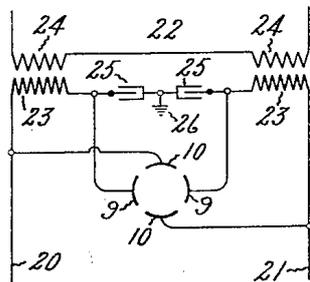
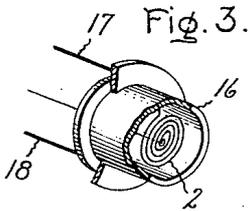
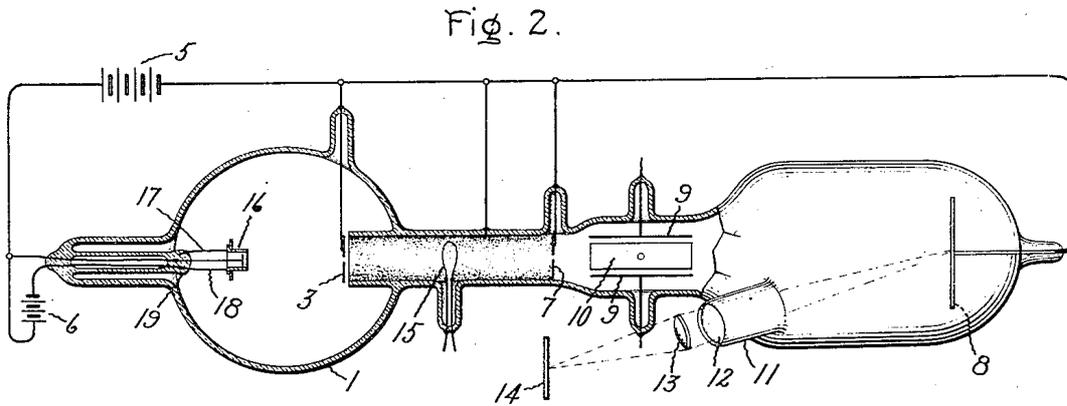
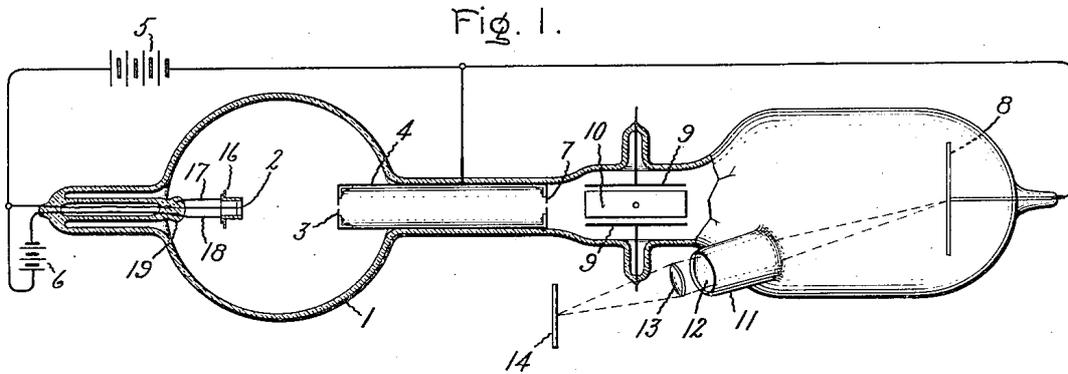


I. LANGMUIR.
 MEANS FOR INDICATING ELECTRICAL CHARACTERISTICS OF ALTERNATING CURRENTS.
 APPLICATION FILED JULY 20, 1914.

1,219,961.

Patented Mar. 20, 1917.



Witnesses:

George H. Tilden
J. Ellis Klen

Inventor:
 Irving Langmuir,

by *Allin D. Davis*
 His Attorney.

UNITED STATES PATENT OFFICE.

IRVING LANGMUIR, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

MEANS FOR INDICATING ELECTRICAL CHARACTERISTICS OF ALTERNATING CURRENTS.

1,219,961.

Specification of Letters Patent. Patented Mar. 20, 1917.

Application filed July 20, 1914. Serial No. 852,118.

To all whom it may concern:

Be it known that I, IRVING LANGMUIR, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Means for Indicating Electrical Characteristics of Alternating Currents, of which the following is a specification.

My present invention relates to the measurement or indication of electric power, the wave form of alternating currents or potentials, or similar conditions in electrical circuits, and has for its object an improvement in apparatus for accomplishing this purpose. More particularly my invention relates to apparatus of the type known as the Braun tube. In devices of this nature as heretofore constructed as shown, for example, in U. S. Patent No. 1,069,187, it has been customary to produce cathode rays by a discharge between two electrodes inclosed in a tube containing a small amount of gas and separate from the main discharge a pencil or a bundle of rays which travel in a desired direction. The pencil of cathode rays thus obtained is directed upon a screen and by a suitable connection with the circuit whose power or wave form is to be indicated; the rays are deflected to trace a path upon the screen, which path will indicate the amount of power in the circuit or the wave form of the current or potential therein as is desired. In devices of this nature in order to produce a discharge between the electrodes it is necessary to have a certain amount of gas present in the tube. As the pressure of gas decreases the voltage necessary to produce the discharge increases and because of the fact that the gas pressure decreases with continued operation of the tube and other irregularities in the operation of the device it is difficult to produce a uniform pencil of rays, and one which will be influenced only by the variations of power or wave form in the circuit.

In order to overcome these difficulties, I propose to employ a tube in which the cathode rays are produced by a pure electron discharge from a cathode which is preferably provided with means for heating it to incandescence in order to cause it to emit electrons. A device of this character instead of requiring a certain amount of gas

for its successful operation, requires a high degree of vacuum, and, in fact, the higher the degree of vacuum obtained, the more efficient the results which can be secured. Tubes of this type as previously constructed have depended upon gas ionization for their operation, while a tube constructed according to my invention is not dependent upon gas ionization for its operation.

My invention will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figure 1 is a plan view partly in section of one form of my improved tube; Fig. 2 is a similar view of a modification thereof; Fig. 3 is an enlarged perspective view of a preferred form of cathode and Fig. 4 is a diagram of the connections which may be employed to deflect the pencil of cathode rays.

As shown in Fig. 1 my improved device comprises an envelop 1 which is exhausted to a high degree of vacuum preferably as low as .01 micron. Inclosed in this tube is a cathode 2 which is preferably of filamentary form and wound in the shape of a spiral in a plane perpendicular to the axis of the tube.

The perforated plate 3 which closes one end of the tube 4 serves as the main anode and a source of energy 5 connected between the cathode and anode causes the passage of cathode rays from the cathode 2 to plate 3 when the cathode is heated to incandescence by the battery 6. The greater part of the electrons given off by the cathode 2 will strike the plate 3. Part of those, however, which are traveling in a direction parallel to the axis of the envelop will pass through the aperture in the plate 3, through the tube 4 and through the aperture in the plate 7 which closes the other end of the tube. In this way a pencil of rays is produced which is directed upon the screen 8. After passing through the aperture in the plate 7, the pencil of rays may be deflected in the desired manner by means of electrostatic fields applied to the two pairs of plates 9 and 10.

It has been found in apparatus of this nature that because of the absence of gas, and consequently of positive ions, that all parts of the tube upon which the electrons strike tend to become negatively charged to the same potential as the cathode and that unless

means are provided for neutralizing the electrostatic field thus produced, electrons will no longer reach the charged part and any electrons coming within its influence will be repelled. In tubes of this type as heretofore constructed, the screen upon which the rays are focused has not been connected electrically with the cathode. The negative charge produced by the cathode rays striking the screen has been neutralized by the positive ions which have always been present in the tube. There being no positive ions present in the tube constructed according to my invention, it is necessary to provide other means for preventing the failure of the tube to operate by reason of an accumulated negative charge on the screen. This may be accomplished by an electrical connection between the screen and the source of energy as I have indicated, thus making the screen an anode. In some cases, however, it may be desired to impress a different potential upon the screen 8 from that impressed upon the plate 3. Also in order to maintain the velocity and direction of travel of the pencil of rays constant between the plates 3 and 7, it is necessary to neutralize any field which may be produced by electrons which pass through the aperture in the plate 3 and which do not travel in a direction parallel to the axis of the envelop. In the present case this is accomplished by impressing upon the tube 4 and the plate 7 the same potential as that impressed upon the plate 3.

In order to be able to photograph the path of the pencil of cathode rays on the screen 8, a projection 11 may be provided on the envelop with a window 12 therein through which the reflection of the spot of light produced by the rays striking the screen, may pass to a suitable lens 13 from which it may be focused upon a photographic plate or similar device 14.

In the form of my invention shown in Fig. 2, instead of providing the metallic tube 4 in the envelop, a thin metallic coating may be deposited upon the section of the tube between the plates 3 and 7. This coating may conveniently be deposited by providing a metallic filament 15 in the envelop at this point and heating this filament to such a high temperature that it rapidly evaporates and the volatilized metal will deposit in a thin conducting layer on the wall of the envelop. A positive charge may be impressed on this thin conducting layer as well as upon the plate 7 by means of the direct current source of energy 5 as in the first modification shown. A conducting layer formed in this way in a high vacuum has the advantage of being substantially free from gas and it is highly desirable that all of the metallic parts inclosed within the envelop should be as free from gas as possible as otherwise gas will be given off during the operation of the tube, the vacuum

will become lower and the successful operation of the tube will be interfered with. In some cases it may be desirable to provide such a conducting film upon other parts of the wall of the envelop and impress a positive potential thereon in order to prevent any undesired deflection of the cathode rays due to a negative charge upon the glass. In Fig. 3, I have indicated in detail the preferred construction for the cathode. A metal tube 16 surrounding the heated portion of the cathode is attached to and supported by wires 17, 18 which are embedded in the top of the stem 19 through which the leading-in wires for conveying current to the cathode are sealed. The tube 16 serves to direct the cathode rays upon the anode 4, and for this purpose is preferably brought to the same potential as the cathode by electrically connecting it to the cathode. It also prevents a discharge of electrons from the heated portion of the cathode in a direction away from the anode 4.

In the preparation of a tube of this nature it is essential that all parts should be thoroughly freed from gases. In order to accomplish this the glass should be freed from moisture and gas by heating during exhaustion and the metal parts also freed from gas by heating to a high temperature in a vacuum. Exhaustion of the tube is preferably carried on by means of a pump which will remove vapors as well as gases, such as the Gaede Molecular Pump. For the complete removal of gas from the electrodes, the tube should be operated while connected to the pump. In thus operating the tube, enough energy should be employed to heat the anode 3 to incandescence. Inasmuch as the screen 8 will not be appreciably heated by thus operating the tube, it may be desirable to provide special means for subjecting it to a discharge of cathode rays sufficient to heat it to incandescence.

In tubes of this nature it has heretofore been customary to employ a fluorescent substance on the screen which will give off light under the influence of the cathode rays. Because of the fact, however, that many fluorescent substances which might be thus employed give off considerable amounts of gas, I have found that an improvement in the operation may be obtained by employing on the screen, instead of a fluorescent substance, a finely divided deposit of a refractory metal such as tungsten or molybdenum. A deposit of the desired nature may be produced by volatilizing the metal in the presence of a low pressure of gas, preferably an inert gas, such for example as argon. When such a metallic deposit is placed in a vacuum, it forms a remarkably poor conductor of heat. When the cathode rays impinge upon this deposit, the surface thereof is heated to incandescence without appreciably

heating the other portions of the screen, and the path of the rapidly moving rays may be traced in the same manner as upon a fluorescent screen. This also offers the further advantage of being a better electrical conductor than any fluorescent substance and hence it will more quickly carry away the negative charge produced on the screen by the electrons.

In Fig. 4 I have shown a system of connections for producing the electrostatic fields for deflecting the pencil of cathode rays in the desired manner. As here indicated 20 and 21 are conductors of the circuit, the power or wave form in which is to be measured. This circuit is supplied from a suitable source of energy such as transformer 22. This transformer preferably has two secondary windings 23 connected in series and energized by two primary windings 24, also connected in series and supplied from a suitable source of energy which is not shown. Connected in series between the two windings 23 I have indicated two condensers 25, the conductor joining these two condensers being connected to ground at 26. As will be seen by an inspection of the drawing the plates 10 are connected across the circuit and the plates 9 are connected across the condensers. Plates 10 will therefore set up an electrostatic field proportional to the voltage of the circuit. Plates 9 which are preferably placed as shown so as to be displaced 90° from plates 10 are connected across the condensers so that the differential of the electrostatic field produced by them will be proportional to the product of the current by the differential of time or the velocity of the movement of the pencil of rays in the direction in which it is influenced by the action of the electrostatic field produced by the plates 9 will be proportional to the instantaneous value of the current. The area of the diagram or the area inclosed by the path of the cathode rays on the screen may be measured and after the instrument has been suitably calibrated the power in the circuit may be computed from this area. This method of deflecting the pencil of cathode rays, however, forms no part of the present invention, being set forth in U. S. Patent 1,069,187, and it will, of course, be understood that the present tube may equally well be adapted to the determination of the wave shape of the current or potential in the circuit by other methods, such for example as the one shown in U. S. Patent 834,998.

While I have described the construction and operation of the tube when it is adapted to give a visual indication of the paths of the cathode rays and thereby show the electrical condition which is being investigated, it may also be used to give desired indications in other ways. For example, the screen 8 may be subdivided into a plurality

of segments and by measuring the amount of current received by each segment, various electrical conditions which produce a deflection of the cathode rays may be determined.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The combination in a vacuum tube of an electron emitting cathode, a perforated anode and a screen having a surface which gives off light under the influence of cathode rays, means for producing a discharge of cathode rays to said anode, and means for directing a portion of said cathode rays through the perforation in said anode and causing them to pass to said screen.

2. The combination in a vacuum tube of an electron emitting cathode, an anode having a surface which gives off light under the influence of cathode rays, a source of energy for producing cathode rays, a pair of plates between said cathode and said anode having perforations through which a portion of the cathode rays may pass, means for maintaining the velocity and direction of travel of said rays between said plates constant, and means for deflecting the cathode rays after they have passed through the said perforations to produce a moving spot of light on the anode.

3. The combination in a vacuum tube of an electron emitting cathode, a perforated anode, a second anode having a surface which gives off light under the influence of cathode rays, and means for directing a uniform pencil of cathode rays through the perforated anode to the second anode.

4. The combination in a vacuum tube of an electron emitting cathode, an anode having a surface which gives off light under the influence of cathode rays, a pair of plates between said cathode and said anode having perforations through which a portion of the cathode rays may pass, means for maintaining the velocity and direction of travel of said rays between said plates constant, and means for deflecting the cathode rays after they have passed through the said perforations to produce a moving spot of light on the anode.

5. The combination in a vacuum tube, of an electron emitting cathode, an anode having a surface which gives off light under the influence of cathode rays, a pair of plates having perforations through which a portion of the cathode rays may pass between said cathode and said anode, a conducting body surrounding the path of said rays between said plates and a source of energy for maintaining a positive electrical potential upon said conducting body.

6. The combination in a vacuum tube of an electron emitting cathode, an anode, a finely divided deposit of a refractory metal upon the surface of said anode, and means

for directing a pencil of cathode rays from said cathode to said anode to heat the deposit thereon to incandescence at the point where the rays strike.

5 7. A screen having on its surface a finely divided deposit of refractory metal adapted to be heated to incandescence when subjected to the influence of a moving pencil of cathode rays so as to trace the path of
10 the rays over its surface.

8. The combination in a device of the class described of an envelop exhausted to such a degree that a cathode discharge therein will take place with substantially no gas
15 ionization, a plurality of electrodes therein, one of which is perforated, and means for directing a uniform pencil of cathode rays through said perforated electrode to one of the other electrodes.

20 9. The combination in a vacuum tube of a cathode provided with means for heating it to incandescence to cause it to emit electrons, a perforated anode and a screen, and means for directing a uniform pencil of
25 cathode rays through said perforated anode to said screen.

10. The combination in a vacuum tube of an electron emitting cathode, a plate-shaped anode, means for directing a uni-
30 form pencil of cathode rays from said cathode to said anode, and means whereby the pencil of cathode rays will give a desired visual indication on said anode.

11. The combination in a vacuum tube of
35 an electron emitting cathode, an anode, means for causing a uniform pencil of cathode rays to pass from said cathode to said anode, and means for preventing any undesired deflection of said pencil of cathode
40 rays.

12. The combination in a vacuum tube of an electron emitting cathode, a screen having a surface which gives off light under the influence of cathode rays, means for directing
45 a uniform pencil of cathode rays upon said screen, and means for preventing any

undesired deflection of said pencil of cathode rays.

13. The combination in a device of the class described of a highly exhausted en- 50
velop containing a cathode which emits electrons independently of gas ionization, a perforated anode and a screen which gives off light under the influence of cathode rays, and means for directing a uniform pencil 55
of cathode rays through said perforated anode to said screen.

14. A highly exhausted envelop containing a screen the surface of which is adapted to be heated to incandescence when subjected 60
to the influence of cathode rays without appreciably heating the other portions of the screen.

15. A screen having a surface of refractory material of low heat conductivity 65
whereby it is adapted to be heated to incandescence when subjected in a vacuum to the influence of a rapidly moving pencil of cathode rays.

16. The combination in a device of the 70
class described of a highly exhausted envelop containing a cathode which emits electrons independently of gas ionization, means for producing a discharge of cathode rays therefrom, means for selecting a uni- 75
form pencil of said rays, and means for causing said pencil of rays to produce a desired indication of electrical conditions.

17. The combination in a vacuum tube of a cathode which emits electrons independ- 80
ently of gas ionization, means for producing a uniform pencil of rays from said cathode, and means for causing said pencil of rays to produce a desired indication of electrical 85
conditions.

In witness whereof, I have hereunto set my hand this 18th day of July, 1914.

IRVING LANGMUIR.

Witnesses:

BENJAMIN B. HULL,
GEORGE M. J. MACKAY.