

March 30, 1943.

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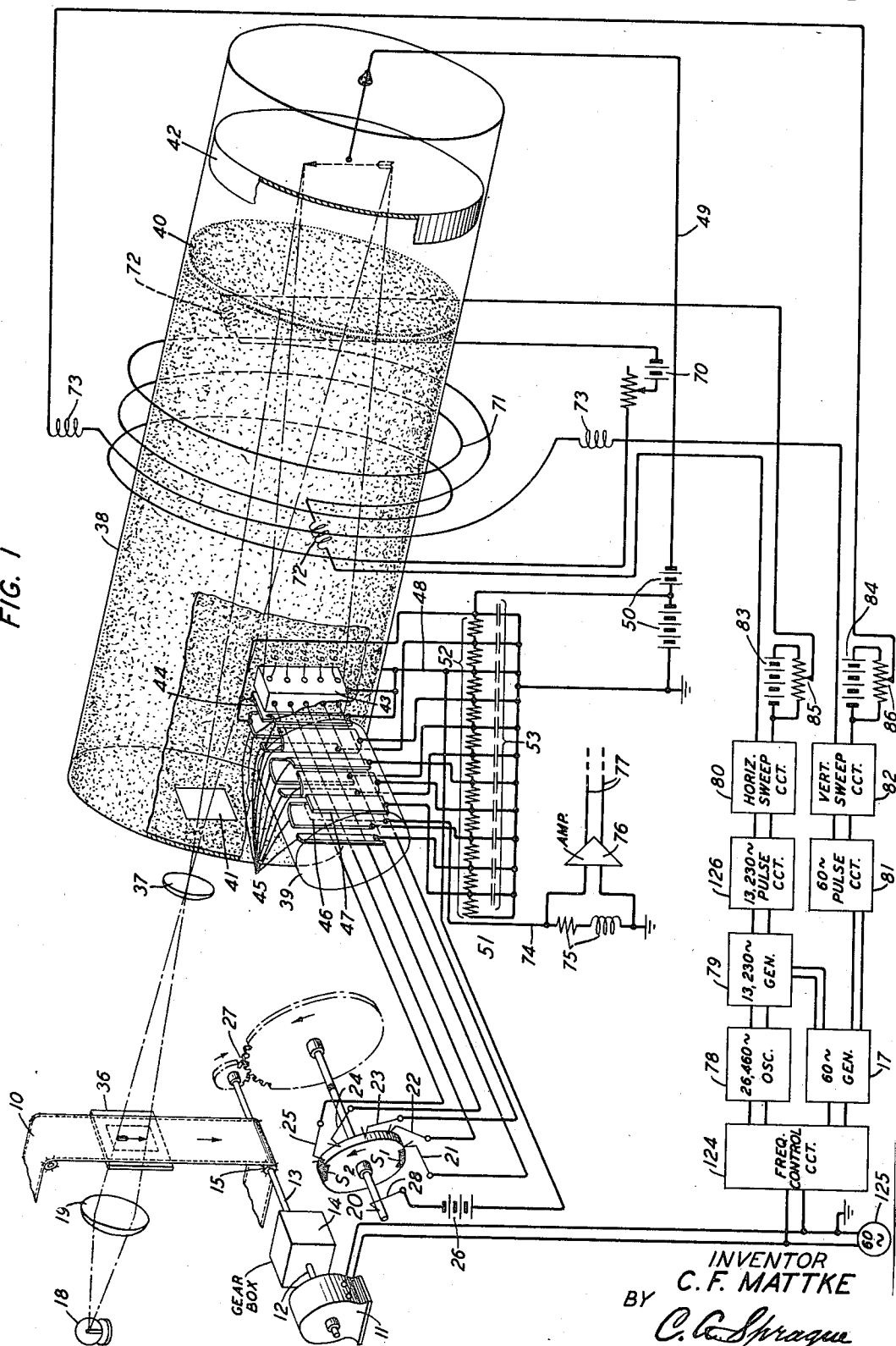
2,315,290

APPARATUS FOR AND METHOD OF GENERATING TELEVISION SIGNALS

Filed Feb. 27, 1941

3 Sheets-Sheet 1

FIG. 1



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FIG. 2

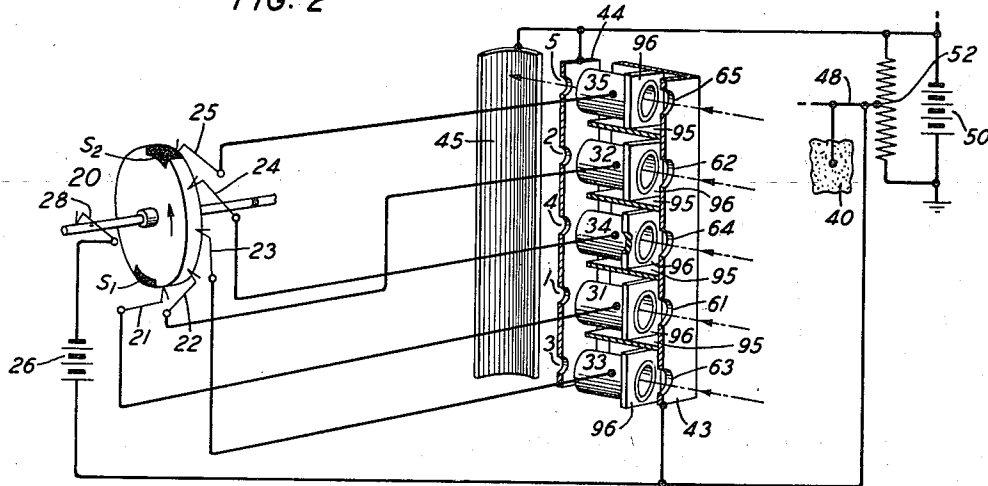


FIG. 4

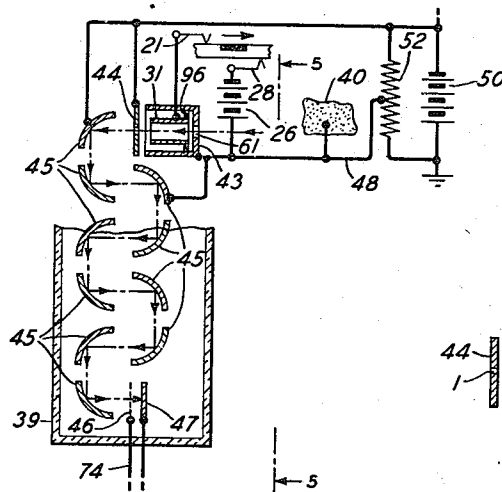


FIG. 3

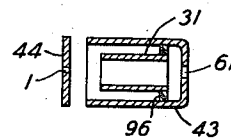
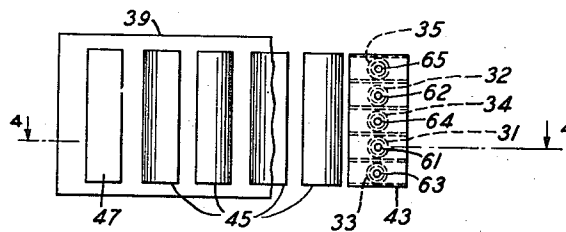


FIG. 5



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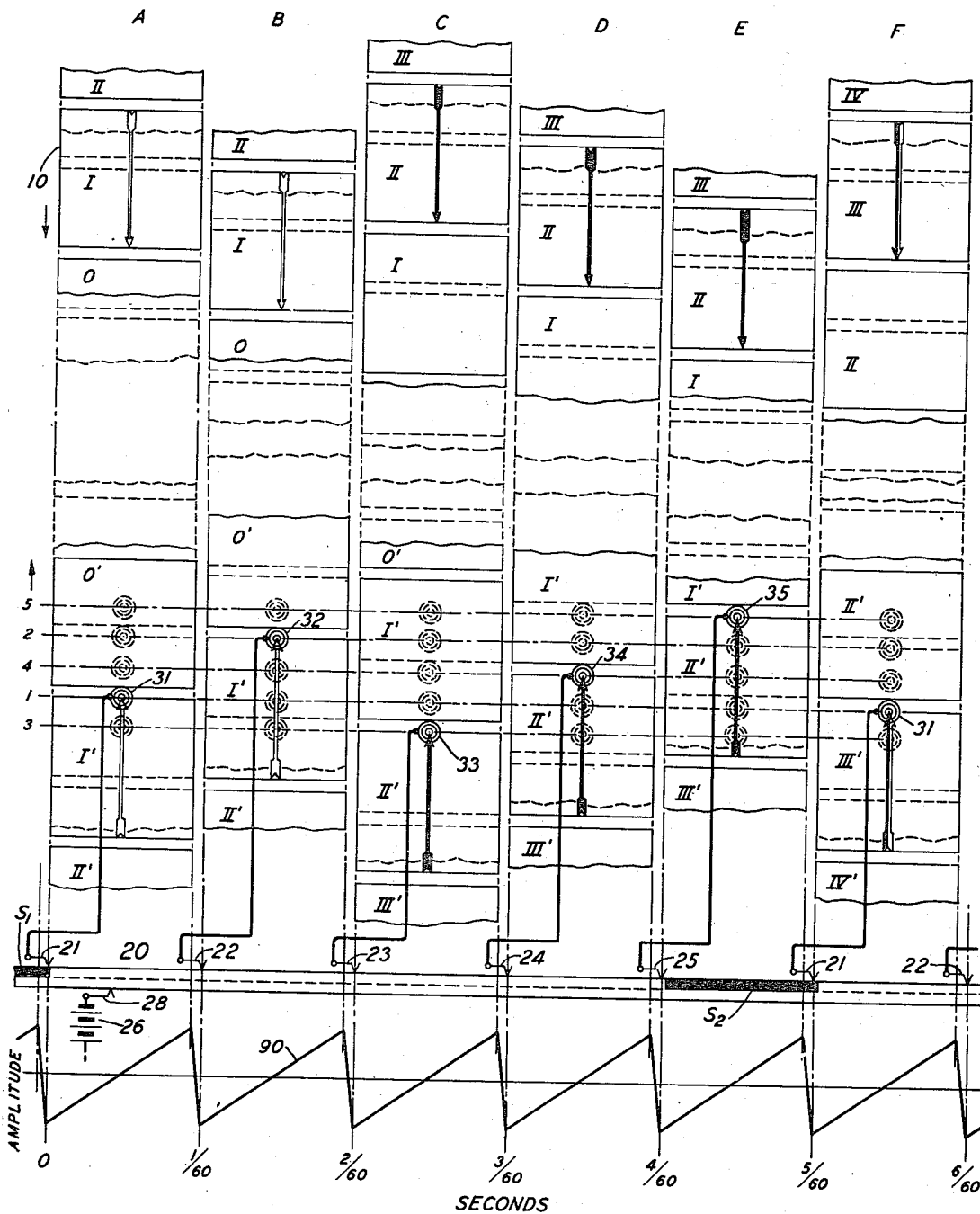
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APPARATUS FOR AND METHOD OF GENERATING TELEVISION SIGNALS

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3 Sheets-Sheet 3

FIG. 6



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2,315,290

APPARATUS FOR AND METHOD OF GENERATING TELEVISION SIGNALS

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Application February 27, 1941, Serial No. 380,773

16 Claims. (Cl. 178—7.2)

This invention relates to signaling and particularly to a method of and apparatus for scanning motion picture film for generating television signals.

An object of the invention is to provide an improved apparatus for scanning a motion picture film for television transmission.

Another object is to provide an improved cathode ray scanning device.

In accordance with standard motion picture practice, a motion picture film is exposed at the rate of 24 frames per second and pictures are projected from the film at the same rate. However, in transmitting television images, in accordance with standards adopted by Radio Manufacturers Association, the field of view is scanned at the rate of 60 field scans of $220\frac{1}{2}$ lines each per second, the lines of one field scanned being interlaced with the lines of the preceding or following field scanned so that 30 complete frame scanings of 441 lines each take place in one second. Therefore, in scanning for television transmission a motion picture film which is moved continuously at the rate of 24 film frames per second, it is desirable to scan the odd film frames twice, for example, and the even frames three times so that there are 5 field scans of $220\frac{1}{2}$ lines each in $\frac{1}{2}$ second or 60 field scans, or 30 complete frame scans of 441 lines each, interlaced, per second.

In accordance with a preferred embodiment of the present invention shown and described herein for the purpose of illustration, there is employed for generating a television image current an image dissector tube of special construction upon the cathode of which are projected images from a continuously moving motion picture film. The image dissector tube is provided with an electrode having five scanning apertures therein (instead of the single aperture heretofore employed) through a plurality of which electrons emitted from the cathode would pass simultaneously if no means were provided to prevent this. However, to cause electrons to pass through only one scanning aperture at a time and through different apertures in a predetermined desired sequence there are provided five cylindrical electrodes in alignment with the scanning apertures respectively and means for impressing an electron repelling potential to a set of four of the cylindrical electrodes simultaneously. Cyclically, one electrode is removed from the set of four to which an electron repelling potential is applied and a different electrode added to the set, so that electrons are transmitted through different scanning apertures cyclically in succession. Specifically,

a commutator rotating in synchronism with the film moving means is provided for impressing the electron repelling potential upon the cylindrical electrodes.

5 The centers of the scanning apertures lie on a line substantially parallel to the direction of vertical deflection of the electron image which is focussed upon the plane of the aperture plate containing the scanning apertures. The usual horizontal and vertical deflecting coils and the usual sources of current for energizing the deflecting coils are provided but, since the motion picture film and therefore the image projected upon the cathode of the image dissector tube is moved continuously at a constant rate, the amplitude of the current supplied to the vertical deflecting coils is correspondingly reduced. The movement of the film, the rotation of the commutator for applying the electron repelling potential and the deflecting fields for controlling the deflection of the electron image are all maintained in synchronism so that the pictures recorded on the film are scanned at a desired rate different from the rate at which the successive pictures recorded on the film are projected.

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

Fig. 1 is a diagrammatic view of a motion picture film scanning apparatus in accordance with the present invention;

Fig. 2 is a diagrammatic view, partly in perspective, of a portion of the apparatus shown in Fig. 1;

Fig. 3 is a view in horizontal section of a portion of the apparatus shown in Fig. 2;

Fig. 4 is a diagrammatic view of a portion of the apparatus shown in Fig. 1 including in plan view the electron multiplier of the image dissector tube;

Fig. 5 is a view taken along the line 5—5 of Fig. 4; and

Fig. 6 is a diagram to which reference will be made in explaining the operation of the apparatus shown in Figs. 1 to 4.

Referring now to the drawings, a modified motion picture projector projects the successive images recorded on the motion picture film 10 upon the cathode of a cathode ray image dissector tube. The motion picture film 10 is driven by synchronous motor 11 through shafts 12 and 13, gear box 14 and film sprocket 15. The motor 11 is energized by current from the 60-cycle power source 125 for controlling the motor speed, the motor speed and the gearing in gear box 14 being such that the film is driven continuously at the

rate of 24 film frames per second. Light from source 18 is directed through condenser lens 19 and through the opening in aperture plate 36 to illuminate a portion of the film 10 while it is in motion. A lens 37 focusses an image of the illuminated portion of the film 10 upon the cathode of an image dissector tube comprising an evacuated glass housing 38 of substantially cylindrical shape from which extends a side tube 39 of smaller diameter.

The inner surface of the housing 38 has a metallic coating or anode 40 in which is formed a window 41 through which the light beam from film 10 is projected to the cup-shaped light sensitive cathode 42, the cathode 42 being positioned near the end of the cylinder 38 opposite the end having the window 41 and beyond the coating or anode 40. The remaining electrodes within the housing 38, 39 constitute an electron multiplier comprising a shield 43, aperture plate 44, multiplier plates 45, collector grid 46, anode 47 and the cylindrical electrodes 31, 32, 33, 34 and 35. The aperture plate 44 has five small, equally spaced scanning apertures 1, 2, 3, 4 and 5 therein and the shield 43 has five larger apertures 61, 62, 63, 64 and 65. The axes of the cylinders 31, 32, 33, 34 and 35 respectively lie on lines joining the centers of apertures 1 and 31, 2 and 32, 3 and 33, 4 and 34, and 5 and 35 respectively. The cylindrical electrodes 31, 32, 33, 34 and 35 are electrically shielded with respect to each other by the electrode 43 and the metallic partitions 95 which form part of the electrode 43. The cylindrical electrodes 31 to 35 inclusive are held in position by any suitable means as, for example, by spacers 96 of insulating material. An electromotive force is applied between cathode 42 and anode 40 through leads 48 and 49 from a circuit comprising battery 50, the positive terminal of which is grounded, and a network 51 made up of voltage dividing resistors 52 and condensers 53 as shown. Leads from the circuit 51 are connected to the electrodes 43, 44, 45 and 47 of the electron multiplier as shown for applying suitable potentials thereto. The electrons emitted from cathode 42 due to the light activation thereof are focussed to form an electron image in the plane of the aperture plate 44, the electron image being focussed by means of an axial magnetic field set up due to the current from source 70 flowing through the coil 71 surrounding the glass envelope 38 and extending substantially the full length of the tube.

There are provided two pairs of deflecting coils, the horizontal or high frequency deflecting coils 72 and the vertical or low frequency deflecting coils 73. The magnetic fields set up when these deflecting coils are suitably energized cause the beam of electrons emitted from the cathode 42, and therefore the electron image focussed in the plane of the scanning apertures 1 to 5 inclusive, to be deflected along both horizontal and vertical coordinates. The electron beam reaching the apertured shield 43 is of such size that electrons could pass simultaneously through a plurality of apertures 61 to 65 inclusive and a plurality of scanning apertures 1 to 5 inclusive, if no means were provided to prevent this occurrence. However, means are provided to render effective the scanning apertures 1, 2, 3, 4 and 5 successively and repeatedly in order by repelling the electrons reaching the apertures 61 to 65 except the one in alignment with that one of scanning apertures 1 to 5 which is to be effective, at a given time, in scanning the image.

The motion of the electron image with respect to the scanning apertures results in progressively selecting elemental areas of the image. Due to the bombardment of the target or first multiplier plate 45 by electrons from different portions of the cathode 42 in succession, an image current is set up in the circuit including lead 74 connected to the collector grid 46, the terminating impedance element 75 and ground. This image current may be amplified by the vacuum tube amplifier 76 if desired and transmitted over a suitable transmission medium such as the balanced line 77 to a receiving apparatus.

Any suitable means may be employed for supplying deflecting currents of saw-toothed wave form to the deflecting coils 72 and 73. As shown diagrammatically in Fig. 1 of the drawings, there are provided a 26,460-cycle controlled oscillator 78 from which is derived by successive steps the submultiple frequency sources 78 and 17 of 13,230-cycle and 60-cycle waves respectively of rectangular wave form. The 60-cycle wave from the power source 125 and the 60-cycle wave from the submultiple frequency generator 17 are impressed upon the frequency regulating circuit 124. There is produced by the circuit 124 as the result of beating together the waves from sources 125 and 17, a control current which is impressed upon the oscillator 78 for maintaining the frequency of the wave produced by the oscillator 78 in step with the frequency of the 60-cycle power source 125, that is, for maintaining the frequency of source 78 at the 441st multiple of the frequency of power source 125. Of course, a line frequency scanning rate, other than 441 lines per frame scanning period may be used in which case the frequency of source 78 would be maintained at some harmonic of the 60-cycle power source other than the 441st harmonic. An arrangement of the type described for generating waves for controlling the sweep circuits which, in turn, control the deflection of a cathode ray beam and for maintaining the waves in synchronism with an alternating current power source is disclosed in an article by A. V. Bedford and John Paul Smith on page 51 of "RCA Review" for July 1940, published by RCA Institute Technical Press, 75 Varick Street, New York, N. Y. The 13,230-cycle source 79 controls a 13,230-cycle impulse generating circuit which, in turn, controls the horizontal sweep circuit 80 for supplying a 13,230-cycle saw-toothed current wave to the horizontal deflecting coils 72. Sixty-cycle pulses produced by the generator 81 under control of the subharmonic generator 17 control the vertical sweep circuit 82 which in turn supplies a 60-cycle saw-toothed current wave to the vertical deflecting coils 73. In order that the electron image produced in the plane of the aperture plate 44 may be brought into correct vertical and horizontal alignment there are provided batteries 83 and 84 from which direct current is supplied through potentiometers 85 and 86 to the horizontal and vertical deflecting coils 72 and 73 respectively. For the purpose of applying a blocking or electron repelling potential to the cylindrical electrodes 31 to 35 and of removing this potential from the electrodes 31 to 35 one at a time in succession to make effective the scanning apertures 1 to 5 successively in order, there are provided a battery 26 and commutator 20 which is driven from the film driving shaft 13 through gears 27. The positive terminal of battery 26 is connected to electrode

43 while the negative terminal is connected through the brush 28 and through brushes 21 to 25 inclusive of commutator 20 to the cylindrical electrodes 31 to 35 respectively. The commutator 20 is made of conducting material except for the two segments of insulating materials S_1 and S_2 . The brushes 21 to 25 inclusive come into engagement successively in order with the insulating segments S_1 and S_2 alternately. At any instant four of the brushes 21 to 25 are in contact with the conducting portion of commutator 20 while one brush engages an insulating segment. However, in some cases it may be preferable to have all five brushes simultaneously in contact with the conducting portion of the commutator during a short interval between successive field scanning periods, that is, during the so-called vertical synchronizing period. The cylindrical electrodes 31 to 35 which are connected to the negative terminal of battery 26 through commutator 20 repel the electrons emitted from cathode 42 reaching the apertures 61 to 65 respectively so that at any instant electrons can pass through one only of the scanning apertures 1 to 5 inclusive, said aperture being in alignment with a cylindrical electrode 31 to 35 which is at that time insulated from the battery 26.

Referring to Fig. 5, the film 10 is moved downwardly, as viewed in the figure, at the rate of 24 film frames per second so that, at the beginning of successive equal periods of $\frac{1}{60}$ second, the film is in the positions designated A, B, C, D, E and F respectively. The time periods are indicated at the lower portion of the figure. The image projected from the motion picture film onto the cathode 42 at any instant is somewhat larger than the image of a single film frame in the direction of movement of the film, the size of the projected image corresponding to about $1\frac{1}{2}$ film frames. Obviously, however, during any one field scanning period, use is made only of electrons emitted from a portion of cathode 42 which receives light from a single film frame of the motion picture film.

At zero time, the projection of an optical image of film frame I upon cathode 42 causes an electron image I' corresponding to film frame I to be focussed in the plane of aperture plate 44 which has therein the scanning apertures 1, 2, 3, 4 and 5 lying on the lines so numbered in Fig. 5. Due to the downward motion of film 10 from position A to position B the optical image focussed on cathode 42 and the electron image focussed in the plane of electrode 44 will move upwardly by a corresponding amount, that is, an amount corresponding to $\frac{2}{3}$ film frame in $\frac{1}{60}$ second or one field scanning period. This vertical motion of the electron image is supplemented by deflecting the cathode ray beam through a distance corresponding to $\frac{2}{3}$ film frame by applying to the vertical deflecting coils 73 a regular saw-toothed wave 90 from source 82. Of the apertures 1, 2, 3, 4 and 5 in the aperture plate 44, one only is effective in the process of scanning the image to generate an image current during a certain field scanning period, the apertures becoming effective successively during successive field scanning periods. The apertures 1, 2, 3, 4 and 5 are rendered effective periodically in succession by removing from the cylindrical electrodes 31, 32, 33, 34 and 35 periodically in succession the negative potential from battery 26. For this purpose there is provided the commutator 20, shown in developed

view in Fig. 5, having the insulating segments S_1 and S_2 embedded in conducting material to which the negative terminal of battery 26 is connected through brush 28. The brushes 21, 22, 23, 24 and 25 are connected to the cylindrical electrodes 31, 32, 33, 34 and 35 respectively. As the commutator rotates, the insulating segments S_1 and S_2 are moved successively into the positions indicated by the dash lines in Fig. 5 during successive field scanning periods to insulate the brushes 21, 22, 23, 24 and 25 in succession and periodically from the battery 26 and thereby render effective the scanning apertures 1, 2, 3, 4 and 5 periodically and in succession.

During the first field scanning period of frame I brush 21 is in contact with insulating segment S_1 and only aperture 1 is effective for scanning. During this period the electron image of frame I moves vertically with respect to aperture 1 through a distance corresponding to a film frame. While the electron image is thus moved along a vertical component, it is also moved horizontally in the usual manner at the rate of 441 lines per frame scanning period of $\frac{1}{60}$ second or $220\frac{1}{2}$ lines per field scanning period of $\frac{1}{60}$ second by applying a saw-toothed wave current from the horizontal sweep circuit 80 to the horizontal sweep coils 72.

At the start of the second field scanning period the film and the electron image are in the positions shown at B in Fig. 5. Aperture 2 is now effective and due to the continuous movement of the film 10 and the deflection of the electron beam from cathode 42, film frame I is scanned a second time. At the beginning of the third field scanning period aperture 3 becomes effective in the process of scanning film frame II. Aperture 4 next becomes effective in the scanning of frame II a second time during the fourth field scanning period and then aperture 5 becomes effective in the process of scanning frame II a third time. At the beginning of the sixth field scanning period, as shown by F in Fig. 5, frame III occupies the position which was occupied by frame I and electron image III' occupies position which was occupied by electron image I' at the beginning of the first field scanning period A. At this time segment S_2 insulates brush 21 from the battery 26. Thus alternate film frames are scanned twice and the remaining film frames are scanned three times along 441 lines per field scanning period, the lines of one field scanning being interlaced with those of the preceding or following field scanning period. The film moving continuously at twenty-four film frames per second is thus scanned at the rate of sixty field scans per second.

In accordance with the standards adopted by the Radio Manufacturers Association, there is an interval, about 7 per cent of the field scanning period, at the end of each field scanning period during which the electron beam of the image producing cathode ray tube is reduced in intensity and returned to its initial scanning position. During this interval frame synchronizing impulses are transmitted and no image production takes place. This 7 per cent of the field scanning period is also required for the return sweep of the cathode ray beam emitted from the cathode 42 of the image dissector tube. Moreover the switching operations of commutator 20 which rendered the apertures 1 to 5 effective in succession occur during the 7 per cent intervals at the ends of the field scanning periods. In standard motion picture film the dimension along

the length of the film of the frame line between two successive picture portions is about 15 per cent of the length of an entire film frame consisting of a picture portion and a frame line. In order to avoid waste of transmission time it is desirable to scan the picture portion only of a film frame during 93 per cent of a field scanning period, thus allowing 7 per cent of the field scanning period between the time of scanning the last scanned elemental area of one field scanning period and the first scanned elemental area of the succeeding field scanning period. In order that the picture portion only of the motion picture film may be scanned during 93 per cent of the field scanning period of $\frac{1}{60}$ second, the amplitude of the vertical deflecting current from source 22 may be reduced so that the electron image will be deflected along the vertical coordinate by an amount corresponding to somewhat less than $\frac{3}{4}$ of a complete film frame which includes both a picture portion and a frame line.

The subject-matter of this application is related to that of my application Serial No. 380,774 filed concurrently herewith.

What is claimed is:

1. Photoelectric apparatus comprising a light sensitive electron emitting surface, means for accelerating the emitted electrons from said surface, a target in the path of said electrons, an electrode having a plurality of spaced apertures therein through which said electrons may pass to reach said target, and electron controlling means for causing said apertures to become effective one at a time in succession in a desired sequence in transmitting electrons to said target.

2. Photoelectric apparatus for generating an image current comprising a source of photoelectrons, means for accelerating electrons from said source, a target in the path of said electrons, an aperture electrode having a plurality of apertures therein through which electrons may pass and strike said target, a plurality of electrodes in alignment with said apertures respectively, and means for selectively impressing upon said electrodes a potential for causing said apertures to become effective one at a time in a desired sequence in the transmission of electrons to said target.

3. Image dissecting apparatus comprising means for producing under control of an optical image a beam of electrons the density of which at different portions thereof corresponds to the tone values of the corresponding portions of the optical image, a target in the path of said electrons, means for intercepting said electron beam having therein a plurality of electron transmitting apertures through which said electrons may pass to reach said target, which apertures are simultaneously in the path of different ones of said portions of said electron beam, respectively, which portions are widely spaced with respect to a dimension of each aperture, and means for causing said apertures to become effective one at a time in a desired sequence in transmitting electrons to said target.

4. Image dissecting apparatus comprising means for producing under control of an optical image a beam of electrons the density of which at different portions thereof corresponds to the tone values of the corresponding elemental areas of the optical image, means for intercepting said electron beam having therein a plurality of electron transmitting scanning apertures which are simultaneously in the path of different ones of said portions of said electron beam, respectively,

and means for causing said apertures to become effective one at a time in succession in a desired sequence in transmitting electrons for controlling the production of an image current.

5. Electronic apparatus comprising means for producing an electron beam, a plurality of electrodes for repelling different portions of said beam when suitably energized, and means for applying an electron repelling potential to a plurality of said electrodes simultaneously and for removing said electron repelling potential from said electrodes one at a time in succession to cause said electrodes to become effective in succession in transmitting electrons.

6. Electronic apparatus comprising means for producing an electron beam, a target electrode, an aperture electrode having therein a plurality of apertures widely spaced with respect to a dimension of an aperture through which electrons may be transmitted to bombard said target electrode, a shield electrode having therein a plurality of spaced apertures, a plurality of cylindrical electrodes the axes of which respectively lie on lines connecting the centers of the apertures in said aperture electrode respectively and the centers of the apertures in said shield electrode respectively, and means for controlling the potential of said cylindrical electrodes to cause the apertures in said aperture electrode to become effective one at a time in succession in transmitting electrons to said target electrode.

7. Electronic apparatus comprising a target electrode, an electrode having therein a plurality of apertures through which electrons may pass to cause different portions of said target electrode to be bombarded by electrons transmitted through different apertures, respectively, means for directing an electron beam upon a plurality of said apertures simultaneously, and electron repelling means for causing said apertures to become effective one at a time in succession in transmitting electrons for controlling the production of an image current.

8. Scanning apparatus comprising a light sensitive electron emitting cathode, means for focusing an optical image upon said cathode to cause the emission of electrons therefrom, means for focussing said electrons to form in a certain plane an electron image corresponding to said optical image, an electrode having therein a plurality of apertures simultaneously in the path of the electron beam from said cathode and spaced with respect to each other in said electron image plane, means for selectively repelling electrons reaching said apertures to cause said apertures to become effective one at a time in succession in transmitting electrons for controlling the production of an image current.

9. Apparatus for scanning motion picture film for television transmission comprising means for moving the film at a substantially constant rate, a light sensitive cathode, means for projecting an optical image from said film while in motion upon said cathode, means for focussing in a certain plane an electron image corresponding to said optical image, an aperture electrode substantially in said plane having therein a plurality of spaced scanning apertures, a target electrode in the path of electrons transmitted through said scanning apertures, a shield electrode having a plurality of apertures therein, one for each of said scanning apertures, a plurality of which may be simultaneously in the path of electrons emitted from said cathode, a plurality of cylindrical electrodes one for each of said scanning apertures,

commutator means for applying an electron repelling potential to said cylindrical electrodes and for removing said potential from said cylindrical electrodes one at a time in succession, and means for maintaining said film moving means and said commutator means in synchronism.

10. Electronic apparatus for producing an image current comprising means for producing a beam of electrons, means for focussing the electrons of said beam to form an electron image corresponding to an optical image, an electrode having a plurality of scanning apertures therein in the path of said electron beam, means for setting up a plurality of electric fields for acting upon different portions of said beam respectively, and means for changing said electric fields in a certain direction cyclically in succession to cause said scanning apertures to become effective one at a time in succession in transmitting electrons for controlling the production of an image current.

11. An image dissector tube comprising a cathode for emitting photoelectrons, means for accelerating electrons emitted from said cathode, an aperture electrode having a plurality of spaced electron transmitting apertures therein, a plurality of control electrodes for controlling the electrons directed toward said apertures respectively in accordance with the potentials applied to said control electrodes respectively and means for applying to said control electrodes in succession a potential for causing the transmission of electrons through said apertures in succession.

12. Apparatus for scanning motion picture film which comprises means for continuously moving the motion picture film, a light sensitive electron emitting cathode, means for projecting from said film upon said cathode an image which is continuously changing due to the motion of said film, an electrode having a plurality of apertures therein for transmitting electrons emitted from said cathode, a plurality of control electrodes for controlling the electrons transmitted toward said apertures respectively in accordance with potentials applied to said electrodes respectively, and means driven by said film moving means for changing the potentials applied to said control electrodes by pairs in succession.

13. Electronic apparatus comprising means for producing a beam of electrons, an electrode having a plurality of spaced electron transmitting apertures therein, means for setting up a plurality of electric fields for simultaneously acting upon different portions of said beam respectively, and means for increasing said fields one at a time in succession and for decreasing said fields one at

a time in succession, one field being increased and another field being decreased substantially simultaneously to cause said apertures to become effective one at a time in succession in transmitting electrons of said beam.

14. Apparatus for scanning motion picture film for television transmission which comprises means for moving the film at a substantially constant rate past a fixed framing aperture, a light sensitive electron emitting cathode, means for projecting an optical image of the portion of the film framed by said framing aperture upon said cathode, means for focussing in a certain plane the electrons emitted from said cathode to form an electron image corresponding to said optical image, an electrode substantially in said plane having a plurality of spaced scanning apertures therein, and means for causing the apertures in said electrode to become effective one at a time in succession in transmitting electrons for controlling the production of a television image current.

15. Apparatus for scanning motion picture film for television transmission which comprises means for moving the film at a substantially constant rate past a fixed framing aperture, a light sensitive electron emitting cathode, means for projecting an optical image of the portion of the film framed by said framing aperture upon said cathode, means for focussing in a certain plane the electrons emitted from said cathode to form an electron image corresponding to said optical image, an electrode substantially in said plane having a plurality of spaced scanning apertures therein, means for causing said apertures to become effective one at a time in succession in transmitting electrons emitted from said cathode, and means for deflecting the electron beam emitted from said cathode.

16. The method of scanning motion picture film which comprises continuously moving the film at a substantially constant rate, projecting from the film upon a fixed area an optical image which changes continuously in accordance with the movement of the film, causing the emission of electrons in accordance with the tone values of elemental areas of said optical image, accelerating and focussing said electrons to form in a certain plane an electron image corresponding to said optical image, deflecting the electron beam along two coordinates of motion, and selecting electrons from said beam at different elemental areas cyclically in succession of said electron image plane to control the production of an image current.

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