

May 3, 1927.

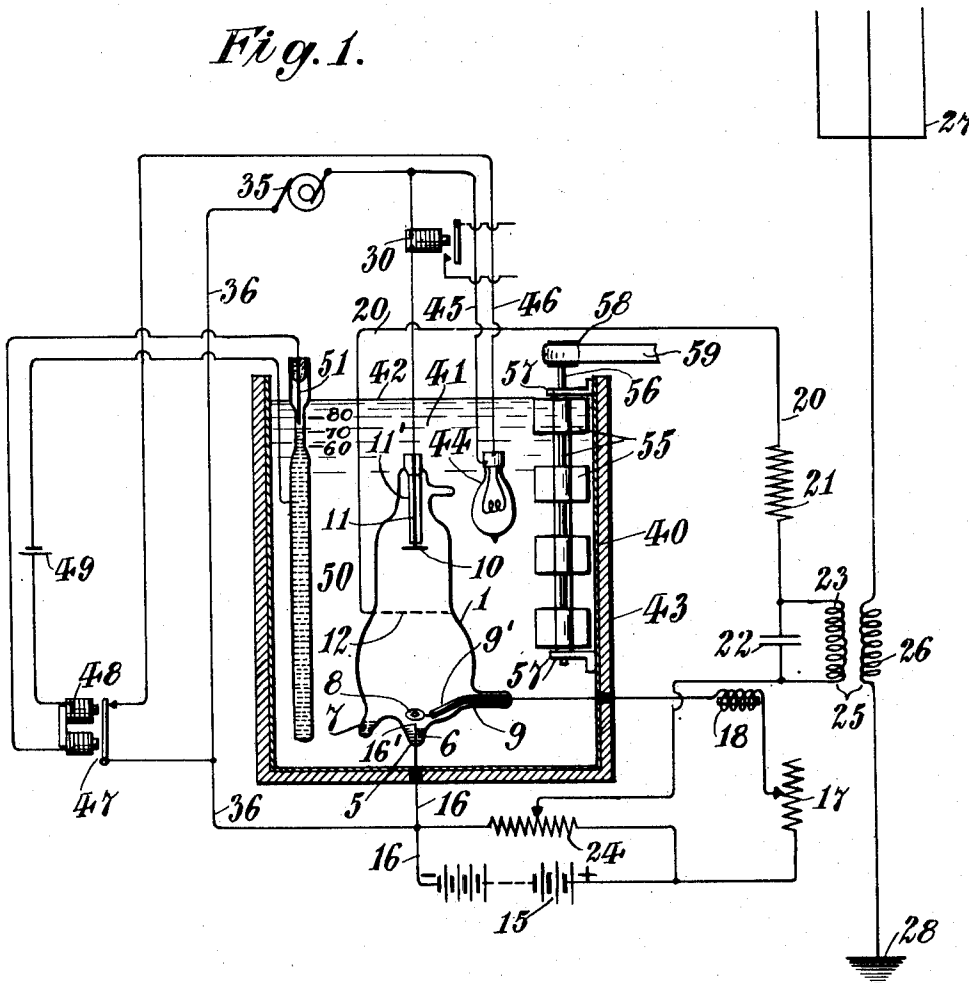
1,627,231

E. L. CHAFFEE

DETECTOR AND METHOD OF CONTROLLING THE SAME

Original Filed March 31, 1915 2 Sheets-Sheet 1

Fig. 1.



WITNESSES

Geoffrey
W. S. Oulton

INVENTOR

Emory Leon Chaffee
BY
A. J. Gardner
ATTORNEY

May 3, 1927.

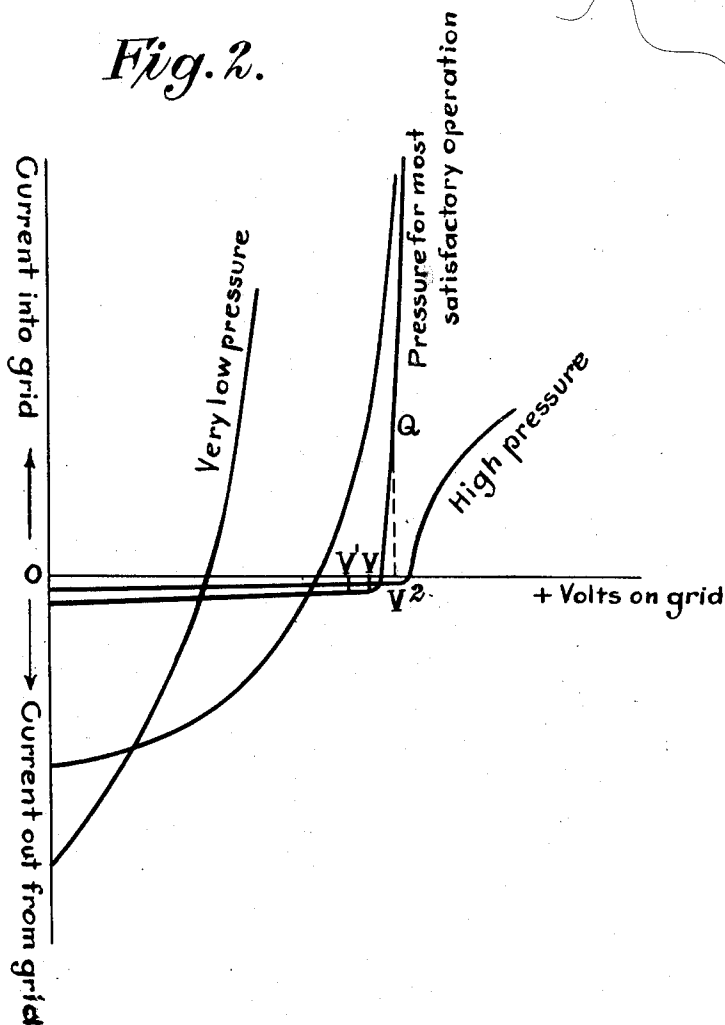
1,627,231

E. L. CHAFFEE

DETECTOR AND METHOD OF CONTROLLING THE SAME

Original Filed March 31, 1915 2 Sheets-Sheet 2

Fig. 2.



WITNESSES

Geoffrey
H. S. Orton

INVENTOR

Emory Leon Chaffee

BY

A. J. Gardner

ATTORNEY

UNITED STATES PATENT OFFICE.

EMORY LEON CHAFFEE, OF BELMONT, MASSACHUSETTS, ASSIGNOR TO JOHN HAYS HAMMOND, JR., OF GLOUCESTER, MASSACHUSETTS.

DETECTOR AND METHOD OF CONTROLLING THE SAME.

Application filed March 31, 1915, Serial No. 18,367. Renewed July 24, 1923.

This invention relates to devices for controlling comparatively large electric currents by comparatively small current disturbances or pulsations, and is set forth herein as applied in a mercury vapor detector, but it is desired that it be understood that the invention is not limited in its application to any particular device or to any particular class of devices.

Some of the objects of this invention are to provide an improved mercury vapor detector which may be readily adjusted to, and successfully operated at a higher degree of sensitiveness than has heretofore been possible; to provide an improved detector which will be constant, stable, and reliable in operation; to provide an improved detector which may be readily adjusted to various degrees of sensitiveness; and to provide other improvements as will appear hereinafter.

In the accompanying drawings:—

Figure 1 is a diagrammatic vertical section of one form of detector constructed in accordance with this invention and connected to the receiving circuit of an ordinary "wireless" system; and

Figure 2 is a diagram explanatory of the operation of the detector.

Referring to the drawings, one embodiment of this invention comprises a suitable glass bulb or container 1 of the usual form, but from the interior of which practically all gases have been exhausted so as to attain as nearly as possible a perfect vacuum.

The lower portion of the bulb 1 is extended downwardly to form a well 5 which contains mercury forming a mercury cathode 6. The lower portion of the bulb 1 is also provided with the usual mercury reservoir 7. Within the bulb 1 and spaced slightly above the mercury cathode 6 is a flat horizontal metal annular plate 8 forming an anode which is supported in a fixed position by the inner end of a metal conductor 9, the outer end of which projects through the bulb 1. The conductor 9 is preferably surrounded by a glass tube 9'.

In the upper portion of the bulb 1 is a flat horizontal metal disc 10 forming a top terminal which is supported in a fixed position on the lower end of a metal conductor 11, the upper end of which projects through the upper end of the bulb 1. The conductor 11

is preferably surrounded by a glass tube 11'. Fixedly secured within the bulb 1 and spaced between the anode 8 and the upper terminal 10 is a horizontal circular perforated metal disc or grid 12.

For maintaining a quiet arc between the mercury cathode 6 and the anode 8, a battery 15 is provided.

The negative terminal of the battery 15 is connected to the mercury cathode 6 by a conductor 16 which is extended upwardly through the cathode 6 and which is provided at its upper end with a platinum tip 16' projecting slightly above the mercury to render the cathode spot of the arc discharge stationary. The positive terminal of the battery 15 is connected to the anode 8 through a regulating resistance 17 and a choke coil 18.

For controlling the potential of the grid 12, the grid is connected through a conductor 20, and resistance 21 to a closed oscillatory circuit comprising a condenser 22 and coil 23, and is connected through the closed circuit with a potentiometer 24 which receives its energy from the battery 15. The potentiometer serves to maintain the grid normally at a potential greater than the potential of the cathode 6 and usually less than the potential of the anode 8. The coil 23 of the closed oscillatory circuit, in the construction shown, forms the secondary of a receiving transformer 25, the primary coil 26 of which is connected in series between an antenna 27 and ground 28, constituting a circuit for the reception of radiant energy.

For operating a relay 30 or other device or instrument as a result of weak current oscillations or current disturbances received in the primary coil 26, the top terminal 11 is connected through the relay 30 or other device or instrument with one terminal of a source 35 of alternating current of about 100 volts, the other terminal of which is connected through a conductor 36 and conductor 16 with the cathode 6.

For controlling the temperature and consequently the internal pressure of the bulb 1, for purposes which will appear hereinafter, the bulb 1 is fixedly located in an oil tight receptacle 40 which is filled with oil 41 or other suitable liquid to a level 42 above the upper end of the bulb. The receptacle 40 is preferably well lagged as at 43

for heat insulation. Any well known or suitable means are provided for raising the temperature of the oil to any desired degree and then maintaining it at that degree. For instance, one or more heating lamps 44 are arranged in the oil 41 and connected to receive current from the source 35 of alternating current, through a circuit 45, 46, controlled by a relay 47 including an electro-magnet 48 arranged to be energized by a battery 49 and controlled by a thermostat 50 of well known construction arranged in the oil 41. The thermostat may be readily adjusted by raising or lowering its movable contact 51 to maintain the oil 41 at any desired temperature through the action of the heating lamps 44, in a well known manner. Any suitable means may be provided for agitating the oil 41 to keep its temperature uniform throughout its mass. For instance, a rotary stirrer may be used, comprising blades 55 rigid with a vertical shaft 56 arranged to rotate in bearings 57 rigid with the receptacle 40, the shaft being provided at its upper end with a pulley 58 fixed thereon and arranged to be driven by a belt 59 from any suitable motor (not shown).

One theory which is thought to describe the operation of this improved detector is as follows:—The arc between the anode 8 and the cathode 6 causes negative corpuscles or electrons to be shot upward through the opening in the anode 8 into the space below the grid 12. The distance these negative particles will go depends upon the pressure of the gases or vapor inside the bulb 1, the higher the pressure the shorter the distance travelled before the collisions with the molecules of the gases or vapor dissipates their energy of motion. Before the velocity of these electrons has been reduced below some value the electrons, on striking a neutral molecule, is capable of ionizing it, that is, splitting it into + and - parts. These ions are carriers of electricity and their presence renders the gas conducting.

The region below the grid 12 in which these ions are produced is more or less sharply defined and relatively far away from or near to the grid according to the pressure. At some definite pressure it is probable that the upper boundary of the ionized region is quite sharply defined and a certain distance below the grid forming an approximately horizontal layer. The negative ions produced in this region will be urged upward toward the grid 12 or downward toward the anode 8 according to their position relative to these two terminals and according to the relative potentials of the grid 12 and anode 8.

Let it be assumed that the potentials of the grid 12 and the anode 8 be adjusted so that both are positive and the positive potential of the grid slightly less than the positive

potential of the anode 8, and so that consequently those negative ions on the extreme upper boundary of the ionized layer will be acted upon by a slight unbalanced force pulling them downward toward the anode 8. Under these conditions there will be no negative ions near the grid 12 and hence none can pass through the grid into the space above. The space above the grid is therefore non-conducting and source 35 causes no current to flow. The positive ions produced in the ionized layer are heavy, sluggish, and practically inactive. They may be attracted toward the grid and there give up their charge which passes through the resistance 21 to the cathode.

Suppose, now that the positive potential of the grid 12 be increased by a very small amount. The increase may be sufficient to reverse the force on the upper electrons which will now move toward the grid. As soon as they are within a short distance of the grid the terminal 10 when charged positively by the source 35 will attract them and the region above the grid will become conducting. A current will now pass through the bulb from the source 35. Since the current passes only in one direction because of the presence of only negative ions, the current is consequently intermittent. The conductivity of the space above the grid vanishes between discharges and the current will restart only if the supply of negative ions above the grid is maintained. The effect of the trains of electrical oscillations received from the secondary coil 23 is to raise the potential of the grid, which increase in potential as has been shown, triggers off the alternating current from 35 to operate the relay 30 or other device.

The increase of potential of the grid due to the electrical oscillation is an accumulative effect as can be made clear from an examination of the characteristic curves of the bulb 1. If a sensitive current measuring instrument be placed in the grid circuit and the current measured for various potentials impressed on the grid, curves such as are shown in Figure 2 will result.

At a certain critical pressure in the bulb 1 of the detector, the curve has the shape shown at Q. Suppose the potentiometer 24 is adjusted to potential V and the electrical oscillations produced in the secondary coil 23 cause fluctuations of potential of the grid between V' and V². Since the change in flow of current to or from the grid due to the same increase and decrease of potential is different when V is near the bend in the curve, there will be a greater flow of electricity to the grid than from it and the potential of the grid will increase more than by the amount of V²—V. It is necessary that the characteristic curve have a sharp bend which characteristic is obtained at one

particular pressure in the bulb. From the foregoing, it is evident that the pressure in the bulb 1 of the detector is very important and that a particular pressure is desirable.

It is to be understood however that the foregoing theory as to the operation of this improved detector may not be correct in every detail and that a more nearly correct theory may be developed later.

Heretofore, it has been customary in constructing mercury detectors to utilize glass bulbs corresponding to the hereinbefore described glass bulb 1, but from which only a portion of the gases have been exhausted, or in other words, to utilize glass bulbs within which only a partial vacuum has been created. These bulbs have been operated so far as I am aware, only at the ordinary atmospheric temperatures. Under those conditions it was found that the best results were obtained when only a partial vacuum was created in the bulb, but that it was practically impossible to maintain reliability or uniformity of operation. This may have been due, at least in part, in accordance with the foregoing theory, to changes caused in the internal pressure of the bulb, caused by gases given up or absorbed by the metal terminals in the bulb, after the bulb was sealed, as it is a well known fact that metals occlude on their surfaces and in their pores large amounts of gases. Moreover, in those old forms of detectors it was a difficult, tedious and expensive operation to obtain even an approximation to the correct amount of vacuum in the bulb at the time it was sealed.

The foregoing defects in detectors are overcome by the present invention, in accordance with which all of the gases are exhausted from the interior of the bulb 1 and from all of the metal terminals or other parts contained therein, thus attaining as nearly as possible a perfect vacuum. The critical pressure is then obtained by heating the bulb and the mercury contained therein as hereinbefore described, until the vapor pressure of the mercury is at the critical pressure necessary to produce the best results. This critical pressure is determined experimentally. Since the vapor pressure of any pure substance depends only upon its temperature, it is necessary only to maintain the temperature of the bulb 1 constant in order to maintain indefinitely a constant pressure within the bulb. It has been found that under the usual working conditions when the bulb 1 is maintained at a constant temperature of about 70° centigrade very satisfactory results are obtained with this improved detector.

It has been found in practice that this improved detector is easy to regulate to attain any desired degree of sensitiveness; is not unfavorably affected by reasonably

heavy currents; may be adjusted and operated successfully at a higher degree of sensitiveness than has heretofore been possible in older forms of mercury detectors; and is constant, stable and reliable in operation.

Although only a single form in which this invention may be embodied has been shown and described herein, it is to be understood that the invention is not limited to the specific construction thus set forth, but may be embodied in other devices without departing from the spirit of the invention or the scope of the appended claims.

Having thus fully described this invention, I claim and desire to protect by Letters Patent of the United States:

1. A mercury detector comprising a container; a mercury cathode, and an anode in said container, means cooperating with said cathode and anode and responsive to radiant energy to cause electrical disturbances in said container, and means arranged to maintain the whole of said container at a substantially constant temperature to control the internal pressure of said container.

2. The method of controlling a mercury vapor detector which consists in forming a mercury arc in a vacuized chamber, maintaining the mercury vapor formed thereby at a predetermined pressure by controlling the temperature of said vapor and its liquid and varying from time to time the apparent conductivity of said vapor in response to radiant energy.

3. An apparatus for controlling electric currents, having in combination a conducting body and means for maintaining it in a critical condition and at a substantially uniform temperature, means for impressing on said body a periodic electro-motive force, and means for from time to time temporarily varying the apparent conductivity of the body by impressing on it an additional electro-motive force so as to control the current produced by the periodic electro-motive force.

4. An apparatus for controlling electric currents, having in combination a conducting body and means for maintaining it in a critical condition and at a substantially constant temperature different from the temperature of the surrounding atmosphere, means for impressing on said body a periodic electro-motive force, and means for from time to time temporarily varying the apparent conductivity of the body by impressing on it an additional electro-motive force so as to control the current produced by the periodic electro-motive force.

5. An apparatus for controlling electric currents, having in combination a conducting body, and means for maintaining said body in a critical condition and at a substantially uniform temperature, means for impressing on said body an electro-motive

force, and means for from time to time temporarily varying the apparent conductivity of the body by impressing on it an additional electro-motive force so as to control the current produced by the periodic electro-motive force.

6. An apparatus for controlling electric currents, having in combination a conducting body, and means for maintaining said body in a critical condition and at a substantially uniform temperature different from the temperature of the surrounding atmosphere, means for impressing on said body an electro-motive force, and means for from time to time temporarily varying the apparent conductivity of the body by impressing on it an additional electro-motive force so as to control the current produced by the periodic electro-motive force.

7. An apparatus for controlling electric currents, having in combination a conducting body and means for maintaining said body in a critical condition and at a substantially constant temperature, means for impressing on said body an electro-motive force, and means for from time to time temporarily varying the apparent conductivity of the body by impressing upon it an additional electro-motive force in response to radiant energy so as to control the current produced by the said first mentioned electro-motive force.

8. The method of controlling electric currents which consists in permanently maintaining a conducting body in a sensitive critical condition and at a substantially uniform temperature, in impressing on said body an electro-motive force, and in from time to time temporarily varying the apparent conductivity of the body by impressing upon it an additional electro-motive force so as to control the current produced by the said first mentioned electro-motive force.

9. The method of controlling electric currents which consists in permanently maintaining a conducting body in a sensitive critical condition and at a substantially uniform temperature, in impressing on said body an electro-motive force, and in from time to time temporarily varying the apparent conductivity of the body by impressing upon it an additional electro-motive force in response to radiant energy, so as to control the current produced by the said first mentioned electro-motive force.

10. A gaseous detector of radiant energy, comprising a container, a fluid in said container, a circuit including a source of electric energy controlled by the fluid in said container, and means for from time to time temporarily varying the conductivity of said fluid by impressing on it an electro-motive force in response to radiant energy so as to control the current flowing through said container from said source.

11. The combination with a container, of a fluid therein, means for generating electrical disturbances in said fluid, means responsive to radiant energy for varying from time to time the apparent conductivity of the interior of said container, and means for maintaining the whole of said fluid at a substantially constant temperature, said last-mentioned means including a receptacle in which said container is positioned, and means for maintaining a fluid in said receptacle at a constant and predetermined temperature regardless of the temperature of the surrounding atmosphere.

12. The combination with a container, of a fluid therein, means for generating electrical disturbances in said fluid, means responsive to radiant energy for varying from time to time the apparent conductivity of the interior of said container, and means for maintaining the whole of said fluid at a substantially constant temperature, said last-mentioned means comprising a receptacle in which said container is positioned, a liquid in said receptacle and in which said container is submerged, means outside of said container for heating said liquid, and a thermostat arranged to automatically control said heating means to maintain said liquid at a substantially predetermined temperature regardless of the temperature of the atmosphere.

13. The combination with a container, of a fluid therein, means for generating electrical disturbances in said fluid, means responsive to radiant energy for varying from time to time the apparent conductivity of the interior of said container, and means for maintaining the whole of said fluid at a substantially constant temperature, said last-mentioned means comprising a receptacle in which said container is positioned, a liquid in said receptacle and in which said container is entirely submerged, means outside of said container for heating said liquid, and a thermostat arranged to automatically control said heating means to maintain said liquid at a substantially predetermined temperature regardless of the temperature of the surrounding atmosphere.

14. A mercury detector comprising a container; a mercury cathode and an anode in said container; means cooperating with said cathode and anode, and responsive to radiant energy, to cause electrical disturbances in said container from time to time; a receptacle in which said container is positioned; a fluid confined in said receptacle and in which said container is submerged; means arranged outside of said container to heat said last-mentioned fluid; and an electrostat automatically operative to control said heating means to cause said last-mentioned fluid to be maintained at a substantially uniform temperature for the purpose of maintaining

a substantially uniform pressure within said container.

15. A mercury detector comprising a container; a mercury cathode and an anode in
5 said container; means cooperating with said cathode and anode, and responsive to radiant energy, to cause electrical disturbances in said container from time to time; a receptacle in which said container is positioned;
10 a fluid confined in said receptacle and in which said container is entirely submerged; means arranged outside of said container to heat said last-mentioned fluid; and an electrostat automatically operative to control
15 said heating means to cause said last-mentioned fluid to be maintained at a substantially uniform temperature for the purpose

of maintaining a substantially uniform pressure within said container.

16. A detector for radiant energy, comprising a receptacle, a liquid in said receptacle, a container submerged in and in contact with said liquid, and containing a fluid, means for generating electrical disturbances in said container, means responsive to radiant energy for varying the apparent conductivity of the interior of said container, and means for maintaining said liquid at a substantially constant temperature.

Signed at Belmont, in the county of Middlesex and State of Massachusetts this twenty-second day of March, A. D. 1915.

EMORY LEON CHAFFEE.