

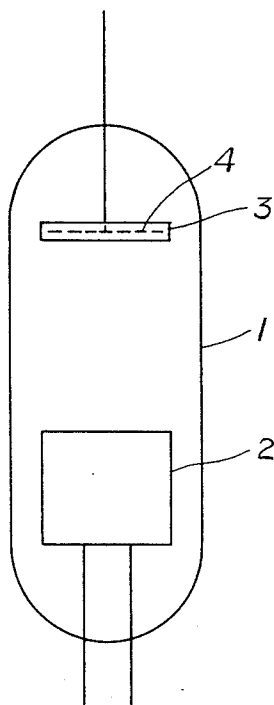
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MATERIAL FOR DISCHARGE TUBE ANODES

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MATERIAL FOR DISCHARGE TUBE ANODES

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Our invention relates to materials for anodes of discharge and like tubes, and contemplates particularly materials having advantageous characteristics for anodes in so-called "gas filled" discharge tubes.

A particular object of our invention is to provide anodes for such tubes that will not readily disintegrate under the continuous ionic bombardment that is usually necessary in the operation of such tubes; in other words to provide anodes that will have long life.

The accompanying drawing illustrates schematically a discharge tube having an envelope 1 containing an ionizable medium or atmosphere, a cathode 2, and an anode 3 which may or may not be provided with a core 4.

It has long been the practice to use metals as the anode materials in such tubes, as for example tungsten, platinum and nickel. Carbon, particularly in the form of graphite, has also found a place among the materials so used. There are however disadvantages in the use of these metals and carbon in discharge tubes, as well as in the manufacture of tubes having anodes of such materials.

The metal anodes have shown themselves to be easily disintegrated and destroyed by the impact energy of the ions of the operating discharge. Carbon presents the particular difficulty of having large capacity for the absorption of undesired gases which cannot be easily expelled by the usual de-gasing processes in the fabrication of such tubes, with the result that after the tube is in operation there is a more or less continuous expulsion of undesired gases from the carbon, so that the characteristics of the tube later change from those originally intended. If carbon anodes are successfully degased by long and laborious treatment the gas absorbing capacity will manifest itself in another undesired way, which is the absorption of large quantities of the desired gas used as a gas filling. Since in most cases it is of substantial importance to keep the gas filling pressure constant with use, this undesirable tendency of a carbon anode may be serious.

It is particularly important in discharge tubes having a gas filling and glowing cathode intended for high outputs, especially where high potentials are used in producing the high outputs, to have materials for the anodes as well as the cathodes which will not be seriously disintegrated by ionic bombardment. We have found that the principal cause of anode disintegration is not ordinary evaporation at high tem-

perature aided by low pressure, but rather the high concentration of the energy of the ionic impacts at the immediate point of impact, so that in certain materials not having sufficient capacity for disseminating this concentrated impact energy in the form of heat to surrounding parts of the anode material with sufficient rapidity to prevent the immediate point of impact from taking on a very high localized temperature there results a localized disintegration of the material. Since the process is continuous the anode under bombardment will be more rapidly destroyed than is desirable in practice.

The effect above outlined appears to be quite different from the ordinary evaporation of an anode material by heating to evaporating temperature, as for instance, by sustained electron bombardment. In the case of ionic bombardment the general content of the anode may be quite cool, that is of a temperature well below that of evaporation of the material, and yet suffer considerable disintegration; whereas in the case of the electron bombardment, the disintegration will occur only when the general content of the anode is heated to the evaporating temperature of the material.

Our investigations have shown that the disintegrating effect of ionic bombardment can be most materially lessened by the use in anodes of materials which have the ability to rapidly conduct heat from one part to another, and which heat conductivity increases with increase of temperature. In many cases materials having this characteristic will also have the characteristic of increasing electrical conductivity with temperature. It is desirable to choose materials having sufficiently high electrical conductivity when fairly cool in order that the starting potentials of the discharge tube will not be undesirably increased by high resistance.

The metals heretofore employed as anode materials, such as tungsten, platinum and nickel, have a temperature-heat conductivity characteristic the reverse of that desired, and therefore suffer rapid disintegration. The carbon, or graphite, heretofore used has a desirable temperature-heat conductivity characteristic, but has many other undesirable characteristics operating against its use as an anode, the affinity for gas being one of the most serious. It is a feature of this invention to provide materials having suitable temperature-heat characteristics, which materials do not include the gas affinity and other undesirable characteristics of carbon.

We have found that very satisfactory anode materials can be made by mixing in powdered form metals, such as tungsten or nickel, in excess quantities to increase electrical conductivity at lower temperatures, with some of the white metal oxides, such as magnesium oxide, zirconium oxide, calcium oxide, erbium oxide, strontium oxide, beryllium oxide, and thorium oxide. Some of the dark metal oxides, such as tantalum oxide or copper oxide, may with advantage be added to the mixtures.

The oxides mentioned may be replaced by metal compounds having metalloids other than oxygen, such as carbon, fluorine, nitrogen and sulphur, there being many of these capable of supplying the desired temperature-heat conductivity characteristic.

It is also possible to employ carbon as the electrical conductivity element in lieu of the metal powders when mixed with suitable compounds such as magnesium carbide, strontium carbide, and the like, which, upon heating will form chemical compounds of carbides in association with an excess of carbon.

Before the mixtures can be finally used as anodes in tubes they must be formed into suitable shapes and reduced to final chemical compounds in suitably hard and strong structures. This may be arrived at by pressing the powder mixtures into suitable shapes, the mixtures including a material which will have the property of binding or sintering the elements into a firm, hard mass upon application of heat provided the materials themselves do not inherently have this property. The sintering material will depend upon the nature of the mixture materials, and may be for instance fluorides, as barium fluoride, analogous to the carbides and oxides previously mentioned.

With or without sintering material the shaped mixtures will require heating for forming the final chemical compounds necessary to the required temperature-heat conductivity characteristic, which compounds or combinations of compounds will generally include carbides, fluorides or amphoteric compounds. The heating can be done in suitable ways, as by baking in an oven or bombardment in a tube.

In those anodes including excess metal powders to improve electrical conductivity it is likely that during operation of the tube the metal powders at the surface will be dissipated. If so the non-dissipated compounds at the surface will protect the metal powders of the inner regions so that the conductivity for electrical current is preserved, and without loss of the desirable temperature-heat conductivity characteristic at the exposed surface.

A further advantage may be obtained by including in the mixtures getter substances, such as magnesium, which will have the property of capturing and binding undesired gases contained within the final anode, and which cannot be readily expelled by the usual gas expelling processes employed in the fabrication of tubes.

In some cases it may not be desirable to form the entire anode of the mixtures or compounds, but to employ a metal core, such as tungsten, tantalum or nickel, having a coating of the mixture or compound. Such an arrangement will provide for dissipating the heat of impact from the immediate point of impact, and will protect the metal core from direct impact. At the same time the metal core will increase the strength of the structure and maintain a high order of elec-

trical conductivity for the necessary current flow.

While we have explained our invention in connection with anodes intended for long life in discharge tubes, such as gas filled discharge tubes for rectifying and like purposes, yet the advantages have application to electrodes in general, and we intend our invention to be limited only by the scope of the appended claims.

Having thus described our invention, we claim:

1. A rectifying discharge tube containing a cathode, an ionizable atmosphere and a non-emissive anode therein which, during operation of the tube, is exposed to ionic bombardment, said anode having high electrical conductivity and comprising a chemical compound having the property of increasing its heat conductivity with increase of temperature.
2. A rectifying gaseous discharge tube having non-emissive anodes which, during operation of said tube, are subjected to ionic bombardment, a cooperating electrode, and a refractory chemical compound on the surface of said anodes having the property of increasing its heat conductivity with increase of temperature.
3. A rectifying discharge tube containing a cathode, an ionizable atmosphere and a non-emissive anode therein which, during operation of said tube, is exposed to ionic bombardment, said anode comprising a mixture of chemical compounds formed into a substantially solid mass and having the property of increasing heat conductivity with increase of temperature.
4. A rectifying discharge tube containing a cathode, an ionizable atmosphere and a non-emissive anode therein which, during operation of said tube, is exposed to ionic bombardment, said anode comprising a mixture of a substance having the property of increasing its heat conductivity with increase of temperature and a powdered refractory metal.
5. An electrical discharge tube containing a cathode, an ionizable atmosphere and an anode therein which, during operation of said tube, is exposed to ionic bombardment, said anode comprising a mixture of a chemical compound having the property of increasing its heat conductivity with increase of temperature, a powdered metal and getter material.
6. A gaseous rectifier tube having a non-emissive anode which, during operation of said tube, is subjected to ionic bombardment, and a cooperating electrode, said anode comprising a core of refractory material which is electrically conductive and substantially non-gas occluding, and a coating on said core the heat conductivity of which increases with increase of temperature.
7. An electrical discharge tube comprising a cathode, an ionizable atmosphere and an anode therein which, during operation of said tube, is exposed to ionic bombardment, said anode having a core of refractory material which is electrically conductive and a coating thereon comprising beryllium oxide and tungsten.
8. An electrical discharge tube comprising a cathode, an ionizable atmosphere and an anode therein which, during operation of said tube, is exposed to ionic bombardment, said anode having a core of refractory material which is electrically conductive and a coating thereon comprising zirconium oxide, beryllium oxide and tungsten.
9. An anode comprising a core of carbon which has been rendered substantially non-gas occluding by the addition of a carbide thereto and a coating on said anode comprising a refractory

metal oxide which increases its heat conductivity with increase of temperature.

10. A rectifying discharge tube containing a cathode, a non-emissive ionizable atmosphere and an anode therein exposed to ionic bombardment, said anode including a substance having the property of increasing its heat conductivity with increase of temperature, mixed with powdered tungsten.

11. An electrical discharge tube containing a cathode, an ionizable atmosphere and an anode therein exposed to ionic bombardment, said anode being composed of carbon intermixed with a carbide of one of the metals magnesium and strontium and having a coating of a substance

which increases its heat conductivity with increase of temperature.

12. An electrical discharge tube comprising an ionizable atmosphere and cooperating electrodes therein one of which is exposed to ionic bombardment, said electrode having a metal core and a coating thereon comprising beryllium oxide. 5

13. An electrical discharge tube comprising an ionizable atmosphere and cooperating electrodes therein one of which is exposed to ionic bombardment, said electrode having a metal core and a coating thereon comprising beryllium oxide and zirconium oxide. 10

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CERTIFICATE OF CORRECTION.

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It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 2, second column, line 51, claim 6, for "ironic" read ionic; line 60, claim 7, for "ironic" read ionic; and line 63, for "berlyllium" read beryllium; page 3, first column, line 4, claim 10, for "a non-emissive" read an; and line 5, for "an" read a non-emissive; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of May, A. D. 1935.

Leslie Frazer

Acting Commissioner of Patents.

(Seal)