May 9, 1933. C. SPAETH 1,908,647

ELECTRICAL DISCHARGE DEVICE

Filed Oct. 28, 1930

Fig. 1.

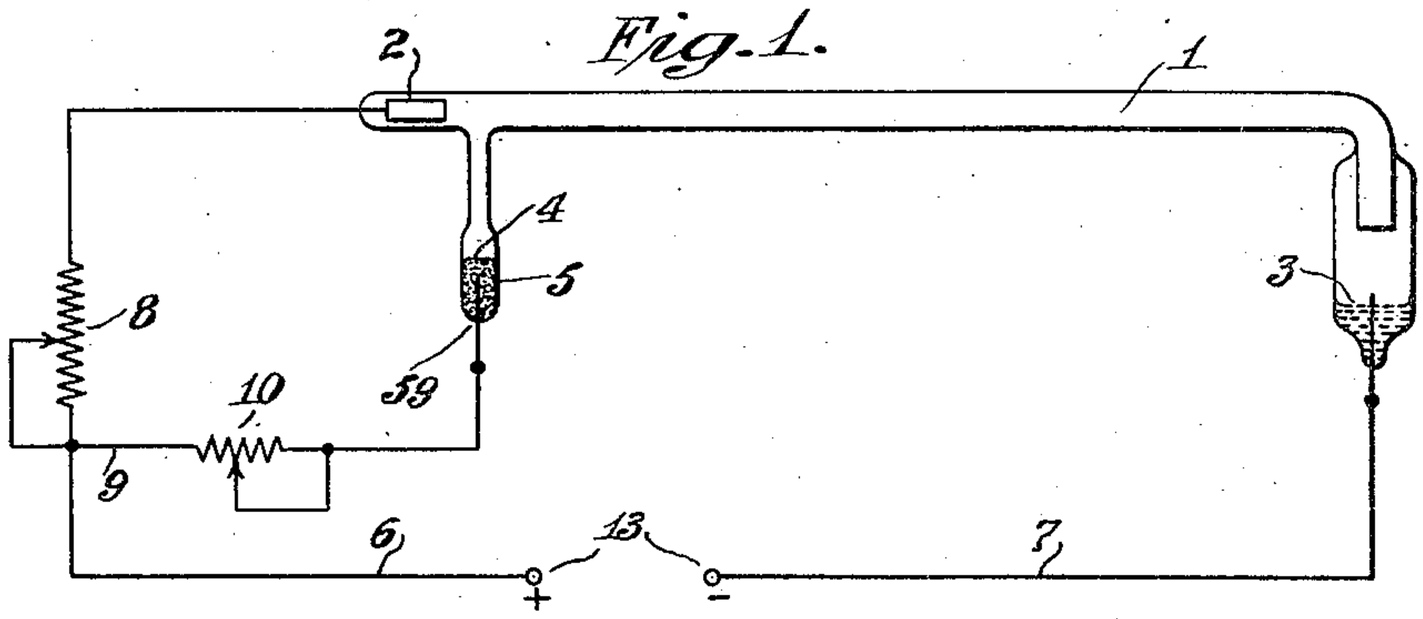


Fig. 2.

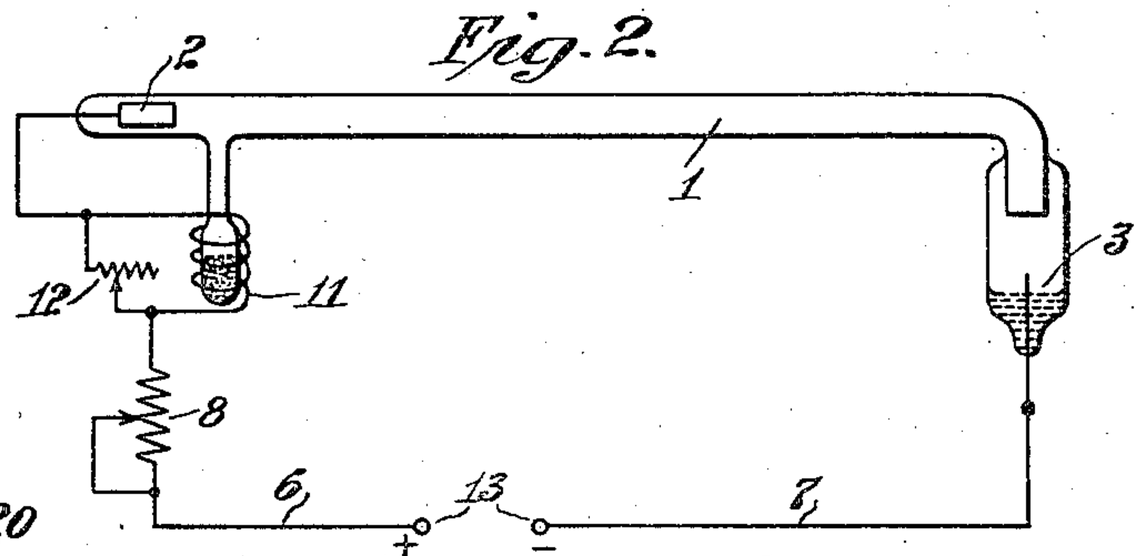


Fig. 3.

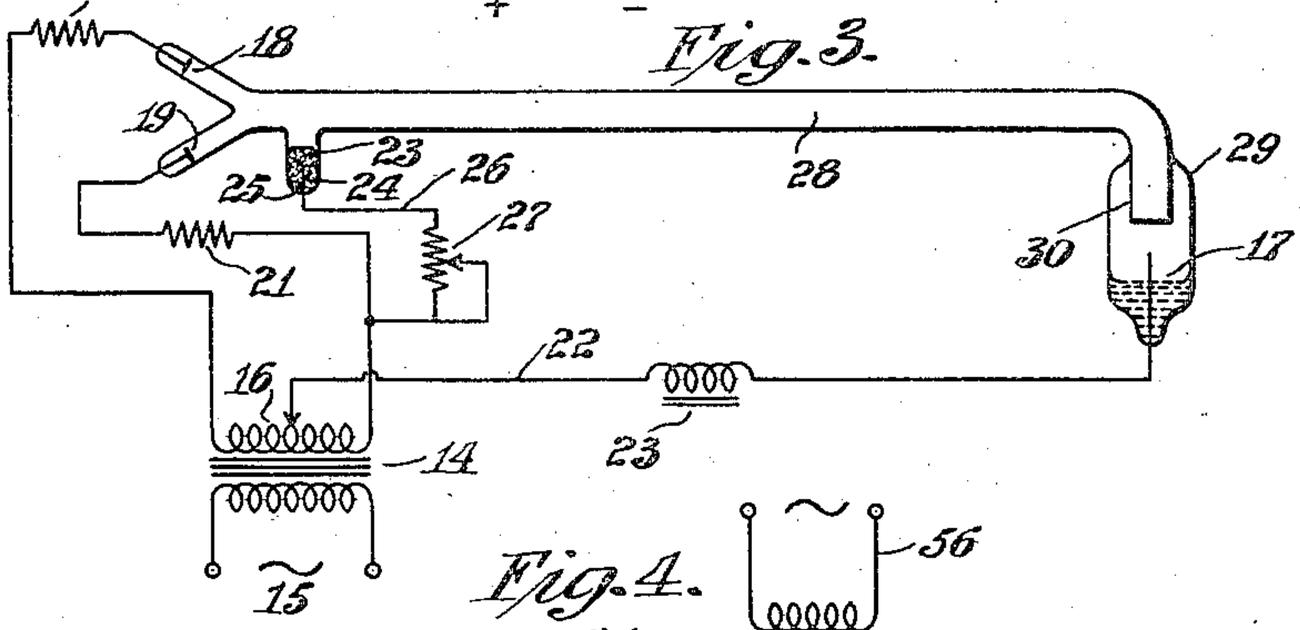
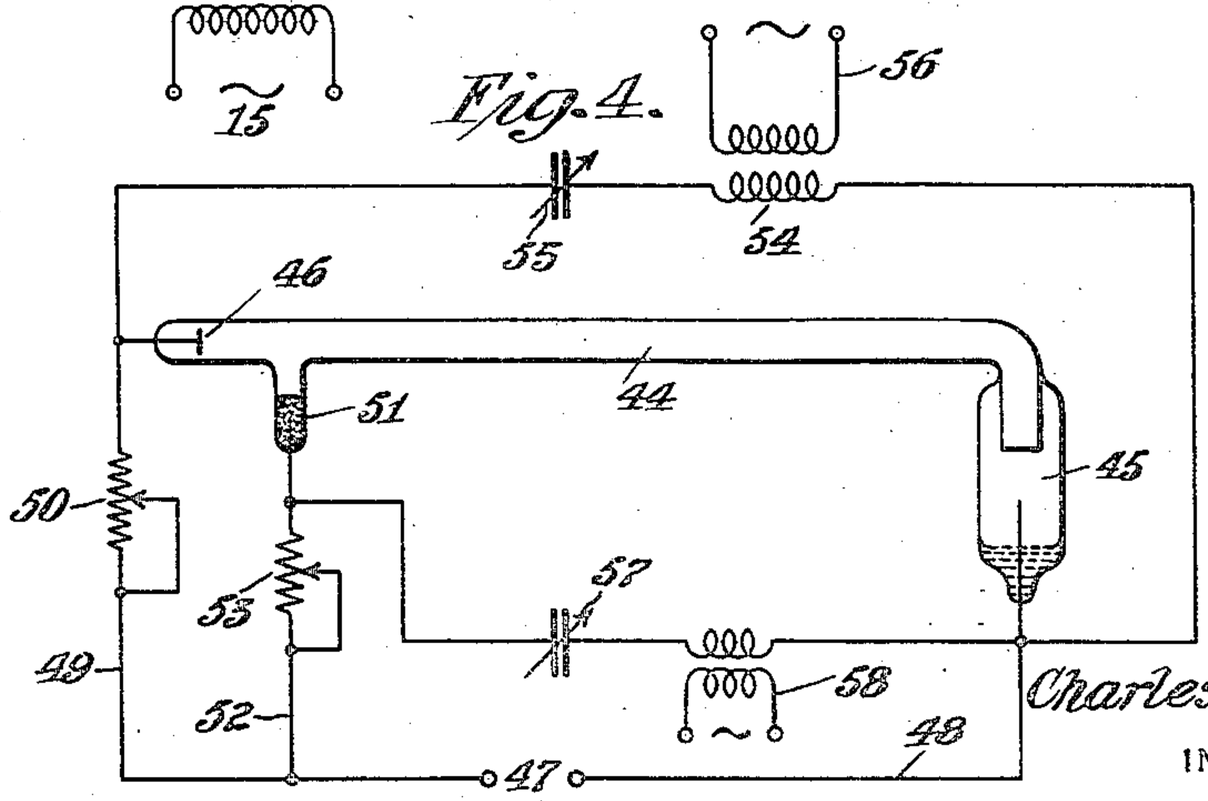


Fig. 4.



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UNITED STATES PATENT OFFICE

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ELECTRICAL DISCHARGE DEVICE

Application filed October 28, 1930. Serial No. 491,724.

This application is a continuation in part of my copending application Serial No. 343,873, filed March 2, 1929 and relating to electrical discharge devices.

My invention relates to electrical discharge devices, particularly to devices used for purposes of illumination.

It is an object of the present invention to provide an electrical discharge tube which is capable of producing a very efficient light.

Another object is to provide an electrical discharge illuminating tube wherein the color characteristics of the emitted light may readily be modified in a predetermined manner or be maintained constant at any desired value.

A further object is the provision of an electrical discharge tube operating at high efficiency and adapted to produce a concentrated brilliant light emission.

In accordance with my invention a radiant energy emitting discharge device is constructed having a filling of gas at reduced pressure and a plurality of electrodes for conducting an electrical discharge therethrough. For modifying the light emission from the device auxiliary means are arranged to add to the gas filling in the desired amounts an agent for modifying the radiation spectrum. This auxiliary device is preferably in the form of a mercury reservoir provided with means for liberating mercury vapor.

A preferred form of my invention for illuminating purposes comprises an envelope containing an atmosphere of rare gas such as neon and having a reservoir of mercury. An alkali metal electrode and a cooperating electrode of any desired kind is provided for passing a discharge directly through the rare gas and another electrode is furnished for causing a discharge to be passed to the mercury in order to vaporize it. In order to secure the desired characteristics of illumination from the device, means such as resistances, inductances or capacitances, may be provided for controlling the relative intensities of the discharges. For liberating the mercury suitable heating means may be employed in place of the auxiliary electrode. This heating means may comprise any suitable source of external heat, but preferably is in the form of a heating coil placed adjacent to the mercury reservoir and adapted to be energized by the discharge current.

When it is desired to secure a white light the filling of the envelope may be of neon gas used in conjunction with a reservoir or other means for supplying an exactly proportioned amount of mercury vapor. It is advisable where the tube is to be operated over a relatively long period of time to maintain the mercury vaporizing means in operation at the correct intensity during the entire operation of the device. It is, however, possible to start the discharge through the rare gas column and then supply the necessary quantity of mercury vapor for a short period of time, after which the device will continue to emit a white light for some time. As operation is continued the mercury is cleaned up, apparently either by condensation, occlusion, absorption or some other phenomena and the light emitted by the device gradually reverts to the characteristic color of the rare gas, which in the case of neon is substantially red. By operating the mercury vaporizing device at the correct intensity mercury vapor is supplied at the same rate at which it is used up and hence the color of the emitted light remains constant.

The alkali metal electrode is very important to the prolonged operation of the tube. This electrode appears to function as a clean-up agent for the excess mercury within the main body of the tube, because when an electrode of ordinary metal is used the tube turns entirely blue after a relatively short period of operation, and cannot be restored to its original mercury free color. During the operation of the discharge device a minute amount of mercury vapor is continuously generated by the auxiliary electrode and carried over into the main body of the tube, where it is excited by the main discharge current. When the exciting current is cut off this mercury vapor remains in the main tube and apparently forms an amalgam, or other association, with the alkali metal electrode, of such character that the mercury is not liberated from the electrode during future operation of the de-

vice. Without the alkali metal the mercury vapor relatively quickly reaches such density in the main tube that only blue light is generated. The alkali also serves to reduce the cathode fall of potential. A single metal or alloy of alkali metals may be used. I find it preferable to use an alloy of potassium and cæsium in the proportions of 90% to 10%. By using such a combination the cathode drop may be made as low as 55 volts. For commercial purposes potassium may be used alone to save expense.

The operating area of the alkaline metal cathode should be so proportioned with respect to the discharge current that the current density will be of but moderate intensity, for example, 3 amperes per square inch or less so that large amounts of metallic vapor will not penetrate the main discharge path and mask the spectrum thereof. The alkali metal should be made the cathode during normal operation of the device for otherwise the excess mercury vapor is not absorbed or prevented from acting, by the metal.

For producing other colors of light other monatomic gases, for example, helium, argon, xenon, crypton, may be used with mercury vapor, or one of a mixture of the rare gases of a given characteristic color emission may be used in conjunction with the means for liberating the vapor.

A device constructed in accordance with my invention may also serve as a generator of oscillations of extremely high frequency and constancy.

Other objects and advantages and the manner of obtaining them will be made clear in the following specification and accompanying drawing.

In the drawing, Fig. 1 shows a device constructed in accordance with my invention wherein the modification of the emitted spectrum is obtained by the passage of a discharge to a spectrum modifying material.

Fig. 2 shows a somewhat similar device wherein the light modifying material is activated by a heating device.

Fig. 3 shows a tube adapted for energization by alternating current.

Fig. 4 shows an oscillator constructed in accordance with my invention.

Referring more particularly to the drawing, Fig. 1 illustrates an electrical discharge tube comprising a light transmitting envelope 1 filled with rare gas, such as neon, and having a pair of main discharge electrodes 2 and 3, cathode 3 being of alkali metal. The pressure of the gaseous atmosphere may range anywhere from .1 to 50 millimeters but I find it preferable to use a pressure in the neighborhood of 6 millimeters. A reservoir for a quantity of mercury 4 is provided in the form of an appendix 5. For energizing the tube the main electrodes 2 and 3 are connected across a suitable source of current 13 by means of conductors 6 and 7. Connected in series with the conductor 6 is an adjustable resistance 8. For causing discharge to pass to the mercury 4 a connection 9 is made between a lead-in wire 59 sealed through the wall of the reservoir 5 and making contact with the mercury, and the conductor 6. In series with the conductor 9 is an adjustable resistance 10. The anode 2 may be of any well known type but preferably comprises a thin walled cylinder or disc of highly refractory material which has a low vapor pressure at high temperatures, such as tungsten or molybdenum, which is so proportioned as to be heated red hot by the passage of normal discharge current through the tube. Nickel or iron may also be used but the electrode must be much larger to carry the same amount of current. The heated anode has a relatively low fall of potential so the entire device may be operated on the ordinary commercial lighting voltage of 110 to 120 volts direct current.

In operation a current is caused to pass from the source 13 between the two electrodes 2 and 3 thereby energizing the filling of rare gas and causing it to emit light having certain color characteristics. For example, where the rare gas is neon the light will be predominantly red. In order to modify these color characteristics the resistance 10 is adjusted so that a discharge passes between the electrode 3 and mercury 4, thereby causing a quantity of the mercury to be vaporized. The mercury vapor diffuses through the gas in the envelope 1, emitting light rays of its characteristic blue color. By properly adjusting the resistance 10 it is possible so to balance the blue rays emitted against the characteristic color of the rare gas as to produce a light emission of any desired color. For example, where the rare gas is neon a proper adjustment of the resistance 10 may be made to cause the emission of white light, the blue rays of the mercury being complementary to the red rays of the neon. The resistances 8 and 10 serve also as ballast resistances for balancing the negative resistance of the gaseous discharge path. These resistances should therefore never be cut entirely out of circuit as the discharge current would increase to an excessive value. While the mercury reservoir is illustrated as positioned near to one of the main electrodes it need not necessarily be so located. The device will likewise be operative with the reservoir at other positions. By placing the reservoir as shown the impedance of its discharge path is made relatively large.

The device shown in Fig. 2 is the same as that shown in Fig. 1 except that mercury vapor is produced by heating coil 11 instead of by passage of a discharge to the mercury. This tube is operated in substantially the same manner as that of Fig. 1, the only dif-

ference being that the amount of mercury vapor generated is controlled by varying the amount of heat generated by the coil 11. This may be done by adjusting the resistance 12.

Fig. 3 shows a tube adapted for operation by alternating current. Current is supplied by means of a transformer 14 energized from a line 15. A connection 22 is made from a center tap 16 of the transformer to an alkaline metal electrode 17 of the tube. This connection includes in series an inductance 23 which functions to prevent flicking of the light in the usual well known manner, when the device is used on low frequency alternating currents. The two main terminals of the secondary of the transformer are connected to two ordinary metallic electrodes 18 and 19 at opposite ends of the tube through resistances 20 and 21 respectively. As the electrodes 18 and 19 are comparatively small in relation to the electrode 17 a rectifying action occurs, the discharge passing alternately between electrodes 17 and 18 and 17 and 19. The electrode 17 is made of an alkaline metal or an alloy of alkaline metals similarly to the electrode of Fig. 1.

The operating area of the alkaline metal cathode should be so proportioned with respect to the discharge current that the current density will be of but moderate intensity, for example, 3 amperes per square inch or less so that large amounts of metallic vapor will not penetrate the main discharge path and mask the spectrum thereof.

While the path between the two electrodes 18 and 19 is relatively short the amount of leakage current passing between these two electrodes will be small, as the cathode fall of potential of an ordinary electrode made of aluminum, iron or other similar material is in the neighborhood of several hundred volts.

For liberating mercury vapor into the gaseous atmosphere an auxiliary circuit comprising a reservoir 23 containing mercury 24 is connected to the tube envelope. A lead-in wire 25 passes through the wall of the reservoir into contact with the mercury. For causing the discharge to pass to the mercury an auxiliary connection 26 is made between the lead-in wire and one side of the secondary of the transformer 14. This connection 26 includes in series an adjustable resistance 27 by means of which the amount of mercury vapor liberated may be controlled in the same manner as that set forth in connection with Fig. 1. For preventing the alkaline metal of the electrode 17 from sputtering into the main portion 28 of the tube the metal is placed in an enlarged reservoir 29 into which the end 30 of the main tube projects. This arrangement also aids in preventing undesired penetration of metallic vapors into the main discharge path at moderate intensities of discharge. As alkaline metal is utilized for one of the electrodes the tube envelope should be made of some alkaline metal resistant glass such as Pyrex or other borosilicate glass. By utilizing such a glass it is also possible to operate at high temperatures without danger of collapse of the tube walls.

Fig. 4 shows a device constructed in accordance with my invention arranged to produce oscillations of any desired frequency. As shown in this figure a discharge device is used comprising an envelope 44 filled with rare gas and provided with an alkaline metal cathode 45 and an anode 46. The anode may be of any ordinary well known type or may comprise a thin walled cylinder of a highly refractory metal as disclosed in connection with Fig. 1. This electrode is proportioned so as to be heated red hot by the passage of normal discharge current through the tube. For causing a discharge between these electrodes a source of alternating or varying electromotive current 47 is provided. Electrodes 45, 46 are connected with the source 47 by means of conductors 48 and 49 respectively. In series with the conductor 49 an adjustable resistance 50 is connected. An auxiliary mercury electrode 51 is connected to the envelope 44 and for energizing this electrode a connection 52 including in series an adjustable resistance 53, is made to the source 47. In order to control the frequency of the generated oscillations a tuned circuit comprising an inductance 54 and a condenser 55 is connected between the electrodes 45 and 46. By varying the capacity of the condenser 55 it is possible to vary the frequency of the generated oscillations. The oscillations may be utilized in any desired manner by coupling to the inductance 54 a work circuit 56. Oscillations of a different frequency may be obtained by connecting between the electrodes 45 and 51 another tuned circuit 57 which may supply a work circuit 58. Extremely short wave length oscillations may be obtained by connecting a suitable work circuit directly across the electrodes 45 and 46 without any auxiliary tuning devices. For example, a tube containing neon gas and having a length of 18 inches will produce oscillations having a wave length in the neighborhood of one meter. The oscillations produced by this type of generator are of extremely constant wave length and amplitude.

It is well known that ordinary light tubes utilizing a filling of rare gas are adapted to operate at only relatively low current densities and that in order to secure life long enough for commercial purposes it has been thought necessary to utilize electrodes operating at relatively low current densities. A device constructed in accordance with my invention will, on the contrary, operate at ex-

tremely high current densities without excessive heating and without excessive deterioration. For example, by utilizing an alkaline metal cathode and hot anode, I am able to pass through a tube 52 inches long and 1 inch in diameter a discharge of 10 amperes under pressure of 220 volts.

Where neon gas and an auxiliary mercury electrode are used, as set forth, the color may be adjusted from the characteristic neon color, through white, to the characteristic mercury color.

Lamps of this type are substantially silent in operation, especially when direct current is used. They are therefore of great value where a white, silent and relatively cool, high intensity illuminating source is desired, as in the recording of synchronized sound pictures. Any oscillations which are inherently generated are of such short wavelength as not to interfere with ordinary amplifying systems.

It will be obvious to those skilled in the art that the invention is capable of a wide variety of modification and adaptation and that the present disclosure is intended merely to illustrate its nature without limiting its scope which is set forth in the appended claims.

What I claim is:

1. An electrical discharge device comprising an envelope containing a rare gas, means to pass an electric current through said rare gas, said rare gas being adapted to discharge light of a characteristic color, a modifying medium, means to heat the modifying medium, said modifying medium being adapted to discharge light of a color complementary to that of the rare gas, which modifying medium is continuously supplied in the gaseous state to the rare gas and which modifying medium is always maintained in said rare gas in quantities to produce a light of a desired value intermediate the color of the rare gas and the modifying medium, and an agent for reducing the modifying medium to non-gaseous form in such quantities as to sustain the light at substantially the intermediate value.

2. An electrical discharge device according to claim 33 characterized in that the agent for reducing the modifying medium is an alkali metal.

3. A lamp comprising an envelope, a filling of rare gas in said envelope, means to pass an electrical discharge through said rare gas, a quantity of material in said envelope, which material, when heated, is adapted to give off a vapor, vaporizing means adapted to be adjusted to selectively control the rate and amount of the material vaporized in order to control the extent to which the rare gas is modified, and an absorbent to remove and retain the vaporized material from the sphere of the light column in substantially the proportions in which it is added to the light column.

4. A lamp comprising an envelope, a filling of neon in said envelope, means to pass an electrical discharge through said neon, a quantity of mercury in said envelope, which mercury when heated, is adapted to give off vapor, heating means adapted to vaporize the mercury at a predetermined rate in order to control the extent to which the neon is modified, an alkali metal to remove vaporized mercury from the sphere of the light column as additional mercury is added to the light column.

5. In an electrical discharge device, an envelope, a filling of gas having certain color characteristics within said envelope, a pair of electrodes for passing a discharge through said gas, a reservoir connected with said envelope containing means for liberating a gas having another color characteristic, and auxiliary means for causing said gas to modify the light produced by said tube, to a predetermined extent.

6. In an electrical discharge device, an envelope, an atmosphere of gas within said envelope having certain color characteristics, means for passing a discharge through said gas, means for liberating within said envelope a substance for modifying the said color characteristics, and auxiliary means for causing said means second mentioned to liberate at a constant rate a predetermined quantity of said substance.

7. In an electrical discharge device, a light transmitting envelope, an atmosphere of rare gas within said envelope, a reservoir of mercury connected to said envelope, means for passing a discharge through said gaseous atmosphere and auxiliary means for passing a discharge to said mercury to cause the liberation of a predetermined quantity thereof.

8. A device in accordance with claim 7 wherein means is provided for varying the relative intensities of the discharges.

9. In an electrical discharge device adapted to produce continuously light of a predetermined modified color, a light transmitting envelope, an atmosphere of rare gas within said envelope, means for passing a discharge through said gas, a reservoir containing mercury attached to said container and means for vaporizing a predetermined quantity of the mercury in said container.

10. In an electrical discharge device, a light transmitting container, an atmosphere of rare gas within said container, means for passing a discharge through said gas, and means for continuously adding at a constant rate a small quantity of mercury vapor to said gas.

11. In an electrical discharge lamp, a light transmitting container, an atmosphere of neon within said container, means for passing a discharge through said atmosphere, and means for continuously adding at a constant

rate a small quantity of mercury vapor to said atmosphere.

12. A device in accordance with claim 11 wherein the means for adding mercury vapor comprises a reservoir of mercury connected with said container, and means for passing an auxiliary discharge to said mercury.

13. In an electrical discharge device, a container, an atmosphere of rare gas within said container, a pair of electrodes for passing discharge through said gas, one of said electrodes comprising a quantity of alkali metal positioned within the container, said container comprising a reservoir containing a quantity of mercury positioned out of the direct path of the discharge, and means for vaporizing said mercury.

14. In an electrical discharge device, a container, a quantity of rare gas within said container, a pair of electrodes for passing a discharge through said atmosphere, means for controlling the intensity of said discharge, said container comprising a mercury reservoir, means for passing a discharge to the mercury in said reservoir, and means for controlling the intensity of the discharge to said mercury.

15. In an illuminating device, a gaseous atmosphere having certain light emitting characteristics, means for passing a discharge through said atmosphere, and means for continuously supplying to said atmosphere at a constant rate a substance for modifying the said light emitting characteristics.

16. In an illuminating device, a container, a plurality of electrodes for said container, means for passing a discharge between certain of said electrodes for energizing a column of rare gas, and means for passing a discharge between other of said eletrodes for liberating a quantity of mercury vapor.

17. In an illuminating device, a container, a plurality of substances within said container, each having a different radiation spectrum, a plurality of electrodes for said container, means for passing a discharge between certain of said electrodes to energize one of said substances and means for passing a discharge between other of said electrodes for energizing another of said substances.

18. In a light emitting device, a container, a quantity of rare gas and a quantity of mercury within said container, adjustable means for passing a discharge through said rare gas, and adjustable means for vaporizing said mercury.

19. In an electrical discharge device, an envelope containing an atmosphere of gas having a certain radiation spectrum, a plurality of electrodes for passing a discharge through said gas, means for liberating within said envelope a substance having another radiation spectrum and means for causing said means first mentioned to function, to liberate a predetermined amount of said substance.

20. A device in accordance with claim 19 wherein the envelope comprises a reservoir for containing a quantity of mercury, and means is provided for vaporizing a quantity of said mercury.

21. In an electrical discharge device, an elongated envelope containing a gaseous atmosphere, an electrode at each end of the envelope, a reservoir for mercury connected to said envelope near one end thereof, means for passing a discharge between said electrodes and means for passing a discharge between the mercury and the more remote of the electrodes.

22. In an electrical discharge device, an envelope containing a filling of neon gas, a pair of electrodes within said envelope, one of said electrodes having a low anode fall of potential, and the other of said electrodes having a low cathode fall of potential, means for passing a discharge between said two electrodes, a mercury reservoir attached to said envelope and adapted to retain a quantity of mercury out of the path of the discharge between the anode and cathode, and means for vaporizing a quantity of said mercury.

23. In an electrical discharge device, an envelope containing a monatomic gas, means for passing a discharge through said gas to ionize it, and electrical means for constantly generating and continuously adding to said gas in predetermined quantities an agent adapted to produce a light color effect complementary to that of said gas.

24. A device in accordance with claim 23 wherein said agent is a metallic vapor.

25. In an electrical discharge device, a container, a gaseous atmosphere within said container, means for passing an electrical discharge through said atmosphere, modifying means for varying the light emitting characteristics of said atmosphere and means for controlling the operation of said modifying means in a definite predetermined manner, said modifying means comprising a non-gaseous substance and the controlling means comprising heating means for vaporizing the substance.

In testimony whereof I have signed my name to this specification this 21st day of October, 1930.

CHARLES SPAETH.