Oct. 30, 1928. 1,689,971

E. Y. ROBINSON

VACUUM ELECTRIC TUBE DEVICE

Filed June 27, 1924 2 Sheets-Sheet 1

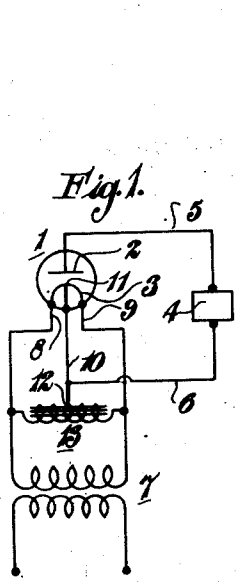


Fig. 1.

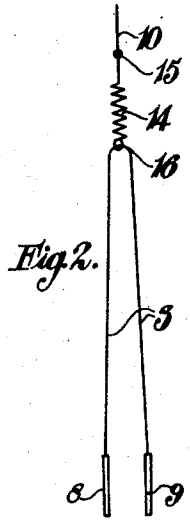


Fig. 2.

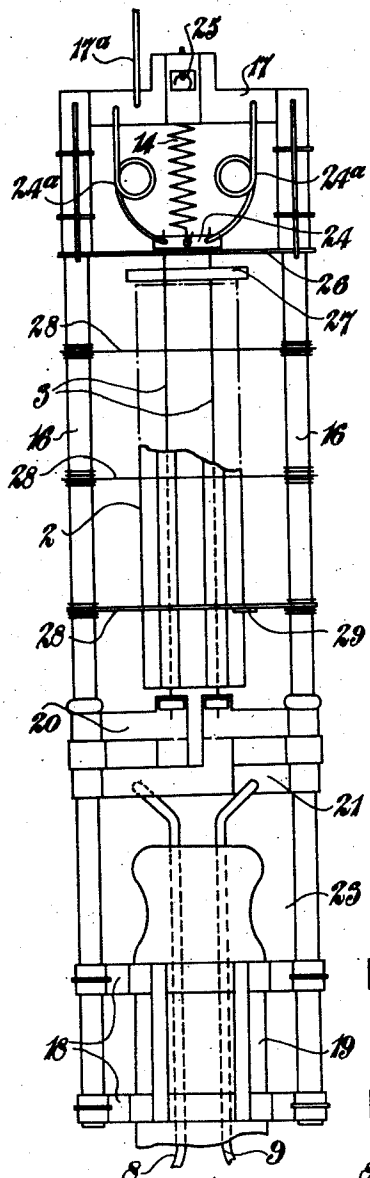


Fig. 3.

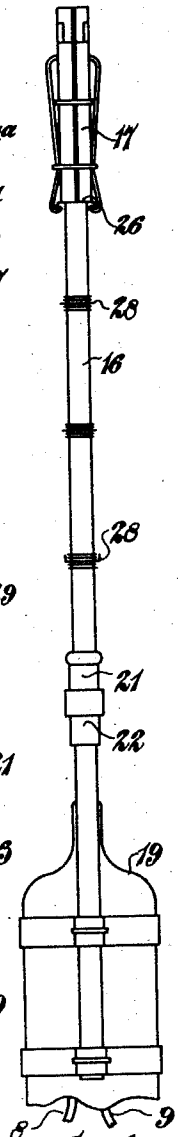


Fig. 4.

Inventor
Ernest Y. Robinson
By James L. Norris
Attorney

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E. Y. ROBINSON

VACUUM ELECTRIC TUBE DEVICE

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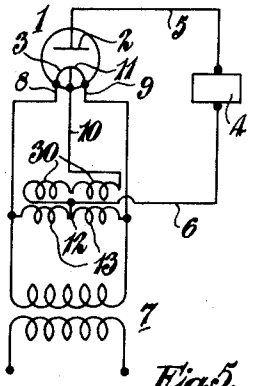


Fig. 5.

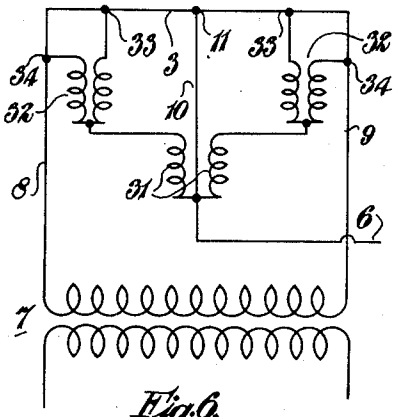


Fig. 6.

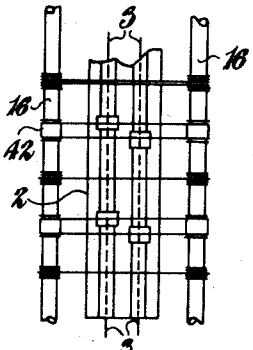


Fig. 7.

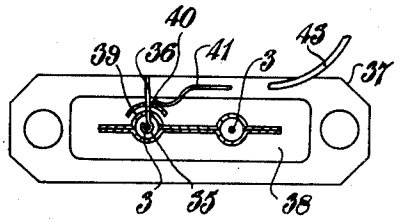


Fig. 8.

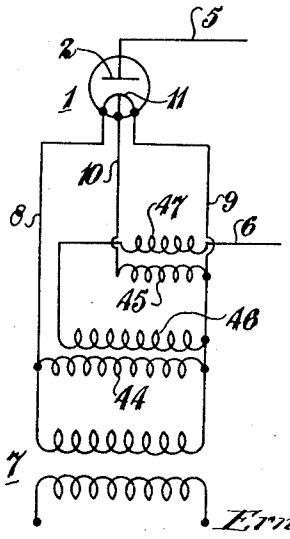


Fig. 9.

Inventor
Ernest Y. Robinson

By

Attorney.

Patented Oct. 30, 1928. 1,689,971

UNITED STATES PATENT OFFICE.

ERNEST YEOMAN ROBINSON, OF WITHINGTON, MANCHESTER, ENGLAND, ASSIGNOR TO METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, A COMPANY ORGANIZED UNDER LAWS OF GREAT BRITAIN.

VACUUM ELECTRIC-TUBE DEVICE.

Application filed June 27, 1924, Serial No. 722,810, and in Great Britain July 24, 1923.

This invention relates to vacuum electric tube devices of the kind employing heated filament cathodes such devices being commonly termed thermionic valves or rectifiers.

Owing to the fact that the space current increases the actual filament current at the negative end of the filament and decreases it at the positive end a flow of space current in the device results in unequal heating of the filament. The life of the filament and hence of the valve is dependent on the temperature of the hottest part of the filament and since at the temperatures at which incandescent cathodes are operated, the rate of evaporation of the filament is extremely sensitive to the temperature of the filament it is necessary that the temperature should not be varied except within very narrow limits. For instance at the operating temperature of a tungsten filament in a thermionic valve a .3 per cent increase or decrease of filament current respectively halves or doubles the life of the valve. In consequence of this it is necessary to arrange in practice that the maximum emission current is not greater than 7 to 10 per cent of the filament current. In large valves this necessitates the use of high filament current which is undesirable.

In order to reduce this unequal heating of the filament alternating current can be used for heating the filament and the space current tapped to the mid point of the secondary of the filament transformer or to the mid-point of a choke coil connected across the filament terminals. It will be seen that both in this case and in the case wherein the filament is heated by direct current the space current is led into the filament at two points, namely at its two ends.

The object of the present invention is to decrease unequal heating of the filament due to the addition of the space current to the filament current proper or conversely the object of the invention is to increase the ratio of space current to filament current which may be used in the device to give the same degree of unequal heating of the filament and so permit the use of filament cathodes supplying a large emission current but which do not take a large heating current.

According to the invention means are provided whereby the space current is led into the filament at more than two points so that the unequal heating of the filament is reduced.

It is arranged that firstly the filament is heated by alternating current, secondly the space current is led into the filament at more than two points and thirdly an inductive winding or windings are connected across the space current taps on the filament in such a manner that they prevent a short circuit of the filament portions while they present no appreciable impedance to the space current flowing to the filament tappings. The tap on the winding is such that the potential thereof is the same as that of the corresponding filament tap.

To enable the invention to be clearly understood several arrangements thereof will now be described with reference to the accompanying drawings in which Fig. 1 is an electrical diagram explaining the invention, Fig. 2 is a view of a hairpin filament illustrating how the invention may be carried into effect according to one arrangement, Figs. 3 and 4 are front and side elevations respectively of a complete electrode structure of a vacuum electric tube with the invention applied thereto. Figs. 5 and 6 are electrical diagrams of further forms of the invention, Figs. 7 and 8 are an elevation and sectional plan respectively of a modified form of part of the structure illustrated in Figs. 3 and 4 and Fig. 9 is an electrical diagram of a still further modification of the invention.

Referring first to Fig. 1, 1 represents a thermionic rectifier having an anode 2 and a filament cathode 3. These electrodes are connected respectively to an external circuit which is indicated at 4 connected between conductors 5 and 6. The filament cathode 3 is heated from an alternating current source (not shown) connected to the primary winding of a transformer 7 the secondary winding of which is connected to the filament leads 8 and 9. The space current is supplied to the filament 3 by means of the leads 8 and 9 and also by means of a lead 10 which is connected to the mid-point 11 of the filament as shown, the said lead 10 being connected to the mid-point 12 of a choke coil 13 which is connected across the filament leads 8 and 9, the conductor 6 being also connected to the mid point 12 of the choke coil and to the mid-point 11 of the filament. It will be seen that the ac-

tual potential of the mid-point 11 of the filament is equal to that of the mid-point 12 of the choke coil 13. The choke coil 13 prevents short-circuiting of the filament 3 by the connections thereto for the space current.

Referring to Fig. 2 which illustrates one arrangement for carrying out the invention as illustrated in Fig. 1, the filament 3 is of the hairpin type the ends of which are connected to supports which may constitute the lead-in conductors 8 and 9 and pass through a seal in the tube envelope as will be well understood. The hairpin filament 3 is placed in tension by means of a spring 14 one end of which is attached at 15 to a member fixed in position with respect to the lead-in conductors 8 and 9 and the other end of which is provided with a hook 16 which engages the bight of the filament. The fixed end 15 of the spring 14 has connected to it the mid-point lead-in conductor 10 which also passes through the valve envelope so that it can be connected to the mid-point 12 of the choke coil 13. It will be understood that a similar effect can be obtained by omitting the coil 13 and connecting the conductors 6 and 10 to the mid-point of the secondary winding of the filament heating transformer 7.

Referring now to Figs. 3 and 4 the electrode structure therein illustrated comprises an anode 2, a twin filament cathode 3 constructed and mounted on a framework as described for example in the specification of my copending application Serial No. 722,811, filed June 27, 1924. The framework comprises two parallel side members 16 of insulating material such as pyrex glass connected together by means of a nickel member 17 at the upper end and a nickel member 18 at the lower end by which latter member the frame thus constituted with the electrodes mounted thereon is attached to a re-entrant tube 19 of the tube envelope (not shown). The two parallel filaments 3 are at one end connected to two rigid supporting members 20 and 21 mounted upon the side members 16 of the framework and insulated from one another. The members 20 and 21 have connected to them the lead-in wires 22 which pass through the seal 23 of the re-entrant tube 19 and are connected with the external conductors 8 and 9.

The upper ends of the filaments are connected to a conducting strip or clamp 24 which in turn has connected to it one end of the tensioning spring 14 the other end of which is attached to a hook 25 provided upon the frame member 17. The two filaments pass through perforations in a cross member 26 which consists of a metal strip of channel section having perforations at its ends through which the side members 16 of the framework pass. The strip 26 serves to register the filament in position with respect to the framework.

The anode 2 is constructed of two similar plates each having a pair of semi-circular channels extending longitudinally therein, the said plates being connected together so that two relatively small cylindrical tunnels are provided through which the filaments 3 pass. The anode thus constituted is supported from the framework by means of cross pieces 28 similar to the cross piece 26, one of which cross pieces 28, for example the lower one, is rigid, the anode being connected thereto by means of a conductor 29 welded both to said cross piece and to the anode.

With the arrangement above described it is possible to construct a valve of the kind set forth in the specification of Serial No. 603,715, filed November 27, 1922, that is to say, a valve in which the cathode is of a kind providing a concentrated source of electrons, the paths available for the space current are short, and the space current confined to the inter-electrode space, this last feature being obtained in the present example by maintaining the ends of the filaments 3 cool, namely, by means of the short-circuiting strip 27 secured across the upper ends of the filaments and by means of the supports 20 and 21 to which the lower ends of the filaments are attached.

The space current is led to the metal clamp 24 by means of flexible conductors 24^a, nickel ligaments for example, welded to said clamp and to the frame member 17, a lead-in conductor 17^a also being welded to the latter. When it is desired to provide greater control of the current flowing in the central tappings to the cathodes the arrangement diagrammatically illustrated in Fig. 5 may be employed, in which instead of the central tap conductor 10 connected direct to the mid-point 12 of the choke coil 13 as illustrated in Fig. 1, it is connected to the point of connection 12 of two similar choke coils, through two similar windings 30 which are respectively coupled to the two choke coils 13, said windings 30 being in series with one another and connected in series between the central lead 10 and the mid-point 12. The turns of the windings 30 may be so proportioned that the current flowing to the mid-point of the filament has any desired value relative to the space current flowing to the ends of the filament but preferably the mid-point tap carries twice the space current of either of the end taps.

Fig. 6 illustrates an arrangement in which the filament is provided with a plurality of taps, namely three intermediate taps. In this figure the anode and external circuit are omitted. The space current conductor 6 is connected to the central tap conductor 10 to the mid-point 11 of the filament and is also connected to the mid-point of a choke coil 31. The space current led through the portions

31 is thus caused to divide equally therein. The terminal of each of the portions 31 is connected in turn to the mid-point of a choke coil one terminal of which is connected to an intermediate tap 33 between the central tap 11 and the lead-in wire 8 or 9 whilst the other terminals 34 of the transformers 32 are respectively connected to the leads 8 and 9. The space current flowing through each of the choke portions 31 is thus again equally divided.

Instead of equal division of the space current as above described it may be caused to divide in any predetermined ratio. Preferably the inner windings of the choke coils 32 which are connected to the filament taps 33 have half as many turns as the outer winding of said transformers or chokes which are connected to the lead-in conductors 8 and 9, so that the current flowing to the taps 33 is twice as much as the current flowing to the ends of the filament.

When the filament is of zig-zag formation the space current taps may be made at the bights of the filament in the manner hereinbefore described.

Referring to Figs. 7 and 8, the portion of the electrode structure therein illustrated is generally similar to that illustrated in Figs. 3 and 4. However, a plurality of space current taps are provided between the ends of each of the two parallel filaments in the manner now to be described.

The filaments 3 are constrained not only at their ends but additionally at intermediate points. The additional constraining means comprises hooks or eyes 35 (see Fig. 8) which project into the anode tunnels and surround the filaments. Each hook or eye 35 forms part of a tungsten wire support 36 which is secured by welding or otherwise to a cross member 37 mounted upon the frame member 16, said member having a relatively large central perforation 38 through which the electrodes extend. Each wire support 36 passes through a perforation 39 formed in a tunnel of the anode such perforation being relatively large to avoid any possibility of the support wire 36 touching the anode. When the valve is of the type set forth in the specification of Serial No. 603,715, filed November 27th, 1922, each perforation 39 may be shielded by means of a curved member 40 which may be carried upon a nickel wire bracket 41 welded or otherwise attached to the cross member 60, the wire 36 passing through a perforation in the shield 40. In Fig. 7 two such intermediate constraining or registering hooks are provided for each cathode filament. The cross pieces 37 for each pair of constraining hooks 35 may be separated from one another by means of insulating washers 42. The constraining hooks 35 constitute the intermediate tapping points by which the space current is led into the filament, a lead-in wire 43 (Fig. 8) being welded to each of the cross pieces 37. In this arrangement the space current is led to the intermediate tapping points through frictional contact. If desired however the tapping point may be constituted by a light flexible member securely attached by welding or otherwise to the filament or a light spring of refractory material which is caused to press against the filament can be used. For example such light spring may comprise a helix of one or more turns and provided with a radial extension pressing against the filament.

Fig. 9 illustrates diagrammatically a modified arrangement in which the space current is led to the centre tap of the filament by means of inductive windings and compensating windings. The inductance 44 is connected across the filament leads 8 and 9 and an inductance 45 is connected between the central filament tap 11 and the filament lead 9. These inductances are provided respectively with two other windings 46 and 47 which are inductively coupled therewith and constitute compensating windings. The windings 46 and 47 are connected in series with one another between the filament lead 9 and the space current conductor 6. The space current therefore passes through the windings 47 and 46, then dividing and passing through the windings 45 and 44 and the lead-in wire 9. The numbers of turns of the compensating windings and the choke coils are proportioned so that the current divides in the various taps in the desired ratio. Preferably the central filament tap carries twice as much space current as the leads 8 and 9 in which case the winding 44 has four times as many turns as the compensating winding 46 and the winding 45 has twice as many turns as the compensating winding 47.

It is preferably arranged that the filaments are tapped at approximately equally distant points and also that the total number of lead-in points to the filament is odd. Further, it is preferably arranged that the intermediate space current taps carry twice the space current carried by either of the end taps.

If desired relatively small impedances such as variable inductances or resistances may be inserted in one or more of the space current taps for providing fine adjustment of the subdivision of the space current flowing into the filament.

Assuming for example that the maximum permissible emission in an ordinary tube is 10% of the filament current when led in at the two ends of the filament, then by the provision of one central filament tap in accordance with the present invention, the maximum permissible emission current is 20% of the filament current. With three such intermediate taps the maximum permissible emission current is 40% of the filament current.

It will be understood that the invention is not limited to the particular valve arrangements diagrammatically illustrated and the particular arrangements described for carrying it into effect, since various modifications may be made without departing from the scope of the invention.

I claim as my invention:—

1. In a system which contains a vacuum electric tube with a filamentary cathode heated by alternating current and provided with end taps and at least one intermediate tap, the method of reducing the inequality in the distribution of heat along the filament due to the space current of the tube flowing therein which consists in leading in the space current to the filament at its end and intermediate taps while the filament is not short-circuited as regards its heating current and no appreciable impedance is offered to the space current.

2. In a system which includes a vacuum electric tube with a filament cathode, a source of alternating current connected across the ends of the filament for heating the same, the filament having end taps and at least one tap intermediate of its ends, a space current lead, and at least one inductive winding having an interconnection between the intermediate and end filament taps and the space current lead whereby the space current enters the filament through all the taps and the impedance of the inductive winding is neutralized as regards the variable component of the space current but is not neutralized as regards the said source of alternating current.

3. In a system which includes a vacuum electric tube with a filament cathode, a source of alternating current connected across the ends of the filament for heating the same, the filament having end taps and at least one tap intermediate of its ends, a space current lead and at least one inductive winding having an interconnection between the intermediate and end filament taps and the space current lead whereby twice as much space current enters the intermediate tap as each end tap and the impedance of the inductive winding is neutralized as regards the variable component of the space current but is not neutralized as regards said source of alternating current.

4. In a system which includes a vacuum electric tube with a filament cathode, a source of alternating current connected across the ends of the filament for heating the same, the filament having end taps and at least one tap intermediate of its ends, a space current lead, sets of magnetically coupled inductive windings having an interconnection between the intermediate and end filament taps and the space current lead whereby twice as much space current enters the intermediate tap as each end tap and the impedance of the inductive windings is neutralized as regards the variable component of the space current but is not neutralized as regards said source of alternating current.

5. In a system which includes a vacuum electric tube with a filament cathode, a source of alternating current connected across the ends of the filament for heating the same, the filament having end taps and a plurality of taps intermediate of its ends, a plurality of magnetically coupled inductive windings having an interconnection betwen the several filament taps and the space current lead and through which the space current passes successively to the filament at a plurality of points whereby twice as much space current enters each intermediate tap as each end tap and the impedance of the inductive windings is neutralized as regards the variable component of the space current but is not neutralized as regards said source of alternating current.

In testimony whereof I have hereunto subscribed my name this 16th day of June, 1924.

ERNEST YEOMAN ROBINSON.