July 1, 1958 G. RYBAKOFF 2,841,735

ELECTRON DISCHARGE TUBE

Filed March 15, 1955

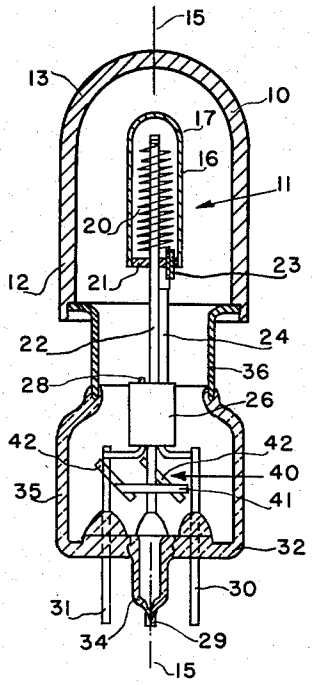


Fig. 1

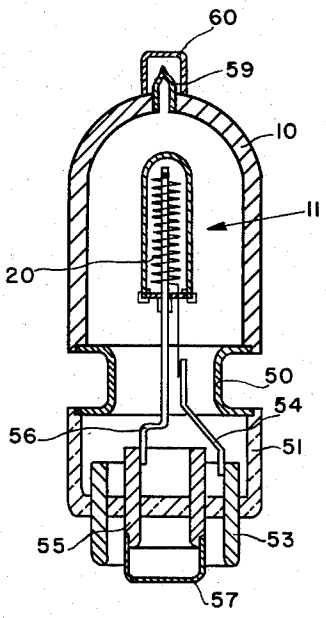


Fig. 2

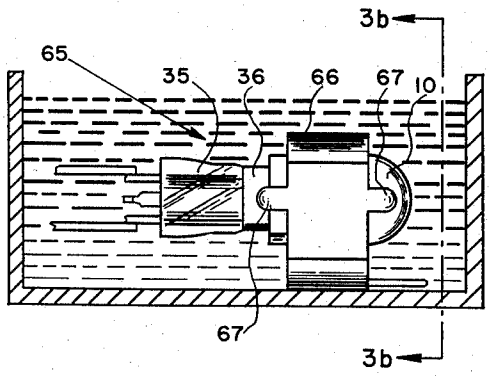


Fig. 3a

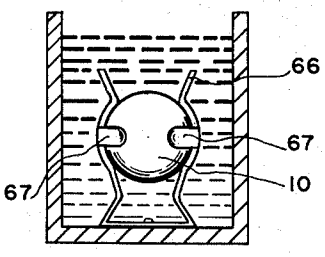


Fig. 3b

INVENTOR
GEORGE RYBAKOFF
BY
AGENT

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ELECTRON DISCHARGE TUBE

George Rybakoff, Little Neck, N. Y., assignor, by mesne assignments, to North American Philips Company, Inc., New York, N. Y., a corporation of Delaware

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3 Claims. (Cl. 313—242)

This invention relates to electron discharge tubes, and, in particular, to electron discharge tubes of the rectifier type.

One object of the invention is to provide a miniature, ruggedized, high-vacuum, diode-rectifier tube.

Another object of the invention is to produce an inherently small, external anode, liquid-immersion type of rectifier tube capable of handling a comparatively large amount of power for its size.

A further object of the invention is to provide a tube of the foregoing type adapted for mounting in a fuse-type plug-in-structure or socket and where the anode serves as the prime means of tube support.

Still a further object of the invention is to provide a miniature vacuum diode suitable for liquid immersion or other type of forced or static cooling and capable of dissipating comparatively high quantities of power under adverse conditions of temperature and mechanical shock and vibration.

Another object of the invention is a tube of the foregoing type which is capable of mass-production at low cost.

These and other objects of the invention will be best understood from the following description, taken in connection with the accompanying drawing, wherein:

Fig. 1 is a cross-sectional view of one form of discharge tube in accordance with the invention;

Fig. 2 is a cross-sectional view of another form of tube in accordance with the invention;

Figs. 3*a* and 3*b* are views showing the tube of Fig. 1 mounted in a socket.

Referring now to the drawing, Fig. 1 shows one construction of the invention whereby the desired objects are attained. The tube shown, which is of the diode type, comprises an external, metal anode **10** and an indirectly-heated cathode **11**. The anode **10**, which may be constituted of copper, comprises a relatively strong, rigid shell forming a part of the envelope of the tube. It includes a cylindrical portion **12** integral with a dome-shaped portion **13**, both symmetrical about the central axis of the tube designated by **15**. The cathode **11** may be of the oxide-type and comprises, for example, a closed-off nickel tube **16** coated with a mixture of barium and strontium carbonates **17** to enhance electron emission. As will be observed, the external contour of the cathode **11** is identical, though on a smaller scale, with the internal contour of the anode **10**. Thus, the cathode also has cylindrical and dome-shaped integral portions, both of which are capable of emitting electrons, and is mounted concentrically with regard to the anode. By this geometry, the spacing between the cathode and anode along their entire active surfaces is the same, thereby maintaining a uniform voltage gradient therebetween at all times and enabling the fullest use to be made of the available cathode and anode surface area. This feature of the invention is important since it enables the dimensions of the tube to be markedly reduced by means of this

electrode geometry which maximizes the electron emitting and receiving surfaces.

The cathode **11** is maintained at electron-emitting temperature by a heating-coil **20** mounted therewithin. To this end, the nickel tube **16** is closed off by a metal, e. g., nickel, member **21** secured to the tube **16** and to a conductive support rod **22**, one end of which is connected to one, the upper, terminal of the heater **20**. Thus, the cathode **11** and one end of the heater **20** are electrically connected together via the common conducting rod **22**. An insulating sleeve **23** is mounted on the member **21**. Through the center of this sleeve **23**, and thus insulated from the cathode **11**, passes a lead from the second conducting rod **24** connected to the bottom or still unconnected end of the heater **20**. The two rods **22**, **24** are maintained in their spaced, insulated relationship by a ceramic support **26** having three equi-spaced bores therein arranged about the central axis thereof. The third bore contains a dummy lead **28**. The three leads **22**, **24** and **28** are then secured each to a separate terminal **29**, **30**, **31** vacuum-tight sealed into the base **32** of the tube. The construction thus obtained results in a three-pin standard input connection for the tube. By means of an exhaust tubulation **34** in the base **32**, the interior of the tube may be evacuated in the conventional manner.

The remainder of the envelope of the tube is constituted by a cylindrical vitreous portion **35**, e. g., a borosilicate glass or a ceramic body, and an annular member **36**, e. g., of Kovar, sealed to the vitreous portion. The member **36** has a reentrant portion constricting the tube volume between the anode **10** and the vitreous base portion **35**. Kovar has the composition of approximately 29% nickel, 17% cobalt, 0.3% manganese, and the remainder iron, and is readily sealed to the usual borosilicate glass having about the same expansion coefficient. As shown, the Kovar annular member or ring **36** is sealed to the vitreous member **35** at one end, and is brazed to the copper anode **10** at the other end. All joints are vacuum-tight and completely seal off the interior of the tube.

The envelope construction just described constitutes an important feature of the invention. As will be observed, the envelope of the tube is constituted of a vitreous base portion **35**, a reentrant ring portion **36** sealed to the base, and the external anode **10** sealed to the ring **36**. This construction offers the advantages of simplicity, ease of manufacture, ruggedness, and inexpensiveness. Two further important advantages obtain from the configuration of the reentrant ring portion **36**. It will be observed that the reentrant ring, as a constriction, serves to divide or restrict the tube into two portions. The first or upper half contains the electron emitting and receiving portions, whereas the second or lower half contains the base and input section. The reentrant ring, lying therebetween, serves as a barrier or shield against the radiation of heat and the passage of electrons from the upper to the lower half of the tube. In the former capacity as a heat shield, it enables operation of the heater at a lower power while still maintaining the desired temperature of the cathode since less heat escapes to the bottom of the tube, producing an important saving in input power. In the latter capacity as a barrier against electrons, it prevents the seal between the ring **36** and the vitreous portion **35**, as well as the remaining portions of the vitreous member, from being bombarded by electrons and possibly deteriorating, cracking or puncturing as a consequence. In sum, therefore, the reentrant ring **36** serves the functions of forming part of the envelope, enabling sealing of the metal anode to the vitreous base, confining the heat in the upper half of the tube to conserve power, and preventing electron bombardment of the vitreous portion.

The usual getter **40** may be mounted in the lower half

of the tube. It comprises, for example, a member **41** consisting of a suitable getter material, e. g. barium-aluminum. The getter is electrically connected by welded leads **42** between the pins **29** and **31**. Heating of the getter in the usual way enables residual gases in the tube to be tied up by the vaporizing getter material.

Fig. 2 illustrates another form of tube construction by which the desired results may be attained. In this embodiment, the reentrant metal ring **50** has a slightly different shape from that of Fig. 1. In particular, in Fig. 1, the ring **36** has a cylindrical lower portion with a transversely extending flange at the top brazed along its periphery to the anode **10**. The bottom of the ring, in turn, is sealed to a reentrant portion of the vitreous member **35**. In Fig. 2, on the other hand, the bottom vitreous portion **51** is cylindrical only with no reentrant portion. However, the Kovar ring **50**, which is sealed to the member **51** and the anode **10**, has the shape illustrated, which may be likened to a cylindrical half-torus section, to enable sealing at both ends to the anode and vitreous portion as required.

The input section of the tube of Fig. 2 is also different from that of Fig. 1 and constitutes a coaxial input. It comprises, in particular, an outer cylindrical conductor **53** sealed in the base and electrically connected by the lead **54** to one end of the heater **20**, and an inner, also cylindrical conductor **55** sealed in the base and electrically connected via the lead **56** to the cathode **11** and the other end of the heater **20**. The inner conductor **55** is closed off by a metal cap **57**. The exhaust tubulation on the tube illustrated in Fig. 2 is located at the top of the anode **10**. It comprises a pinched-off metal tubing **59** which is ultimately covered with a metal protective cap **60**. The provision of the exhaust tubulation at this location on the anode does not substantially interfere with the field gradiant in the anode-cathode space.

Fig. 3 illustrates the tube of Fig. 1 mounted in a lock-in type of fuse socket **65**. As will be observed, the fuse clip **66** tightly embraces practically all of the external anode **10** and rigidly holds it in position. Thus, the anode **10** supports the entire tube. Further, the anode **10** is in intimate mechanical and electrical contact with the fuse clip **66**, and this latter member thus can serve, in addition to its electrical and mechanical functions, as an additional conductor and radiator, i. e., dissipator, of the heat generated at the anode. The input connections can then be made directly to the exposed tube terminals as shown. In operation, the tube as shown may be operated completely submerged in insulating oil, which thus directly contacts the external anode **10** and the supporting fuse clip **66** and enables a maximum dissipation of heat. It will be noted that the anode **10** is locked in place by the tabs **67** which engage the reentrant portion of the annular member **36**, as well as the dome-shaped end of the anode **10**.

To illustrate the excellent operation attained with tubes of the type described above, there follows below a detailed description of one such tube made as shown in Fig. 1. The overall height of the tube was 2 inches. The diameter of the anode **10** was ¾ of an inch and that of the constricted portion ½ of an inch. The height of the anode **10** was 1 and ⅛ inches. As a rectifier, the filament was rated at 6.3 volts and 1 and ½ amps. The operating potentials were 16 kilovolts, for which the average current was 70 milliamperes and the peak current 275 milliamperes, thereby expending a comparatively high amount of power in view of the small dimensions of the tube. The tube was subjected to extensive shock and vibration without having any of its characteristics altered in the very least. In connection with liquid immersion cooling in insulating oil, the tube of the invention can operate at peak ratings at an ambient oil temperature range of −65° C. to +165° C. without any adverse effects appearing.

While we have described our invention in connection with specific embodiments and applications, other modifications thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the invention as defined in the appended claims.

What I claim is:

1. An electron discharge device comprising an evacuated envelope, said envelope including an external metal anode, a vitreous base portion spaced from said anode, and an intermediate annular member having a reentrant portion constricting the space communicating with both the anode and the base and constituting part of the envelope, a cathode within said anode, said cathode having surface portions spaced equal distances from corresponding portions of the anode whereby a uniform voltage gradient is maintained therebetween, and terminal connections for such cathode extending through said reentrant portion to said base whereby said annular member shields said base from destructive electron flow from said cathode.

2. An electron discharge tube comprising an evacuated envelope, said envelope including an external cylindrical metal anode, a glass base portion spaced from one end of said cylindrical anode, an intermediate annular metal member, having a reentrant portion constricting the space communicating with both the anode and the base portion, said annular member constituting part of the envelope and vacuum-tight sealed to said anode and base, a cylindrical cathode mounted substantially concentrically within said anode, and terminal connections for said cathode extending through and sealed into said base, said annular member shielding said base from excessive flow of electrons from said cathode.

3. An electron discharge device comprising an evacuated envelope, said envelope including an external metal anode having a cylindrical portion and a dome-shaped end portion closing one end of said cylindrical portion, a vitreous base spaced from the other end of said anode, and an intermediate annular metal member between said base and said anode, said annular member having a reentrant portion constricting the space communicating with both the anode and the base and constituting part of the envelope, a cathode mounted concentrically within said anode and also having integral electron emissive cylindrical and dome-shaped portions substantially equally spaced from corresponding portions of said anode, and terminal connections for said cathode extending through and sealed into said base, said reentrant portion shielding said base from destructive current flow from said cathode.

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