

Nov. 12, 1940.

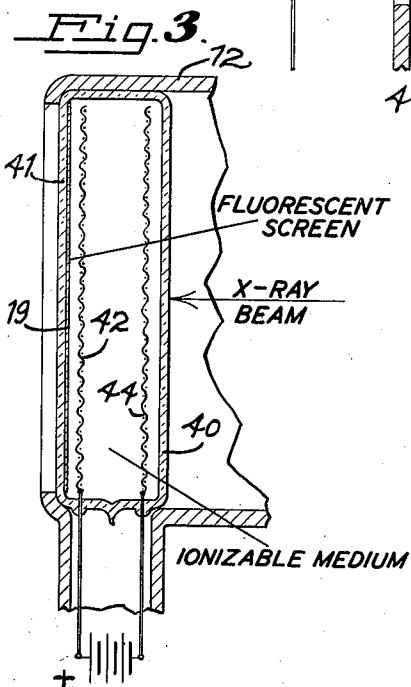
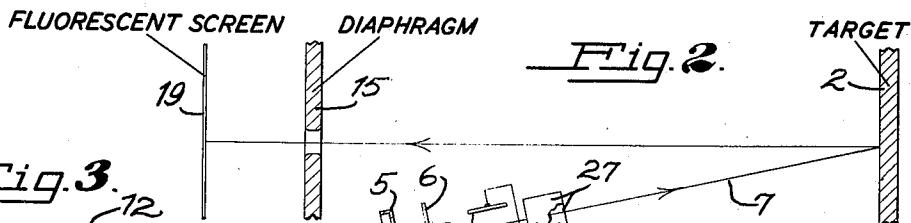
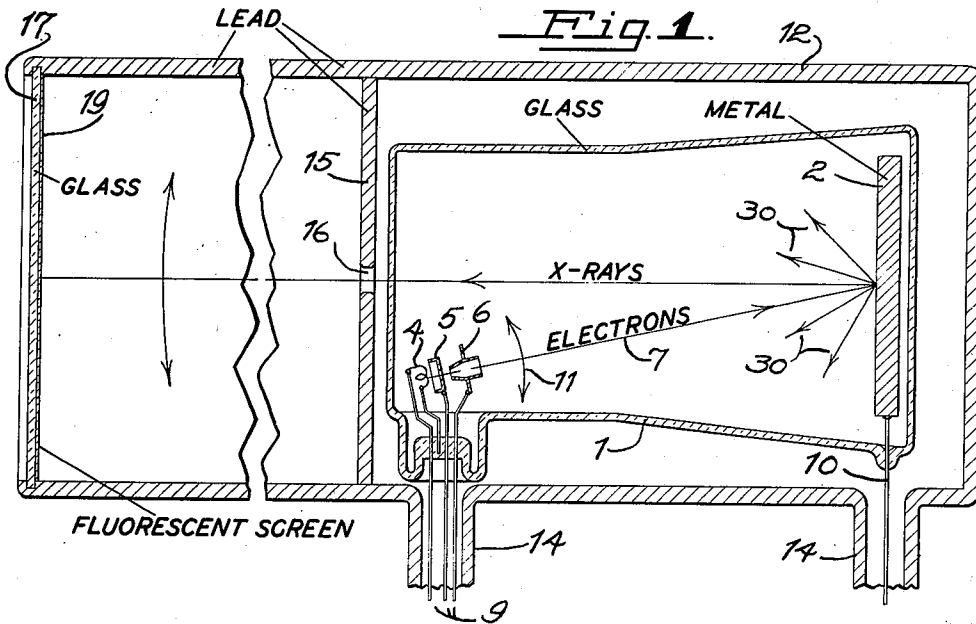
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2,221,374

X-RAY PROJECTION DEVICE

Filed March 22, 1937

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

FLUORESCENT
SCREEN

Fig. 4.

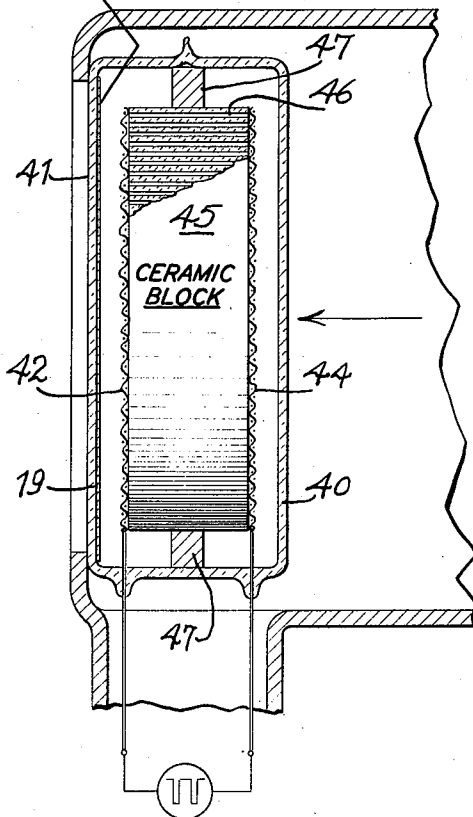
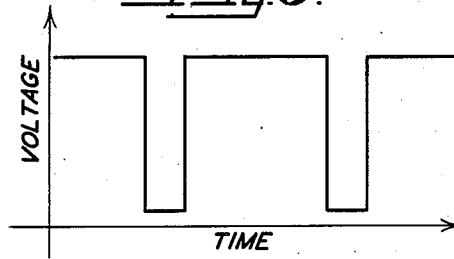


Fig. 5.



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X-RAY PROJECTION DEVICE

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Application March 22, 1937, Serial No. 132,328

9 Claims. (Cl. 250—150)

My invention relates to an X-ray projection device, and more particularly to an oscillograph utilizing X-rays to form a visual trace.

My device is particularly applicable, in one form, for use in television, whereby a picture image may be produced having a large area.

Among the objects of my invention are: To provide an oscillograph having a large viewing screen; to provide an oscillograph giving a large picture area wherein the evacuated vessel is relatively small; to provide a means and method for forming a visual image by the use of an X-ray beam; to provide a means and method of scanning a viewing screen with an X-ray beam; to provide a television receiving tube utilizing X-rays; to provide a viewing screen on which a picture may be developed by the use of a moving beam of X-rays; to provide a means and method of scanning a luminescent screen with an X-ray beam; to provide a safe television receiving tube having a large viewing screen; and to provide a new and unique means and method of developing an image.

My invention possesses numerous other objects and features of advantage, some of which, together with the foregoing, will be set forth in the following description of specific apparatus embodying and utilizing my novel method. It is therefore to be understood that my method is applicable to other apparatus, and that I do not limit myself, in any way, to the apparatus of the present application, as I may adopt various other apparatus embodiments, utilizing the method, within the scope of the appended claims.

Referring to the drawings:

Figure 1 is a schematic, longitudinal sectional view of a preferred form of my invention, reduced to the simplest terms.

Figure 2 is a schematic diagram showing how the device of Figure 1 may be operated.

Figure 3 is a longitudinal sectional view of an ionization chamber that may be used in conjunction with the device of Figure 1.

Figure 4 is a view partly in section and partly in elevation, of a regenerative image amplifier that may be used in conjunction with the device of Figure 1.

Figure 5 is a graph showing a waveform that may be utilized in conjunction with the device shown in Figure 4.

At the present time television receiving sets are provided with two types of viewing screens: First, those that are coated on the inside of a cathode ray tube and on which a moving and modulated beam of electrons having an elemen-

tary cross section is projected. This beam is scanned over successive elementary areas of the screen to produce light, thus developing the television picture. This screen is usually large and is directly viewed. Second, a tube similar to the first described, except that the luminescent screen is made relatively small and the image extremely brilliant, so that by means of a lens system the image may be projected on to a viewing screen, placed external to the cathode ray tube. In this latter case, an enlargement of the image is possible, consistent with the brilliancy of the original image.

Both of these receiving systems have marked disadvantages.

For example, in the first case it is desirable to have the viewing screen as large as possible. This means that the entire tube has to be enlarged, as electrons require an impractical amount of energy to be projected through air to an outside screen. Making the tube large, however, creates a danger in breakage. Inasmuch as the modern cathode ray tubes are vacuum tubes, collapse of large tubes such as those, for example, having an eighteen inch screen therein, is highly dangerous and involves the projection of glass particles to a considerable distance. Under these circumstances, the installation of such large tubes in homes, is impractical, unless placed back of a rather heavy plate glass window. This latter procedure involves loss of light and an addition of reflecting surfaces. Furthermore, such large tubes are highly expensive and would tend to raise the cost of a home receiving set to a prohibitive degree.

In the second instance, that of the projection type tube, the tube is small and therefore no great danger is encountered. However, the question of expense does enter the picture, as a vicious cycle exists with relation to the size of the projection tube picture area and the lens needed for projection. For example, the only really inexpensive lenses available for projection use are those which are produced in quantity for motion picture work. Under these circumstances the projection tube picture area can be only that of a standard thirty-five millimeter motion picture frame. Modern high definition television, however, requires in the neighborhood of five hundred lines per picture, thus limiting the size of the electron spot on the luminescent screen. Reducing the size of the spot likewise reduces the amount of power in the beam, and consequently, the brilliancy. If, in order to remove this disadvantage, the projection tube pic-

ture area is increased in size, then special projection lenses are necessary, and as these projection lenses are not common in the industry, they are exceedingly expensive and raise the price of a home receiving set again to an impractical degree.

The means and method described herein is directed toward solving all of the disadvantages outlined above, and to make possible the use of a large screen without the use either of a large vacuum tube or expensive projection lenses.

Broadly as to method, my invention comprises generating a beam of X-rays and scanning a fluorescent screen with this beam to produce a visual image.

Broadly as to apparatus, my invention comprises means for producing a moving beam of X-rays, and means for directing this beam against a fluorescent screen to produce a visual image. The X-rays are produced within a vacuum tube or a receptacle exhausted to some degree at least, and inasmuch as the X-rays pass easily through the wall of the receptacle envelope, the X-rays may be directed against a screen which is not limited as to its size by the size of the receptacle.

My invention may be more easily understood by direct reference to the drawings, which show one preferred form of my invention, illustrative of the method involved.

A cathode ray tube is provided comprising the usual vitreous envelope 1, enclosing at one end an X-ray target 2. The latter is provided with a picture area size X-ray generating surface, preferably of such dimensions as to allow the use of an X-ray generating electron beam having a sufficiently large elemental cross section to carry considerable power. This beam is produced by an electron gun positioned out of the path of the generated X-rays, and may comprise, for example, a cathode 4, an apertured control electrode 5, and an apertured accelerating anode 6, the three electrodes cooperating to produce a defined electron beam of elemental cross section directed, when at rest, at a central point on the X-ray target 2. The path of the electron beam from this gun is represented in the drawing by a beam line 7. The usual leads 9 are brought out from the electron gun, and a target lead 10 is likewise sealed through the envelope wall. Means are also provided, either electrostatic or electromagnetic, as will later be described, to move the electron beam preferably in two dimensions over successive elemental areas of the target 2, as indicated by the arcuate arrow 11 crossing the path of the electron beam 7. The entire cathode ray tube is mounted in a lead case 12, provided adjacent the lead wires of the cathode ray tube with lead sheaths 14 to prevent any X-rays from passing outside the case.

At the end of the cathode ray tube adjacent the gun and opposite the target 2, and preferably outside of the envelope, is positioned a lead diaphragm 15, provided with a central aperture 16, the latter being preferably positioned along the axis of the cathode ray tube. The lead case 12 is then extended and terminates by having its end closed with a lead glass plate 17, on the inside of which is deposited a fluorescent coating 19. The thickness of the lead glass 17 is such that no X-rays generated by the tube may pass therethrough, and of course the lead case forms the same function for any stray X-rays emitted from the target.

A circuit for operating the system is shown in

Figure 2. Here, the cathode 4 is energized from cathode source 20. The control grid 5 is supplied with a modulating signal through line 21, from any convenient source. Apertured anode 6 is energized to a positive potential by anode source 22, and the X-ray target 2 is energized to a still higher potential by target source 24. The potentials are so arranged that the electrons in beam 7 will impact the target at a velocity sufficient to generate X-rays.

Electrostatic means are shown to deflect the electron beam 7 over successive elementary areas of a picture area on target 2, and this scanning means may comprise vertical deflection plates 25, energized by vertical oscillator 26, preferably giving a sawtooth output, and horizontal deflection may be imparted to the beam by horizontal deflection plates 27, energized by horizontal oscillator 29, also giving a sawtooth output.

It will be obvious, however, that I do not wish to be limited to any particular electron gun structure or deflecting means, the main desideratum being that an electron beam of elementary cross section be generated, directed at the X-ray target with sufficient velocity to produce X-rays therefrom, and that the beam be moved to produce scansion of a picture area on the target.

In describing the operation of the device, it is convenient to consider that the tube is to be used for television picture reception, although it is obvious that my device may be utilized to produce visual traces for any oscillographic purposes, and that it is possible to obtain such traces of large size. Under these conditions, we may then consider that the oscillators 26 and 29 are synchronized with a television transmitter and that television signals are being received over input line 21.

When electron beam 7 impacts the X-ray target 2, X-rays are generated having, of course, random directions, as indicated by arrows 30 in Figure 1, and also having an intensity in all directions which does not vary greatly from an average value. These X-rays travel toward the lead diaphragm 15 and are absorbed, with the exception of that small portion which passes through aperture 16 to strike the fluorescent screen 19. Thus, of all the X-rays emitted from the impact area of the electron beam, a small range having certain angles with the target and the cathode ray will pass through the aperture, and it is obvious that as the electron beam 7 is scanned over the target 2, the angle of the X-rays passing through the aperture will change, and therefore the impact area of the X-rays on the fluorescent screen 19 will also change in accordance with the position of the X-radiation from the target.

The size of the picture area thus developed on fluorescent screen 19 may be larger than the picture area on the target. The enlargement is proportional to the ratio of the distance between screen and aperture, and the distance between aperture and target. The definition on the viewing screen 19 is determined, of course, by the size of the aperture 16, and it will be obvious to those skilled in the art that the size of this aperture may be proportioned to coincide with the impact area of the electron beam on the target, in combination with the degree of enlargement produced. The electron gun 4-5-6 is so positioned in the tube as to be out of the path of the X-rays passing through the aperture 16.

However, it will be seen that the device imme-

diately above described allows the use of a relatively large target 2 and a still larger viewing screen 19. Thus, a relatively large amount of energy may be imparted to the electron beam, and the entire system is relatively inexpensive, as compared to prior systems, and is not subject to implosions inasmuch as the cathode ray tube itself does not have to be made large enough to accommodate the viewing screen, and is thoroughly protected.

There will be, however, a loss of efficiency, due to the fact that only a selected amount of the X-rays emitted at any moment pass through the aperture 16, whereas the remainder of the rays are absorbed by the lead case and diaphragm. When, therefore, an exceptionally large image is desired on screen 19, I may use, in addition to the structure above described, an ionization chamber in connection with the fluorescent screen. One such ionization chamber is shown in Figure 3 and another shown in Figure 4.

Referring directly to Figure 3, a receptacle 40 is provided having, preferably, a lead glass side 41 closing the lead case 12. Thus, the X-ray beam may enter the receptacle from the side facing the X-ray source, but may not leave the receptacle. The receptacle is provided with two opposed screens 42 and 44 parallel to end 41, and the fluorescent screen 19 is deposited on the inner wall of the lead plate 41. The vessel is filled with a gas, for example, such as bromine vapor at perhaps four or five atmospheres, or even with a liquid, considering the fact that the denser the material, the more ions and electrons will be liberated by ionization.

A potential is applied between screens 42 and 44 with the positive potential on screen 42 nearest the fluorescent screen. The X-ray beam will ionize the gas or liquid in the receptacle 40, and the ions developed will be attracted by the negative screen 44 and the electrons by the positive screen 42. The mesh of screen 42 should be so regulated that it will not throw a shadow on the fluorescent screen, nor should it be of such a fine mesh as to attract too many electrons. It should therefore be made of relatively fine wire woven to a medium mesh. However, it will be thoroughly understood that the mesh will be dependent upon other factors, and therefore cannot be made a constant for all systems.

The distance between screen 44 and the luminous screen 19 should be approximately of the same magnitude as a desired definition. This is because an electron, liberated by ionization, will have an initial velocity of random direction, and will probably collide on its trip to the anode 42 with molecules in a non-ionized zone, thus liberating new electrons. It is therefore obviously desirable to maintain the distance between screen 44 and fluorescent screen 19 within the recited limit in order that a sufficiently precise spot of the desired size will be obtained on the screen.

Another form of image amplifier is shown in Figure 4. Here, screens 42 and 44 are separated by a ceramic block 45 which is provided with a large number of small holes 46 perpendicular to the screens and to the fluorescent screen 19. The block may be conveniently supported by a spacer 47. The holes 46 may be conveniently made, for example, by molding a large number of fine wires in the ceramic and dissolving these wires out after baking. I also prefer to form the screens so that at least screen 44 will be photoelectric. The entire receptacle is, for example, filled with neon gas of one millimeter pressure, or at least a

gas which will become luminous upon ionization.

In operation the X-ray beam is focused on screen 44 and the gas will become ionized and glow. If, then, the two screens are energized with D. C. as before, the electrons will pass through the holes to impact the fluorescent screen 19, which will also become luminous. Ceramics of sufficient conductivity can be provided to prevent blocking. There are, then, two sources of illumination present; one, the gas glow, and two, the light of the fluorescent screen. The latter acts regeneratively on screen 44 by causing photoemission therefrom which adds to the ionization, and consequently to the number of electrons reaching fluorescent screen 19.

I prefer, however, to operate the device with A. C., and particularly with a square top voltage wave, as shown in Figure 5. The device, with this alternating voltage, can be run up to a high degree of ionization, and use can be made of this high ionization over a greater part of the cycle. Even if the breakdown point should be reached, time for deionization is given in every cycle. Thus, a much higher efficiency can be obtained by the use of the alternating current, inasmuch as with the D. C. energization care must be taken that the D. C. voltage does not reach a value where the tube will break down. As an indication as to the relative dimensions of the ceramic block 45, it may be stated that the thickness should be approximately one-fourth of an inch for a picture area of one square foot. While I have in this specification described this regenerative image amplifier as operating under the control of an X-ray beam, it is obvious that it can be controlled by visible light, or an electron beam.

The invention herein described obviously has a tremendous advantage over prior oscillograph tubes in that an enlarged visual image may be obtained without the necessity of enlarging an evacuated envelope or providing an expensive lens system. This is accomplished by the use of an X-ray beam which is able to pass beyond the confines of the evacuated envelope to produce an image at a distance. Any lack of efficiency in the device may easily be compensated for by adding energy to the device, either in the electron beam or by the use of ionization chambers, either direct or regenerative; and it is obvious that because of the fact that the original electron beam picture area may be made relatively large, the elementary cross sectional area of the beam may also be made large and thereby carry a relatively large amount of energy.

Further advantage is found in the fact that even though the cathode ray tube itself is made large so that a relatively large X-ray target may be used, that it is fully encased in a strong metal container far removed from the viewing screen. Inasmuch as this viewing screen is the only portion of the device subject to impact in use, no danger will occur if it is broken. As far as danger from X-rays is concerned, if the lead glass end is broken it will be obvious to all those skilled in the art that breakage of this plate may easily be made to operate a complete shutoff of the device.

I claim:

1. In combination, a screen responsive to the bombardment of X-rays and of electrons to produce from said bombardment visible light, ionizable means responsive to the passage of X-rays therethrough for producing electrons, means for producing a beam of X-rays of elemental cross

section, means for directing said beam to said screen to produce thereon a point of light, means positioning said ionizable means in the path of said X-ray beam to produce therefrom electrons, and means for causing electrons produced by said ionizable means to bombard said screen thereby to increase the luminous intensity of said point of light.

2. In combination, a screen responsive to the bombardment of X-rays and of electrons to produce from said bombardment visible light, ionizable means responsive to the passage of X-rays therethrough for producing electrons and ions, means for generating a beam of X-rays of elemental cross section, means for directing said beam to said screen to produce thereon a point of light, means positioning said ionizable means in the path of said X-ray beam to produce therefrom electrons and ions, and means to effect movement of said electrons to said screen and of ions away from said screen thereby to increase the luminous intensity of said point of light.

3. In combination, means responsive to the impact of X-rays and of electrons for producing from said impact visible light, ionizable means responsive to the passage of X-rays therethrough for producing electrons, means for generating a beam of X-rays of elemental cross section directed at said first named means, means positioning said second named means in the path of said beam to produce from the action of said beam electrons, means for moving said beam over said first named means to produce a trace of light, and means for effecting bombardment of said first named means by the electrons produced by said second named means to increase the luminous intensity of said trace of light.

4. In combination, means including a screen responsive to the impact of X-rays and of electrons for producing from said impact visible light, ionizable means responsive to the passage of X-rays therethrough for producing electrons and ions, means for generating a beam of X-rays of elemental cross section directed at said first named means, means for positioning said ionizable means in the path of said X-rays to produce by the action of said X-rays, electrons and ions, means for moving said beam of X-rays over said screen to produce a pre-determined pattern of traces of light, and means for effecting movement of electrons to said screen and of ions away from said screen thereby to increase the luminous intensity of said pre-determined pattern of traces of light.

5. In combination, a screen responsive to the bombardment of X-rays to produce from said bombardment visible light, ionizable means responsive to the passage of X-rays therethrough for producing visible light, means for generating a beam of X-rays of elemental cross section, means for directing said beam to said screen to produce thereon a point of light, and means positioning said ionizable means in the path of said X-ray beam to produce by the action of said beam a point of light in said ionizable means

thereby to increase the luminous intensity of said point of light appearing on said screen.

6. In combination, a screen responsive to the bombardment of X-rays and of electrons to produce from said bombardment visible light, ionizable means responsive to the passage of X-rays therethrough for producing visible light, a photoelectric cathode for producing from the action of light thereon electrons, means for generating a beam of electrons of elemental cross section directed at said screen to produce thereon a point of light, means positioning said ionizable means in the path of said beam to produce in said ionizable means a point of light, means positioning said cathode to be acted upon by the light produced by said ionizable means, and means for effecting the bombardment of said screen by electrons produced by said cathode thereby to increase the luminous intensity of the point of light produced by said X-ray beam.

7. In a recording system, the combination of a screen comprised by a plurality of minutely spaced cells of minute dimension, said cells being filled with an ionizable means for producing upon the ionization thereof, visible light, means for producing a beam of X-rays of elemental cross section directed at said screen to ionize the ionizable medium of those cells upon which said beam is projected, and means for moving said beam over said screen to produce a trace of light.

8. In a recording system, a screen responsive to bombardment of X-rays to produce from said bombardment visible light, means having a plurality of minutely spaced cells of minute dimension opening toward said screen, said cells being filled with an ionizable medium for producing upon the passage of X-rays therethrough visible light, means for generating a beam of X-rays of elemental cross section directed through said last named means to said screen, the light produced by the action of the X-ray beam on said ionizable medium increasing the luminous intensity of the light produced by said beam on said screen, and means for moving said beam of X-rays over said screen to produce thereon a trace of light.

9. In combination, a screen responsive to the bombardment of X-rays and of electrons to produce from said bombardment visible light, means for generating a beam of X-rays of elemental cross section directed at said screen to produce thereon a point of light, means for moving said beam over said screen to produce by said movement a trace of light on said screen, and means for increasing the luminous intensity of said trace of light, said last named means including means positioned in the path of said X-ray beam and having a plurality of minutely spaced elongated cells of minute dimension, said cells being filled with an ionizable medium for producing visible light upon the passage of X-rays therethrough, photoelectric means positioned and arranged to produce electrons from the light produced by said ionizable medium, and means for effecting bombardment of said screen by the electrons produced by said photoelectric means.

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