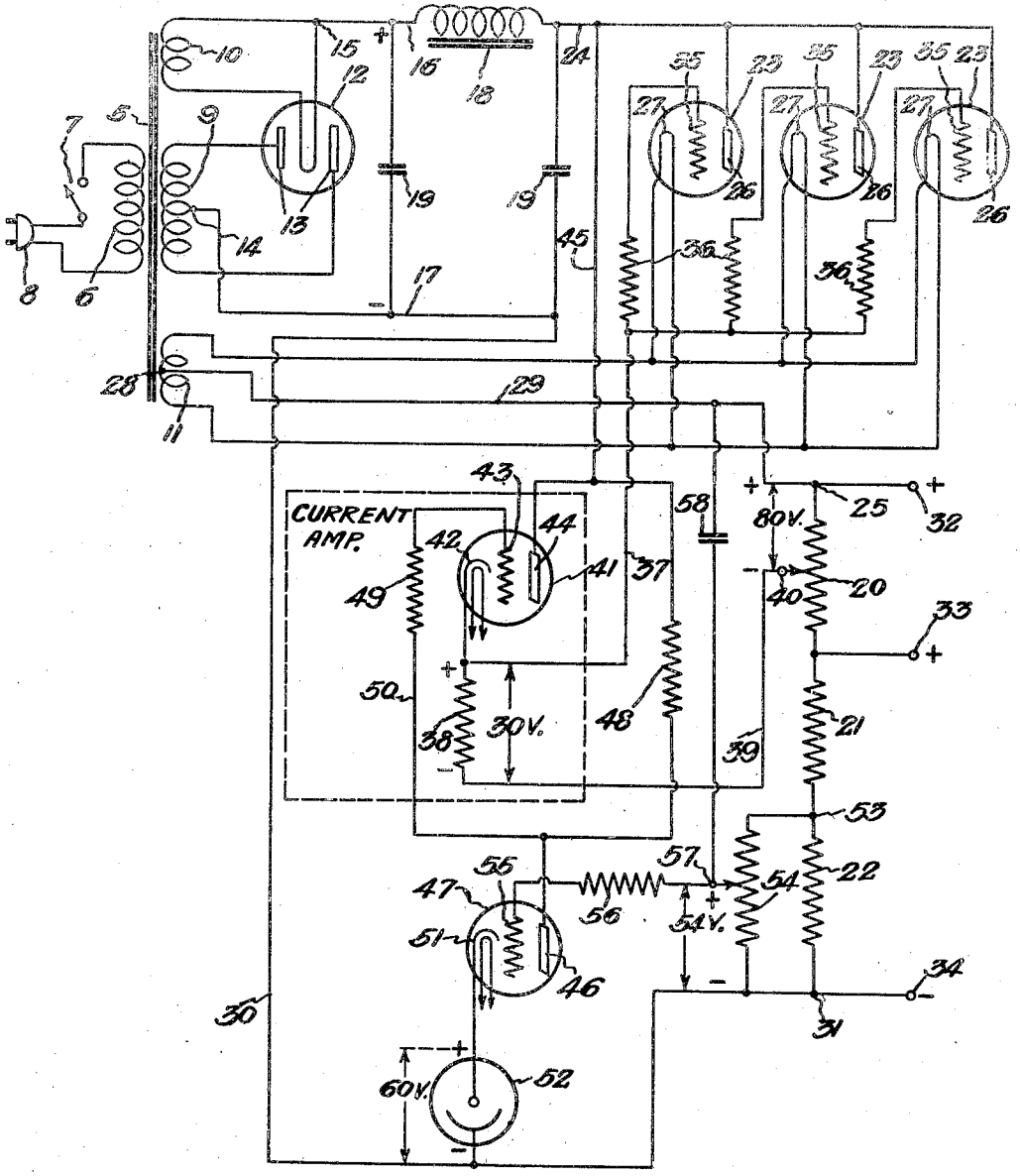
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REGULATED POWER UNIT

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REGULATED POWER UNIT

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The present invention relates to regulated power units or potential supply units, for converting alternating current line power into direct current potentials and power, suitable for use with devices normally requiring constant voltage and necessitating the use of "B" batteries as a source of such voltage. Such devices may include radio and audio frequency amplifiers for testing apparatus, for example, requiring a source of constant potential for the anode and bias supply circuits thereof.

The basic power supply unit may include an alternating current step-up transformer, rectifier and filter means, together with an output or bleeder resistor to which the rectifier supplies rectified current at a potential suitable for anode and other circuits. In regulated power supply units, however, means may be provided for maintaining substantially a constant potential at the terminals of the bleeder resistor or output terminals, through the intermediary of a regulating or control circuit including an electric discharge amplifier tube network.

Heretofore, it has been found desirable and substantially necessary to provide high resistance in the grid circuits of control tubes to obtain regulation and gain thereby precluding the use of more efficient and higher power tubes not adapted to so operate. Furthermore, while certain of the control tubes are heating, over-voltage may exist across the output impedance, and while undesirable, has not heretofore been overcome in a practical manner.

Accordingly, it is a primary object of the present invention to provide an improved regulated power supply unit having improved regulation with large current carrying capacity and which does not produce over-voltage when initially energized.

It is also an object of the present invention to provide an improved regulated power unit which supplies substantially constant direct current at the output potentials thereof with varying load and with varying alternating current supply potential with a higher degree of regulation, and in which the output potentials are maintained at safe subnormal values until the control tubes thereof have heated for proper operation.

It is also a further object of the present invention to provide an improved regulated power supply unit wherein higher capacity regulating tubes may be utilized in connection with low resistance control circuits through the intermediary of a current amplifier.

The invention will, however, be better understood from the following description when considered in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing, the figure is a schematic circuit diagram of a regulated power supply unit embodying the invention, and in which the usual rectifier and filter circuit comprises an alternating current step-up transformer **5**, provided with a primary winding **6** connected through a power switch **7** with a plug **8** for the usual alternating current power outlet (not shown).

The transformer is further provided with a high voltage secondary **9** and filament supply secondaries **10** and **11**, the former supplying a full wave rectifier tube **12**, the anodes **13** of which are connected with the high voltage secondary. Rectified alternating current is taken from the center tap **14** on the secondary **9** and a filament connection **15** on the rectifier, through positive and negative output leads **16** and **17** respectively, the polarities of which are indicated.

The output circuit further includes a series filter inductance or choke coil **18** and shunt filter capacitors **19**, the filter inductance being in the positive lead in this case.

The potential derived from the rectifier and filter is applied across an output or supply resistor comprising three series connected resistor sections **20**, **21** and **22** through a plurality of parallel connected high capacity voltage regulating tubes, **23**, the parallel space current paths of the tubes being connected in series between the positive output lead **24** of the filter and the high potential terminal **25** of the output resistor series. This arrangement is provided by connecting the anodes **26** of the voltage regulating tubes in parallel to the lead **24**, while the cathodes **27** are connected in parallel across the filament supply winding **11**, the center tap **28** of which is connected through a supply lead **29** with the terminal **25**.

The negative lead **17** of the rectifier output circuit is connected directly through a supply lead **30** with the negative terminal **31** of the series output resistor circuit. Suitable output terminals **32** and **33** are provided in connection with the output resistor and a negative output terminal **34** is provided in connection with the terminal **31**. Any other suitable taps may be provided on the series connected resistors for power supply purposes to utilization circuits (not shown).

The space path or anode impedance of the parallel connected voltage regulating tubes **23** provide, in effect, a variable resistance in series in

the output circuit of the rectifier and filter, for controlling the load or output current therefrom, and the resistance is governed by the value of the control or bias voltage of said tubes, each of which is provided with a control grid indicated at 35. Each control grid is provided with a series isolating resistor 36 and through one or another of said resistors is connected in parallel to a control lead 37 to which a variable biasing potential is applied to control the impedance of the tubes and, therefore, the potential applied to the output resistor of the power supply unit and the output terminals 32, 33 and 34.

Heretofore it has been considered advisable to provide high resistance or impedance coupling means in a control circuit for voltage regulating tubes in order to secure relatively high gain or regulating range, thereby precluding the use of certain tubes having desirable characteristics for use as voltage regulating devices. For example, tubes of the type known commercially as RCA 2A3 tubes are particularly desirable for use as regulating tubes, having low plate impedance and heavy current carying capacity and are adapted for a wide range of control in the grid circuit. However, such tubes require a relatively low resistance grid to cathode circuit or otherwise unstable operation may result, the recommended value of the resistance in the grid circuit being less than 10,000 ohms.

A sufficient number of tubes 23 are connected in parallel to provide a desired heavy current carrying capacity and a low resistance grid circuit is provided therefor which may be traced through a resistor 38 connected with the control lead 37, and through a lead 39 to a positive tap point 40 on the high potential resistor section 20 adjacent to the high potential terminal 25. In a practical embodiment such as that shown, the resistor 38 may have a resistance of substantially 9,000 ohms, while the resistance between the tap 40 and the terminal 25 may be substantially 1,000 ohms. This provides a desired resistance requirement in circuit between the control grids 35 and the filaments 27, since the terminal 25 is connected as hereinbefore pointed out through the lead 29 with the filament supply winding 11 of the voltage regulating tubes 23.

Since the tap point 40 is more negative than the terminal 25, a negative biasing potential is applied to the grids of the voltage regulating tubes, and is such that the regulating tubes are biased toward cutoff to reduce the potential existing across the output terminal substantially below normal. In the present example substantially 80 volts negative bias is provided for this purpose, between the tap 40 and the terminal 25 in connection with the RCA–2A3 tubes.

In the bias supply circuit, the resistor 38 is made the source of a variable controlling potential acting in opposition to the high negative bias provided as above at terminal 40, and this potential increases in opposition as the output voltage across the supply resistor and output terminals tends to fall below a fixed value.

To permit the use of the relatively low resistance above pointed out in the control resistor 38, and to provide the proper polarity, the latter resistor is included in the anode output circuit of a current amplifier stage, comprising an amplifier tube 41, adjacent to the cathode thereof. For this purpose the cathode 42 of the current amplifier 41 is connected to the grid end of the control resistor 38 and the anode thereof indicated at 44 is connected with the potential supply lead 24 preceding the voltage regulating tubes and directly at the output of the rectifier filter. This connection is indicated by the lead 45. The resistor 38 is therefore located in both the grid circuit of the voltage regulating tubes and in the anode circuit of the current amplifier 41. As this is a low resistance output circuit, the potential impressed between the control grids 35 and cathodes 27 is derived across two low resistance elements permitting high capacity devices at 23. The anode potential for the current amplifier is derived across the tubes 23 and the resistor section 20 between the contact 40 and the terminal 25.

The current amplifier is provided with a control grid 43 which is directly coupled to the output anode 46 of a voltage amplifier or control tube 47, through an anode coupling resistor 48 taking anode potential from the same source as the current amplifier tube 41, that is, from the positive supply lead 45 back of the voltage regulating tubes 23. The direct coupling connecting between the grid 43 and the anode 46 is made through an isolating resistor 49 and a connection lead 50.

The cathode 51 of the control tube or voltage amplified is connected to the negative supply lead 30 through a voltage regulating tube 52. This is preferably of the type known commercially as an RCA–991 or similar type of gaseous discharge tube providing substantially constant voltage drop and operates to provide a constant reference voltage on which to regulate the output voltage of the power supply unit.

Voltage variations across the output terminals of the power supply unit are applied to the voltage amplifier 47 from a relatively low voltage tap point 53 in connection with the output resistor system. In the present example the average value of the potential applied to the tube 47 is controlled by a high resistance potentiometer device 54 connected in parallel with the resistor section 22 as shown, and having a tap 57 connected through an isolating resistor 56 with the control grid 55 of the control tube. The use of a high resistance shunt potentiometer device in connection with a relatively low voltage portion of the output resistor, adjacent to the negative terminal of the output system, provides effective voltage adjustment for application to the voltage amplifier or control tube without dissipating any appreciable amount of energy in the resistor 54.

The initial adjustment of the contact 57 is such that the plate current established through the amplifier 47 and the output resistor 48 provides, with normal voltage across the output resistor combination 20, 21 and 22, an opposing potential in the control resistor 38 to reduce the negative potential supplied by the resistor 20 between the tap 40 and the terminal 25 to a value normal for the operation of the voltage regulating tubes 23. In the case of RCA–2A3 tubes, the voltage normally established across the resistor 38 may be substantially 30 volts which, in opposition to the 80 volts derived from the resistor 20, provides a normal biasing potential on the grids 35 of substantially 50 volts.

The operation is as follows: When the power switch 7 is closed, the rectifier and filament circuits are energized and, since the rectifier 12 and the voltage regulating tubes 23 are of the filament type, operating current and voltage are at once applied to the output terminals 32, 33 and 34. Since the current and voltage ampli-

fiers are provided with heater type cathodes as indicated, they are initially inoperative to control the system. The voltage regulating tubes **23** may, therefore, receive the full biasing potential from the resistor **20** and the output current is thereby materially reduced below normal, whereby the output voltages across the terminals **32**, **33** and **34** are reduced below a normal value thereby preventing over-voltage. Upon heating of the current amplifier and control tubes to normal, the potential across the control or output resistor of the current amplifier operates to reduce the biasing potential on the voltage regulating tubes **23** to normal and a normal output potential is established across the output terminals **32**, **33** and **34**.

In case that the voltages between the terminals **32** and **33** and the terminal **34** tend to be reduced below normally desired and established values, by reason of load or by reason of a reduction in the supply potential derived from the rectifier, the negative bias on the control grid **55** is increased, for the reason that the voltage between the tap **57** and the negative lead **30** regulates against the voltage provided by the regulating tube **52**. The polarity of this voltage is indicated adjacent to the tube and it will be seen is in opposition to the drop in potential between the tap **57** and the negative lead **30** which is initially adjusted to some value below the constant voltage of the device **52**, to permit a normal negative biasing potention to be placed on the grid **55**. For example, if the tube **52** provides a drop in potential of 60 volts, the drop in potential selected across the potentiometer resistor **54**, in opposition thereto, may be 54 volts, thereby resulting in an effective normal negative bias of 6 volts on the grid **55**.

With the reduction in output potential from the power supply terminals **32**, **33** and **34**, under conditions above pointed out, the increase in negative bias on the grid **55** of the control tube causes a reduction of the anode current flowing from the latter through the coupling resistor **48**, thereby increasing the potential on the control grid **43** of the current amplifier in a positive direction. This, in turn, causes the anode current of the amplifier **41** to increase, resulting in a higher drop in potential through the output or control resistor **38** and greater opposition to the fixed negative biasing potential derived from the resistor **20**, whereby the grids **35** of the voltage regulating tubes receive a lower negative biasing potential, thereby lowering their anode or plate impedance and permitting increased current to flow to the output resistor, which, in turn, restores the potential to normal. An increase in the potential at the output terminals for any reason causes the system to operate in the opposite manner to restore the potential to normal by increasing the plate impedance of the regulating tubes.

By utilizing low impedance voltage regulating tubes, which, in turn, are made possible by the use of a direct current amplifier the output impedance of which provides a desired low resistance in the grid control circuit of the regulating tubes, a greater portion of the voltage supplied by the rectifier and filter is made available for use at the output terminals of the power supply unit. Furthermore, by utilizing a current amplifier, the low resistance grid circuit is provided without additional voltage supply or change in direction of control. It should also be noted that the circuit shown and described, provides protection against over-voltage when the power supply unit is initially energized, or if, for any reason, the controlling tube **41** fails. The output potential is, therefore, amply protected against over-voltage because of faulty operation, for the reason that, if the control circuit fails by reason of the faulty operation of the control tubes, such as burning out of the heaters, the initial full negative bias is applied to the voltage regulating tubes **23** from the tap **40** on the resistor **20**, whereby the output potential falls below normal.

It is also preferable that the control tube or voltage amplifier **47** be of the high mu type, providing a wide range of voltage control through the output resistor **48** in connection with the grid of the current amplifier **41**. Furthermore, if any appreciable amount of ripple potential is present in the output circuit, the same may be applied to the grid of the control amplifier **47** through a coupling capacitor **58** connected between the grid circuit for the grid **55** and the high potential terminal **25** of the output resistor system, as indicated. Such a ripple is then suitably amplified without distortion through the current amplifier and is applied to the regulating tubes further to reduce the hum potential as present in the output.

I claim as my invention:

1. A voltage regulating power supply unit comprising a voltage supply circuit having positive and negative output leads, a voltage output resistor connected in shunt with said leads, a voltage regulating tube having its space path included serially in said last named connection and having a control grid whereby the impedance of said space path is varied, means including a grid control circuit connected with said output resistor adjacent to the positive end thereof to provide an initial negative biasing potential on said control grid, a direct current amplifier including an electric discharge device having a control grid, an anode connected with said positive supply lead, and a cathode connected with said voltage output resistor in common with said grid control circuit connection, a resistor in said last named connection providing with the resistance of said output resistor a minimum total predetermined resistance in the grid circuit of the regulating tube, means providing an adjustable tap connection adjacent to the negative end of said output resistor, a voltage amplifier tube having a control grid connected with said adjustable tap connection, and a cathode connected with the negative end of said output resistor, a voltage regulating tube in said last named connection providing substantially constant reference voltage for said unit, and means for coupling said voltage amplifier to said control grid of the direct current amplifier.

2. A regulated power unit comprising in combination, means for supplying electrical energy at substantially constant direct-current voltage including a positive and a negative supply lead, a load circuit connected with said supply leads and including a potentiometer resistor connected between said leads in shunt relation to said supply means, a regulating tube having an anode connected with the positive supply lead and a cathode connected with the load circuit, and having a control grid, a direct-current amplifier tube having an anode connected with the positive supply lead and having a cathode connected with a voltage tap point on said potentiometer resistor, said first named control grid being connected

with said last named cathode, a cathode resistor connected between said last named cathode and said voltage tap point, said resistor having a resistance less than a predetermined minimum, a control tube coupled to said direct-current amplifier, means providing substantially constant biasing potential for said control tube, and means for deriving a controlling potential from said potentiometer resistor adjacent to the negative end thereof for said control tube in opposition to said substantially constant potential.

3. A regulated power supply unit comprising, in combination, a direct current supply circuit, a power output resistor having positive and negative terminals, at least one electric discharge regulating tube having its anode-cathode impedance in circuit between the positive side of said supply circuit and the positive terminal of said output resistor, and said tube having a control grid adapted to receive a controlling potential whereby the internal impedance of said tube is controlled, a grid circuit for said control grid including a series potential drop producing resistor and a tap connection on said output resistor adjacent to the positive terminal thereof, whereby an initial negative bias potential as applied to said control grid from said output resistor, said bias potential being such that the internal impedance of at least one regulating tube is relatively high with respect to the normal internal impedance of said tube, a current amplifier tube having an anode connected with the positive side of said supply circuit, a cathode connected with the grid end of said last named potential drop producing resistor, and a control grid, a voltage amplifier tube having an anode connected in parallel with said last named grid and having a common connection therewith to the positive side of said supply circuit, a coupling resistor in said connection, said voltage amplifier having a control grid and a cathode, said cathode being connected with the negative side of said supply circuit, a voltage regulator tube in said connection providing a constant reference voltage for said unit, and a tap connection for said last named grid on said output resistor adjacent to the negative terminal thereof to provide a positive potential on said last named grid substantially less than the potential provided by said regulating tube.

4. In a regulated power supply unit comprising a direct current supply circuit, at least one regulating tube and a power output resistor in series across said circuit, the combination of a grid circuit for said regulating tube comprising a series resistor and a portion of the output resistor adjacent to the positive terminal thereof, the total resistance of which circuit is less than a predetermined minimum, a current amplifier tube having a cathode connected with said series resistor at a point to place said resistor jointly in the cathode circuit of said last named tube and the grid circuit of said first named tube, said current amplifier having an anode connected with the positive side of said supply circuit, a voltage amplifier tube having an anode and said current amplifier having a grid, a coupling resistor common to said anode and grid providing a connection therefor with the positive side of said supply circuit, said voltage amplifier further having a control grid and a cathode, and means providing a source of substantially constant voltage and a portion of said output resistor adjacent to the negative terminal thereof between said last named control grid and cathode, said connection with the output resistor being variable.

5. In a regulated power supply unit comprising a direct current supply circuit, at least one regulating tube and a power output resistor in series across said circuit, the combination of a grid circuit for said regulating tube comprising a series resistor and a portion of the output resistor adjacent to the positive terminal thereof, the total resistance of which circuit is less than a predetermined minimum, and a current amplifier tube having a cathode connected with said series resistor at a point to place said resistor jointly in the cathode circuit of said last named tube and the grid circuit of said first named tube.

6. In a regulated power supply unit comprising a direct current supply circuit, at least one regulating tube and a power output resistor in series across said circuit, the combination of a grid circuit for said regulating tube comprising a series resistor and a portion of the output resistor adjacent to the positive terminal thereof, the total resistance of which circuit is less than a predetermined minimum, a current amplifier tube having a cathode connected with said series resistor at a point to place said resistor jointly in the cathode circuit of said last named tube and the grid circuit of said first named tube, said current amplifier having an anode connected with the positive side of said supply circuit, a voltage amplifier tube having an anode and said current amplifier having a grid, a coupling resistor common to said anode and grid providing a connection therefor with the positive side of said supply circuit, said voltage amplifier further having a control grid and a cathode, and means providing a source of substantially constant voltage and a portion of said output resistor adjacent to the negative terminal thereof between said last named control grid and cathode, said connection with the output resistor being variable, said current amplifier and said voltage amplifier being of the indirectly heated cathode type and said regulating tube being of the filamentary type, whereby when said power unit is energized, the output current applied to said output resistor is reduced initially and until said current and voltage amplifiers are rendered operative.

7. In a regulated power supply unit, the combination of a direct current supply circuit, a power output resistor having a negative terminal connected with the negative side of said supply circuit and having a positive terminal connected with the positive side of said supply circuit, at least one regulating tube connected between said positive terminal and the positive side of said supply circuit whereby the anode-cathode impedance thereof is included in circuit with said output resistor, said tube having a control grid whereby said impedance is controlled by the application of a biasing potential thereto with respect to cathode, a grid circuit for said regulating tube connected with said output resistor through the medium of a tap on said output resistor adjacent to the positive terminal thereof to establish a predetermined biasing potential on said tube, means for deriving a controlling potential from said output resistor adjacent to the negative terminal thereof, an electric discharge amplifier for said potential of the indirectly heated cathode type, a current amplifier tube controlled by said voltage amplifier, said current amplifier tube having an indirectly

heated cathode and an anode directly connected with the positive side of said supply circuit and having a cathode connection in common with said first named grid circuit to said tap on said output resistor, and a resistor of less than a predetermined minimum resistance in said last named common connection.

8. In a regulated potential supply system, the combination with a direct current supply circuit and at least one regulating tube having a cathode, an anode connected with the positive side of the supply circuit and a control grid, of means for deriving potentials therefrom comprising a voltage output resistor having a positive terminal connected with the cathode, and having a negative terminal, a direct current amplifier tube having an anode connected with the positive side of the supply circuit, and having a cathode connected with the control grid of said regulating tube, a common resistor for said last named cathode and control grid of a predetermined maximum resistance, connected with said output resistor adjacent to the positive terminal thereof to establish a predetermined initial biasing potential on said grid, and means connected with the negative end of said output resistor to receive a controlling potential therefrom for said direct current amplifier tube.

9. In a regulated potential supply system, the combination with a direct current supply circuit and at least one regulating tube having a cathode, an anode connected with the positive side of the supply circuit and a control grid, of means for deriving potentials therefrom comprising a voltage output resistor having a positive terminal connected with the cathode, and having a negative terminal, a direct current amplifier tube having an anode connected with the positive side of the supply circuit, and having a cathode connected with the control grid of said regulating tube, a common potential drop producing impedance device for said last named cathode and control grid connected with said output resistor adjacent to the positive terminal thereof whereby a positive bias potential for the last named control grid is provided by said impedance device and an opposing negative biasing potential is provided by said output resistor through said connection, and means for adjusting said connection to provide a predetermined relation between said biasing potentials.

10. In a regulated potential supply system, the combination with a direct current supply circuit and at least one regulating tube having a cathode, an anode connected with the positive side of the supply circuit and a control grid, of means for deriving potentials therefrom comprising a voltage output resistor having a positive terminal connected with the cathode, and having a negative terminal, a direct current amplifier tube having an anode connected with the positive side of the supply circuit, and having a cathode connected with the control grid of said regulating tube, a common potential drop producing impedance device for said last named cathode and control grid connected with said output resistor adjacent to the positive terminal thereof whereby a positive bias potential for the last named control grid is provided by said impedance device and an opposing negative biasing potential is provided by said output resistor through said connection, means for adjusting said connection to provide a predetermined relation between said biasing potentials, a control tube, a regulating tube, a circuit comprising a resistor, the anode-cathode impedance of said control tube and space path of said regulating tube connected serially in the order named between the positive and negative sides of the supply circuit, a control grid for the direct current amplifier connected with said last named circuit between the resistor and the control tube, and a control grid for the control tube connected with the voltage output resistor adjacent to the negative terminal thereof.

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