

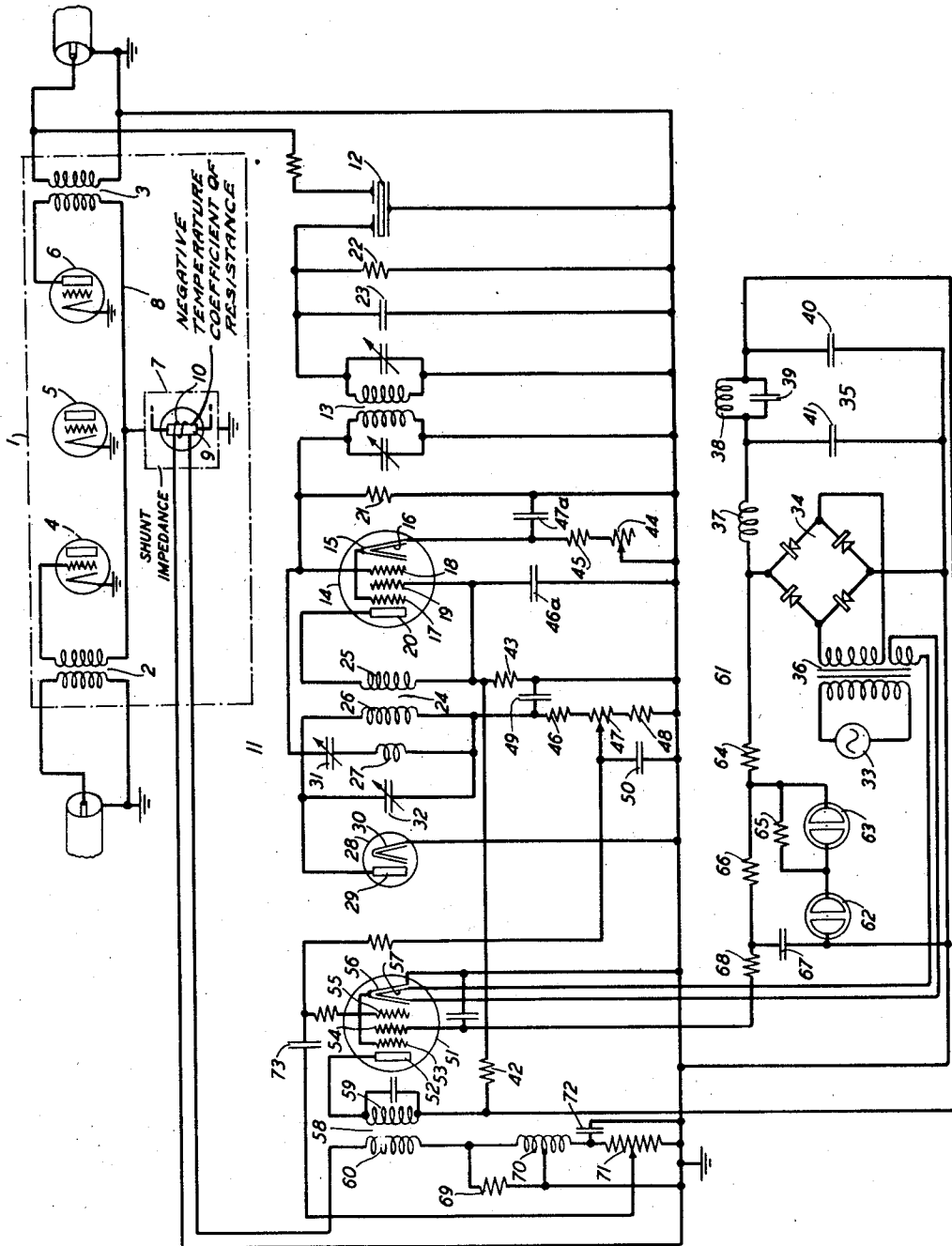
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REGULATOR CIRCUIT

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REGULATOR CIRCUIT

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This invention relates to regulator circuits and particularly to regulator circuits for governing the gain on signal transmission systems.

One object of the invention is to provide a regulator circuit having a pentode tube therein that shall control the potential supplied to the screen grid circuit of the pentode tube in an improved manner to control the pentode tube characteristic.

Another object of the invention is to provide a regulator circuit having a vacuum tube including a screen grid with a cathode heated by alternating current that shall govern the screen grid circuit in a manner to compensate the tube operation for any changes in the potential of the cathode heating circuit.

A further object of the invention is to provide a regulator circuit having a pentode tube with a cathode heated by alternating current and a screen grid supplied with regulated rectified potential from said source of alternating current that shall govern the rectified potential supplied to the screen grid in a manner to compensate the tube operation for any changes in the potential of the cathode heating current.

In long signal transmission lines it is necessary to provide amplifiers or repeaters at intervals along the line to maintain the energy level of the signals above a predetermined level. Regulators or gain control circuits are required at certain of the repeater stations to hold the energy level of the signals substantially constant. The regulators if of the dynamic type are generally controlled by a pilot frequency.

According to the present invention a regulator circuit having a pentode oscillator tube therein is employed to control a feedback amplifier of the type disclosed in the patent to H. S. Black, No. 2,102,671, December 21, 1937, which is connected into a transmission line carrying signal and pilot currents. The regulator circuit which is connected to the signal line beyond the amplifier therein is provided with a filter for selecting the pilot current and means for amplifying and rectifying the selected pilot current. The rectified pilot is used to control the oscillator which in turn controls a resistance element in the feedback or beta circuit of the line amplifier.

The cathode of the pentode oscillator is heated from a source of alternating current, a rectifier and a smoothing filter are connected to the source of alternating current for supplying potential to the anode of the oscillator and a potential regulator is connected to the output of the rectifier for supplying constant potential to the screen

grid circuit of the oscillator. The screen grid circuit is controlled in a manner to compensate for any change in the oscillator operation caused by variations in the heating circuit for the oscillator cathode.

It has been found that variations in the potential employed to heat the cathode of the oscillator cause variations in the oscillator output and accordingly variations in the regulating operation. In order to compensate for the variations in the oscillator output caused by variations in the heating of the cathode, the screen grid circuit is supplied with a constant potential and the potential impressed on the screen grid itself is controlled according to variations in the potential of the heater circuit for the cathode.

The anode of the pentode oscillator is supplied with potential from a source of alternating current by means of a rectifier of the selenium type and a smoothing filter. The source of alternating current is also connected to the heater for the cathode and any change in the potential supplied to the cathode heater is compensated for by changes in the potential impressed upon the screen grid of the oscillator. It has been found that small changes in the potential impressed on the anode of the oscillator cause little change in the oscillator operation. It has also been found that while the regulator maximum output varies somewhat with plate or anode voltage, the position of the cut-off for the oscillator remains practically fixed if the screen grid voltage on the pentode oscillator is held constant. In order to supply substantially constant voltage to the screen grid of the oscillator, two cold cathode tubes connected in series with a resistance element are shunted across the output from the selenium rectifier. A leak resistance is connected across one of the cold cathode tubes in order to initially impress all the voltage from the rectifier on the other cold cathode tube and thus insure ignition thereof. Upon ignition of one of the cold cathode tubes, the other tube will be ignited by the ripple voltage from the rectifier. There is always substantial ripple voltage from the rectifier to insure the ignition of both cold cathode tubes. Regulation by the two cold cathode tubes is effected by reason of the resistance element in series therewith. The screen grid circuit is connected across the cold cathode tubes in circuit with a smoothing filter.

A resistance element is inserted in the screen grid circuit of the pentode oscillator to compensate for variations in the oscillator operation caused by variations in the potential supplied to

the heater for the cathode of the oscillator. If the heater current of the oscillator cathode tends to go down, the potential impressed on the screen grid will be raised by reason of the reduced loss across the resistance element in the screen grid circuit. An increase in the screen grid voltage increases the oscillator output to compensate for the reduction tending to be produced by the reduction in the heater current supplied to the cathode heater. This operation may take place by reason of supplying the screen grid circuit with substantially constant potential.

The single figure in the accompanying drawing is a diagrammatic view of a regulator circuit constructed in accordance with the invention.

Referring to the drawing, an amplifier 1 of the feedback type is shown in a transmission line of the coaxial type. A transformer 2 connects the input terminals of the amplifier to the coaxial cable and a transformer 3 connects the output terminals of the amplifier to the coaxial cable. The amplifier 1 may be of the type disclosed in the patent to H. S. Black, No. 2,102,671, December 21, 1937. The amplifier 1 is shown comprising three tubes 4, 5 and 6 which may be of any suitable type.

An impedance pad 7 is shown connected across the beta circuit 8 of the amplifier 1. One element of the impedance pad comprises a resistance element 9 having a high negative temperature coefficient of resistance. The resistance element may be composed of nickel, manganese and copper oxide or may be composed of silver sulphide. The resistance element 9 is controlled by a heater element 10. An increase in the current flow through the heater element 10 decreases the resistance of the resistance element 9 to decrease the feedback through the beta circuit 8. This action increases the gain of the amplifier. A decrease in the current flow through the heater coil 10 produces an opposite action.

Regulator circuits 11 are provided for controlling the heater element 10 to maintain the pilot output from the amplifier 1 substantially constant. The coaxial cable shown on the drawing transmits not only carrier currents but also a pilot current. The pilot current is employed for controlling the operation of the regulator or gain control circuits 11. The control circuits 11 comprise a filter 12 which is preferably of the crystal type and which selects the pilot frequency. The crystal filter 12 is connected directly across the secondary winding of the output transformer 3 connected to the amplifier 1. The crystal filter 12 is connected by a transformer 13 to the input circuit of a pentode amplifier tube 14. The transformer 13 is provided with tuned primary and secondary windings. The windings of the transformer 13 are tuned to the pilot frequency selected by the crystal filter 12. The pentode amplifier 14 comprises a cathode 15 having a heater 16, a suppressor grid 17, a control grid 18, a screen grid 19 and an anode 20. A resistance element 21 provides terminating impedance for the secondary winding of the transformer 13 and a resistance 22 provides terminating impedance for the crystal filter 12. A condenser 23 comprises a part of the tuned primary circuit of the transformer 13.

A transformer 24 having a primary winding 25, a secondary winding 26 and an auxiliary winding 27 connects the output circuit from the pentode tube 14 to a diode rectifier 28. The diode 28 is operated in a circuit of sufficiently high resistance and with a sufficiently high

voltage applied to its anode 29 that variations in the heater current for the cathode 30 do not appreciably affect its direct current output. The diode rectifier 28 comprises an anode 29 and a cathode 30. The auxiliary winding 27 of the transformer 24 is connected through an adjustable condenser 31 to the control grid 18 of the pentode amplifier 14 for neutralization purposes. The secondary winding 26 of the transformer 24 is tuned by an adjustable condenser 32 to the pilot frequency.

Plate potential for the anode 20 of the pentode amplifier 14 is supplied from a source of alternating current 33 through a selenium rectifier bridge 34 and a smoothing filter 35. The source of alternating current 33 is connected by a transformer 36 to the input vertices of selenium bridge 34. The smoothing filter connected to the output vertices of the bridge 34 comprises inductance elements 37 and 38 and capacitance elements 39, 40 and 41. The output terminals of the smoothing filter 35 are connected in circuit with two resistance elements 42 and 43. Potential for energizing the anode 20 of the pentode amplifier 14 is obtained by the potential drop across the resistance element 43. Plate circuit for the pentode 14 may be traced from the anode 20 through the primary winding 25 of the transformer 24, resistance element 43 and resistance elements 44 and 45 to the cathode 15. The potential drop across the resistance element 45 serves as a minimum bias on the pentode 14 and the potential drop across the resistance element 44 serves as an adjustable bias for the pentode 14. The condensers 46a and 47a are connected in shunt respectively with resistance 43 and resistances 44 and 45 in series and serve as by-pass condensers for those resistances.

The rectifier circuit through the diode of rectifier 28 may be traced from the anode 29 through the secondary winding 26 of the transformer 24 and resistance elements 46, 47 and 48 to the cathode 30. The condensers 49 and 50 are connected respectively across these resistance elements in series and across resistance element 48 and the lower variable portion of resistance element 47 in series and serve as by-pass condensers for these resistances. The potential drop across the resistance element 48 and a portion of the resistance element 47 is impressed on the input circuit of a pentode oscillator tube 51. The pentode oscillator tube 51 comprises an anode 52, a suppressor grid 53, a screen grid 54, a control grid 55 and a cathode 56 having a heater 57. The heater 57 for the cathode 56 the same as the heater for the cathode 30 in the rectifier 28 and the heater 16 for the cathode 15 in the pentode amplifier 14 is energized from the source of alternating current 33. The output circuit of the pentode oscillator tube 51 is connected by a transformer 58 having a tuned primary winding 59 and a secondary winding 60 to the heater coil 10. Anode potential for the pentode oscillator 51 is obtained directly from the output terminals of the smoothing filter 35 connected to the selenium rectifier 34.

The screen grid circuit for the pentode oscillator 51 is connected by a regulator 61 to the rectifier 34 ahead of the smoothing filter 35. The regulator 61 comprises two cold cathode tubes 62 and 63 and a resistance element 64. The cold cathode tubes 62 and 63 are connected in series with the resistance element 64 across the output terminals of the selenium rectifier 34. The resistance element 64 serves as a regulating re-

sistance to produce substantially constant voltage across the two tubes 62 and 63. A resistance element 65 is connected across the cold cathode tube 63 in order to permit ignition of the tube 62 by the entire voltage from the rectifier 34. Ignition of the cold cathode tube 63 is insured by the ripple voltage from the rectifier output. Assuming that the two tubes 62 and 63 each have a striking voltage of 70 and an operating voltage of 60 it is clear the two tubes cannot be ignited simultaneously if only 130 volts are supplied from the source. However, by reason of the resistance 65 shunted around the tube 63, the tube 62 may first be ignited and after ignition of tube 62 effect the ignition of the tube 63. A resistance element 66 and a condenser 67 serve to filter out the ripple voltage appearing across the two cold cathode tubes 62 and 63.

The screen grid circuit for the oscillator pentode 51 may be traced from the screen grid 54 through a resistance element 68, resistance element 66 to one electrode of the cold cathode tube 63 and from an electrode of the cold cathode tube 62 to the cathode 56 of the oscillator 51. The resistance element 68 serves to vary the potential impressed on the screen grid 54 in a manner to compensate for any changes in the potential impressed on the heater 57 for the cathode 56. If the heater potential employed to heat the cathode 56 goes down then there is a tendency to reduce the screen grid current which flows through the resistance element 68. A reduction in the screen grid current reduces the potential drop across the resistance 68 which in turn increases or raises the potential impressed on the screen grid 54. This raising of the screen grid potential compensates for the reduction in the oscillator output which would be caused by the reduction in the heater current supplied to the cathode 56. If the heater current tends to increase an opposite action takes place. The variations in the gain of the amplifier 14 caused by changes in the heater current for the cathode 15 and the variations in the potential impressed on the anode 20 and the screen grid 19 are opposite and about equal to the shift in the operating point of the oscillator tube 51 caused by variations in the potential supplied to the anode 52.

The oscillator 51 is of the type disclosed in the R. R. Blair patent, No. 2,178,333, October 31, 1939. The oscillator is adjusted to have an output-input characteristic curve with a steeply inclined cut-off portion. The oscillator is operated along the steeply inclined cut-off portion so that a small change in bias on the grid 55 will cause a more than proportional change in the output from the oscillator. The bias impressed on the grid 55 of the oscillator 51 varies according to the strength of the pilot current on the coaxial cable. The pilot current is selected by the crystal filter 12, amplified by the pentode amplifier 14, rectified by the diode 28 and impressed on the grid 55 in order to control the oscillator according to the strength of the pilot current.

The circuit for energizing the heater coil 10 by the oscillator output may be traced from one terminal of the secondary winding 60 of the transformer 58 through the coil 10 and resistance element 69 to the other terminal of the secondary winding 60. The potential drop across the resistance element 69 energizes an autotransformer 70 for use as an oscillator feed-back voltage on the oscillator 51. The autotransformer 70 is connected to a resistance element 71 shunted by condenser 72. The resistance 71 is adjusted across

the autotransformer secondary winding to obtain an exact degree of cut-off sharpness for good regulation without hunting action. The adjustable resistance 71 is connected to the control grid 55 of the oscillator by means of a condenser 73.

The pentode oscillator 51 has a very high resistance and serves in fact as a constant current generator. The constant current supplied by the oscillator to the secondary winding 60 of the transformer 58 flows in series through the load resistance comprising the heater coil 10 and the resistance 69 which controls the oscillator feedback. The load resistance comprising the heater coil 10 may be of the order of 100 ohms and effects little interference with the constant current flowing through the circuit of the secondary winding 60. Thus the output from the oscillator 51 is independent of the resistance of the heater coil 10. Any suitable heater coil may be coupled to the oscillator output without changing the oscillator operation. The resistance 69 being of the order of 20 ohms supplies a constant potential to the autotransformer 70 by reason of the constant current flow therethrough. The autotransformer 70 serves merely to step up the potential drop from across the resistance element 69.

In a regulator circuit of the above-described type, the pilot frequency appearing beyond the amplifier 1 is selected by the crystal filter 12, amplified by the pentode 14 and rectified by the diode 28 for controlling the oscillator 51. The oscillator 51 controls the current flow through the heater coil 10 for adjusting the feedback on the line amplifier 1. When the energy level of pilot current beyond the amplifier 1 falls below normal value there is a reduction in the negative bias impressed on the control grid 55 of the oscillator 51. This causes a relative increase in the heater current supplied to the heater coil 10. An increase in the current flow through the heater element increases the temperature of the resistance element 9 to decrease the resistance value thereof. The feedback on the amplifier 1 is thereby reduced to increase the gain effected by the amplifier. In case the energy level of the pilot current beyond the amplifier 1 tends to increase above level then an opposite action takes place. In the operation of the oscillator pentode 51, the cathode 56 is heated by current from an alternating current source and provision is made by the regulator 61 and the resistance element 68 to insure that a change in the transconductance of oscillator tube 51 caused by aging of the tube or by a change in the potential on the heater for the cathode 56 of the oscillator will not effect the regulating operation of the oscillator.

Modifications in the circuits and in the arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In a regulator circuit, an oscillator having an output-input curve with a steeply inclined cut-off portion, said oscillator comprising a vacuum tube having a cathode, a control grid, a screen grid and an anode, a source of alternating current, means for heating the cathode of said oscillator from said source of alternating current, means for rectifying current from said source of alternating current, means including a smoothing means connecting said rectifying means to the anode of said oscillator to supply potential to the oscillator anode, means additional to and exclusive of said smoothing means which addi-

tional means includes a source of constant voltage and is connected to said rectifying means for supplying potential to the screen grid of said oscillator, and means connecting said source of constant voltage of said additional means to said screen grid circuit for controlling the screen grid circuit of said oscillator independently of the other electrodes by changing the potential of said screen grid to compensate for changes in the oscillator operation caused by changes in the potential from said source of alternating current supplied to heat the oscillator cathode.

2. In a regulator circuit, a pentode tube, a source of alternating current, means for heating the cathode of said pentode tube from the source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said pentode tube, a smoothing filter for connecting said rectifying means to the pentode anode, means including a source of constant voltage connected to said rectifying means to supply voltage to the screen grid of said pentode independently of said smoothing filter, and means connecting said supply means to said screen grid for controlling the screen grid circuit of said pentode by changing the potential impressed on said screen grid to compensate for changes in the pentode operation caused by changes in the potential from said source of alternating current supplied for heating the pentode cathode.

3. In a regulator circuit, a pentode tube, a source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said pentode tube, a smoothing filter for connecting said rectifying means to the pentode anode, two cold cathode tubes connected in series with a resistance element across said rectifying means and before said filter to insure ignition of said cold cathode tubes by the ripple voltage, a resistance in shunt with one of said cold cathode tubes for insuring ignition of said tubes in succession, and means for connecting the screen grid circuit of said pentode tube across said cold cathode tubes.

4. In a regulator circuit, a pentode oscillator having an output-input characteristic curve with a steeply inclined cut-off portion, a source of rectified potential, a smoothing filter connecting said source to the anode of said pentode, two cold cathode tubes connected in series with a resistance element across the source of rectified current before said filter to insure ignition of said tubes by the ripple voltage, a resistance in shunt with one of said tubes for insuring ignition of said tubes in succession, and means for connecting the screen grid circuit of said pentode across said cold cathode tubes.

5. In a regulator circuit, a pentode oscillator having an output-input characteristic curve with a steeply inclined cut-off portion, a source of alternating current, means for heating the cathode of said oscillator from said source, means for rectifying current from said source, a smoothing filter connected to said rectifying means, means to supply potential from said smoothing filter to said oscillator anode, two cold cathode tubes connected in series with a resistance element across said rectifying means ahead of said smoothing filter to effect ignition of said tubes by the ripple voltage from the rectifying means, a resistance in shunt with one of said tubes for insuring ignition of said tubes in succession, a

circuit for connecting the screen grid circuit of said oscillator across said tubes and a resistance element inserted in said screen circuit to compensate for changes in the oscillator operation caused by changes in the potential from said source of alternating current supplied to the heater for the oscillator cathode.

6. In a regulator circuit, a pentode oscillator having an output-input characteristic curve with a steeply inclined cut-off portion, a source of alternating current, means for heating the cathode of said pentode tube from the source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said pentode tube, a smoothing filter for connecting said rectifying means to the pentode anode, two cold cathode tubes connected in series with a resistance element across said rectifying means and before said filter to insure ignition of said cold cathode tubes by the ripple voltage, a resistance in shunt with one of said cold cathode tubes for insuring ignition of said cold cathode tubes in succession, means for connecting the screen grid circuit of said pentode tube across said cold cathode tubes to energize the screen grid circuit, and means for controlling the screen grid circuit of said pentode to compensate for changes in the potential from said source of alternating current supplied to heat the pentode cathode.

7. In a regulator circuit, a pentode tube, a source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said pentode tube, a smoothing filter for connecting said rectifying means to the pentode anode, two cold cathode tubes connected in series with a resistance element across said rectifying means and before said filter to insure ignition of said cold cathode tubes by the ripple voltage, the voltage across said two tubes in series required to ignite them being greater than the voltage generated by said rectifier, a resistance in shunt with one of said cold cathode tubes only for insuring ignition of said tubes in succession, and means for connecting the screen grid circuit of said pentode tube across said cold cathode tubes.

8. In a regulator circuit, a pentode oscillator having an output-input characteristic curve with a steeply inclined cut-off portion, a source of rectified potential, a smoothing filter connecting said source to the anode of said pentode, two cold cathode tubes connected in series with a resistance element across the source of rectified current before said filter to insure ignition of said tubes by the ripple voltage, the voltage across said two tubes in series required to ignite them being greater than the voltage generated by said rectifier, a resistance in shunt with one of said tubes only for insuring ignition of said tubes in succession, and means for connecting the screen grid circuit of said pentode across said cold cathode tubes.

9. In a regulator circuit, a pentode oscillator having an output-input characteristic curve with a steeply inclined cut-off portion, a source of alternating current, means for heating the cathode of said oscillator from said source, means for rectifying current from said source, a smoothing filter connected to said rectifying means, means to supply potential from said smoothing filter to said oscillator anode, two cold cathode tubes connected in series with a resistance element across

said rectifying means ahead of said smoothing filter to effect ignition of said tubes by the ripple voltage from the rectifying means, the voltage across said two tubes in series required to ignite them being greater than the voltage generated by said rectifier, a resistance in shunt with one of said tubes only for insuring ignition of said tubes in succession, a circuit for connecting the screen grid circuit of said oscillator across said tubes and a resistance element inserted in said screen circuit to compensate for changes in the oscillator operation caused by changes in the potential from said source of alternating current supplied to the heater for the oscillator cathode.

10. In a regulator circuit, a pentode oscillator having an output-input characteristic curve with a steeply inclined cut-off portion, a source of alternating current, means for heating the cathode of said pentode tube from said source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said pentode tube, a smoothing filter connecting said rectifying means to the pentode anode, two cold cathode tubes connected in series with a resistance element across said rectifying means and before said filter to insure ignition of said cold cathode tubes by the ripple voltage, the voltage across said two tubes in series required to ignite them being greater than the voltage generated by said rectifier, a resistance in shunt with one only of said cold cathode tubes for insuring ignition of said cold cathode tubes in succession, and means for connecting the screen grid circuit of said pentode tube across said cold cathode tubes to energize the screen grid circuit, including means for controlling the screen grid circuit of said pentode to compensate for changes in the output of the pentode oscillator due to changes in the potential from said source of alternating current supplied to heat the pentode cathode.

11. In a regulator circuit, a pentode tube, a source of alternating current, means for heating the cathode of said pentode tube from said source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said pentode tube, a smoothing filter connecting said rectifying means to the pentode anode, constant voltage regulating means comprising a cold cathode tube connected to said rectifying means independently of said smoothing filter, and means connecting said constant voltage means to the screen grid of said pentode for controlling the screen grid circuit of said pentode by changing the potential impressed on said screen grid to compensate for changes in the pentode operation caused by changes in the potential from said source of alternating current supplied for heating the pentode cathode.

12. In a regulator circuit, a pentode tube, a source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said pentode tube, a smoothing filter connecting said rectifying means to the pentode anode, two cold cathode tubes connected in series with a resistance element across said rectifying means and before said filter to insure ignition of said cold cathode tubes by the ripple voltage, a resistance of proper amount connected in shunt with one of said cold cathode tubes to make the conductances between the terminals of said cold cathode tubes individually different for insuring ignition of said tubes in succession, and means for connecting the screen grid circuit of said pentode tube across said cold cathode tubes.

13. In a regulator circuit a vacuum tube having a cathode, a control grid, a screen grid and an anode, a source of alternating current, means for heating the cathode of said vacuum tube from said source of alternating current, rectifying means connected to said source of alternating current for supplying potential to the screen grid and the anode of said vacuum tube, a smoothing filter connected to said rectifier, means connecting the output of said smoothing filter to the anode of said vacuum tube, means connected to the rectifier ahead of said smoothing filter producing a substantially constant voltage, and means comprising a resistance connecting said constant voltage means to said screen grid whereby changes in the output of the vacuum tube caused by changes in the potential from said source of alternating current supplied for heating the cathode of said vacuum tube are compensated.

14. In a regulator circuit, a vacuum tube having a cathode, a control grid, a screen grid and an anode, a source of alternating current, means for heating the cathode of said vacuum tube from said source of alternating current, rectifying means connected to said source of alternating current for supplying rectified potential to the screen grid and the anode of said vacuum tube, a smoothing filter connecting said rectifying means to the anode of said vacuum tube, constant voltage regulating means comprising a cold cathode tube connected to said rectifying means independently of said smoothing filter, and means connecting said constant voltage means to the screen grid of said vacuum tube for controlling the screen grid circuit of said vacuum tube by changing the potential impressed on said screen grid to compensate for changes in the operation of said vacuum tube caused by changes in the potential from said source of alternating current supplied for heating the cathode of said vacuum tube.

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