June 28, 1932. J. E. FOSTER 1,864,591

THERMIONIC DEVICE

Filed Jan. 8, 1925 2 Sheets-Sheet 1

Fig. 1.

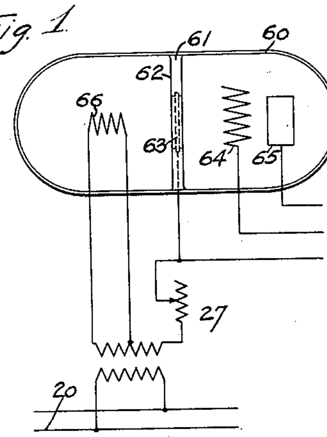


Fig. 3.

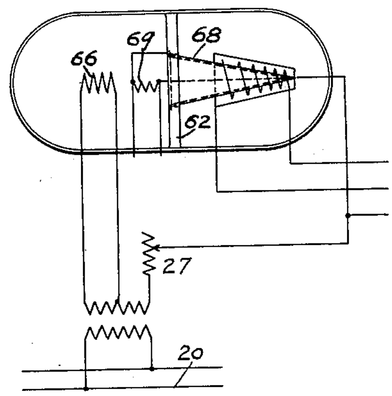


Fig. 2.

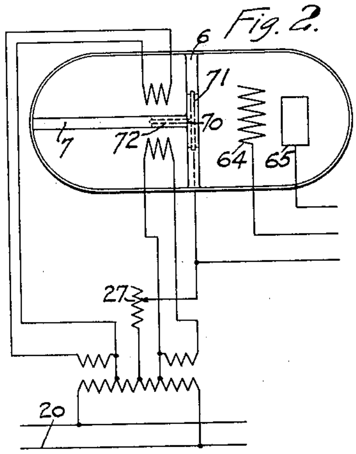


Fig. 4.

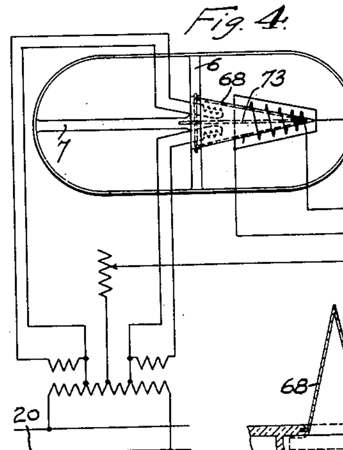


Fig. 7.

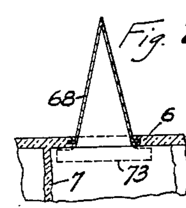


Fig. 5.

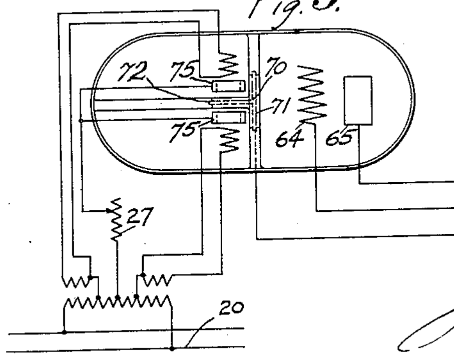


Fig. 6.

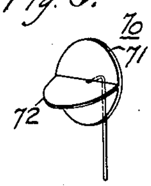
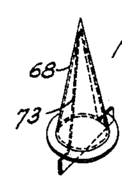


Fig. 8.



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June 28, 1932. J. E. FOSTER 1,864,591

THERMIONIC DEVICE

Filed Jan. 8, 1925 2 Sheets-Sheet 2

Fig. 9.

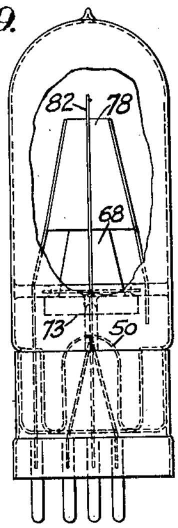
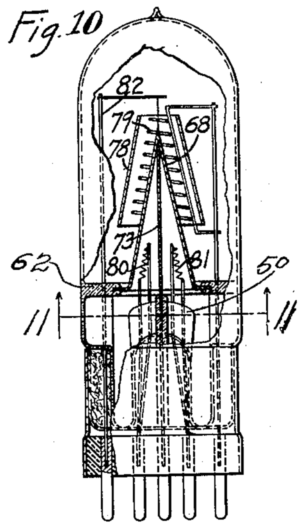


Fig. 10



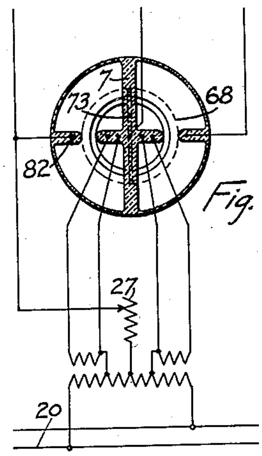


Fig. 11.

Fig. 12.

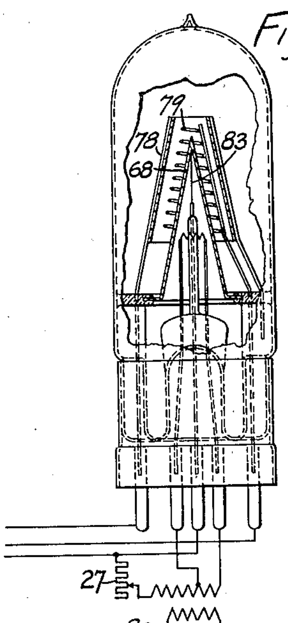
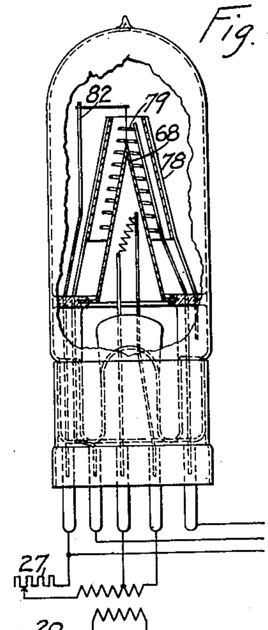


Fig. 13.



INVENTOR

Julius E. Foster

Patented June 28, 1932 1,864,591

UNITED STATES PATENT OFFICE

JULIUS E. FOSTER, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO RADIO CORPORATION OF AMERICA, A CORPORATION OF DELAWARE

THERMIONIC DEVICE

Application filed January 8, 1925. Serial No. 1,182.

My invention relates, in general, to electronic devices and particularly to audion tubes used as detectors or amplifiers in radio work.

The primary object of my invention is to provide an audion that may be energized by energy derived from a source of alternating current, such as the usual light and power circuit generally available.

Another object of my invention is to provide an audion of novel construction embodying means for modifying an alternating current to render it suitable to energize the electron-emitting filament employed as the cathode.

Another object of my invention is to provide a novel method of establishing an electron stream in a thermionic device.

In a tube of one type embodying my invention, I provide a non-filamentary cathode which occupies the usual position, however, within a cylindrical grid and plate. The cathode is of cone-shape, the base being supported upon a glass annulus which together with the cone serves as a partition to separate the tube into two compartments. One compartment constitutes the operating compartment containing the cone cathode, a grid and a plate. The other compartment contains a filament which is energized from an alternating current circuit, and which cooperates with the cone to constitute an electric valve. The cone thus serves as an anode for the filament and as a cathode for the grid and the plate. The cone extends into the active region of the operating compartment within the grid and the plate. On its inner surface it receives the electron stream from the filament and the current conducted by ionization. It is thus heated to incandescence and emits an electron stream from its outer surface into the active region within the grid and the plate.

A modified form of this tube comprises two valve compartments separated from the main operating compartment and also from each other. The cone is divided into two compartments by a partition of corresponding metal which is anchored in a glass partition between the valve compartments. The two valve compartments are alternately conductive and the cone is thus continuously energized.

It is apprehended that the principles involved in the embodiments illustrated and described herein may have further application and additional uses. The application to the arts of X-ray tubes and photo-electric devices is contemplated.

A tube of still another type, not enjoying certain advantages of construction inherent in the foregoing types, is also illustrated and described herein. The principle of focusing energy waves upon the cathode is employed to establish an active condition conducive to electron emission.

The principles involved will be better apprehended upon consideration of the structures illustrated in the accompanying drawings.

Figures 1 to 5, inclusive, illustrate schematically different modifications of tubes embodying my invention;

Figure 6 is a perspective view of the element common to both compartments of the tube illustrated in Fig. 2;

Figures 7 and 8 illustrate the construction and arrangement of the cone-shaped electrode employed in the tubes illustrated in Figure 4;

Figures 9 to 13, inclusive, are front views, partially in elevation and partially in section, of tubes embodying the features illustrated in Figs. 1 to 5, inc.;

The tube illustrated in Fig. 1 comprises a vessel 60 divided into two compartments by a partition 61 consisting of a glass annulus 62 and a tungsten disk or plate 63 supported in the center thereof. The main compartment contains the usual grid 64 and plate 65. The other compartment, which may be termed the auxiliary or control compartment, contains a filament 66 and some inert gas such as argon. The filament is energized from an alternating current circuit 20 through a transformer which is also connected through a resistor 27 to include the auxiliary chamber in a series circuit. The filament is thereby rendered incandescent and the target or plate 63 is heated by bombardment and by the current traversing it. The plate 63 should have an oxide coating on the surface in the operating compartment but not on the surface in the rectifying compartment. The plate will thus be rendered active at a temperature considerably lower than the operating temperature of the filament. There will therefore be less activity and electron emission from the uncoated surface of the plate than from the filament. The rectifying character of the filament and the plate will therefore not be affected inasmuch as the potential difference between them will be insufficient to cause a reversal of current and a penetration of the highly active electron field near the filament. The striking potential necessary to cause a reversal would be of the order of 175 to 200 volts for about ¼ inch spacing. The voltage necessary to operate the rectifying compartment need only be somewhat in excess of the initial striking potential which would be about 25 to 30 volts for he same spacing. The operation is similar to that of the tungar battery charging rectifier.

In Fig. 3 is illustrated a modified form in which the plate or anode of the rectifying compartment is employed in the form of a hollow cone 68. The rim of the base of the cone is supported in the glass annular partition 62, and the apex of the cone extends into the operating chamber where it serves as a nonfilamentary cathode and is surrounded by the usual grid and plate. The latter elements are preferably of the same shape as the cone in order to present the minimum spacing between the cone and the plate.

Due to the decreasing cross-sectional area of the cone from the base to the apex, and the greater radiating surface near the base, the portion at the apex will heat more quickly and retain its heat.

The cross-section of the wall of the cone may be increasingly tapered to a small degree from the rim of the base to the apex to present a conducting path whose area will diminish less rapidly than in the cone having a constant wall thickness. The apex will thus have more concentrated mass or body to retain the heat and maintain the temperature substantially even. A heat-storage element 69 is provided which supplies heat to the cone while no current is transmitted thereto through the rectifying compartment.

In Fig. 2 is illustrated a modification which utilizes all current waves of both polarities, thereby supplying a continuous unidirectional current to the plate or anode, and maintaining the temperature more even. Two rectifying compartments are provided which are partitioned from the main compartment and from each other. The plate 70 embodies two portions 71 and 72 respectively disposed in the partitions 6 and 7 separating the several compartments. The filaments in the auxiliary compartments transmit current alternately to the plate 70 which is consequently energized continuously by unidirectional current. The value of the current transmitted may be controlled by the variable resistor 27, and the temperature and electron-emitting character of the surface of the plate in the main compartment varied accordingly.

In Fig. 4 is illustrated a modification embodying the cone structure 68 which is energized in accordance with the principle controlling the tube in Fig. 2. The cone is divided into two pockets or chambers by a partition 73 of corresponding metal. Each pocket communicates with the corresponding rectifying compartment and constitutes part thereof. The filaments are supported within the respective pockets as close to the apex as is practicable, considering the design of the cone. The rim of the base of the cone is secured to the main glass partition 6 and the metal cone partition 73 is anchored in the auxiliary glass partition 7. In this structure the cone is traversed and heated by a continuous unidirectional current.

By means of the partition in the cone as by the partition between the auxiliary compartments, any tendency to transmit current between both filaments is obviated.

In Fig. 5 is illustrated a tube of modified form in which the electron-emitting element or cathode for the main operating compartment is not electrically connected in circuit with the rectifying units. The plate of each rectifying chamber consists of an annulus 75 having a relatively large opening which registers with one surface of the portion 72 of the common element. The energized particles move from the filaments to the annular elements with sufficient velocity to pass through the opening and bombard the portion 72 which conducts heat to the portion 71 in the main compartment to render it active. This modification requires a greater amount of energy to operate it since only a portion of the energy is transmitted to the common plate element by bombardment.

Fig. 6 is a perspective view of the element or plate 70 common to the three compartments of the tube illustrated in Figs. 2 and 5.

Figs. 7 and 8 are views illustrating the disposition of the partition 73 in the cone and in the auxiliary partition 7 between the rectifying chambers. By means of the partition 73 in the cone and the glass partition 7, the two chambers are entirely separated.

In Figs. 9, 10 and 11 are shown the embodiment containing the features illustrated in Fig. 4. The view in Fig. 9 shows the disposition of the cone cathode 68 within the plate 78 of truncated cone shape. The partition 73 is anchored in a glass partition 7 across the tube underneath the cone and its supporting annulus 62.

The view in Fig. 10 is a side sectional view of the tube in Fig. 9 with parts broken away.

to show the disposition of the various elements. The cone is surrounded by a grid 79 within the plate 78 and is supported by a conductor proceeding to one of the base terminals. The rectifying filaments 80 and 81 are disposed within the pockets in the cone, on each side of the partition 73. The filament supports are sealed in the inner shell 50, and connected to base terminals. The apex of the cone is connected to a base terminal through a conductor and support 82.

By disposing the rectifying filaments within the cone, all heat developed thereby is pocketed and confined to establish a heat zone to maintain the temperature of the cone substantially constant.

The view in Fig. 11 is a sectional view of the tube in Fig. 10 taken along the line 11—11 in the direction of the arrows. The vertical glass partition 7 cooperates with the cone partition to separate the rectifying compartments. The circuit connections correspond to those illustrated in Fig. 4.

In Fig. 12, the connection from the apex of the cone to an external circuit is made by a conductor 83 connected to the internal surface of the apex. In Fig. 13 the connection is made by a conductor 82 connected to the external surface of the apex of the cone.

By means of the cone structures illustrated in the described figures, an even constant temperature may be maintained, due to the heat storage capacity of the cone and to the fact that the heated air is pocketed in the cone. The outer surface of the cone may be coated with the commercial oxides as at present employed to obtain high electron emission at relatively low temperatures. The heating and temperature of the cone may be controlled by the resistor 27 in the energizing circuit. By means of such a system a relatively large heating current may be supplied to the cone which permits of greater flexibility and regulation. By controlling the current traversing the rectifying filaments and also the current traversing the filament-cone circuit, the operating characteristics of the cone in the operating compartment may be readily controlled.

It is essential for proper operation of the rectifying units that the filaments be separated to obviate a clear path between them which would permit a partial short circuit and consequent erratic operation resulting in a fluctuating energizing current. Such erratic operation results when both filaments have an unimpeded gas path between them. By means of the glass partition and that in the cone, a transfer of energy between the filaments is prevented and all energy transmitted to the cone.

My invention is not limited to the specific constructions or arrangements illustrated but may be variously modified without departing from the spirit and scope of the invention as set forth in the appended claims.

I claim as my invention:

1. A thermionic tube comprising an audion and a full-wave rectifier, said full-wave rectifier having heatable cathodes and a common anode which is the cathode for the audion, and an insulating barrier means isolating the active spaces surrounding said cathodes.

2. A full-wave rectifier comprising a closed envelope containing two heatable cathodes, co-operating anode means comprising two chamber enclosures respectively surrounding the active spaces surrounding the cathodes, and a dielectric medium adjacent the chamber enclosures to prevent current leakage between the active spaces adjacent to the cathodes.

3. An electron discharge device comprising a sealed glass envelope having a press therein, a plurality of thermionic cathodes supported from said press within said envelope, an anode surrounding said cathodes and having an outer surface adapted to function as an equi-potential cathode, means associated with said anode for forming a separate sealed compartment enclosing said cathodes, means for dividing said separate enclosure into separate space discharge regions, each region having one cathode, and a control electrode and an anode disposed around said equi-potential cathode.

4. An electron discharge device comprising a sealed glass envelope having a press therein, a plurality of thermionic cathodes supported thereon, a conical anode enclosing said cathodes and having an outer surface adapted to function as an equi-potential cathode, means co-operating with said anode for forming a separate sealed chamber enclosing said cathodes, means for separating said enclosed space into distinct space discharge regions, and a control electrode and an anode disposed around said equi-potential cathode.

In testimony whereof, I have hereunto subscribed my name this 7th day of December, 1925.

JULIUS E. FOSTER.