April 5, 1938 A. N. LUCIAN 2,112,854

LUMINESCENT DEVICE

Filed Dec. 31, 1934 2 Sheets-Sheet 1

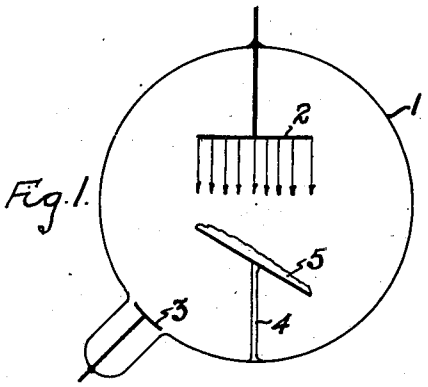


Fig. 1.

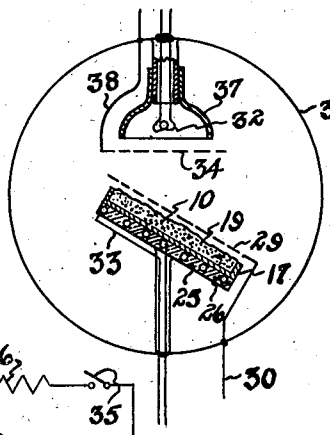


Fig. 4.

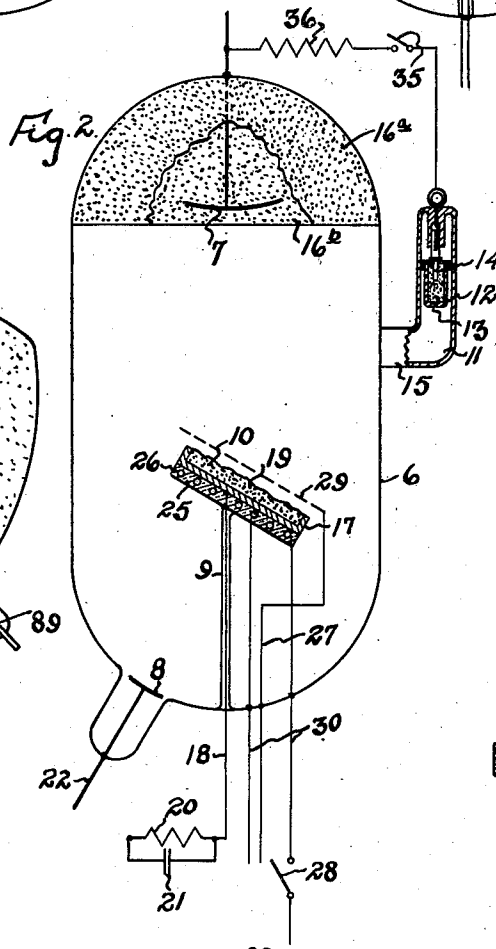


Fig. 2.

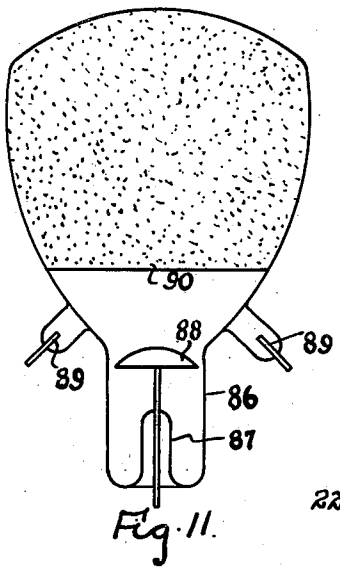


Fig. 11.

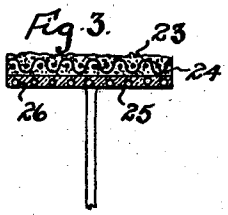


Fig. 3.

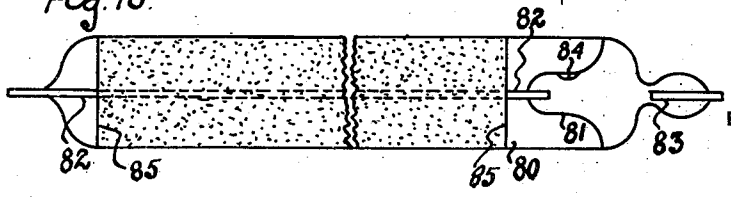


Fig. 10.

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April 5, 1938. A. N. LUCIAN 2,112,854

LUMINESCENT DEVICE

Filed Dec. 31, 1934 2 Sheets-Sheet 2

Fig. 5.

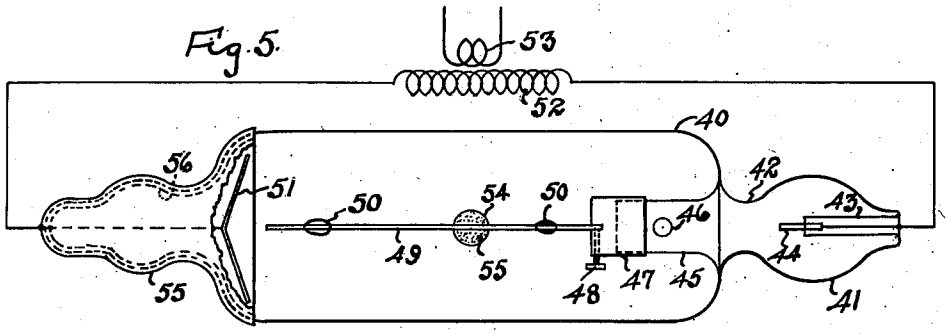


Fig. 6.

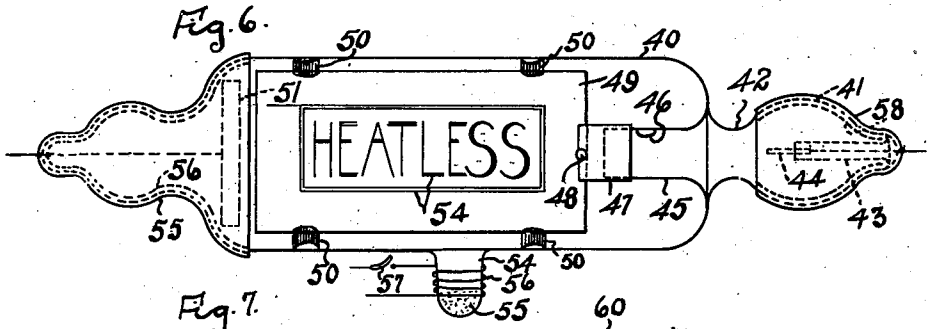


Fig. 7.

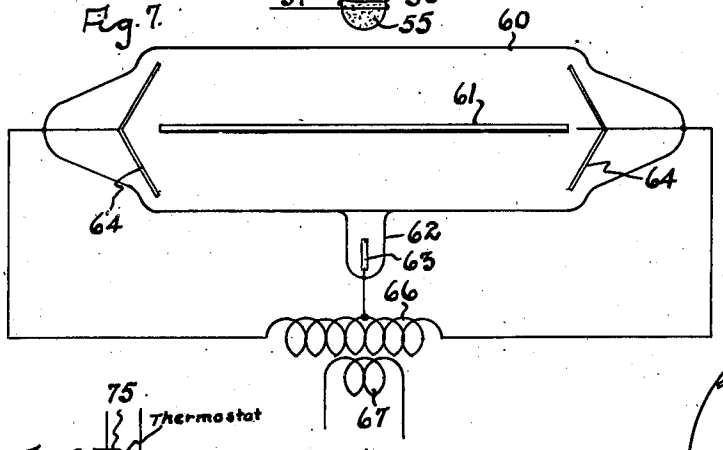


Fig. 8.

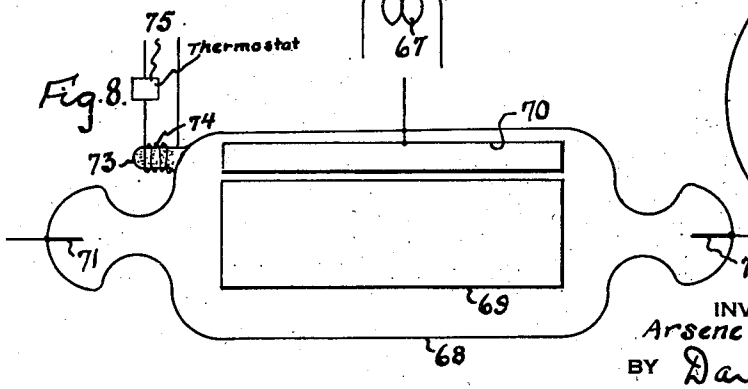
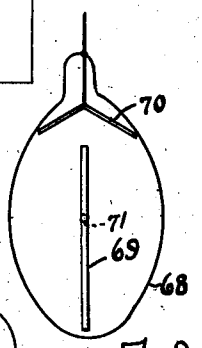


Fig. 9.



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UNITED STATES PATENT OFFICE

2,112,854

LUMINESCENT DEVICE

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Application December 31, 1934, Serial No. 759,836

13 Claims. (Cl. 176—1)

This invention involves the use of cathode ray or electron devices having luminescent screens for the purpose of providing commercially useful lighting devices designed and constructed in accordance with the principles of luminescence phenomena, which term as employed in this case, includes phosphorescence, fluorescence, and allied phenomena which may be caused by the excitation of certain natural or synthetic compounds by heat, light, cathode rays, X-rays, radium rays, and the like.

An object of this invention is to provide commercially new and useful combinations based particularly upon cathode ray or electron excitation of luminescent compounds arranged to form display or advertising devices and light sources.

A specific object of this invention is to provide constructions of cathode, anode and a plurality of extended surfaces in such geometrical relation to each other, so that the surfaces to be illuminated will be uniformly irradiated by the action of a uniformly disposed beam of electrons or cathode rays.

Another object of this invention is to provide in combination with devices of this type, and as parts thereof, alternating current rectifiers which directly supply the rectified current for the operation of the device.

Another object is to provide adequate and reliable pressure regulating means in combination with devices of this type, and as parts thereof in order to give to such devices long and uniform life of operation.

Other objects of this invention are—

To provide a luminous device for advertising purposes in which the areas to be impressed upon or brought to the observer's attention are completely luminous in themselves, and these areas supply all the light used in illuminating the sign or other advertising device.

To provide a source of illumination more efficient as regards the ratio of current consumption to quantity of light produced than any other illuminating device of which I am aware.

To provide a source of illumination which emits light of practically any desired color being generated on a luminous area of such extent that the light is diffused ipso facto.

To provide a sign or source of illumination which generates a lower ratio of heat in proportion to the quantity of light produced than any other such device.

These and many other objects, as will appear from the following detailed disclosure, are successfully secured by means of this invention.

In the drawings,

Fig. 1 illustrates a cathode ray excited luminescent device of a form now generally known and illustrating the basic features of devices of this nature;

Fig. 2 is one form of the device in accordance with this invention employing a cold cathode;

Fig. 3 is a detailed cross-sectional view of an element of the invention;

Fig. 4 is a view illustrating the application of the principles of this invention to the hot cathode type of tube;

Fig. 5 is a top plan view of a commercially practical form of advertising or display device in accordance with this invention and embodying as a part thereof a halfway rectifier;

Fig. 6 is a front elevational view of this device;

Fig. 7 is a top plan view of a modified form of device in which a full-way rectifier is incorporated;

Fig. 8 is a front elevational view of a still further modification in accordance with this invention;

Fig. 9 is a central vertical cross-sectional view of the device of Fig. 8;

Fig. 10 is a plan view of a modified form of device in accordance with this invention particularly adapted as a light source;

Fig. 11 is a still further modified form employing a dome-shaped vessel.

Cathode ray devices employing luminescent materials have been known scientifically and in the laboratory for at least half a century. Very little practical and commercial use has been made of this device. The well known X-ray screen which has been highly developed, is in no sense in the same category and is not governed by the same considerations and physical and chemical laws as the cathode ray device. In the X-ray device a luminescent screen is frequently employed wherein this screen is external to the tube in which the X-rays are generated and which, of course, is excited by X-rays. Furthermore, many substances which respond to X-rays will not respond to cathode rays and vice versa.

The only commercially useful forms of cathode ray tubes are the cathode ray oscillograph and a modification thereof as employed in television. The cathode ray oscillograph may or may not employ a luminescent screen. For example, through the use of a Lenard window the cathode ray beam may be projected upon a photographic

plate or upon a screen for use, for example, in visually displaying the voltage and current characteristics of electric currents. As employed in television apparatus the cathode ray tube employs a luminescent screen over which a concentrated beam of electrons is caused to travel by and in accordance with electric currents or impulses representative of a scene whereby those currents are transformed into visible displays of the scene.

The distinctive object of the present invention is to disclose a new type of vacuum tube, for the purpose of uniformly exciting, without flicker and fluctuation, large areas of luminescent materials which have been arranged in accordance with predetermined color and shape combinations to provide advertising and display devices or to provide light sources for use in lighting homes, offices, factories, and the like. Heretofore, no vacuum tube devices of any kind have been disclosed or used commercially, to our knowledge, which are capable of accomplishing the advertising and lighting objects which this invention actually does accomplish. The difficulty has been in the failure to devise structures and practice whereby relatively large areas may be illuminated with sufficient intensity, uniformity and longevity to make the device practical. The principal intent and purpose of this invention is to accomplish these objects.

In furtherance of these objects the present invention provides a device having a life comparable with filament types of light sources and gas discharge types of light sources.

A luminescent light source is one which emits light of practically any desired color by the conversion of cathode ray or other radiations of shorter wave length than red light into visible light while generating very little heat; that heat which is generated not being used as a source of light.

While the cathode ray luminescent device is well known scientifically, it may be of help to briefly described in connection with Fig. 1, the fundamental principles involved. The device employs usually a glass envelope 1 having a hot or cold cathode 2, and an anode 3 mounted therein. Such devices usually contain a residual of rarefied gas, in the use of cold cathodes, such as air or other desirable gas in which the discharge takes place between the electrodes. The application of potentials across the electrodes sets the gas molecules in motion, causing collisions which break the molecules up into positive and negative ions. The passage of current through the device is accomplished by the movement of the positive ions toward the cathode and of the negative ions toward the anode. The impact of the positive ions upon the cathode surface causes the ejection of electrons or cathode particles, which in turn travel at high velocities in straight lines at right angles to the surface of the cathode. If any one of a large number of known chemical compounds is positioned to intercept the electrons the compound will become luminescent. This is usually accomplished by mounting upon a suitable support 4, a layer of such compound as indicated at 5. The compound will give off light of a color depending upon the nature of the compound.

Such devices as known and experimented with mostly by scientists have always been characterized by the fact that the area of the layer 5 has been extremely limited, thus generally keeping the device out of the field of commercial utility. Furthermore, uniformity of illumination of the surface has been entirely lacking, which, added to the fact that such devices have had an extremely short life, has prevented them entering useful fields aside from the cathode ray oscillograph, and even in this case the life of the device is unduly short. In accordance with this invention, in adapting the device for the intended purposes, certain definite combinations and control factors have been discovered which must be employed in the device.

The nature of the cathode and anode materials and the areas of the cooperating electrodes are important factors in developing a commercially useful lighting or display source. The electropositive elements are the most suitable and efficient materials of which to make the electrodes and of which sodium, potassium, barium, strontium, calcium, magnesium and aluminum are examples. These elements may be used individually or in any suitable combination. A preferred combination is an alloy of aluminum, magnesium and calcium with traces of barium and strontium.

An important feature of the present invention resides in the form, shape, size and position of the cathode to secure uniformity of irradiation of the luminescent surface. Basically the projected area of the cathode should coincide with the area of said surface.

Furthermore, it has been discovered that the electrode area (referring to anode) in relation to the current density is important. In accordance with this invention it has been found that a current density of 1 milliampere for an electrode area of 0.2 to 0.5 square centimeter is satisfactory. The minimum value holds particularly where the electrodes are not artificially cooled and where one electrode must act as an element of the rectifier. Larger current densities may be employed in cases where the device is artificially cooled, depending somewhat upon the design of the cooling system.

Other important factors in the correct operation of a device of this type involve the nature of the rarefied atmosphere within the vessel as well as the pressure thereof. In addition to residual air, and preferably the so-called noble gases, such as argon, neon and helium, may be employed, either singly or in combination. Likewise, hydrogen, nitrogen and carbon dioxide, either alone or in combination, may be employed sometimes. The pressure range is, of course, variable, depending upon the nature of the gas, the dimensions of the device, and the potentials at which it is desired to operate the device. As a working range, the pressure within the vessel would be from approximately 0.1 millimeter of mercury down to as low a pressure as is permissible with a particular operating potential. For example, a pressure of 0.001 millimeter of mercury represents a practical minimum value for the range of potentials to be preferably employed. With cold cathode tubes potentials ranging from 1000 volts upwards to 25,000 volts are suitable. The above pressure range is not used in any cathode ray or electron device now in commercial use.

These devices may be operated from energy sources having a rather wide frequency range of the order of from a direct current of zero frequency to infinity. However, commercial practice limits the operation of the tubes from a 60 cycle alternating current source. Since devices of this type must be energized by high potential direct current, special provision for the supply of such current must be made as the available commercial current sources do not have the

required characteristics. This has not been a problem in the operation of the experimental cathode ray device referred to above as used by the scientist. This problem is solved by the invention by combining in a single device a cathode ray irradiated luminescent surface and a half or full wave rectifier by a novel arrangement and circuit interconnection of electrodes. Where high frequency currents are used a high intensity of luminescence may be secured with a high frequency source connected to electrodes external to the vessel. Likewise, efficient excitation may be obtained through a combination of electrodes external and internal to the vessel. It is understood that in case of high frequency excitation proper safeguard must be used to eliminate loss of power by leakage.

There is, of course, a very wide range of luminescent materials or compounds that may be employed. By way of example only, kunzites, calcites, sulphides of zinc, cadmium, barium, strontium and calcium, willemite, cadmium tungstate, calcium tungstate, uranyl salts, metallic salicylates, calcium larsenite, and the like, are available.

A feature of the invention insuring constancy and uniformity of operation is illustrated in Fig. 2, wherein at 6 is shown the vessel having a rarefied atmosphere within which is mounted the cold cathode 7 and an anode 8. Intermediate these electrodes and in the path of the cathode rays is the support 9 as a mounting for the luminescent material, comprising a metallic support 17 in which the luminescent material 10 is contained in the form of a layer. Since the device is of the cold cathode type a suitable gas content is employed at the desired pressure. As is well known in the operation of devices of this type, there is a tendency of the internal pressure to fluctuate with the age of the device and particularly at the beginning of its useful life. The tendency is for the tube to become "hard", that is, a decrease in the pressure within the tube which may be restored by means of a suitable pressure regulating device indicated generally by the reference numeral 11. Such a device may be, although not necessarily, of the form disclosed in Patent No. 1,603,707, to Lucian, dated October 19, 1926. For the purposes of the present disclosure the regulating device consists of a porous thimble 12 within an extension 15 of the vessel containing a suitable chemical compound 13 and a spark generating apparatus, designated generally by the numeral 14 and energized from the cathode circuit through a resistance 36 and a switch 35. When the regulator is in operation a small amount of suitable, and preferably inert gas is released into the tube to return it to a "soft" condition, that is, raise the pressure therein.

An important feature of the invention by means of which uniformity and constancy of excitation of the luminescent material and hence a corresponding uniformity and constancy of luminescence is obtained resides in the use of the conducting surfaces 16ª and 16ᵇ on the exterior and interior walls of the vessels over an area at least co-extensive with the internal extension of the cathode 7. In addition to the above advantages, the use of these conducting surfaces which are either grounded or may be electrically connected to the cathode circuit as illustrated, serve to materially increase the brilliancy and uniformity of the luminescent surface under any given set of operating conditions. These conducting surfaces may be either internal or external to the vessel or both, and if desired, may be employed at both ends of the vessel, as will be illustrated later. These coatings may, for example, take the form of actual metallic deposits upon the vessel walls as has been illustrated diagrammatically in the drawings. It might be noted at this point that the current density relationship to the electrode areas is in no way affected and does not include the areas of these coatings, except when the device is energized by strictly high frequency current.

In order to prevent the accumulation of charges on the luminescent coating, the container or support 17 therefor is preferably grounded or connected to some part of the circuit or to a special circuit combination such as illustrated in Fig. 2 as involving the wire 18 and the resistance 20 shunted by capacitance 21. To further aid in the removal of these charges should they accumulate, the coating itself may have mixed therewith conductive material, such as a metal powder, as illustrated at 19 in Figure 2. The drain circuit if not grounded is preferably connected into the anode circuit and includes the impedances 20—21 to impart the proper impedance to this drain circuit. At this point it may be noted that the construction of Fig. 3 merely illustrates another way of increasing the conductivity of the luminescent material and of mounting it upon and holding it on a support. At 24 is illustrated a fine metallic screen or wire mesh into which the coating material 23 is pressed.

In order to take advantage of the fact that at elevated temperatures the luminescent material is often more active, a heating coil 25 is imbedded in the insulating support 26 upon which the container 17 is mounted. This heating coil may be energized through the external circuit 30 and the control switch 28. The temperature variation is dependent upon the nature of the materials and the limits in either direction are likewise dictated by the results secured.

It has also been discovered that the application of an intense electric field for a short period of time to the luminescent material in some cases enhances its intensity of luminescence. In other cases continued application of this field results in a gradual diminution of the luminescent intensity. To take advantage of this feature, a suitable grid electrode 29 is supported close to the surface of the luminescent material 10 and connected to the electric circuit in any one of a number of ways, as will be apparent to those skilled in the art, to impress thereon a direct or an alternating electric field of a desired frequency through the lead 27.

In the arrangement of Fig. 2 the various features as emphasized are shown in combination, but it will be apparent that in any particular devices these various features may be used independently of each other or in desired combinations.

In Fig. 4 has been illustrated a hot cathode type of device in accordance with this invention. The vessel 31 with a suitable atmospheric content has mounted therein a cathode 32 in the form, for example, of a filament or indirectly heated cathode of suitable shape, which may be energized from any suitable current source. This cathode is surrounded with a metallic shield 37 having a function similar to the coatings 16ª and 16ᵇ of Fig. 2. The luminescent coating assembly is substantially as previously described, and need not be further discussed. In this case the metal-

lic member 17 carrying the luminescent coating 10 functions as anode in the usual circuit.

In the operation of a device of this type the cathode rays are produced due to the emission of electrons from the hot cathode. Since in a high vacuum device of this type the space charge effect is present, limiting the total electron current flow, a grid element 14 is employed and is adapted to be connected by wire 38 to a suitable potential source in order to neutralize the space charge effect. An advantage of a structure of this type resides in the fact that it may be operated with a relatively low potential on the anode of the order of a few hundred volts, or even as low as the usual house lighting circuit voltage. In some cases the introduction of a suitable gas, preferably inert, into the hot cathode type of tube, increases the intensity of luminescence of the layer 10, which action may be further intensified by increasing the applied voltage within maximum limits that are not too high to cause disintegration of the hot cathode.

It is, of course, apparently within the scope of this invention to make the coating 10 of any one of a number of suitable materials or a combination of them, either in juxtaposition upon the support or in mixture, to give any desired design and color effects. By means of this invention, as will be further illustrated, the areas of the designs may be greatly increased beyond anything herefore practical, because of the features of construction employed. It is likewise clear that under the term "luminescent material" it is intended to include both fluorescent and phosphorescent substances. Likewise, as is well known, there are many liquids which are either fluorescent or phosphorescent under the excitation of cathode rays, and hence may be employed as luminescent media in connection with devices of this type.

A practical form of device in accordance with this invention, and which has been successfully operated for a considerable period of time is illustrated in Figs. 5 and 6. It comprises a closed vessel 40 having a rarefied atmosphere of suitable gases and provided with an extension 41 forming a smaller chamber and connected with the vessel 40 by means of a restricted neck 42. The chamber 41 is provided with a re-entrant stem 43 upon which the anode 44 is mounted. As illustrated, the anode chamber is surrounded with internal and external coatings 58 which are at least co-extensive with the longitudinal extension of the anode. At the same end of the larger vessel is provided another re-entrant stem 45 which is sealed at its inner end and open at its outer end to the anode chamber. This stem is provided with an aperture 46 establishing communication between the vessel 40 and the anode chamber. Supported on the stem 45 is a metallic collar 47 having a slit therein in which the plate 49 is located by means of a set screw 48. The plate or screen 49 may be either of metal or of a non-conducting material such as glass, and is further supported within the larger vessel by means of the pinches 50. At the other end of the vessel is the cold cathode 51 which may be either circular or rectangular in form and is preferably made of a thin sheet of suitable metal such as previously set forth. The cathode is provided with a central crease or bend so that its projected area will coincide with both sides of the screen. By this construction the cathode rays which depart from the cathode along lines perpendicular thereto will be directed over the entire surface of the screen. The luminescent material 54' on one or both sides of the screen is thus subjected to direct impact by the cathode rays uniformly over its entire surface.

The cathode end of the tube is likewise provided with the external and internal coatings 55 and 56 which are at least co-extensive with the cathode. As illustrated in Fig. 5 all coatings are connected to the respective electrode circuits. The terminals of the secondary 52 of a high voltage transformer are connected to the anode and the cathode. The primary of the transformer is illustrated at 53. This device is a combined halfway rectifier and display device. When the anode is positive and the cathode is negative cathode rays will be generated and projected over the entire area of the screen. When the anode becomes negative and the cathode positive, current flow is interrupted. Actual experience has shown the device after initial ageing capable of the generation of high intensity luminescence of great uniformity and without flickering or fluctuation. A device of this type will not operate satisfactorily on ordinary 60 cycle current. For this reason a rectifier is essential, and in accordance with this form of structure the rectifier is embodied as a part of the device. If necessary, in order to maintain uniform pressure conditions within the vessel 10, a side chamber 54 is provided containing a vapor or gas generating substance 55 which may be heated by means of the heating coil 56. To make this structure automatic a thermostatic device 57 is connected in the heater circuit and subjected to temperature or current fluctuations of the main device so that the heating coil will be switched on and off as necessary to maintain the pressure in the main device.

The structure of Fig. 7 involves a combined display and full wave rectifying device. In this case the vessel 60 is provided with the screen 61 which supports the luminescent material. At each end of the vessel are the cathodes 64 shaped to project the cathode rays onto the screen. The anode 63 is mounted in a side chamber and is connected to the electrical midpoint of the secondary 66, the terminals of which are connected to the cathodes. At 67 is the energizing primary. No discussion is necessary to illustrate the operation of the device as a full wave rectifier.

Another structure for accomplishing similar results is illustrated in Figs. 8 and 9. In this case the vessel 68 is of oval cross-section, illustrating that the transverse dimensions of the tube may be reduced where desired. Within the vessel is the screen 69 for supporting the luminescent material. At 70 is the cathode, which in this case may be termed a sort of "roof", which extends along the top of the screen and is bent so as to direct the cathode rays over the entire surface of both sides of the screen. In this case a pair of anodes 71, 72 are provided which would be connected to the secondary of the transformer while the cathode 70 would be connected to the midpoint thereof. Here again the side tube 73 is supplied to hold a gas generating substance which may be heated as desired by the heating coil 74 through the thermostatically controlled circuit by means of a thermostat diametrically illustrated at 75.

All of the devices described preferably employ a non-sputtering metal for the anode such as aluminum or magnesium in accordance with well known principles of this art, and as specifically discussed above. The dimensions of said anode

are proportioned in accordance with current density variations previously described.

The form of the invention as illustrated in Fig. 10 is that of a long tube of relatively small diameter somewhat like that of the luminescent gas discharge devices now employed for advertising purposes in the form of designs, letters, devices, and the like. As shown it comprises a long glass tube 80 formed into an airtight vessel and having a rarefied atmosphere in accordance with the principles previously described. The vessel has a re-entrant stem 81 in which one end of the cathode 82 is supported. The other end of this cathode passes through a seal in the opposite end of the vessel and to which electrical connections can be made. The cathode in this case is in the form of a long rod of suitable proportion. At 83 is an anode sealed into the vessel and exposed to the interior thereof through the openings 84 in the re-entrant stem 81. At 85 is shown the luminescent coating which in this case is deposited upon the interior wall of the vessel 80 so as to surround the cathode 82 and to form, so to speak, a thin coating. The coating in this case, which may be of any one of the known luminescent materials or desired mixtures thereof, is preferably very thin or else made in the form of a discontinuous surface so that when the material is excited by the cathode rays the light generated may be transmitted therethrough so as to be observed from the exterior of the vessel.

This tube, although illustrated as a straight cylinder in the drawings, may, of course, assume any desired shapes and sizes and may be formed up into letters, symbols, devices, or other display forms.

The structure of Fig. 11 comprises a dome-shaped vessel 86 having a re-entrant stem 87 in which is supported the curved cathode 88. At 89 are a pair of anodes mounted in small chambers open to the interior of the main vessel. The upper dome-shaped portion of the vessel 86 is provided with a coating 90 of luminescent material which may, as stated before, be either extremely thin or in the form of a discontinuous surface so that light may be transmitted to the exterior of the vessel.

In all of these modifications it will be apparent that the general principles above described in detail, as well as the materials employed and the various circuit connections, may be used therewith to attain the important objects of uniform excitation of the luminescent coating. Furthermore, the current conditions of operation and the features of rectification previously described may likewise be employed in connection therewith.

It will be apparent to those skilled in the art that this invention resides in certain principles of construction and operation which may be employed in other physical forms. I do not, therefore, desire to be strictly limited to the disclosure as given for purposes of illustration, but rather to the scope of the appended claims.

What I seek to secure by United States Letters Patent is—

1. In a luminescent device, a sealed vessel having a rarefied atmosphere, a luminescent substance supported within the vessel, means for exciting said substance, comprising an anode and a cathode, and conductive surfaces surrounding the anode and the cathode and in electrical contact therewith.

2. The combination described comprising a closed vessel having a rarefied atmosphere, a cathode and an anode for said vessel, a luminescent substance supported substantially between the electrodes and in the dark space region of the discharge within the vessel so as to be excited by the rays generated by the cathode, and means subject to the temperature of the rarefied atmosphere for controlling the pressure thereof to render the operation of the device more stable.

3. In a luminescent device, the combination comprising a closed vessel having a rarefied atmosphere therein, a film of luminescent material supported within said vessel, a cathode and an anode within said vessel positioned so as to project cathode rays uniformly over the surface of said film, and conductive shields surrounding the cathode and the anode and connected thereto for increasing the uniformity of excitation of said film.

4. The combination as described comprising a closed vessel having a rarefied atmosphere, a cathode and an anode for said vessel, a luminescent substance supported within the vessel so as to be between the electrodes and in the dark space region of the discharge, and means controlled by the current for operating the device for controlling the pressure in the vessel to render the operation of the device more stable.

5. A luminescent light source of the type described comprising a closed vessel having a rarefied atmosphere, a cathode and an anode supported in said vessel in spaced relation and in longitudinal alignment, a surface coated with a luminescent substance supported between the cathode and the anode, and conducting shields surrounding the cathode and anode and extending in an axial direction a distance sufficient to substantially surround the cathode and the anode and connected thereto respectively whereby the electron discharge between the electrodes is uniformly distributed over said coating to effect uniform excitation thereof.

6. A luminescent light source of the type described comprising a closed vessel having a rarefied atmosphere, said vessel having a sealed re-entrant stem forming an anode chamber and having an aperture in the wall thereof establishing communication between the chamber and vessel, an anode supported in said chamber, a cathode mounted in said vessel and spaced from said anode, a body of luminescent material supported between the cathode and the anode, and means comprising conducting shields connected respectively to the anode and the cathode for causing uniform distribution of the discharge between the electrodes over the surface of the luminescent material.

7. In a luminescent device the combination comprising a closed vessel having rarefied atmosphere, an anode and a cathode supported in said vessel, means forming a layer of luminescent material supported between the anode and the cathode, means forming with a portion of said vessel a restricted chamber in which said anode is supported, and a source of alternating current connected to the cathode and the anode whereby the cathode and anode cooperate to produce a rectifier for producing a rectified current which is applied to the cathode and anode to excite the cathode to produce an electron discharge which is projected over the surface of said luminescent layer to excite it.

8. A device of the type described comprising a closed vessel having a rarefied atmosphere, a cathode, an anode of small area compared with that of the cathode positioned in an adjoining

chamber of the main vessel of restricted volume, a screen supported between the electrodes and in the dark space region of the discharge, and an alternating current supply source connected to said cathode and anode whereby the alternating current is rectified and applied to the electrodes so that said coating is excited to luminescence.

9. A device of the type described comprising a closed vessel having a rarefied atmosphere, cathodes in said vessel, a plate supported therein substantially between the electrodes and in the free electron region of the discharge having a luminescent coating on both faces, said cathodes having such a geometric shape as to project cathode rays uniformly over the entire area of the luminescent coating, and an anode in and adjoining extension of the main vessel.

10. A device of the type described comprising a closed vessel having a rarefied atmosphere, a screen supported within said vessel, a cathode supported above the screen having such a geometric shape as to project cathode rays uniformly over the entire area of the screen, a luminescent coating on said screen, and anodes in adjoining extensions of the main vessel, said coating lying substantially between the electrodes and in the dark space region of the discharge.

11. The combination described comprising a closed vessel having a rarefied atmosphere, a cathode and an anode for said vessel, a luminescent substance supported within the vessel, substantially between the electrodes and in the free electron region, so as to be excited by the rays generated by the cathode, and means for maintaining the pressure of the rarefied atmosphere to render the excitation of the luminescent substance substantially constant.

12. In a luminescent device the combination comprising a closed vessel having a rarefied atmosphere therein, a surface of luminescent material supported substantially between the electrodes and in the free electron region of the discharge within said vessel, an anode placed in an adjoining extension of the main vessel, and a cathode having such a geometric shape as to project cathode rays uniformly over the entire area of the surface covered with luminescent material.

13. A luminescent light source comprising a closed vessel having a rarefied atmosphere, an anode and a cathode supported in said vessel in spaced relation, and means having a luminescent coating supported substantially between the anode and the cathode and in the free electron region of the vessel, the cathode being shaped and positioned with respect to the luminescent coating whereby electrons projected therefrom are uniformly distributed over the entire surface of the coating.

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