Oct. 2, 1934. E. L. KOCH 1,975,610

THERMIONIC TUBE

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Fig:1.

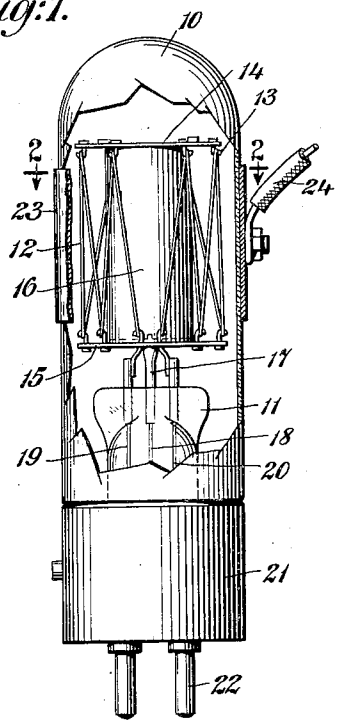


Fig:2.

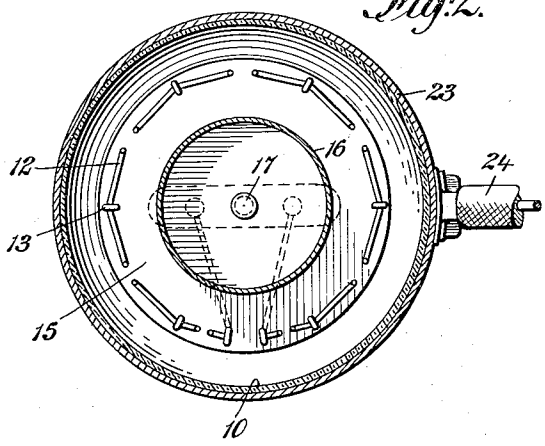


Fig:3.

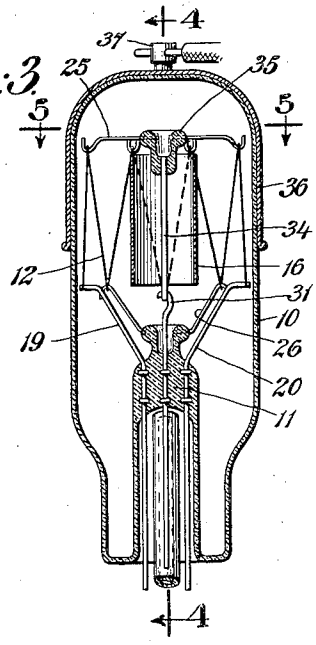
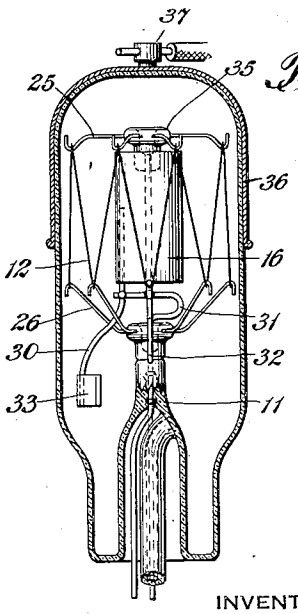


Fig:4.



INVENTOR
Earl L. Koch
BY
H. C. Van Deventer
ATTORNEY

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Fig. 5.

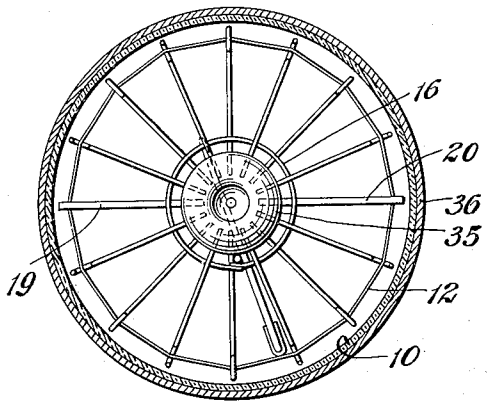


Fig. 7.

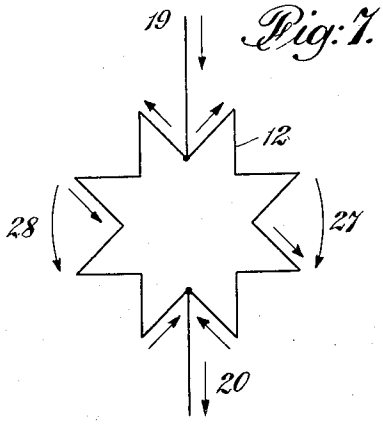


Fig. 8.

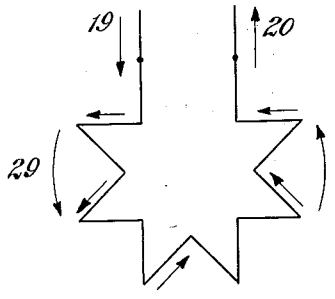
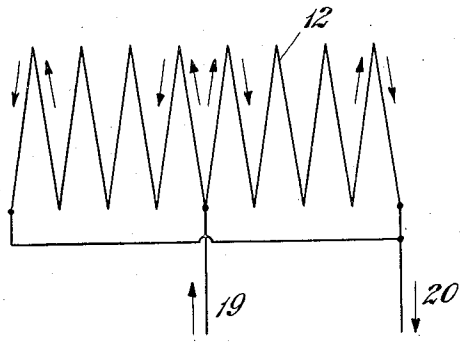


Fig. 6.



INVENTOR
Earl L. Koch
BY
H. C. VanDeventer
ATTORNEY

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1,975,610

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THERMIONIC TUBE

Earl L. Koch, Chicago, Ill., assignor, by mesne assignments, to Earl L. Koch Holding Corporation, New York, N. Y., a corporation of New York

Application September 30, 1931, Serial No. 566,008

9 Claims. (Cl. 250—27.5)

This invention relates to thermionic tubes and is a continuation in part of the application entitled Thermionic tubes filed March 21, 1931, Serial No. 524,254. In the said application there is disclosed a thermionic tube having a plate and filament structure enclosed in the usual evacuated glass bulb and having a grid outside said bulb, said tube being shown in Figure 1 of the instant application.

One object of the present invention is to improve the construction of such tubes and to simplify the quantity production thereof and particularly to provide an improved filamentary cathode structure therefor.

Another object of the invention is to provide an improved filament structure adapted to be operated with alternating current and in which magnetic field neutralization is obtained by reason of a flow of current in opposite directions in adjacent loops of the filament.

Another object is to obtain general neutralization of the magnetic field of the filament structure by reason of a flow of current in opposite directions through two sections of the filament structure.

A further object is to arrange the filament structure so as to keep at a minimum the "Edison effect."

Other objects and advantages will be apparent from the following description taken in conjunction with the accompanying drawings, in which

Figure 1 is one embodiment of the invention showing a thermionic tube having an external grid;

Figure 2 is a top view on the line 2—2 of the tube of Figure 1;

Figure 3 is a view, partly in section, of a tube showing a modified form of construction of the embodiment shown in Figure 1, with the outside grid cap but with the base and terminals omitted;

Figure 4 is a view of the tube of Figure 3 rotated 90 degrees;

Fig. 5 is a cross sectional view of the tube shown in Figs. 3 and 4.

Figure 6 is a diagram showing the arrangement of the improved filament structure of the tube of Figure 3, the arrows showing the neutralization of the filament loops by reason of the flow of current in opposite directions therein;

Figure 7 is a diagram showing the improved filament structure of the tube of Figure 3 showing how general neutralization of the magnetic field about the filament structure is accomplished; and

Figure 8 is a diagram illustrating the flow of current in the series zig-zagged filament as employed in the tube of Figure 1.

The tube of Figure 1 consists of the usual evacuated bulb 10 having the usual press 11 supporting the filamentary cathode 12 which is in the form of a zig-zag filament which may be supported by any suitable means such as the hooks 13 mounted upon supporting members 14, 15 of mica or other suitable insulating material.

The members 14, 15 may abut upon the opposite ends of the anode or plate 16 and may be held in assembled relation thereto by crimped portions of the plate extending through said members.

The plate 16 and the insulating members 14, 15 connected thereto form a unit structure which may be mounted upon a suitable stem 17 which may extend through the bottom member 15 only or through member 14. This stem 17 may have connected to it the terminal wire 18 connecting to one of the circuit terminals of the tube and this, together with the usual connections 19, 20 to the filament are sealed into the press 11 in the usual manner and are brought through the base 21 and connected to the usual terminals, one of which is designated by the numeral 22.

The grid 23 is located outside the glass tube 10 and is provided with an outer lead 24. This grid may be of any suitable form such as a band of thin copper, a layer of tinfoil or it may consist of a metal coating sprayed on the glass, a piece of wire gauze or a perforated cap as hereinafter described.

It will be observed that the external grid as used with this tube is electrically insulated from the space-current within the tube, whereas grids of the conventional type placed in the path of the electron flow between filament and plate are not so insulated. For this reason, tubes of the conventional type having a grid within the electron stream must be operated normally with a fixed negative voltage bias connected to the grid. This bias must be at least equal to the peak value of the voltage it is desired to superimpose on the grid or input circuit, for the reason that the grid must at no time be allowed to reach a positive value, inasmuch as under such a condition grid current would flow resulting in lower input impedance with consequent distortion of signal reproduction in the plate circuit when the tube is used as an amplifier.

In the case of the tube herein disclosed, however, it is quite possible to normally operate same with a steady voltage bias, either negative, zero or positive, by reason of the effective insulation

of the grid from the plate-filament electron stream.

Another advantage of the tube herein disclosed is the reduction of grid-plate capacity, by reason of the fact that the filament structure is physically positioned between the grid and plate and functions to serve much the same purpose as the screening grid in the conventional type of four element screen-grid tube.

While the physical presence in the tube herein described of the filament wires form to some extent a screen, it is only with the filament heated (as in normal operation) that screening becomes sufficiently effective to reduce the grid-plate capacity to a value sufficiently low to prevent harmful feed-back or self oscillation when operating the tube as a radio frequency amplifier. This is because the greater part of the screening is accomplished not by the filament wires but rather by the space-charge or electron cloud immediately surrounding said wires; the electrons closely adjacent the filament wires as well as the filament per se are substantially at ground potential much the same as the screening grid in the four element type tube. By reason of the fact that the screening grid in the conventional four element tube is placed directly in the space-current path between the control grid and plate, it tends to increase considerably the space-charge within the tube, resulting in a characteristically high plate impedance. This condition is not present in the tube herein described because of the absence in the physical structure of an additional element within the space-current region. In fact, there are no elements between the filament and plate resulting in greater efficiency as compared to the four and even three element tubes.

The tube herein described is essentially a diode or two element tube and possesses the low space-charge and high power output possibilities of such a tube together with a practical accomplishment of the theoretical ideal arrangement of the control element placed outside the filament plate region. And while the principle of operation of this tube has been briefly referred to, the method of operation and circuits necessary in connection therewith form the subject matter of a separate application, the instant case being limited to the constructional features per se of the tube.

While the tube shown in Figure 1 has the advantages just described by reason of the location of the grid outside the glass envelope, it will be obvious that such a tube may not give entire satisfaction when the filament is supplied with alternating current on account of lack of general neutralization of the magnetic field of the filament structure, for in the tube shown in Figure 1, current enters one end of the zig-zag filament and flows completely around the cylinder formed by the complete filament and tends to form a magnetic field about the entire filament which field (in the case of alternating current) is necessarily alternating in character and would therefore cause disturbances in the operation of the tube mainly due to modulation of the space-current between the filament and plate.

Also it will be observed that the tube of Figure 1 makes no provision to minimize the so-called "Edison effect" which is present when two filament surfaces of opposite potential are closely adjacent, thus enabling the flow of appreciable space-current between said surfaces. When any one surface is at a given instant positive it acts in itself as an anode with respect to the adjacent negative surface and vice versa. Such action under the influence of an alternating potential may prove a disturbing factor as it causes modulation, and in the case of the use of the usual 60 cycle current to excite the filament, causes an audible hum in the audio circuits connected to the tube.

Figures 3, 4 and 5 show a modified form of tube construction having an improved filament structure obtaining general neutralization of the magnetic field of the filament and at the same time reducing the "Edison effect" to a minimum.

Referring to Figure 3, the filament 12 is arranged therein substantially the same as the filament in the tube of Figure 1, except that instead of the filament being mounted upon the supporting members 14 and 15 of Figure 1, it is supported on a plurality of hooks 25, 26 and instead of the entire filament being in series with the leads or wires 19, 20 as shown in Figure 1 the filament forms a continuous cylinder or closed coil connected at two equi-distant points to the filament wires 19, 20 as shown in the diagrams of Figures 6 and 7.

The advantages obtained by this arrangement are that magnetic field neutralization is obtained in the filament by reason of a flow of current in opposite directions in adjacent loops of the filament as shown by the arrows in Figure 6. This neutralization takes place in the tube of Figure 1, having a straight series filament as well as in the modified form of construction wherein the filament forms a closed coil, as shown in Figure 3.

The filament structure shown in Figures 6 and 7 also obtains general neutralization of the magnetic field of the filament structure by reason of the production of the magnetic fields indicated by the arrows 27, 28 which fields neutralize each other. This is accomplished by constructing the filament in a closed loop or coil and connecting the current wires 19, 20 thereto at equi-distant points as shown in Figure 7.

The improvement gained by the arrangement shown in Figure 7 will be apparent from a comparison of the operation of the tube of Figure 1 with that of the tube of Figure 3. In the tube of Figure 1 the entire filament being connected in series as shown in Figure 8, alternating current entering at 19 and leaving at 20 would establish a magnetic field revolving in one direction about the filament structure as indicated by the arrow 29 and no general neutralization of the magnetic field about the filament will take place. The effect obtained may be comparable to the condition existing about a single turn or loop of wire having impressed thereon an alternating current.

The tube of Figure 3 having a filament structure as shown in Figure 7 may be compared to a single closed turn or loop of wire to which alternating current is admitted at two equi-distant points. The resultant magnetic field about such a closed turn of wire would be zero at any given point in space as compared with the full magnetic field obtained when the coil is cut and the ends are connected as shown in Figure 8.

The tube of Figure 3 differs somewhat in general construction from that shown in Figure 1 in that the plate 16 is welded to and supported by means of the vertical upright 30 which may be welded to the horizontal support 31 which in turn is welded to the stem support 32 which is supported in the press 11. The vertical support 30 may also carry the usual "getter" receptacle 33.

Welded to the horizontal support 31 and extending upwardly through the plate 16 is the support 34 for the upper insulating member 35 carrying the filament hooks 25 which are insulated from each other. Insulating member 35 may be of glass and the hooks are merely fused into this glass in the usual manner.

The grid cap 36 may be of any suitable form such as a metal stamping split to insure that it will firmly grip the outside of the glass bulb and may be provided with a suitable terminal 37.

It will be observed that the filament and plate structure in the tube (Figures 3 and 4) forms a unit structure which may be easily and cheaply manufactured to very accurate dimensions which is necessary in connection with the location of the filament in respect to the wall of the bulb 10. It is necessary in this type of tube having an external grid, that the cathode be located as near the inner surface of the glass bulb as possible without actually touching it, and by the construction herein described and shown this object is easily and cheaply obtained and uniformity in manufacture assured.

The reasons for accurately spacing the cathode in relation to the inner wall of the bulb are disclosed in detail in copending application Serial Number 524,254, above referred to, relating more to the principle of operation of the tube than to its constructional features. The grid is located outside of the glass bulb, embracing the same in a zone adjacent to the cathode, the cathode being adjacent to the control grid but insulated therefrom by the glass bulb, and under operating conditions a cloud of electrons formed about the cathode substantially reduce or nullify the capacity effect between the grid which is located outside of the glass bulb and the plate which is mounted within the glass bulb and surrounded by the cathode. In this form of construction it will be noted that the grid is consequently insulated from the stream of electrons which it controls. As the cathode is located as near to the inner surface of the glass bulb as possible without actually touching it, the effective control by the outside grid is maximum for this type of construction, and in quantity production tubes having uniform characteristics may be obtained.

The "Edison effect" is reduced to a minimum in the tube of Figure 3 by the relative position of the plate 16 and the cathode 12.

In tubes as heretofore constructed wherein the plate and grid surround the cathode there is nothing interposed between the cathode surfaces of opposite potential and consequently space currents are free to flow therebetween.

In the improved tube shown in Figure 3 however, the plate 16 is interposed between opposite cathode surfaces connected to terminals 19, 20, and the action of the plate is such as to reduce to a minimum the space current (Edison effect) between said surfaces.

It is not necessary to physically interpose a plate between all of the opposite cathode surfaces, that is to say, the bottom of the plate need not extend down and between the terminals or lead-in wires 19, 20 as reduction of the space current is brought about by the electric field existing around the plate, which field extends downwardly from the bottom of the plate sufficiently to prevent space current flowing between the opposed cathode surfaces when the plate is substantially of the dimensions and positioned as shown in Figures 3 and 4.

While the preferred arrangement to minimize the "Edison effect" is to use the plate or anode element of the vacuum tube as just described, it is obvious that the same result would be produced by a member mounted within the conductive cylinder formed by the filamentary cathode and that this member need not necessarily form the plate or anode proper of the tube, that is to say, this member could be used solely for the purpose of reducing the "Edison effect" if so desired, and need not necessarily form the anode.

Although the invention has been disclosed in connection with the specific details of preferred embodiments thereof, it must be understood that such details are not to be limitative of the invention except in so far as set forth in the accompanying claims.

What is claimed is:

1. A thermionic tube comprising a cathode defining a substantially cylindrical surface formed of zig-zag sections and forming a closed coil, an anode within said cathode, a glass body surrounding said cathode and anode, said cathode being positioned between the anode and the glass body nearer to the latter than to the anode, and a grid on the exterior of the glass body.

2. A thermionic tube comprising a cathode defining a substantially cylindrical surface and forming a closed coil, a cylindrical anode within said cathode, a glass body enclosing said cathode and plate, the space between the cathode and said glass body being less than the space between the cathode and the anode, and a grid on the exterior of said body surrounding a portion of said cathode.

3. A thermionic tube comprising a glass body, a cathode within the body, a plate within the cathode, and a grid cap having a terminal secured thereto and fitting over and embracing the end of said glass body when supported thereby.

4. A thermionic tube comprising a glass body, an anode supported therein, a filamentary cathode surrounding a portion of said anode, said cathode being comprised of zig-zag loops, and means supported wholly from one end of the glass body and supporting said filamentary cathode closely adjacent the inner wall thereof.

5. A thermionic tube comprising a glass body, a plate supported centrally therein, a filamentary cathode mounted in zig-zag order and forming a closed loop surrounding said plate and spaced apart therefrom and located closely adjacent to the inner wall of the glass body, and a grid on the exterior of the glass body.

6. A thermionic tube comprising a filamentary cathode comprising a closed figure mounted in zig-zag form so that current through one portion thereof flows in a direction opposite to that flowing in the next adjacent portion, the magnetic field about one portion tending to neutralize the magnetic field about the adjacent portions, current supply connections to said figure and an anode positioned within said figure.

7. A thermionic tube comprising a glass body, a cathode therein consisting of loops of filament defining a substantially cylindrical surface, the ends of said filament being joined to form a closed loop, and current carrying connections to the cathode at substantially equi-distant points thereon whereby current may be caused to flow through two sections of the cathode in opposite directions in order to obtain neutralization of the general field thereof, and an anode positioned within and disposed parallel to said cathode.

8. A thermionic tube comprising a glass body having a reentrant stem, a support secured in the press of said stem, a cylindrical anode carried by said support, a plurality of hooks carried by said support, a filament supported by said hooks and mounted in zig-zag loops about said anode thereby defining a substantially cylindrical surface, said filament having its ends connected together to form as a whole a closed loop, and wires connected to said filament at substantially equi-distant points thereon whereby current entering said filament will flow therethrough in substantially equal sections therein, thereby causing neutralization of the general field about said filament.

9. A thermionic tube having a glass body portion, a unit structure located within said body portion, said structure comprising the usual glass reentrant stem and press and a cylindrical anode supported thereby, a filamentary cathode surrounding said anode comprised of a plurality of loops forming a closed coil, said filament being closely adjacent the inner wall of said glass body when said unit structure is in place therein, and terminals connected to said filament at substantially equi-distant points thereon.

EARL L. KOCH.