May 7, 1940. H. G. LUBSZYNSKI 2,199,438

ELECTRON DISCHARGE DEVICE

Filed Jan. 15, 1937

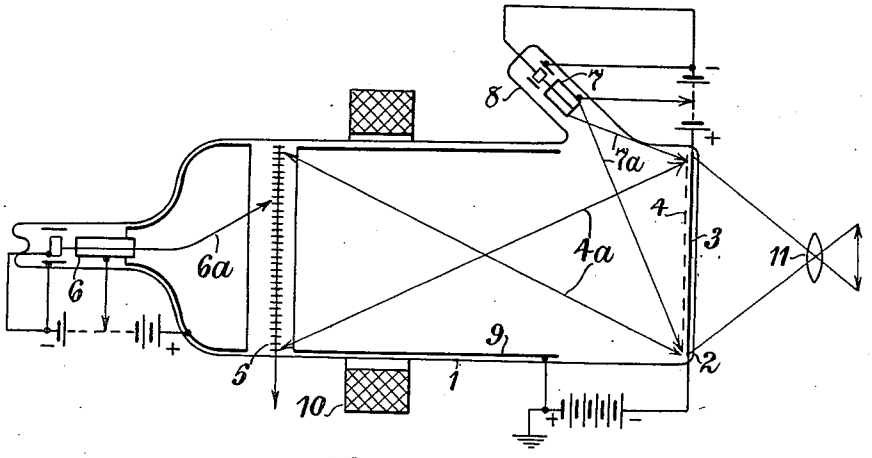

Fig. 1.

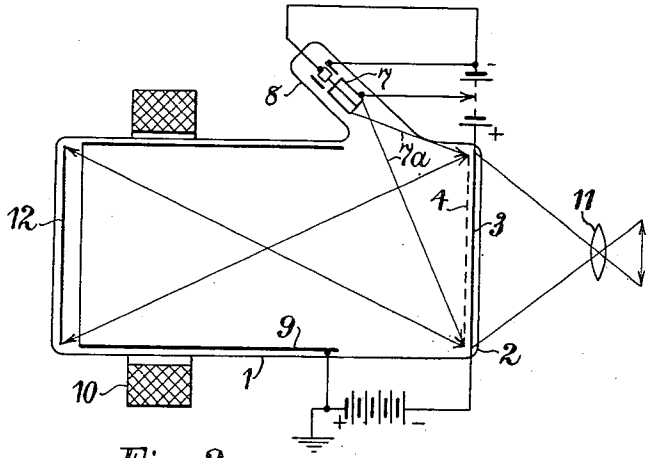

Fig. 2.

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Patented May 7, 1940 2,199,438

UNITED STATES PATENT OFFICE

2,199,438

ELECTRON DISCHARGE DEVICE

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Application January 15, 1937, Serial No. 120,771
In Great Britain January 15, 1936

14 Claims. (Cl. 250—150)

This invention relates to improvements in electron discharge devices and is particularly, although not exclusively, concerned with devices suitable for use in television and like systems and more particularly with apparatus suitable for television transmission.

It is well known that a solid body, if bombarded with electrons, will emit secondary electrons, which may be drawn off to an electrode held at a potential which is positive (or only slightly negative) relatively to the potential of the solid body. If the velocity of the bombarding primary electrons is suitably chosen relatively to the material of the solid body, the number of secondary electrons emitted may be made greater than the number of incident electrons, and at a certain velocity of incident electrons the ratio of the number of secondary electrons emitted to primary electrons arriving will reach a maximum value: the maximum value of the ratio varies from substance to substance. This phenomenon is known as true secondary emission. There is, however, another kind of secondary emission produced by bombardment of certain special materials which differs from true secondary emission in that the amount of emission may be varied, other factors remaining constant, by allowing radiant energy to fall on the material. This latter kind of secondary emission will be referred to throughout as "abnormal secondary emission."

It is the chief object of the present invention to provide a method of and apparatus for employing this abnormal secondary emission for television and other purposes, since it is found that it provides a convenient means for transforming variations of radiant energy in to electrical energy of sufficient magnitude for use in television and like systems and for other purposes.

The present invention, therefore, consists in, according to one aspect, a method of transforming radiant energy into electrical energy by employing an electron discharge device having a first screen, the properties of which are such that, when said screen is bombarded with primary electrons the abnormal secondary emission therefrom varies in intensity in accordance with the intensity of radiant energy falling thereon, projecting radiant energy, such as a light image on to said screen bombarding said screen with primary electrons so as to cause abnormal secondary emission therefrom and focusing said secondary electrons on to a second screen so as to form an electron image on said second screen.

For carrying out this method, an electron discharge device is provided comprising a first screen adapted to receive radiant energy, the properties of said screen being such that, when said screen is bombarded with primary electrons, the abnormal secondary emission therefrom varies in intensity in accordance with the intensity of the radiant energy falling thereon, means for bombarding said screen with primary electrons, a second screen adapted to receive abnormal secondary emission from said screen, and means for focusing electrons from said first screen to form an electron image on said second screen.

By the term "radiant energy" is to be understood not only light of the visible portion of the electro-magnetic spectrum, but any electro-magnetic radiations which are capable of effecting the abnormal secondary electron emissive properties of the screen, for example, infra-red rays or X-rays.

The second screen may have the form of a mosaic screen comprising a multiplicity of mutually insulated elements capacitatively associated with a signal plate, in which case means may be provided to scan the screen with a beam of electrons or a light beam according to the nature of the screen, to provide picture signals for transmission. Various methods of using such mosaic screens have been proposed, and the apparatus may be adapted for use with any of these methods which are suitable for use in the present case. The exact method of scanning the screen, however, forms no part of the present invention.

Alternatively, the second screen may have the form of a fluorescent screen, in which case a visible image of the image projected on the first screen will be produced on the former. The uses of this modification will be described later.

In order that the said invention may be clearly understood and readily carried into effect, one embodiment of the invention will now be described with reference to the accompanying diagrammatic drawing in which—

Fig. 1 illustrates an electron discharge device in accordance with the invention and embodying a mosaic screen and

Fig. 2 illustrates a device similar to that shown in Fig. 1 but embodying a fluorescent screen.

The apparatus shown in Fig. 1 is particularly suitable for use in television transmitting systems in which an image of an object for transmission is resolved into electrical impulses which are fed to a suitable transmitter. As shown, the apparatus comprises an evacuated glass envelope 1 on the inner surface of a plane end wall 2 of which there is formed a transparent coating of material the properties of which are such that

when the material is bombarded with primary electrons, the abnormal secondary emission therefrom varies in intensity in accordance with the intensity of radiant energy falling thereon. Such a layer may be formed as follows: On the said wall of the tube a thin transparent layer 3 of metallic aluminium is applied. On the surface of this layer is formed a thin film of aluminium oxide (for example by electrolytic treatment of the transparent aluminium layer). On this oxide layer is deposited a mono-molecular layer 4 of an alkali metal such as caesium, which is then oxidised. When the layer formed in this way is bombarded with primary electrons, and light is allowed to fall on it, the amount of abnormal secondary emission from any point on the layer is dependent upon the intensity of the light falling on that point. The layer thus forms a photo-sensitive screen when bombarded with primary electrons.

In the envelope is also arranged a so-called double-sided mosaic 5 (shown diagrammatically) and comprising a number of conducting rivets insulated from one another, and capacitatively associated with a metallic signal plate, through which they project. This mosaic screen 5 is arranged spaced from and parallel to the photo-sensitive screen, and both are arranged at right angles to the axis of the tube. On the side of the mosaic screen remote from the photo-sensitive screen is arranged a cathode ray gun 6 of any suitable kind, by means of which the screen 5 may be scanned by a beam of electrons indicated at 6*a*.

A second cathode ray gun 7 is arranged in a side tube 8, so positioned that it can project electrons on to the photo-sensitive screen on the side thereof facing the mosaic screen. The focusing system of this gun is so arranged that the electron beam, indicated at 7*a*, from the gun bombards the whole of the photo-sensitive screen continuously. Surrounding the space between the two screens is a cylindrical metallic accelerating electrode 9, and outside the tube is arranged a magnetic focusing coil 10 which is so positioned that it is capable of focusing electrons indicated at 4*a* emitted from the photo-sensitive screen on to the mosaic screen 5, to form an electrostatic image thereon.

In operation the photo-sensitive screen may be given a high negative potential relatively to the cylindrical electrode which may be earthed, the electrodes of the two cathode ray guns being given suitable potentials to enable them to function in the desired manner.

The operation of the tube is as follows:

The electrons from the second cathode ray gun 7 cause abnormal secondary emission from the photo-sensitive screen. The electrons so emitted are accelerated towards the mosaic screen by the electrostatic field existing between the photo-sensitive screen on the one hand and the cylindrical electrode 9 and the elements of the mosaic screen 5 on the other hand. The electrons striking the mosaic screen charge the elements thereof either positively or negatively, according to their incident velocity on the elements, and these charges are periodically neutralised by the beam 6*a* from the first cathode ray gun 6 which scans the screen, to give rise to picture signals in a circuit associated with the signal plate of the mosaic screen. The operation of this part of the apparatus, which forms no part of the present invention, need not be described further.

If now an image of an object is projected on to the photo-sensitive screen (from the side of the screen remote from the mosaic screen) through a lens system indicated at 11 the abnormal secondary emission from the photo-sensitive screen will become less at each point by an amount dependent upon the intensity of the light from the image falling on that point. Thus there will be formed on the mosaic screen an electrostatic image of the object, since the charge on each element of the mosaic screen depends on the number of electrons reaching it. As the cathode ray 6*a* from the first gun 6 scans the screen 5, the signals set up in the circuit associated with the signal plate will vary in intensity in accordance with the variation in intensity of illumination of the image from point to point. These signals may then be amplified and transmitted.

The invention is not limited to television transmission apparatus. In Figure 2 of the drawing a modified construction is shown in which the mosaic screen 5 of Figure 1 is replaced by a fluorescent screen 12 deposited on a wall of the tube 1 opposite to the photo-sensitive screen, or otherwise suitably disposed, on which an intensified image of the image projected through the lens 11 on to the photo-sensitive screen will be formed. If the number and incident velocity of the electrons striking the fluorescent screen are sufficiently great, an image of the image on the sensitive screen may be formed, which is brighter than the latter image. The apparatus can therefore act as a light amplifier. By suitable choice of fluorescent screen the apparatus may be used as a light transformer; an image in light of one colour (for example red) may be projected on to the photo-sensitive screen and an image formed on the fluorescent screen in light of another colour, for example blue. In this way objects emitting only infra-red or other invisible radiation may be made visible. In this aspect the invention may have application to permit vision through fog.

The invention is also not limited to the particular arrangement of electrodes described. For example the photo-sensitive screen may be opaque, and the image projected on the side thereof facing the mosaic screen. This image may be projected obliquely on the photo-sensitive screen, when the latter and the mosaic screen are parallel as already described, or it may be projected normally on the photo-sensitive screen, when the latter and the mosaic screen are inclined to one another and to the axis of the focusing coil, for example, in the manner described in co-pending application Serial No. 82,300 filed May 28, 1936. Further the mosaic screen may be of the so-called single sided type, that is to say, of the kind which is scanned on the side thereof facing the photo-sensitive screen. In this case the mosaic screen may, in known manner, be composed of mutually insulated conductive elements provided with a suitable signal plate, or may take the form of a sheet of material of high transverse resistance, such as mica, the signal plate being constituted by a metallic coating on the unscanned side of the mica sheet.

Electrostatic focusing may be employed instead of, or in conjunction with, electromagnetic focusing if desired.

Between the photo-sensitive screen and the mosaic or fluorescent screen there may be arranged means for producing amplification of the abnormal secondary emission from the photo-sensitive screen. Such means may take the form of one or more target electrodes adapted to emit

secondary electrons on being struck by the emission from the photo-sensitive screen, and means for focusing this secondary emission on to a further target electrode or the mosaic or fluorescent screen. The operation of electron amplifiers of this kind is fully described in the specification of the aforesaid co-pending application.

I claim:

1. In an image producing system, the method steps which include developing an unfocused beam of relatively high velocity electrons, directing the developed beam of electrons to flood simultaneously substantially the complete area of an impact surface to release therefrom a flow of secondary electrons, directing radiant energy upon the impact surface simultaneously with the electron beam for modifying the produced secondary electron flow under the influence of the directed radiant energy, and then focusing the modified secondary emission flow upon a receiving target.

2. In a radiant energy translating system an electron discharge device comprising a screen element, means for simultaneously flooding substantially the entire screen element with relatively high velocity electrons to release therefrom secondary electrons, means for simultaneously directing the radiant energy upon said screen element, said screen element being so formed that the number of secondary electrons released under flooding vary in accordance with the intensity of the radiant energy falling thereon, an electron responsive target member positioned to receive the secondary electron emission from the screen, and means for focusing the electrons released from the screen upon the target member.

3. An electron discharge device as in claim 2, wherein said target member is an electrostatic storage screen or mosaic, means including an additional source of electrons for producing a narrow focused beam of electrons, and means for causing said beam to scan the member.

4. An electron discharge device as in claim 2, wherein the target member is a double-sided mosaic electrode, means for directing the secondary electrons from said screen element so as to cause impact thereof on one side of said mosaic electrode, and means for generating a scanning beam of electrons, and means for causing said beam to scan said mosaic electrode on the opposite side from that upon which the secondary electrons fall.

5. An electron discharge device as in claim 2, wherein said target member is a fluorescent screen.

6. In an image producing system the method steps which include directing primary electrons simultaneously upon the entire area of an impact surface to release therefrom a flow of secondary electrons, modifying the released secondary electron flow in accordance with radiant energy, focussing the modified secondary electron flow upon a second impact surface to produce thereupon an electrostatic charge replica of the modified secondary electron flow, and periodically releasing the electrostatic charges to a load circuit.

7. In an image producing system the method steps which include directing primary electrons simultaneously upon the entire area of an impact surface to release therefrom a flow of secondary electrons, simultaneously directing an optical image upon the surface to modify the released secondary electron flow in accordance with the brilliance of the optical image, focussing the modified secondary electron flow upon a second impact surface to produce thereupon an electrostatic charge replica of the modified secondary electron flow and of the optical image, and periodically and electronically releasing the electrostatic charges to a load circuit to produce a train of energy representative of the optical image.

8. In an image translating system the method steps which comprise directing a primary electron flow simultaneously upon the entire area of an impact surface to release secondary electrons, simultaneously subjecting the impact surface to radiant energy to modify the released secondary electron flow, focussing the modified secondary electron flow upon an impact plane to produce thereover discrete electrostatic charges representative of coordinated portions of the radiant energy, and then electronically scanning the discrete charges for neutralizing the produced charges in sequence to release to a load circuit electrical signalling impulses representative of the radiant energy.

9. In an image translating system the method steps which comprise directing a primary electron flow simultaneously upon the entire area of an impact surface to release secondary electrons, simultaneously illuminating the impact surface with an optical image to modify the intensity of the released secondary electron flow, focussing the modified secondary electron flow upon an impact plane to produce thereover discrete electrostatic charges representative of coordinated portions of the optical image, and electronically neutralizing the produced charges in sequence to release to a load circuit electrical signalling impulses representative of the optical image.

10. In an image translating device a light responsive impact surface, means for simultaneously subjecting the entire surface to primary electrons to cause the release of secondary electrons from the surface, means for simultaneously subjecting the entire surface to a radiant energy image to cause a modification of the released secondary electron flow, an electrostatic charge storage target positioned to receive the secondary electron flow, means for focussing the secondary electrons upon the target to produce thereupon a plurality of discrete electrostatic charges representative of the radiant energy, and means for scanning the target to neutralize the accumulated electrostatic charges and thereby to realease a train of electrical signalling impulses representative of the radiant energy.

11. In an image translating device a light responsive impact surface, means for simultaneously subjecting the entire surface to substantially uniform velocity primary electrons to cause the release of secondary electrons from the surface, means for simultaneously illuminating the entire surface with an optical image to cause a modification of the released secondary electron flow, an electrostatic charge storage target positioned to receive the secondary electron flow, means for focussing the secondary electrons upon the target to produce thereupon a plurality of discrete electrostatic charges representative of the optical image, and means for scanning each elemental area of the target in sequence to neutralize the accumulated electrostatic charges and thereby to release a train of electrical signalling impulses representative of the optical image.

12. In a device wherein is included a screen member having the property of releasing secondary electrons upon bombardment with primary electrons and which screen member has the

property of producing a variable secondary electron emission in proportional to variations in intensity of radiant energy falling thereon simultaneously with primary electron bombardment, the method of transforming radiant energy into electrical energy which includes the steps of bombarding the screen member simultaneously over substantially the entire area thereof with high velocity primary electrons so as to cause secondary emission of electrons therefrom, projecting radiant energy upon the screen member to vary the secondary emission therefrom under bombardment by primary electrons and to cause thereby a variable secondary electron emission proportional to the intensity of the radiant energy, focussing the released secondary emission electrons upon a predetermined focal plane spaced apart from the plane of release of secondary electrons and converting at the focal plane the electron flow into an electrostatic replica of the radiant energy.

13. The method steps claimed in claim 12 comprising, in addition, the step of scanning the plane of the produced electrostatic replica to obliterate in sequence the electrostatic representations and to produce thereby electrical signals for transmission.

14. An electron discharge device comprising a screen element, an electron source for simultaneously flooding the entire area of the screen element with relatively high velocity electrons to cause the release of secondary electrons therefrom, means for concurrently directing radiant energy upon the screen element to vary the normal release of secondary electrons from the entire area thereof in proportion to the intensity of the radiant energy, a target element positioned to receive simultaneously over its entire area the released secondary electrons from the screen element, and means intermediate the screen member and the target member for focussing the secondary electrons upon the target member in a relationship spacially coordinated with the released secondary electrons and the radiant energy reaching the screen element.

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