Sept. 15, 1964 A. M. SKELLETT 3,149,262

DIRECT CURRENT COLD CATHODE VACUUM LAMP

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Fig. 1.

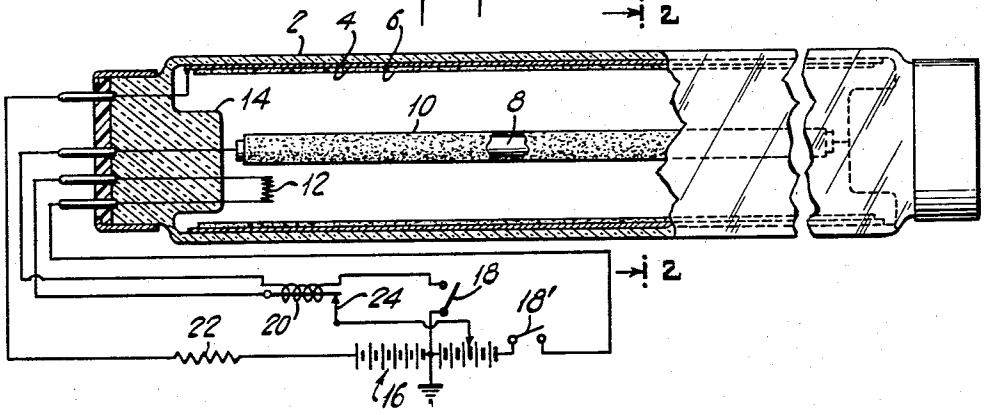


Fig. 2.

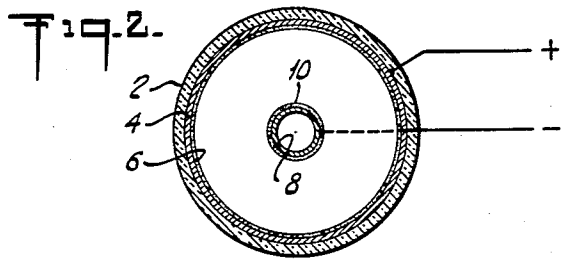


Fig. 3.

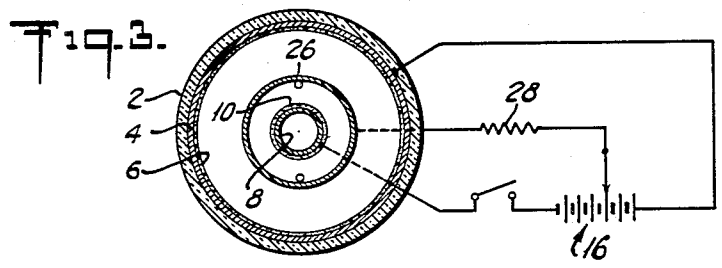
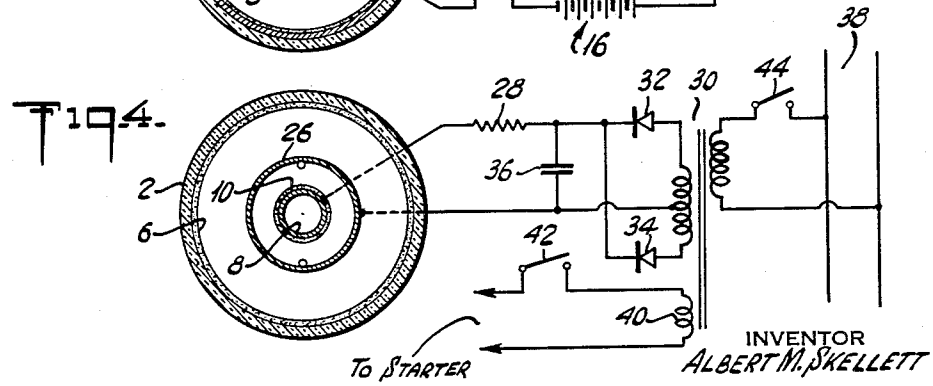


Fig. 4.



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DIRECT CURRENT COLD CATHODE VACUUM LAMP

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The present invention relates to cold cathode vacuum electronic devices of the type wherein the cathode comprises a conducting sleeve or the like coated with a porous sponge-like layer of magnesium oxide. In such type of device, once electron emission is initiated from the cathode coating, the emission becomes self-sustaining provided one or more electrodes of higher potential are present for collection of the emitted electron stream. The invention comprises a novel direct current fluorescent lamp utilizing such type of coated cathode.

Conventional fluorescent lamps contain mercury vapor, are subject to flicker upon change in pressure within the lamp, and are relatively slow in starting. The new lamp, being a vacuum lamp, is more reliable in operation, gives greater brilliance per square centimeter of luminous area and is fast starting. The new lamp can be made to operate on lower voltage than that required in conventional lamps and over a wider range of temperature.

Briefly, the new lamp comprises an elongated tubular envelope of glass or the like carrying on its inner surface a layer of cathodo-luminescent phosphor material, a cathode sleeve axially disposed in the envelope and coated with a porous layer of magnesium oxide and at least one other electrode, which may be a thin transparent conducting layer on the inner wall of the envelope and carrying the phosphor material. Preferably the new lamp includes also means for initiating electron emission from the cathode.

For a better understanding of the invention and of specific embodiments thereof reference may be had to the accompanying drawing of which:

FIG. 1 is a diagrammatic longitudinal sectional view of a cold cathode lamp embodying the invention together with a suitable energizing circuit therefor;

FIG. 2 is a transverse sectional view through the lamp of FIG. 1 taken on the line 2—2 thereof;

FIG. 3 is a view similar to FIG. 2 but representing a modification and showing diagrammatically the external energizing circuit for the lamp; and

FIG. 4 is another view similar to FIGS. 2 and 3 representing still another embodiment of the invention and showing diagrammatically an energizing circuit therefor suitable for use with alternating current supply lines.

In FIG. 1 the lamp embodying the invention is shown as comprising a tubular envelope 2 of glass or the like which is evacuated and which carries on the inner wall thereof a thin conductive film 4 of tin oxide or of other transparent conducting material. On the inner surface of the film 4 is a layer 6 of cathodo-luminescent phosphor material such as is employed in cathode ray picture tubes, for example, zinc sulfide activated with silver. Preferably the phosphor layer is made somewhat conductive, as by addition thereto of a colloidal solution of graphite in water such as aquadag or the like. Axially disposed within the envelope 2 is a sleeve of nickel or other metal upon the outer surface of which is a layer 10 of magnesium oxide in the form of microscopic sponge-like structures. In the particular embodiment illustrated in FIG. 1, starting means in the form of a filament 12 are provided within the envelope 2, the filament when heated to incandescence giving off primary electrons for bombardment of the coating 10 and initiating electron emission therefrom. Instead of the filament 12 electron emission from the coating 10 could be initiated by irradiation of the coating with ultraviolet light or by subjection of the coating to high frequency energy from a Tesla coil. Through the press 14 of the tube 2 the various leads for the conductive film 4, for the cathode sleeve 8 and for the filament 12 are taken out to suitable terminals, illustrated as pin terminals, for connection to an external circuit. The energizing and starting circuit for the lamp of FIG. 1 may comprise a source 16 of direct current which is grounded at a point intermediate its positive and negative terminals and at that point is connected through a switch 18 and winding 20 of a thermal switch to the pin terminal connected to the sleeve 8. The positive terminal of battery 16 is connected through a current limiting resistor 22 to the coating 4. The filament 12 is connected at one end through a switch 18' to the negative terminal of source 16 and at its other end through a bimetal element 24 of the thermal switch to a tap on the source 16 of suitable voltage and at a potential below that of the cathode sleeve 8. Winding 20 and bimetal element 24 comprise parts of a conventional thermal switch, the switch being normally closed and opening when current through the winding 20 heats the element 24 sufficiently to flex it to circuit opening position.

With the above described circuit when switches 18 and 18' are closed, the starter filament 12 is energized and electrons emitted thereby are attracted to the sleeve 8 because of the higher potential thereon. These electrons bombard the magnesium oxide coating and initiate electron emission therefrom. The cathode coating has the characteristic that once electron emission is started over any small area, the emission becomes self-sustaining and spreads rapidly over the entire surface of the coating so long as an electrode of higher potential is provided that attracts the emitted electrons. In the lamp of FIG. 1 the conductive film 4 serves as such an electrode. The electrons from the coating, which are attracted to the film bombard the phosphor material 6 and thus cause luminescence thereof. This current from the cathode to conductive film which flows through the winding 20 causes heating of the bimetal element 24 and consequent opening of the circuit of filament 12. The lamp, due to the self-sustaining emission characteristic of the cathode coating will continue to be lighted so long as switch 18 is closed. The voltage source 16 may be anywhere from 200 to 1000 volts depending upon the dimensions of the lamp and upon the brilliancy desired.

The operating voltage may be reduced if an additional electrode is included in the envelope and maintained at a potential positive with respect to the cathode. FIG. 3 schematically represents such a modification of the invention. In this embodiment of the invention a grid 26 is provided intermediate the cathode sleeve 8 carrying the coating 10 and the phosphor layer 6 on the conductive film 4 of the tube. The grid 26 is connected through a current limiting resistor 28 to an intermediate point on the source 16. The grid, once electron emission is initiated, accelerates electrons emitted from the magnesium oxide coating toward the phosphor layer 6 and therefore relatively less potential is necessary on the conductive layer 4. If the grid 26 is maintained at a sufficiently high potential the conductive layer 4 may be entirely omitted as the electrons will have obtained sufficient velocity when they reach the grid to continue toward the phosphor layer and the emission of secondary electrons from the phosphor layer will be sufficient to maintain the phosphor layer at a potential positive with respect to the cathode.

In FIG. 4 an arrangement such as has been just suggested is shown. In this embodiment of the invention the conductive layer 4 on the inner wall of the tube 2 is omitted, the phosphor layer being disposed directly

upon the glass wall of the tube. The grid **26**, in the particular circuit diagrammatically illustrated in FIG. 4, is supplied with positive potential through a current limiting resistor **28** from a simple full-wave rectifier and filter circuit coupled to an alternating current supply line. The rectifier comprises the secondary of a transformer **30** the mid point of which is connected to the cathode and the ends of which are connected through respective silicon diodes **32** and **34** to the grid **26** through the resistor **28**. A capacitor **36** connected between the mid point of the secondary of transformer **30** and the cathodes of the rectifiers gives a little smoothing to the rectifier output. The primary of transformer **30** is connected to alternating current supply lines **38** which may be 120 volt 60 cycle lines. If the starter such as the filament **12** of FIG. 1 is provided within the lamp of FIG. 4 it may be energized from a separate secondary winding **40** on the transformer **30** as indicated in the drawing. A suitable switch **42** in the starter circuit and a switch **44** in the primary circuit of transformer **30** provide the means for initiating operation of the lamp. Obviously the switch **42** could be a thermal switch such as that comprising the elements **20** and **24** of FIG. 1 and alternatively the thermal switch of FIG. 1 could be replaced by a manually operable switch if desired. Obviously also the lamps of FIGS. 1 and 3 could be energized from an alternating current source through a suitable rectifier and filter.

The invention has now been described with respect to specific embodiments thereof. Obviously various changes could be made without departing from the spirit of the invention or the scope of the accompanying claims. For example, although the new lamp has been shown and described as being incorporated within an elongated cylindrical tube obviously the invention is not concerned with the specific external shape of the lamp. Also, although filamentary starting means have been illustrated, other known means for initiating electron emission from the cold cathode coating could be employed and energizing circuits other than those specifically illustrated could be used with the new lamp.

The following is claimed:

1. A direct current cold cathode vacuum lamp comprising an evacuated envelope of transparent insulating material, cathodo-luminescent phosphor material supported on the inner wall of said envelope, a cathode within the envelope comprising a metallic conductor having a porous sponge-like coating thereon, said coating being adapted to emit a copious self-sustaining stream of electrons once electron emission therefrom is initiated, and an electrode within the envelope adapted to be maintained at a potential above that of the cathode and positioned to direct electrons emitted by said coating to said phosphor material to cause luminescence thereof, the light emitted by said lamp when energized being substantially entirely that given off by the phosphor material.

2. The cold cathode lamp according to claim 1 wherein said electrode comprises a film of transparent conductive material on the inner wall of said envelope, said phosphor material being on said film.

3. The cold cathode lamp according to claim 2 including a second electrode within said envelope comprising a metallic grid positioned between said cathode and said phosphor material and adapted to be maintained at a potential intermediate that of the cathode and said film.

4. The cold cathode lamp according to claim 1 wherein said electrode comprises a metallic grid positioned between the cathode and said phosphor material.

5. The cold cathode lamp according to claim 1 including means within the envelope for initiating electron emission from said coating.

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