Dec. 17, 1940. H. G. LUBSZYNSKI 2,225,063

TELEVISION SYSTEM

Filed May 14, 1937

Fig. 1

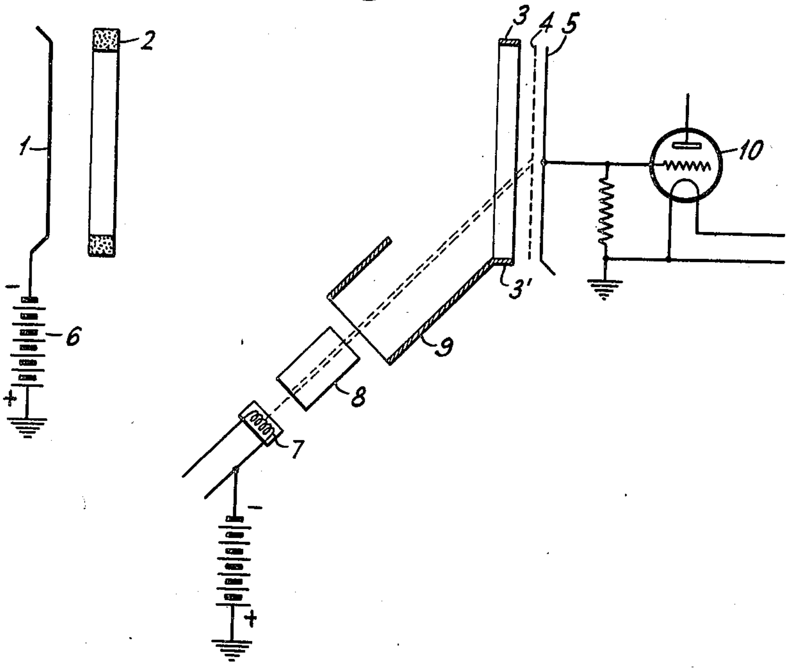
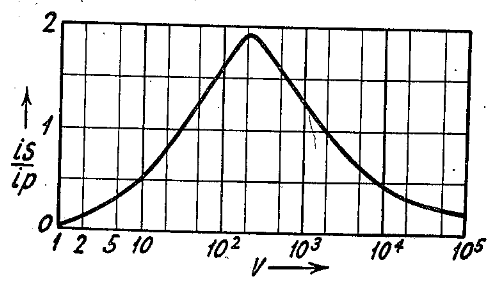


Fig. 2



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TELEVISION SYSTEM

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In Great Britain May 20, 1936

2 Claims. (Cl. 178—7.2)

This invention relates to improvements in or modifications of the invention forming the subject matter of the specification of British Patent No. 442,666.

In the parent specification there is described a television transmission system in which use is made of a cathode ray tube. The cathode ray tube comprises essentially a photo-electrically active screen, a mosaic screen of mutually insulated elements spaced apart from the photo-electrically active screen, and means for scanning the mosaic screen with a cathode ray. In operation an image of the object to be transmitted is projected upon the photo-electrically active screen, and the photo-electrons emitted therefrom are focused by means of an electron focusing system upon the mosaic screen to form an electro-static image thereon. The velocity of the photo-electrons is such that they cause the elements of the mosaic to emit secondary electrons greater in number than the incident primary electrons whereby each element in the intervals between scans becomes positively charged to an extent dependent on the brightness of the corresponding point of the image of the object. The cathode ray serves to discharge each element in turn by supplying it with electrons, whereby each element is brought, when scanned, to an equilibrium potential. The change in potential resulting from the said scanning operation may be used to provide signals for transmission.

If a curve is plotted with the ratio of the number of secondary electrons emitted by a substance to the number of primary electrons incident on that substance as ordinates and the velocity of the incident primary electrons as abscissae, the velocity being expressed as a voltage difference between the source of primary electrons and the substance, it will be found that from zero the curve rises to a point where the ratio of the secondary electrons to the primary electrons is unity continues to rise as the voltage difference increases to a peak value where the ratio of the secondary electrons to the primary electrons reaches its maximum value greater than unity, the curve then falling with increasing voltage differences to a point where the ratio is again unity and continues to fall below this point where the ratio is less than unity. The first point on the curve where the ratio is unity will hereinafter be referred to as the "first cross-over point" and the second point where the ratio is again unity as the "second cross-over point."

According to the present invention, there is provided an improvement in or modification of the invention forming the subject of the specification of the British Patent No. 442,666 which is constituted by a method of transmitting images of an object to a distance in which an optical image of the object is formed upon a photo-electrically sensitive surface, the photo-electrons emitted from any point on said surface being accelerated towards and focused upon a mosaic screen formed of or comprising a substance possessing a characteristic such that it has two cross-over points, the velocity of the photo-electrons on striking such mosaic screen being such that secondary electrons are emitted from each element of said screen in greater number than the incident photo-electrons, whereby such element acquires a positive charge dependent upon the number of photo-electrons reaching it, and scanning the elements by a primary beam of electrons which brings the potential of each element to a more negative or an equilibrium potential value which is substantially the same for each element, and in arranging that the velocity of the scanning beam corresponds to a potential higher than the second cross-over point of said substance. The velocity of the photo-electrons is preferably such as to cause a maximum number of secondary electrons to be emitted for every incident primary electron.

With such a method, disadvantages which result from the spread of secondary electrons across the mosaic screen are substantially overcome and when a ratio of 2 (or more) to 1 of secondary electrons are emitted as compared with the incident photo-electrons, an amplification effect may be obtained.

The mosaic screen may be replaced in some cases by an insulator which has such a high transverse resistance, for example, greater than 10^{12} ohms per centimetre, that it may be regarded as a mosaic the elements of which consist of the atoms or molecules or crystals of the insulating substance.

In order that the said invention may be clearly understood and readily carried into effect the same will now be more fully described with reference to the accompanying drawing in which:

Fig. 1 is a diagrammatic representation of the form of apparatus with which the invention may be performed, and

Fig. 2 is a diagram for illustrating the operation of the apparatus of Fig. 1.

Referring now to Fig. 1, a photo-electrically sensitive screen 1 connected to earth through a battery 6, is disposed so that an optical image of an object to be transmitted can be formed upon it. The "photo-electrons" from the screen 1 are accelerated towards a non-photo-sensitive mosaic screen 4, consisting of a number of conducting or semi-conducting elements insulated from one another and from a common plate 5 which may be called to signal plate. The individual elements may be screened electrostatically from one another by means of a suitable screen which may be connected to the signal plate 5. An electron image of the screen 1 is formed upon the mosaic screen 4 by means of an electron lens constituted by the magnetic field of a coil 2. The lens may be of the short type if an enlarged or reduced electron image is required, or it could be of the long type if the electron image is only required to be of the same size as the optical image on the screen 1. If desired an electro-static lens or a combination of electro-static and electro-magnetic means may be used for focusing purposes. An electrode 3 which may have the form of a ring electrode (as shown) or of a grid placed parallel to the mosaic screen 4 and which is held at a positive potential relatively to the screen 1 accelerates the photo-electrons from the screen 1 towards the mosaic screen 4.

The mosaic screen 4 is scanned by a primary electron beam 12 from a cathode ray "gun" of the usual type, consisting of an indirectly heated cathode 7, an electrode system represented diagrammatically at 8 and a second anode 9 connected to the ring electrode 3.

In practice all the above parts with possibly the exception of the coil 2 are positioned in an exhausted bulb of suitable form, and suitable deflecting means are provided to cause the cathode ray to sweep over the screen 4, usually in a series of parallel lines.

In Fig. 2 a curve is depicted representing the relation between the ratio of the number of secondary electrons (i_s) emitted by aluminium to the number (i_p) of primary electrons incident on that substance, plotted as ordinates against the velocity of the incident primary electrons plotted as abscissae in a logarithmic scale and expressed as a voltage difference between the source of primary electrons and the substance. It should be carefully borne in mind in considering the application of the information afforded by the curve of Fig. 2 to the present invention that this velocity is due to a potential difference. The ordinate 1 represents a value of the ratio i_s/i_p of 1:1. It will be seen that for increasing potential difference the ratio i_s/i_p rises from zero at zero potential difference through unity at about 35 volts constituting the first cross-over point to a maximum at about 200 volts and then falls again to a value equal to unity at about 2000 volts constituting the second cross-over point and then falls below unity with increasing voltage difference. The curve shown in Fig. 2, is that of aluminium and the shape of the curve will vary with different materials and with the purity thereof. In practice where aluminium is employed the purity of the aluminium may be such that the maximum ratio of the secondary electron and primary electrons occurs at about 350–400 volts and in the following description the maximum ratio will be assumed to occur at this potential. The second cross-over point in this case is substantially the same as that shown iln Fig. 2.

The operation of the apparatus of Fig. 1 is as follows:

The elements of the mosaic screen 4 will be assumed, to commence with, to be at earth potential (that is at the potential of the ring electrode 3). The voltage of the cathode 7 is arranged to be such (in relation to the potential of the screen elements) that the velocity of the scanning beam 12 at impact with the screen 4 lies above the second cross-over point of the curve of Fig. 2. From the curve it is seen that i_s/i_p then is always less than unity. The number of secondary electrons emitted from the elements of the screen 4 is, therefore, less than the number of incident primary electrons, so that the elements of the screen 4 become more negative, the secondary electrons being collected on electrode 3 until the potential difference between the elements and cathode is substantially equal to the potential of the second cross-over point. Thus an equilibrium potential is reached and at this equilibrium potential the voltages of the cathode 7 and the mosaic screen elements are, for the sake of example, −2500 volts and −500 volts respectively, with respect to the second anode 9 which is assumed to be at earth potential.

Now considering the effect of the photo-electrons which are incident on the screen 4: the battery 6 is sufficiently large to give the screen 1 a potential of, say −900 volts relatively to earth; the potential difference between the screen 1 and the elements of the mosaic 4 (at their equilibrium potential) will therefore be 400 volts, represented by the peak of the curve when i_s/i_p is greater than unity, so that the elements of the screen 4 will become more positively charged under the influence of photo-electrons. During the interval between two successive scans of the screen 4 by the cathode ray it will be supposed that the light from the image to be transmitted falling upon an elemental area of the sensitive screen 1 is such that the corresponding photo-emission falling upon the corresponding element of the mosaic 4 increases the potential difference between the screen 1 and this element of the mosaic 4 from 400 to 403 volts. The potential of the mosaic element relatively to earth has therefore increased 3 volts. The potential difference between this mosaic element and the cathode is thus now 2003 volts, corresponding to a point on the curve in Fig. 2 where the corresponding ratio is i_s/i_p given at this voltage, is less than unity. When the scanning beam again reaches the mosaic element under consideration, the mosaic element will acquire electron, due to the primary emission exceeding the secondary, and be restored to the equilibrium potential of −500 volts relatively to earth.

This sudden change in potential, which occurs while the scanning beam 12 is on the element, furnishes a picture signal for transmission and is transferred through the condenser formed between the mosaic element and the signal plate 5 to the grid of the valve 10, the anode of which is connected to the transmitter. The capacity of the element of the mosaic screen to the signal plate 5 should be as small as possible.

Suitable materials for the mosaic elements are for example carbon, aluminium, beryllium or lithium borate. It is, of course, desirable that the second cross-over point should occur at as low a potential as possible and accordingly the material for the screen should be chosen bearing this in view. If desired, the elements may be composite, a body of low secondary emitting material, for example, being coated on the side on which the electrons fall with a very thin layer of a high secondary emitting material.

The optical image to be transmitted may be formed obliquely upon the side of the screen 1 facing the mosaic screen 4, or if desired the image may be cast upon the opposite side of the screen 1, the body of the screen 1 then being made of transparent material or in the form of a grid.

In some cases the screen 1 may be disposed obliquely relatively to the lens 2 which focuses the photo-electrons on to the mosaic screen 4 which, in this example, is not parallel to the screen 1 but is disposed obliquely to the lens. The image is projected normally on to the screen 1 whilst the mosaic is scanned by a beam of electrons which is projected on to the mosaic in such a manner as to compensate for the distortion arising from the obliquity or non-parallel relationship of the screen 1 and the mosaic 4.

With mosaic elements of a composite nature use in the past has been made of caesium, but this element has the disadvantage that it readily evaporates when scanned by a beam of high energy and accordingly the invention provides for the use of other materials, for a composite construction, such as zinc sulphide, lithium borate or other insulators with a low work function with the attendant advantage that when bombarded by photo-electrons at a velocity corresponding to the peak of the curve shown in Fig. 2 the yield of secondary electrons is high.

The materials mentioned, apart from caesium, are capable of withstanding the high scanning beam current and consequently, any tendency of the caesium from the photo-cathode endeavoring to become deposited on the mosaic surface would be prevented by the high velocity scanning beam.

If desired, instead of the mosaic screen 4 being composed of carbon or aluminium, it may be composed of a suitable support, such as mica, the surface of which facing the screen is provided with a multiplicity of minute mutually insulated elements of nickel.

It will be appreciated that in the normal manufacture of a cathode ray tube of the kind contemplated in the invention, the photo-sensitive screen 1 is rendered photo-sensitive by evaporating a photo-sensitive material, such as caesium, on to the surface of the screen after the tube containing the elements has been evacuated. In order to prevent the caesium during the sensitizing process from becoming deposited on the screen 4, which is liable detrimentally to affect its properties, a flap may be provided which normally covers the active area of the screen 4 during the photo-sensitising operation and after such operation is completed the flap may be displaced to expose the active area of the screen. Alternatively, in order to prevent caesium from becoming deposited on the screen 4, the latter, during the photo-sensitising operation, may be maintained at such a temperature compared with the vaporising temperature of the caesium that substantially no caesium can become deposited on the screen 4.

Whilst in the above description reference is made to the use of certain specific potentials, it will, of course, be understood that the invention is not limited to these specific values as other potentials may be used, particularly since the operating potentials will vary with the nature of the mosaic screen and the photo-cathode.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. The method of operating a television transmitting tube which includes an imperforate photo-cathode upon which an optical image may be projected to release photo-electrons therefrom, a mosaic electrode screen comprising a number of discrete elements each of which is adapted to produce secondary electrons at a ratio from greater than one-to-one to less than one-to-one as compared to the electrons bombarding the same as the velocity of the bombarding electrons is increased, and an electron gun for producing a cathode ray beam for scanning the mosaic screen, which comprises the steps of projecting a light image on the photo-cathode to produce a stream of photo-electrons, causing the photo-electrons to travel toward and to become focused upon the mosaic screen, the rate of travel being sufficient to produce secondary electrons at the screen in excess of the photo-electrons arriving thereat to produce a positive charge image on the mosaic screen in proportion to the intensity of the light image, and directing the cathode ray beam against the screen at a rate in excess of the velocity of the photo-electrons and sufficiently high to preclude the production of secondary electrons at the screen in excess of the impinging beam electrons.

2. The method of operating a television transmitting tube which includes a photo-cathode upon which an optical image may be projected to release photo-electrons therefrom, a mosaic screen electrode which, when bombarded by primary electrons, is adapted to produce secondary electrons from a ratio greater than two to a ratio less than one as the impact velocity of the primary electrons is increased, and an electron gun for producing a cathode ray beam for scanning the mosaic screen, which comprises the steps of projecting an optical image on the photo-cathode to produce a stream of photo-electrons, accelerating the photo-electrons toward the mosaic screen at a rate sufficient to produce secondary electrons at the sceren in excess of the photo-electrons arriving thereat to produce a positive charge image on the mosaic screen in proportion to the intensity of the light image, and directing the cathode ray beam against the mosaic screen at a rate in excess of the velocity of the photo-electrons and sufficiently high that the secondary electrons generated at the screen are less than the impinging beam electrons.

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