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COLD CATHODE LIGHT SOURCE

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~~Fig. 1.~~

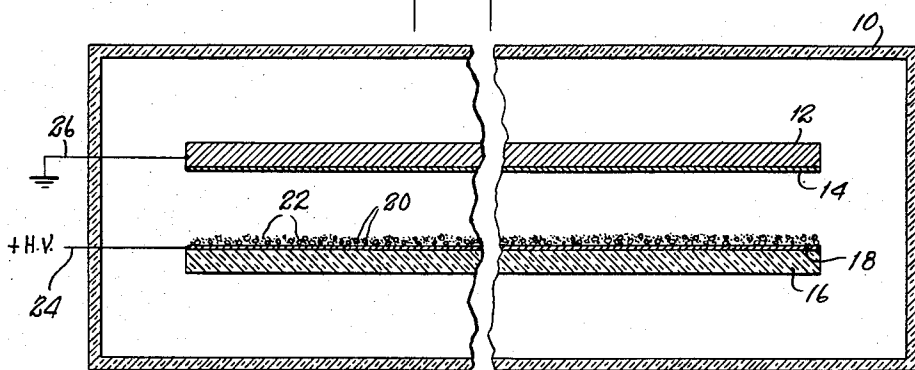


Fig. 2.

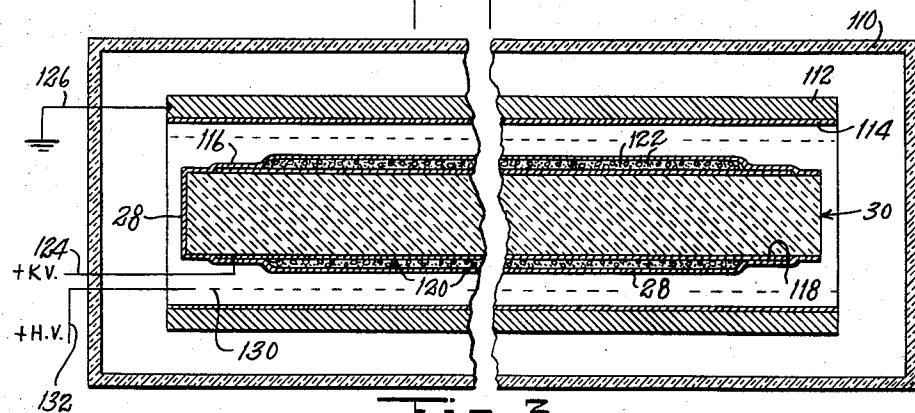


Fig. 3

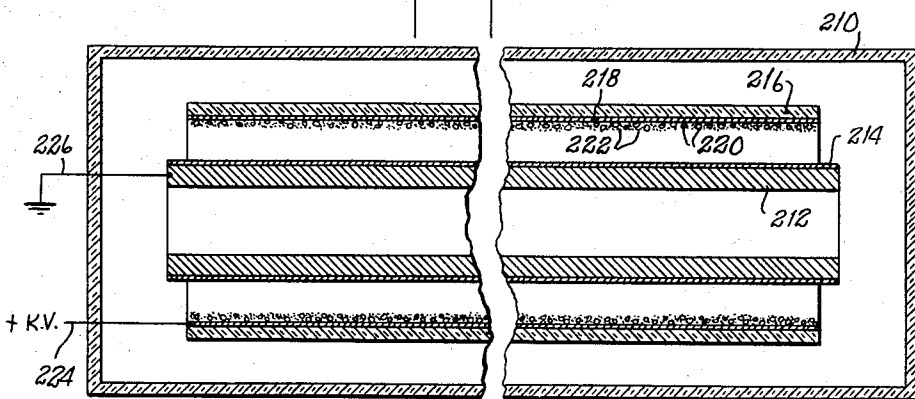
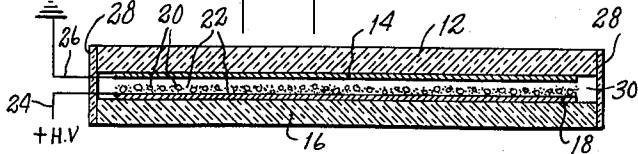


Fig. 4.



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COLD CATHODE LIGHT SOURCE

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15 Claims. (Cl. 313—108)

This invention comprises a light source of the type using a cold cathode and employing cathodo-luminescence, as the source of light.

An object of this invention is to provide in a simplified form a cathodo-luminescent light source employing a cold cathode.

Another object of the invention is to provide a novel combination for initiating operation of such light sources.

A more specific object of the invention is to employ the phenomenon of electro-luminescence for initiating the operation of cathodo-luminescent light sources.

Still another object of the invention is to provide a light source of this type constructed to provide high intensity illumination.

Other and more detailed objects of the invention will be apparent from the following description of the embodiment illustrated in the attached drawings for explanatory purposes.

In the drawings,

Figure 1 is a typical, longitudinal, vertical, cross-sectional view through one form of light source in accordance with this invention in which the elements are diagrammatically illustrated;

Figure 2 is a similar diagrammatic illustration in cross-section of another form of such light source designed to provide high intensity illumination;

Figure 3 is a similar view of a third form of the invention in which in principle there is a reversal of the relationship of the parts of the light source of Fig. 2; and

Figure 4 is a typical cross-sectional view of a fourth form of the invention.

The light source of this invention employs a cold cathode of the type which can be generally referred to as a magnesium oxide cold cathode. The electron emission of such cathode is employed to excite cathodo-luminescent phosphors to produce visible and useful light.

Electron tubes employing such a cathode are known but have heretofore in their practical forms required auxiliary starting apparatus, usually in the form of a tungsten filament, and it is the purpose of this invention to eliminate this starting element.

In accordance with this object it is proposed to initiate the operation of the cold cathode by the use of electro-luminescent materials, which in a practical form of the lamp are incorporated in the cathodo-luminescent layer. The electro-luminescent and cathodo-luminescent materials could take the form of a coating in which these materials are present as a mechanical mixture. In another form the fluorescent layer may consist of a single phosphor which exhibits both electro-luminescent and cathodo-luminescent properties.

To better understand these objectives the several forms of lamps illustrated in the drawings will be described in detail.

As is usual with light sources of this type, there is provided a light transmitting envelope 10, usually of glass, having any physical shape and dimensions suited to the particular use proposed for the light source. The

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envelope 10 is evacuated so as to be as free as practicable of air and particularly oxygen. As illustrated in Fig. 1, the cathode 12 comprises a body of suitable metal which may be of nickel, a nickel-plated metal such as iron, or may even be a sheet of glass or other ceramic having a nickel coating. Assuming that the body 12 is a rectangular plate, it is provided on its lower face, as shown at 14, with a magnesium oxide film. In the case where the body 12 is non-conducting it would first be provided with a thin coating of nickel which would be overlaid by the magnesium oxide coating 14.

There are a number of ways to form the magnesium oxide film or coating 14 which are available to those skilled in the art, and they will not, therefore, be detailed herein. It is understood, of course, that the film is very thin, having a thickness of the order of 10^{-3} to 10^{-4} cm. These dimensions are not given here in a critical sense, any cold cathode of this type is suited to the purposes of this invention.

As is well known, such cold cathodes are rendered active by providing a collector electrode facing the magnesium oxide film and maintained at a positive potential of from 200 to 300 volts with respect to the body 12 or the conducting coating underlying the film in the case of a non-conducting body. The collector electrode under potential creates a high intensity electric field across the thin magnesium oxide layer and when the magnesium oxide film is charged to the collector potential it starts and continues to emit electrons. The oxide film is charged by light, by the discharge of a Tesla coil or by a radioactive source. By varying the collector voltage the electron emission can be controlled from a few micro amperes to several tens of milliamperes, changing exponentially with the collector voltage. As is well known a blue fluorescence appears on the film during emission and its variation in uniformity of brightness is a measure of the uniformity of emission over the surface area of the film. Some electron tubes use in conjunction with the collector electrode an incandescent filament to aid in the starting of the electron emission. Such starting filament is eliminated in accordance with an object of this invention.

The lamp includes a second body 16, in this case light transmitting, and hence preferably of glass. The glass is of the so-called conducting type, that is it has a thin transparent conducting tin oxide coating 18 over the face thereof, which faces the film 14, as clearly shown in Fig. 1. The conductive coating 18 is transparent and is very thin.

Deposited on the exposed face of the layer 18 is a phosphor coating illustrated as consisting of a mixture of a cathodo-luminescent phosphor 20 and an electro-luminescent phosphor 22. The coating consists of a homogeneous mixture of those phosphors in powder form which can be applied to the conductive coating in accordance with well known practices in the related lighting art.

A suitable source of high voltage is connected across these two electrodes thus formed by means of the circuit connectors 24 and 26, which are respectively conductively connected to the coating 18 and the body 12, as illustrated.

An important feature of this invention is the close spacing between the two electrodes so that the phosphor coating 20—22 is spaced close to the magnesium oxide film 14.

When a potential of from 200 to 300 volts is applied across the connections 24 and 26, the electro-luminescent particles 22 of the coating are caused to luminesce, thereby sensitizing the magnesium oxide coating 14 which then starts emitting electrons. The sequence of operation is as follows: the potential of 200 to 300 volts is applied be-

tween the connectors 24 and 26; the electro-luminescent particles emit light; the light causes the magnesium oxide cathode to start emitting electrons under the influence of the collector potential; and these electrons are drawn to the anode (the collector) and bombard the cathodo-luminescent layer resulting in the efficient generation of light.

Specifically these electrons flow from the film 14 to the coating 20—22, bombarding the cathodo-luminescent content 20 of the phosphor layer causing it to luminesce. The luminescence of the electro-luminescent material is very low as such materials are known to be inefficient light sources. On the other hand, the cathodo-luminescent content of the phosphor layer is an efficient light generator under electron excitation. The resulting luminescence is transmitted through the transparent body 16, and of course, through the housing 10 for use. This type of lamp, as will be apparent, is suitable for panel lighting, for example, where the bodies 12 and 16 can be in the form of six rectangular plates of any suitable and practicable dimension.

The housing 10 (as well as the housings 110 and 210 to be referred to later) diagrammatically illustrates one way in which the active elements of the lamp are confined within a vacuum. However, in a practical lamp of this type a seal between the two elements 12 and 16 can be formed around the edges thereof and vacuum created between them to produce the completed lamp, eliminating in such case the larger housing 10, for example. Such a seal could be formed between the elements by using a low melting solder glass, of which different types are commercially available. The coatings 14, 18, 20 and 22 would, of course, terminate short of the edges of the plates 12 and 16, so that a seal directly to the plates could be made. The space between the plates when sealed would of course be evacuated by the required operating conditions, which evacuation can be effected in accordance with well known practices. It is emphasized that the active surfaces 14, 20 and 22 will be much closer together in an actual lamp. Relatively wide spacing is shown in the drawing to facilitate illustration.

The art is familiar with phosphors suitable to this purpose which include phosphors such as ZnS:Cu, ZnS:Ag, ZnCdS:Cu, ZnO, zinc silicate: Mn. Some phosphors are both electro and cathodo-luminescent, and of those listed above, zinc sulphide activated with copper is such a phosphor. When this phosphor is used it is the sole constituent of the coating of the conductive layer 18. As those skilled in the art will appreciate, there are other phosphors having either or both of these characteristics which are suited to the purposes of this invention.

The light source Fig. 2 is designed to be one of high intensity. As before, it comprises an evacuated envelope 110 of suitable configuration and dimensions. Within the envelope is a metal cylinder 112 having the magnesium oxide film 114 on its interior surface, as illustrated. As in the previous case, the cylinder 112 can be of nickel, a nickel plated metal, or of a ceramic having a nickel coating underlying the magnesium oxide film 114.

Positioned within the cylinder 112 is a rod 116 of accurately formed glass or quartz, having a transparent conductive coating 118 deposited on the surface thereof, like the coating 18 of the previous form. In cases where heavy currents are encountered, a silver strip, not shown, may run the length of the rod and underlie the coating 118. On the surface of the coating 118 is the phosphor coating comprising a mixture of cathodo-luminescence and electro-luminescent materials 120 and 122, as before.

The thin coating of phosphor may be enclosed within a highly reflective aluminum coating 28 which extends around one end of the rod, as shown in Fig. 2. The opposite end 30 of this rod is ground or polished. Also as shown in Fig. 2, the spacing between the interior filmed surface of the cylinder 112 and the exterior coated surface of the rod 116 is very small. As in the case of the

lamp of Fig. 1, a suitable source of the proper voltage is connected between the leads 126 and 124 to create a field, as in the previous case. In the case of this lamp, where the aluminum coating 28 is used, the potential applied to the leads 124 and 126 must be considerably higher than in the case where no reflector is used, in order that the electrons may penetrate it. This has been indicated by the symbol KV and represents voltages of several kilovolts or higher, in order to get proper operation. In such a lamp an additional collector 130 must be imposed between the cathode and anode and a potential of the order of 200 to 300 volts applied across the leads 126 and 132 in order to prevent cathode breakdown.

Under the influence of this field the electro-luminescent material 122 causes electron emission from the magnesium oxide film 114, which emission in turn bombards the cathodo-luminescent material 120 to render it luminescent. This light is reflected by the reflecting coating 28 into the rod 116 through which it is transmitted to the point of emission at the end 30 of the rod. The light intensity emitted is of a very high order, depending, of course, upon the geometry of the elements of the lamp. Indeed, a lamp of this form emits light of the order of a carbon arc or greater. The reflective coating 28 being thin, does not seriously interfere with the movement of electrons between the charged surfaces.

The lamp of Fig. 3 is quite similar to that of Fig. 2, but structurally involves a reversal of the parts, so to speak, so that the light is emitted radially through the side walls of the envelope rather than through the end. In this case the lamp includes the evacuated envelope 210 as before. The cold cathode is in the form of a rod or tube 212, having the magnesium oxide film 214 on the outer surface thereof. This rod or tube lies concentrically of a cylinder 216 of glass having the transparent conductive coating 218 on the inner surface thereof. Deposited on this surface is the phosphor mixture comprising the cathodo-luminescent and the electro-luminescent constituent 220 and 222. As in the previous case a high voltage source is connected to the lamp elements through the leads 224 and 226.

In this case the luminescence of the cathodo-luminescent material is transmitted through the transparent conducting coating 218 and the glass cylinder 216 to issue radially thereof through the surrounding wall of the envelope 210. Of course, in this form of the lamp as in the other two forms the magnesium oxide film 214 is positioned closely adjacent to the layer 220—222 so that the electric field from the charge electrodes will have sufficient intensity to activate the electro-luminescent material, and thus initiate operation of the lamp.

Those skilled in this art will appreciate that the principles of this invention are applicable to physical lamp forms of a wide variety of sizes and shapes, and the details of the invention are subject to considerable variation within the knowledge of the art. It is preferred, therefore, that the subject matter of this invention be limited by the scope of the appended claims rather than by the examples given for explanatory purposes. In this connection it can properly be said that the phosphor coated element of each lamp acts as an anode with respect to the magnesium oxide coated cold cathode.

As an indication of these possibilities, reference is made to Fig. 4, wherein a form of light source is illustrated which is basically that of Fig. 1, but wherein a separate envelope has been omitted. Since the device of Fig. 4 is quite similar to that of Fig. 1 in so far as the same parts are used, the same reference characters have been applied. In this form the plate 12 has been indicated as being made of a light transmitting material such as glass, but as pointed out above with regard to Fig. 1, it can also be made of metal. In this arrangement the main difference is in the fact that, as suggested above, a seal can be provided around the edges of the plates 12 and 18 to form the chamber 30 within which the active

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elements are mounted. This chamber as suggested, can be evacuated or otherwise prepared in accordance with knowledge in the art, to provide the proper atmosphere for these active elements. In order to provide the chamber 30, a seal which has been diagrammatically illustrated at 28 in the figure, is provided around all of the edges of the plates to join them together in a manner to render the joint hermetically tight. Here again, those skilled in the art will see obvious ways of sealing the plates at the edges for this purpose, and so the illustration in Fig. 4 is diagrammatic.

Fig. 4 also illustrates the point brought out above that in the actual light source the conductive layer 14 and the cathodo-luminescent layer 20—22 will be quite close together for reasons understood in this art.

What is claimed is:

1. A luminescent light source comprising a magnesium oxide type of cold cathode emitter, a light transmitting unit having a luminescent coating facing and positioned close to said cathode, an evacuated light transmitting envelope enclosing said cathode and anode, and means including said coating for rendering said cathode electron emissive.
2. In the combination of claim 1, said last means including a high voltage source connected across said cathode and anode.
3. In the combination of claim 1, said coating having properties of electro- and cathodo-luminescence.
4. In the combination of claim 1, said luminescent coating comprising ZnS:Cu.
5. In the combination of claim 1, said coating comprising a mixture of electro-luminescent and cathodo-luminescent phosphors.
6. In the combination of claim 1, said cathode and anode comprising parallel plates.
7. In the combination of claim 1, said cathode and anode comprising parallel plates, said anode being light transmitting.
8. In the combination of claim 1, said cathode being

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of cylindrical form and said anode comprising a light transmitting rod lying concentrically therewithin.

9. In the combination of claim 1, said cathode and anode comprising concentrically arranged cylindrical bodies.

10. In the combination of claim 1, said anode comprising a light transmitting sleeve having said luminescent coating on its surface and said cathode being arranged concentrically thereof.

11. In the combination of claim 1, said anode comprising a light transmitting sleeve having said luminescent coating on its inner surface, and said cathode comprising a rod concentrically thereof.

12. In the combination of claim 10, a collector grid interposed between said cathode and anode maintained at several hundred volts positive with respect to said cathode.

13. In the combination of claim 11, a collector grid interposed between said cathode and anode maintained at several hundred volts positive with respect to said cathode.

14. A luminescent light source comprising a member providing a magnesium oxide type of cold cathode emitter, another member having a luminescent layer facing and closely spaced from said cathode, means including said layer for causing said cathode to become emissive, and means uniting said members to form a chamber to be evacuated between them.

15. In the combination of claim 14, said members being of light transmitting material.

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