May 5, 1931. E. A. QUARRIE 1,803,976

RECTIFIER

Filed June 10, 1927

Fig. 1.

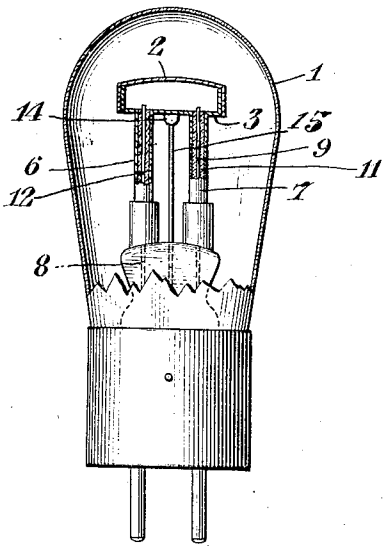



Fig. 2.

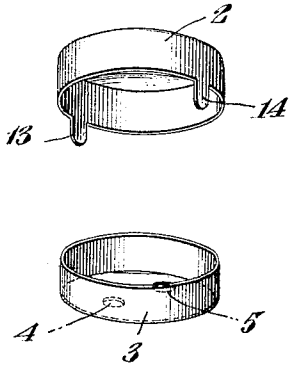
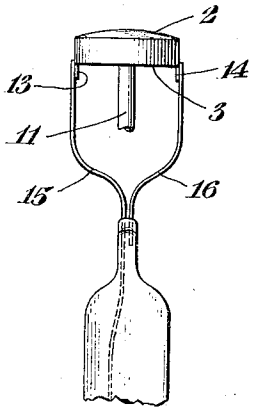



Fig. 3.




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# UNITED STATES PATENT OFFICE

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## RECTIFIER

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My invention relates to apparatus for rectifying alternating currents and more particularly to such apparatus as depend upon the use of a conductive gas. The device of the present invention is furthermore of the type which employs a closed hollow cathode and one or two anodes consisting of rods, the points or ends of which are presented to the inside of said hollow cathode.

In such devices the space within the hollow cathode forms an ionization chamber; that is, a chamber within which the conductive gas becomes ionized during operation and to which such ionization is confined.

The efficiency of rectification of current and in part the life of such devices depends upon the proper proportioning of the inner superficial area of the cathode to the anode and upon a proper shaping of the cathode with respect to the anode. The efficient life is, furthermore, prolonged by maintaining the internal resistance of the cathode chamber at its initial low value.

When a proper proportion of these elements is observed, there is little disintegration of the anode under the bombardment from the cathode. During disintegration of metal parts a considerable quantity of gas is evolved which renders the conductive gas impure and produces a deleterious effect in that it increases the resistance of the cathode chamber. With increase of resistance a great deal of energy is lost as heat. Such gases as are evolved in the tube of the present invention produce no appreciable increase of resistance in the cathode chamber and are of such small quantity that they may if desired be neutralized in the manner hereinafter set forth.

It is an object of the present invention to provide a device such as will have great efficiency during a long life and which is characterized by a very rugged and strong supporting structure. By properly correlating the cathode and anodes of my device, I obtain a rectifier which gives a very large output and in which because of the constant low internal resistance very little of the energy is lost in the form of heat.

The invention will be better understood from the drawings to which reference is now made:—

Fig. 1 shows the electrode structure of the device of my invention in sectional elevation.

Fig. 2 shows the elements comprising the cathode.

Fig. 3 shows the electrode structure mounted.

Similar reference numerals indicate similar parts in all the figures.

In Fig. 1, one form of the device is illustrated. It is a full wave rectifier and consists of a hermetically sealed bulb, 1, which is filled with a conductive monatomic gas such as helium or neon. The cathode is formed of two elements shown in Fig. 2, an upper part or cap, 2, the upper surface of which is curved outward on an arc rising to $\frac{1}{8}$ of an inch on a segment of one inch, the lower element is a cup, 3, over which the cap, 2, fits with a tight frictional fit. In the bottom of the cup, 3, are two openings, 4 and 5, through which the tubular cathode supports, 6 and 7, extend and which also receive the insulated rods, 8 and 9. The supporting legs 6 and 7, of the cathode structure are formed of a conductive metal and are in effect a part of the cathode being in the form of hollow metallic tubes that form a passage for the anode rods, 8 and 9, which are encased where they pass through said tubes in insulating material such as glass, 11 and 12. The cathode and its supports are shown in Figure 3, in which 2, shows a cap with small tabs or extensions, 13 and 14, on opposite sides. To these tabs are welded the cathode lead 15 and a support 16, which is anchored in the press of the stem.

It will be observed therefore that the cathode is held by two sets of supporting elements comprising the tubular legs, 6 and 7,

on the one hand, and the lead wire, 15, and the support, 16, on the other. It will also be observed that both the lead wire, 15, and the support, 16, are in a plane at right angles to the plane of the tubular legs, 6 and 7, an arrangement which gives the device an exceptional strength and ruggedness and enables it to withstand shocks incurred in the handling and shipping.

Moreover, the anodes consist of metal rods, the uninsulated points or ends of which project very slightly into the cathode chamber.

As previously pointed out the efficiency of a rectifier depends upon several considerations. In the first place, the interior space of the cathode chamber should bear a proportionate relation to the size of the anodes. Assume that in the form of the invention shown in the drawing the cathode chamber is circular in plan having a diameter on the floor thereof of approximately one inch. In such case I prefer to make my anode in the form of a rod having a diameter of 0.06″ and being composed of a conductive material such as nickel. I find that in a chamber of the size mentioned by increasing the diameter of the anode above .06″, I can correspondingly increase the life of the tube, but at the expense of efficiency of rectification. Similarly by decreasing the diameter of the anode, I can correspondingly increase the efficiency of rectification but at the expense of life. For instance, with a cathode chamber of the size mentioned and an anode of 2 mils diameter, I approximate perfect rectification but the life of the rectifier under these conditions is only a few hundred hours. By increasing the diameter to 60 mils or .06 inches, other relations remaining constant, I can obtain a current output of 85 milliamperes for a period of from one to two thousand hours. I prefer, therefore, to employ anodes having a diameter in the neighborhood of six hundredths of an inch.

The cathode chamber should have a sufficiently large superficial area on the inside to afford a large emitting surface but this area is limited by the necessity of keeping the internal resistance at a low value. Assuming that with a diameter of one inch, the cathode chamber had also a height of one inch, the internal resistance of the cathode chamber would be so great that the efficiency of rectification would be very much impaired, despite the very large emitting surface. According to my invention, I so construct the cathode chamber that its interior superficial area will be regulated by balancing these two principles. It is thus evident, that by a proper balance between the interior superficial area of the cathode and the size of the anode, I can initially produce and, by the means hereinafter mentioned, effectively maintain the efficiency of rectification and limit the heat loss to a constant low value during a period of operation of the tube of fifteen hundred hours or more.

In the form of the invention shown in the drawings I preferably make the cathode in the form of a hollow chamber having a diameter of one inch, a height at the sides of approximately $\frac{3}{16}$ of an inch and I curve the top or roof thereof upwards about $\frac{1}{8}$ of an inch above the top of the sides; and the anode I form of a rod of a diameter of .06″.

The proportions of cathode area and anode diameter may be varied to gain greater life at the expense of efficiency or greater efficiency at the expense of life but I find the best results are obtained when these relative proportions are observed. I do not, consequently, limit myself to an anode having a diameter of .06 inch, for any structure having the relative proportions hereinabove indicated by the specific dimensions given will be within the scope of my invention. Furthermore, the curvature of the top of the cap serves to focus the electron stream upon the anodes, since the electrons have a tendency to move in a direction normal to the emitting surface.

In operation of the device, the gas contained within the chamber, for example, a monatomic gas, such as helium, becomes highly ionized and there is a considerable bombardment of the anodes. In such tubes the desired action is a flow of electrons from the cathode to the anode and in the ideal case the anode should be infinitesimal in order to nullify the effect of this bombardment. Practically, however, the anode has to be of finite size. This results in a certain amount of disintegration of the metal of the anode, which tends to evaporate or to evolve gases. Such gases tend to increase the resistance of the tube and the increased resistance results in a loss of energy in the form of heat. The overheating of the metal parts in this manner still further promotes the evaporation of the metal parts with very great injury both to the efficiency and life of the tubes. It should also be noted that the nature of the metal forming the anode also has a bearing on the amount of disintegration and on the amount of gases evolved.

I have previously explained that by properly proportioning the cathode and anode, I am enabled to reduce this effect to very small proportions regardless of other considerations. It cannot, however, for reasons above stated be wholly eliminated. I, therefore, enclose within the cathode chamber a small quantity of cerium and calcium in a metallic state and either in the form of a powder or as a small pellet of an alloy of these metals. During the operation of the tube these metals give off gases at a comparatively low temperature and these gases are not only advantageous in adding to the conductivity of the helium but they also combine with foreign

gases that may be liberated from the interior parts of the tube, rendering them harmless. Careful tests have shown that the device constructed according to the principles of this invention is capable of producing a very large output current and voltage and that the device has little tendency to become overheated which is a great defect in most rectifiers of this type, in which a large proportion of the energy is dissipated as heat.

Having thus described my invention, what I claim is:—

1. A rectifier comprising a sealed glass envelope, a closed hollow cathode, anodes consisting of rods, the points of which project within said cathode, a conductive gas within said envelope and said cathode, conductive tubular supports for the cathode and auxiliary cathode supports lying in a plane substantially at right angles to the plane of the tubular supports.

2. A rectifier tube comprising a sealed glass envelope, a hollow cathode and two rod shaped anodes the points of which project within said cathode, a cathode structure consisting of a cup shaped element, a cap fitting thereon with a tight frictional fit, two metallic supporting legs receiving said rod shaped anodes and, in a plane at right angles to said supporting legs, an auxiliary system of supports consisting of the cathode lead and another supporting wire; said cathode structure being mounted upon a stem forming part of said envelope.

3. In a rectifying tube, a cathode consisting of a cup-shaped element supported by metallic legs and a cap having a frictional fit on said element; and rod-shaped anodes insulated within said metallic legs.

4. A rectifying tube comprising a hollow cathode within which the rectifying action is confined, an anode consisting of a rod, the point of which is presented to the interior of the chamber formed by said hollow cathode a conductive gas within said chamber and a quantity of metallic cerium and calcium adapted to give off vapors during operation of said tube which vapors coact with deleterious vapors within said chamber thereby maintaining the resistance of said cathode chamber at a constant low value.

5. In a rectifying tube a cathode comprising a hollow chamber within which the rectifying action is to be confined mounted upon supporting conductive legs, anodes consisting of rods insulated within said legs, the points of said anodes being presented within said hollow cathode chamber, a conductive gas within said hollow cathode chamber and means also within said chamber for maintaining the resistance of said chamber at a constant low value.

6. In a rectifying tube, a cathode comprising a hollow chamber, within which the rectifying action is to be confined, mounted upon a supporting conductive leg, an anode consisting of a rod insulated within said leg, the point of said anode being presented within said hollow cathode chamber, a conductive gas within said hollow cathode chamber, and means also within said chamber for maintaining the resistance of said chamber at a constant low value.

In witness whereof, I have hereunto set my hand, on this 7th day of June, in the year one thousand nine hundred and twenty-seven.

EUGENE A. QUARRIE.