Feb. 14, 1939. F. C. P. HENROTEAU 2,146,822

TELEVISION

Filed Dec. 15, 1932 2 Sheets-Sheet 1

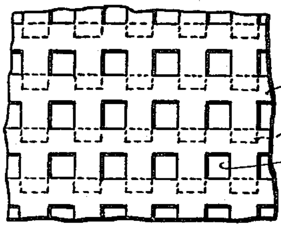

Fig. 2.

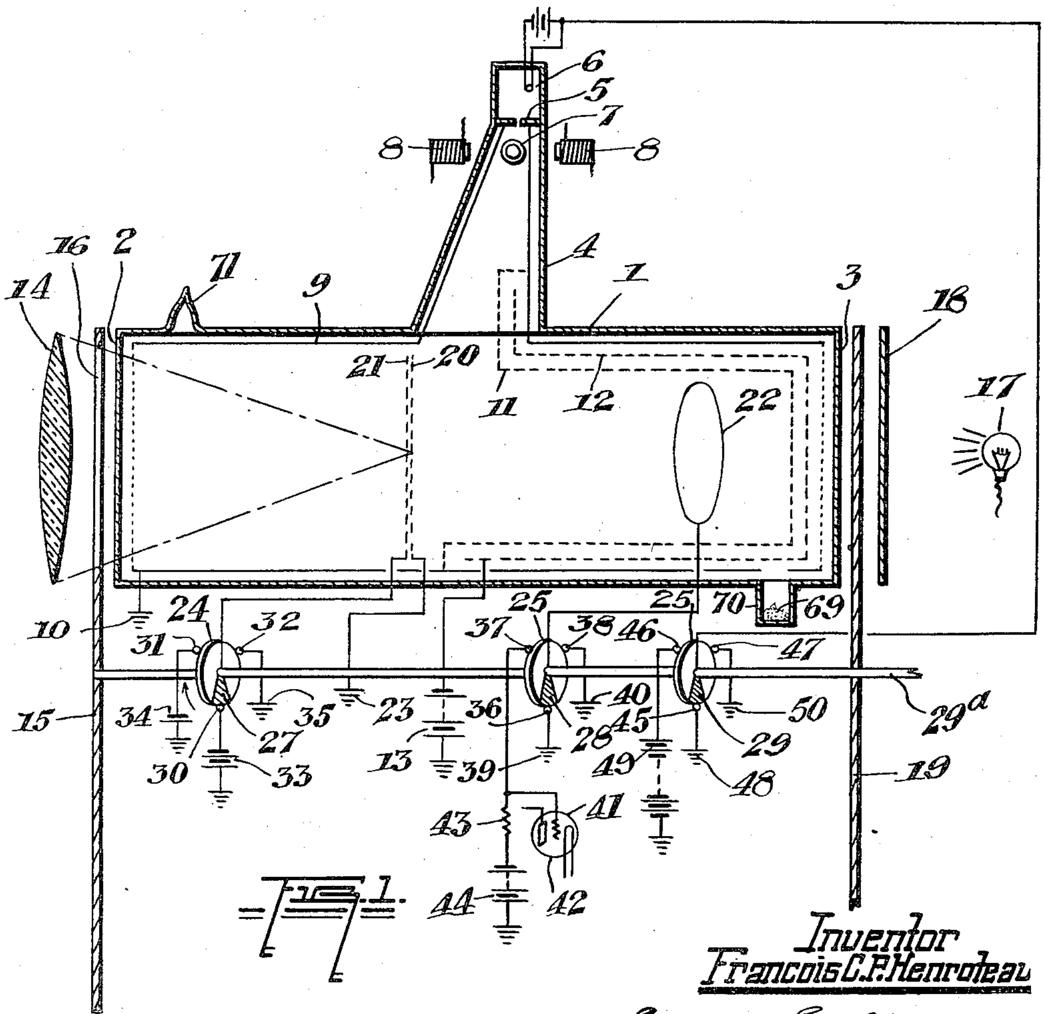

Fig. 1.

Inventor
Francois C.P. Henroteau

BY Eugene E. Stevens
Atty.

Feb. 14, 1939. F. C. P. HENROTEAU 2,146,822

TELEVISION

Filed Dec. 15, 1932 2 Sheets-Sheet 2

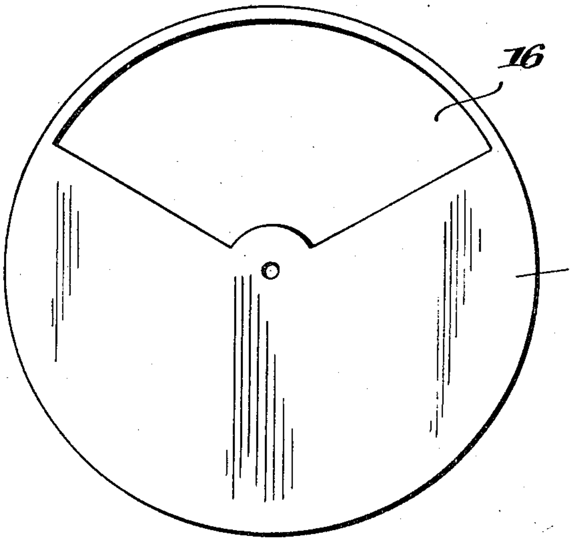

Fig. 5.

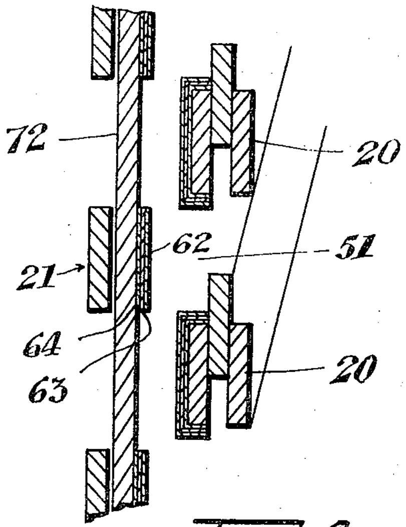

Fig. 4.

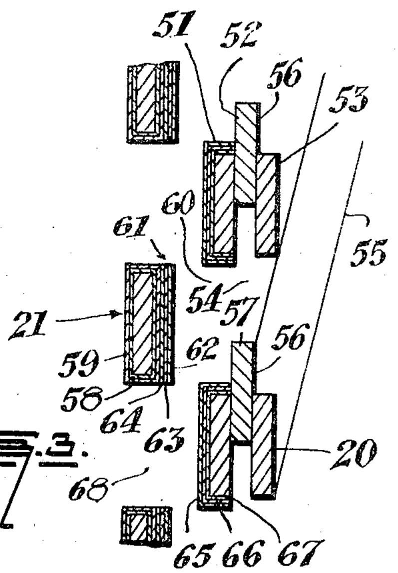

Fig. 3.

Inventor
Francois C. P. Henroteau

BY Eugene E. Stevens
Atty.

Patented Feb. 14, 1939 2,146,822

UNITED STATES PATENT OFFICE

2,146,822

TELEVISION

François Charles Pierre Henroteau, Ottawa, Ontario, Canada, assignor, by mesne assignments, to Radio Corporation of America, New York, N. Y., a corporation of Delaware

Application December 15, 1932, Serial No. 647,440

6 Claims. (Cl. 178—7.2)

This invention relates to television, that is to say, electrical image transmission, which includes the transmission either by wire or wireless of images of actual animate or still objects or of moving or still pictures or transparencies.

One object of the invention is to transmit such images either by wire or by radio under ordinary illumination and at the same time to provide that the image transmitted be exceedingly sharp and well defined, showing even the smallest details.

Another object of the invention is to permit the transmission of animate or still views under ordinary daylight illumination regardless, within limits, of the size of these views, that is to transmit all views which it is possible at present to photograph with a moving picture camera.

Yet another object of the invention is to provide a method whereby each point of the scene to be televised can be impressed on the photoelectric surface for a far greater time than has hitherto been possible.

A further object of the invention is to provide a method whereby all the points of the scene to be televised are simultaneously projected on the transmitter and not successively projected thereon, as is the case with all practical methods of television now in use.

In all methods of television used at present the scene to be televised is divided into a number of elements according to the amount of detail required in the scene received. Each of these elements is then successively projected on the photoelectric transmitting cell and sent to the receiving station. My method, however, differs radically from the above methods in that all the elements of the scene are simultaneously projected on the transmitter.

If, according to known methods, it is desired to transmit an entire scene every sixteenth of a second and the scene is to be divided into ten thousand elements, then each element will be projected on the transmitting screen for only one one hundred and sixty-thousandth of a second. It is known that the electric energy liberated by photoelectric material is proportional to the amount of light falling on the material multiplied by the time during which the light acts. If, therefore, each element of the scene is to remain on the transmitter for only one one-hundred and sixty thousandth of a second, a very strong illumination of this scene is necessary in order that the photoelectric material may emit enough energy for transmission and, for this reason, it is at present extremely difficult to transmit scenes under ordinary daylight illumination.

According to my method, transmission is divided into three or, in one case, four periods, the scene being projected on the transmitter during one of these periods. Since all the elements of the scene are simultaneously projected on the transmitter, the light from each element of the former falls on the latter for one-third of one sixteenth of a second, that is, for almost four thousand times longer than in known methods. If, however, the number of elements into which the scene is divided increases, then this proportion becomes still greater.

In prior arrangements which I have devised for carrying out my method, an electrostatic reproduction of the view has in each case been formed and a photosensitive surface then scanned by very strong light to cause an emission of electrons, the amount of which picked up by the anode would be controlled by the electrostatic reproduction. Since the light of the scanning beam acts on each element of surface for only one ten-thousandth (assuming division into 10,000 elements) of the time during which the light from the view acts, the beam must, in order to give the same energy as the light from the view, be 10,000 times as intense as the latter. Now in practice, if the light from the view is bright, this may be difficult to attain. For this reason, even with a light 10,000 times as bright as that from the view, the output energy from the cell might not equal the input. Thus, with my prior methods, while the results are better than with other methods involving scanning of the object to be televised, they are capable of improvement.

A further object of the invention is, therefore, in a method where all points of the scene are simultaneously projected on the transmitter, to ensure that as large a proportion as possible of the energy of the scanning beam becomes effective for transmission.

A still further object of the invention is, in a method as referred to in the last paragraph, to obtain an effective energy for transmission as nearly as possible equal to the energy liberated under the influence of the light from the view.

The basic difference between my method of television and those now used lies in the formation and retention, after the light from the view has been interrupted, of an electrostatic reproduction of the image of the view, which reproduction during subsequent scanning modulates the electronic current passing towards the anode. My prior arrangements for carrying out this general method have been disclosed in my Patents

1,903,112 and 1,903,113 and in my co-pending application Serial No. 510,705. In the arrangement according to the two patents, the surface of a cathode was divided into a multiplicity of tiny photoelectric elements insulated from one another. An image of the view, being projected on this cathode, raised the individual elements thereof to different positive potentials depending upon the intensity of the light which struck these elements. The image of the view was then shut off and the cathode scanned by a strong beam of light, a modulated electronic current being thus received by an anode. The electrostatic reproduction of the image on the cathode was caused to disappear by projecting on a coating of photosensitive material on the interior of the cell, a beam of light of such a wave length as to cause the expulsion from the coating of relatively slow-moving electrons, which were attracted by any elements of the cathode at positive potential. Thus all these elements were brought to a uniform potential of zero or nearly zero. The arrangement shown in the copending application differed in a number of respects from that shown in the patents. In it the cathode was uniformly photosensitive and the electrostatic reproduction of the image of the view was formed by collecting on a grid consisting of a multiplicity of mutually insulated electro-conductive elements non-photosensitive to visible but photosensitive to ultra-violet light, the electronic emission from the cathode resulting from the projection thereof of the image of the view. The grid was interposed between the anode and cathode and, during subsequent scanning of the cathode by a strong beam of light to cause the emission from it of an electronic stream, the electrostatic reproduction of the view formed on the grid modulated this stream, thus causing the current received by the anode to be modulated in accordance with the light from the view. To cause the electrostatic reproduction to disappear, the grid was exposed to ultra-violet light which caused the elements to emit electrons until they reached a uniform and slightly positive potential.

My present method and apparatus differ essentially from those described above in a number of respects. According to the invention, I provide a cell having at one side thereof an opening through which the image of a view may be focussed and at the opposite side thereof an opening through which a beam of light for causing the electrostatic reproduction of the view to disappear may be projected. Arranged in the cell between these openings are an anode and two members or plates each formed with a multiplicity of tiny openings therethrough and arranged parallel, close to and in such relation to one another that the openings of one plate are opposite the solid portions of the other. These plates are interposed between the anode and the opening for the image of the view. That nearest this opening will be referred to as the first plate and that nearest the anode as the second plate. In the preferred form of my invention the first plate has an insulating coating on it and its surface facing the anode carries, opposite the openings in the second plate, a multiplicity of mutually insulated electroconductive elements having photosensitive surfaces. The surface of the second plate facing the opening for the light from the view is made photosensitive. Formed as a part of the cell in the side thereof out of line with the openings therein is a cathode ray oscillograph, the beam of rays from which is not designed to strike a fluorescent screen, but is designed to scan the surface of the second plate facing the anode at such an angle that it will not pass through the openings in this plate.

Transmission, using the preferred form of this invention, is carried out in four operations which may be briefly described as follows:—

(*a*) The first plate is at a low positive potential, the second plate and the anode are grounded and no emission of cathode rays is taking place. The image of a view is projected through the opening in the cell and the openings in the first plate onto the photosensitive surface of the second plate. By reason of the different intensities of the light from different parts of the view, different areas of this photosensitive surface will emit different numbers of electrons which will be picked up by the nearest electro-conductive elements on the first plate, owing to the slight positive potential to which this plate is raised. In this way the elements will be raised to varying negative potentials, and as a whole they will thus carry an electrostatic reproduction of the view.

(*b*) As the light from the view is interrupted, the first plate is raised to a very low positive potential, the second plate is grounded, and the anode is raised to a comparatively high positive potential. A beam of cathode rays from the cathode ray oscillograph scans the surface of the second plate facing the anode and causes a secondary electronic emission therefrom. The emission from any point in this surface is subjected from one direction to the attraction of the anode, and from the other direction to the attraction of the positive potential of the first plate less the negative potential of the nearest electro-conductive element on this plate. Depending upon the potential of the various electro-conductive elements, therefore, a different number of electrons of the emission will be attracted towards the first plate from different points of the second plate scanned, and thus a different number will reach the anode from these different points. In this way, the electronic emission picked up by the anode will be modulated in accordance with the potentials of elements on the first plate adjacent to points of the second plate successively scanned and thus in accordance with the intensity of light of corresponding areas of the view. The modulated potential of the anode is impressed on the grid of a three-electrode valve and transmitted.

(*c*) Scanning is stopped. The two plates and the anode are grounded and through the other opening in the cell the elements on the first plate are exposed to light of a wave length such as to cause the emission from them of relatively very slow-moving electrons. Since the elements are at negative potentials, the electrons are picked up by other members in the cell. The insulating coating of the first plate is of such a nature that, while it opposes a high resistance to the passage of current through it from a negative to a positive conductor, it opposes a much lower resistance to the passage of current from a positive to a negative conductor. Thus, as soon as any element under the influence of the beam of light reaches a slightly positive potential, the leakage of current from it to the plate balances any increase in positive potential caused by the light. The elements thus all reach a uniform and slightly positive potential.

(*d*) The various members in the cell are kept grounded as in operation (*c*) but the beam of light is shut off. There is then nothing to counteract the leakage of current from the elements to the plate and they are all reduced to a uniform potential of practically zero. The cell is then in condition for a repetition of the operations described.

The invention will now be described in detail with reference to the attached drawings in which:

Figure 1 is a diagrammatic view of the complete transmitting arrangement.

Figure 2 is a front view of one of the plates showing in dotted lines the positions of the openings in the other plate when the two plates are properly mounted.

Figure 3 is a cross-sectional view through my preferred system of plates, showing their arrangement with reference to one another and the various coverings and layers on them, the thickness of these coverings and layers being very greatly exaggerated.

Figure 4 is a similar view of a modified system of plates.

Figure 5 is an elevation of one of the discs used for permitting entry of light to the cell at proper intervals.

I will first describe the apparatus as it is when completed, next the production of certain of its parts and lastly its operation.

In the drawings, 1 is a cell darkened to prevent the entry of light thereinto except through openings 2 and 3, the cell being suitably of cylindrical form and the openings being at each end of the cylinder. Formed at one side of the cell between its ends is a pocket-like portion 4 arranged in the form of a cathode ray oscillograph, the place of the fluorescent screen of which is taken by an opening into the cell. The oscillograph is provided with the usual anode 5, having a very small opening therein, an electron emitting cathode 6 and pairs of magnets 7 and 8, for oscillating the beam of cathode rays. The cell and the portion 4 are electrically shielded by a shielding 9 which is grounded at 10. Where it extends across the openings 2 and 3 this shielding is made in the form of a relatively wide mesh screen so that it will interfere as little as possible with the passage of light. Connected and arranged parallel to and inside the shielding 9 at some distance therefrom is a metallic screen 11 of relatively narrow mesh but made up of very thin wires. This screen extends over the lower part of the wall of the pocket 4 nearest the opening 3 in the cell and all around that part of the cell between the opening of the pocket 4 and the end in which the opening 3 is situated. Between the screen 11 and the shielding 9 and parallel therewith is arranged a grid 12 of wider mesh than the screen. The grid is insulated from the screen and the shielding and is connected to a battery 13 of relatively high positive potential. The screen 11 and shielding 9 constitute a Faraday cage outside which the potential of the grid 12 has no effect. Outside the cell and in front of the opening 2 is a lens 14 and mounted between it and the opening 2 is a rotatable disc 15 having therein an opening 16 through which the light from the view may pass at suitable intervals. At the other end of the cell in front of the opening 3 is a lamp 17 having before it a screen 18 designed to let pass only light of such wave length as will detach from a photosensitive surface electrons of relatively very low velocity. Between the screen 18 and the opening 3 is a rotatable disc 19 similar to the disc 15 but having in it an opening extending over a lesser arc.

Across the cell parallel to its ends and approximately in line with the wall of the portion 4 nearest the opening 2 are two very thin members or plates 20 and 21 mounted very close to one another and in such a way that the surface of plate 20 facing the opening 2 lies in the focal plane of the lens 14. Mounted in the cell between the opening 3 and the plates 20 and 21 is an anode 22. The plate 20 is grounded at 23, while the plate 21, anode 22 and electron emitting cathode 6 of the cathode ray oscillograph 4 are connected to rotating commutators 24, 25 and 26 respectively, having therein electro-conductive sectors 27, 28 and 29 respectively, extending over slightly less than 120° of arc. The three commutators 24, 25 and 26 and the rotatable discs 15 and 19 are preferably mounted for rotation upon a common shaft 29a. Arranged around each commutator are three contacts spaced from each other by 120° of arc. In the case of the commutator 24, the contacts 30, 31 and 32 are connected to the positive terminal of a battery 33 of low voltage, the positive terminal of a battery 34 of even lower voltage and ground 35 respectively. In the case of the commutator 25 the contacts 36 and 38 are connected to grounds 39 and 40 respectively, while the contact 37 is connected to the grid 41 of a thermionic tube 42 and also through a resistance 43 to the positive terminal of a battery 44 of relatively high voltage. In the case of commutator 26, the contacts 45, 46 and 47 are connected to ground 48, the negative terminal of a battery 49 of high voltage and ground 50 respectively.

In Figures 2 and 3 the construction and arrangement of the plates 20 and 21 are shown in detail. As shown in Figure 2 they are so arranged with respect to one another that the openings of one are opposite solid portions of the other. In this figure the openings of plate 21 are shown in full lines and those of plate 20 in dotted lines. As will be seen from Figure 3, the plate 20 is composite and is made up of sections 51, 52 and 53, all perforated correspondingly. The section 52 is offset with respect to the sections 51 and 53 in a direction towards the opening of the cathode ray oscillograph portion 4 so that in this direction the openings 54 through the plate are about half as long as in the direction perpendicular to it. The angle of incidence of the beam 55 of cathode rays on the surface of the plate 20 is so chosen that this beam will always strike the surface 56 of the section 52 and never the side walls 57 of its openings. It is of course desirable that the angle of incidence of the beam of cathode rays be as small as possible in order that at any one time the beam may cover as small an area of the plate as possible. For this reason, while the sections 51 and 52 should be made as thin as possible the section 53 may be made thicker than these sections so that the angle of incidence of the beam of cathode rays may be reduced without, however, the beam being able to penetrate through the openings in the plate.

As shown in Figure 3 the plate 21 is entirely coated with a layer of aluminium oxide 58, overlying a layer of pure aluminium 59. On the surface of this plate facing the plate 20 and covering areas the full size of the openings 60 in the section 51 of the plate 20 are formed mutually insulated electroconductive elements designated generally by the numeral 61. These elements 61 have photosensitive surfaces 62 of caesium, intermediate layers 63 of caesium oxide silver and inside layers 64 of silver. The surface of the plate 20 facing the view, and incidentally also the walls of the openings 60 in the section 51, has a photosensitive coating 65 of caesium and underneath it an intermediate layer 66 of caesium oxide silver and an inside layer 67 of silver.

The reason for the particular formation of the plate 20 and for choosing the angle of incidence of the beam of cathode rays so that it will never strike on the surface 57 of the section 52, is to prevent destruction of the photosensitive surfaces 62 of the elements 61. It is necessary, to ensure not only that the beam of cathode rays does not strike these elements directly, but also that they are not struck by any fast moving electrons of the secondary emission from the plate 20 caused by the beam. Since the fast moving electrons of the secondary emission, being substantially entirely unaffected by the attraction of the anode, move in straight lines, it will be seen from an inspection of Figure 3 that none of them can strike the surfaces 62 of the elements 61.

I shall now describe the method of producing the plates 20 and 21 in the form in which they appear in the completed cell.

The plates 20 and 21 are preferably made of pure copper, for example, electrolytic copper which can be produced in sheets having a thickness as small as one two-thousandths of an inch. At this thickness the plates may easily be perforated with a number of openings up to ten thousand or more to the square inch by means of photo-engraving, as used in the preparation of ordinary half-tone plates. After being perforated, the plates are placed in a tube heated to red heat and degasified by means of the formation of a high vacuum in the tube.

In order to prepare the insulating coating on the plate 21, the plate is placed in a tube under high vacuum and is coated with aluminium by the well known explosion method, such as is used for silvering the interior of photoelectric cells and the like. Care must be taken that the vacuum is high in order to prevent oxidation of the aluminium. The coated plate is then used as the anode in an electrolytic bath in which the electrolyte is, for example, a concentrated solution of borax and boracic acid. When a gradually increasing potential is applied between the cathode and anode in the electrolytic bath, a uniform coating 58 of aluminium oxide forms on the aluminium-coated copper plate, the thickness of this coating being proportional to the potential applied between the electrodes. For my purposes, the potential may be gradually increased to 350 volts and then retained at this point for some time in order to insure absolute uniformity of the coating. After its coating with aluminium oxide, the plate 21 is placed in a tube under a high vacuum and in front of it is placed an auxiliary plate perforated and arranged in exactly the same way with respect to it as the section 51 of the plate 20 in the final cell. A bead of silver is now exploded through the openings in the auxiliary plate onto the plate 21 from a point relatively remote therefrom, so that a multiplicity of mutually insulated silver spots 64 are formed on the plate 21. Pure oxygen at about 1 millimetre pressure is then admitted to the tube and the plate is made the anode and bombarded with electrons so that the silver re-acts with the oxygen. This reaction is carried on until the elements show a bluish colour, the layer of silver oxide on the silver being then about 10 atoms thick. This method of oxidation is well known and needs no further explanation.

When the plate 20 has been degasified as above described, the section 51 thereof is placed in a high vacuum tube and silver exploded onto it without, however, any plate being interposed between it and the source of the explosion. The section has, thus, a uniform coating 67 of silver over one surface and probably also incidentally, along the walls of the openings 60 through it. A coating of silver oxide is then formed on the silver in the manner described with reference to the plate 21.

When the two plates have been thus prepared, they are mounted in the final tube in the relation to each other described above and shown in the drawings, the silver oxide elements on the plate 21 facing the silver oxide coated surface of the plate 20 and the plates being about two-thousandths of an inch distant from each other. The interior of the cell is now heated to a temperature of about 125° C. and at the same time a pellet 69 of a mixture of caesium dichromate and silicon contained in a side pocket 70 of the cell 1 is heated and caesium vapour evolved. The tube is during this time under a high vacuum and is kept thereunder by a pump attached at 71 (which is shown in the drawings as closed off in the final tube). At the temperature of the cell the caesium vapour reacts with the silver oxide with the formation of caesium oxide silver, which is referred to thus since it is not well known whether the caesium oxide and silver are in distinct layers or not. On the outside of this layer of caesium oxide silver is formed a layer of pure caesium which, though only one atom thick, is extremely tenacious. The surplus caesium is partly removed by the pump and, after the reaction with the silver oxide is complete, the tube is heated to a temperature of 250° C., at which temperature the remaining caesium vapour is fixed by a getter such, for example, as lead glass. The cell is then sealed off at 71 and is ready for use.

In Figure 4 I have shown a system of plates somewhat different from that of my preferred system. This system includes, as in my preferred system, the plates 20 and 21, the plate 21 having, however, no insulating coating around it. Instead of this coating on the plate 21 an unperforated transparent plate 72 of insulating material such as, for example, mica, is interposed between the plates 20 and 21, and on the surface of the plate 72 facing the anode are formed the mutually insulated electroconductive elements 61, these elements having, as in the preferred form, photosensitive surfaces 62 of caesium, intermediate layers 63 of caesium oxide silver, and inside layers 64 of silver. The elements 61 are formed opposite solid portions of the plate 21 and the openings 60 in the section 51 of the plate 20. The insulating plate 72 may be made as thin as possible, and is arranged at the same distance from the plate 20 as is the plate 21 in my preferred system. It performs the same function as the coating 58 of aluminium oxide on the plate 21 used in the latter system, and owing to the fact that it is transparent so that the light from the view may pass through it, no openings need be made in it. In this modified system the plate 20 is arranged in exactly the same way as in my preferred system.

Using the system of plates shown in Figure 3, transmission is carried out in four operations, while with the system of plates shown in Figure 4 transmission is in three operations, all of which take place within one-sixteenth of a second. The division of the total time between the various operations will depend upon circumstances, but in general, with either system of plates the first two operations will each last 1/50 second, while with the preferred system the last two operations will each last 1/100 second, and with the modified system the third operation will last 1/50 second. If, however, the light from the view is weak it may be found desirable to lengthen the time of the first operation at the expense of that of the second, since if the variation of potential of the different elements 61 is too small a certain part of the energy released by the beam of cathode rays is wasted. This additional energy may therefore be sacrificed by shortening the scanning period to allow more time for the electrostatic reproduction of the view to build up. In the case of weak light from the view the length of time for the first operation might, for example, be increased to 3/100 second, and that for the second operation reduced to 1/100 second. It may also be found desirable, when using the preferred system of plates, to lengthen the time for the third operation at the expense of that for the fourth operation. It is to be noted in this connection that the term "substantial" used in referring to the length of time for the fourth operation is to be taken in its relative rather than its absolute sense. Thus, if the exposure to infra-red light is stopped 1/100 or even 1/200 second before the first operation is begun again, this time is substantial in relation to the total time for all operations, i. e. 1/16 second, as it constitutes approximately one-sixth or one-twelfth of this period.

I shall now describe the transmission operations when the preferred system of plates, as shown in Figure 3, is used:—

(a) Through the rotation of the shaft 29a carrying the commutators 24, 25 and 26 and the discs 15 and 19, the opening 16 in the disc 15 is brought into registry with the lens 14 and opening 2 in the cell. At the same time the plate 21 is connected to positive battery 33 of low voltage through the sector 27 of commutator 24 and the contact 30, the anode 22 is grounded through the sector 28 of commutator 25 and the contact 36, and the hot cathode 6 is likewise grounded through the sector 29 of commutator 26 and the contact 45. Through the opening 16 in the disc 15 the image of the view is focussed by the lens 14 on the photosensitive surface 65 of the plate 20. Under the influence of and in accordance with the intensity of the light from the view striking different parts of the surface 65, different numbers of electrons are emitted from these parts, and owing to the positive potential of the plate 21, the electronic emission from each part of the surface 65 is attracted to the nearest element 61, this element being thus raised to a certain negative potential. The potential of plate 21 should be high enough adequately to attract electrons to the elements but not so high as to cause any substantial leakage of current to it from the elements when charged. A suitable potential would be approximately two volts. Since the potentials to which the various elements 61 are raised depend upon the amounts of the electronic emissions from corresponding parts of the surface 65, and since the amounts of these emissions depend in turn upon the intensity of the light from the view striking the parts from which they are emitted, the negative potentials of the various elements 61 will be proportional to these intensities. On the elements 61 as a whole, there will therefore be formed an electrostatic reproduction of the image of the view.

(b) Through the rotation of the shaft 29a, the light from the view is interrupted, plate 21 is connected to battery 34 of very low positive potential, the anode 22 is connected through the contact 37 to the grid 41 of the thermionic valve 42 and through resistance 43 to battery 44 of relatively high positive potential, while the hot cathode 6 is connected through contact 46 to battery 49 of high negative potential. The positive potential of the plate 21 in this operation must be at least slightly higher than the maximum negative potential of any element and may suitably have a value of from one-half volt to two volts. By reason of the connection of its cathode 6 to the high negative potential, the cathode ray oscillograph portion 4 is caused to emit a beam 55 of cathode rays, which is caused by the magnets 7 and 8 to scan the surface of the plate 20 facing the anode, the beam striking this surface at approximately the angle shown in Figures 3 and 4. Under the influence of the beam a secondary electronic emission is produced from every part of the plate 20 which is struck. As is known, the greater part of the secondary emission is made up of relatively slow moving electrons which, on being emitted, are subjected to two attractions acting in opposite directions. The first of these is that of the anode 22 and the second is that of the positive potential of the plate 21 less the negative potential of the nearest element 61 on this plate. Thus, of the secondary electronic emission from any area of the surface of plate 20 struck by the cathode ray beam, that part which consists of slow moving electrons will be divided in accordance with the relative intensities of the two attractions to which it is subjected. The electronic current reaching the anode from any area of the surface of the plate 20 will therefore depend upon the negative potential of the element 61 nearest this area, which potential is proportional to the intensity of the light from a corresponding part of the view. Thus the electronic current reaching the anode during the scanning operation will be one modulated by the electrostatic reproduction of the image of the view. The variations of potential caused in the anode by the reception of the modulated electronic current are impressed on the grid 41 of the thermionic valve 42, whence transmission takes place by known methods.

As mentioned above, not all the electronic emission caused by the cathode ray beam consists of electrons having a velocity low enough to be materially affected by the attractions of the anode 22 and plate 21. The electrons of high velocity not so affected will tend to move from the surface of the plate 20 in straight lines, and a large proportion of them will have such velocity that if they were to strike some other surface in the cell they would themselves cause the emission of further secondary electrons of lower velocity, which would be picked up by the anode 22 and thus cause distortion of the image currents transmitted. It is to prevent this that I have provided the screen 11 and grid 12. The grid 12 is connected to battery 13 of a positive potential equal to or even greater than that of the battery 44 to which the anode is connected, but since the screen 11 and shielding 9 together constitute a Faraday cage the potential of the grid 12 has no influence outside the screen 11. Fast moving electrons detached from the surface of the plate 20 will pass through the screen 11, and in the great majority of cases through the grid 12, to strike the shielding 9 and cause the emission of further electrons of lower velocity. The great majority of these latter electrons will be captured by the grid 12. If some of them escape it and pass outside the Faraday cage they will merely strike the shielding 9 again at some other point, and the process of capture by the grid 12 of the electrons which they emit will be repeated. Since the area of the anode 22, which is in the form of a wire loop, is extremely small in relation to the area of the rest of the cell, the number of fast moving electrons which will either strike it directly or pass so close to it as to be captured by it will be negligible.

(c) Through further rotation of the shaft 29a the opening in the disc 19 is brought into registry with the opening 3 in the cell, and the hot cathode 6, anode 22 and plate 21 are grounded at 50, 40 and 35 respectively through contacts 47, 38 and 32 respectively. Through the opening in the disc 19 the light of the lamp 17 which passes through the screen 18 is admitted to the cell and strikes the photosensitive surfaces 62 of the elements 61 on plate 21. This light is of such frequency that it will detach from the photosensitive surfaces 62 electrons of low velocity, and it is preferably in the infra-red region. Since the elements 61 are at various negative potentials the rest of the members of the cell are positive with respect to them and will thus attract any electrons which they emit under the influence of the light striking them. The coating of aluminium oxide on the plate 21 has, as is well known, the property of opposing a resistance approximately a thousand times as great to the passage of current from a negative element to a positive element as from a positive element to a negative element. Thus while the elements 61 are negative there will be substantially no passage of current from them to the plate 21. As soon, however, as they reach a positive potential by reason of the detachment of electrons from them under the influence of the light, the leakage current from them to the plate 21 will become very great and thus any further increase in their positive potential will be counteracted. At the end of this operation all the elements will be at a uniform and slightly positive potential.

(d) Through further rotation of the shaft 29a the opening in the disc 19 moves out of registry with the opening 3 in the cell, and the light from the lamp 17 is cut off. Since, however, the arc over which the opening in the disc 19 extends is substantially less than 120°, this will happen while the metallic sectors 27, 28 and 29 of the commutators 24, 25 and 26 are still passing over the contacts 32, 38 and 47 respectively, so that the potential of the various members in the cell will remain as in operation (c), but the cell will be completely dark. There will now be nothing to counteract the leakage currents from the elements 61 to the plate 21, and these elements will thus all be reduced to a uniform potential of practically zero. At this point the cell is ready for a repetition of the operations described.

The only difference between the operations with the system of plates shown in Figure 3 and that shown in Figure 4 is that with the latter system the electrostatic reproduction of the view is caused to disappear in one operation which lasts for the same length of time as operations (c) and (d) described above. The one operation is as follows:—

(c) The members in the cell are all grounded as in operation (c) above, and the light of the lamp 17 is admitted to the cell through the opening in the disc 19. Under the influence of the light electrons are emitted from the elements 61 on the plate 72 and are picked up by the members in the cell. The elements are thus all brought to a uniform and slightly positive potential, which potential will not be exceeded owing to the increased leakage of current above it from the elements to the plate, and also owing to the fact that above it electrons emitted will be re-attracted by reason of the higher positive potential.

The frequency band necessary for transmission might be narrowed if, instead of using only one apparatus where the whole cycle of operations is completed in one sixteenth of a second, three apparatuses were used. In this case while the first apparatus was performing operation (a) the second would be performing operation (b) and the third operations (c) and (d). Thus, though a picture would be transmitted every 1/16 second each operation could last 1/16 instead of only 1/50 of a second. This would be of importance in transmitting the picture since transmission could then be spread over three times the period which could be allowed when only one apparatus was used and the frequency band for transmission thus narrowed.

Very strong, enlarged and contrasted images of very faint, still objects could be produced with my system owing to electrical amplification. The disc 15 would be brought to a position to allow the view to fall on plate 20 for a suitable length of time. The shaft 29a would then be rotated to a position to allow scanning of the screen and this scanning could be repeated without any intermediate operation for as long as desired since the electrostatic image of the object would always remain on the elements 61. My device could, for instance, be attached to a powerful astronomical telescope and, while the image focussed would be large and weak, a very vivid strong image would appear on the receiver. The device could also be attached to a microscope and permit hitherto invisible objects to be seen.

Various modifications may be made in the invention without departing from the spirit thereof or the scope of the claims and, therefore, the exact forms shown are to be taken as illustrative only and not in a limiting sense, and I desire that only such limitations shall be placed thereon as are imposed by the prior art or are specifically set forth in the appended claims.

What I claim as my invention is:

1. Apparatus for the electrical transmission of images, which comprises means for impressing an image upon a photosensitive surface, means for scanning a surface other than said photosensitive surface to cause the emission of an electronic stream of substantially constant intensity from said other surface, means for causing the formation at one time of an electrostatic reproduction of the whole of said image to modulate said stream, an anode for picking up the modulated stream, and means for thereafter causing said electrostatic reproduction to disappear.

2. Apparatus for the electrical transmission of images, which comprises means for impressing an image upon a photosensitive surface, means for scanning a surface other than said photosensitive surface to cause the emission of an electronic stream of substantially constant intensity from said other surface, means for causing the formation at one time of an electrostatic reproduction of the whole of said image to modulate said stream, an anode for picking up the modulated

stream and means for thereafter exposing said electrostatic reproduction to infra red light.

3. Apparatus for the electrical transmission of images, which comprises means for impressing an image upon a photosensitive surface, means for scanning a surface other than said photosensitive surface to cause the emission of an electronic stream of substantially constant intensity from said other surface, means for causing the formation at one time of an electrostatic reproduction of the whole of said image to modulate said stream, an anode for picking up the modulated stream, means for thereafter exposing said electrostatic reproduction to infra red light, and means for stopping said exposure a substantial time before an image is again impressed upon the photosensitive surface.

4. Apparatus for the electrical transmission of images, comprising a cell, a photosensitive surface within said cell, means for impressing an image on said surface, means in the form of a multiplicity of mutually insulated elements for retaining an electrostatic reproduction of said image, said elements being formed on the surface facing said photosensitive surface of a member interposed between said photosensitive surface and the view.

5. Apparatus for the electrical transmission of images, comprising a cell, a photo-sensitive surface within said cell, means for impressing an image on said surface, means in the form of a multiplicity of mutually insulated elements for retaining an electrostatic reproduction of said image, said elements being formed in the surface facing said photosensitive surface of an opaque member interposed between said photosensitive surface and the object of which an image is projected on said photosensitive surface and formed with a multiplicity of openings therethrough.

6. Apparatus for the electrical transmission of images, comprising a cell, an opening in said cell for the projection therethrough of an image, an anode in said cell, a member between said anode and said opening having a multiplicity of openings therethrough and having a photosensitive surface facing said opening, another member between said opening and said first mentioned member and having on its surface directed towards said first mentioned member a multiplicity of mutually insulated elements arranged opposite the openings in said first mentioned member, means for impressing an image on said photosensitive surface, means for causing said multiplicity of elements to retain an electrostatic reproduction of said image and means for scanning the surface of said first mentioned member facing said anode to cause an electronic emission from said surface and means for picking up said emission, modulated by the electrostatic reproduction, at the anode.

FRANÇOIS CHARLES PIERRE HENROTEAU.