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THERMIONIC EMITTING DEVICE

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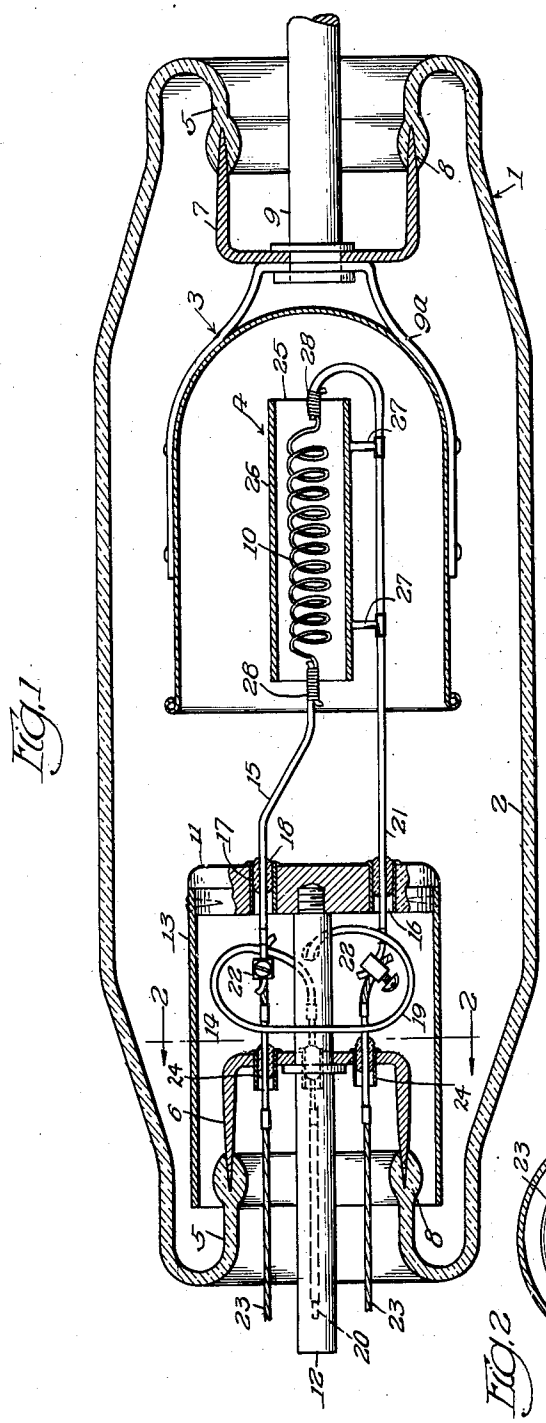


FIG. 1

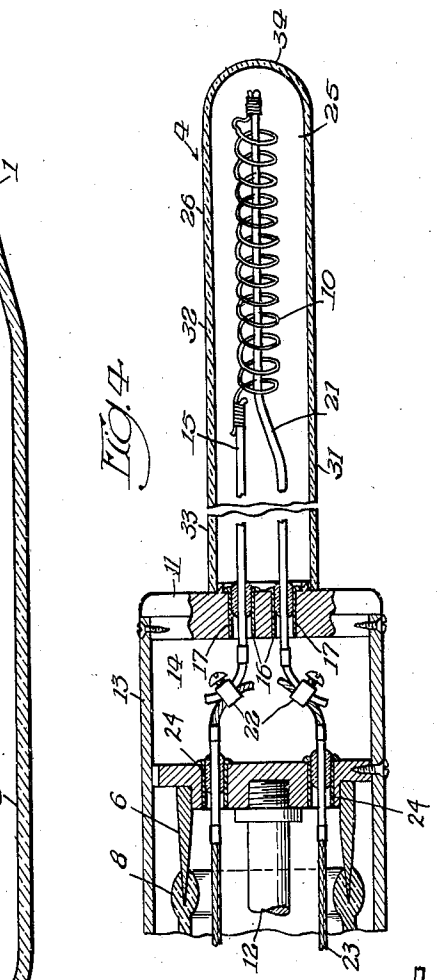


FIG. 4

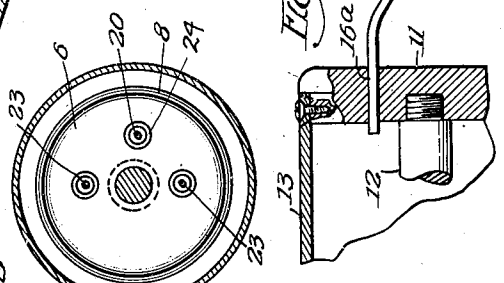


FIG. 3

FIG. 2

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THERMIONIC EMITTING DEVICE

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1 Claim. (Cl. 250—27.5)

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This invention relates to electronics in general, and particularly to electron flow devices, such as electronic rectifiers, X-ray tubes, radio tubes, and such other devices as employ electron emitting elements.

An important object of the invention is the provision of a new and improved electron emission element adapted to be heated for electron emission at a relatively low temperature; a further object being to use columbium for electron emission.

Another object of the invention is the provision, in an electron flow device, of an electron emission element comprising columbium supported on a suitable structure such as tungsten, molybdenum, or other high melting point material.

Another object of the invention is the provision of a columbium emitter indirectly heated, as by means of a suitable electrically energized filament, whereby electron emission is obtained at low operating temperatures well below the normal operating temperature of a conventional tungsten electron emitting filament, thereby rendering indefinite life to the tube; also, the heating of the anode is more uniform and the efficiency of the device is greatly enhanced.

Another object of the invention is the provision of an electron emitter made of columbium, either in the form of a strip, coil, tube or other wire; a further object being to form the emitter as a support member of material having a high melting point and having a coating of columbium forming an emitting surface.

A further object is to provide an electron flow device including an anode and a columbium electron emitting element so constructed and arranged that it will shield a co-operating heater filament to thus protect the filament from the electrostatic force between it and the anode without creating an undue space charge with respect to the anode, to make possible a relatively large uniform emitting surface of the cathode, to permit the proper and ideal design of the cathode from the standpoint of high voltage stresses, to make possible greater electronic emission for a given amount of heater or filament wattage, as well as to provide for greater efficiency in general and more rugged construction.

A still further object is the provision of an improved electron emitting element in the form of a cylindrical member having a columbium emitting surface.

Still another object of the invention is to form an electron emitting element of columbium, and

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further that the thermionic emitting temperature of columbium is substantially 1700° to 1900° Kelvin, being considerably lower than tungsten and tantalum, the two pure metallic thermionic emitters heretofore generally employed.

Numerous other objects and advantages will be apparent throughout the following specification.

The accompanying drawing illustrates a selected embodiment of the invention, and the views therein are as follows:

Fig. 1 is a sectional view taken longitudinally through an electronic rectifier embodying the invention;

Fig. 2 is a sectional view on the line 2—2 of Fig. 1;

Fig. 3 is a fragmentary sectional view showing a modified arrangement of filament mounting; and

Fig. 4 is a detail sectional view of a modified cathode structure in which the columbium emitter is substantially elongated to provide a gettering or gas absorbing effect.

To illustrate the invention, the drawings show an electron flow device 1 embodying an anode 3 and a cathode 4 enclosed in a sealed envelope 2, suitable conductor means being provided for connecting the anode and cathode in electrical operating circuits externally of the envelope. While the invention is not limited to the shape of the anode, the same is shown as a hollow cup-shaped element enclosing the electron emitting portions of the cathode.

The electron emitting portion of the cathode comprises columbium which functions to emit electrons at a temperature of 1700° to 1900° Kelvin. This is substantially below the temperature at which tungsten and tantalum emit electrons so that devices embodying my present invention avoid the disadvantages inherent to devices embodying conventional emitters.

The columbium emitter element of my present invention may comprise an element of pure metal, or the element may comprise a support of metal, such as tungsten or molybdenum, having a high melting point, the support being coated with columbium to form the electron emitting surface thereof.

The emitting element, however formed, may be heated for electron emission either by direct application of electric power to the element or by mounting the element in position to be heated indirectly by suitable heating means. Where it is desired to heat the emitting element by direct electrical action, the same may be

formed either as a coil, wire or strip of pure columbium, or of other metal coated with columbium, and means may be provided to connect the element with a suitable electrical power source. Where the element is heated by indirect action, it may be operatively associated with a suitable heater. To this end, the emitting element may comprise a coil inductively associated with an induction coil or may be formed as a plate, strip or shell in heat exchange relation with respect to a heater, preferably an electrically energized coil or filament of metal such as tungsten.

The particular structure herein shown for the purpose of illustrating the invention comprises an electronic device in the form of a rectifier tube 1, although the several features of the invention are not limited to rectifiers but may be utilized to advantage generally in electron flow devices, including X-ray tubes, radio tubes, and such other devices where thermionic emission is desired from a pure metallic source.

The rectifier tube 1, as shown in the drawing, comprises a sealed envelope 2 of suitable material, such as glass or metal, glass being specifically shown in the drawing. The envelope 2 contains the anode 3 and the co-operating cathode 4. The envelope 2 may be arranged in any convenient or preferred form, but is shown in the drawing as being a tubular glass shell having re-entrant necks 5 at opposite ends of the shell. The anode 3 and the cathode 4 are respectively supported on the said necks at the opposite ends of the envelope in any suitable fashion, although I prefer to employ supporting and sealing means of the sort shown in my previous U. S. Patents Nos. 2,250,323 and 2,336,769, respectively issued July 22, 1941 and December 14, 1943. In this connection, the necks 5 define openings which are closed by seal members 6 and 7 of generally cup-shaped configuration. These seal members 6 and 7 are preferably made of sheet metal. Each of said members 6 and 7 has an annular rim which forms a glass-to-metal seal 8 with the inwardly facing end of the neck 5 on which the seal member is mounted, to thus seal the end of the envelope.

The seal member 7, at one end of the envelope, carries the anode 3, which preferably comprises a cup-shaped element formed with a stem 9 which projects outwardly of the end of the envelope through an opening formed in the seal member 7, the stem 9 being sealed in said opening and carrying a bracket 9a, within the envelope, on which the cup-shaped anode element is mounted, as by rivets or other fastening.

The seal member 6, at the other end of the envelope, carries the cathode 4 which, as shown, preferably comprises an electron emission element suitably mounted on support means carried by the seal member 6.

According to the present invention, the electron emission element comprises columbium and is preferably supported in position within and surrounded by the cup-shaped anode 3. The columbium emission element may be formed as a filament for direct connection in an electrical heating circuit or may be formed as a separate element and heated to a proper electron emitting temperature by a heater element 10 which is preferably made of tungsten.

The cathode structure 4, as shown in Fig. 1, may be mounted and sealed on the envelope by means of a support and sealing structure of the sort shown in my U. S. Patent No. 2,250,323, such structure comprising a disk-like head 11, preferably of metal, which head is mounted on a stud 12 extending in an opening formed in the seal member 6, the stud being sealed in said opening and having portions extending outwardly of the envelope. The head 11 carries a tubular skirt 13 secured at one end on the head and extending at the other end in position enclosing the glass-to-metal seal 8. The skirt thus encloses a space 14 between the seal member 6 and the head 11, which space is in open communication with the interior of the envelope 2 through the annular space defined between the end of the skirt 13 and the glass-to-metal seal 8. Within this space, means may be provided for performing a gettering operation during the fabrication of the tube in order to insure the maintenance of a high degree of vacuum within the envelope. This operation is accomplished by means of a loop of gettering wire 19 in the space 14, said wire being connected at one end to the stud 12 and at the other end to a conductor 20 which extends outwardly of the envelope through a suitable seal in the member 6. By applying electric potential between the wire 20 and an extension of the stud 12, outwardly of the envelope, the gettering wire may be energized to perform its gettering function within the envelope.

The opposite ends of the filament 10 may be mounted on, electrically connected to, and supported by conductor stems 15 and 21 which extend through openings 16 formed in the head 11. The ends of the stems may be mounted on and insulated from the head by fitting the openings 16 with grommets 17 which receive the stems 15 and 21 and which, in turn, are sealed in the openings as by welding or brazing. The stems are supported in and electrically insulated from the grommets and the head 11 by means of globules of glass 18, which support the stems in the grommet and seal the grommet opening around the stems. Within the space 14, the ends of the stems 15 and 21 are electrically connected, as by clamps 22, with conductors 23 which extend through openings in the seal member 6, said openings being provided with grommets 24, like the grommets 17, in which the conductors 23 are sealed by means of glass globules similar to the globules 18, all as taught in my aforesaid U. S. Patent No. 2,250,323. The filament 10 thus is electrically connected with the conductors 23 which extend outwardly of the envelope, such connection being accomplished by way of the stems 15 and 21 which are electrically insulated from the head 11.

The filament 10, which is the heater for the cathode 4, may be made of columbium and thus form an electron emitter in accordance with the present invention, or the filament may comprise tungsten coated with columbium as an emitter. However, the filament may be used merely as a heater element enclosed or encased within a cylindrical tube 25 made of columbium, or of other metal coated with columbium. In either case, the tube 25 will have a columbium surface 26 for emitting electrons. The columbium cathode emitter 25 is thus arranged to be indirectly heated by the heater which, in such case, may be made of tungsten or other suitable material. While the drawings disclose the use of a tubular or cylindrical columbium emitter 25, it is of course understood that the emitter may be of any suitable size and shape for the purpose intended; and the emitter may be supported on the head 11 in any suitable or convenient fashion, as by mounting it on support brackets 27 carried by one or other of the stems 15 and 21.

The use of columbium for electron emission indirectly heated by the tungsten filament 10 produces results greatly superior to any conventional electron emission material, and the operating temperature of a device embodying the invention is considerably below that of like devices employing other emission materials and still produces greater efficiency and effectiveness. Temperatures of 1700° to 1900° Kelvin obtain emission which is more than adequate for various applications, and the temperature of the tungsten heater filament is well below the normal operating temperature of tungsten. The use of columbium as a cathode emitter does not produce high space charges in the tube itself and still protects the filament to prevent the formation of any substantial electrostatic force between the filament and the anode. The heating of the anode is uniform whereby localized melting of the anode is overcome. In addition, low filament current eliminates the burning out of the filament. Moreover, the cathode emission per watt of filament consumption is very great. In addition, the thermionic emitting device, as herein disclosed and comprising the columbium tube or equivalent columbium structure, makes possible a large uniform emitting surface of the cathode, as well as making it possible for the proper design of a cathode from the standpoint of high voltage stresses. Also, the use of columbium has the further advantage in that it can be formed more easily than tungsten, tantalum, or other emission materials. The thermionic emitting temperature is approximately 600° Kelvin lower than tungsten, and thereby prolongs the life of the filament and the cathode emitter itself. Columbium makes possible more emission for a given heater or filament wattage.

The tubular emitter 25 is preferably arranged concentrically about the tungsten filament 10 and may be supported in position by molybdenum ribbons 27 welded or otherwise secured to the outside of the tube 25 and to the upstanding support stem 21. The filament 10 is connected at its upper end to the stem 21, and at its lower end to the stem 15, preferably by wrappings of 5 mil (.005 inch) molybdenum wire, as indicated at 28 in the drawing. The construction is such that the columbium tube is rigidly supported and is so arranged with respect to the filament that there will be no obstruction to the emission of electrons. It will be seen that the cathode emitter 25 is electrically connected with one of the conductors 23, outwardly of the envelope, through the support stem and the molybdenum ribbons 27.

An electron flow device functions by the flow of electrons emitted from 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.

The columbium emitter 25, regardless of its shape or where its operative position may be, is capable of electron emission by indirect heat radiation or by electron bombardment through a difference in potential between the filament and the columbium. Also, the emission from the columbium may occur by the electronic bombardment plus radiant heat from the filament to the columbium emitter.

For tungsten filament 10 may be substituted a filament or heater made of columbium, and such columbium filament may be in the form of a helix, as shown, with respect to the tungsten, or the columbium filament may be a tube or a strip or it may assume any shape proper to perform the function intended. The columbium emitter as herein disclosed may be indirectly heated by co-operation with a separate heating filament, or may be heated directly by making the heater or filament itself of columbium.

In some applications, as indicated in Fig. 3, it may be desirable to ground one or other of the stems 15 or 21 on the head 11 instead of mounting them both in insulating grommets. This may be accomplished by press-fitting the stem to be grounded in an opening or socket 16a, in the head 11, as taught in my U. S. Patent No. 2,250,323, in which case one of the connection conductors 23 may be eliminated and connection with the grounded stem accomplished through the support stem 12, outwardly of the envelope. At least one stem, however, must be insulated from the head and end seal. Where one of the stems is grounded, the emitter 25 may be connected either to the grounded or to the insulated stem, but if connected to the insulated stem, the emitter also must be insulated from the head 11.

As shown in Fig. 4, the columbium emitter 25 may be provided with an integral elongated lower end 31 extending considerably below the bottom end of the filament 10. The part of the emitter above the projection or elongation may attain a temperature range of between 1700° and 1900° Kelvin during operation. However, the temperature range of the projection or elongation may vary from 1700° Kelvin at the upper end 32 of the elongation 31 to about 600° Kelvin at the lower end 33 thereof. The elongation 31 acts continuously as a getter preventing the formation of gaseous matter within the envelope. The use of columbium, therefore, not only acts as a greatly improved emission element, but when extended, as shown in Fig.4, the elongation 31 acts as a gas absorber, eliminating gaseous material within the envelope. In this embodiment, the lower end of the tube may be supported on the head 11 and thus electrically connected thereto, in which case electrical connection with the emitter may be had outwardly of the envelope through the stem 12 and its extension. To this end, it is desirable to employ a modified cathode support structure of the sort shown in my U. S. Patent No. 2,336,769, in which the head 11 is supported on and electrically connected with the seal member 6 by the skirt 13 instead of by the extension of the stem 12 inwardly of the seal member. Elimination of the inwardly extending portion of the stem 12 allows for supporting the stems 15 and 21 centrally on the head 11. Alternately, the tube 25 may be supported on the head by suitable insulating means, in which case electrical connection of the emitter may be had outwardly of the envelope by connecting the tube 25 with one or other of the stems 15 or 20.

The tube 25 also may be formed with a closed top 34 whereby the filament is entirely enclosed within the tube and thus completely shielded from electrostatic forces that otherwise might prevail between the anode and filament when the device is in operation.

The invention provides an extremely efficient thermionic emitting device for use in connection

with rectifying tubes, X-ray tubes, radio transmitting tubes, and other vacuum tubes where pure thermionic emission is desired. The construction is such that the filament is properly located and supported without any obstructions, as is the case where a spiral support is provided for the filament. Moreover, the use of a columbium cathode emitter, indirectly heated by a tungsten filament, or by making the filament of columbium for direct emission, permits lower operating temperatures well below the normal operating temperature of tungsten, thereby rendering indefinite life to the tube. The heating of the anode is uniform, and the efficiency of the device is greatly enhanced. The use of the columbium as herein disclosed also acts as a getter in that gases within the envelope are absorbed or eliminated.

Changes may be made in the form, construction and arrangement of the parts without departing from the spirit of the invention, and the right is hereby reserved to make all such changes as fairly fall within the scope of the following claim.

The invention is hereby claimed as follows:

An electron flow device comprising an enclosing envelope, a cathode emitter having a columbium surface arranged inside of said envelope, a filament heater arranged adjacent said surface and indirectly heating said surface, a conductor stem for the filament, and getter means of columbium on the emitter extending below the end of the filament a predetermined distance and acting as a getter.

ZED J. ATLEE.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,607,467	Latour	Nov. 16, 1926
1,972,162	Parott	Sept. 4, 1934
2,362,468	Clark	Nov. 14, 1944

FOREIGN PATENTS

Number	Country	Date
135,878	Switzerland	Jan. 16, 1930
277,997	Great Britain	Sept. 23, 1926
563,148	Germany	May 18, 1930