April 27, 1937. H. W. KA DELL 2,078,666

THERMIONIC DEVICE

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Fig. 1.

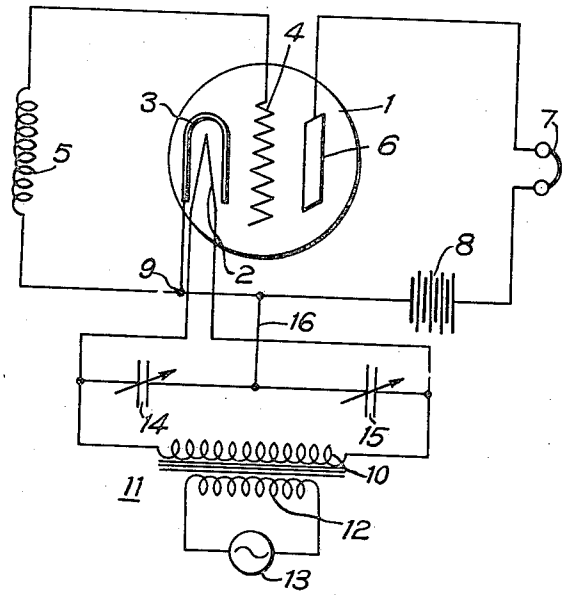
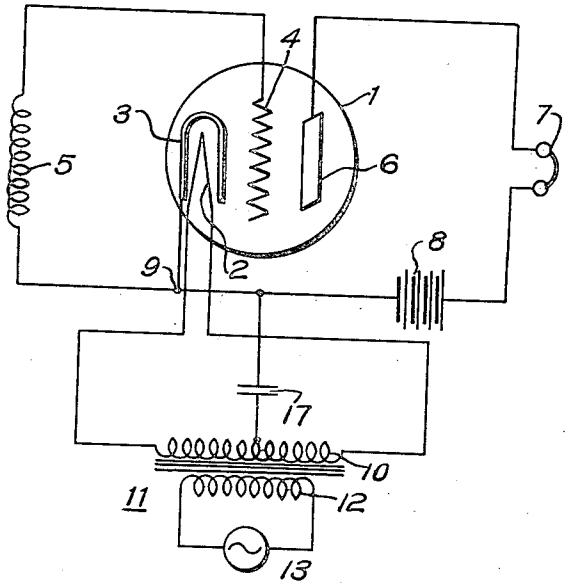


Fig. 2.



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THERMIONIC DEVICE

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9 Claims. (Cl. 250—27)

My invention relates to means for supplying heating current to the cathodes of thermionic devices and it has particular relation to systems in which the heating current is alternating or fluctuating in character.

There is, at present in the art, a very notable trend toward the use of alternating current for heating the cathodes of thermionic tubes. These tubes have, in general, very satisfactory characteristics as detectors or amplifiers but they have never gone into very extensive use because it has been found extremely difficult to eliminate the hum caused by the fluctuations in heating current.

The hum is due, in part, to the variation in temperature of the electron-emitting means and, in part, to modulation of the space current by the magnetic field surrounding the heater element. The hum is also due, to a great extent, to variations in the potential of both grid and plate with reference to the thermionic emitting element or cathode.

Many efforts have been made to construct an alternating-current tube in which no hum will be apparent but, so far as I am aware, none of the forms shown in the prior art have been practically successful.

It is accordingly an object of my invention to provide means whereby a thermionic tube may be operated by current which is fluctuating in character without the hum thereof being noticeably present in the tube output.

A further and more specific object of my invention is to provide a system of connections whereby a thermionic tube having a cathode of the equi-potential type may have such cathode energized by alternating current without objectionable hum being present.

I attain these objects and others, which will be mentioned later, in the following manner: Thermionic devices designed for cathode energization by alternating current generally employ, as cathodes, tubes or analogous elements coated with electron-emissive substances through which heating elements extend.

The heating element, which may be either a substantially non-inductive winding or one or a plurality of wires, is usually connected across the secondary terminals of a transformer, the primary of which is designed to be supplied with alternating current.

As is well known in the art, a point may be found somewhere along the secondary of this transformer having a potential that is a mean between the potentials of the terminals. I have discovered that, if the grid, the electron-emitting element and the anode are all kept at the potential of such point, the heating current will not give rise to an objectionable amount of hum. I have discovered also that, of these three, it is more important to keep the cathode at the neutral potential with reference to the transformer secondary terminals.

In one form of my invention, I accordingly connect a plurality of condensers across the secondary of the heating transformer in series and so adjust the capacity of these condensers that a point may be found between them, the potential of which does not vary with reference to that of the secondary terminals of the transformer.

In a simplified form of my invention, I make use of two condensers of equal size connected in series, and use the connection between these two condensers as the point having the desired neutral potential. This point I connect to the cathode alone or to the cathode, the grid return and the anode.

In another form of my invention, I make a direct conductive connection to the electrical midpoint of the transformer secondary and interpose between this connection and the cathode a condenser having a large capacity.

Referring now to the drawing and to the following description from which a more complete understanding of my invention may be had,

Fig. 1 is a diagrammatic view of a preferred form of my invention; and

Fig. 2 is a diagrammatic view of a modified form of my invention.

Referring specifically to Fig. 1, a thermionic device 1, having a filament 2, an electron-emitting cathode 3 and a grid 4, has connected between the grid 4 and the cathode 3, an input circuit comprising an inductance 5, and is further provided with an anode 6. The anode 6 is connected through a load 7, which may be a transformer, a pair of telephones or an analogous device, and an anode battery 8 one terminal of which is connected to a junction 9 between the cathode 3 and the grid cathode and the other terminal of which is connected to the load 7. The filament or heating means 2 is connected across a secondary 10 of a heating transformer 11 having a primary 12 connected to a source of alternating or fluctuating current 13.

Bridged across the transformer secondary 10 are two impedance devices 14 and 15 which may be either condensers or resistors. From the connection between these two impedance devices, a

lead 16 is taken to a junction between the grid, cathode and plate circuits.

In Fig. 2, elements analogous to those illustrated in Fig. 1, are designated by similar numerals. The impedance devices 14 and 15 are, however, replaced by an arrangement wherein the cathode 3 is connected to the electrical midpoint of the secondary 10 through a condenser 17.

In the operation of a device arranged according to my invention, the shunting condensers 14 and 15 are adjusted until the lead 16 assumes a potential which is a mean between the potential of the secondary terminals. Since the grid, cathode and anode are connected to this point of mean potential, neither varies in potential with respect to the others and neither varies in potential with respect to the secondary terminals of the transformer. Such being the case, it is obvious that the electron-emitting cathode will not vary in electron emission because of a change in the potential between it and the anode caused by fluctuations in the heating current. At the same time, the potential of the grid with respect to the cathode will remain constant.

It is assumed that the tube is so constructed that the heating means 2 has substantially no external magnetic field, and it is further assumed that the cathode 3 has sufficient heat lag to prevent fluctuations in the heating current from causing the electron emission to vary. These characteristics may be found to a greater or less degree in certain alternating-current thermionic tubes which are now on the market or which are constructed according to the teachings of the patent to Nicolson, No. 1,459,412. It is, therefore, apparent that the only remaining cause of hum is the variation in potential between two elements, due to the alternating character of the heating supply which might cause either a variation of the grid-cathode potential, the plate-cathode potential or the plate-grid potential.

By my invention, I eliminate periodic fluctuations in potential between these elements and, as a result, when the system is in operation, there is substantially no hum in the output circuit.

In the modified form of my invention shown in Fig. 2, I maintain the cathode, grid and anode at the neutral potential desired by means of a connection between these elements and the electrical center of the transformer. The interposition of condenser 17 prevents any flow of direct current between the filament 2 and the cathode 3.

By my invention, I am enabled to employ alternating current of any desired, or commercial, frequency as heating current for the equipotential cathode without having the hum thereof interfere with the reception of signals. This is very advantageous, as the cost of the transformer required is slight in comparison with the expense attendant upon the employment of cathode-heating or "A" batteries, which have but a limited life.

Although I have illustrated and described herein certain specific embodiments of my invention, I am fully aware that other modifications are possible. I do not intend, therefore, to be limited except as is necessitated by the prior art and by the scope of the following claims.

I claim as my invention:

1. In combination, a thermionic device comprising an evacuated envelope having therein an equipotential cathode heating means associated therewith but spaced therefrom and a cooperating anode, a transformer connected to a source of alternating current and having its secondary connected to said heating means, impedance means connected to said secondary and a connection between said cathode and a portion of said impedance means, the average potential of which is constant with reference to the secondary terminals of said transformer.

2. In combination, a thermionic device having a grid and an equipotential cathode heating means associated therewith but spaced therefrom, a transformer connected to said heating means for supplying current thereto, impedance means associated with said transformer, and connections from said grid and said cathode to a portion of said impedance means the average potential of which is constant with reference to the terminals of said transformer.

3. The combination with a space discharge vessel comprising an anode, a cathode and cathode heating means, a transformer connected to a source of alternating current and having its secondary connected to said heating means, and means external to said vessel and to said secondary winding for preventing the heating current in said heating means from causing variation of the average voltage between the cathode and the anode during a half cycle of said alternating current.

4. In a vacuum tube circuit, the combination of a plate, a grid, a cathode, a heater for said cathode, a transformer and lines from the secondary terminals thereof to supply fluctuating current to said heater for heating said cathode, a current path other than said heater shunting said lines, and an electrical connection between said cathode and a point on said current path the average potential of which is substantially constant with reference to the terminals of said heater.

5. In combination, a thermionic device comprising an evacuated envelope having therein an equipotential cathode, heating means associated therewith but spaced therefrom and a cooperating anode, a transformer connected to a source of alternating current and having its secondary connected to said heating means, impedance means connected to said secondary and a connection between said cathode and a portion of said impedance means, the average potential of which is constant with reference to the secondary terminals of said heating means.

6. In combination, a thermionic device comprising an evacuated envelope having therein an equipotential cathode, heating means associated therewith but spaced therefrom, and a cooperating anode, a transformer connected to a source of alternating current and having its secondary connected to said heating means, two substantially equal capacitors connected in series across the terminals of said secondary and a connection between said cathode and the common terminal of said capacitors.

7. In combination, a thermionic device comprising an evacuated envelope having therein an equipotential cathode, heating means associated therewith but spaced therefrom and a cooperating anode, a transformer connected to a source of fluctuating current and having lines connecting its secondary to said heating means, means for shunting said lines with a pair of serially-connected capacitors, a connection between said cathode and the common terminal of said capacitors, the relative magnitudes of said capacitors being such that the potential of said common terminal remains the same as the potential of the

mid-point of said heater when said transformer is energized.

8. In combination, a thermionic device comprising an evacuated envelope having therein an equipotential cathode, heating means associated therewith but spaced therefrom, and a cooperating anode, a transformer connected to a source of fluctuating current and having its secondary connected to said heating means, two substantially equal capacitors connected in series across the terminals of said heating means and a connection between said cathode and the common terminal of said capacitors.

9. The combination with a space discharge vessel comprising an anode, a cathode and a heater for said cathode, a transformer having a secondary with two terminals, means supplying a fluctuating current to said transformer, a connection from each of said terminals of said transformer secondary to said heater and capacitor connections from said cathode to each of said terminals of said transformer secondary.

HAROLD W. KA DELL.