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[54] **GLOW CATHODE**

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[51] **Int. Cl.** **H01j 1/14,** H01j 19/06

[58] **Field of Search** 313/346, 62, 209, 210, 313/211, 346, 189

[56] **References Cited**

UNITED STATES PATENTS

2,972,078	2/1961	Levi	313/346 R
3,270,239	8/1966	Lozier et al.	313/346 R
3,732,454	5/1973	Okagaki et al.	313/346 R

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[57] **ABSTRACT**

An improved glow cathode for use as an ion source for cyclotrons is provided wherein the electron-emitting means is formed as a pill or button of a high melting point metal or metal carbide which is supported in a mounting of a highly refractory, substantially infusible material having a high electron work function. Preferably, the electron-emitting button is formed as a cylinder of tungsten and the mounting is formed of graphite. This device can be operated at a gas pressure of approximately 0.2 to 0.5 Torr and a heating voltage of 100 to 200 volts to provide deuterium or hydrogen ions for a cyclotron.

12 Claims, 2 Drawing Figures

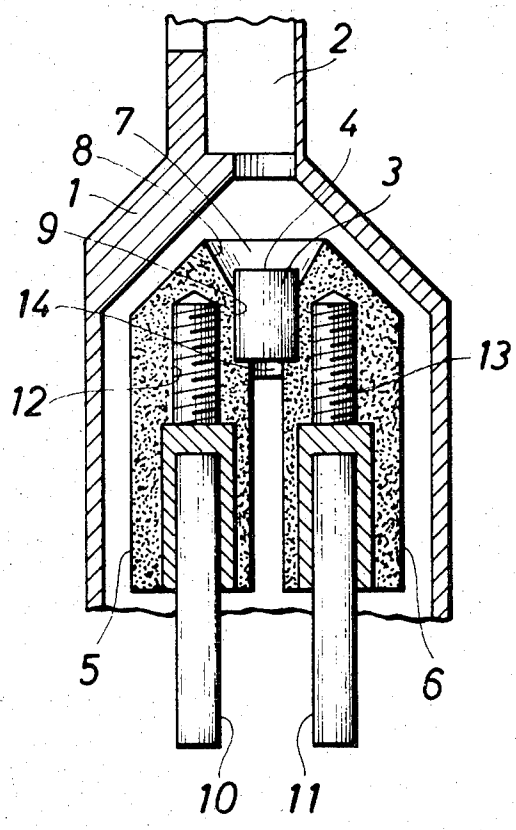


Fig.1

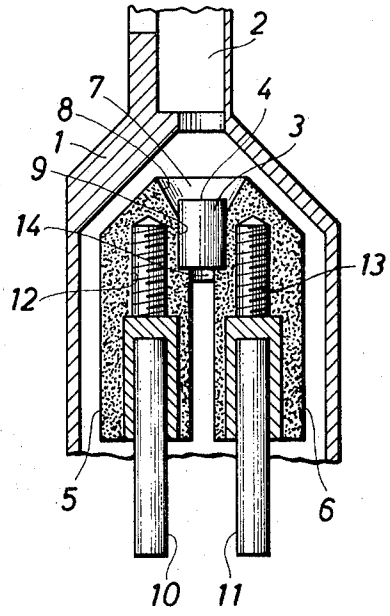
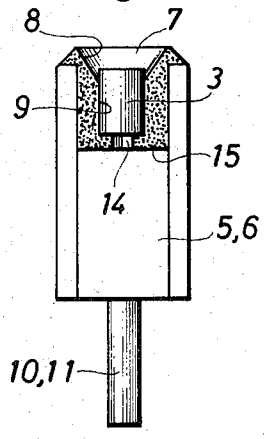


Fig.2



GLOW CATHODE

The present invention relates to a glow cathode with a current input and output and to the use of such a glow cathode.

BACKGROUND OF THE INVENTION

Ion sources are known for cyclotrons which are all based on the ion source developed by Livingston and Jones (*The Review of Scientific Instruments*, Volume 25, Number 6, June 1954, pages 252–557). In one of these ion sources, a tungsten wire bar heated with 100 to 300 amperes direct current serves as the glow cathode. At a predetermined voltage, a low pressure gas discharge burns at a low gas pressure (e.g. 10^{-2} Torr deuterium gas) between the glow cathode and the burn chamber which is formed of graphite. The discharge plasma is constricted by a strong magnetic field which is disposed in the plane of the tungsten wire bar or in a plane parallel thereto to form a more or less precisely defined column between the glow cathode and a reflector for electrons which is insulated from the burn chamber. The reflector is negatively charged during operation. The ions are extracted transversely to the magnetic field through a slit in the burn chamber by a high frequency voltage at an acceleration sector.

Such ion sources furnish beam currents up to 100 μA ($1\mu A = 1$ micro amps) deuterons — when deuterium gas is used for the low pressure gas discharge — and have a maximum life of 0.5 to 1.0 mAh ($1\ mAh = 1 \times 10^{-3}$ Ampere hours). An increase in the ion yield through an increase in the heating of the glow cathode of the ion source, or of the gas pressure in the burn chamber or of the discharge voltages is secured only at the expense of an even shorter life for the ion source. Moreover, the relatively large area of the tungsten wire bar as the emission surface for the electrons and the area of the reflector prevent an increase in the electron density in the discharge plasma, make a perfect congruence in the centering more difficult and permit no further approximation of the reflector and the glow cathode due to the mechanical constriction in the burn chamber of the ion source in the area of the slit for taking off the ions. Also, the tungsten wire bars are not resistant against ion bombardment and are not stable enough against transverse magnetic forces.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a glow cathode in which only a predetermined fixed portion emits electrons and in which the direct vicinity, at least, of the emitting portion is resistant to magnetic forces even at high temperatures, so that it does not bend or deform and does not furnish a significant part of the electron emission.

It is a further object of this invention to provide a glow cathode in which the electron-emitting means is in the form of a button or pill of a metal or metal carbide having a high melting point and a support for the electron-emitting means composed of a highly refractory, substantially infusible material having a high electron work function.

These and other objects will be apparent to workers in this art from the following detailed description and the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. **1** is a sectional view of a preferred embodiment of the present invention.

FIG. **2** is a sectional view of a detail.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Improvement in ion yield, electron density in the discharge plasma, ion emitter life and stability against transverse magnetic forces and other objects of this invention are achieved by providing the electron-emitting portion of the glow cathode in the form of a pill or button of a high melting point metal or metal carbide and a mounting therefor of a highly refractive, substantially infusible material with a high electron work function.

For the emitter, any of the metals or metal carbides which are used in known electron sources may be used, but tungsten is preferred. Similarly, graphite is preferred as the mounting material in electrical contact with the electron emitter of this invention, but other materials having the indicated physical and electrical properties may be used.

The present invention is disclosed in further detail in the following description and the accompanying drawing, wherein FIG. **1** is a vertical view, partly in section, of an electron source embodying this invention, and FIG. **2** is another vertical view, also partly in section, of the emitter and mounting means of this invention.

In a preferred embodiment of the invention, the mounting for the emitter means is more-or-less in the form of an inverted "U" with the upper, arcuate connecting portion having a cross section of lesser area than that of the lower depending arms.

Referring now to the drawing, FIG. **1** shows the lower portion of an ion source for an isochron cyclotron (not shown) in which, by a low pressure gas discharge of approximately 0.2 to 0.5 Torr, deuterium or hydrogen ions are produced in the throat **2** of a burn chamber **1.** The discharge burns between emitter means **3** and a reflector (not shown) in the throat **2** at a heating voltage between 100 and 200 volts. Between the glow cathode **3** and the throat **2,** the discharge plasma is disposed which is constricted to a precisely defined column by a strong magnetic field of approximately 10 kG ($1\ kG = 10^3$ gauss). The magnetic field is disposed in or parallel to the sectional plane of the illustrated device. The ions produced in the discharge plasma are extracted by a high frequency voltage (approximately 40 kV and 33 MHz) ($1\ MHz = 1MC/s$) in an acceleration sector (not shown) in a direction transversely to the magnetic field through a slit (also not shown) in the wall of the burn chamber throat **2.** In order to obtain a particularly high yield of electrons from the emitter **3,** it must be brought as closely as possible to the throat portion **2** of the burn chamber. To meet this requirement, the glow cathode **3** can be designed as a pill or button, which may be rectangular or cylindrical with straight or tapering sides, and is heated by a direct current of 100 to 300 amperes. This strong direct current heats the emitter **3** in such a way that with an arc voltage of approximately 200 V an arc current of 1.5 ampere can flow for the discharge plasma, resulting in an arc output of **300** watt.

In order to keep the discharge stable, the electron source must be locally stable. When the electrical conductors in contact with the glow cathode are of metal

this local stability cannot be maintained because the burning spot or the emission surface, respectively, of the electrons would be formed by the tip **4** of the emitter **3** as well as by the surface portions of the conductive arms **5** and **6** directly enclosing the emitter means. In order to prevent this almost completely, the electron emitter **3**, which may be made of a metal or a metal carbide such as, for example, tungston hafnium carbide, zirconium carbide, molybdenum carbide, or an alloy of these carbides, is mounted in conductive elements **5** and **6** which consist of a highly refractory, substantially infusible material with a high electron work function. This is preferably graphite.

The current conductors **5** and **6** form the arms of a U-shaped device, and each has a cross section larger than that of the arcuate connecting portion **7**, so that in this region the resistance to the heating current for the emitter means **3** is increased. Portion **7** is provided with a bore **8** which is conically tapered, flaring outwardly at its upper region and terminating at its lower region in a recess **9** of reduced cross section with such dimensions as to at least partially enclose the pill **3** and retain it snugly. If desired, bore **8** can be so designed that the tip **4** of the emitter means will extend beyond the surface of portion **7**. The material of portion **7** which contacts the pill **3** must be such that the two do not react chemically.

The arms **5** and **6** of the retaining means, each of which may be made of a single piece of graphite in the same manner as the curved portion **7** are provided, respectively, with leads **10** and **11** which serve as connections to the source of current for operating the device. In a preferred embodiment, these leads **10** and **11** are designed in the form of rods which are inserted into recesses **12** and **13** in the arms **5** and **6**, and are retained therein threadedly, frictionally, or in any other conventional manner out of contact with the electron emitter button **3**, as it may be observed in FIG. **1**.

FIG. **2** is a vertical view of the glow cathode transversely of the arc **7** of the mounting means. The cross section of the arcuate retainer **7** is less, at least in the region **9** containing the pill or button **3** therein, than the cross section of the arms **5** or **6**. In order to readily remove emitter **3** from recess **9** when unserviceable for replacement with a new unit, a bore **14** is preferably worked in the underside **15** of the arcuate portion **7** of the mounting means, through which a pin may be inserted to eject the spent pill out of recess **9**.

The leads **10** and **11** for arms **5** and **6** of the bar may be made of tungsten or another conductive material with a high melting point, and may have a surface layer of another substance, for example tantalum, on the portions within the arms **5** and **6**, which can be easily worked so as to provide retaining means, such as a screw thread, for example. By thus placing the leads **10** and **11** within the arms **5** and **6** the leads also provide reinforcement for their respective arms so that they will not be bent by strong extraneous magnetic fields.

It will be understood that the above description of the present invention is susceptible to various modifications, changes and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

I claim:

1. Glow cathode comprising:

a. an electron emitter of button shape, made of a metal or metal carbide having a high melting point;

b. an electrically conductive mounting made of a highly refractory, substantially infusible material having a high electron work function, said electron emitter being held by said mounting; and

c. lead wire means in contact with said mounting and out of contact with said electron emitter for passing an electric current through said electron emitter for heating the same.

2. Glow cathod as defined in claim **1** wherein the material of said mounting is graphite.

3. Glow cathode as defined in claim **1** wherein the mounting has a substantially U-shaped configuration including a connecting portion and arms, the connecting portion has a smaller cross-sectional area than that of the arms.

4. Glow cathode as defined in claim **3**, said connecting portion of said mounting including means for holding said electron emitter.

5. Glow cathode as defined in claim **3**, including means defining a bore in said connecting portion of said mounting, said electron emitter being disposed in, and held by said bore for at least partially embedding said electron emitter.

6. Glow cathode as defined in claim **3**, wherein the arms of the U-shaped mounting receive said lead wire means.

7. Glow cathode as defined in claim **5** wherein the bore is conically tapered outwardly with the inner portion forming a recess substantially conforming to the shape and size of the electron emitter for holding the same.

8. Glow cathode as defined in claim **7** wherein the depth of the recess is less than the height of the electron emitter.

9. Glow cathode as defined in claim **1** wherein the electron emitter is in the form of a cylinder made of, hafnium carbide, zirconium carbide, molybdenum carbide or alloy of these carbides.

10. Use of the glow cathode as defined in claim **1** as the electron source for the ion source of a cyclotron.

11. Glow cathode as defined in claim **1** wherein the electron emitter is in the form of a tungsten cylinder.

12. Glow cathode as defined in claim **1** wherein said lead wire means have end portions embedded in said mounting.

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