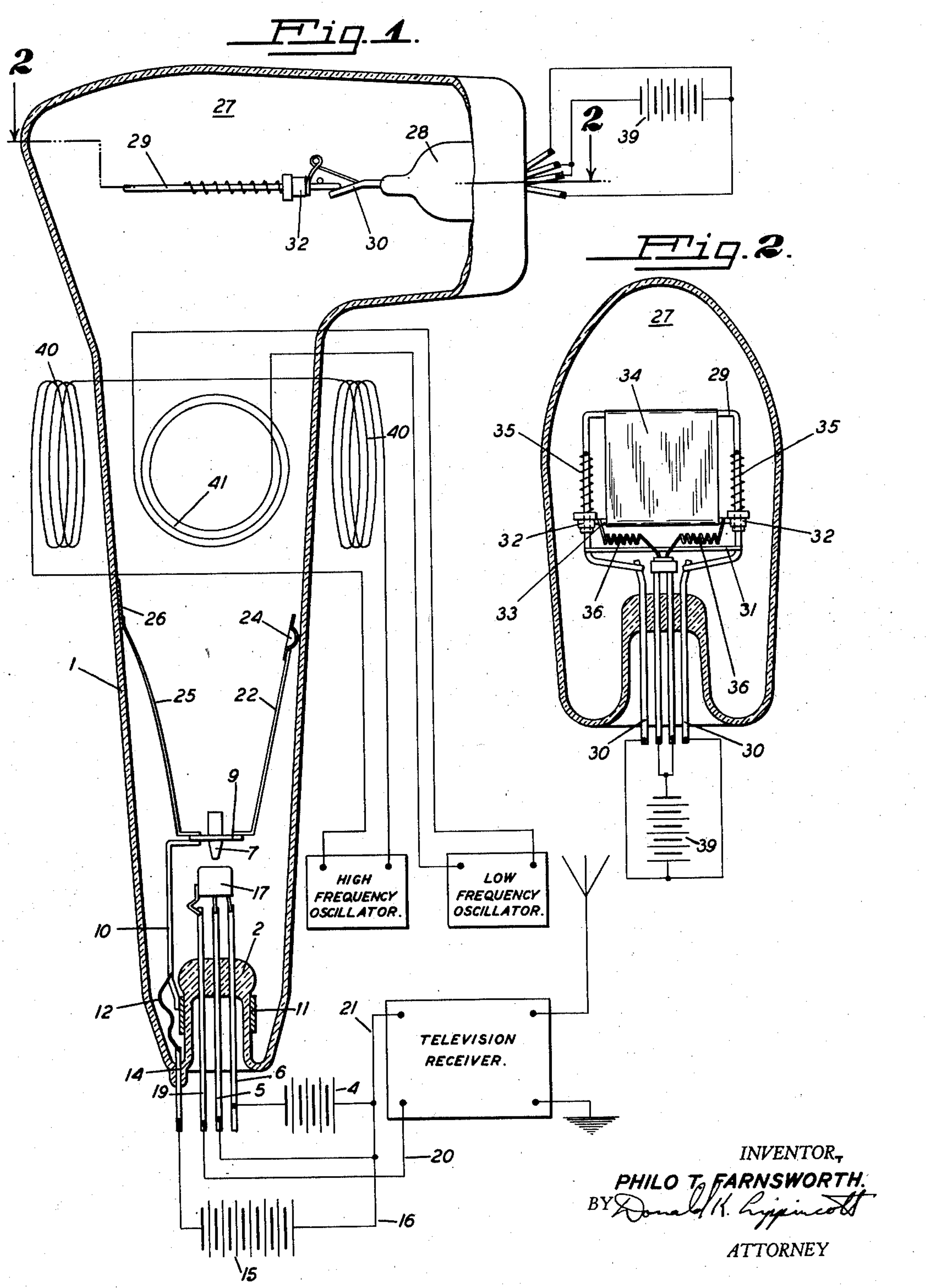
Jan. 4, 1938.   P. T. FARNSWORTH   2,104,253

LUMINESCENT SCREEN AND METHOD OF USE

Filed Feb. 8, 1933



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Patented Jan. 4, 1938 2,104,253

UNITED STATES PATENT OFFICE

2,104,253

LUMINESCENT SCREEN AND METHOD OF USE

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Application February 8, 1933, Serial No. 655,784

8 Claims. (Cl. 250—27.5)

My invention relates to luminescent screens for use in cathode ray apparatus, such as oscilloscope or oscillographic tubes, and oscillights or television receiver tubes, this application being an improvement on the invention disclosed in the Farnsworth and Gardner application, Serial Number 614,501, filed May 31, 1932.

Among the objects of my invention are: To provide a luminescent screen giving a pure white light; to provide a screen which may be luminously excited to a greater degree than the known screens of the fluorescent type; to provide a luminescent screen in the form of a thin sheet of refractory metal which is stable in operation and is strong mechanically; to provide a means of biasing such a screen by heating the entire area to a uniform temperature, said means being independent of the action of the cathode ray beam; and to provide a means for increasing the visual efficiency of the heating produced by a cathode ray beam.

Other objects of my invention will be apparent or will be specifically pointed out in the description forming a part of this specification, but I do not limit myself to the embodiment of my invention herein described, as various forms may be adopted within the scope of the claims.

Referring to the drawing:

Figure 1 is a longitudinal sectional view through an oscillight or television receiver tube embodying this invention, the circuit connections being shown diagrammatically.

Figure 2 is a cross sectional view taken as indicated by the line 2—2 in Figure 1.

For many years it has been customary to form the luminescent screen used in cathode ray oscillograph tubes and the like, of materials which fluoresce under the impact of the rays. Luminescent screens of this character have the advantages of large luminous efficiences with low power input, but the unit brilliancy is low. When beam velocities are increased, only slight increases in light are obtained with large increases in power, and there is a strong tendency for the material to break down and become inactive under bombardment. Moreover, the light from such fluorescent screens is very definitely colored, usually a bluish or greenish tinge, making it undesirable for television use. The purpose of this invention is to provide a screen which shows the trace of the cathode ray beam in pure white light. Although the method here employed is less sensitive on small power inputs than is the fluorescent screen, it has been found that with large power inputs the efficiency may approach that of the conventional screen, in addition to giving effective images vastly more brilliant than possible with conventional methods.

Broadly considered from the aspect of the apparatus employed, this invention comprises the combination with a source of cathode rays of a screen formed of thin metal, of sufficient thinness to be raised to incandescence by the impact of the rays. These requirements are met in a preferred form by a tantalum screen having a thickness of from 50 to 100×10^{-6} inches.

The operation of a heat screen without polarization has been fully described in application, Serial Number 614,501, filed May 31, 1932, above mentioned, wherein it has been shown that as a cathode ray beam is moved constantly from one elementary area to another, the mass of material in the path of the beam is so small that its rise to incandescence is practically instantaneous. Furthermore, conduction to adjacent areas is so restricted that heat loss by radiation cools the bombarded area before the incandescence can spread appreciably. Should the beam spot be applied continuously to one location on the screen there would, of course, be spreading of the luminous area no matter how great the thermal resistance. The practically continuous movement of the spot is therefore, an essential feature in the operation of any heat screen.

In operating such a heat screen as above described, I have found that as the power necessary to heat the screen increases rapidly with temperature, additional means for maintaining the screen at a uniform base temperature can be advantageously used, thus relieving the necessity of including a relatively large amount of power in the electron beam, as the screen does not begin to emit light until the screen temperature rises to around 800° Kelvin, and the beam power necessary to raise the screen to that temperature is wasted from the point of view of light.

Considering the method involved, the invention comprises broadly the steps of generating a pencil or beam of cathode rays, directing the rays against a screen formed from a thin sheet of refractory material so as to raise the point of impact to incandescence, deflecting the beam so that it impinges upon successive elementary areas of the screen, and meanwhile maintaining the sheet at a uniform predetermined temperature, preferably at a low red heat, around 800° K. The beam may then be modulated in accordance with a television signal to produce a brilliant effective oscillographic or, if desired, a television image, with all of the beam power effective to produce light.

The form of the invention illustrated in the drawing comprises the usual evacuated envelope 1 having at one end a reentrant stem 2 which carries an electron gun. The type of gun used is preferably that shown in detail in the copending application of Gardner and Brolly, Serial No. 614,500, filed May 31, 1932, this form of cathode ray projector being capable of producing a cathode ray beam of high intensity. The cathode (not shown) is heated by current supplied by battery 4, or like source, through leads 5 and 6, emitting electrons which are attracted by a conical projection 7 on a circular anode 9 and pass through a beam canal in the anode to form the required beam of cathode rays. The anode is welded to a support 10, this in turn being supported from a clamp ring 11. A lead wire 12 connects to the anode support and is brought out through a side seal 14 to which the anode battery 15 or similar source is connected, the other end of the battery being connected to one cathode lead through anode wire 16.

The intensity of the beam is regulated by a control electrode or grid 17, mounted on lead 19 sealed through the stem, and connected by grid wire 20 to the television receiver, or other modulator as desired. The cathode lead 5 is also connected to the receiver through lead wire 21.

Welded to one side of the anode 9 is an arm 22 extending away from the anode at an angle and terminating in a cup 24 which is used to vaporize a volatile metal on the walls of the tube. A spring contact arm 25 extends from the opposite side of the anode, and terminates in a contact 26 which is held by the pressure of the arm against the wall of the tube and is therefore in contact with the film of metal deposited from the cup 24. The film being energized at anode potential and covering the barrel of the tube, the beam is thus protected from the influence of extaneous potentials.

The end of the envelope opposite the gun is slightly expanded to form a screen chamber 27, into which is sealed a heat screen assembly supported by a screen stem 28. This screen assembly preferably comprises a rectangular wire frame 29 mounted on frame leads 30. A cross bar 31 provides additional strength. Insulating sliders 32 of lava or similar material are connected by a mounting bar 33 and are movable along the framework. A heat screen 34 of any desired shape, but preferably rectangular, is welded to the top of the frame, and to the mounting bar. Springs 35 welded at one end to the frame press against the sliders 32 and maintain the screen 34 under tension. Flexible leads 36 connect the mounting bar to screen leads 37, sealed through the stem. A circuit is thereby established so that a source of current 39 may be used to heat the entire screen to a uniform predetermined temperature by passing current through the screen.

The screen itself should be of a refractory metal capable of being raised to incandescence by the impact of the beam, and it has been found that tantalum foil formed as described in the application of Gardner and Varian, Serial Number 637,772, filed October 14, 1932, is entirely satisfactory.

The type of electron gun used is highly efficient, delivering as much as 80% of the total emission of the cathode into the active electron stream, and cathode ray beams carrying as much as 10 milliamperes are readily producible, the entire electron emission of the beam falling on the screen as a very fine spot.

The beam is systematically deflected to form a trace by the magnetic field produced by passing an alternating current through coils 40, so that the beam sweeps across the screen from side to side and falls only instantaneously upon any given elementary area. The current for these coils is supplied by a high frequency oscillator as shown. A similar set 41 of coils arranged at right angles to the coils 40 is used to deflect the beam in the opposite direction, one of these coils being omitted in the drawing for sake of clarity.

When an alternating current is passed through coils 41 at a different frequency from that in coils 40, the trace of the ray will describe a rectangular area on the screen, traversing each element of the field successively. The oscillator supplying this second set of coils is designated as a low frequency oscillator.

In practice, an anode potential of 5,000–7,000 volts is used, so that from 50 to 70 watts are expended in the beam, this power being available for heating the screen at the point of impact of the beam.

As the device is ideally adapted to reproduce television pictures, I have shown means for modulating the beam in accordance with signals as received by radio on a television receiver. In this case the high and low frequency oscillators are synchronized with the picture signals in such a manner as to produce a proper image. As there are many ways of producing this synchronism, I have not shown the oscillators connected to the receiver, as they might be driven, for example, by a synchronous motor operating from the same power line as the television transmitter.

It is necessary to provide a screen of thickness just sufficient to allow its being heated to incandescence when the beam spot moves at the required rate. A suitable thickness of tantalum foil has been found, as above stated, to be from 50 to 100×10^{-6} inches. The total radiation required to heat the screen is given by the formula

$W=SAT^4$ where T=degrees Kelvin, A=area, $S=5\times10^{-12}$ watts (for tantalum).

An idea of the power required for a given temperature is tabulated in the table below:

Watts per square centimeter	Temperature	Color
10	800°	Red, barely visible
40	1100°	Yellow
150	1600°	Yellow white
900	2500°	White

As will be seen, the power increases so rapidly with temperature that the cooling time for high temperatures will be extremely short compared to that of low temperatures. A base, or polarizing temperature may thus be maintaind over the whole screen, from a source apart from the beam. This polarizing temperature may be 800° without disturbing the detail, thus allowing all of the beam intensity to be used for producing visible results. It is possible also, because of the sluggishness of the screen at low temperatures, to supply this polarizing power from A. C. mains, instead of a battery.

It is of course possible to adjust beam power and polarizing power to compensate for various thicknesses of metal foil, and for various other metals than tantalum. Tungsten, molybdenum and other screens capable of being raised to incandenscence without disintegration or excessive sputtering are satisfactory.

Obviously, also, means other than resistive heating may be employed to raise the temperature of the screen as a whole. Infra-red radiation has been employed with excellent results, and an auxiliary unmodulated cathode ray beam, is an example of another way that the screen may be polarized.

The invention as described has been used to form effective television images of extreme brilliancy, the pictures so formed on the metal screen being used as a light source for projection lenses, sufficient light being obtained to allow the pictures to be projected on a screen greatly enlarged. The illumination is of the order of 2 candlepower per watt of input energy. With 70 watts input in the beam, and a polarizing heat of 800°, thus maintaining the screen at a dull, barely visible red heat during the continuous movement of the beam spot, the television image produced on a screen of this type an inch and a half to two inches square is so brilliant that the screen cannot be viewed directly, and when projected the effect of the illumination is substantially twice to four times that available with home moving picture outfits using a 100 watt lamp. The actual luminous flux is, of course, much less than that of the home projection equipment, but in the case of the screen of my invention it is the image of the luminous source itself which is projected, whereas in the case of the motion picture film approximately 90% of the infalling light is absorbed by the film. It is therefore possible, using screens of this type, to project television images in rooms having a fair degree of general illumination, and to a size of from one to five feet square, depending on the general illumination level and the amount of power expended in the cathode ray beam, together with the constants of the screen itself.

The aesthetic value of the picture is the same as the projected pictures to which the public is now accustomed, from the point of view of color. The color values of the picture projected from the screen of my invention are identical with the values in the usual motion picture, as an incandescent source is used in both cases, and the use of the heat screen as here described has completely removed the objection formerly held to the older colored fluorescent screen images.

I claim:

1. The method of producing a visible trace on a screen which comprises uniformly heating said screen to a temperature approximating the threshold of visible radiation therefrom, and simultaneously heating successive elementary volumes including opposing faces of said screen to incandescence.

2. The method of producing a visible trace on a screen which comprises uniformly heating said screen to a red heat, and simultaneously heating successive elementary volumes including opposing faces of said screen to a white heat.

3. The method of obtaining a visible trace on a screen of the deflection of a beam of cathode rays, which comprises the steps of uniformly heating said screen to a predetermined temperature of the order of 800° K., directing said beam against said screen, and imparting sufficient energy to said beam to raise the entire cross section of said screen beneath the points of impact to a higher temperature.

4. In combination with a beam of cathode rays, luminescent means disposed wholly within said envelope in the path of said rays, said means consisting of a tantalum sheet having a thickness from 50 to 100×10^{-6} inches.

5. Means for producing an effective visual image comprising the combination of an envelope containing a cathode and anode adapted to produce a beam of cathode rays, a thin refractory metal sheet supported solely by its edges disposed in the path of said rays, means for deflecting said beam two-dimensionally to scan elemental areas of said sheet to raise the entire cross section beneath said areas to an incandescent temperature, and means for heating said sheet to a uniform temperature.

6. The method of forming a visual image which comprises resistively heating a conductor to a uniform temperature and simultaneously heating successive elementary volumes including opposing faces of said conductor to varying luminous temperatures by electron impact.

7. In a cathode ray apparatus, the combination of an envelope containing a cathode and anode cooperating to produce a defined beam of cathode rays, and an opaque metal luminescent screen, said screen being of such thin section that the impact area of said screen, together with the remainder of the section of said screen below said area, is raised to incandescence.

8. The method of producing visible temperature radiations modulated in accordance with the intensity of a beam of energy from a thin sheet of heat-conducting material, which comprises initially raising said sheet to a temperature approximating the threshold value at which visible radiation will be emitted, and thereafter directing the beam of energy against successive elementary portions of said sheet with sufficient intensity in said beam to cause substantially all temperature variations resulting to occur within the range of visible radiation.

PHILO T. FARNSWORTH.

DISCLAIMER

2,104,253.—*Philo T. Farnsworth*, San Francisco, Calif. LUMINESCENT SCREEN AND METHOD OF USE. Patent dated January 4, 1938. Disclaimer filed April 1, 1940, by the assignee, *Farnsworth Television & Radio Corporation*.

Hereby enters this disclaimer to claim 7 of said Letters Patent.

[*Official Gazette April 23, 1940.*]