

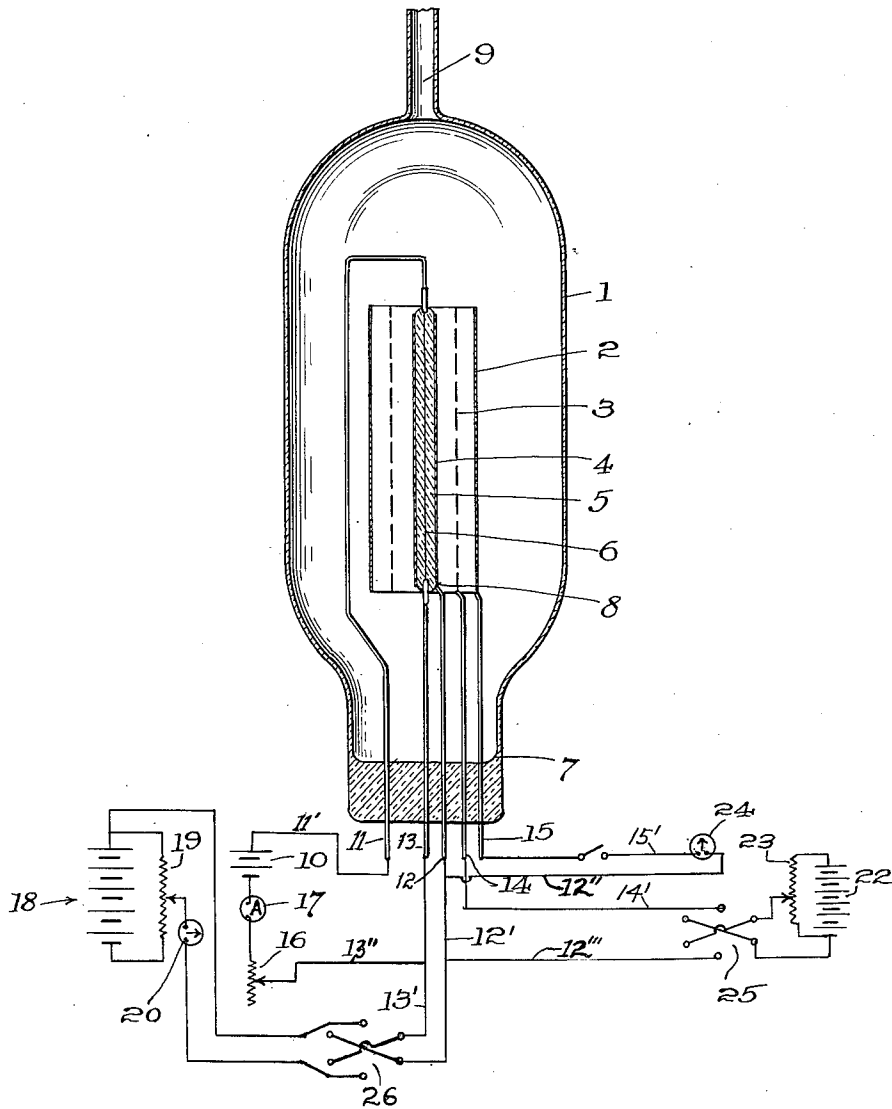
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METHOD AND APPARATUS FOR PRODUCING IONS

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INVENTOR

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UNITED STATES PATENT OFFICE

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METHOD AND APPARATUS FOR PRODUCING IONS

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(GRANTED UNDER THE ACT OF MARCH 3, 1883, AS AMENDED APRIL 30, 1928; 370 O. G. 757)

This application is made under the act approved April 30, 1928, and the invention herein described, if patented, may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

My invention consists in a novel method and apparatus for supplying and controlling the supply of volatilizable alkali metal or other ions to the active surface of an electrode discharging into gas or so-called vacuum.

It has long been known that when an ordinary metallic wire, for example, platinum, is strongly heated, especially in a suitable electric field it emits positive ions consisting for the most part of positively charged atoms of the alkali or alkali earth metals which were in the metal or on its surface as impurities. If the major metal of the wire is essentially non-volatile at the temperature employed and the amount of volatile impurity is slight, the stream of ions given off into the gas rapidly sinks in amount if the temperature is maintained constant. By definitely incorporating moderate amounts of the volatilizable material in the body of the wire an essentially uniform emission of gas ions from the metal may be insured for long periods of time if the temperature is properly controlled, but in general this rate of emission will be a function of the temperature of the wire.

It is often desirable, however, to be able to vary the rate of emission and the temperature independently, and my invention is directed in the first instance to accomplishing this result which I do by using as the gas ion emitting surface not that of a massive metallic wire or strip as has heretofore been customary, but a metallic film upon an electrolytically conducting solid, out of which upon the passage of an electric current, ions of the desired composition may be deposited onto the surface of the aforesaid metallic film in contact with said electrolyte and from thence diffuse through or along the surface of said metallic film to the gas and there escape or be discharged into the gas as ions.

The essential part of the apparatus or anode is constructed by fusing a thin walled

potassium glass tube about a platinum strip making sure that a gas-tight seal exists between the glass and the platinum at the two ends. This is now placed in molten potassium nitrate and a considerable amount of potassium electrolyzed through the glass onto the platinum strip. A thin coating of platinum is sputtered onto the glass by means of a discharge, with the exception of short lengths near the two ends, which are kept free in order to insulate the platinum surface from the central platinum strip. This assembly, when mounted as an anode in a vacuum tube and heated to 625° C. by passing a current through the central platinum strip, gives off currents of positive potassium ions up to 10⁻⁶ amps. per sq. cm. The emission obeys Richardson's equation. By varying the potential of the platinized emitting surface with respect to the central platinum strip the positive ion current may be varied over a wide range.

The advantages of this source over other sources is quite obvious, in that (1) the emission can be made very pure, that is, a single alkali as potassium and not a mixture of ions, (2) a large amount of alkali can be electrolyzed onto the platinum strip which assures no decrease in current with time at a constant temperature, and (3) at a given temperature the positive ion currents can be changed by simply varying the potential of the emitting surface with respect to the potential of the hot strip. This relatively low temperature catalytically inactive surface is essential in experiments on gaseous activation by ions where one wishes to reduce the effect of the hot surface to a minimum.

The accompanying figure serves to illustrate concretely one method of construction and use of such electrode.

A thin piece of platinum or other wire suitable for sealing into glass is welded at its extremities to heavier wires 11 and 13 to act as current leads and supports. A capillary tube of say pure potash glass is next slipped over the thin wire and its junction with the supports and melted down upon all three so as to form a solid continuous coating 5. The portion of this glass coating over the thin

wire is then surrounded either with a potassium amalgam or a fused potassium salt. Sufficient current is next sent through the thin wire to raise the temperature of the glass coating to a temperature at which it becomes appreciably conducting electrolytically. An electro-motive force is now applied between the thin wire and the bath of amalgam or fused salt making the thin wire the cathode which will cause the deposition of a coating of metallic potassium on the thin wire within the glass covering and thus render it nonpolarizable for small currents in the opposite direction later. The amalgam or fused salt bath is next removed from the glass covered wire and the latter thoroughly cleaned. Another platinum lead wire 12 is next sealed lightly into the surface of the glass covering as shown at 8. A thin film of platinum 4 is next deposited on the glass surface by the well known method of cathode sputtering in such wise as to contact wire 12 and completely cover the glass surface concentric with the thin wire, but leaving uncovered glass surfaces at the two ends, to prevent metallic connection between the film and the leads 11 and 13.

The whole assembly, constituting the analogue of the filament of the ordinary positive ion tube, may next be sealed within the glass bulb 1, together with the conventional arrangement of grid and plate also shown in the figure at 3 and 2 respectively provided with leads 14 and 15, all the leads passing out through the glass seal 7 and the bulb being connected to gas pump, gas supply, manometers, etc. as needed, through the tube 9.

To demonstrate or utilize the fundamental characteristics and operation of the electrode, a sensitive galvanometer 24 may be connected to leads 12 and 15 by wires 12', 12'' and 15', and a controllable source 22 of variable voltage may be connected by wires 12', 12''' and 14' to leads 12 and 14. A separate source of current 10 is connected in a circuit including regulating rheostat 16, ammeter 17 and wires 11' and 13'' connected respectively to leads 11 and 13 for the purpose of heating the filament. Another controllable source of direct current comprising, for example, battery 18 and controlling means 19 and equipped with galvanometer 20 and reversing switch 26 is connected by wire 13' to lead 13 and by wire 12' to lead 12.

The operation of the apparatus in producing and controlling emission of ions, may be described as follows. Current is passed through the heating element 6, such current passing from source 10 through rheostat 16, ammeter 17, wire 11, heating element 6, and wire 13 back to said source, the current being regulated by rheostat 16 so as to maintain the emitting electrode at a desired temperature, and the body 5 acting as a solid electrolyte

at such temperature. Current is then passed through the body 5, between the conducting members 6 and 4, in sufficient amount to cause electrolytic transfer of the alkali metal from the supply of such metal which has been formed on the inner electrode element 6, to the outer or emitting electrode element 4, or by reversing the direction of the current by the reversing switch 26 the emitting electrode element 4 may be stripped of alkali metal already there. The potential difference necessary to produce this emission controlling current is applied through a circuit including source 18, wire 13', lead 13, electrode element 6, lead 12, wire 12' reversing switch 26 and potential controlling means 19 which may be a potentiometer or means for tapping variable voltage from the source 18, the amount of current passing being indicated by the ammeter 20 in said circuit.

On reaching the outer or emitting electrode element or film 4, the alkali metal or equivalent metal passes through such film by diffusion or otherwise and is emitted at the surface thereof. On being emitted from the surface of the emitting electrode, the motion of the ions may be controlled by a suitable electrical field, maintained for example between the emitting electrode element 4 and the grid 3 by connections including wires 12' and 14', a source 22 and a regulating means such as a potentiometer 23. The resulting current in this case represents the flow of positive ions between elements 4 and 3. As a result of this flow of ions and impingement of some of such ions on plate electrode 2, current will also flow in a circuit including element 4, lead 12, wire 12'', galvanometer 24, wire 15', lead 15 and plate electrode 2, this current being measured or indicated by galvanometer 24. A reversing switch 25 may be provided in the circuit connection 12, 14 so as to apply either positive or negative bias to the grid with reference to the emitting electrode.

It will be understood that the bulb 1 will be occupied by a gas which may be emitted or withdrawn through the means 9, the latter being sealed off if desired when the required condition of rarefaction has been reached. In general this condition of rarefaction is such as to represent a so-called vacuum or partial vacuum, but it will be understood that in this condition there is generally some residual gas present.

I claim:

1. An apparatus for production and control of ion emission into gas, comprising a container for the gas, an emitting electrode mounted and insulated within said container and formed with an emitting electrode element exposed to the gas, an internal electrode element, a body of solid electrolytic material, containing an ion-forming constituent, interposed between said electrode ele-

ments, means for applying heating current to said inner electrode element, means for applying and regulating electrolyzing current between the said electrode elements, to electrolytically supply ion-forming material to the ion-emitting electrode element at the rate required.

2. An apparatus for production and control of ion emission into gas, comprising a container for the gas, an emitting electrode mounted and insulated within said container and formed with a thin nonvolatile metallic film as an emitting electrode element exposed to the gas, an internal electrode element, a body of solid electrolytic material, containing an ion-forming constituent, interposed between said electrode elements, means for electrically heating said solid electrolyte, means for applying and regulating electrolyzing current between the said electrode elements, to electrolytically supply ion-forming material from the solid electrolyte directly to the ion-emitting electrode element at the rate required.

3. An apparatus for production and instantaneous control of ion emission into gas, comprising a container for the gas, an emitting electrode mounted and insulated within said container and formed with a thin non-volatile metallic film as an emitting electrode element exposed to the gas, a nonpolarizable internal electrode element, a body of solid electrolytic material, containing an ion-forming constituent, interposed between said electrode elements, means for applying heating current to said inner electrode element, means for applying and regulating electrolyzing current between the said electrode elements, to electrolytically supply ion-forming material from the solid electrolyte directly to the ion-emitting electrode element at the rate required.

4. An apparatus for production and control of ion emission into gas, comprising a container for the gas, an emitting electrode mounted and insulated within said container and formed with an emitting electrode element exposed to the gas, a solid metallically conducting internal electrode element, a body of solid electrolytic material, containing an ion-forming constituent, interposed directly without intermediate gas or vacuum spaces between said electrode elements, thus binding them together directly into an electrolytic cell, means for applying heating current to said electrolytic cell, means for applying and regulating electrolyzing current between the said electrode elements, to electrolytically supply ion-forming material directly from the solid electrolyte to the surface of the ion-emitting electrode element in contact with the solid electrolyte at the rate required.

5. The method of controlling the emission

of ions into gases from an electrode whose outer shell comprises as a terminal a thin non-volatile metallic film on the surface of a solid electrolytic material containing an ion-producing material and having another metallically conducting terminal imbedded therein, which consists in sending a current of such direction and magnitude between said terminals as to effect liberation of the ion producing material at the rate required to supply the desired emission.

6. The method of positively and practically instantaneously controlling independent of the temperature the rate of emission of gaseous ions from an electrode comprising an interior electric resistor and non-polarizing electrode surrounded by a solid electrolyte of which the material of the desired ion is a constituent and whose outer surface is covered with a thin non-volatile metallically conducting film, which consists in maintaining the system at the desired temperature by regulation of current through the resistor and regulating separately the direction and magnitude of current flowing between the imbedded electrode and the superficial metallic film to electrolytically deliver to the latter the ion forming material at the rate necessary to maintain emission into the gaseous space at the rate desired under the existing conditions.

7. An electrode for a vacuum tube whose outer shell comprises as a terminal a thin non-volatile metallic film on the surface of a solid electrolyte containing an ion-producing material and having another metallically conducting terminal imbedded therein.

8. An electrode for a vacuum tube comprising an interior electric resistor and non-polarizing electrode surrounded by a solid electrolyte of which the material of the desired ion is a constituent whose outer surface is covered with a thin non-volatile metallically conducting film.

9. An electrode for a vacuum tube from which the emission of gas ions may be accurately and practically instantaneously controlled, comprising a thin non-volatile metallically conducting film, serving simultaneously as emitting electrode into the gas and receiving electrode from a mass of solid electrolyte on whose surface it has been deposited and a second electrode in effective contact with the solid electrolyte.

10. An electrode for a vacuum tube from which the emission of gas ions may be accurately and practically instantaneously controlled, comprising a thin non-volatile metallically conducting film, serving simultaneously as emitting electrode into the gas and receiving electrode from a mass of solid electrolyte on whose surface it has been deposited, and a second electrode in effective contact with the solid electrolyte, means for heating and maintaining the system at the

desired temperature and means for applying and controlling the direction and magnitude of an electrolyting current between the two electrodes.

5 In testimony whereof I have hereunto subscribed my name this 9th day of October 1929.

FREDERICK G. COTTRELL.

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