June 1, 1937. K. H. KINGDON 2,082,638

ELECTRICAL DISCHARGE DEVICE

Original Filed June 1, 1928

Fig. 1.

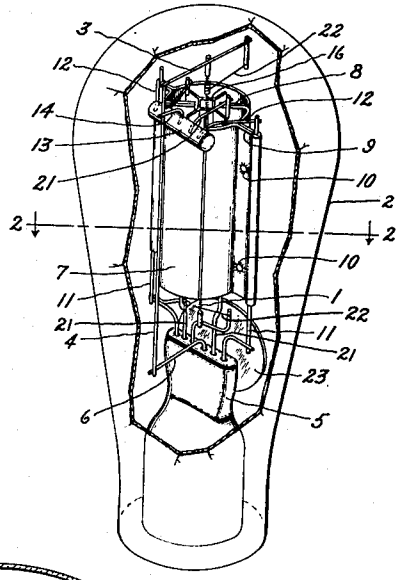


Fig. 2.

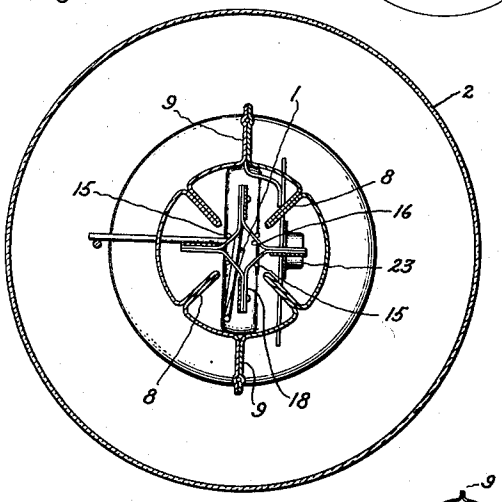


Fig. 3.

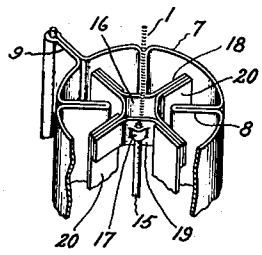
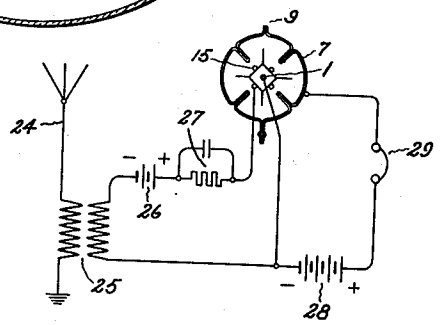


Fig. 4.



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UNITED STATES PATENT OFFICE

2,082,638

ELECTRICAL DISCHARGE DEVICE

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Original application June 1, 1928, Serial No. 282,160. Divided and this application December 20, 1933, Serial No. 703,285

6 Claims. (Cl. 250—27.5)

The present invention relates to electron discharge devices and especially to devices in which the discharge is carried principally by negative electrons in the absence of substantial ionization by collision.

This application is a division of my application, Serial No. 282,160, filed June 1, 1928, entitled "Electrical discharge devices" and assigned to the same assignee as the present application.

Patent No. 1,648,312 granted November 8, 1927 to Irving Langmuir and me jointly discloses an electron discharge device containing a filamentary cathode treated with an alkali metal, specifically caesium or rubidium, hereinafter referred to as a caesiated filament, and operating under conditions of low vapor pressure. The purpose of the alkali metal is to enhance the electron emissivity of the cathode. It is stated in the patent that when operating a filament of this type in a substantial vacuum, the effectiveness of the alkali is increased many fold by first treating the cathode in an electro-negative medium, e. g. oxygen, which forms on the cathode a foundation layer to which the alkali metal adheres most tenaciously. The presence of the oxygen increases the electron affinity of the cathode for the caesium at vapor pressures too low to promote substantial ionization.

I have discovered that during operation of the device, the electrons, in moving through the attenuated atmosphere collide with the migratory caesium molecules in the region of the electrodes, also with the gaseous particles evolved from the various glass and metal parts within the envelope, forming in each case certain products of ionization, all or part of which may find their way to the cathode. These products which include variously charged gaseous particles of different material, may impact with the filament in force and number sufficient to disturb the alkali layer or oxygen binder or both, either by reforming and adding thereto oxygen and other gases derived from the material occluded in the glass or other parts or by sputtering and driving off portions of the layer or binder from the filament core, which portions may combine with some of the caesium vapor present to form stable compounds and hence are lost to the filament. However, in both cases, i. e., film reforming and disintegrating, and including all other effects produced by the ionization products, the electron emissivity of the cathode and the efficiency of the device as a translator of electrical energy may be impaired by the change in the character of the adsorbed layer. While the deteriorating effects are particularly noticeable in the case of filaments which depend for their operation on adsorbed surface films of alkali metals or other materials, the impairment applies in some degree to all cathodes which are subjected to ion bombardment.

My invention therefore contemplates all types of cathodes immersed in an activating medium, gas or vapor, which forms on the cathode, layers of electronically emitting material sensitive to ion impact. Whatever be the cause of this impairment, I have found that if a body be placed in the neighborhood of the electrodes and a definite potential assigned thereto, of a polarity opposed to the preponderant polarity of the bombarding ions, the effectiveness and operating life of the adsorbed layer or other electronically active film formed on a binding material is thereby increased.

While I do not wish to be limited to any particular theory, I believe the discovery to be based upon the fact that the products of ionization are for the most part attracted to or intercepted by the body and hence deflected from the cathode. The ion attracting member which conveniently may take the form of a metal cylinder as shown and claimed in my prior application referred to hereinbefore, or in some instances, a flat plate, has the additional advantage when placed between the electrode organization and the envelope of preventing the migration of ions toward the latter where they ordinarily would form conducting layers or surfaces resulting in increased current leakage and erratic performance of the device. The ion attracting member may also form an integral part of the control element instead of being a separate member electrically connected to the electrodes. The present application discloses and claims a novel form of grid electrode which combines the usual electrostatic controlling function with that of collecting the positive ions which normally might be attracted toward the cathode.

Among the objects of my invention are to enhance the electron emitting efficiency and operating life of a heated electrode, the surface of which is sensitive to ion bombardment, and to improve the construction and operation of electrical discharge devices which employ for electron emission purposes, adsorbed films of alkali metal and other materials. Other objects of the invention will be apparent as the specification is perused in connection with the accompanying drawing. As an example of an additional feature, I disclose hereinafter a means for sup-

porting a filamentary cathode in a manner such that microphonic noises or disturbances caused by filament vibration may be substantially eliminated.

Fig. 1 is an elevational view in perspective of a three-electrode tube partly broken away and improved in accordance with my invention; Fig. 2 is an enlarged view of a cross section taken along the line 2—2 in the direction of the arrows shown in Fig. 1, Fig. 3 is a perspective view of the upper portion of the electrode structure, while Fig. 4 shows a typical circuit in which the improved tube may be employed to advantage.

Referring more particularly to Figs. 1, 2 and 3, numeral 1 designates a filamentary cathode of a type, for example, caesiated, which is sensitive to positive ion bombardment for reasons stated hereinbefore. The filament is positioned axially of the envelope 2 and supported at the top from a transversely disposed rod 3 carried by the rigid upright member 4 which constitutes the main support of the electrodes. The member 4 is positioned from the stem or press 5 by means of a right angle extension 6 to which it is attached. The anode takes the form of a hollow cylinder 7 concentrically arranged with respect to the filament and has a plurality of vanes or slats 8 equidistantly spaced about the inner periphery of the cylinder, each directed toward the filament. For convenience in manufacture, the anode may be fashioned out of relatively thin sheet metal stock and comprises two parts secured together at their inner faces to complete the plate member. Each strip is cut sufficiently wide so that when bent along predetermined parallel lines, two of the vanes 8 are formed; each strip in addition, provides one-half of the flange member 9. The latter terminates in a semicircular extension of small radius so that when the adjacent flange surfaces are secured together, for example, by punching two holes 10 and turning over the edges as shown, the extensions form a circular opening running longitudinally of the anode with which to embrace upright rods 11. These rods are secured to the press in any suitable and convenient manner and one is extended through the stem to serve as a leading-in conductor. At their upper ends, the rods are maintained rigidly in a direction of the tube axis by means of two transversely disposed wires 12 fused in a glass bead 13 which is secured to upright rod 4 by connecter 14.

The grid or control element which preferably contains as many members as there are anode vanes comprises wires 15 (see Figs. 2 and 3) disposed longitudinally of the envelope and positioned in line between each anode vane 8 and the filamentary cathode 1. The grid wires are equidistantly spaced about the filament by means of a hollow spider 16 upon which ears or lugs 17 are raised at suitable places around the upper portion of the spider. The wires, at their upper ends are loosely threaded through apertures in these ears and at their lower ends, are preferably welded to the spider. The sliding support offered by the openings in the ears provides for thermal expansion of the wires.

The spider 16, the function of which will be described hereinafter, is of a general rectangular design with radial extending vanes or slats 18 similar to those of the anode but which are interleaved with the latter in the manner shown. The interior of the spider is hollow to accommodate the filament 1.

While various constructions will at once suggest themselves to those skilled in the art, I prefer to fabricate the spider out of a number of component sheet metal parts as in the case of the anode. Two header or frame members 19 are first formed, each being conveniently made of four relatively narrow strips, the ends of which are bent outwardly and secured together to form an approximate star shaped construction with four flat surfaces radiating from the center. A pair of headers are then aligned at the proper distance from one another which roughly is comparable to the length of the anode, and the metal strip 20 laid on and secured to each of the header surfaces, thus joining the header or frame members together to form a compact and rugged unit 16. The unit is suspended within the envelope between two pairs of wire supports 21, the two upper of which are supported from the bead 13 and the two lower fused in the press, one being extended through the stem as the leading-in conductor.

I have also illustrated an arrangement for reducing vibration of the filament. Two wires 22 angularly disposed with respect to one another and extending in an angular direction with respect to the filament are provided at intermediate points on the latter, preferably near its ends.

For a source of alkali metal or other electronically active material for sensitizing the filament, there is provided a capsule 23 containing a suitable compound which in the case of a caesiated filament, may contain caesium chloride and a reducing agent such as silicon.

Fig. 4 shows a typical detecting circuit within which the device illustrated in Figs. 1, 2 and 3 finds utility. However, it is not to be understood my invention is limited specifically to detecting or amplifying circuits but is broad enough to cover all forms of energy translating systems which employ a cathode sensitive to ion bombardment. In the detecting circuit, the input is represented by a receiving-antenna-ground circuit 24, the energy of which is supplied to grid wires 15 and filament through a transformer 25, also through a positive biasing battery 26 and grid-leak-condenser network 27. The output circuit comprises a high voltage battery 28 and a telephone receiver 29 connected across the filament and anode members.

In a tube of this construction, the ions are formed almost entirely in the space between the anode and control electrodes and not between the filament and control member. The ions, therefore, are produced at points where the electric field draws them for the most part to the slat members 20 of the spider from which the grid wires 15 are hung.

It will be noted the position of the grid wires is such, when introduced in line between the filament and anode, that the electrons assume curved paths in traveling toward the anode, which facilitates the change in direction of the moving ions toward the slat members after they are produced. The efficacy with which the ion-collecting or deflecting function is performed by the control member depends to some extent upon its average potential with respect to that of the cathode and the preponderant potential of the ions produced in this manner, which function is exercised without interfering with or detracting from the usual electrostatic control of the grid as a whole.

A tube which includes a cathode sensitive to positive ion bombardment and is provided with a grid improved in accordance with the present

invention which not only performs its usual control function but in addition, serves to collect the positive ions which normally might strike the sensitive cathode surface, obviously, has a much longer operating life than tubes not so provided.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. An electrical discharge device comprising an envelope containing a thermionic cathode having a surface which is sensitive to ion bombardment, an anode having a plurality of projections, a control element positioned between the cathode and anode, in line with said cathode and said projections, an ionizable medium in said envelope, and a metallic member forming part of the control element and positioned out of line with said projections and said cathode, said member being adapted to receive the products of ionization during operation, thereby shielding the cathode from ion bombardment.

2. An electrical discharge device comprising an envelope containing a thermionic cathode, a cylindrical anode having a plurality of inwardly extending projections, a control electrode positioned between the cathode and anode, in line with said cathode and said projections, an electronically active ion-producing vapor surrounding the cathode, said vapor being adapted to form an adsorbed layer on the cathode, and a metallic member forming part of the control electrode and positioned out of line with said cathode and said projections, said member being adapted to receive the products of ionization during operation, thereby shielding the cathode from ion bombardment.

3. An electrical discharge device comprising an envelope containing a thermionic cathode, an anode having a plurality of projections which extend toward said cathode, a control electrode positioned between the cathode and anode, in line with said cathode and said projections, caesium vapor surrounding the cathode, said vapor being adapted to form an adsorbed layer on the cathode, and a metallic member secured to the control electrode and adapted to receive the products of ionization during operation thereby shielding the cathode from ion bombardment, said member being positioned out of line with the cathode and the projections on said anode.

4. An electron discharge device comprising a plurality of electrodes comprising an anode provided with extensions and an electron emitting body sensitive to ion bombardment immersed in an attenuated ion-producing atmosphere, and means for shielding the electron emitting body from ion impact, said means comprising an electrostatic control member having a plurality of electrically connected but physically separate members, one of said members including grid wires mounted in line with the extensions on said anode and the electron emitting body, and another of said members including an element out of line with the extensions on said anode and electron emitting body but in attracting relation with respect to the products of ionization formed during operation.

5. An electron discharge device comprising an envelope containing alkali vapor, an electron emitting body sensitive to ion bombardment and immersed in said vapor, an electrostatic control element, and an anode surrounding said body and electrostatic control element and provided with inwardly extending projections, said element being interposed between and in line with the projections on said anode and electron emitting body, and means for shielding the electron emitting body from the ions produced in said vapor, said means including a metal member connected to the control element and positioned out of line with said projections and said body.

6. An electron discharge device comprising an envelope containing an anode, an electrostatic control member and a cathode sensitive to ion bombardment immersed in an ion-producing medium, said anode surrounding the cathode and provided with vanes which extend in planes intercepting the cathode, said control member interposed between the cathode and anode and having a portion in line therewith, and having another portion which constitutes a vane positioned between a pair of anode vanes for receiving the products of ionization during operation.

KENNETH H. KINGDON.