May 9, 1933. C. SPAETH 1,908,649

ELECTRICAL DISCHARGE DEVICE

Filed March 2, 1929 2 Sheets-Sheet 1

Fig. 1.

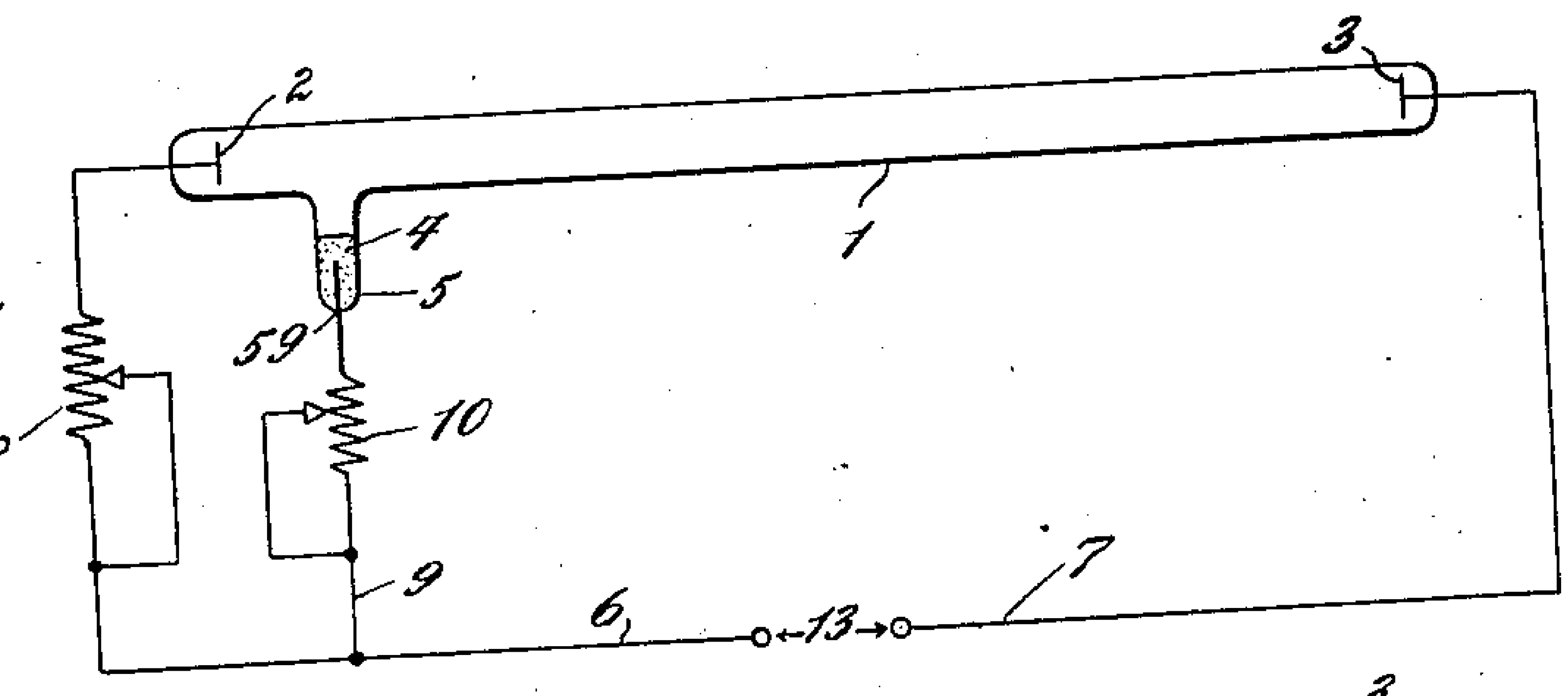

Fig. 2.

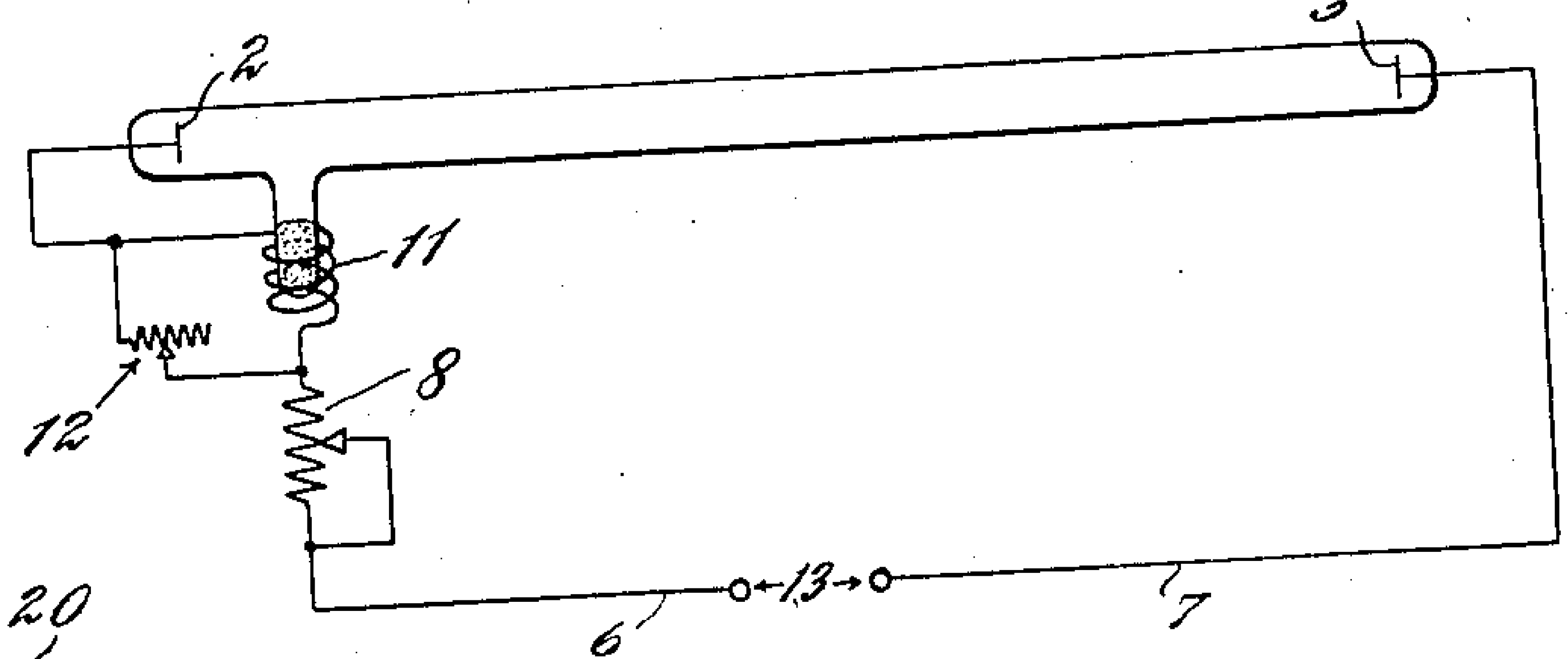

Fig. 3.

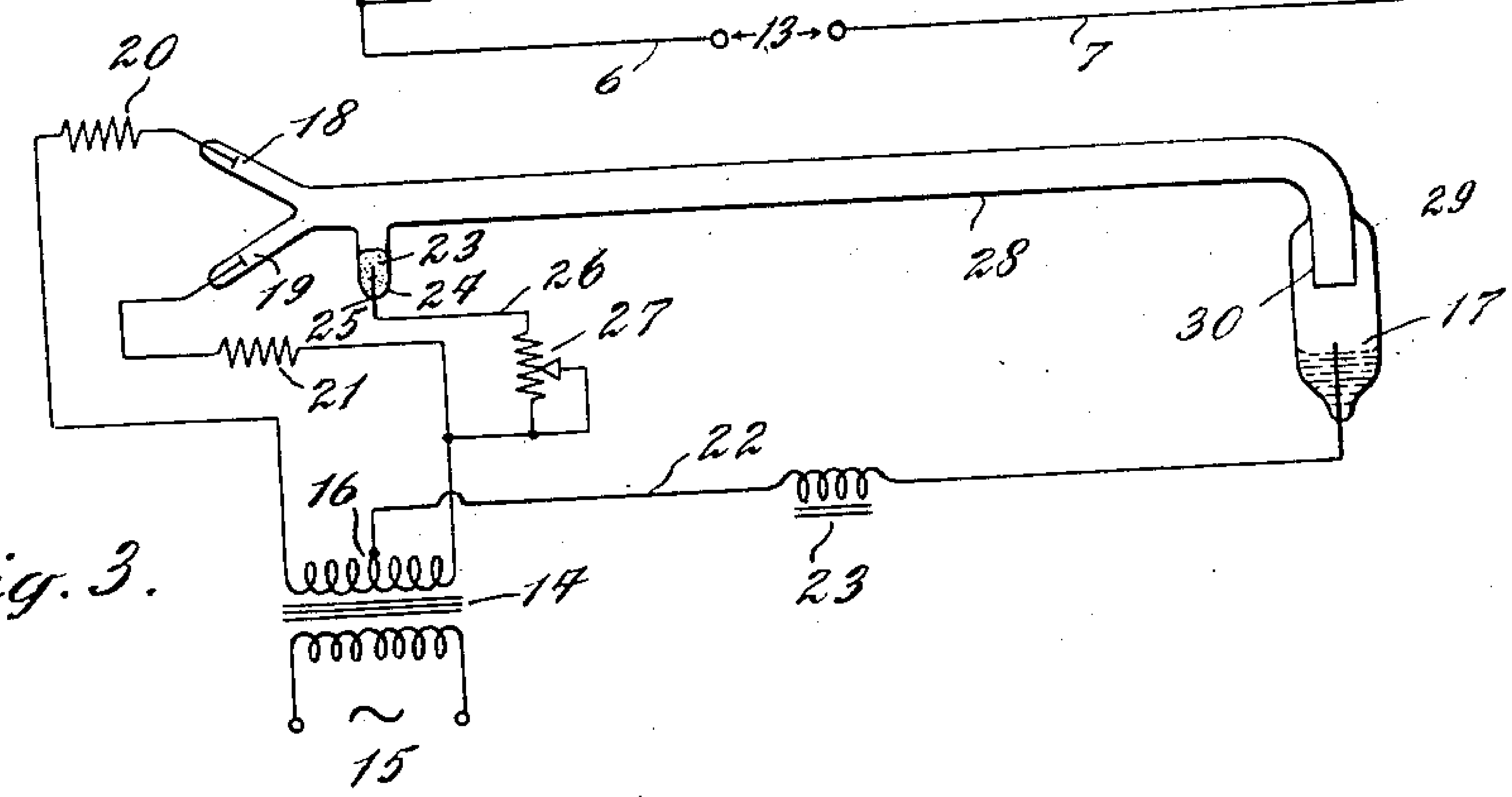

Fig. 8.

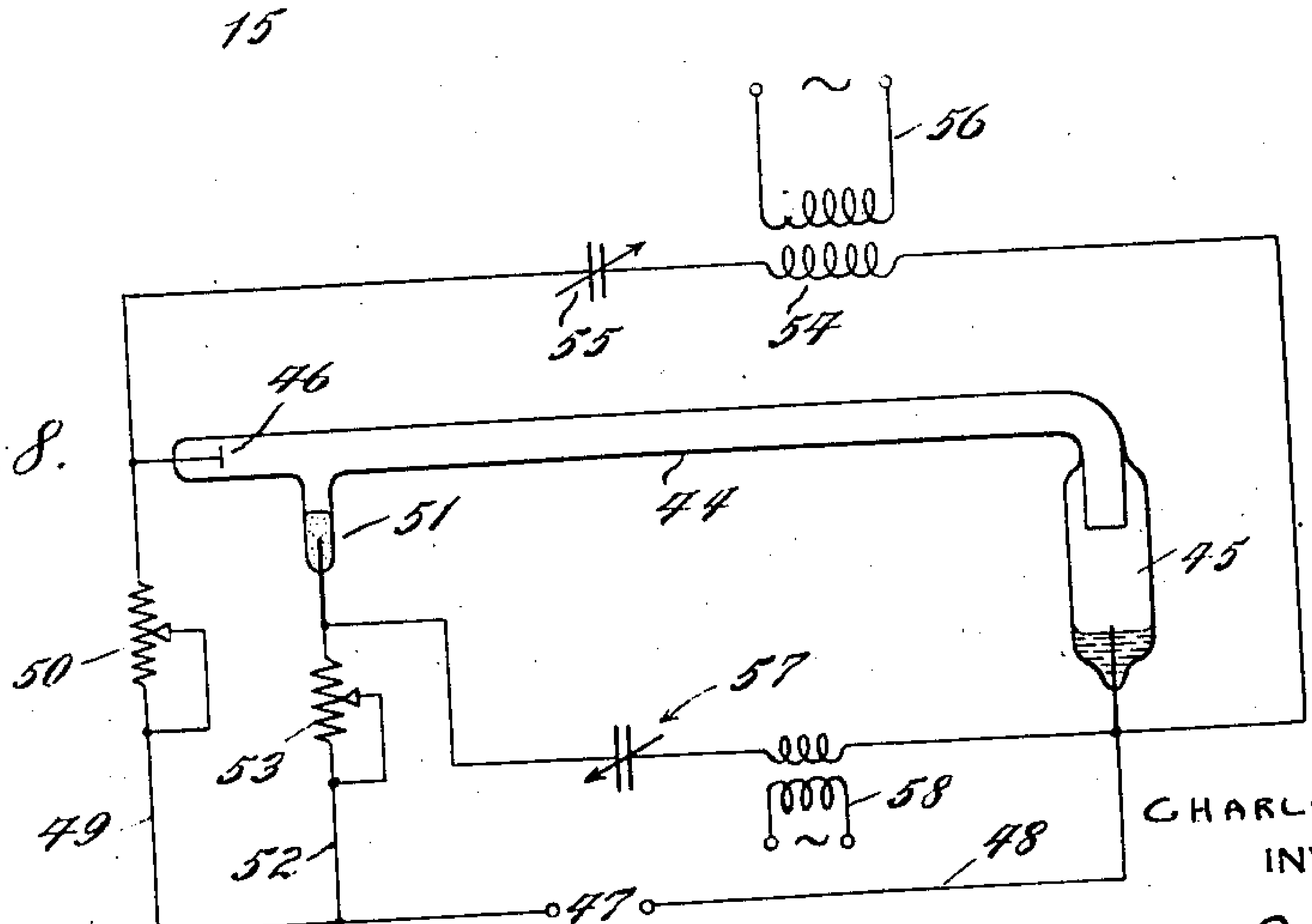

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Fig. 4.

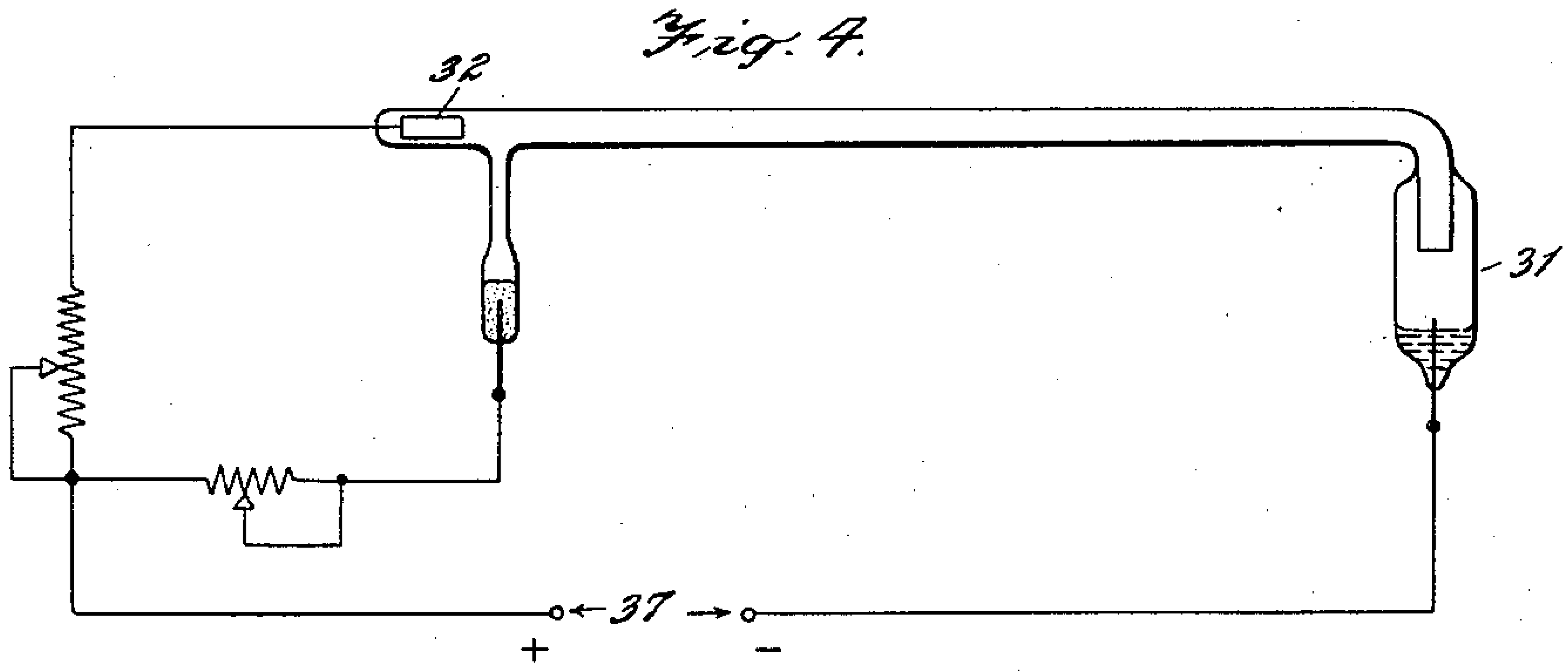


Fig. 5.

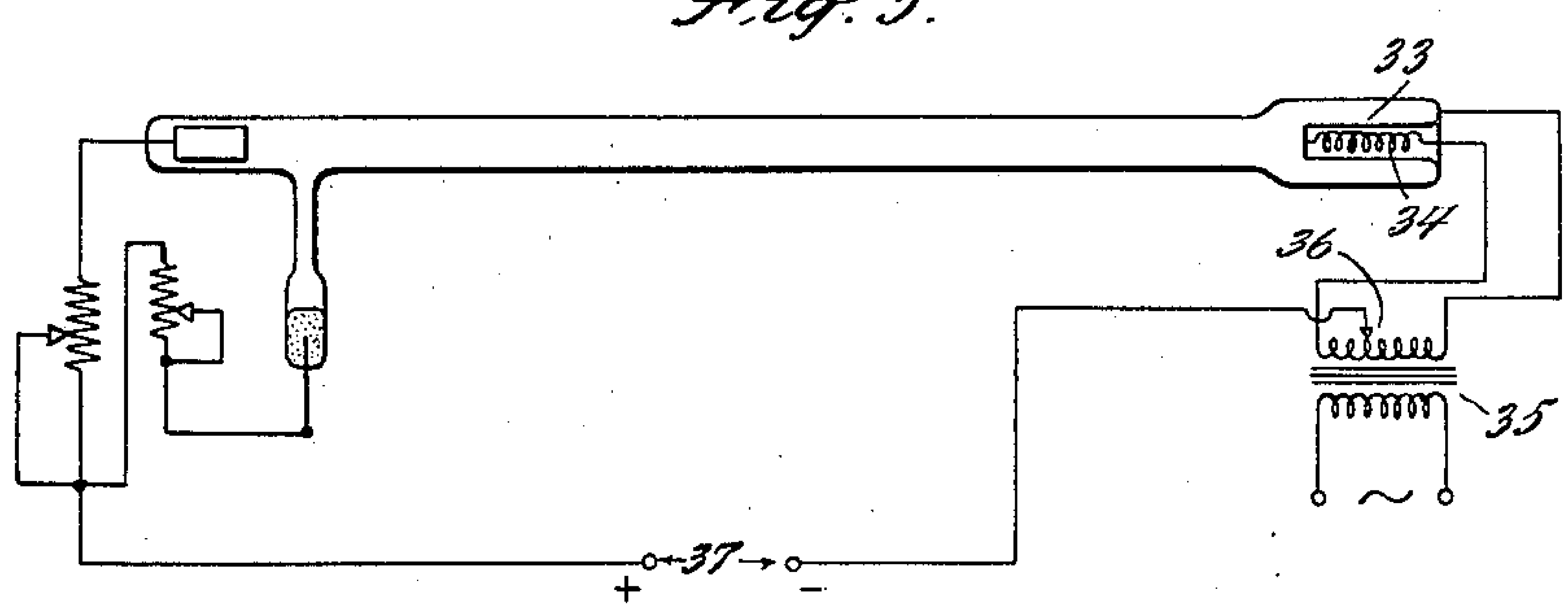


Fig. 6.

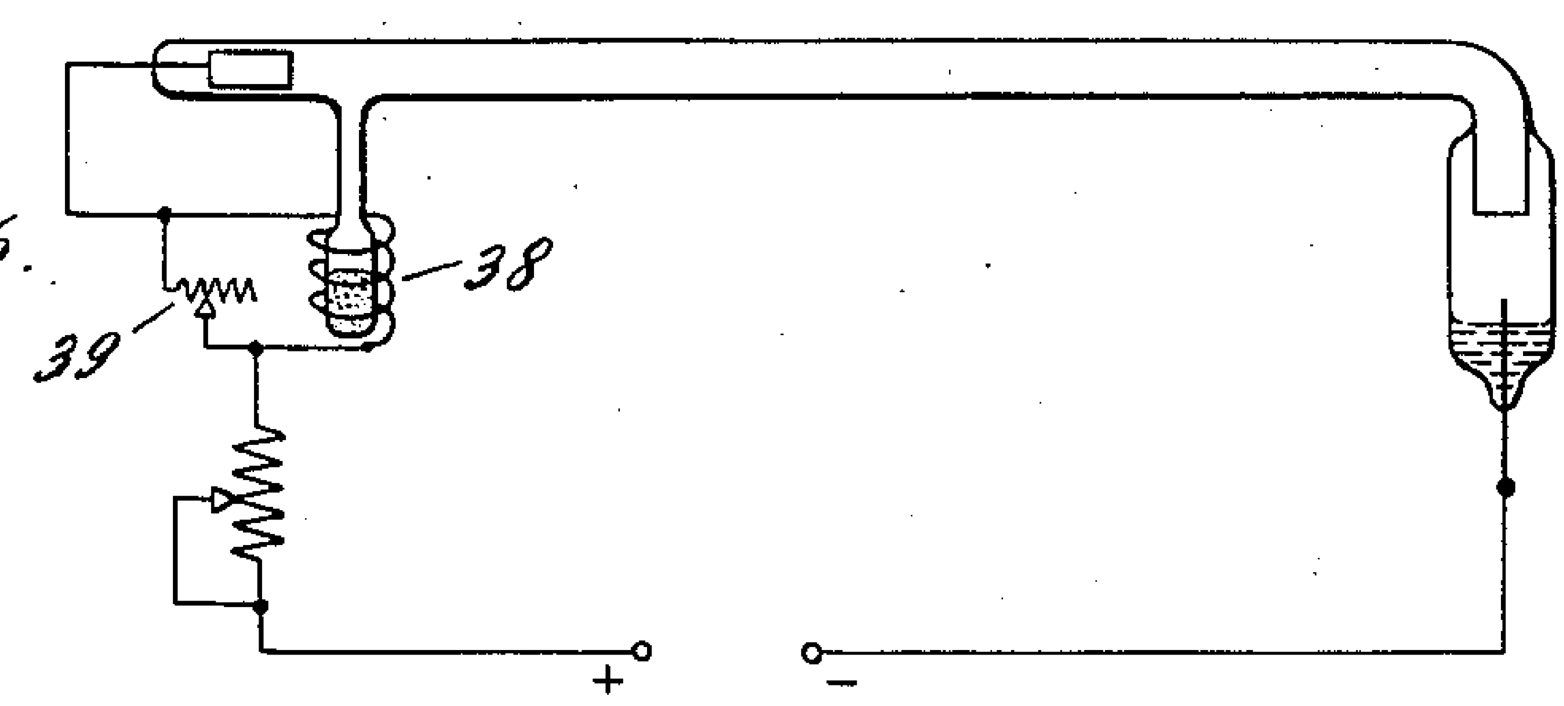
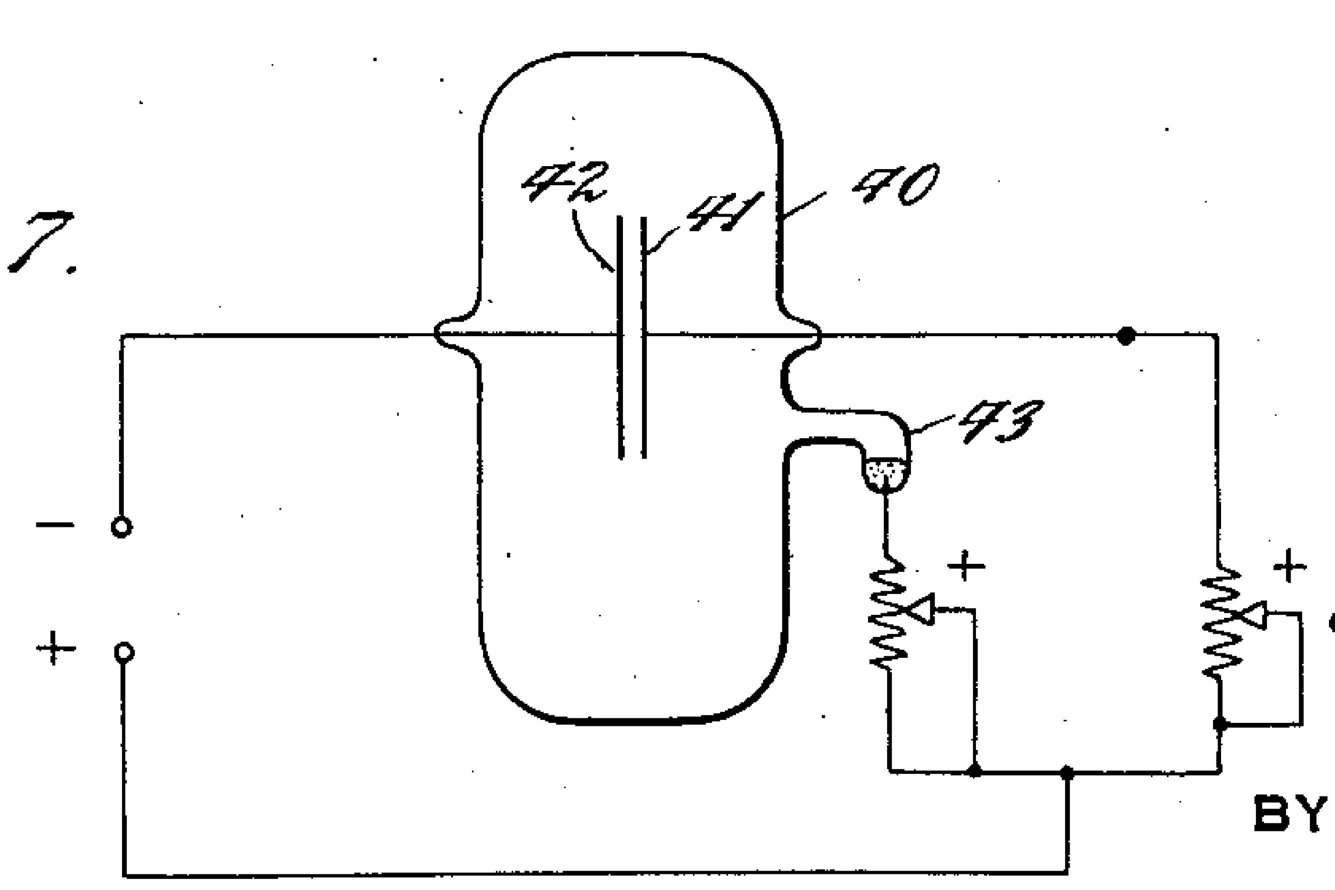


Fig. 7.



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Patented May 9, 1933 1,908,649

UNITED STATES PATENT OFFICE

CHARLES SPAETH, OF FLUSHING, NEW YORK

ELECTRICAL DISCHARGE DEVICE

Application filed March 2, 1929. Serial No. 343,873.

This 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 white 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.

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

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. In place of mercury other elements or combinations of elements may be used, for example, cadmium, thallium, sodium or calcium, depending on the spectrum modification desired.

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. Electrodes are provided for passing a discharge directly through the rare gas and another electrode 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 are 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 approximating that of sunlight 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 rear 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.

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 means for liberating a gas or metallic vapor having another color characteristic.

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 drawings.

In the drawings, 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 an alternating current tube utilizing an alkaline metal cathode.

Fig. 4 shows a device similar to that shown in Fig. 1 except that an alkaline metal cathode is utilized.

Fig. 5 shows a device wherein the cathode is of the oxide coated indirectly heated type.

Fig. 6 shows a device similar to that of Fig. 2 with the exception that an alkaline metal cathode is used.

In Fig. 7 a lamp suitable for television use is illustrated.

Fig. 8 shows an oscillator constructed in accordance with my invention.

Referring more particularly to the drawings, 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 of any well known type, having the usual lead-in wires. 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 14 by means of conductors 6 and 7. The source 13 may be of either direct or alternating current of a suitably high potential. 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.

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 to 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 difference 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 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 in order to reduce the cathode drop potential. Sodium, potassium, rubidium, caesium or alloys of these metals may be used. I find it preferable to use an alloy of potassium and caesium in the proportion 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.

Where one or several of these metals is

used in place of mercury for light modification the auxiliary discharge used for the vaporization thereof should be of relatively greater density in order to insure penetration of the metallic vapor into the main discharge path of the device.

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. Where no alkaline metal is used it is, of course, possible to make the tube envelope of any ordinary type of glass provided the intensity of the discharge is not sufficient to heat the glass to the softening point.

The device shown in Fig. 4 is substantially the same as that shown in Fig. 1 except that it is especially adapted to operate on low voltage direct current from a source 37. The cathode 31 is of the alkaline metal type similar to electrode 17 of Fig. 3. The anode 32 may be of any well known type but preferably comprises a thin walled cylinder of nickel or iron which is so proportioned as to be heated red hot by the passage of normal discharge current through the tube. The heated nickel anode has a fall of potential of but approximately 10 volts. The entire device may therefore be operated on the ordinary commercial lighting voltage of 110 to 120 volts direct current.

Fig. 5 shows a tube similar to that of Fig. 4 with the exception that instead of an alkaline metal cathode an indirectly heated oxide coated cathode of well known construction may be used. I find that a suitable electrode may comprise a thin cylinder 33 of nickel coated with an oxide of barium, strontium or calcium.

This cylinder may be heated by a resistance coil 34 energized by a heating transformer 35, the secondary of which is provided with an adjustable tap 36 by which the neutral point may be determined.

Fig. 6 shows a device similar to that of Fig. 4 with the exception that a heating coil 38 is provided for liberating the necessary amount of mercury vapor. This heating coil is the same as that shown in Fig. 2 and may be similarly controlled by a suitable resistance 39.

Fig. 7 illustrates a lamp adapted for television purposes, the lamp comprising a gas filled envelope 40 having a pair of plate electrodes 41 and 42 spaced apart a distance less than the mean free path of the gas in the well known manner. The envelope is filled with an atmosphere of inert gas, for example, neon and a reservoir 43 containing mercury is provided. In operation a white light is obtained in the same manner as set forth in connection with Fig. 1. The discharge cannot pass directly between the two plates because of their close spacing and therefore passes around to the outside faces of the plates illuminating them in the well known manner.

Fig. 8 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 nickel or iron, as disclosed in connection with Fig. 4. 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 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 wavelength 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 wavelength in the neighborhood of one meter. The oscillations produced by this type of generator are of extremely constant wavelength 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 extremely 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 18 inches long and 1 inch in diameter a discharge of 6 amperes under pressure of 220 volts. Even when operating at this relatively high current density the life of the tube is from 3,000 to 7,000 hours.

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. The efficiency of tubes constructed in accordance with my invention is extremely high. For example, when using neon gas with mercury vapor to produce a white light the amount of energy consumed is only about 0.20 watt per spherical candlepower. Because of this relatively high efficiency the amount of heat generated by the device is correspondingly small.

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 wave length 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. In an oscillator, an envelope containing a filling of rare gas, a plurality of electrodes for passing a discharge through said gas, a mercury reservoir attached to said container, means for vaporizing a quantity of said mercury, and an output circuit for high frequency oscillations connected between two of said electrodes.

2. A device in accordance with claim 1 wherein the output circuit comprises an inductance and a variable condenser.

3. In an oscillator, an envelope containing a filling of gas, a plurality of electrodes for passing a discharge through said gas, a reservoir containing a light color modifying substance attached to said container, means for vaporizing a quantity of said substance, and an output circuit for high frequency oscillations connected between two of said electrodes.

In testimony whereof, I have signed my name to this specification this 28th day of February 1929.

CHARLES SPAETH.