March 22, 1932. J. E. FOSTER 1,850,957

RECTIFYING SYSTEM

Original Filed Jan. 8, 1925

Fig. 1.

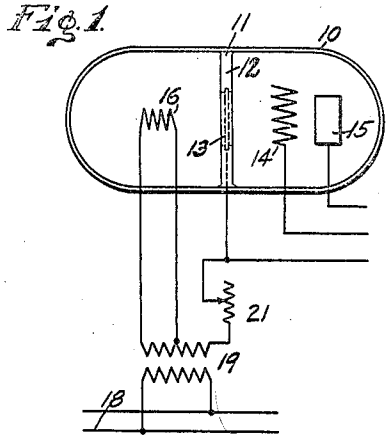
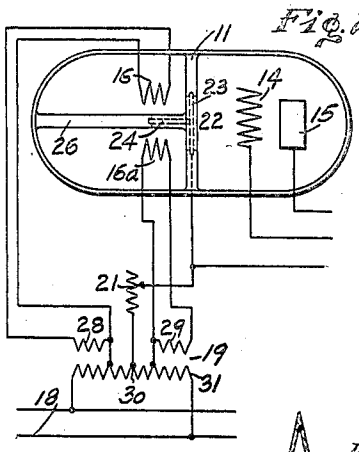


Fig. 2.



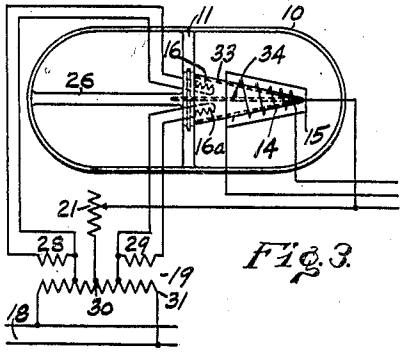


Fig. 3.

Fig. 4.

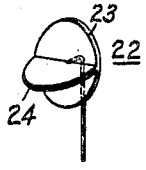
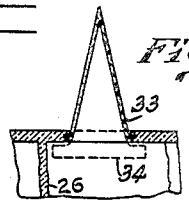


Fig. 5.



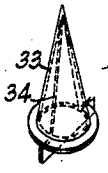


Fig. 6.

Fig. 7.

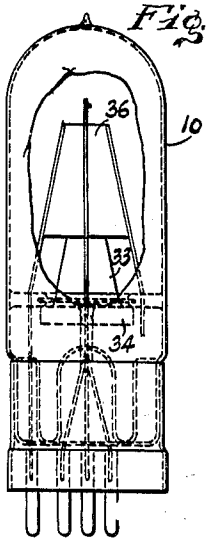
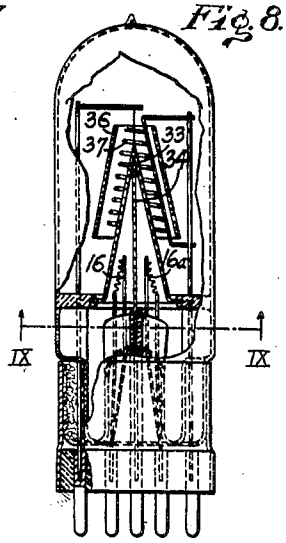


Fig. 8.



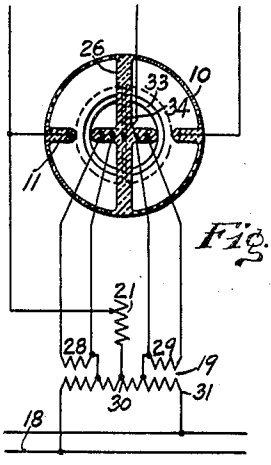


Fig. 9.

INVENTOR

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Patented Mar. 22, 1932 1,850,957

UNITED STATES PATENT OFFICE

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RECTIFYING SYSTEM

Original application filed January 8, 1925, Serial No. 1,182. Divided and this application filed March 5, 1929, Serial No. 344,336. Renewed July 11, 1931.

This application is a division of my application relating to thermionic devices filed Jan. 8, 1925, Ser. No. 1,182, and is directed particularly to a rectifying system, including thermionic devices.

The primary object of my invention is to provide a rectifying system employing a full-wave thermionic rectifier provided with a plurality of thermionic cathode elements and co-operating anode means arranged to prevent current leakage between the cathode elements, and, thereby, to prevent short-circuiting of a transformer or other source of energy with which the rectifier may be employed.

Another object of my invention is to provide a rectifying system for radio application, which shall transmit substantially all of the rectified energy, and thereby maintain a substantially constant source of direct voltage.

Another object of my invention is to provide a rectifying system, of the foregoing character, that may be utilized in radio equipment with a transformer that supplies voltage of desired value, and that shall function in such manner as to protect the transformer against short-circuit conditions caused by current leakage between the filaments of a double wave rectifier.

Recent developments in radio receiving equipment have been towards the elimination of the various storage and dry batteries heretofore used, in order that the usually available source of house-lighting current might be utilized for the energization of radio tubes and the operation of the receiving sets. In order to obtain a suitable supply of substantially direct current and direct current voltage, rectifying devices of different kinds have been employed, utilizing the thermionic valve character of a heated cathode. With the employment of two heated cathodes in the same envelope, however, for transmitting both waves of an alternating current, certain problems are encountered which must be eliminated in order to obtain satisfactory operation of the rectifier of such type.

Where two filamentary electrodes disposed in the same enclosing vessel are heated, the spaces or zones immediately surrounding the filaments become electronically active due to the electronic emission of the heated filaments. If the medium surrounding the filaments is gaseous, it becomes ionized by the electronic activity of the heated filaments and establishes a current-conducting path between them. When the filaments and the co-operating anode element are connected to an external transformer to cause the filaments to alternately transmit current waves to the anode element, the differences of potential set-up between the various elements, in the confined space within the envelope, tend to establish greater activity between the several electronic spaces surrounding the active cathodes, and a short circuit condition is established on the transformer to which the rectifier is connected.

If both filaments are to be disposed within the same envelope, as is preferable for reasons of economy and for saving of space, it is essential to prevent the leakage of current between the two filaments, or proper operation of the rectifying system will not be established and maintained, and a short-circuit condition will be established by such leakage.

In order to prevent current leakage between two cathodes, or the active spaces surrounding them, the anode means should be disposed to isolate and confine the active spaces surrounding the respective cathodes, and thereby prevent leakage of current between the cathodes or the active spaces surrounding them, and thus prevent the possibility of a short circuit upon the transformer or source of alternating current with which the rectifier is to be used.

In the modification which is illustrated herein, the cathode filaments are isolated and separated from each other by a common anode which is provided with a partition to divide the anode into two chamber enclosures. A filamentary cathode is disposed in each chamber. The active space surrounding each filament is thus confined and limited and isolated by the chamber enclosure wall, and the potential of the anode partition is such as to permit the passage of current in a proper direction between the anode and one filament or the other, depending upon the potential

of the circuit or transformer to which the rectifier is connected. At the same time, current transfer between the filaments is prevented and the transformer is protected against short-circuit conditions.

The operation of the rectifying system will be better understood upon reference to the following detailed description in consideration with the accompanying drawings, in which

Fig. 1 illustrates schematically a 3-element tube with a single wave rectifier system for excitation of the cathode;

Fig. 2 illustrates schematically a similar system to that shown in Fig. 1 but arranged to supply double-wave rectification;

Fig. 3 is a schematic and diagrammatic view of a tube and system similar to that shown in Fig. 2 but employing an anode of special construction for the rectifying operation;

Fig. 4 is a perspective view of the common anode used in the rectifying operation in the tube shown in Fig. 2;

Fig. 5 is a sectional view of the anode of modified construction employed in the tube shown in Fig. 3;

Fig. 6 is a perspective view of the same anode illustrating the manner in which the partition separates the anode into two chambers for receiving the cathodes;

Fig. 7 is a front elevational view of a tube embodying the features illustrated in Fig. 3;

Fig. 8 is a front view, partially in elevation and partially in section, of the tube shown in Fig. 7;

Fig. 9 is a sectional view of the tube shown in Fig. 8, taken along the line IX—IX, together with the connected circuits.

The tube illustrated in Fig. 1 comprises a vessel 10 divided into two compartments, an operating compartment and a rectifying compartment, by a partition 11 consisting of a glass annulus 12 and a tungsten disc or plate 13 supported in the center thereof. One compartment contains a grid 14 and a plate 15. The other or rectifying compartment, contains a filament 16 and some inert gas such as argon. The filament 16 is energized from an alternating current circuit 18 through a transformer 19 which is also connected through a resistor 21 to include the rectifying chamber in a series circuit. The filament is thereby rendered incandescent and the target or plate 13 is heated by bombardment and by the current traversing it. The plate 13 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 the same spacing. The operation is similar to that of the tungar battery charging rectifier.

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 22, and maintaining the temperature more even. Two rectifying compartments are provided, which are partitioned from the main compartment and each other. The plate 22 embodies two portions 23 and 24 respectively disposed in partitions 11 and 26 separating the several compartments. Two filaments 16 and 16*a* in the rectifying compartments transmit current alternately to the plate 22 which is consequently energized continuously by uni-directional current. The value of the current transmitted may be controlled by the variable resistor 21, and the temperature and electron-emitting character of the surface of the plate in the main compartment varied accordingly.

The filaments are heated by separate auxiliary low-voltage windings 28 and 29 of the transformer. The anode 22 is connected to the neutral point 30 of the main transformer winding 31, and the auxiliary windings are connected to points on either side of the neutral 30, according to the voltage that is to be impressed upon the rectifier.

In Fig. 3 is illustrated a modification embodying an anode 33 of cone shape, which is energized in accordance with the principle controlling the tube in Fig. 2. The anode cone 33 is divided into two pockets or chambers by a partition 34 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 11 and the metal cone partition 34 is anchored in the auxiliary glass partition 26. In this structure the cone is traversed and heated by a continuous uni-directional current.

By means of the partition 34 in the cone, as by the partition between the auxiliary rectifying compartments, any tendency to transmit current between both filaments is obviated.

Fig. 4 is a perspective view of the anode element or plate 22 common to the three compartments of the tube illustrated in Fig. 2.

Figures 5 and 6 are sectional and perspective views illustrating the disposition of the partition 34 in the cone-shaped anode 33 and in the auxiliary partition 26 between the rectifying chambers. By means of the partition 34 in the cone and the glass partition 26, the two chambers are entirely separated.

In Figs. 7, 8, and 9 are shown the embodiment containing the features illustrated in Fig. 3. The view in Fig. 7 shows the disposition of the cone 33 as a cathode within a plate 36 of truncated cone shape. The partition 34 in the cone is anchored in a glass partition 26 across the tube underneath the cone and its supporting annulus 25.

The view in Fig. 8 is a side sectional view of the tube in Fig. 7 with parts broken away to show the disposition of the various elements. The cone is surrounded by a grid 37 within the plate 36 and is supported by a conductor proceeding to one of the base terminals. The rectifying filaments 16 and 16*a* are disposed within the pockets in the cone, on each side of the partition 34. The filament supports are sealed in the usual reentrant stem or press, and connected to base terminals. The apex of the cone is also connected to a base terminal through a conductor and support.

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. 9 is a sectional view of the tube in Fig. 8 taken along the line IX—IX in the direction of the arrows. The vertical glass partition 26 co-operates with the cone partition to separate the rectifying compartments. The circuit connections correspond to those illustrated in Fig. 3.

By means of the cone structure 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 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 21 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.

In order to ensure proper operation of the rectifying unit the two filaments and their active spaces should be confined in separate compartments, to preclude leakage or short-circuit currents between them.

My invention is not limited to the specific arrangement and construction that is illustrated but may be variously modified to employ the same principle of separating and segregating or isolating the active zones around the respective cathodes to prevent inter-electronic action or current leakage between them that would be detrimental to and would short circuit the associated transformer, all as are set forth as being within the spirit and scope of the invention as defined in the appended claims.

I claim as my invention:

1. The combination in a rectifying system, comprising a transformer, a source of energy therefor, a rectifier provided with two filamentary electrodes energized from the transformer, anode means associated with the filaments and means conductive to direct current between the transformer and the filaments and the anode means to transmit alternate waves from the filaments, said anode means being disposed around the active zones of the filaments to prevent current leakage between them and consequent short-circuiting of the transformer.

2. In a radio system, the combination with a transformer, of a thermionic tube comprising an audion and a full-wave rectifier having heatable cathodes and a common anode which is the cathode for the audion, means energized from the transformer for heating the cathodes, and means conductive to direct current connecting the transformer, the cathodes and the anode in a rectifying circuit, the anode having a barrier isolating the active spaces surrounding the cathodes to prevent current leakage between them which would short-circuit the transformer.

3. In a radio system, the combination with a transformer, of a full-wave rectifier having heatable cathodes and anode means, means energized from the transformer for heating the cathodes, and means for conducting direct current connecting the transformer and the cathodes and anode means in a rectifying circuit, said anode means isolating the active spaces surrounding the cathodes to prevent current leakage between them and, thereby,

to prevent consequent short-circuiting of the transformer.

4. In an electrical system, the combination with a transformer, of a rectifier having a plurality of heatable cathodes, means energized from the transformer for heating the cathodes, anode means associated with the cathodes, and means conductive to direct current connecting the transformer, the cathodes and the anodes as a rectifying circuit, the anode means embodying a conducting barrier between the active spaces surrounding the cathodes, and an insulating medium cooperating with the conducting barrier to prevent current leakage between them and, thereby, to prevent consequent short-circuiting of the transformer.

5. In a rectifying system, the combination with a transformer, of a rectifier provided with a plurality of cathode elements, means energized from the transformer for energizing the cathode elements, and means connected to the transformer for causing the cathode elements alternately to transmit a current wave, said means including anode means associated with the cathode elements and arranged to receive the current waves therefrom, means conductive to direct current between the anode means and the transformer, and an insulating medium cooperative with the anode means to isolate the active spaces surrounding each cathode element, thereby to prevent current leakage between the cathode elements and consequent short-circuiting of the transformer.

6. A rectifying system comprising a transformer, a rectifier embodying a plurality of cathode elements and anode means associated therewith, and means conductive to direct current connecting the cathode elements and the anode means to the transformer to cause current waves to be transmitted alternately between the respective cathode elements and the anode means, said anode means being disposed to isolate the active spaces surrounding the respective cathode elements, thereby to prevent current leakage between them and to prevent consequent short-circuiting of the transformer.

7. In a rectifying system, the combination with a transformer, of a rectifier provided with two filamentary cathodes, means energized from the transformer for energizing the cathodes, and means electrically associating the cathodes and the transformer to cause the cathodes to be alternately effective to transmit current waves, said means including anode means comprising two chamber enclosures respectively surrounding and isolating the active spaces surrounding the cathodes, whereby leakage between the cathodes and consequent short-circuiting of the transformer are prevented, and means conductive to direct current connecting the anode means and the transformer

8. A rectifying system comprising a transformer, a full-wave rectifier having heatable cathodes and co-operating anode means, a load circuit, and circuit connections conductive to direct current operatively connecting the transformer and the cathodes and the anode means to supply double-wave rectified current to the load circuit, said anode means surrounding and isolating the active spaces surrounding the cathodes to receive the full current waves from the cathodes for the load circut and, thereby, to prevent current leakage between the cathodes and consequent short-circuiting of the transformer.

9. In a rectifying system, the combination with a transformer, of a thermionic rectifying device comprising two filamentary cathodes and co-operating anode means, means energizable from the transformer for heating the cathodes; an impedance device conductive to direct current, and means including the anode means electrically associating the transformer and the cathodes to render the cathodes alternately effective to transmit current waves to the anode means and the impedance device, said anode means isolating and surrounding the cathodes to prevent current leakage between them that would short-circuit the transformer.

10. In a rectifying system, the combination comprising a thermionic device provided with two elements for establishing two spaced electronically active zones, means for energizing said elements, and means for controlling said elements, when energized, to alternately establish a current-carrying stream from each active zone to said means, and precluding any leakage or interchange of current between said zones, said means and said elements being electrically connected by direct current conductors externally of said streams.

11. In a rectifying system, a thermionic rectifier comprising a plurality of filaments, means for energizing them to render them electronically active, means for supplying out-of-phase currents to the respective filaments to be electronically transmitted by them, a common anode for receiving current from all of the filaments and for isolating the active spaces surrounding them to prevent current-leakage between them, and means conductive to direct current connecting the filaments and the anode externally of the rectifier.

12. In a rectifying system, a thermionic rectifier provided with a plurality of filamentary cathodes, means for energizing them to render them electronically active, co-operating anode means disposed around and between the cathodes to transmit current waves to the respective cathodes and to prevent current leakage between them due to their electronic activity, a source of energy therefor and means electrically conductive

to direct current connecting the cathodes and the anode means externally of the rectifier.

13. In a rectifying system, a rectifier having a plurality of cathodes, means for rendering them electronically active, means for rendering them sequentially current-transmitting, means for collecting all the transmitted current comprising means isolating the active spaces surrounding the cathodes to prevent current leakage between them, and means electrically conductive to direct current connecting the cathodes and the collecting means externally of the rectifier.

14. In an electrical system, the combination comprising a single phase transformer, a rectifier having two spaced heatable cathodes, means energizable from the transformer for heating the cathodes to establish two spaced active zones, anode means associated with the cathodes, means conductive to direct current connecting the transformer, the cathodes and the anode means as a rectifying circuit and setting up the full transformer voltage between said zones, the anode means embodying a conducting barrier disposed directly between the two spaced active zones, and an insulating medium co-operative with the conducting anode barrier to separate the spaced active zones and to prevent energy interchange between them in response to the transformer voltage between the two active zones, and, thereby, to prevent consequent short-circuiting of the transformer.

15. In a rectifying system, the combination comprising a single phase transformer, a rectifier having two spaced heatable cathodes, effective, when heated, to establish two spaced active zones, means energizable from the transformer for heating the cathodes, anode means associated with the cathodes, and means conductive to direct current connecting the transformer, the cathodes and the anode means as a rectifying circuit and introducing the potential of each terminal of the transformer into the respective active zones, said anode means embodying a conducting barrier disposed directly between the two spaced active zones and establishing a potential and an effective reaction upon the energy of the two zones according to the changing potential of the transformer terminals, and an insulating medium, in a path beyond the conducting barrier and between the active zones, co-operative with the anode barrier to separate the spaced active zones and to prevent energy interchange between them in response to the potential difference established between the two zones by the transformer voltage, and, thereby to prevent consequent short-circuiting of the transformer.

In testimony whereof, I have hereunto subscribed my name this 2nd day of March, 1929.

JULIUS E. FOSTER.