

Feb. 15, 1938.

A. V. BEDFORD ET AL

2,108,097

TELEVISION TRANSMITTER

Filed Aug. 31, 1934

3 Sheets-Sheet 1

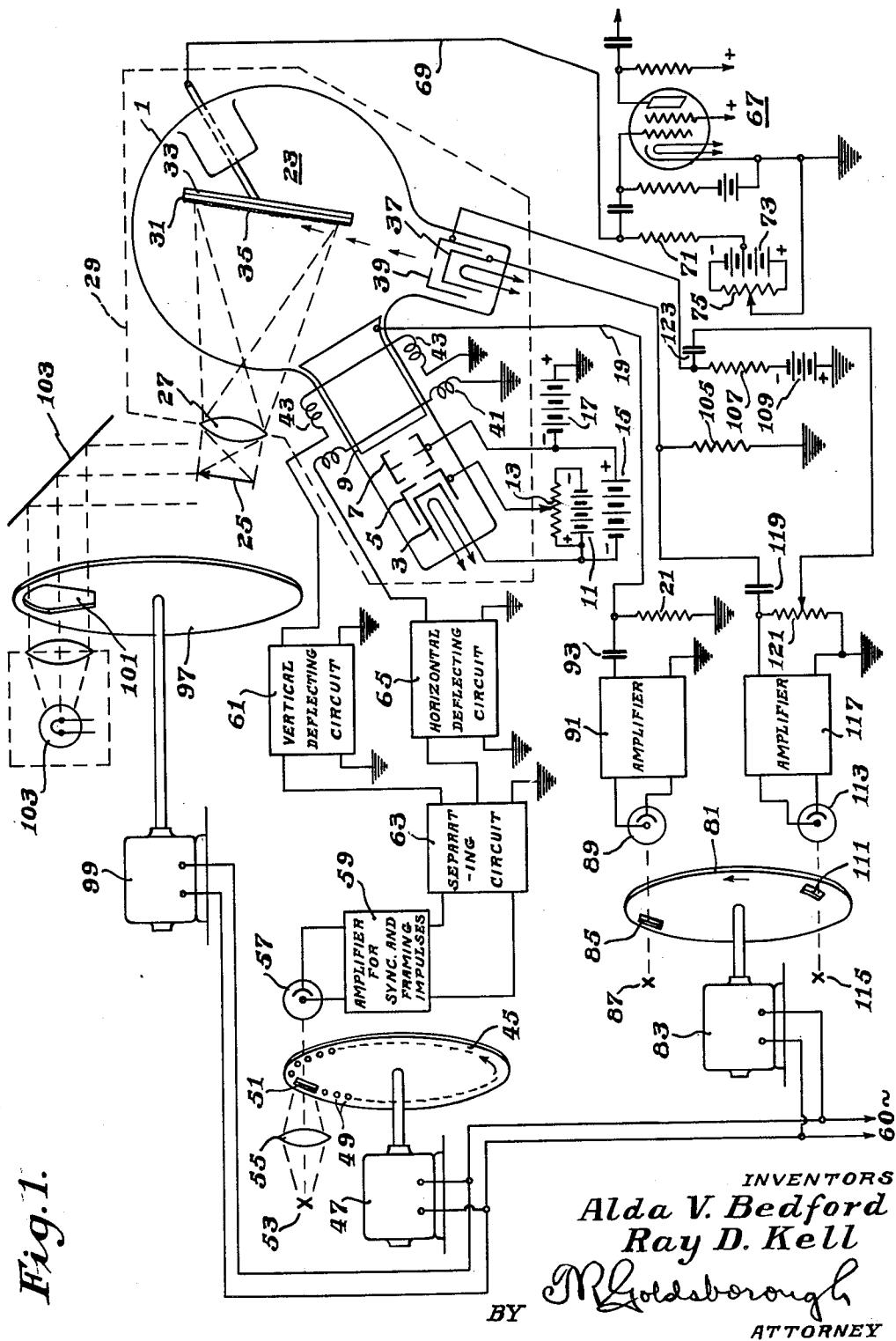


Fig. 1.

INVENTORS
Alda V. Bedford
Ray D. Kell
BY *M. Goldborough*
ATTORNEY

Feb. 15, 1938.

A. V. BEDFORD ET AL

2,108,097

TELEVISION TRANSMITTER

Filed Aug. 31, 1934

3 Sheets-Sheet 2

Fig. 2.

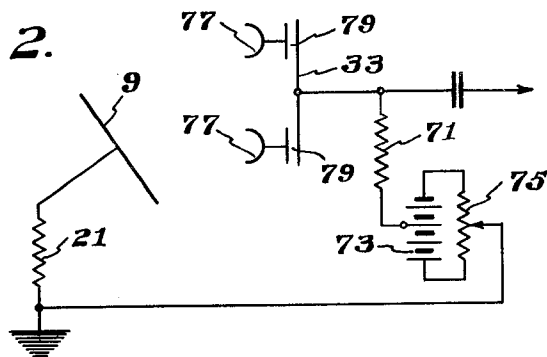


Fig. 3.

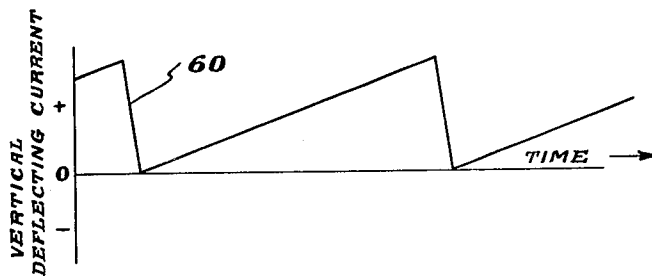


Fig. 4.

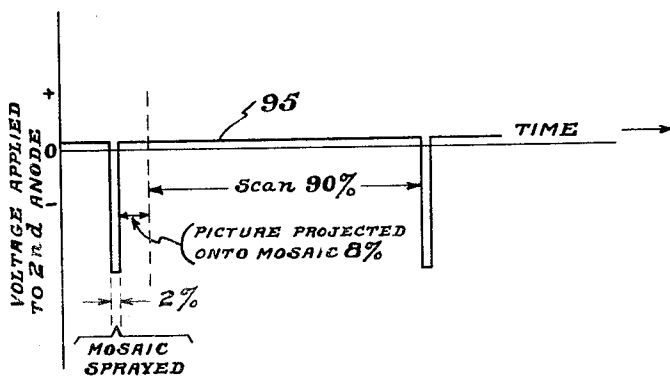
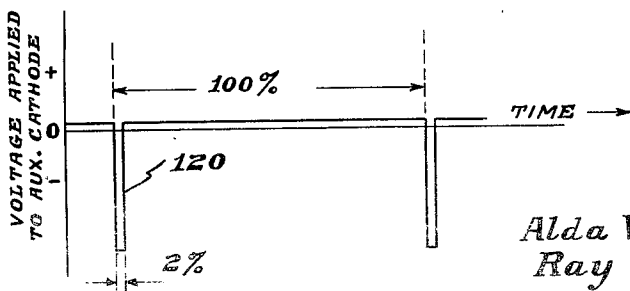


Fig. 5.



INVENTORS
Alda V. Bedford
Ray D. Kell

BY *JR Goldborough*

ATTORNEY

2,108,097

3 Sheets-Sheet 3

3 Sheets-Sheet 3

Fig. 6.

Fig. 6 is a schematic diagram of a circuit for a relay or switch mechanism. The diagram shows a central component (3) with two sets of contacts (41, 43) and a coil (7). A positive impulse (10%) is applied to the coil through a resistor (21) and a switch (93). A negative impulse (2%) is applied to the contacts through a resistor (121) and a switch (119). The circuit is powered by a battery (109) and includes various resistors (71, 107, 105, 123) and a switch (23).

The diagram shows a series of three pulses on a horizontal axis labeled 'TIME'. The vertical axis is labeled 'VOLTS' with markings for '+', '0', and '-'. The first pulse is labeled '10%' and the second pulse is labeled '8% PICTURE ON'. The third pulse is labeled '125 scan 90%'. The pulses are shown as positive-going signals.

Alda V. Bedford

Ray D. Kell

BY J R Goldborough

ATTACHED

UNITED STATES PATENT OFFICE

2,108,097

TELEVISION TRANSMITTER

Alda V. Bedford, Collingswood, and Ray D. Kell,
Haddonfield, N. J., assignors, by mesne assignments,
to Radio Corporation of America,
New York, N. Y., a corporation of Delaware

Application August 31, 1934, Serial No. 742,200

18 Claims. (Cl. 178—7.2)

Our invention relates to television transmitters and particularly to transmitters of the type employing cathode-ray tubes.

A preferred form of device for converting the elements of a picture into electrical impulses, whereby the picture may be transmitted, comprises a cathode-ray tube containing a mosaic of light-sensitive elements so positioned that it may be scanned by the cathode ray. The mosaic is also so positioned that an optical image of the picture to be transmitted may be formed thereon. A transmitter tube of this type is described in detail in an article by V. K. Zworykin published in the Proceedings of the Institute of Radio Engineers for January 1934.

One of the main objects of our invention is to improve the sensitivity of a cathode-ray tube of the above-mentioned type.

A further object of our invention is to provide a television transmitting system which does not require an excessive amount of illumination on the subject being televised.

Other objects, features and advantages of our invention will appear from the following description taken in connection with the accompanying drawings, in which

Figure 1 is a schematic diagram of a preferred embodiment of our invention.

Fig. 2 is a circuit diagram which is referred to in explaining the operation of the transmitter tube shown in Fig. 1.

Figs. 3, 4 and 5 are curves which are referred to in explaining the operation of the apparatus shown in Fig. 1.

Fig. 6 is a schematic diagram of another embodiment of our invention, and

Figs. 7 and 8 are curves which are referred to in explaining the operation of the apparatus shown in Fig. 6.

A preferred embodiment of our invention is illustrated in Fig. 1 where a cathode-ray transmitter tube is indicated at 1. The tube comprises a highly evacuated envelope having an electron gun which consists of an indirectly heated cathode 3, a control electrode 5, and a first anode 7.

A second anode 9, which may consist of a metallic coating on the inner surface of the envelope, is provided both for accelerating the electrons and for aiding in the focusing of the electron beam as well as for functioning as a photoelectric cell anode as will be explained hereinafter.

The electrodes of the cathode-ray tube 1 may be maintained at the proper potentials by means of any suitable voltage source such as batteries.

As illustrated, the control electrode 5 is maintained negative with respect to the cathode 3 by means of a battery 11 having a potentiometer 13 shunted thereacross. The first anode 7 is maintained positive with respect to the cathode 3 by means of a battery 15 while the second anode 9 is maintained more highly positive with respect to the cathode 3 by means of the battery 15 and a second battery 17 connected in series therewith. The second anode 9 is connected to the positive terminal of the battery 17 through a conductor 19, a resistor 21 and ground.

A mosaic 23 of light-sensitive elements is positioned inside the transmitter tube envelope in such position that it may be scanned by the electron beam produced by the electron gun. The mosaic 23 is also so positioned that an optical image of the object to be televised may be formed thereon, such an object being indicated by the arrow 25. An image of the object 25 is formed upon the mosaic 23 by means of an optical system indicated at 27, this optical system being mounted in the wall of a light-tight box, indicated by the dotted lines 29, in which the transmitter tube 1 is located.

As stated in the above-mentioned article, the mosaic 23 may be constructed in various ways, a preferred construction consisting of a sheet of mica 31 having a metallic coating 33 on its back surface to form what will be referred to as the signal plate, and having a mosaic of light-sensitive elements 35 on its front surface. The light-sensitive elements 35 preferably are insulated from each other and are insulated from the signal plate 33 by means of the mica sheet 31.

In accordance with one embodiment of our invention, an auxiliary cathode 37 is provided so positioned with respect to the mosaic 23 that electrons may be sprayed thereon. In order to control the flow of electrons from the auxiliary cathode 37 to the mosaic, a control electrode 39 is provided.

The cathode-ray tube 1 may be provided with horizontal and vertical deflecting coils 41 and 43, respectively. The electrical impulses for producing a flow of saw-tooth current through the deflecting coils for scanning purposes may be generated by means of a disc 45 driven by a synchronous motor 47 which is connected to a 60-cycle power line. The disc 45 has a large number of small evenly spaced openings 49 near its circumference for generating the horizontal synchronizing impulses and a single opening 51 which is comparatively large for generating the framing or vertical synchronizing impulses. The appa-

ratus for generating these impulses includes a light source 53 and an optical system 55 for directing light through the openings in the disc 45 upon a photoelectric cell 57 which is included in the input circuit of an amplifier 59.

The framing impulses are impressed upon a vertical deflecting circuit 61 which is connected to the vertical deflecting coils 43 for causing saw-tooth current to pass therethrough. The current which flows through the coils 43 is represented by the curve 60 in Fig. 3.

The horizontal deflecting impulses are separated from the framing impulses in a separating circuit 63 and impressed upon a horizontal deflecting circuit 65 which is connected to the horizontal deflecting coils 41 for causing the higher frequency saw-tooth current to pass therethrough.

As the electron beam is caused to scan the mosaic 23, charges are successively released from elements of the mosaic whereby a flow of picture current is produced which may be amplified by a suitable amplifier 67. As is well known, the scanning beam brings the mosaic to a certain equilibrium potential each time it scans the mosaic due to the emission of secondary electrons. Thus, at the end of a scanning period, the mosaic is in condition to repeat the cycle of operation. The flow of picture current may be traced from the signal plate 33 of the mosaic, through a conductor 69, a resistor 71, a battery 73, and potentiometer 75 to ground, and through ground, the resistor 21 and the conductor 19 to the second anode 9. The resistor 71 and the battery 73 are connected in series in the input circuit of the amplifier 67, the battery 73 with its shunting potentiometer 75 being so connected that either a positive or negative potential of any value within certain limits may be applied to the signal plate 33 for improving the operation of the transmitter under certain conditions.

The action of the transmitter tube in generating a picture current will be more clearly understood by referring to the circuit diagram in Fig. 2. In this diagram two light-sensitive elements of the mosaic are indicated at 77, these light-sensitive elements being electrically connected to the signal plate 33 only through the capacity between a light-sensitive element and the signal plate represented by the condensers 79. When an optical image is formed upon the mosaic, electrons flow from each light-sensitive element or photoelectric cell cathode 77 to the second anode 9, the number of electrons flowing from a light-sensitive element depending upon the intensity of light striking it. Therefore, the condenser 79 which the light-sensitive element forms with the signal plate 33 is charged to a value depending upon the light intensity at the particular point under consideration.

When the electron beam strikes the light-sensitive element in scanning the mosaic, the condenser 79 is discharged through the resistor, this discharge current being the picture current. It will be apparent from Fig. 2 that since there is no conductive connection between the light-sensitive elements 77 and the second anode 9 it is impossible to obtain maximum sensitivity of the photoelectric cell circuit by including a battery in the circuit for making the second anode positive with respect to the light-sensitive elements 77. While the battery 73 is shown in the circuit, it is included for a different purpose, which will be described later.

In accordance with one feature of our invention, we give the second anode 9 a certain posi-

tive potential with respect to the light-sensitive elements of the mosaic 23 by impressing a square-top wave of voltage across the resistor 21 in the second anode circuit. This square-top voltage wave may be generated by means of a disc 81 which is driven by a synchronous motor 83 connected to the 60-cycle power line. An opening 85 is provided in the disc 81 near its circumference to permit light from a suitable source 87 to pass therethrough and strike a photoelectric cell 89 once for every rotation of the disc. The photoelectric cell 89 is connected in the input circuit of a suitable amplifier 91, and the output circuit of the amplifier 91 is connected through a coupling condenser 93 across the resistor 21.

The resulting voltage which appears across the resistor 21 is shown by the curve 95 in Fig. 4. It will be seen that the voltage impulse is applied to the second anode 9 in a negative direction whereby a smaller positive voltage is applied to the second anode between voltage impulses because of the fact that the current supplied to the resistor 21 must flow through the coupling condenser 93. Consequently, the zero axis of the curve is so located that the area of the curve above the axis is equal to the area of the curve below the axis. By comparing curve 95 with curve 60 in Fig. 3 it will be apparent that the positive impulse applied to the deflecting coils 43 and the negative impulse applied to the second anode 9 begin at the same time.

It will be apparent that at the end of the negative impulse the second anode 9 has a definite positive voltage with respect to the light-sensitive elements 35 whereby photoelectrons released by the optical image are more readily drawn away from the mosaic, thus rendering the transmitter tube more sensitive.

Although a picture may be projected onto the mosaic 23 at the same time that the mosaic is being scanned by the electron beam, it is preferred to project the picture onto the mosaic for a short period and then scan the mosaic. In order to obtain the preferred operation we provide a light shutter 97 which is driven by a synchronous motor 99 connected to the 60-cycle power line. An opening 101 is provided in the shutter disc such that light from a suitable source 103 may be directed upon the object 25 being televised for a certain period, for example, 8% of the total time between picture frames. In the drawings a mirror 103 is shown reflecting the light towards the object 25 merely for the purpose of simplifying the lay-out of the drawings.

Because of the fact that the mosaic 23 loses a large number of electrons at the time the photoelectrons are drawn away from it by the second anode 9, it is desirable to supply the mosaic with additional electrons from some source just before the optical image is projected thereon.

The circuit and apparatus for supplying the mosaic with electrons during the return period of the electron beam and just prior to the time the picture is projected onto the mosaic will now be described. The auxiliary cathode 37 is connected through a resistor 105 to ground while the control electrode 39 is connected through a resistor 107 and through a biasing battery 109 to ground. It is desired to apply a negative voltage impulse to the cathode 37 and to the control electrode 39 at the same time the negative voltage impulse is applied to the second anode 9, whereby the mosaic 23 will be made positive with respect to the auxiliary cathode 37 and electrons will be released and sprayed uniformly over the mosaic.

The negative impulses for the auxiliary cathode 37 are generated by means of the disc 81 which has a second opening 111 therein diametrically opposed to the opening 85 and spaced farther from the circumference of the disc than the opening 85. A photoelectric cell 113 is so positioned that it receives light through the opening 111 from a suitable light source 115 at the same time that the other photocell 89 receives light through the opening 85. The photoelectric cell 113 is connected to the input circuit of a suitable amplifier 117, and the output circuit of the amplifier is connected through a coupling condenser 119 to the auxiliary cathode 37. The output circuit of the amplifier 117 is also connected through a potentiometer 121 and through a coupling condenser 123 to the control electrode 39 whereby the control electrode receives a negative impulse at the same time as the auxiliary cathode, but an impulse of a lower value.

For the purpose of explanation it will be assumed that a negative voltage impulse of 100 volts is applied to the second anode 9, that a negative voltage impulse of the same value is applied to the auxiliary cathode 37, and that the adjustment of the potentiometer 121 is such that a negative impulse of 80 volts is applied to the control electrode 39. It will also be assumed that the biasing battery 109 applies a negative voltage of 20 volts to the control electrode 39. Hence it is apparent that the cathode is swung 20 volts further negative than the control electrode. This is equivalent to a 20 volt positive swing on the control electrode with respect to the cathode. This is enough to overcome the effect of the biasing battery 109 and permit flow of electrons from the cathode during this interval.

Referring to Figs. 4 and 5, a cycle of operation is illustrated in which the negative impulse applied to the second anode 9 lasts for 2% of the total time from the beginning of one framing impulse to the beginning of the next framing impulse. At the same time, a negative voltage impulse of the same duration is applied to the auxiliary cathode 37 and to the control electrode 39 whereby electrons are sprayed upon the mosaic 23. The impulse applied to the cathode 37 is represented by the curve 120 in Fig. 5. By applying a negative voltage to the second anode 9 at the same time that the negative voltage is applied to the auxiliary cathode 37, electrons are prevented from moving over to the second anode instead of to the mosaic as would be the case if the second anode were positive with respect to the auxiliary cathode.

As indicated in Fig. 4, at the end of the negative impulse, the second anode becomes positive with respect to the mosaic, whereby the photo-electric cell portion of the transmitter tube is rendered more sensitive than it is when operated in the usual manner. Immediately following the negative impulse, an object of the image 25 being televised is projected upon the mosaic for a period which, in the example being described, is 8% of the total time between framing impulses. At the end of this time, the light is cut off from the object 25 by means of the shutter 95 and the dark mosaic is then scanned by the cathode-ray beam for the remaining 90% of the time between framing impulses.

At the end of the scanning period, the above described cycle of operation is repeated, electrons being sprayed upon the mosaic to replace the photo-electrons which were drawn over to

the second anode during the period the optical image was on the mosaic.

The battery 73 which is connected between the signal plate and ground is not essential to the operation of our transmitter but it has been found that, under certain conditions, the operation will be improved if the signal plate is made negative with respect to ground, while under other conditions, the operation will be improved if it is made positive with respect to ground.

In Fig. 6 there is shown a modification of the invention as shown in Fig. 1. In the two figures, like parts are indicated by the same reference numerals. The transmitter tubes are identical in construction except that the tube shown in Fig. 6, the metallic coating which forms the second anode 9 is extended to form an anode for the auxiliary cathode 37. In this construction, the extended section of the metallic coating 9, the auxiliary cathode 37 and the control electrode 39 form a gun for spraying electrons upon the mosaic 23. It will be noted that in the tube shown in Fig. 1 the electrons from the auxiliary cathode 37 are not shot upon the mosaic, but instead, are pulled over to it by the potential on the signal plate 33.

In operating the transmitter tube shown in Fig. 6, a positive potential impulse which may have a duration of 10% of the time between framing impulses is impressed upon the second anode 9. This impulse is represented by the curve 125 in Fig. 7. At the same time, a negative impulse 127 (Fig. 8), which may have a duration of 2% of the time between framing impulses, is impressed upon the auxiliary cathode and the control electrode to release the electrons.

The amplitude of the positive impulse applied to the second anode 9 is made such that when added to the negative potential applied to the auxiliary cathode 37, the potential difference between the auxiliary cathode and the second anode is sufficient to project electrons from the cathode 37 upon the mosaic 23. It will be apparent that during the period the positive impulse is impressed upon the second anode 9, the photo-electric cell circuit of the tube is in a sensitive condition. Therefore, at the end of the negative impulse which is applied to the auxiliary cathode 37, an image of the object being televised is projected upon the mosaic 23 and then cut off at the end of the positive impulse, as indicated by the legend in Fig. 7. The mosaic 23 is then scanned by the cathode-ray beam for the remaining 90% of the time between framing impulses.

From an inspection of Fig. 7 it will be evident that, at the end of the positive impulse, the second anode goes negative with respect to the mosaic whereby the tube is rendered insensitive so that there would be no advantage in having an image of the picture projected upon the mosaic continuously. Therefore, as described above, the studio light is interrupted by the shutter 97, shown in Fig. 1, with no loss in efficiency of operation and with a great reduction in the glare and heat of studio lights.

It will be understood from the foregoing description that various modifications may be made in our invention and we desire, therefore, that only such limitations shall be placed thereon as are necessitated by the prior art and set forth in the appended claims.

We claim as our invention:

1. The method of operating a television trans-

mitter tube of the type comprising an evacuated container having a mosaic of light-sensitive elements therein, said elements being mounted adjacent to a non-foraminous signal plate whereby they are capacitively connected thereto, and having an electrode positioned to collect photoelectrons from said mosaic, which comprises the steps of periodically sweeping said mosaic with an electron beam whereby said mosaic is brought to an equilibrium potential at the end of each sweeping period due to the emission of secondary electrons from said mosaic and impressing a voltage impulse across said signal plate and said electrode at the end of each sweeping period.

2. The method of operating a television transmitter tube of the type comprising an evacuated container having a mosaic of light-sensitive elements therein, said elements being mounted adjacent to a signal plate whereby they are capacitively connected thereto, and having an electrode positioned to collect photoelectrons from said mosaic, which comprises periodically impressing a voltage impulse across said signal plate and said electrode, spraying electrons upon said mosaic each time said voltage impulse occurs to replace electrons drawn over to said electrode and then sweeping said mosaic with an electron beam, whereby said mosaic is brought to an equilibrium potential at the end of each sweeping period due to the emission of secondary electrons from said mosaic.

3. In combination, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, said elements being mounted adjacent to and insulated from a non-foraminous conducting plate, an electrode common to said elements and positioned to collect photoelectrons therefrom, a circuit connecting said plate and said electrode, means for supplying voltage impulses to said circuit whereby said electrode periodically becomes positive with respect to said elements, and means for sweeping said mosaic by an electron beam at the end of each of said voltage impulses whereby said mosaic is brought to an equilibrium potential at the end of each sweeping period due to the emission of secondary electrons from said mosaic.

4. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a non-foraminous conducting plate, said elements being mounted adjacent to said plates whereby they are capacitively connected thereto, an electrode common to said elements and positioned to collect photoelectrons therefrom, means for generating an electron beam in said container, means for scanning said mosaic periodically with said electron beam whereby said mosaic is brought to an equilibrium potential at the end of each scanning period due to the emission of secondary electrons from said mosaic, and means for impressing a voltage impulse between said conducting plate and said electrode at the end of each scanning period.

5. A system according to claim 4 characterized in that additional means is provided for spraying said mosaic with electrons at the end of each scanning period for the purpose of replacing electrons drawn over to said electrode.

6. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, an electrode common to

said elements and positioned to collect photoelectrons therefrom, means for generating an electron beam in said container, means for scanning said mosaic periodically with said electron beam whereby said mosaic is brought to an equilibrium potential at the end of each scanning period due to the emission of secondary electrons from said mosaic, and means for impressing a negative voltage impulse between said conducting plate and said electrode at the end of each scanning period, said impulse being fed through a condenser whereby said electrode is made positive with respect to said plate at the end of said impulse.

7. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, an electrode common to said elements and positioned to collect photoelectrons therefrom, means for generating an electron beam in said container, means for sweeping said mosaic periodically with said electron beam, a circuit including a resistor connecting said conducting plate to said electrode, a circuit including a condenser in series therewith connected across said resistor, and means for applying a negative voltage impulse to said electrode through said condenser at the end of each sweeping period.

8. Apparatus according to claim 6 characterized in that means is provided for projecting an image of the object being televised upon said mosaic during the period between the end of the negative impulse and the beginning of the sweep period following said impulse.

9. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, an electrode common to said elements and positioned to collect photoelectrons therefrom, an impedance unit connected between said electrode and said plate, means for generating an electron beam in said container, means for sweeping said mosaic periodically with said electron beam whereby said mosaic is brought to an equilibrium potential at the end of each scanning period due to the emission of secondary electrons from said mosaic, means for making said electrode periodically first negative and then positive with respect to said mosaic, and means for projecting the image of an object to be televised upon said mosaic during at least a portion of the period said electrode is made positive, and means for taking picture signals from said impedance unit.

10. Apparatus according to claim 9 characterized in that means is provided for spraying electrons upon said mosaic during the period said electrode is negative for the purpose of replacing electrons drawn to said electrode.

11. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, an electrode common to said elements and positioned to collect photoelectrons therefrom, an impedance unit connected between said electrode and said plate, means for generating an electron beam in said container, means for making said electrode periodically first

negative and then positive with respect to said mosaic, means for projecting the image of an object to be televised upon said mosaic during the first part of said positive period, means for scanning said mosaic with said electron beam during the last part of said positive period whereby said mosaic is brought to an equilibrium potential at the end of each scanning period due to the emission of secondary electrons from said mosaic, and means for taking picture signals from said impedance unit.

12. Apparatus according to claim 11 characterized in that means is provided for spraying electrons upon said mosaic during the period said electrode is negative for the purpose of replacing electrons drawn to said electrode.

13. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, an electrode common to said elements and positioned to collect photoelectrons therefrom, an impedance unit connected between said electrode and said plate, means for generating an electron beam in said container, means for sweeping said mosaic periodically with said electron beam whereby said mosaic is brought to an equilibrium potential at the end of each scanning period due to the emission of secondary electrons from said mosaic, means for impressing a short positive voltage impulse and a longer negative impulse alternately upon said electrode for making it positive for a certain period with respect to said mosaic, means for projecting an image of the object to be televised upon said mosaic during the period said electrode is positive, and means for taking picture signal from said impedance unit.

14. Apparatus according to claim 13 characterized in that means including an auxiliary electron gun is provided for spraying electrons upon said mosaic during a portion of the period said electrode is positive.

15. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a non-foraminous conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, an electrode common to said elements and positioned to collect photoelectrons therefrom, means for generating an electron beam in said container, means for scanning said mosaic periodically with said electron beam whereby said mosaic is brought to an equilibrium potential at the end of each scanning period due to the emission of secondary electrons from said mosaic, means for increasing the

photoelectric sensitivity of said tube between scanning periods, and means for projecting an image of the subject to be televised upon said mosaic during, and only during, the period of said increased sensitivity.

16. Apparatus according to claim 15 characterized in that said last means includes a device for projecting light upon said subject during, and only during, said period of increased sensitivity.

17. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, an electrode common to said elements and positioned to collect electrons therefrom, means for generating an electron beam in said container, means including a cathode and a control grid for spraying said mosaic with electrons when said cathode and control grid are at the proper relative potential, means for simultaneously driving said electrode and said cathode and control grid negative with respect to said plate for a certain period and for driving said cathode and control grid to said proper relative potential during said period, and means for scanning said mosaic by said electron beam at the end of said period.

18. In a picture transmitting system, a cathode-ray tube comprising an evacuated container, a mosaic of light-sensitive elements therein, a conducting plate, said elements being mounted adjacent to said plate whereby they are capacitively connected thereto, means for generating an electron beam in said container, an electrode common to said elements and positioned to collect electrons therefrom and also positioned out of the path of said electron beam, means including a cathode, a control grid and an anode for spraying said mosaic with electrons when said cathode, control grid and anode are at the proper relative potentials, a connection between said anode and said electrode for maintaining them at the same potential, means for simultaneously driving said electrode positive with respect to said plate and said cathode and control grid negative with respect to said plate for a certain period, and for driving said cathode, grid and anode to said proper relative potential during a portion of said period, means for projecting an optical image of a picture upon said mosaic for another portion of said period, and means for scanning said mosaic with said electron beam at the end of said period.

ALDA V. BEDFORD.
RAY D. KELL.