter-

posed between said source and at least one of said cathode circuits, connections for energizing at least one of said cathode circuits with alternating current from said power source, and an independent rectifier interposed in series between said rectification system and the input circuit of at least one of said electron tube circuits for supplying biasing potential to said electron tube circuit.

5. A power amplifier system comprising a plurality of electron tubes, each having input and output circuits, cathode circuits for each of said electron tubes, a power source of alternating current for energizing the circuits of said electron tubes, a rectification system, a tapped resistor, a circuit connecting the cathode of at least one of said electron tubes in series through said resistor to said rectification system, the tap on said resistor being connected to supply anode potential to said tube, said tapped resistor being in shunt with the output circuit of another of said electron tubes, for supplying cathode heating current and space current to said power amplifier system and an auxiliary rectifier connected in series with said rectification system and connected with the input circuit of at least one of said electron tubes for supplying biasing potential thereto.

6. In a power amplifier system a plurality of electron tubes, each having input and output circuits, cathode circuits for said electron tubes, an alternating current source for exciting the cathode of one of said electron tubes, a rectification system for supplying power to at least one of the cathode circuits of said electron tubes and to the output circuits thereof, and an auxiliary rectification system connected in series between said first mentioned rectification system and the input circuit of one of said tubes for supplying biasing potential to the input circuit of said electron tube whose cathode is energized by alternating current and means for preventing interference between the biasing potential thus developed and the alternating current supplied to said electron tube circuits.

7. A power amplifier system comprising a plurality of electron tubes, cathode heating circuits for each of said electron tubes, a rectification system for supplying power to at least one of said cathode heating circuits and to the output circuits of said electron tubes, an inductive reactance connected in series with said rectification system and an auxiliary rectifier operating upon the potential difference existing across said inductance for supplying biasing potential to at least one of said electron tubes.

8. A power amplifier system comprising a plurality of electron tubes, cathode heating circuits for each of said electron tubes, a rectification system for supplying power to at least one of said cathode heating circuits and to the output circuits of said electron tubes, an inductive reactance connected in series with said rectification system, the input circuit of one of said electron tubes including a condenser and an auxiliary rectifier disposed between said inductive reactance and one side of said condenser for charging said condenser and supplying biasing potential to said electron tube circuit.

9. A power amplifier system comprising a plurality of electron tubes, cathode heating circuits for said electron tubes, a power source of alternating current, a rectification system for delivering rectified current to at least one of said cathode heating circuits and to the output cir-

cuits of said electron tubes, an inductive reactance interposed in series with said rectification system and an auxiliary rectifier disposed between the input circuit of at least one of said

electron tubes and said inductive reactance for deriving biasing potential for said last mentioned electron tube proportional to the drop across said inductive reactance.

10. In a power supply source to be used with amplifying apparatus including a thermionic tube having anode, cathode and control electrodes, a source of pulsating direct current, a current smoothing filter having output terminals, and input terminals connected to said source and a filter impedance connected between one of said input terminals and one of said output terminals, means arranged to provide a connection between said last named output terminal and the cathode of said tube, and means for utilizing a potential derived from said filter impedance for determining the potential of said control electrode relative to said cathode.

11. The combination of a thermionic relay, and energizing means therefor including a source of pulsating direct current, a current smoothing circuit including a reactor in series with said source and a condenser in parallel with said source, output terminals connected to said smoothing circuit, means for utilizing the potential drop between said terminals to energize an element of said thermionic relay, and means arranged to derive a potential from said reactor for energizing another element in said relay.

12. In a power supply source to be used with relay apparatus including a thermionic tube having anode, cathode and control electrodes, the combination of a source of pulsating direct current, a current smoothing circuit including a reactor in series with said source and a condenser in parallel with said source, output terminals connected to said circuit, a connection between one of said terminals and the cathode of said tube, a connection between another of said terminals and the anode of said tube, and means for deriving a potential from said current smoothing circuit for determining the potential of the control electrode of said tube relative to said cathode.

13. The combination of an alternating current rectifier, a filter including a reactor for eliminating alternating current ripple from current supplied by said rectifier, a space discharge device provided with a cathode connected to said rectifier through means including said filter reactor and with a grid, means for applying between said cathode and said grid the potential drop of said filter reactor.

14. The combination of an alternating current rectifier, a filter for the rectifier including an impedance element, a space discharge device provided with a cathode connected to said rectifier through means including said element, means providing an impedance in circuit with a grid for applying signal current thereto, an impedance connected to a terminal intermediate said rectifier and said element and arranged to complete a circuit between said cathode and said impedance means.

15. The combination of an alternating current rectifier, a filter comprising an impedance element, a space discharge device provided with a cathode connected to said rectifier through means comprising said element and with a grid, a circuit comprising a resistor and a condenser connected in shunt to said element, and means

for connecting said cathode to said grid through said element and said resistor.

16. The combination of an alternating current rectifier, a filter comprising a reactor, an amplifier provided with a cathode connected to said rectifier through means comprising said reactor and with a grid for controlling the current transmitted through said cathode, a circuit for connecting said cathode to said grid through said reactor, and means comprising a condenser connected in shunt to said reactor for excluding high frequency impulses from said circuit.

17. The combination of an alternating current rectifier, a filter for the rectifier including an impedance element, a space discharge device provided with a cathode connected to said rectifier through means comprising said element and with a grid, means for applying between said cathode and said grid the potential drop of said element, and means including a condenser and a reactor in series connected in shunt to said element for attenuating the alternating current ripple of the current supplied to said device through said rectifier.

18. The combination with a power supply means for an amplifier, including a filter having an impedance for eliminating ripple in the current supplied by said means, of a power amplifier connected with said power supply means to receive operating current therefrom and having a grid circuit connected with said impedance to receive a bias potential therefrom.

19. The combination with a power supply means for an amplifier, including a filter having an impedance for eliminating ripple in the current supplied by said means, of a power amplifier connected with said power supply means to receive operating current therefrom and having a grid circuit connected with said impedance to receive a bias potential therefrom, a resistor interposed between said grid circuit and said impedance, and a condenser connected in shunt to that portion of the grid circuit connection included between said resistor and said impedance.

20. In a power supply source to be used with amplifying apparatus including a thermionic tube having anode, cathode, and control electrodes, a source of pulsating direct current, a current smoothing filter having output terminals and having input terminals connected to said source, said filter including a filter impedance connected between one of said input terminals and one of said output terminals and a condenser connected to said one of said input terminals, means arranged to provide a connection between said last named output terminal and the cathode of said tube, and means for utilizing a potential derived from said filter impedance for determining the potential of said control electrode relative to said cathode.

21. The combination of a thermionic relay, and energizing means therefor including a source of pulsating direct current, a current smoothing circuit including a condenser in parallel with said source, a reactor in series with said source, said reactor constituting an essential impedance element of said current smoothing circuit, output terminals connected to said smoothing circuit, means for utilizing the potential drop between said terminals to energize an element of said thermionic relay, and means arranged to derive a potential from said reactor for energizing another element in said relay.

22. In a power supply source to be used with relay apparatus including a thermionic tube hav-

ing anode, cathode and control electrodes, the combination of a source of pulsating direct current, a current smoothing circuit including a reactor in series with said source and two condensers in parallel with said source, said condensers being connected respectively to opposite terminals of said reactor, output terminals connected to said circuit, a connection between one of said terminals and the cathode of said tube, a connection between another of said terminals and the anode of said tube, and means for deriving a potential from said current smoothing circuit for determining the potential of the control electrode of said tube relative to said cathode.

23. In signalling apparatus, a space discharge device provided with an anode, a cathode, and a control electrode, means for establishing a flow of current through the space path of said device comprising a source of unidirectional space current having positive and negative terminals, means connecting the anode of said device to the positive terminal of the source, means for connecting the cathode of the device to the negative terminal of the source, said latter connection being made through an impedance circuit, said impedance circuit acting to maintain the cathode of the device at a positive potential relative to the negative terminal of the source by current flow through the space path of the discharge device and through said impedance circuit, a high resistance path in parallel with the impedance circuit, said path comprising a diode in series, with resistance external to the diode, the impedance of the impedance circuit being proportioned relative to the impedance of the high resistance path, so that the difference in potential between the negative terminal of the source and the cathode is determined chiefly by the drop across the impedance circuit, and means for biasing the control electrode of the space discharge device with respect to the cathode comprising a connection between the control electrode and a point on the high resistance path.

24. In signalling apparatus, a space discharge tube provided with an anode, a cathode and a control electrode, a source of uni-directional space current for said tube, said source being provided with positive and negative terminals, means connecting the anode of said tube to the positive terminal, a relatively low impedance path between the cathode of the tube and the negative terminal of the source, a relatively high impedance path in parallel with the low impedance path, said high impedance path comprising a diode in series, with impedance external to the diode, and means for applying a biasing potential to the control electrode of said tube comprising a connection between the control electrode and a point on said high resistance path.

25. In signalling apparatus, an electronic tube provided with an anode, a cathode and a control electrode, a source of uni-directional space current, said source being provided with a positive terminal and a negative terminal, means connecting the anode of the tube to said positive terminal, a relatively low impedance path including at least one impedance element, connected between the cathode of the tube and the negative terminal of the source, a relatively high resistance path connected in parallel with said low resistance path, said high resistance path including a chain of impedance elements and a diode in series, and means for applying a biasing potential to the control electrode of the tube, said

last-named means including a connection between the control electrode and a point on the last-named chain of impedances.

26. In signalling apparatus, an electronic tube provided with an anode, a cathode and a control electrode, a source of uni-directional space current for the electronic tube, said source being provided with a negative terminal and a positive terminal, means for connecting the anode of the tube to the positive terminal of the source, means including at least one impedance element for connecting the cathode of the tube to the negative terminal of the source, and an additional connection between the cathode of the tube and the negative terminal of the source, said connections comprising a diode in series with impedance external to the diode, and means connecting the control electrode of the tube to a point on said last-named connection.

27. In signalling apparatus, an amplifying tube provided with an anode, a cathode and a control electrode, a source of uni-directional space current, said source being provided with positive and negative terminals, a connection between the anode of the amplifier tube and the positive terminal of the source, a connection between the anode of the amplifier tube and the negative terminal of the source, said last named connection including at least one resistor element, a diode provided with an anode and a cathode, a connection between the negative terminal of the source and the diode cathode, means connecting the control electrode of the amplifier tube to the diode and means including a chain of resistors connecting the diode anode and the amplifier cathode.

28. In signalling apparatus, an amplifier tube having an anode, a cathode, and a control electrode, a filter circuit provided with a pair of input terminals and a pair of output terminals, said pair of input terminals being adapted to be connected, respectively, to the negative and positive terminals of a source of unidirectional current, a connection between the input terminal which is adapted to be connected to the negative terminal of the source, and one of the output terminals, said last named connection including an impedance device, means connecting the cathode of the amplifier tube to the last-named output terminal, means connecting the other of said input terminals to the other of said output terminals, means for connecting the anode of the amplifier tube to the last-named output terminals, said impedance device being traversed by the filter current to produce a potential more negative than the potential of the first output terminal, a diode, a connection between the diode cathode and a point of the impedance, a resistance path connected between the diode anode and the amplifier cathode, and means for applying a biasing potential to the control electrode of the amplifier tube comprising a connection between the amplifier control electrode and a point on the last named resistance path.

29. In an electrical circuit, a space discharge device provided with an anode, a cathode and a grid electrode, a source of uni-directional current, a circuit connected across said source including the space path of said space discharge device and an impedance element in series, a circuit connected across said impedance element including a rectifier device and a chain of resistance elements in series and a connection between the grid electrode of the space discharge

device and a point of said chain of resistor elements.

30. In an electrical circuit, a space discharge device provided with an anode, a cathode and
5 a grid electrode, a source of space current for said tube, said source being provided with a negative terminal and a positive terminal, means connecting the anode of the space discharge device to the positive terminal of the source, means
10 including a plurality of impedance elements for connecting the cathode of the tube to the negative terminal of said source, a circuit connected across at least one of said plurality of impedances comprising a rectifier device and a chain of re-
15 sistance elements in series and a connection be-

tween the grid electrode of said space discharge device and a point of said last named circuit.

31. In an electrical circuit, a space discharge device having an anode, a cathode and a grid electrode, a source of potential, a circuit connected across said source including a rectifier
5 device and a chain of resistance elements in series, one end of said chain being positive with respect to the other end thereof, means for connecting the grid electrode of said space discharge device to a point of said chain, and means con-
10 necting the cathode of said space discharge device to a point having a more positive potential than the point to which the grid is connected.

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