Oct. 19, 1943. Z. J. ATLEE ET AL 2,332,428

ELECTRON FLOW DEVICE

Filed March 26, 1942

Fig. 2.

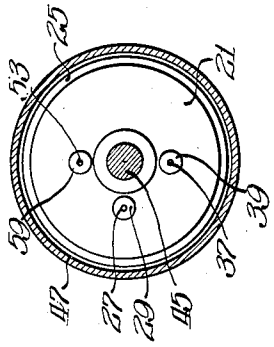


Fig. 1.

INVENTORS:—
Zed J. Atlee
Robert F. Wilson

BY:—
Spencer, Marzall, Johnston & Cook,
ATTORNEYS.

Patented Oct. 19, 1943 2,332,428

UNITED STATES PATENT OFFICE

2,332,428

ELECTRON FLOW DEVICE

Zed J. Atlee, Elmhurst, Ill., and Robert F. Wilson, Washington, D. C., assignors to General Electric X-Ray Corporation, Chicago, Ill., a corporation of New York

Application March 26, 1942, Serial No. 436,290

3 Claims. (Cl. 250—27.5)

The present invention relates in general to electronics and has more particular reference to improved electronic rectifier means.

An important object of the invention is to provide an electron flow device embodying an extremely efficient electron emission source; a further object being to provide an emission element adapted to be heated for electron emission at relatively low temperature; a still further object being to utilize an emission element comprising thorium for highly efficient electron emission.

Another important object is to provide an electron emision element comprising thorium supported on a suitable mounting, such as a tungsten filament; a further object being to support the thorium as a surface film on the supporting filament.

Another important object is to carbonize the tungsten filament whereby to carry the thorium thereon in a sheath of tungsten carbide on said filament.

Another important object is to provide an electron flow device embodying the improved electron emission element as a cathode, in combination with a co-operating anode, enclosed in a sealed evacuated envelope, and to preserve the thorium by providing means for maintaining the exhausted envelope at a high degree of vacuum of the order of 0.02 micron of mercury or better; a further object, to this end, being to provide gettering means within the envelope and supported on a mounting preferably comprising a part of the cathode structure, said gettering means being operable to produce a gettering material such as barium in vaporized condition at intervals during the service life of the device to maintain the desired degree of vacuum within the envelope for the preservation of the electron emission element for operation at high efficiency.

Another important object is to provide means within the envelope, operable as an ionization gauge, for the determination of vacuum conditions within the envelope during the operating life of the device; a further object being to form the gauge as a plate having a connection extending outwardly of the sealed envelope for attachment in an external measuring circuit and operable as an ionic collector, said plate serving, in conjunction with the external measuring circuit, to measure the degree of ionization and hence vacuum conditions within the envelope; a further object being to form the ionization gauge plate as a part of the cathode structure of the device; a still further object being to utilize the said gauge plate as a housing or enclosure for gettering means to prevent end products of the gettering operation from settling upon the anode and cathode elements of the device.

These and numerous other important objects, advantages, and inherent functions of the invention will be fully understood from the following description, which, taken in connection with the accompanying drawing, discloses a preferred embodiment of the invention.

Referring to the drawing:

Figure 1 is a sectional view taken longitudinally through an electronic rectifier embodying the invention, the figure including a diagrammatic representation of external electrical connections for the operation of the rectifier; and

Figure 2 is a sectional view taken substantially along the lines 2—2 in Figure 1.

To illustrate the invention, there is shown on the drawing an electronic device comprising a rectifier 11, although the several features of the invention are not necessarily limited to rectifiers but may be utilized to advantage generally in electronic devices embodying means forming an electron emitting source.

The rectifier 11, as shown on the drawing, may comprise a sealed envelope 13 containing an anode 15 and a co-operating cathode 17. The envelope 13 may be formed of any suitable envelope material and may be arranged in any convenient or preferred form. As shown, the envelope may comprise a tubular glass shell having re-entrant necks 19 at the opposite ends of the shell, the anode 15 and cathode 17 being, respectively, supported on said necks at the opposite ends of the envelope. The necks 19 define openings which are closed by seal members 21 and 23 of generally cup-shaped configuration. These members preferably comprise sheet metal, and each has an annular rim which forms a glass-to-metal seal 25 with the inwardly facing end of the neck 19 on which the seal member is mounted to thus seal the end of the envelope.

The member 23, at one end of the envelope, carries the anode 15, which preferably comprises a cup-shaped element formed with a stem 26 which projects outwardly of the end of the envelope through an opening formed in the seal member 23, the stem 26 being sealed in said opening.

The member 21, at the other end of the envelope, carries the cathode 17 which, as shown, preferably comprises an electron emission filament.

The filament 17 is preferably supported in

position within and surrounded by the cup-shaped anode. The filament comprises a highly efficient electron emission source when electrically excited, and to this end, the filament comprises a suitable support element for thorium.

The electron emission filament 17 may be formed by mixing thorium in quantities of the order of 2% with tungsten, sintering the mixture, and then drawing it through a suitable die to produce a filamentary wire comprising tungsten with the thorium component substantially uniformly distributed in the filament. By operating the filament at high temperature, the thorium is driven to the surface of the filament to form a thorium film on the surfaces of the filament. The heating of the filament to form a thorium film thereon need not be accomplished until the filament has been assembled in the electron flow device and may be accomplished as a part of the process of conditioning the finished device for service. The process of thus conditioning the filament merely comprises the heating of the filament to a temperature of the order of 2900° Kelvin, somewhat below the melting temperature of tungsten.

A thoriated filament of the character herein described is characterized by the ability to emit effective electron quantities at a temperature substantially lower than the effective operating temperature of a pure tungsten filament. As a consequence, an electron flow device embodying a thoriated filament, in accordance with the teachings of the present invention, is capable of functioning at a lower temperature and hence at appreciably higher efficiency with substantially longer life than is the case with electron flow devices containing electron emission elements of the character heretofore known.

In order to aid in holding the thorium on the filament during the service life of the cathode and to thereby maintain the cathode as a highly efficient electron source, it is desirable to carbonize the filament in order to provide a surface coating of carbide, specifically a tungsten carbide layer, where the filament comprises tungsten, since the thorium has a greater affinity and will be held more securely on the filament by the carbide than on pure tungsten. To this end, the filament is preferably carbonized by heating it to a temperature of the order of 2,000 degrees centigrade in a hydrogen bottle or container in the presence of a carbonizing gas such as acetylene. In this fashion, a sheath of tungsten carbide may be applied to the surfaces of the filament to serve as a foundation for holding the thorium on the filament. The carbonizing process should be limited to the surfaces and should not penetrate completely to the center of the filament in order to avoid extreme brittleness. In performing the carbonizing process, the degree of carbonization may be determined by measuring the electrical resistance of the filament from time to time, the resistance of tungsten carbide being substantially higher than that of pure tungsten, so that a desired degree of carbonization may be readily determined by measuring the resistance of the filament being treated and by terminating carbonization when a predetermined resistance has been reached.

The cathode structure includes a disk-like head 43, preferably of metal, which head is mounted on a stud 45 extending in an opening formed in the seal member 21, the stud being sealed in said opening and having portions extending outwardly of the envelope. The head 43 carries a tubular skirt 47 secured at one end on the head and extending at the other end in position enclosing the glass-to-metal seal 25. The skirt thus encloses a space 49 between the seal member 21 and the head 43, which space is in open communication with the interior of the envelope 13 through the annular space defined between the end of the skirt 47 and the glass-to-metal seal 25. Within this space, means is provided for performing a gettering operation in order to insure the maintenance of a high degree of vacuum within the envelope.

The cathode comprises the filament 17 which, at one end, is mounted on, electrically connected to, and supported by a conductor stem 27 which extends through an opening 28 formed in the head 43. The end of the stem 27 is mounted on the seal member 21 which is formed with an opening fitted with a grommet 29 which receives the stem 27. The stem 27 is supported in and electrically insulated from the grommet and the seal member 21 by means of a globule of glass which supports the stem and seals the grommet opening around the stem. Outwardly of the grommet, the stem 27 is electrically connected to a conductor 31. The other end of the filament 17 is mechanically and electrically connected on a mounting member comprising a wire 33 which has a helically coiled portion 35 embracing the filament and a supporting portion 37 which is supported on and electrically insulated from the head 43 by means of a grommet 38 sealed in an opening in the head, the stem 37 being secured in place by a glass globule sealed in the grommet around the stem. Behind the head 43 the end of the stem 37 is electrically connected with a conductor 41 which extends through the seal member 21 at a grommet 39 therein in which grommet the conductor 41 is sealed by means of a glass sealing globule. The filament 17 thus is electrically connected with the conductors 31 and 41 which extend outwardly of the envelope, such connection being accomplished by way of the stems 27 and 37 which are electrically insulated from the head 43.

It should be understood, of course, that an electron flow device functions by the flow of electrons emitted at the cathode and traveling to and impinging upon the anode. When the flow device is constituted as a rectifier, the stream of electrons passing between the cathode and anode form a conduction path along which electrical current may flow in one direction only between the anode and cathode. This uni-directional flow phenomena is utilized for the purpose of rectifying alternating or fluctuating electrical energy in order to provide uni-directional electrical power.

For efficient operation of the electron flow device, the atmosphere within the envelope 13 is preferably maintained at pressures of the order of 0.02 micron of mercury, and the maintenance of low vacuum conditions is of particular importance where the electron flow device embodies a thoriated filament in accordance with the present invention. The operation of an electron flow device results in the ionization of any gas particles within the envelope with which an electron may collide during its travel between cathode and anode. Such a collision results in the production of a positively charged ion which may impinge upon the cathode filament and dislodge therefrom a particle of thorium. In order, therefore, to preserve the thorium in situ during an extended service life, it is necessary to reduce the

possibility of ionic impact on the cathode filament and consequent dislodgment of thorium by eliminating, as far as possible, the presence of gaseous matter within the envelope. To this end, means is provided for insuring high vacuum conditions within the envelope throughout the service life of the device. To this end, the envelope is first thoroughly evacuated as a part of the manufacture of the device, evacuation being accomplished after the parts of the device have been assembled and sealed in the envelope. During the evacuation of the envelope, which is preferably accomplished by attaching the same to a suitable exhaust means, such as an exhaust pump, the device and all of its operating parts are strongly heated in order to remove all impurities, including such gases as may be occluded in the anode, cathode and envelope walls. After the device has thus been exhausted to the greatest possible extent, the envelope may be sealed off and, as a final operation to remove all remaining impurities, a gettering operation is performed within the envelope. According to the present invention, gettering is accomplished by vaporizing a suitable gettering material within the envelope, more particularly within the space 49. Barium may be utilized as a gettering material, and by vaporizing the same within the envelope, all remaining impurities may be caused to unite with the barium vapor to form innocuous solid end products which, upon condensation of the gettering material, will become deposited within the envelope 13. By providing a head 43 and the skirt 47, the end products will be deposited upon the internal surfaces defining the gettering chamber 49 and thus will be prevented from depositing either upon the wall surfaces of the envelope 13 or upon working surfaces of the anode and cathode.

Barium or other suitable gettering material may be supported within the chamber 49 and evaporated therein by any suitable or preferred means. Preferably, however, the gettering material is supported by a carrier wire 51 electrically connected at one end on the stud 45 and at the other end of a conductor 53, the carrier wire 51 having portions intermediate the anchored ends thereof arranged in loops within the chamber 49. The conductor 53 extends through the seal member 21 and is sealed, as by means of a globule of glass, in a grommet 59 similar to the grommets 29 and 39 and, like them, sealed in the member 21. Outwardly of the envelope, the conductor 53 is electrically connected to a conductor 55.

The gettering material may be supported in any suitable or preferred fashion upon the carrier wire 51, which preferably is a hollow conductor wire enclosing the gettering material and having weakened wall portions. By passing electrical current through the wire 51, as by connecting a suitable electrical power source 57 between the stud 45 and the conductor 55 outwardly of the envelope, the hollow carrier wire 51 may be heated to thereby vaporize the gettering material carried by the wire, the material thus vaporized being projected outwardly of the wire through its weakened wall portions to perform the gettering operation within the chamber 49, resulting end products being deposited upon the inner walls of the head 43 and tubular skirt 47.

The gettering circuit between the stud 45 and the conductor 55, in addition to the power source 57, preferably includes a meter 61 for measuring current flow in the gettering circuit, an adjustable control rheostat 65, and a control switch 63 for regulating current flow in the gettering circuit for gettering control through regulation of vaporization of the gettering material in the chamber 49. It will be apparent, of course, that sufficient gettering material may be supplied within the chamber 49 to enable successive gettering operations to be performed within the envelope at intervals during the service life of the device to thereby periodically re-establish desired vacuum conditions within the envelope in the event that the vacuum be impaired during the operating life of the device.

The device of the present invention also includes means for testing and measuring vacuum conditions within the envelope from time to time by ionization gauge means, including the head 43 and skirt 47 which, it will be noted, are electrically connected on the stud 45 and otherwise insulated from the cathode and anode.

The degree of vacuum within the envelope 13 is a function of the number of gaseous particles present within the envelope, and the number of such particles, in turn, is a function of the degree of ionization developed as a result of collision between electrons emitted by the cathode with any such gas particles present within the envelope. By measuring the degree of ionization within the envelope resulting from a measurable electron flow between cathode and anode, it is possible accurately to determine the presence of gas particles within the envelope and thereby determine the vacuum condition at any time during the service life of the device. This may be accomplished by promoting a known electron flow between cathode and anode and then measuring the resulting ionization by collecting resulting positive ions on the head and skirt 43 and 47 and quantitatively measuring the ions thus collected. To this end, an ionization gauge circuit comprising a meter 67 and a power source 69 may be connected between either of the conductors 31 or 41 and the anode stem 26, preferably under the control of a switch 71 and an adjustable current flow regulating device, such as a rheostat 73. By adjusting the rheostat, a known electron flow, as indicated by the meter 67, may be established between the cathode and anode.

By applying a negative bias to the head 43 and skirt 47 with respect to the cathode 17, as by means of a power source 75 connected between one of the cathode leads 31 or 41 and the stud 45 which is electrically connected with the head 43 and the skirt 47, positive ions produced within the envelope will be caused to impinge upon the head 43 and skirt 47, the extent of such ionic impingement being accurately measurable upon the meter 77 which is included with the power source 75 in the biasing circuit between the stud 45 and the cathode 17. Whenever the meter 77 shows ionization above a predetermined minimum, it will be known that the desired vacuum condition within the envelope 13 has been impaired and that the device should be reconditioned by the performance of a gettering operation in order to recondition the device for operation at maximum efficiency.

It will be understood, of course, that the circuits shown in solid lines, namely, the ionization circuit including the meter 67, the ionization measuring circuit including the meter 77, and the gettering circuit including the meter 61, are connected with the device in the manner shown only when it is desired to measure vacuum conditions within the envelope 13 and recondition the device by the performance of a gettering

operation. When the device is in service, it may be connected in any preferred rectifier system. For example, the rectifier may ordinarily be connected as indicated in dotted lines, illustrating a filament transformer 79 connected to supply filament current through the filament conductors 31 and 41 and an alternating current power input transformer 81 connected between the anode 15 and cathode 17 through a unidirectional power outlet connection 83.

It is thought that the invention and its numerous attendant advantages will be fully understood from the foregoing description, and it is obvious that numerous changes may be made in the form, construction and arrangement of the several parts without departing from the spirit or scope of the invention, or sacrificing any of its attendant advantages, the form herein disclosed being a preferred embodiment for the purpose of illustrating the invention.

The invention is hereby claimed as follows:

1. An electron flow device comprising a sealed evacuated envelope containing an anode and a co-operating cathode comprising thorium on a suitable support, means forming an enclosure in communication with the space in said envelope, a supply of evaporable gettering material in said enclosure, means operable outwardly of the envelope for the controlled evaporation of said material within said enclosure, said enclosure serving as a collector in and on which the gettering material may condense after evaporation to thus prevent condensation of gettering material on the anode and cathode, said means forming the enclosure comprising electrical conducting material forming an ionization gauge plate in the envelope and electrically insulated from said anode and cathode, and means for connecting said plate in an ionization measurement circuit outwardly of the envelope.

2. An electron flow device comprising a sealed evacuated envelope containing an anode and a co-operating cathode comprising thorium on a suitable support, and means for measuring ionization within the envelope to determine the evacuated condition therein comprising conductor means forming an ionization gauge plate in the envelope in position to collect positively charged ions produced by electron flow between anode and cathode, said plate being insulated from said anode and cathode, and means for connecting the plate in an external electric circuit for the quantitative measurement of ions collected thereon.

3. A high voltage, high vacuum electronic rectifier comprising a sealed evacuated envelope, an anode and a cooperating cathode in said envelope, said cathode comprising support means and thorium carried thereon, selectively operable gettering means in said envelope comprising an enclosure and a supply of evaporable metallic material sealed in said enclosure, said enclosure having a weakened wall portion rupturable upon predetermined expansion of the material therein, and means connected with said enclosure and operable outwardly of said envelope to cause the material to expand within the enclosure to rupture said wall portion and at intervals thereafter to evaporate the material in the envelope to maintain high vacuum conditions within the envelope and thereby preserve the thorium in situ on the support means.

ZED J. ATLEE.
ROBERT F. WILSON.