Aug. 30, 1938. H. J. SPANNER ET AL 2,128,270

LIGHTING DEVICE

Filed March 30, 1929 2 Sheets-Sheet 1

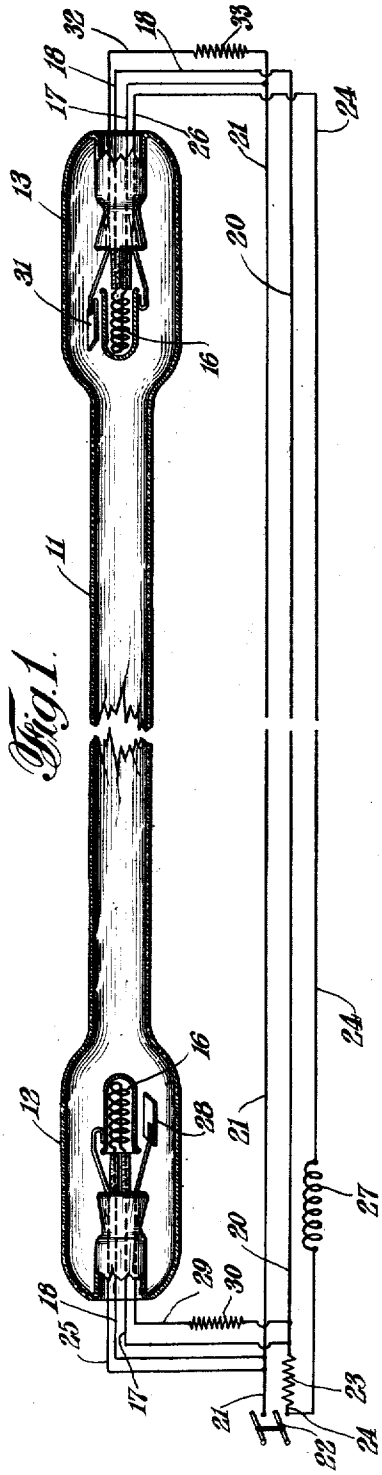


Fig. 1.

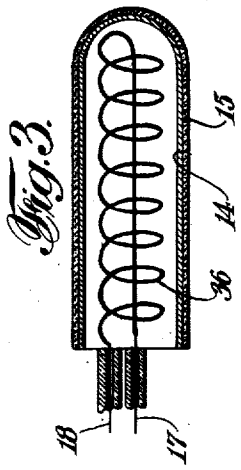


Fig. 3.

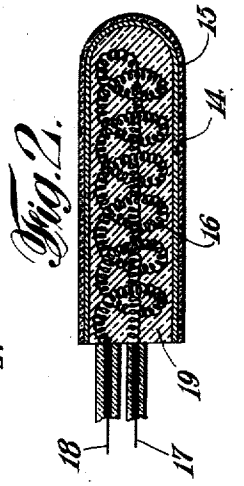


Fig. 2.

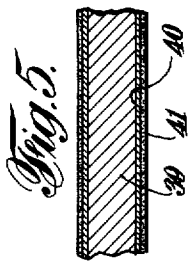


Fig. 5.

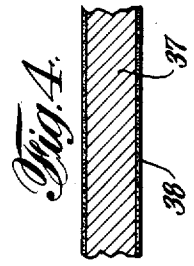


Fig. 4.

INVENTOR
Hans J. Spanner
BY Ulrich Doering
Edwards, Bowen & Cook
ATTORNEY

Aug. 30, 1938. H. J. SPANNER ET AL 2,128,270

LIGHTING DEVICE

Filed March 30, 1929 2 Sheets-Sheet 2

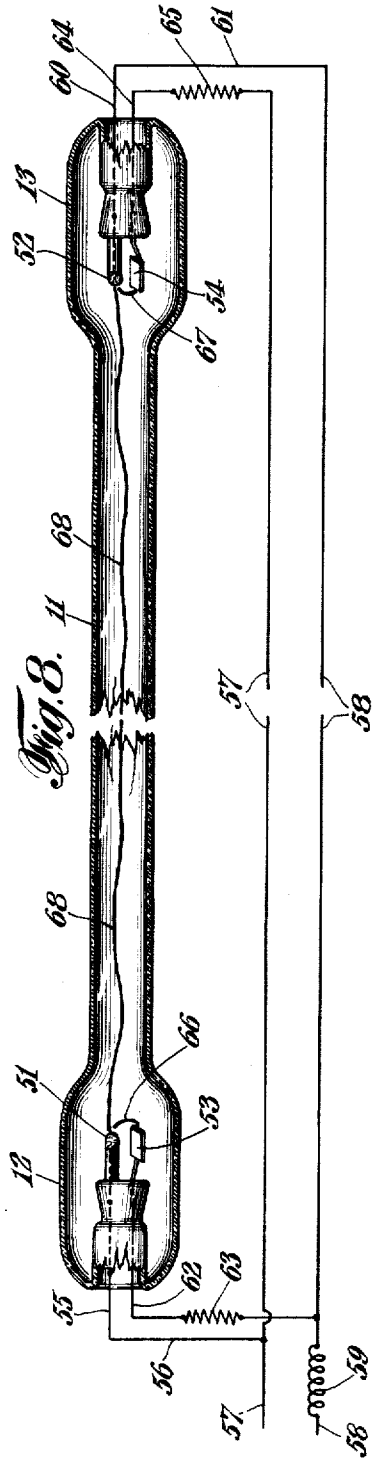


Fig. 8.

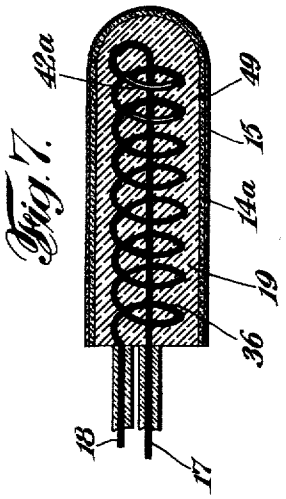


Fig. 7.

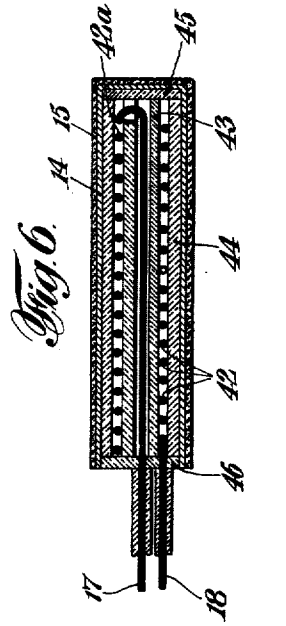


Fig. 6.

INVENTOR
Hans J. Spanner
BY Ulrich Doering
Edwards, Bowes & Dorr
ATTORNEY

Patented Aug. 30, 1938 2,128,270

UNITED STATES PATENT OFFICE

2,128,270

LIGHTING DEVICE

Hans J. Spanner, Berlin, Germany, and Ulrich Doering, New York, N. Y., assignors, by mesne assignments, to said Hans J. Spanner

Application March 30, 1929, Serial No. 351,368
In Germany April 30, 1928

13 Claims. (Cl. 176—122)

This invention relates to gaseous discharge devices and more particularly to gaseous discharge illuminating devices adapted to furnish either or both visible and ultra-violet radiation by a luminous electrical discharge from a hot cathode.

Heretofore tubes of the type commonly known as "neon" or gaseous discharge tubes have employed an electrical discharge through a tube filled with an inert gas such as neon. In such tubes the discharge usually takes place between cold electrodes and is characterized by a high voltage drop which takes place near the cathode and is called the cathode drop. These tubes require a very high voltage which, as stated, is largely consumed in the cathode drop, which high voltage is in itself capable of supporting and maintaining the discharge. Inasmuch as in such tubes the discharge provides its own ions it can be readily understood that the discharge is extremely sensitive to slight changes in gas pressure, impurities contained in the gas, and so forth. The high voltage required is also a disadvantage because of the extra cost of the high voltage transformer required and because of the personal hazard involved when such high voltages are brought onto the premises of the ordinary customer of the lighting company. Furthermore the high voltage cathode drop produces a high velocity of the ions within the tube and the resulting ionic bombardment of the cathode disintegrates it and the tube consequently has a short life.

Oxide coated cathodes both filaments and indirectly heated sleeves, etc., have been commonly used in radio tubes and the effect of the oxide coating to activate or increase the electron emission of the heated cathode is well known. It has also been suggested to use cathodes of this type in gaseous discharge tubes, but this has not been considered satisfactory because of phenomena such as ion bombardment which occur in gaseous discharge tubes but are not encountered in vacuum tubes such as thermionic valves.

One object of our invention is to provide in gaseous discharge tubes operating at widely different gas pressures and with rare gases or metal vapors or both, and with various current inputs, a thermionic cathode which will give full advantage of the activation with an electron emitting material, but which, unlike other devices of this nature known prior to our invention, will maintain its desirable characteristics over a long useful life.

Another object of our invention is to provide a device of the character described in which the electrode drop is so far reduced by activation that the device may be operated by direct connection to a low voltage distributing circuit.

Another object of the invention is to simplify the construction and operation of devices of the character described by the elimination of the necessity for heating transformers and even by the entire elimination of heating circuits.

Other objects and advantages of our invention will be apparent to those skilled in the art from the following description and drawings.

In the accompanying drawings we have shown a preferred embodiment of our invention and various modifications thereof which we have chosen with a view to explaining the principles involved in our invention and the method of applying them to practical use. These, of course, are not to be taken as limiting, but merely illustrative of our invention.

Fig. 1 is a longitudinal section of a lighting tube, the external connections thereof being shown in diagrammatic form;

Fig. 2 is an enlarged section of one of the cathodes of the tube shown in Fig. 1;

Fig. 3 is an enlarged section of another form of cathode;

Fig. 4 is an enlarged longitudinal section of the cathode filament as used in another form of the invention;

Fig. 5 is an enlarged longitudinal section of still another form of a cathode filament;

Fig. 6 is a detailed sectional view of another cathode employing a different form of insulation;

Fig. 7 is a detailed sectional view of still another form of cathode; and

Fig. 8 is a sectional view of another form of gas discharge lighting device, the external connections being shown in diagrammatic form.

A suitable container or tube for the gaseous discharge is shown at 11 and has enlarged portions 12 and 13 at each end for the reception of electrodes. This tube may be of ordinary glass or if it is desired to make use of the ultra-violet radiation it may be of quartz or suitable material which permits the ultra-violet rays to pass through, or special effects may be attained by the use of colored or fluorescent material such as lead glass, glass with an addition of scandium or with varnishes of fluorescent materials. The tube may be filled with a rare gas or a gas or vapor of a chemically inert substance such as mercury vapor. Or preferably an inert gas and a metal vapor are used together, the gas serving to provide a medium for carrying the initial discharge when the device is started and the mer-

cury vapor becoming available after starting as the heating of the initial discharge vaporizes the metal.

The detailed construction of one of the electrodes which is specially adapted for use as a cathode in such a lighting tube is shown in Fig. 2. The complete tube illustrated in Fig. 1 is shown connected to an alternating circuit and therefore each electrode is of this special form. It should be understood that when used on a direct current circuit it is only necessary to have one electrode in this special cathode form and the other electrode or anode may be constructed of graphite or other suitable material.

The reference character 14 indicates an inclosing shell which may be cylindrical in form and may be one of the metals which form amphoteric oxides. As illustrative of the class of compounds known as amphoteric oxides may be mentioned aluminum oxide, zirconium oxide, nickel oxide, iron oxide, copper oxide, cobalt oxide, and chromium oxide. On this shell 14 as a support may be provided a layer 15 of highly emissive material whose electrons' work function is less than three volts and which does not attack the glass of the container, such as barium, strontium, calcium, or thorium, or some compound thereof such as an oxide, carbide or silicide. A layer of the amphoteric oxide may advantageously lie between the metal base and the activating surface mass. The nickel, or other material, of the shell diffuses slowly through the barium in the form of an amphoteric oxide and tends to prevent the too rapid dissipation of the barium. Instead of the coating on a metal which forms an amphoteric oxide, a coating may be used which is a mixture of an emissive substance such as barium oxide, with an amphoteric compound such as aluminum oxide, zirconium oxide or nickel oxide. The amphoteric oxides unite with the emissive oxides to form compounds such as barium aluminate, barium zirconate, barium nickelate, and so forth.

The emissive material may also with advantage be distributed throughout the body of the cathode so that the emissive substance, as it is slowly released by heating and action of the discharge, may diffuse to the outside of the cathode and become effective.

A cathode constructed as indicated above is particularly suitable for use because it is resistable to ion bombardment and is not subject to mechanical disintegration by crumbling away. By the above means such highly emissive substances as caesium and rubidium have been satisfactorily used for the cathode material which were impossible to use heretofore because of their disassociation tendency, vapor pressure, and so forth.

The materials used for their emissive properties may be used as oxides and because of improved ignition and reliability they may also be used in the form of such compounds as hydrides, nitrides, cyanides, azides, and so forth, which decompose by heating and free the metal. The metal is held by the amphoteric oxide probably by ejecting some of the aluminum, nickel, and so forth, or by forming so called complex compounds, e. g. by means of additional valences.

Within the shell 14 there may be provided a separate heating element which as shown is in the form of a double helix 16 of wire with which are connected two leading-in terminals 17 and 18. The space within the shell 14 not occupied by the heating element may be filled with electrical insulating material 19. By thus inclosing the heating element and shielding it from the space in which the gaseous discharge takes place it is possible to operate the filament at a higher voltage such as directly from the line without in any way affecting the gaseous discharge. With such higher voltages the selection of the proper insulating materials becomes a matter of considerable importance.

Heretofore quartz has sometimes been used but is open to the objection that it will combine with tungsten at the higher temperatures to form tungsten silicate with the result that the tungsten is gradually eaten away. Another objection to quartz as well as to certain other materials is that at red temperatures there takes place electrolytic current flow because of the sodium or potassium ions which are always present. To some extent magnesium either in the form of oxide or in the form of steatite has been used. This also is open to the objection that it attacks tungsten chemically and moreover its resistance falls off rapidly at the higher temperatures.

Besides the requirement that there shall be little or no electrolytic current flow or actual movement of ions it is also necessary that the metallic or electronic conductivity shall be low. In general, electronic conductivity is inversely proportional to the electrons' work-function.

Materials which are particularly adapted for use in accordance with the above requirements are compounds, especially oxides of zirconium and beryllium and also of pure aluminum and scandium. Furthermore, the oxide of beryllium and zirconium have a very high melting point and remain chemically quite indifferent to such materials as are used for filaments and heating elements. These materials may be used as a powdered mass and they may also be used by being sprayed on the heating body and filament and thereafter sintered at a temperature at about 2000° centigrade so as to form a covering or enamel on the wire.

Referring again to Fig. 1 the terminals 17 and 18 of the filament 16 are connected to conductors 20 and 21. The conductor 21 is connected directly to one terminal of a line switch 22 and the other conductor 20 is connected through a resistance 23 to a conductor 24 which is connected to the other terminals of the switch 22. The shell of one of the cathodes is connected through a terminal 25 to the conductor 21 while the shell of the other cathode is connected through a terminal 26 to the conductor 24. The conductor 24 may have connected in its circuit an inductance coil 27 which limits the current passing through the gaseous discharge path between the two electrodes. The cathode connected to the conductor 21 has positioned adjacent thereto an auxiliary anode 28 which anode has a terminal 29 which is connected through a high resistance 30 to the conductor 20. Likewise the cathode connected to the conductor 24 has positioned adjacent thereto an auxiliary anode 31 which has a terminal 32 connected through a high resistance 33 to the conductor 21.

In operation the switch 22 is closed and the current passes through the resistance 23 and into the terminals 17 and 18 of both cathodes and heats the emissive material on the cathodes. When the temperature on the cathodes is sufficiently high and the rate of emission is sufficiently great a gaseous discharge starts between the auxiliary anode 28 and the cathode adjacent thereto and also from the auxiliary anode

31 and the cathode adjacent thereto. Because of the high resistances 30 and 33 in series with these auxiliary anodes the current flow to the auxiliary anodes is limited and the discharge is transferred for the most part to the gaseous path between the main electrodes.

Because of the emissive materials on the cathodes there is no so-called cathode drop and the tube operates on the ordinary voltages of a distribution circuit such as 110 volts or 220 volts. The use of the amphoteric oxides or materials capable of forming such amphoteric oxides prevents the cathode from disintegrating rapidly and results in a tube having a longer life than has heretofore been possible with gaseous discharge devices having a hot cathode.

The form of cathode shown in Fig. 3 is somewhat similar to that shown in Fig. 1. The heating element 36, however, is in the form of a single helix instead of a double helix as in Fig. 1. The resistance of a heating element of this form is less than that of a double helix and it is more adapted to carry heavy currents at lower potentials across its terminals. With such lower potentials across its terminals it is not so likely to interfere with the current distribution of the gaseous discharge in the neighborhood of the cathode and if the potential is sufficiently low the filling of insulating material may be omitted.

Fig. 4 shows a filament which acts both as a cathode and as a carrier for the current used for heating the cathode. A support 37 of nickel or some material adapted to form an amphoteric oxide is coated with a layer 38 of a highly emissive material such as barium oxide. Such a construction is particularly adapted for use where a low voltage is used for heating the filament.

In Fig. 5 a supporting core 39 is covered with an intermediate layer 40 of an amphoteric oxide which in turn is covered with a layer 41 of a highly emissive material. The layer 40 of amphoteric material may be used in metallic form in which case the core may be plated with the metal in question. The core in such cases may be of tungsten, platinum, or molybdenum. When the core is plated with a metal suitable for forming an amphoteric oxide it is desirable to oxidize the surface so that thin but even and cohesive coatings may be obtained.

In Fig. 6 the metal shell 14 has an external emissive layer 15 and has positioned therewithin a helix 42 of wire which provides the initial heating of the cathode. The helix 42 is wound on a hollow cylinder 43 of insulating material such as zirconium or beryllium oxide. The leading-in wire 17 is carried through the interior opening of the cylinder 43 and is connected to one terminal of the helix 42. The other leading-in wire 18 is connected to the remaining terminal of the helix. A second hollow cylinder of insulating material 44 surrounds the helix 42, and disks 45 and 46 are positioned at the ends so that the coil of helix 42 is substantially inclosed although not gas tight. In making these preformed pieces of insulating material such as cylinders, tubes, disks, etc., the substances may be ground in a colloid mill, then small amounts of acid and water added thereto to form a paste. After the paste has been given a suitable form it is then burned at a temperature somewhat higher than usually required for porcelain, clay, and so forth, a temperature of about 2200° centigrade being suitable. It may also be desirable to furnish the filament of the helix 42 with a protecting surface layer as indicated at 42a in Fig. 6. This layer may be an oxide or a nitride which may be formed by bringing the filament to an incandescent temperature in an atmosphere of nitrogen or air. Similar protection can also be obtained by a covering or layer of the boride of the core metal.

In Fig. 7 the emissive material is shown embedded as at 49 in the body of the supporting shell 14a and a thin layer of emissive material is also provided as at 15. In Fig. 8 electrodes 51 and 52 are provided which have no internal means for heating the cathode but are dependent entirely upon the heating received from the gaseous discharge, either from the main discharge or from auxiliary electrodes to be presently described. Each electrode 51 and 52 has positioned adjacent thereto auxiliary electrodes 53 and 54 respectively. A leading-in wire 55 for the electrode 51 is connected by means of a conductor 56 to one of the conductors 57 of a supply circuit. The other conductor 58 of the supply circuit is connected through an inductance coil 59. A leading-in wire 60 for the electrode 52 is connected by means of a conductor 61 to the conductor 58 from the supply circuit. A leading-in wire 62 for the auxiliary electrode 53 is connected through a high resistance 63 to the conductor 58 from the supply circuit and similarly a leading-in wire 64 from the auxiliary electrode 54 is connected through a resistance 65 to the conductor 57 of the supply circuit.

Referring to Fig. 8, when the tube is first put into operation, by closing the switch which connects the supply lines, the electrical potential is only sufficient to start an auxiliary discharge between the main electrode 51 and the auxiliary electrode 53, as indicated at 66, and a similar discharge as indicated at 67. These auxiliary discharges gradually heat the electrodes 51 and 52 until the main discharge takes place as indicated at 68.

By the foregoing means a device has been obtained which has electrodes specially adapted for use in a gaseous discharge tube for either lighting or ultra-violet radiations. A reasonable long life is obtained, the operation is rendered simple, and the connections may be made directly from the supply line and the heating filament can also be directly connected to the supply line without employing a transformer. The electrodes can be built in any desired size which means that it is possible to operate such tubes or lamps with rare gases or metal vapors at different gas pressures and with different amperes input without noticeable disintegration, inactivation, or burning out by uneven action of the gaseous discharge on the heated cathode.

We claim:

1. A radiant electrical discharge device which comprises an envelope permeable to at least a part of the radiation from the discharge, an ionizable filling adapted to carry said discharge, a plurality of electrodes permanently spaced apart therein at least one of which serves as a cathode and has an activating mass comprising free metal of the electropositive group Ba, Sr, Ca, Cs, Rb and a refractory insulating material.

2. A radiant electrical discharge device which comprises an envelope permeable to at least a part of the radiation from the discharge, an ionizable filling adapted to carry said discharge, a plurality of electrodes permanently spaced apart therein at least one of which serves as a cathode and has an activating mass comprising a material of the electropositive group Ba, Sr, Ca, Cs, Rb and a refractory insulating material, all

given strength and resistance to disintegration under ionic bombardment by heating and a part of the material of the electropositive group is free metal and a part is combined in a compound adapted to be slowly reduced by the action of the discharge whereby to serve as a reservoir of the activating metal.

3. A radiant electrical discharge device as defined in claim 1 in which the refractory insulating material comprises a refractory oxide partially combined with the activating metal of said electro-positive group.

4. A radiant electrical discharge device as defined in claim 1 in which the refractory insulating material comprises a silicon compound.

5. A radiant electrical discharge device as defined in claim 1 in which the refractory insulating material comprises a refractory oxide of the group zirconium oxide, aluminum oxide.

6. In an electrical discharge device an indirectly heated cathode having a conducting member forming the cathode proper and a heating element and insulation between them consisting essentially of at least one of the pure oxides of the group beryllium oxide, zirconium oxide, scandium oxide, aluminum oxide.

7. In an electrical discharge device an indirectly heated cathode as defined in claim 6 in which the insulating oxide material is in the form of a sintered mass intimately fitting on the heating element.

8. In an electrical discharge device an indirectly heated cathode as defined in claim 6 in which the insulating oxide and the heating element are separated by a protective layer of a material of the group, nitrides and borides of the metals of the heating element.

9. The method of activating an electrode which comprises coating it with a refractory amphoteric oxide and a compound of an electropositive metal with a reducing ion constituent, mounting said electrode in a discharge tube, evacuating said tube and decomposing the compound of the electropositive metal by heating.

10. The method as defined in claim 9 in which the surface of the electrode on which the activation is applied comprises a metal which forms an amphoteric oxide and is oxidized to form such amphoteric oxide before the compound of the electropositive metal is applied.

11. The method of activating an electrode which comprises coating it with an activation material including a hydride of a strongly electropositive metal, mounting it in a discharge tube, evacuating the tube and heating the electrode to decompose the hydride at least partially.

12. The method of activating an electrode which comprises coating it with an activation material including a silicide of a strongly electropositive metal, mounting it in a discharge tube, evacuating the tube and heating the electrode to decompose the carbide at least partially.

13. The method of activating an electrode which comprises coating it with an activation material including a silicide of a strongly electropositive metal, mounting it in a discharge tube, evacuating the tube and heating the electrode to decompose the silicide at least partially.

HANS J. SPANNER.
ULRICH DOERING.

CERTIFICATE OF CORRECTION.

Patent No. 2,128,270. August 30, 1938.

HANS J. SPANNER, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 24, claim 12, for the word "silicide" read carbide; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of October, A. D. 1938.

Henry Van Arsdale

(Seal) Acting Commissioner of Patents.

given strength and resistance to disintegration under ionic bombardment by heating and a part of the material of the electropositive group is free metal and a part is combined in a compound adapted to be slowly reduced by the action of the discharge whereby to serve as a reservoir of the activating metal.

3. A radiant electrical discharge device as defined in claim 1 in which the refractory insulating material comprises a refractory oxide partially combined with the activating metal of said electro-positive group.

4. A radiant electrical discharge device as defined in claim 1 in which the refractory insulating material comprises a silicon compound.

5. A radiant electrical discharge device as defined in claim 1 in which the refractory insulating material comprises a refractory oxide of the group zirconium oxide, aluminum oxide.

6. In an electrical discharge device an indirectly heated cathode having a conducting member forming the cathode proper and a heating element and insulation between them consisting essentially of at least one of the pure oxides of the group beryllium oxide, zirconium oxide, scandium oxide, aluminum oxide.

7. In an electrical discharge device an indirectly heated cathode as defined in claim 6 in which the insulating oxide material is in the form of a sintered mass intimately fitting on the heating element.

8. In an electrical discharge device an indirectly heated cathode as defined in claim 6 in which the insulating oxide and the heating element are separated by a protective layer of a material of the group, nitrides and borides of the metals of the heating element.

9. The method of activating an electrode which comprises coating it with a refractory amphoteric oxide and a compound of an electropositive metal with a reducing ion constituent, mounting said electrode in a discharge tube, evacuating said tube and decomposing the compound of the electropositive metal by heating.

10. The method as defined in claim 9 in which the surface of the electrode on which the activation is applied comprises a metal which forms an amphoteric oxide and is oxidized to form such amphoteric oxide before the compound of the electropositive metal is applied.

11. The method of activating an electrode which comprises coating it with an activation material including a hydride of a strongly electropositive metal, mounting it in a discharge tube, evacuating the tube and heating the electrode to decompose the hydride at least partially.

12. The method of activating an electrode which comprises coating it with an activation material including a silicide of a strongly electropositive metal, mounting it in a discharge tube, evacuating the tube and heating the electrode to decompose the carbide at least partially.

13. The method of activating an electrode which comprises coating it with an activation material including a silicide of a strongly electropositive metal, mounting it in a discharge tube, evacuating the tube and heating the electrode to decompose the silicide at least partially.

HANS J. SPANNER.
ULRICH DOERING.

CERTIFICATE OF CORRECTION.

Patent No. 2,128,270. August 30, 1938.

HANS J. SPANNER, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 4, second column, line 24, claim 12, for the word "silicide" read carbide; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of October, A. D. 1938.

Henry Van Arsdale

(Seal) Acting Commissioner of Patents.