Sept. 14, 1948. H. F. FRUTH 2,449,113

ELECTRIC DISCHARGE DEVICE

Filed July 22, 1944

Fig. 1

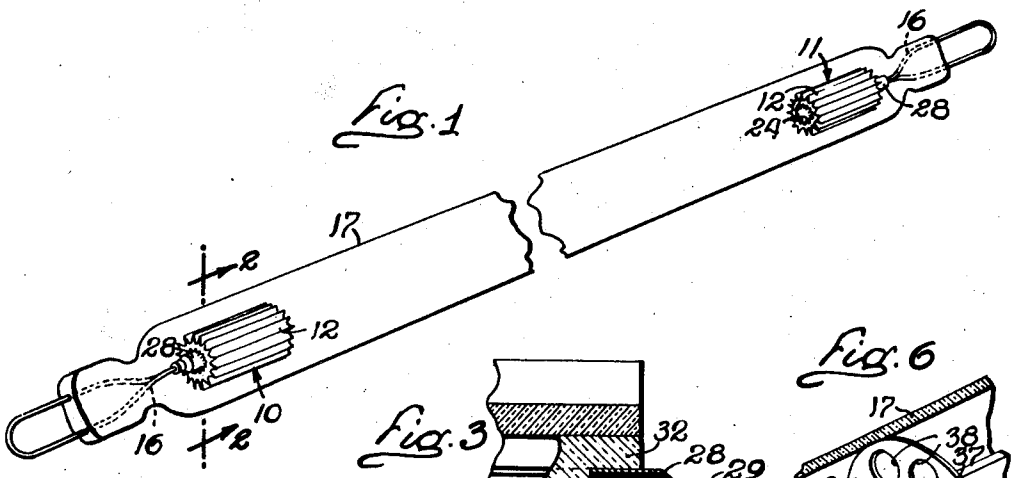


Fig. 3

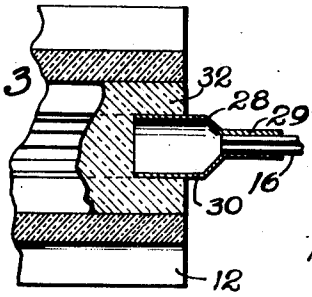


Fig. 6

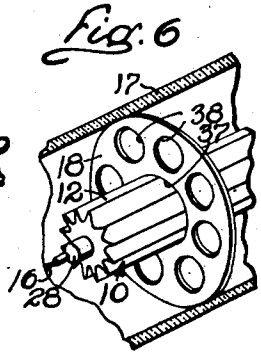


Fig. 2

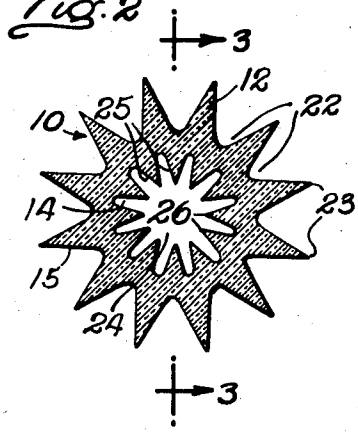


Fig. 4

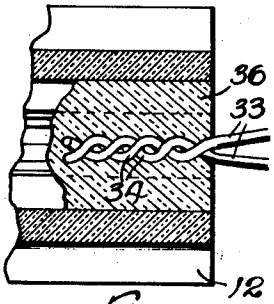


Fig. 7

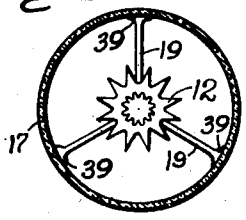


Fig. 8

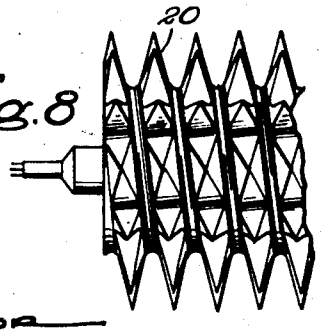
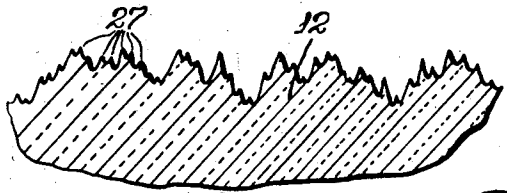


Fig. 5



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ELECTRIC DISCHARGE DEVICE

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4 Claims. (Cl. 176—126)

1

This invention relates to electrodes, and more particularly to novel electric discharge devices of the general type utilized in gaseous electric discharge tubes or other installations where the electrode is to serve as a source of electrons.

The general object of the invention is to provide an electrode of the general class indicated which achieves long life in operation, has unusually good emission characteristics, and is well suited to quantity production. In carrying out the invention, such superior characteristics are obtained by extruding or otherwise fashioning the electrode from a conductive ceramic, such, for example, as a metallic titanate, and firing the same at high temperature.

Other objects and advantages of the invention will become apparent from the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a perspective view of one type of gaseous electric discharge tube provided with an electrode embodying a preferred form of this invention.

Fig. 2 is a sectional view of a preferred form of electrode for a gaseous discharge tube or the like, such as that shown in Fig. 1, with the section taken substantially on a line 2—2 of Fig. 1.

Figs. 3 and 4 are side sectional views of electrodes, such as that shown in Fig. 2, with the section taken substantially on a line 3—3 of Fig. 2, but disclosing different forms of connections which may be made to the electrode body.

Fig. 5 is a magnified fragmentary view of a portion of the surface of an electrode such as those shown in Fig. 1.

Figs. 6 and 7 are respectively perspective and end sectional views of different forms of electrode supports adapted for use with electrodes embodying the present invention.

Fig. 8 is a fragmentary side elevational view of a modified form of electrode body.

While the invention is susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiment, but it is to be understood that I do not thereby intend to limit the invention to the specific form disclosed, but intend to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

Generally considered, electrodes 10 and 11, shown in Fig. 1, constitute a preferred embodiment of this invention, and since the two may be substantially identical, a description of one will suffice for both. These electrodes include a body 12 of conductive ceramic material generally cylindrical in form and having recessed or fluted inner and outer surfaces 14 and 15, respectively. The fluted inner and outer surfaces of the body

2

provide a large exposed surface area. Connecting and supporting leads 16 are secured and electrically connected to one end of the inner surface of the body 12 and are adapted to be sealed into a glass tube or closure 17 of a gaseous electric discharge tube. In some instances auxiliary supports of insulating material such as a mica disk 18, shown in Fig. 6, or glass beads 19 extending inwardly from the sides of the glass tube or closure, as shown in Fig. 7, are desirable to assist in supporting and steadying the electrode body within the tube. Also, when greater surface area and pointed outer projections are desired, circumferential grooves may be used to supplement the longitudinal flutes, as illustrated in the modified disclosure of an electrode 20, shown in Fig. 8.

The material of the electrode body is, generally speaking, a conductive ceramic or refractory which, when emission is desired, has an actinic or electron emitting substance added thereto. The firing of the electrode body at high temperatures after formation is desirable because it has a tendency to produce a multiplicity of sharp fine points on the electrode surface somewhat as shown in Fig. 5, and also makes the electrode hard and heat resistant.

The material and its characteristics are especially well adapted to the production by simple and inexpensive manufacturing processes of an electrode having particularly desirable electrical and discharge characteristics. That is, the material may not only be suited to the particular purpose of use by the selection of a desirable actinic or electron emitting substance, but also, the characteristics of the material adapt it to formation by convenient processes, such as extrusion to shapes having sharp or knife edges which are well suited to efficient use in gaseous electric discharge tubes.

Considering the disclosed structure in the drawings in greater detail, an exemplary form of gaseous electric discharge tube is shown in Fig. 1, and has a sealed glass container or closure 17 in which the electrodes 10 and 11 are mounted in spaced relation. This gaseous electric discharge tube may be considered to represent any one of a large variety of discharge tubes some of which utilize electron emitting electrodes, and some of which have non-emitting electrodes and are dependent upon the ionization of gas to effect a discharge. Still other varieties of such tubes incorporate a vapor or vaporizable substance within the tube to obtain the desired color or result therefrom. In this instance the electrodes 10 and 11 are similar in shape and have similar supporting structures. They may both be electron emitting electrodes, or they may both be non-emitting electrodes. In some instances also, one may be an emitting electrode and the other a non-emitting electrode. The emission characteristics of

the electrodes in this disclosure are dependent upon the material which is put into the electrode body.

As shown in Fig. 2, the outer surface of the electrode body 12 has a plurality of longitudinally extending flutes 22 shaped in such a way that they greatly increase the exposed surface area of the outer surface and provide a series of sharp longitudinally extending knife edges 23. The electrode body also has an inner opening 24 and a plurality of adjoining inner flutes 25 which greatly increase the inner exposed surface of the electrode and define a series of inner longitudinally extending knife edges 26. The sharp or knife edges on the inner and outer surfaces of the electrode improve the discharge characteristics of the electrode and reduce the potential drop at the surface of the electrode which is often referred to as the cathode drop. The flutes in the surfaces of the electrode serve to segregate thin sections, and thereby to improve the emission characteristics of an electrode which includes an emitting substance by increasing the heating of the segregated thin sections as a result of the low thermal conductivity of the ceramic.

The particular form of the electrode disclosed, which has longitudinally fluted inner and outer surfaces, is well adapted to simple and inexpensive manufacture by processes such as extrusion or molding while the ceramic material of the electrode is in a plastic state. In the extrusion of the electrodes, as is quite evident, the sectional shape is extruded and the electrode bodies are cut to the desired length. After the formation of the electrode body the firing of the ceramic material at a high temperature, for example 2500° F., produces a multiplicity of fine sharp points, such as 27 in Fig. 5, on the surface of the electrode. These points are advantageous in reducing the potential drop at the surface of the electrode and improving the emission characteristics thereof. In that connection it should be noted that the provision of points, even microscopic ones, increases the voltage gradient, as compared to that from a flat surface, thereby resulting in higher acceleration of the electrons away from the points when potential is applied between the electrodes. The fired ceramic material used is capable of operation at high temperatures without deterioration in shape, that is, blunting of the points. Consequently such material is well adapted to withstand the heating of the points on it incident to the high current density in such points and positive ion bombardment of the same. In the event that emissive material is incorporated in the ceramic, as hereinafter more particularly described, the heating of the points materially increases emission by such material. Heating of the non-deforming points is augmented here by reason of the thermal insulating character of the ceramic material of which they, together with the body from which they project, are made. Such material having a low thermal conductivity or, in other words, thermal insulating properties, it follows that the heat imparted to the points is largely trapped in them since it cannot readily flow through the ceramic material. The points are, in effect, thermally isolated from the body from which they project by reason of the shape of the points, as such, plus the low thermal conductivity of the ceramic.

In the form shown in Figs. 1 and 3, the connecting and supporting leads 16 are connected to the electrode body 12 through a connector element 28 which includes a tubular portion 29 and a connected tubular portion 30. The tubular portion 29 is preferably crimped onto and soldered to the ends of the leads 16. The larger tubular portion 30 fits into the opening 24 at one end of the electrode body. The tubular portion 30 is made secure in the opening 24, and the electrical connection between that portion and the electrode body is improved by filling the spaces between the tubular portion and electrode body with a conductive cement 32.

In the modification shown in Fig. 4, connecting leads 33 are twisted together at 34 and extend into the opening 24 in the electrode body. In this instance, again, the connecting leads are secured in place by filling the space between the twisted portion of the leads and the electrode body with a conductive cement 36. In both instances the conductive cement 32 and 36 is one which not only provides an electrical connection between the connecting leads and the electrode body, but also has the property of adhering to the electrode body and solidifying to form a firm and dependable connection. One example of a cement which is satisfactory is one composed of copper powder, copper titanate and lead borate. Silver paint is a second example of a satisfactory material and has the advantage of permitting soldering to the silvered area. A third example is a material made of graphite paste including gelatin or starch and carbonized after the application by heat treatment.

Considering more fully and completely the material of which the electrode body may be made, the conductive ceramic of which the electrode body may be made is desirably a metallic titanate. Examples of the metallic titanates suitable for the purpose of making such electrodes are iron-copper-chromium titanate, iron-copper titanate, iron titanate, copper titanate, and chromium titanate. Examples of other conductive refractories which might be used are those containing silicon carbide, copper oxide, or porcelain heavily loaded with carbon or metal powder or metallic oxides. When conductive refractories such as these are used, magnesium oxide or zirconium oxide may be added to improve the refractory qualities. The magnesium oxide has the additional advantage in some electrodes that it is an electron emitting substance. When the magnesium oxide is used in the conductive refractory material the quantity may be varied from approximately five per cent to approximately ten per cent by weight.

When it is desired that the electrode shall be one of the electron emitting type, an electron emitting substance or material is added to the metallic titanate or other conductive ceramic material. Examples of such electron emitting substances include both the metals and the oxides of barium, calcium and strontium. This group includes the alkaline earth metals. Actinic or radioactive materials which emit alpha particles, or in some instances also beta and gamma particles or rays, may also be added to the conductive ceramic material to suit a desired purpose. Such materials include polonium, thorium, radium and uranium oxide. The addition of an electron emitting substance to the conductive ceramic material, in addition to providing the emission of electrons, also reduces the potential drop at the surface of the electrode. The electron emitting material which is added to the conductive ceramic in the preferred embodiment of this invention is thoroughly inter-

mixed with the ceramic material and distributed throughout the electrode body. As a result of this thorough mixture of the electron emitting material throughout the electrode body, the material distills in an outward direction through the electrode body during use to replenish gradually the active portion of the material on the surface of the body. This feature contributes to the long effective life of the electrodes.

In the modification disclosed in Fig. 6, the auxiliary support 18 fits into the tube or closure 17 and has a central opening 37 which fits over the outer surface of the electrode body 12. This auxiliary support is made of an insulating material such as sheet mica. It is disposed between the ends of the electrode body and serves to support that electrode body from the wall of the tube. A plurality of openings 38 are provided in the support for the passage of the discharge within the tube to the exposed surfaces of the electrode.

A modified form of auxiliary electrode support is disclosed in Fig. 7. In this auxiliary support a plurality of radially extending and circumferentially spaced glass beads 19 extend inwardly from the wall of the tube 17 and engage the outer surface of the electrode body at circumferentially spaced points. Additional support for the beads 19 may be provided by dimples 39 in the wall of the tube. With this type of auxiliary support the discharge may pass between the spaced bead to the exposed surfaces of the electrode body.

In some instances, and particularly where high emission and low surface potential drop are desired, the electrode 20, shown in Fig. 8, is grooved circumferentially in addition to the longitudinal flutes to provide a large number of projecting points on the electrode surface. One satisfactory method of obtaining or making an electrode having the projecting points is to make the electrode body as previously explained, with the longitudinal flutes, and then thread the outer surface with a V-groove thread while the ceramic material is still in a plastic state but sufficiently solid to withstand the operation.

In the claims which follow, the term "cold cathode" will be understood to refer to electrodes not having a filament or similar auxiliary source of heat. As is well known to those skilled in the art cathodes of this general type become heated only by reason of the current in the discharge path.

I claim as my invention:

1. A radiation emitting cold cathode type discharge tube comprising, in combination, first and second electrodes having means for supplying current thereto, a radiation transparent envelope mounting said electrodes therein in spaced apart relation, at least one of said electrodes consisting of a homogeneous refractory ceramic material, said material being comprised predominately of a titanate having the property of conducting electricity through the body thereof even at low temperatures, said ceramic electrode having a surface which is covered by a multiplicity of microscopically fine points resulting from high temperature firing, said points giving rise to an intense potential gradient in the region thereof upon application of voltage to said electrodes to facilitate the passage of electrons therefrom at a magnitude sufficient to produce localized heating at said points.

2. A radiation emitting cold cathode type discharge tube comprising, in combination, first and second electrodes having means for supplying current thereto, a radiation transparent envelope mounting said electrodes therein in spaced apart relation, at least one of said electrodes being constructed of refractory ceramic material having the property of conducting electricity through the body thereof even at low temperatures, said ceramic electrode having a surface which includes a multiplicity of sharp outward protrusions formed thereon and giving rise to a high potential gradient in the region thereof upon application of voltage to said electrodes, said one electrode comprising a metallic titanate as its major constituent and with magnesium oxide added in minor proportion.

3. A radiation emitting cold cathode type discharge tube comprising, in combination, first and second electrodes having means for supplying current thereto, a supporting envelope mounting said electrodes therein in spaced apart relation, at least one of said electrodes being constructed of refractory ceramic material having the property of conducting current through the body thereof, said ceramic material including a metallic titanate as its major constituent, together with an added electron emitting substance comprehending actinic material of the group consisting of the oxides of polonium, thorium, radium and uranium.

4. A radiation emitting cold cathode type discharge tube comprising, in combination, first and second electrodes having means for supplying current thereto, a supporting envelope mounting said electrodes therein in spaced apart relation, at least one of said electrodes being constructed of refractory ceramic material having the property of conducting current through the body thereof, said ceramic material including a metallic titanate as its major constituent, together with an added electron emitting substance including a metallic oxide of the group consisting of the oxides of barium, calcium and strontium.

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