March 30, 1937. O. KRENZIEN 2,075,208

ELECTRON DISCHARGE DEVICE

Filed July 19, 1935

Fig. 2

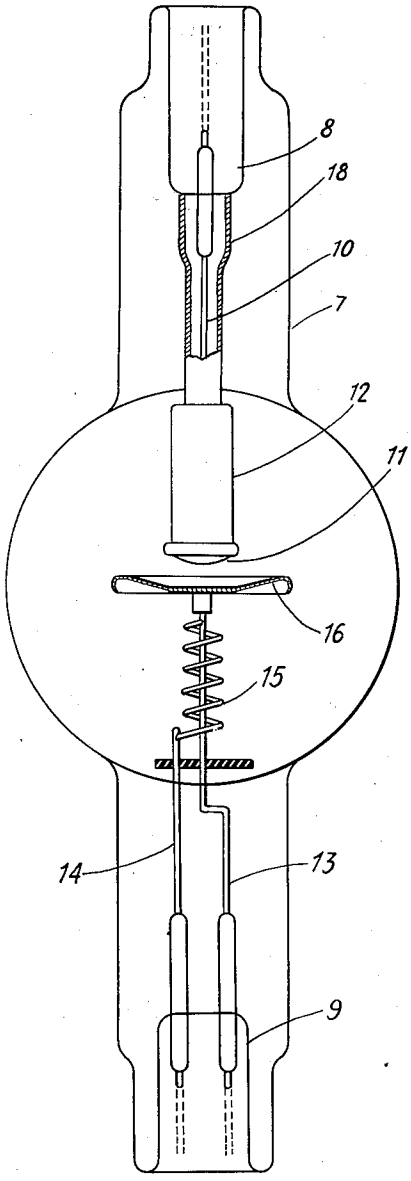


Fig. 1

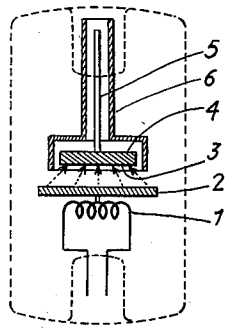
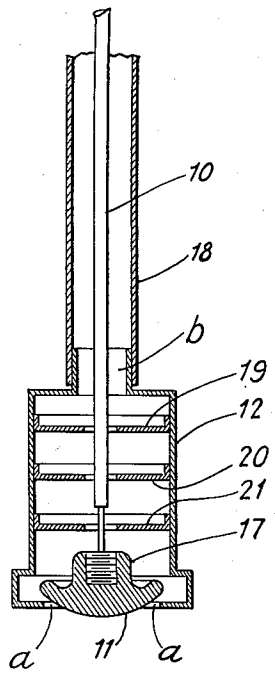


Fig. 3



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ELECTRON DISCHARGE DEVICE

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4 Claims. (Cl. 250—27.5)

My invention relates to electron discharge devices, more particularly to improvements in electron discharge devices of the gas or vapor type.

One of the most difficult problems in the manufacture of electron discharge tubes having a gas or vapor atmosphere, especially tubes designed for relatively high voltages, is in the prevention of back-arcing, that is to say, the initiation of a discharge during the blocking or non-conducting phase. Various ways and means have been suggested to prevent back-arcing, but up to the present no really satisfactory method has been devised, especially where high voltages are dealt with.

Use has been made of conducting and non-conducting screens or grids interposed between the discharge of electrodes to prevent such back-arcing or to at least cut down the intensity of such arcing. The anodes (which, in the case of back-flashing or back-arcing, operate as the cathodes) have also been positioned within extensions or arms of the tube envelope or disposed within shields which minimize the strength of the current likely to flow thru the arc discharge once the latter has been initiated in a reverse direction because the shields cause a restricted discharge. All of these ways and means and others of a similar nature, however, are found to fail when the potentials to be blocked are greater than, for example, 15 to 20 kv. Back-arcing with these potentials is preventable only when the initial or breakdown voltage of the gaseous discharge is increased beyond the value to be blocked or prevented in a safe and dependable manner. It is well known that the breakdown voltage of unassisted gas discharges is a function of the quantity of gas or vapor confined between the electrodes, i. e., a function of the product of inter-electrode distance and the prevailing gas pressure. It is likewise known that below a critical point of this product with decreasing values, the ignition or breakdown potential rises very suddenly or steeply. It is difficult if not impossible to secure values of any desired small amount for this critical product by choosing a desired low pressure for the gas filling inasmuch as gases or unsaturated vapors, at unduly low filling pressures become occluded, in the course of a few working hours, in the walls of the discharge vessel or in the electrodes. Hence, it is necessary to choose as small as feasible a distance between the electrodes in question. However, this step involves the difficulty that when the distance is unduly small between the electrodes between which a discharge takes place, the flashing or arcing voltage of the discharge attains inacceptably large magnitudes in the desired or working direction. (So-called impeded discharge.)

It is an object of my invention to provide an improved type of electron discharge device of the gas or vapor type intended for use as a rectifier in which breakdown in a reverse direction during the non-conducting phase will be practically eliminated.

According to my invention, the electron discharge device is provided with an envelope having a gas or vapor content and enclosing an anode, and a cathode providing the main electron source, the cathode and the anode being so disposed and constructed that the discharge path of the electrons from the cathode to the anode in the working direction during the conducting phase is several times longer than the paths of the electrons released at the anode in the blocking or non-conducting phase from the anode to the cathode.

In this connection care must be taken so that the possible paths of such secondary electrons as may have been released at the plate during the blocking phase are so small or short that the flashing or arcing potential of a gaseous discharge in the blocking phase will be above the maximum voltage liable to occur in operation; in other words, that the product of gas pressure and distance inside the discharge vessel, wherein an electric field is set up during the blocking phase, will be kept as small as feasible.

To do this the lines of force of the field during the blocking phase should not differ in length from each other by more than a factor of 3. In order that this condition may be insured it is necessary that such lines of force as issue from the posterior face of the plate, from the lateral surfaces or the supporting elements thereof are suppressed by suitable means such as shields or the like, that is the tendency of discharges along these lines of force should be suppressed while at the same time insuring that the cathodic parts of the discharge vessel are so shaped that lines of force along which discharges are possible will terminate only in a plane parallel to the front face of the anode. The distribution of the lines of force inside the electron discharge device during the blocking or non-conducting phase can be determined by the application of well-known electrostatic laws and methods, while during the conductive phase, once ionization of the gases has been initiated, the situation will be found to be totally different

since then space-charges of positive ions cause an essential change in the distribution of the field.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a diagrammatic vertical section of an electron discharge device embodying my invention; Figure 2 is a view with parts in section of an electron discharge device embodying my invention; and Figure 3 is a vertical section of a modification of the anode and shield of the electron discharge device shown in Figure 2.

In Figure 1, cathode 1 supports an element or shield 2 which may be dish-shaped and is disposed at a small distance opposite the front face 3 of the plate 4. The anode or plate 4 as well as its supply lead 5 are surrounded by a shield 6. The latter may be metal in which case it must be either insulated or be kept at cathode potential or substantially so. In either case, it is necessary that the distance between anode 4 and its lead 5, on the one hand, and the shield 6, on the other hand, be such that no discharge is likely to take place in the interstitial spaces regardless of whether this discharge is brought about by a potential difference between the anode and the shield or by the discharge between anode and cathode.

Referring to the schematic view Figure 1, with reference first to conducting or regular working phase the electrical fields are established only in the positive space charge layer which closely surrounds all such parts as are at the voltage of the cathode, while outside of this comparatively thin layer, space charges of approximately the same intensity and of both signs prevent the formation of electrical fields.

In the blocking or non-conducting phase, on the other hand, lines of force along which a discharge can take place, as shown in the figure by dotted lines, exist only in the space between the front surface of the anode and the dish part of the cathode. Along the lines of force which issue from the lateral surfaces of the anode or from the supporting elements thereof (and which are not indicated in the drawing) discharges are not likely because of the snug fitting or surrounding of the shield 6, while no lines of force are established which begin at the front surface of the anode and terminate at that surface of the cathode which is on the opposite side of the cathode from the anode and on the supporting elements therefore. The result is that, at the operating pressures and at the predetermined distances between the electrodes and unassisted gas discharge during the blocking phase cannot take place. Hence, not only the distance between the anode and the anode screen is important, but the proper dimension of the diameter of the planar part of the cathode turned towards the anode compared with the length of the other structural parts of the cathode and their cross sectional diameter must be selected so that under no conditions will stray lines of force starting at the front surface of the anode terminate at parts of the cathodic structure other than the cathode surface opposite the anode frontal surface.

In Figure 2, the envelope 7 of the electron discharge device is provided with two presses 8 and 9, the press 8 supporting the anode with its shielding means, while press 9 carries the cathode structure. The anode consists of a supporting element 10, the anode body with frontal surface 11, and a shield 12. The press 9 supports two supporting wires 13 and 14 which carry the loop-shaped heated cathode 15 as well as the cathode dish 16. The thermal electron emission issues from the cathode 15; hence, in the transmitting phase the electrons travel from the cathode 15 to the anterior surface of the anode 11, while in the reverse phase or blocking phase such electrons as may be released on 11 will have available for their travel only the short path between 11 and 16 for ionization.

In Figure 3 is shown the details of construction of the anode including the shield. On the support wire 10 is secured the anode or plate body 17, having the anterior surface 11. A shield 12 preferably of metal is carried by the insulating tube 18. The distance between the shield 12 and the plate body at the points marked *a* and *b* is so small that no unassisted discharge is possible. The cylindrical portion of the shield may be placed either so close to the lead 10 that no discharges can take place or else as shown in the figure, diaphragms 19, 20, 21, may be provided by means of which the space formed between the anode lead 10 and the interior of the shield is subdivided so that in these subdivisions no discharges can occur. The shield 12 as well as the diaphragms or baffles 19, 20 and 21 may be made either of insulating material or else of some conducting material. If the shield is metal it may be desirable to apply to it the cathode potential. When this shield has a potential which is equal or close to that of the cathode, it is very important to make the distances between the anode or anode lead, on the one hand, and the shield, on the other hand, such that no unassisted discharge can be initiated. By impressing proper voltages upon the anode shield, the shield can be used for control purposes. It may be advantageous in this connection to cover the lower open front surface of the anode screen or shield by a grid- or grate-like structure which would thus be placed outside of the frontal surface of the cathode. It will be understood that the control action of the anode screen could be combined with the control action of some other part of the tube.

The distance between the front surface of the anode and the surface of the cathode turned towards it is limited by the field intensity on the surface of the anode which when the electrodes are very close may cause a marked auto-electronic discharge which may occasion an undesired breakdown or discharge.

While the preferred construction of the cathode is shown in Figure 2, it may be made so that the entire dish portion 16 acts as the heated cathode. In this case the electron emission should occur only from the face turned away from the frontal surface of the anode. The electron emissive coating may be of any conventional kind. The cathode may be a directly or an indirectly heated type, and it may be advantageous to provide heat insulating means as well known in the art. It is possible to use a discharge gap or path to act as a source of electrons from which the electrons can be extracted by the action of the anode field. It is also feasible to use as the electron source the spot of an arc discharge, as well known in the art.

Tubes of the kind hereinbefore disclosed and described may be used not only as simple non-

controlled discharge vessels, but in addition to the control action hereinbefore described and obtained by the protective shield surrounding the anode, further electrodes may be employed as suggested in the art to control actions either of a continuous or an intermittent kind. For example, possible to position on the part of the dish 16 turned away from the anode (see Figure 2) a control element adapted to regulate the initiation of the discharge current during the conducting phase by providing an initial auxiliary discharge. It is essential in this connection, so far as practicing the invention is concerned, that these control elements as well as their supply leads must be so disposed that the possibility of long stray lines of force emanating in the blocking or non-conducting phase from the anode surface will be prevented.

The gases or vapors used to fill the discharge vessel according to the invention may consist of saturated or unsaturated metallic vapor, e. g., mercury vapor or else of inert gases such as nitrogen, hydrogen, iodine or else rare gases or mixtures of vapors and gases.

While I have indicated the preferred embodiment of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:—

1. An electron discharge device having an envelope containing a gaseous atmosphere, an anode having a lead-in supported within said envelope and having a surface transverse to the longitudinal axis of the envelope, a cathode oppositely disposed to said anode and having an electron emitting surface, a shield connected to the cathode and positioned between the emitting surface of said cathode and the anode and having a surface transverse to the longitudinal axis of the envelope and extending radially beyond the anode and cathode, whereby the discharge path of the electrons from the emitting surface of said cathode to said anode is greater than the distance between said anode and said shield, and a shield around said anode and its lead-in spaced from said anode at such a distance that no discharge will occur between the shield and the anode and its lead-in under operating conditions of voltage and gas pressure, said shield being open only at the transverse surface of the anode.

2. An electron discharge device having an envelope containing a gaseous atmosphere, an anode, a lead-in for supporting said anode from one end of the envelope, a shield surrounding said lead-in and anode and having an opening for partially exposing the surface of said anode, transverse metallic shields positioned within the enlarged end of said shield and spaced from each other, and provided with aligned apertures thru which the anode lead-in extends out of contact with said shields, a cathode supported from the other end of the envelope and having a surface transverse to the longitudinal axis of said envelope, said cathode having an electron emitting portion shielded by the transverse surface from said anode.

3. An electron discharge device having an envelope containing a gaseous atmosphere, an anode supported from one end of said envelope and having a surface transverse to the longitudinal axis of the envelope, a shield surrounding said anode except at said surface whereby any discharge is confined to said surface and a cathode assembly supported from the other end of the envelope and including an imperforate surface transverse to the longitudinal axis of the envelope and an electron emitting portion disposed on the opposite side of said transverse surface from said anode, the transverse surface of the cathode extending in a radial direction beyond the outside surface of the anode whereby the path of electrons from the emitting portion of the cathode to the transverse surface of the anode is greater than the distance between the transverse surface of said anode and the transverse surface of said cathode.

4. An electron discharge device having an envelope containing a gaseous atmosphere, an anode supported from one end of said envelope and having a surface transverse to the longitudinal axis of the envelope, a shield surounding said anode and having an opening adjacent the transverse surface of the anode, and a cathode having a dish-shaped portion transverse to the longitudinal axis of the envelope and opposed to the surface of the anode, the surface of said dish-shaped portion of the cathode opposite from said anode being coated with an electron emitting material and a heater for said cathode.

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