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COLD CATHODE FOR ELECTRIC VACUUM TUBES

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Fig. 1.

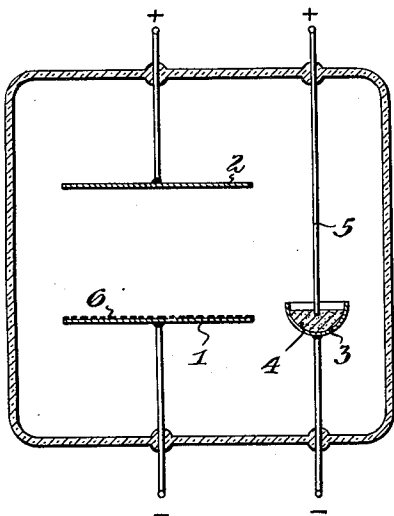


Fig. 2.

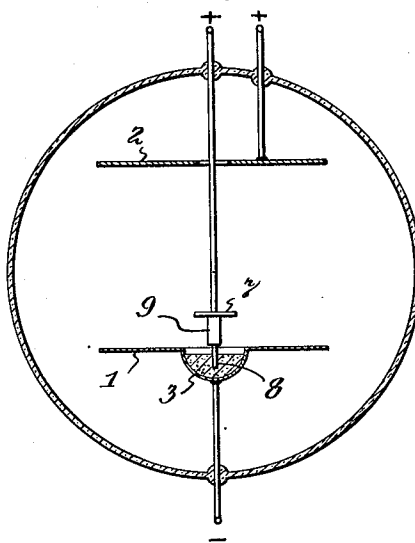


Fig. 3.

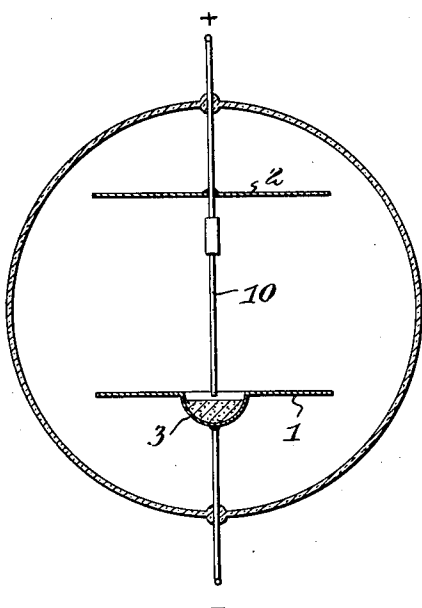
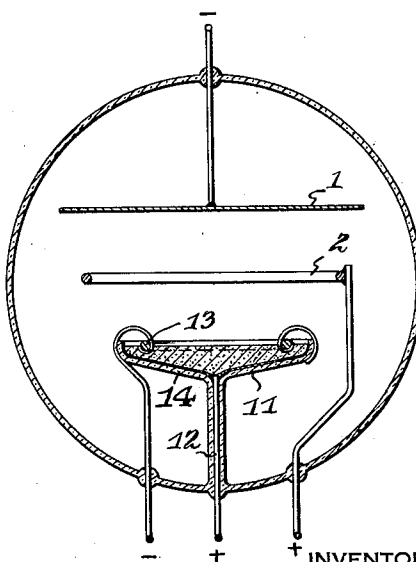


Fig. 4.



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COLD CATHODE FOR ELECTRIC VACUUM TUBES

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8 Claims. (Cl. 250—27.5)

My invention relates to discharge devices, and especially to a cold cathode for an electric vacuum tube.

An object of my invention is to provide a cold cathode for a vacuum discharge tube that will give off appreciable currents of electrons even with low voltages.

Other objects and advantages of my invention will be apparent from the following description and drawing, in which:

Fig. 1 is a cross-sectional view of an electrode assembly embodying my invention.

Figs. 2, 3 and 4 are cross-sectional views of modifications of the electrode assembly of Fig. 1.

The invention consists of a cold cathode for electrical discharge tubes. It is known that a large number of materials, such as metals, give off electrons while cold, if the electrons are freed from the cathode by the action of a high field strength at the cathode. However, the streams of electrons which can be produced in this manner are extremely small, if the voltage of the electrode is not raised to a very high value. The purpose of this invention is to form a cold cathode of such a type that it will give off appreciable currents of electrons even with low voltages, and consequently it is suited for practical application where existing types of cold cathodes could scarcely be considered.

There have already been many efforts to improve the emission characteristics of cold cathodes and they have met with a certain degree of success. For example, it is known that one can obtain an appreciable emission from a cold cathode even with low voltages, if the metallic body of the cathode is covered with a thin insulating layer and this is bombarded with electrons from a suitable source of electrons. The bombardment must take place during the entire time of operation, or otherwise the high emission characteristics quickly disappear. Even if one succeeds in increasing the ability of a cold cathode to emit electrons by the described method, the increase in the electron stream is not sufficiently great to make this cold cathode the practical equivalent of other hot cathodes. Moreover, these cathodes deteriorate rapidly in service. In addition to this, there are certain difficulties in maintaining the electron bombardment of the insulating covering continuously during the entire operating period, even neglecting the power loss which accompanies such supplementary measures.

The invention consists of a cold cathode for which steps have been taken to reduce apprecia-

bly the operating voltages, so that for anode currents of the same value as in the conventional hot cathode tubes, the tube requires the same anode voltage as that used for these hot cathode tubes. In accordance with this invention, means are provided for placing positively charged insulating particles on the outer surface of the cathode at least at the beginning of the discharge for the purpose of starting and increasing the emission of electrons of an electrical discharge tube having a cold cathode. The insulating particles are preferably very finely divided and it has been determined that the emission from the cathode is specially good and uniform if the insulating particles cover the body of the cathode in a thin, even layer. Various methods are available for placing the charged insulated particles on the outer surface of the cathode. For example, one can charge the insulating particles in some part or other of the tube by the action of an electric field and then transport them to the cathode by electrostatic attraction, through electric forces. It is also possible to load the particles with a positive charge on some other electrode, for example, an auxiliary electrode, by energizing this electrode, and then to let them go to the outer surface of the cathode under the action of some mechanical force, for example, by making use of inertia. If occasion should arise, it is also possible to bring the particles in an uncharged condition to the surface of the cathode and to impart to them there a positive charge before the starting of the main discharge. This can be accomplished for example by first charging the cathode positively and then connecting it to a source of negative voltage.

An arrangement in accordance with this invention has special advantages for high vacuum tubes, since now for the first time by means of this new art of treating or of operation of the cold cathode it is possible to take continuously high values of electron streams out of the cathode with a low operating voltage without the necessity of utilizing some type or other of auxiliary means for the sustaining of the conductivity of the cathode.

The covering of the cathode with the positively charged particles by means of electric forces can be accomplished in a specially advantageous and simple manner. For example, an auxiliary container filled with the pulverized insulating material can be brought into the vicinity of the cathode. The pulverized insulating material is in contact on one side with a negative electrode; on the other side are either one or more positive

electrodes which either extend very close to the pulverized material or actually into it, without, however, touching the negative electrode. This auxiliary container with its arrangement of electrodes serves to activate the cathode, that is, to change it to a condition in which it is able to give off large electron streams even with low anode voltages. The activating takes place in the following manner: on the upper electrode, which reaches into the vicinity of or actually into the insulating material, is applied a voltage which (as has been implied) is positive with respect to the negative electrode, which extends preferably from below upward into the auxiliary container. When this is done an interesting effect is obtained; the pulverized insulating material is sprayed out of the container in fine particles and these particles are precipitated on the outer surface of the cathode. As tests have shown, the cathode is thus activated. After a very short time, during which the cathode is treated in this manner, the cathode is able to emit even in a high vacuum at a low anode voltage, a disproportionately large stream of electrons, as compared with what could previously be obtained with cold cathodes. How the phenomenon takes place within the insulating material is not yet quite clear. There is no doubt, however, that the fine particles of the insulating material, which are sprayed out of the container, are positively charged and therefore are attracted by the negatively charged cathode and are repelled by all of the positively charged parts within the tube, including also the positively charged auxiliary electrode. The positive auxiliary electrode if suitably designed can also assist, by its repelling force, in driving the particles of insulating material to the cathode. The action of the thin surface coating of positively charged particles on the metallic plate of the cathode is evidently traceable to the formation of a high field strength over the cathode surface as a result of this coating and electrons are emitted from the cathode metal because of this high gradient.

The dusting on of the insulating material need take place for only a very short time, until the cathode is able to deliver a relatively strong stream of electrons with a low voltage applied. This occurs, as already mentioned, in an extremely short time. Then it is possible to remove the positive voltage from the auxiliary electrode and the discharge, after the initiating treatment of the cathode, will sustain itself continuously at the same magnitude with a low voltage applied. The auxiliary container with its system of electrodes is therefore in action for only a very short time, namely at that time when the discharge is to be started. Naturally, it is possible to continue the described activating of the cathode during the operating time of the tube; however, as previously stated, this is in no way necessary. The action of a device made according to this invention is independent of the gas or vapor pressure existing in the discharge vessel and is present in full magnitude in the best high vacuum.

With a tube made in accordance with this invention, it is possible to produce an anode current having a current density over the entire surface of the cathode of, for example, 100 milliamperes per square centimeter when an anode voltage of from 60 to 300 volts is applied. A heavy emission of this type sustains itself without an auxiliary means after the discharge has once changed from the starting or igniting form

into the stable discharge form with low voltage.

A still further improvement in the emission can be obtained, if one does not apply the insulating material layer directly to the metallic surface forming the cathode, but first covers this outer surface of the electrode with a fine layer of a material which reduces the energy required to free electrons from the surface, for example with cesium.

It is often advantageous to have a rough surface on the cathode which is to be covered with insulating material. Materials of very different natures are suitable to be used as the insulating material for activating the cathode; for example: aluminum-oxide, magnesium oxide, and powdered glass. The insulating material should be finely ground when placed in the auxiliary container. The size of the particles which deposit on the cathode surface has been found to be 0.1μ to 10μ in experimentally tested tubes.

The invention is shown schematically in Fig. 1. The cold cathode is designated by 1, the anode by 2. The auxiliary container is 3 and contains the pulverized insulating material 4. The auxiliary container in this case is metallic and is connected with the negative pole of a constant potential source such as direct current. The positive pole of this voltage source is connected to the electrode 5 which extends into the pulverized insulating material. It is sufficient to so arrange this electrode that it ends a little above the supply of material 4.

The initiating of the discharge phenomena occurs, as has already been mentioned, by making the electrode 5 positive with respect to the container 3. In a short time, the freeing of positively charged particles, as described above, begins from the auxiliary container 3 and these particles travel to the surface of the cathode 1 and there form a thin layer 6. The anode voltage can be applied simultaneously with the application of the auxiliary voltage. After a short dusting of the cathode 1 with the insulating material, a heavy stream or current of electrons begins to pass from the cathode to the anode. It is then possible to remove the auxiliary voltage and thereby put the igniting device out of action. The heavy current discharge, which has been produced in the described manner, then sustains itself without any auxiliary means.

Fig. 2 shows another form of the invention. In this one too the cathode is designated by 1 and the anode by 2. The auxiliary container 3 is in this case arranged in the middle of the cathode. The auxiliary container and the cathode have in this construction a common current path. The auxiliary electrode in this case is made in a special manner, namely, it consists of a part of the electrode 7 which is located outside of the insulating material, and a part 8 which extends into the insulating material and which is connected by a poor conductor 9 with the part 7. It has been shown that in this manner the forming of the cathode with the help of the charged particles of insulating material takes place faster.

Fig. 3 shows a simplified form of this invention. In this form the anode 2 is connected directly with the auxiliary electrode 10, which ends close to the supply of the insulating material without actually penetrating into it. It is possible to permit the auxiliary cathode to actually extend into the supply, and to place a resistance in the line leading to the cathode, that is, between the cathode and the anode.

A very advantageous form of the invention,

which has proved to be of good practical value, is shown in Fig. 4. The insulating material in this arrangement is stored in an insulating container 11, which has on its inner surface a conducting layer or coating 14 (for example, of aquadag), which preferably does not extend to the rim of the container. The connection of this inner coating with the source of constant direct current voltage is accomplished by means of the fused-in conductor 12. The auxiliary electrode is made in this case as a ring 13, which lies by or in the pulverized insulating material. The cathode 1 is a plate located facing the auxiliary container. The anode 2 is made in the form of a ring and is located between the plate 1 and the auxiliary grid 11 and has a diameter which is greater than that of the auxiliary container. A special arrangement of the anode which in no manner hinders the formation of the discharge, has the advantage, with suitable dimensioning, of grouping the positive particles with the result that they are distributed in a more uniform manner on the surface of the cathode. Of course, a single auxiliary container and its auxiliary electrode system can be used for activating several cathodes if the proper arrangement of electrodes is provided, so that with respect to the development and form of the cathode, one is by no means bound to a special type, for example, to the plate type which has been described in explaining this invention.

Although I have shown and described specific embodiments of my invention, I do not desire to be limited thereto, as various other modifications of the same may be made without departing from the spirit and scope of the appended claims.

I claim:

1. A discharge device comprising an anode, a cathode and small positively charged particles on the surface of said cathode.

2. A discharge device comprising an anode, a cathode, small insulating particles on the surface of said cathode and means for positively charging said small particles.

3. A discharge device comprising an anode, a cathode, small particles in said device, means for positively charging said particles and means for placing said particles on said cathode.

4. The method of initiating a discharge in a discharge device having an anode and cathode, which comprises positively charging small particles, placing said particles on the cathode and applying voltage to the anode and cathode.

5. The method of initiating a discharge in a discharge device having an anode and a cathode, which comprises placing small particles on the cathode, positively charging said small particles and applying a voltage to the anode and cathode.

6. A discharge device comprising an anode and a cathode, an auxiliary container in proximity to said cathode, small insulating particles in said container and a positive electrode terminating at said small insulating particles.

7. A discharge device comprising an anode, a cold plate cathode and small particles from the group of aluminum oxide and magnesium oxide on said cathode.

8. A discharge device comprising an anode, a cold plate cathode and small particles from the group of aluminum oxide and magnesium oxide on said cathode, said particles being positively charged.

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