June 28, 1949. M. G. FAVRE 2,474,575

HEATING DEVICE FOR HOT CATHODE TUBES

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Fig. 1.

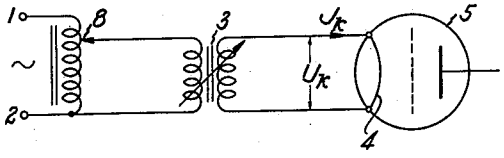
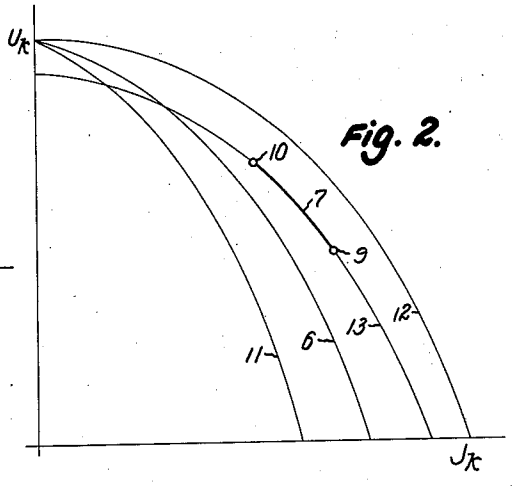


Fig. 2.



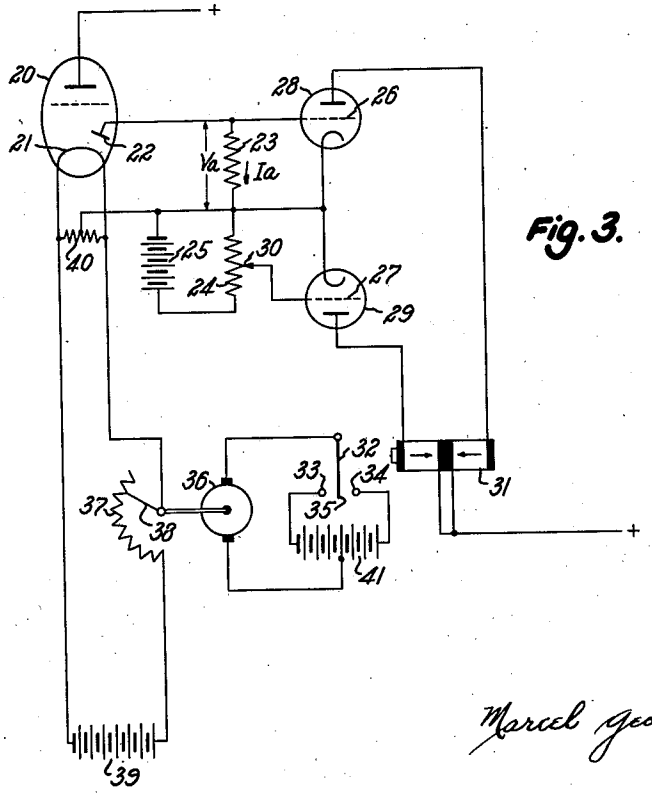


Fig. 3.

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HEATING DEVICE FOR HOT CATHODE TUBES

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3 Claims. (Cl. 315—106)

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The life of hot cathode tubes is determined by the evaporation of the filament. The thermionic emission as given by the Richardson law, as well as the evaporation of a hot cathode rises with higher temperature. High electron emission means also high temperature and therefore short tube life.

Through evaporation of filament material the filament diameter decreases gradually, so that its electrical resistance increases during the tube's life. The heating with constant current means also an increase of filament temperature, of electronic emission current and of evaporation and so gives shorter life than heating the tube's filament with a constant voltage.

In order to achieve as long a life as possible, the temperature of the filament should never be higher than is necessary to give the minimum emission current, which is required by the operating condition of the tube.

It has now been shown that the life of hot cathode tubes, particularly of tubes with tungsten filament, is the longest possible when the filament is heated to such a degree that its emission current remains constant, during the whole life of the tube, at the minimum value required for correct operation. This applies specially to tungsten filaments which show high operation temperature and evaporation.

The present invention, which is a continuation in part of my copending and now abandoned application Serial No. 522,925, filed February 18, 1944, applies to a device for heating the filament of a hot cathode tube, particularly a transmitter tube with tungsten filament, which provides means to maintain the emission current of the filament practically constant at a predetermined desired value.

The control of the heating current of a tube by its space current is already known but such a control system is unsatisfactory because the space current varies with, and therefore the control action varies with changes in the tube grid voltage. This is not the case for a system according to the present invention, which uses the filament emission for the control.

Constructional examples of devices according to the present invention, are illustrated diagrammatically in the accompanying drawings, but the invention is not limited to the examples shown.

Fig. 1 shows a circuit in which the heating power is supplied from a transformer. Fig. 2 is an explanatory figure showing the voltage-current curves of the transformer and of the filament of the tube to be heated according to Fig. 1. Fig. 3

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shows a device designed to control the heating power of the tube by means of an auxiliary diode plate 20. In the constructional example of Fig. 1, the alternating current filament heating supply is connected to the terminals 1—2. Heating current flows through the adjustable voltage tap 8 of an autotransformer and then through the transformer 3 to the hot filament 4 of the tube 5. The transformer 3 has an adjustable magnetic leakage flux. By regulating the primary voltage of the transformer 3 to the right value by means of tap 8 and adjusting the leakage of this transformer to the proper amount, the voltage-current curve of the transformer 3 can be made to match approximately the voltage-current characteristic of the filament 4 of the tube 5.

This matching process will be better explained by the aid of the graph of Fig. 2. In this figure different voltage-current curves Uk—Jk are shown. Curve 7 indicates the heating characteristic of the cathode 4, i. e. the law relating Uk to Jk, for obtaining a constant emission current during the whole life of the tube. Point 9 of the curve 7 corresponds to the instant when the tube is first put into service and point 10 corresponds to the end of the tube's life, when the filament is burnt-out; the passage from 9 to 10 marks the progressing evaporation of the cathode. Curve 6 is the voltage-current characteristic of transformer 3 for a given amount of leakage, curve 11 can now be obtained by adjusting for greater leakage and curve 12 by adjusting for lower leakage. Thus it is possible to obtain a curve of similar shape to that of curve 7, for example curve 12. Moreover, by regulating the voltage tap 8 the curve as a whole can be shifted, for example lowering the voltage will shift the curve 12 to the new position of curve 13. These adjustments enable obtaining a curve 13 which coincides with close approximations to the characteristic 7 of the hot filament 4.

By using a heating device in which, according to the invention, the voltage current characteristic 13 matches curve 7 of the filament 4, the hot cathode tube 5 will be heated to the right degree, its emission current remaining constant at the wanted value during the whole life of the tube.

To obtain the characteristic 13, the heating transformer 3 should have a very large amount of magnetic leakage so that a transformer of special design is necessary.

A further constructional example of a device according to the present invention is given in Fig. 3. This figure shows a transmitter tube 20 with its filament 21 and an auxiliary diode plate 22

near the filament 21. This auxiliary diode plate 22 is connected through the resistance 23, to the tap on a resistance 40 lying across the filament 21. The plate current Ia of the diode 22 produces a voltage Va in resistance 23. If the plate current Ia of the diode 22 is so minute, that in the space between filament and diode plate space-charge effects do not take place, its value is given, as a function of the electronic emission current Ie of the filament 21, by the equation:

$$Ia=cIee^{kVa}$$

where c and k are two constants and $e=2{,}718\ldots$

Va is proportional to Ia and it is therefore possible to determine the emission current Ie of the filament 21 by means of the anode current Ia or anode voltage Va of the diode 22. For control purpose the voltage appearing across the resistance 23 is compared to a voltage at the adjustable tap point 30 of potentiometer 24, which is provided by the constant voltage supply 25. These two voltages are applied to the grids 26 and 27 of tubes 28 and 29 and control their respective anode currents. These anode currents traverse the polarized relays 31, which is designed so that its armature 32 is in the mean position 35 when the two anode currents are equal and switches to position 33 or 34 when 28 or 29 passes a higher current.

A direct-current motor 36, which is fed from supply 41, rotates in opposite directions following the positions 33 or 34 of armature 32, and is at rest for position 35. Rotation of motor 36 displaces the sliding contact 38 of resistance 37 which is in series with the filament's heating supply 39. The variable resistance 37 adjusts the amount of filament's heating power applied by source 39 to the value required to maintain constant the emission current of the filament at the desired value. This current can easily be adjusted by means of slider 30 of potentiometer 24 to the value required for proper operation of the tube 5. The bias voltage on the diode plate 22, relative to the mean cathode voltage can be exactly adjusted by means of the tap on the resistance 40 across filament 21.

I claim:

1. The combination with a tube having a hot cathode cooperating with a grid and an anode, said hot cathode comprising a filament; of a source of cathode-heating current, and regulating means automatically varying the voltage impressed by said source across said filament to maintain the electronic emission current of said cathode constant and independent of variations in the anode space current; said regulating means comprising a transformer having a secondary winding connected across said filament and a primary winding connected to said current source, means for adjusting the magnetic leakage flux of said transformer to impart to the secondary winding a voltage-current relation over a resistance range which has substantially the curvature of the voltage-current characteristic for a constant electronic emission current from said filament as its resistance increases during use of the tube, and means for adjusting the voltage imposed by said source upon said transformer primary winding to that constant value at which the voltage impressed across said filament varies with the resistance thereof to maintain the electronic emission current constant.

2. A circuit for supplying current to the cathode filament of an electronic tube to maintain a constant electronic emission current from said cathode throughout the life of the tube; said circuit comprising a source of current, a transformer having a secondary winding for connection across the tube filament and a primary winding for connection across said current source, the voltage-current characteristic of the secondary winding conforming to the shape of the voltage-current characteristic of said filament for constant electronic emission as the resistance thereof increases during use of the tube, and means for adjusting the voltage impressed across the transformer primary winding by said current source to bring the voltage-current characteristic of said secondary winding into substantial coincidence with the voltage-current characteristic of the filament for constant electronic emission throughout the useful life of the tube.

3. A circuit as recited in claim 2, wherein said transformer includes means for varying the magnetic leakage flux of said transformer to adjust the voltage-current characteristic of the secondary winding to conform to the shape of the voltage-current characteristic of the tube filament.

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