

April 23, 1940.

I. LANGMUIR

2,198,479

IMAGE REPRODUCTION

Filed Nov. 3, 1937

Fig. 1.

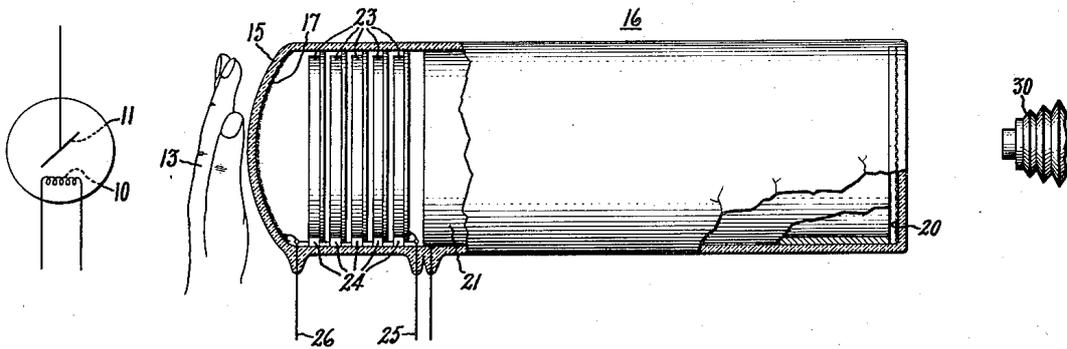


Fig. 2.

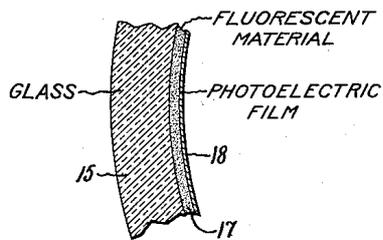
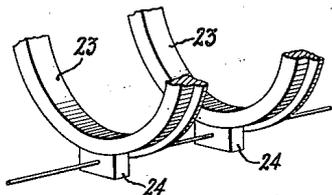


Fig. 3.



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# UNITED STATES PATENT OFFICE

2,198,479

## IMAGE REPRODUCTION

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Application November 3, 1937, Serial No. 172,509

3 Claims. (Cl. 250—153)

The present invention relates to image reproduction, and more particularly to improvements in image reproduction systems of the type described and claimed in Patent No. 2,158,853 of W. D. Coolidge, granted May 16, 1939, and assigned to the General Electric Company.

The aforementioned Coolidge patent discloses apparatus by means of which a relatively weak or transitory primary visible image produced by a source of radiation, for example X-rays (including gamma-rays) or other ultra-visible radiations may be converted into a secondary visible image of substantially greater intensity or greater duration than the primary image. This is accomplished by producing an electron beam having a section pattern corresponding to that of the primary visible image and by accelerating such beam toward a suitable reproduction means such as a fluorescent screen. It is an object of the present invention to provide means whereby the functions of producing the primary visible image and the electron beam advantageously may be combined in a single sensitized element. In one embodiment of this invention this is accomplished by providing an extended electrode surface which comprises fluorescent and photoelectric materials in close mechanical association.

The features of novelty which I desire to protect herein will be pointed out with particularity in the appended claims. The invention itself, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the drawing, in which Fig. 1 shows in partial section an image reproduction system suitably embodying the invention and Figs. 2 and 3 show fragmentary details of various parts of the construction of Fig. 1.

Referring particularly to Fig. 1 there is shown at the extreme left of the figure an X-ray tube comprising a cathode 10 and a target or anode 11. In the use of this device for diagnostic purposes radiations originating at the target 11 impinge upon an object to be examined, such as an object being represented in the present case as a human hand 13. Radiations transmitted through the object are caused to fall upon the end wall 15 of an evacuated transparent or translucent envelope 16, suitably of glass which constitutes the enclosure for an image reproduction device. In accordance with the invention the wall 15 is provided with common means whereby the transmitted X-radiations may be successively converted into a visible image and then into a beam of photoelectrons having a section pattern cor-

responding to that of the visible image. Such a means may include, for example, a combination of fluorescent and photoelectric materials applied to the inside of the wall 15. One particular combination which I consider suitable for this purpose comprises a layer of calcium tungstate superficially coated with a film of photoelectrically active material. The photoelectric film is preferably at least slightly conductive in character and should be so thin as to be substantially transparent. It may be composed, for example, of a deposit of slightly oxidized silver which has been activated with an alkali metal, preferably caesium. The physical structure of the composite surface is indicated in Fig. 2 in which 17 is a layer of a material which is adapted to fluoresce under the influence of X-rays and 18 is a conducting transparent film comprising a photoelectric substance. In an alternative arrangement the fluorescent and photoelectric materials may be admixed to form a single layer.

Under the action of impinging X-radiations the fluorescent material will form a visible image whose nature will be determined by that of the interposed object 13. The light thereby developed will in turn be effective to release electrons from the associated photoactive material in a pattern which corresponds closely to that of the image itself. As explained in the Coolidge application above referred to, the electrons so developed may be focused electron-optically to impinge on another fluorescent screen 20 where they will produce a secondary visible image corresponding in outline to the section pattern of the electron beam. If, during the transition period the electrons are accelerated to a sufficiently high velocity, this secondary image may be of substantially greater intensity than the primary image. Consequently, a camera positioned as indicated at 30 may obtain a good photographic record of the image even though a relatively weak source of X-rays is employed.

In the present instance a suitable accelerating and focusing system is shown as comprising an accelerating electrode 21 adapted to be charged to a high potential with respect to the emissive surface 18 and an associated focusing electrode comprising a series of rings 23. These rings, which are electrically connected by connections including interposed resistors or resistance bodies indicated within the envelope at 24, and shown in enlarged detail in Fig. 3 may be used to modify the focal length of the lens system by varying the potential impressed between the terminals 25 and 26. In this way the electron beam orig-

inating at the cathode surface 18 may be caused to form on the fluorescent screen 20 a clear and intensified secondary image corresponding to the primary image which appears on the surface 17.

5 In some cases it may be desirable to augment the electron-optical lens formed by the electrodes 21 and 23 by means of additional magnetic or electrostatic focusing means.

10 While I have shown particular embodiments of my invention, it will be understood by those skilled in the art that many modifications may be made without departing from the invention, and I aim by the appended claims to cover all such modifications as fall within the true spirit and scope of my invention.

15 What I claim as new and desire to obtain by Letters Patent of the United States is:

1. A composite electrode comprising a layer of calcium tungstate adapted to be excited to fluorescence by the action of impinging radiations and a transparent film of oxidized silver thereon, said film being photoelectrically activated with caesium, whereby fluorescence of the calcium tungstate layer results in electron emission from the electrode.

2. In an image-reproducing system, a source of primary radiations, an electrode exposed to the said primary radiations and having contiguously arranged fluorescent and photoelectric compo-

nents, the fluorescent component being adapted to luminesce in response to impingement of the said primary radiations thereon, and the photoelectric component being substantially non-emissive when excited solely by said primary radiations but being capable of effective electron emission when excited by light from the fluorescent component, and image-reproducing means for receiving electrons emitted by the photoelectric component in response to excitation of the fluorescent component by the said primary radiations.

3. In an image-reproducing system, a source of X-rays defining a primary image, an electrode exposed to the said source and having a photoelectric component arranged in direct contact with a fluorescent component which is adapted to luminesce when excited by X-rays, the said photoelectric component being substantially non-emissive when excited solely by X-rays but being highly emissive when excited by light generated by the said fluorescent component, and image-reproducing means for receiving electrons emitted by the said electrode in response to impingement of X-rays thereon and for producing an intensified secondary image corresponding to said primary image.

IRVING LANGMUIR.