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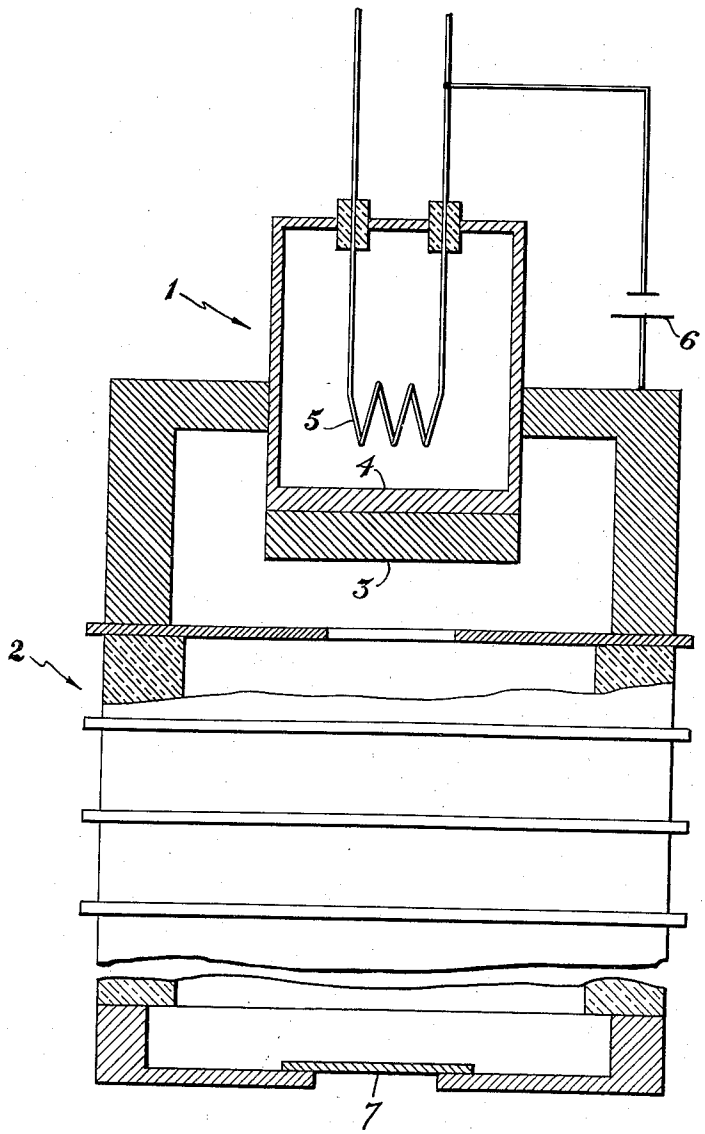

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SEALED-OFF DIODE WITH ELECTRON EMITTING ANODE

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This invention relates to electron emitters and in particular to an electron emitter comprising a sealed-off diode of which the anode is adapted to emit electrons in response to bombardment by electrons from the cathode thereof. The electron emitter of the invention is designed to be used in devices where an electron emitter may be subject to chemical attack as a result of adverse vacuum conditions or where the electron emitter may be subject to positive ion bombardment. The invention may therefore be used as part of an electronic tube such as a klystron or a gas-focused cathode ray tube or a gas discharge tube. The invention is particularly useful as part of an electron acceleration tube for electron-processing work, and, accordingly, in the following detailed description thereof, the invention will be described with particular reference to its use in such an electron accelerator. However, it is clearly to be understood that the invention is not limited to use in such accelerators.

Electron accelerators are becoming increasingly useful for irradiation of materials in radiation chemistry and in the sterilization or preservation of foods and drugs. In such accelerators electrons are accelerated to high energy in an evacuated region and then released through an electron window into the atmosphere for the irradiation of various materials. One of the problems associated with such accelerators is the construction of the electron emitter. In the first place, under adverse vacuum conditions which necessarily occur from time to time in electron acceleration devices for electron processing, the selection of materials for the electron emitter is limited. In general, those emitters which can be made in filamentary form are generally degraded by adverse vacuum conditions. Such materials include tungsten, tantalum, thoriated tungsten, etc.; and the effect of adverse vacuum conditions is to subject these materials to chemical attack. Materials which can withstand the adverse conditions better cannot be made successfully in filamentary form. Such materials include lanthanum boride, molybdenum thoria, etc. In the second place, because all materials are to some extent eroded by back ion bombardment occurring in high voltage electron acceleration tubes, it is advisable to make the cathode of heavy section.

The electron-emitter of the invention comprehends a sealed-off diode in which the anode emits electrons externally of the sealed-off enclosure in response to electron bombardment thereof from the cathode of the diode. The cathode of the diode is thus shielded from positive ion bombardment; and, since the diode is enclosed, the cathode thereof is protected against corrosive chemical attack. Moreover, a favorable selection of materials may be made for the cathode and the anode. The cathode filament may comprise a material having an extremely low work function, such as barium oxide coated materials. On the other hand, the emitting surface of the anode may be selected for best resistance to chemical and ion attack, which is not possible for materials

in filamentary form. Appropriate materials for the emitting surface of the anode include lanthanum boride and, as a special case, irridium, which is difficult to fabricate in filamentary form but which is not adversely affected by air. This characteristic of irridium is advantageous in the event of implosion of the electron window of the electron accelerator, because the resulting admission of the atmosphere to the cathode causes an ordinary electron emitter to be completely destroyed. One of the effects of the chemical and ion attacks upon a filamentary emitter is to cause it to be decreased in cross section at the spot attacked. When the cross section is reduced to 80 or 90% of its original value, a hot spot is formed and the rate of deterioration at that spot increases very rapidly. By using the diode of the invention, it is the thickness of the anode emitter which is reduced, through which a current of only 5 milliamperes flows, rather than the thickness of the filamentary cathode, through which a current of 50 amperes flows. Moreover, the filament is further protected by the fact that the diode is sealed off.

The invention may best be understood from the following detailed description thereof having reference to the accompanying drawing in which:

The single figure shows a portion of an electron acceleration tube having an electron emitter constructed in accordance with the invention.

Referring to the drawing, a sealed-off diode 1 is hermetically sealed at the cathode end of an evacuated electron acceleration tube 2. Said electron acceleration tube 2 may be an acceleration tube suitable for use in electron processing machines such as that disclosed in U.S. Patent No. 2,722,620. By the term "sealed-off" I mean that the diode 1 is sealed off from the region in which the electrons are emitted by the eletron-emitting anode of the diode. The diode 1 is shown as being sealed-off from the atmosphere also, but in the alternative it might be pumped by a getter-ion pump or other suitable pump. At least part of the anode of the diode 1 is made preferably of some low-work-function material which will emit in the presence of contaminating gases and vapors. In the device shown in the drawing, the anode of the diode 1 comprises an electron-emitting portion 3 such as lanthanum boride and a second portion 4 which is adapted to withstand bombardment such as carbon. Alternatively the entire anode 3, 4 may be of electron-emitting material, such as tungsten, tantalum, or iridium. Said anode 3, 4 is heated by electron bombardment from the cathode of the diode 1, which may be a filament 5 or other type of cathode, which is not exposed to the contaminating gases and vapors of the acceleration tube 2. Electron bombardment of the anode 3, 4 of the diode 1 is produced in the conventional manner by a power supply 6 electrically connected to the cathode 5 and the anode 3, 4. Said power supply 6 may be either D.C., as shown in the drawing, or A.C.

When filamentary emitters are employed, it is difficult to design good electron optical systems. By using the emitter of the invention, one can use good ion optics because there is no limitation on the shape of the cathode surface. Appropriate shaping of electron emitters is well known in the art and is disclosed, for example, in Theory and Design of Electron Beams by J. R. Pierce (1954), D. Van Nostrand Company, Inc., Chapter X, "Electron Guns," pp. 173–193. Moreover, an emitter constructed in accordance with the invention may readily be adapted to the elongated electron emitter disclosed in a co-pending application assigned to the assignee of the present application, Serial No. 594,243, filed June 27, 1956, now abandoned.

It will be appreciated that the electron emitter of the invention is capable of providing a relatively large sur-

face area. This particular feature may be useful in some applications, but it is not necessary to the invention. In fact, a large emitting surface area is not particularly significant in most present-day electron processing, where currents of the order of 30 milliamperes are involved, compared with the 300 amperes used in klystrons.

As stated hereinbefore, the electron emitter of the invention is capable of holding up under adverse vacuum conditions since the electron-emitting surface 3 is constructed of material which is adapted to adverse vacuum conditions, whereas the filament 5 or other cathode emitter of the diode 1 is effectively sheltered from adverse vacuum conditions. By choice of a proper material, such as iridium, for the electron-emitting surface 3, the electron-emitter of the invention can even be operated in air. Such a device would provide protection of the electron-emitter in the event of implosion of the electron window 7 of the main acceleration tube 2.

Having thus described the principles of the invention together with an illustrative embodiment thereof, it is to be understood that although specific terms are employed, they are used in a generic and descriptive sense and not for purposes of limitation, the scope of the invention being set forth in the following claims:

I claim:

1. Apparatus for the irradiation of materials in processing work comprising in combination an elongated evacuated electron acceleration tube having an electron window at one extremity thereof and an electron emitter at the opposite extremity thereof for the emission of electrons into the evacuated region bounded by said electron acceleration tube, said electron emitter comprising a diode having a cathode, an anode and an enclosure hermetically sealed off from said region and surrounding said cathode, said cathode being adapted to bombard said anode with electrons and said anode having a surface transverse to the longitudinal axis of said electron acceleration tube which surface is adapted to emit electrons into said region in response to electron bombardment of said anode from said cathode.

2. Apparatus in accordance with claim 1 wherein the electron emitting surface of said anode comprises lanthanum boride.

3. Apparatus in accordance with claim 1 wherein the electron emitting surface comprises iridium.

4. Apparatus in accordance with claim 1 wherein said cathode comprises material of extremely low work-function.

References Cited in the file of this patent

UNITED STATES PATENTS

1,864,591	Foster	June 28, 1932
2,283,639	Kling	May 19, 1942
2,284,389	Hansen	May 26, 1942
2,348,814	Herriger	May 16, 1944
2,476,060	Moss	July 12, 1949
2,608,664	Van De Graaff et al.	Aug. 26, 1952