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D. G. LITTLE ET AL.

RADIO SYSTEM

Filed April 6, 1927

Fig. 1.

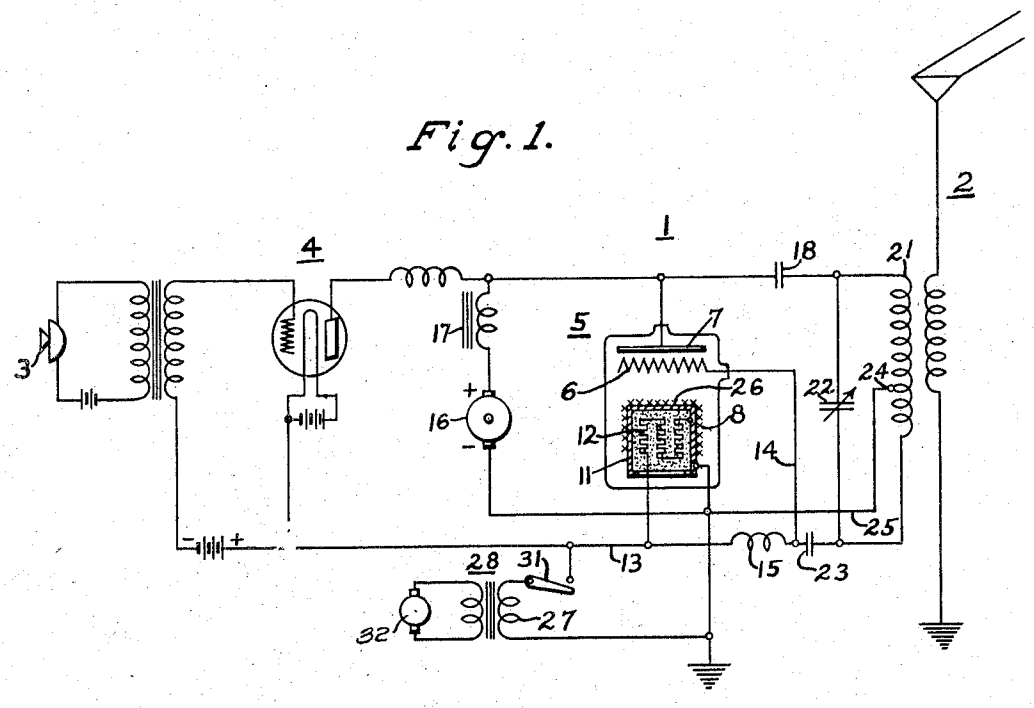
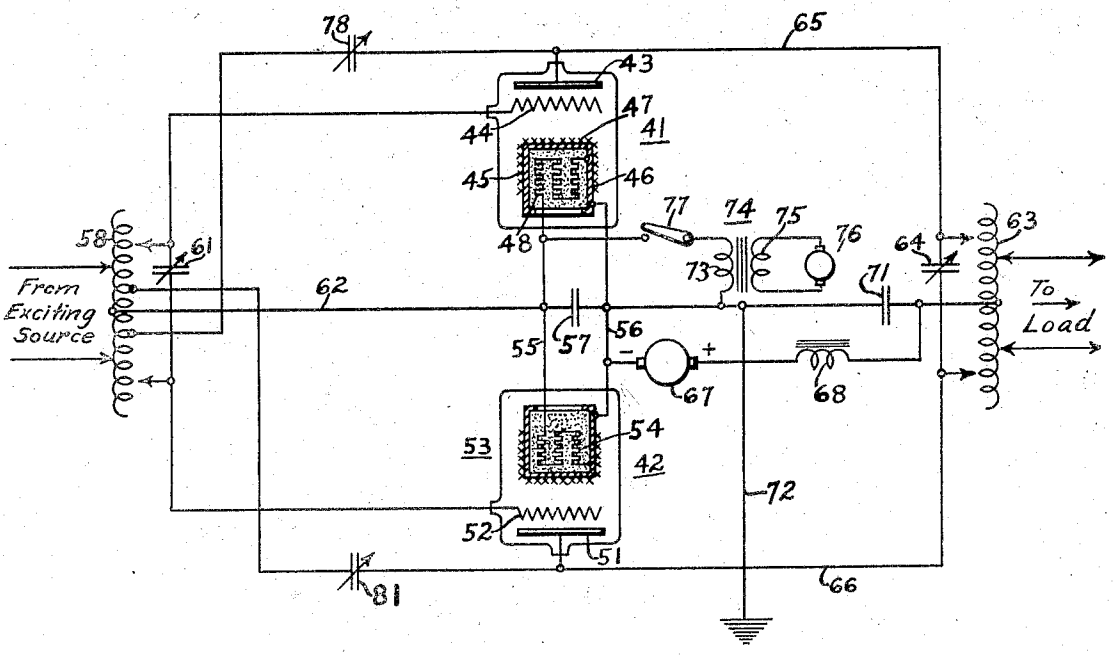


Fig. 2.



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UNITED STATES PATENT OFFICE.

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RADIO SYSTEM.

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Our invention relates to radio systems, and more particularly to radio transmitters, oscillation generators, amplifiers and the like, in which are employed thermionic devices capable of dissipating comparatively large amounts of power.

One object of our invention is to provide, in systems of the types described, means for utilizing energy that has heretofore been wasted.

Another object of our invention is to provide in systems of the types described, means for indirectly deriving, from a source of plate potential, sufficient power for energizing the cathodes of certain of the thermionic devices involved.

A still further and more specific object of our invention is to provide a thermionic device particularly adaptable for use in systems of the types specified.

In the operation of high-power thermionic devices, such as oscillation generators, amplifiers and the like, using a grid-condenser and grid-leak resistor to secure the proper grid-bias, a relatively large amount of energy must be dissipated in the grid-leak resistor. Hertofore, this energy has been entirely wasted, except in so far as its function of producing an IR drop is concerned, the heat evolved being merely dissipated by exposure of the resistor to the atmosphere.

By the present invention, we provide means whereby advantage may be taken of the heat which has heretofore been wasted, and are thus enabled to materially reduce the amount of energy required to produce a given output from either an oscillation generator or an amplifier.

Specifically, we provide a thermionic device of an entirely new type, in which the cathode is so arranged and constructed that it may be energized directly by the heat dissipated in the grid-leak resistor, and we are thus enabled to dispense with a separate source of cathode energy. In addition, we have provided means, including a source of alternating potential, whereby a preliminary energization of the cathodes of such devices may be accomplished, which source is disconnected therefrom as soon as the amplifier, or oscillator, as the case may be, starts to deliver energy to an output circuit and, consequently, to the grid-leak resistor referred to.

Among the novel features of our invention are those particularly set forth in the appended claims. The invention, in its entirety, however, as well as further objects and advantages thereof, will best be understood by reference to the following description of certain specific embodiments, taken in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a radio transmitting system comprising an oscillation generator embodying a preferred form of our invention; and

Fig. 2 is a diagrammatic view of a power-amplifier embodying our invention.

The radio transmitting system illustrated in Fig. 1 comprises an oscillation generator 1 having its output circuit coupled to a radiation structure 2, and being arranged to be controlled by a microphone 3 and modulator 4, according to the well-known Heising modulation system.

The oscillation generator 1, with which my invention is mainly concerned, comprises a thermionic device 5 having a grid 6, an anode 7 and an electron-emissive cathode 8. The cathode comprises a metallic shielding element 11, shown in cross-section, in which is positioned a resistor 12, preferably non-inductive, having a resistance of the order of 3,000–10,000 ohms. One end of the resistor element 12 is connected to a conductor 13, and the junction point therewith is connected to the grid 6 by a conductor 14, the connection including a radio-frequency choke coil 15. The other end of the resistor element is connected to the shielding element 11.

The resistor 12, for the major portion of its length, is preferably insulated from the interior of the shielding element by a non-conductive material having a comparatively high thermal lag.

A source 16 of plate potential is provided, the positive pole thereof being connected to the plate 7 through an audio-frequency choke 17 and the negative pole being connected to the shielding element 11. The plate is coupled, through a condenser 18, to an oscillatory circuit comprising an inductor 21 and a tuning condenser 22, and the grid is

coupled through a condenser 23 to the said oscillatory circuit at the end opposite to that to which the plate is coupled. A midpoint 24 on the inductor 21 is connected to the shielding element by a conductor 25.

The shielding element or cathode 11 is provided with an exterior coating 26 of electron-emissive oxides, or other material that will liberate electrons when heated.

The secondary 27 of a power transformer 28 is connected to the conductors 13 and 25, a switch 31 being interposed in circuit therewith. The transformer is energized from any convenient source 32 of commercial-frequency current.

In order that oscillations may be generated by the thermionic device 5 and the associated circuits, it is first necessary that the cathode 8 be heated sufficiently to cause the liberation of electrons from the oxide coating thereof, for this purpose, the switch 31 is first closed, permitting a heating current to traverse the resistor 12. As soon as the cathode reaches the proper operating temperature, plate potential is applied to the device from the source 16, and the switch 31 is opened. By reason of the fact that the oscillatory circuit, comprising the inductor 21 and the condenser 22, is coupled to the grid, the anode and the cathode, according to the usual Hartley scheme, oscillations will be initiated therein and will be maintained just so long as the cathode emits electrons and the plate potential is uninterrupted.

The heat necessary for maintaining the cathode at operating temperature is obtained from the resistor 12, which carries the leakage current from the grid to the cathode, and maintains the grid at the predetermined operating potential. As is well known to those skilled in the art, the leakage current will flow as long as oscillations in the tube and associated circuits are sustained, and the device is, accordingly, self-energized after such oscillations have been started by the preliminary heating of the resistor.

A thermionic device constructed according to our invention to handle a power output of ten kilowatts will, in general, dissipate from three to five hundred watts in the grid-leak resistor. The IR drop along the resistor may reach a value of eight hundred volts, and the current therein a value of fifty milliamperes, which is amply sufficient to maintain the cathode at the electron-emitting temperature. Naturally, when handling such high power, we have found it best to provide means for cooling the anode, as by circulating water around it in the customary manner.

Thermionic devices such as we have described have also been found capable of utilization in the power-amplifier stages of radio transmitters adapted for heavy duty. Such an amplifier is illustrated in Figure 2, and, as shown, it comprises two thermionic devices, 41 and 42, arranged for push-pull operation.

The device 41 has a plate 43, a grid 44 and a cathode 45, the latter element comprising a shield 46 coated with electron-emissive oxides 47, and an interior heating element in the form of a grid-leak resistor 48.

The device 42 has a plate 51, a grid 52, and a cathode 53 provided with a heating element 54, and is preferably so chosen as to have substantially the same electrical characteristics as the device 41.

The resistor elements 48 and 54 are connected in parallel by means of conductors 55 and 56, and a grid-condenser 57 is bridged across these conductors. The grid 44 of the device 41 is connected to one end of a tuned input circuit comprising an inductor 58 and a condenser 61, the grid 52 of the device 42 being connected to the other end of the inductor 58

A conductor 62 extends from a mid-point on the input inductor 58 to the conductor 55 which is connected between the resistor elements 48 and 54, in order that a conductive leakage path may be provided between the grids and the cathodes of the thermionic devices.

The output circuit of the amplifier comprises an inductor 63 shunted by a tuning condenser 64, one end of the inductor being connected to the plate 43 by a lead 65 and the other end being connected to the plate 51 by a lead 66. Plate potential for both thermionic devices is provided by a source 67, the negative terminal thereof being connected to the conductor joining the cathodes 45 and 53, and the positive terminal being connected to a mid-point on the output inductor 63, a choke coil 68 being serially interposed in the latter connection.

The grid condenser 57 may be replaced by separate condensers individual to the several tubes, in which event, the grid-leak-resistor of the corresponding tube would be shunted therearound.

It is necessary, in order that the amplifier shall be stable, to effectively connect the cathodes and the mid-point of the output inductor to ground. A condenser 71 is accordingly provided in the circuit between the inductor 63 and the connection 56 common to the cathodes, the cathode side of this condenser being provided with a ground connection 72.

In order that the grid-leak resistors 48 and 54 may be given a preliminary heating, they are connected in parallel to the secondary 73 of a power transformer 74, the primary 75 of which may be energized from a source 76 of commercial-frequency alternat-

ing current. A switch 77, interposed between the secondary and the cathodes, controls the application of the energizing potential.

The spontaneous generation of oscillations in the thermionic devices and accompanying circuits is prevented by the use of neutralizing condensers 78 and 81, which serve to place on the grids potentials of such phase that the inception of oscillations is impeded.

In the operation of the modification of our invention illustrated in Fig. 2, the exciting source is so arranged that it will cause the grids of the several tubes to alternately draw grid current. The grid condenser discharges through the several resistors in parallel and keeps them heated to a temperature which causes the electron-emitting oxides or other material to become and remain electronically active. For this reason, the tubes will remain energized just so long as there exist on the grids thereof exciting potentials from the preceding stage.

In general, it may be said that thermionic devices constructed according to our invention are increasingly efficient as the power handled thereby increases. In other words, the leakage current from the grid of a 10 kilowatt oscillator is much larger than would be expected from a consideration of the leakage current from the grid of a 250 watt oscillator. For this reason, our invention finds its largest field of application in systems designed for the handling of super-power.

Although we have illustrated and described only two specific embodiments of our invention, many modifications thereof will be apparent to those skilled in the art. Our invention, therefore, is not to be limited, except in so far as is necessiated by the prior art and by the spirit of the appended claims.

We claim as our invention:

1. In combination, a thermionic device having an electron-emissive cathode, a grid leak resistor, and means whereby energy dissipated in said resistor may be utilized to heat said cathode.

2. In a thermionic device, an electron-emissive cathode and a heating element associated therewith having a resistance of the order of three thousand to ten thousand ohms.

3. In a thermionic device, an electron-emissive cathode and a non-inductive heating element associated therewith having a resistance sufficiently high to enable it to serve as a grid leak.

4. In a thermionic device, a resistor having a resistance of the order of three thousand to ten thousand ohms, a shielding element enclosing said resistor and means for rendering outer portions of said shielding element electron-emissive under the influence of heat, whereby said element may be caused to function as a cathode.

5. In a thermionic device, a resistor element having a resistance of the order of three thousand to ten thousand ohms, a metallic shielding element enclosing said resistor, heat conveying means having an appreciable time-lag interposed between said resistor and said shielding element and means for rendering outer portions of said shielding element electron-emissive under the influence of heat, whereby said element may be caused to function as a cathode.

6. In a thermionic device, a resistor element having a resistance of the order of three thousand to ten thousand ohms, a metallic shielding element enclosing said resistor and means for electrically insulating the major portion of said resistor element from said shielding element.

7. In a thermionic device, a resistor element having a resistance of the order of three thousand to ten thousand ohms, a metallic shielding element enclosing the resistor and a conductive connection between said resistor and said shielding element.

8. In combination, a thermionic device comprising a grid and an electron-emissive cathode having associated therewith a heating resistor, and means for establishing a leakage current through said resistor from said grid to said cathode, whereby the latter is heated.

9. In combination, a thermionic device comprising a grid, an electron-emissive cathode and an anode, said cathode comprising a shielding element within which is positioned a resistor element having a resistance of the order of three thousand to ten thousand ohms, and means whereby the leakage current from said grid, when the tube is energized, is caused to pass through said resistor and to thereby heat said cathode to an electron-emissive temperature.

10. In combination, a thermionic device comprising a grid and an electron-emissive cathode having a heating resistor associated therewith, means whereby said resistor may be utilized as a grid-leak when the device is in operation and means whereby said resistor may be energized from an independent source of potential preparatory to operating the device.

11. In combination, a thermionic device comprising a grid and an electron-emissive cathode, and means for heating said cathode to an electron-emissive temperature, said heating means including a leakage path between said grid and said cathode.

In testimony whereof, we have hereunto subscribed our names this 31st day of March, 1927.

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