

Aug. 25, 1942.

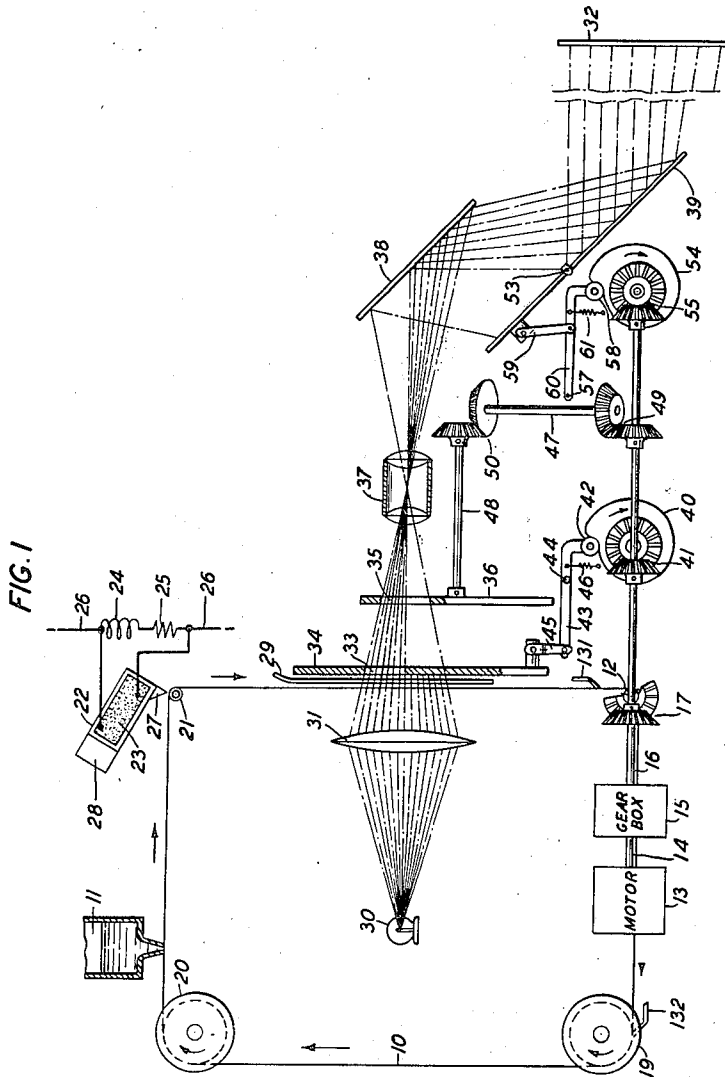
R. A. HEISING

2,294,180

APPARATUS FOR AND METHOD OF PRODUCING TELEVISION IMAGES

Filed Aug. 1, 1940

5 Sheets-Sheet 1



INVENTOR
R. A. HEISING
BY
Chas. Sprague
ATTORNEY

Aug. 25, 1942.

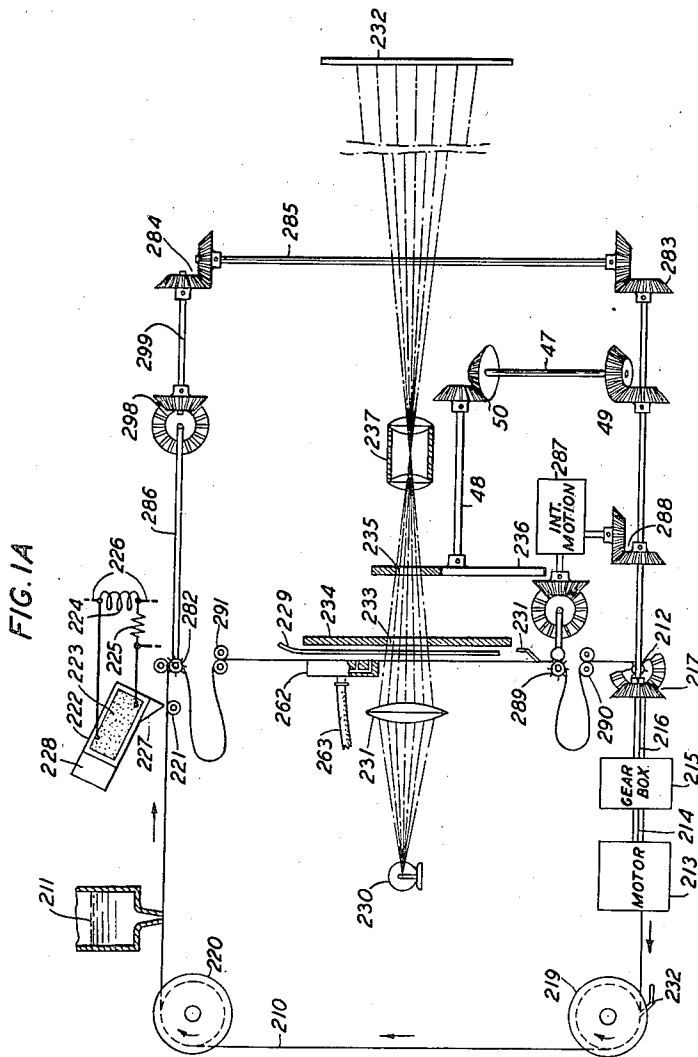
R. A. HEISING

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INVENTOR
R. A. HEISING
BY *C. M. Sprague*
ATTORNEY

Aug. 25, 1942.

R. A. HEISING

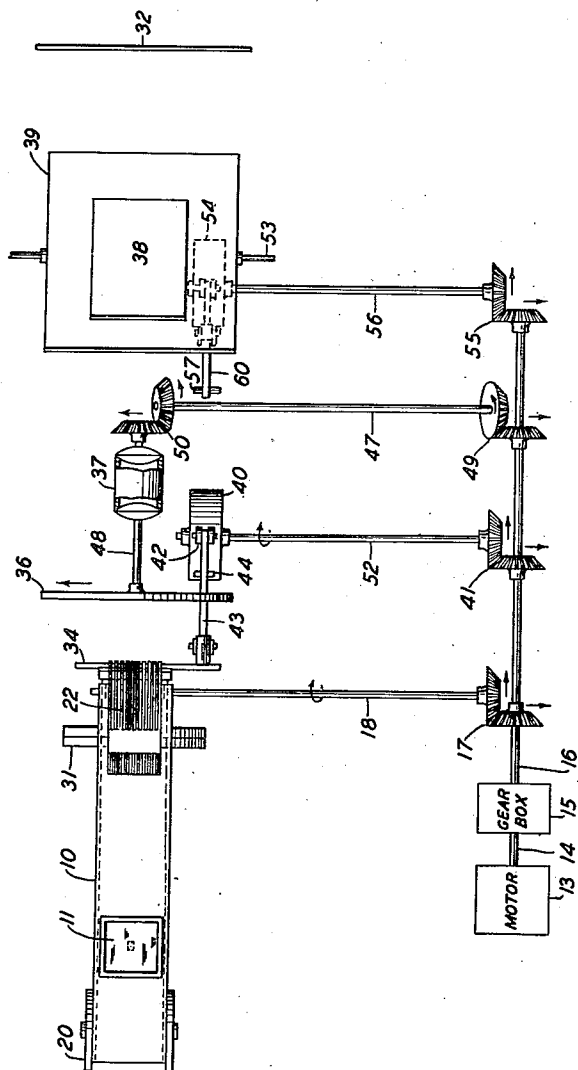
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FIG. 2



INVENTOR
R. A. HEISING
BY *C. H. Sprague*
ATTORNEY

Aug. 25, 1942.

R. A. HEISING

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FIG. 3

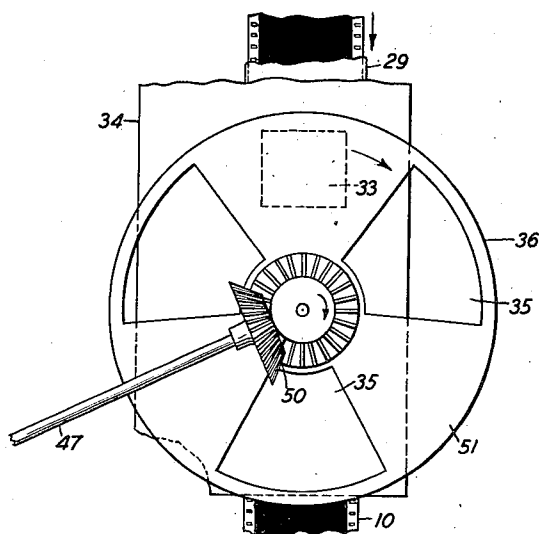


FIG. 5A

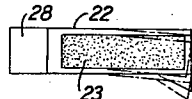


FIG. 6



FIG. 4

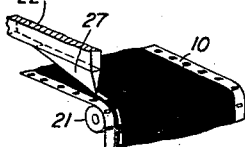


FIG. 5

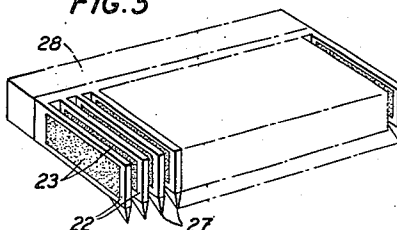
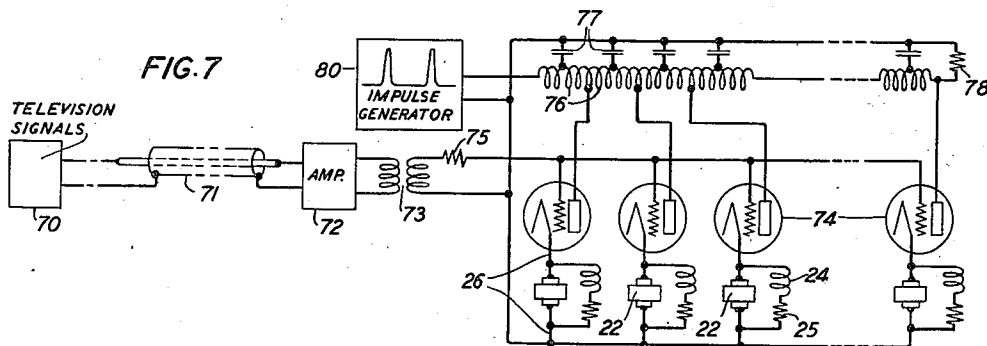


FIG. 7



INVENTOR
R. A. HEISING
BY
C. Sprague
ATTORNEY

Aug. 25, 1942.

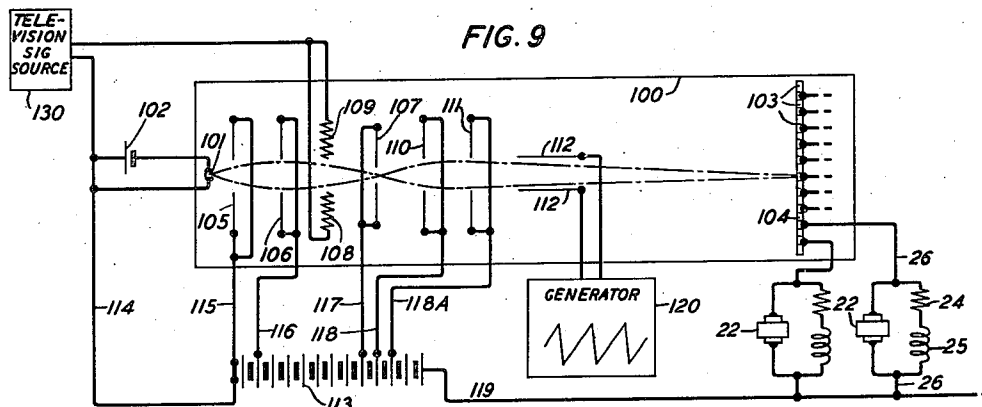
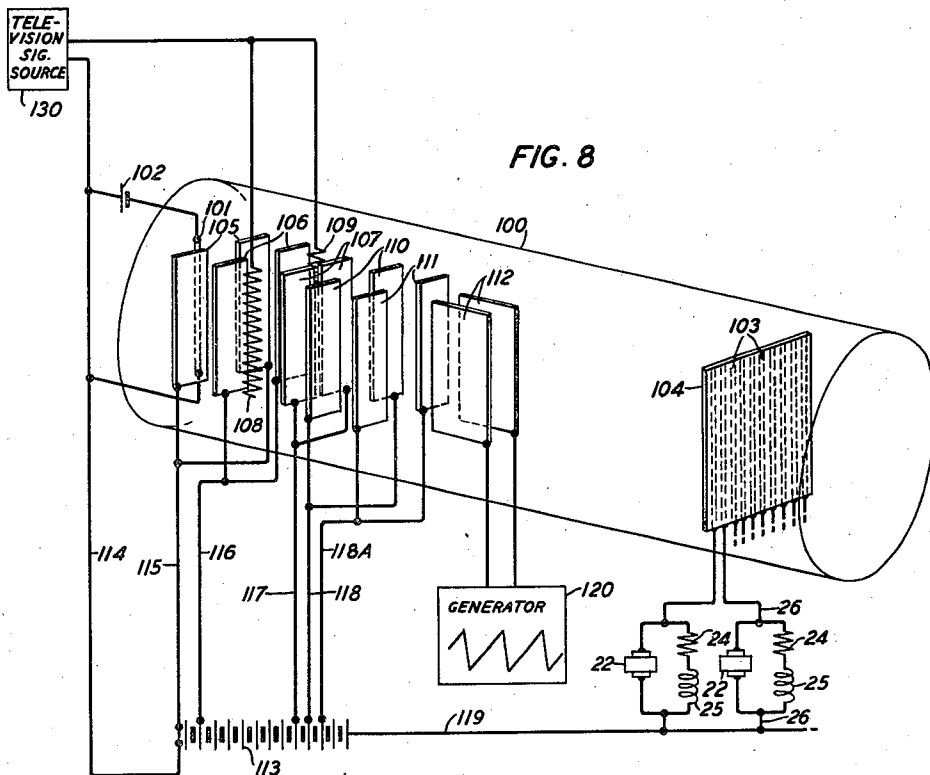
R. A. HEISING

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5 Sheets-Sheet 5



INVENTOR
R. A. HEISING
BY *Ch. Sprague*
ATTORNEY

UNITED STATES PATENT OFFICE

2,294,180

APPARATUS FOR AND METHOD OF PRODUCING TELEVISION IMAGES

Raymond A. Heising, Summit, N. J., assignor to
Bell Telephone Laboratories, Incorporated,
New York, N. Y., a corporation of New York

Application August 1, 1940, Serial No. 349,043

16 Claims. (Cl. 178—6.6)

This invention relates to signaling and particularly to apparatus for and method of producing television images upon a projection screen.

An object of the invention is to utilize piezoelectric crystals for light control in television image projection.

In accordance with a specific embodiment of the invention herein shown and described for the purpose of illustration, television images are projected upon a screen from an intermediate record produced upon a continuously moving band or film of transparent material having on one surface thereof an opaque coating, a viscous liquid, for example. For producing the record there are provided a row of styli, made of rubber, for example, arranged along a line substantially perpendicular to the direction of motion of the film, for displacing the coating from portions of the film in accordance with the movement of the styli. The styli are attached respectively to the ends of a plurality of thin piezo-electric crystal elements which are caused to move by the television signals supplied to the crystal elements in turn to cause the displacement of the coating on the record blank in accordance with the amplitude of movement of the crystal elements, respectively. Each image after it is formed upon the film is projected upon a screen while the film is in motion, an optical rectifier being employed for maintaining each image stationary upon the screen during the projection period. The successive images are formed upon the film at a rate within the period of persistence of vision in synchronism with the scanning of a field of view which is scanned to produce a television image current for controlling the piezoelectric crystal elements, and the successive images are projected upon the screen at the same rate. After being projected, each picture is erased by means of brushes which smooth the viscous coating on the film.

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

Fig. 1 is a diagrammatic view in side elevation of an apparatus for producing television images in accordance with the present invention;

Fig. 1—A is a diagrammatic view of a modification of the apparatus shown in Fig. 1;

Fig. 2 is a plan view of the apparatus shown in Fig. 1;

Figs. 3, 4 and 5 are detail views of the apparatus shown in Figs. 1 and 2;

Fig. 5—A is a detail view of one of the piezoelectric elements shown in Fig. 5;

Fig. 6 is an enlarged view of a section of the film with an image recorded thereon as produced in the operation of the apparatus shown in Figs. 1 and 2;

Fig. 7 is a diagrammatic view of an arrangement for energizing the piezoelectric crystal elements of the apparatus shown in Figs. 1 and 2; and

Figs. 8 and 9 are diagrammatic views of a modified arrangement employing an electronic switching device for energizing the piezoelectric elements of the apparatus shown in Figs. 1 and 2, the electronic switching device being shown in perspective in Fig. 8 and in plan view in Fig. 9.

Referring now to Figs. 1 and 2 of the drawings, there is provided an endless transparent band or film 10 made of cellulose nitrate or acetate or other suitable material coated with a dark opaque substance. For example, a viscous liquid such as glycerine or castor oil to which a coloring substance has been added may be applied to one surface of the film from a reservoir 11. The film 10 is driven continuously at a constant rate by means of a sprocket wheel 12 which in turn is driven by motor 13 through shaft 14, speed reduction gears 15, shaft 16, bevel gears 17 and shaft 18. The film 10 passes over guide rollers 19, 20 and 21. The pictures or images are formed upon the film 10 by means of piezoelectric marking elements 22 located in a row near the film as it passes over the roller 21. The piezoelectric crystal elements 22 are actuated successively in turn by applying an image electromotive force to the electrodes 23 for the respective crystals in succession, in a manner to be described below. As shown in Fig. 1, a circuit comprising an inductor 24 and a resistor 25 in series is connected across the electrodes 23 of each piezoelectric crystal and the energizing electromotive force for actuating the crystal is applied to the leads 26. A marking stylus 27, of rubber or other suitable material, is attached to each crystal element near one end thereof and the opposite end of each crystal is rigidly attached to a suitable support 28.

The assembly of the piezoelectric marking elements is shown more in detail in Fig. 5. The crystals may be individually cut and then fastened together or made in one piece. For this purpose Rochelle salt is preferred though the device is not restricted to its use. A single crystal is long, less wide, and as thin as can be economically made, with faces perpendicular to one axis, preferably the X axis. Each face of each,

crystal element 22 has a conductive coating 23 attached. When an electromotive force is applied across the conductive coatings or electrodes 23 of a crystal, the crystal warps into a new position as indicated by the dash line of Fig. 5—A, the amount of warping being exaggerated as shown in the figure. The crystal is supported rigidly at one end 28. The shape of the rubber stylus is shown in Fig. 4. As depicted in Fig. 6, the line markings produced upon the coated film by the styli 27 vary in width in accordance with the amount of warping of the piezoelectric crystal elements 22. Each rubber stylus may be attached to a crystal with Rochelle salt cement, for example.

The film 10 is moved in a clockwise direction, as indicated by the arrows in Fig. 1, and, after it passes over the roller 21, it is moved into the picture projecting position. Light from lamp 30 is directed by condensing lens 31 upon the film 10 to project a frame of the film upon a screen 32. After passing through the transparent portions of the coated film 10, light from source 30 is projected through the frame aperture 33 in gate 34, aperture 35 in rotating shutter 36, lens 37 and optical rectifier comprising mirrors 38 and 39 to the screen 32. As the film 10 moves downwardly, as viewed in Fig. 1, the gate 34 is moved in synchronism with the motion of the film to keep the frame aperture 33 in alignment with the picture on the film which is being projected. The gate is set in motion by the motor 13 which drives a cam 40 through shaft 16, bevel gears 41 and shaft 52. The cam follower 42 is located at one end of the cam lever 43 which is supported at the fulcrum 44 and the other end of the cam lever is coupled to the gate 34 through a mechanical linkage 45, a spring 46 maintaining the cam follower in engagement with the cam. Due to the action of the cam 40, the film gate 34 is moved downwardly in synchronism with the movement of the film 10 while the film is moving through a distance equal to the height of a single picture frame. The gate 34 is then rapidly moved upwardly so that the frame aperture 33 is brought into alignment with the following picture frame on the film. The rotating light interrupting disc 36 is driven by motor 13 through shafts 16, 47 and 48 and bevel gears 49 and 50. As shown in Fig. 3, the disc 36 is provided with a plurality of equally spaced apertures 51 separated by light intercepting portions 51 which interrupt the projecting light beam transmitted through the aperture 33 a plurality of times during the projection period of each picture or image. The light intercepting portions 51 are of such size that the projecting light beam is interrupted during the short period occurring between the projection periods of successive picture frames in which period the gate 34 moves in a direction opposite to the direction of motion of the film 10.

Any suitable optical rectifier may be employed for maintaining stationary upon the screen 32 each image which is projected from the continuously moving film 10. As shown in Figs. 1 and 2 of the drawings, the optical rectifier comprises a stationary plane mirror 38 and a movable plane mirror 39 which is adapted to oscillate about a shaft 53. This mirror 39 is set into oscillatory motion by the motor 13 which drives a cam 54 through shaft 16, bevel gears 55 and shaft 56. The cam lever 60 which has its fulcrum 57 at one end thereof carries a cam follower 58 at its opposite end and is coupled to the

mirror 39 through a linkage 59. A spring 61 holds the cam follower 58 in engagement with the cam 54.

The arrangement shown in Fig. 1—A is like that shown in Fig. 1 but employing apparatus for moving the images on the film 210 into the projecting position intermittently. In Figs. 1 and 1—A the corresponding parts are given the same designations except that the first digit "2" is added to the designations in Fig. 1—A. The motor 213 drives the sprocket wheels 212 and 282 at a constant speed and in synchronism through shaft 214, speed reduction gears 215, shaft 216, bevel gears 217 and a shaft (not shown) to sprocket 212 and through gears 283, 284 and 298 and shafts 285, 286 and 299 to sprocket 282. A suitable apparatus 287 for moving the film 210 intermittently into the projecting position is driven by motor 213 through bevel gears 288. The apparatus 287 may comprise, for example, a Geneva movement which drives the pull-down sprocket 289. The film 210 is driven continuously over rollers 219, 220, 221 and 290 and intermittently over rollers 291, there being a loop of film between sprocket 282 and rollers 291 and another loop between sprocket 289 and rollers 290. The film 210 is coated, the images produced thereon and later erased therefrom as explained in connection with Fig. 1. The images on the film are also projected upon screen 232 as in Fig. 1 except that in Fig. 1—A the images are stationary while being projected, the optical rectifier 38, 39 of Fig. 1 and the mechanism for moving the aperture gate 34 being not employed in Fig. 1—A.

In view of the fact that it is difficult to make the crystals 222 extremely narrow, the arrangement described in general makes use of an endless belt 210 having a width several times that used in motion picture work but of about the same thickness. It is difficult, therefore, to support such a wide film at the edges only, as in motion picture work. To overcome this difficulty, there is placed above the frame aperture 233 and adjacent to the uncoated side of the film 210 a mechanism 262 to hold the film flat at that position. The mechanism 262 comprises a hollow plate with a corrugated front portion. An air pump (not shown) provides a partial vacuum through a flexible tube 263. The vacuum is sufficient to just hold the film flat and stationary and insufficient to cause undue friction during the intermittent periods when the film is moved forward by standard intermittent film moving methods. Spring 229 on the opposite side of the film 210 with respect to the device 262 holds the edges of the film 210 against plate 262 as in standard motion picture practice.

A circuit arrangement for energizing the piezoelectric crystal elements 22 repeatedly in succession in accordance with the tone values of successively scanned elements areas of a field of view which is scanned at a television transmitting station is shown in Fig. 7. Current from a source of television signals 70, having variations in accordance with the tone values of successively scanned elemental areas of a field of view, is transmitted over a suitable transmission medium such as the coaxial conductor cable 71 to a receiving station where it is amplified, if necessary, by an amplifier 72 and the amplified wave is transmitted through transformer 73 or other suitable transducer to the control grid-cathode circuits of a plurality of vacuum tubes 74, one for each of the piezoelectric crystal elements 22,

a resistive element 75 being included in the lead going from one terminal of the secondary winding of transformer 73 to the control grids of the vacuum tubes 74. The piezoelectric elements 22, each shunted by a circuit having inductance 24 and resistance 25 in series, are connected in the anode-cathode circuits of electric discharge tubes 74, respectively. The circuit for energizing each piezoelectric element may be traced from the cathode of a tube 74 through a piezoelectric element 22 through a delay line comprising series inductive elements 76, shunt capacitive elements 77, and terminal resistors 78, to the anode of the tube 74. A generator of periodic current impulses 80 is connected to the input terminals of the delay line or network 76, 77. Although the received television electromotive force is impressed upon the grid-cathode circuits of all the electric discharge tubes 74 simultaneously, current flows in the anode circuits of the tubes one at a time in succession, since anode voltage is supplied to the tubes from the impulse generator 80 through delay network 76, 77. The periodic brief impulses are generated at such a rate and are sufficiently delayed in transmission through the delay network 76, 77 that the piezoelectric marking elements 22 are energized periodically in succession under control of the received image current in accordance with the tone values of the successively scanned elemental areas of a field of view which is scanned at the transmitting station. The direct component of the anode currents of the tubes 74 is shunted through the circuits each comprising inductance 24 and resistance 25. A suitable impulse generator for producing impulses in synchronism with the scanning of the successive lines of a field of view and a suitable network for delaying the transmission of the impulses is disclosed, for example, in Patent No. 2,195,864 of W. A. Knoop, granted April 2, 1940. If desired, moreover, the received television energy may be supplied to the anode circuits of the tubes 74 simultaneously and the impulses from source 80 which are transmitted through delay line 76, 77 may be impressed upon the control grids of tubes 74 in a manner similar to that disclosed in said Knoop patent.

If, in the system described, the field of view at the transmitter station is scanned in the usual manner along successive horizontal lines to produce a television signal, it will be observed that the arrangement of Fig. 7 in effect converts this television signal into a plurality of signals, each corresponding to a vertical line of the field of view, which signals are supplied to the piezoelectric elements 22 or 222, respectively.

A cathode ray tube designed to pass currents of relatively large amplitude may be used, if desired, for supplying to the piezoelectric elements 22 in succession periodically energy which varies in accordance with and under control of television signals, as depicted in Figs. 8 and 9. The cathode ray device comprises an evacuated glass housing 100 into which are sealed leads going to the external circuit. The elongated filamentary cathode 101 is heated by current from battery 102 to cause it to emit electrons which are accelerated and focussed to impinge upon one of a plurality of elongated anodes 103 along substantially its entire length, these anodes extending in a direction substantially parallel to the length of cathode 101. These anodes are mounted in a frame 104 of insulating material which may be suitably secured to the housing 100.

Plates 105 and 106 are focussing electrodes to bring the electrons of cathode 100 to a focus at the slit between the electrodes 107. Electrodes 108 and 109 are control electrodes for varying the amount of electron current passing through the slit between electrodes 107. These control electrodes may be placed at some other position between cathode 101 and electrodes 107, if desired. The electrodes 110 and 111 focus the beam of electrons upon the anodes 103. The electron beam is deflected by the electrodes 112 to cause the beam to impinge upon the anodes 103 in succession periodically in synchronism with the scanning of the successively scanned elemental areas of successive linear elements of the field of view, an image of which is to be produced. Suitable potentials are impressed upon the various electrodes by a battery 113, cathode 101 being connected to the battery through lead 114, electrodes 105 through lead 115, electrodes 106 through lead 116, electrodes 107 through lead 117, electrode 110 through lead 118 and electrode 111 through lead 118A. The anodes 103 are connected to one terminal of the piezoelectric elements 22, respectively, and the other terminals of the piezoelectric elements are connected to a lead 119 going to the positive terminal of battery 113. Saw-toothed wave generator 120 supplies a deflecting electromotive force to the plates 112 for causing the cathode ray beam to impinge upon the anodes or targets 103 in succession at a rate corresponding to the rate of scanning the successive elemental areas of a line of the field of view at the transmitting station and any well-known means may be provided for maintaining the generator 120 in synchronism with the generator for controlling the deflection of a scanning cathode ray beam, for example, at the transmitting station. A cathode ray beam from the cathode 101 is preferably reduced to a low intensity or extinguished between successive line scanning periods and, during each interval between successive line scanning periods, and the cathode ray beam is returned to its starting position, that is, to impinge upon the anode 103 at one end of the row of anodes. A source of television image signals 130 is connected to the appropriate electrodes of the cathode ray device for controlling the density or velocity, or both, of the electron beam reaching the anodes 103, and, therefore, the amplitude of the electromotive force impressed across the piezoelectric elements 22 in succession, in accordance with the amplitude variations of the television signals from source 130. As shown in the drawings, one terminal of the source of television signals 130 is connected to the two grids 106 while the other terminal of the source 130 is connected to the cathode 101. If desired, however, the grids 106 may be connected to the terminals, respectively, of the source 130 and the connection from source 130 to cathode 101 omitted.

Each picture, after it is recorded upon the film 10 due to the action of the marking styli 27, and after it is projected upon the screen 32, is erased due to the action of the brushes 131 and 132.

What is claimed is:

1. Image producing apparatus comprising a plurality of piezoelectric elements, a stylus for each of said elements, an image recording surface, means for effecting relative motion between said styli and said surface, a source of image electromotive force, and means for applying image electromotive force from said source, to said piezoelectric elements in succession to

cause said styli to produce an image upon said surface.

2. Image producing apparatus comprising a continuous band having a coating of viscous liquid thereon, means for continuously moving said band, a source of image current, means under control of current from said source for displacing the liquid coating at different portions of said band in succession for recording an image upon said band, a source of light, a screen, and means for directing light from said source through said film upon said screen to produce an image thereon.

3. In combination, a plurality of piezoelectric elements, means for rigidly supporting one end of each of said elements, a plurality of marking styli attached to the opposite ends of said elements, respectively, and means for setting said elements into vibration in succession.

4. Recording apparatus comprising a transparent record band having an opaque coating on a surface thereof, means for displacing the coating on said band comprising a piezoelectric crystal, a marking stylus secured to said crystal and means for applying an electric field to said crystal for actuating it.

5. Recording apparatus comprising a light transmitting record band having a relatively opaque coating on a surface thereof, a stylus for displacing the coating from portions of said surface, a piezoelectric crystal secured to said stylus, and means for applying a varying electric field to said crystal to cause the movement of said stylus.

6. Recording apparatus comprising a plurality of thin piezoelectric crystal elements each having a length greater than its width, means for rigidly supporting the crystal elements at one end so that the crystal faces lie in substantially parallel planes to prevent movement of said crystals with respect to each other at said one end, and a plurality of styli secured to the crystal elements, respectively, at the unsupported ends thereof of a source of electric signals, and means for setting said elements into vibration in succession under control of signals from said source.

7. Recording apparatus comprising a plurality of thin piezoelectric crystal elements each having a length greater than its width, means for rigidly supporting the crystal elements at one end so that the crystal faces lie in substantially parallel planes to prevent movement of said crystals with respect to each other at said one end, a plurality of styli secured to the crystal elements, respectively, at the unsupported ends thereof, a pair of electrodes for each of said crystal elements, and means for applying to said pairs of electrodes in succession an electromotive force for successively causing a strain in said crystals and thereby effecting the movement of the styli attached thereto.

8. Television image producing apparatus comprising an endless band having a coating thereon, means for continuously moving said band in the direction of its length, a plurality of piezoelectric elements, the faces of which lie in parallel planes substantially perpendicular to the width of the film, a plurality of styli attached to one of the ends of said elements respectively, said styli being contiguous to said band, means for rigidly supporting the ends of elements opposite to the ends to which the styli are attached, a source of electromotive force for controlling the actuation of said elements to record

pictures upon said band, means for successively projecting said pictures, and means for successively erasing the pictures from the band after being projected.

9. In combination, a plurality of piezoelectric crystal elements, a source of television image electromotive force and electronic means for impressing upon said piezoelectric elements in succession periodically for actuating the elements, an electromotive force having an amplitude which varies in accordance with the amplitude variations of said television image electromotive force.

10. In combination, a plurality of piezoelectric crystal elements, a source of television image electromotive force and electronic means for impressing upon said piezoelectric elements in succession periodically for actuating the elements, an electromotive force having an amplitude which varies in accordance with the amplitude variations of said television image electromotive force, and a plurality of circuits each having inductive reactance connected in shunt with said piezoelectric elements, respectively.

11. In combination, a cathode for emitting cathode rays, means for accelerating and focusing rays emitted from said cathode upon a plane intersecting the beam of cathode rays along a line of substantially uniform width, a plurality of elongated anodes located in said plane and extending substantially parallel to said line, means for deflecting said beam in a direction substantially perpendicular to said line for causing said beam to impinge upon said anodes in succession, a plurality of piezoelectric elements and means for connecting said elements in the anode-cathode circuits, respectively, to cause movement in said elements in succession in accordance with the intensity of the cathode ray beam impinging upon the respective anodes.

12. In combination, a cathode for emitting cathode rays, means for accelerating and focusing rays emitted from said cathode upon a plane intersecting the beam of cathode rays along a line of substantially uniform width, a plurality of elongated anodes located in said plane and extending substantially parallel to said line, means for deflecting said beam in a direction substantially perpendicular to said line for causing said beam to impinge upon said anodes in succession, a plurality of piezoelectric elements connected in the anode-cathode circuits respectively, a source of signaling electromotive force, and means for modulating said cathode ray beam in accordance with and under control of the electromotive force of said source for causing said piezoelectric elements to be correspondingly actuated in succession.

13. In combination, an elongated cathode for emitting cathode rays, a plurality of elongated anodes, a plurality of movable members having energizing means therefor connected in circuit between said cathode and different anodes, respectively, the longitudinal axes of said anodes and the longitudinal axis of said cathode being substantially parallel, the axes of said anodes lying in a plane substantially perpendicular to a line drawn perpendicular to the axis of said cathode, means for focusing the cathode ray beam upon one of said anodes, the width of said beam intercepted by said anode being less than the width of said anode and the length of said beam being substantially as long as said anode, means for modulating said beam in accordance with signals, and means for deflecting said beam

to cause it to impinge upon said anodes one at a time repeatedly in succession for causing the movement of said movable members successively in accordance with the intensity of the cathode ray beam.

14. In combination, an elongated cathode for emitting cathode rays, a plurality of elongated anodes, the major axes of said anodes and the major axis of said cathode being substantially parallel, the axes of said anodes lying in a plane substantially perpendicular to a line drawn perpendicular to the axis of said cathode, means for focusing the cathode ray beam upon one of said anodes, the width of said beam intercepted by said anode being less than the width of said anode and the length of said beam being substantially as long as said anode, means for modulating said beam with respect to intensity in accordance with signals, means for deflecting said beam to cause it to impinge upon said anodes one at a time repeatedly in succession, a plurality of marking styli, and a plurality of piezoelectric crystal elements for actuating said styli respectively, said piezoelectric elements be-

ing actuated under control of the cathode ray beam impinging upon said anodes, respectively.

15. The method of controlling the actuation of a plurality of piezoelectric crystal elements which comprises generating a cathode ray beam, directing said beam upon different anodes in succession, modulating the cathode ray beam in accordance with signals and controlling the actuation of said piezoelectric elements in succession in accordance with the electron current flowing to said anodes, respectively.

16. The method of image production under control of television signals which comprises coating a film, displacing the coating from portions of said film under control of said television signals to record images upon said film in succession, projecting said recorded images in succession upon a screen, smoothing the coating on said film to erase the recorded images in succession and subsequently recording images upon the portions of said film from which previously recorded images have been erased.

RAYMOND A. HEISING.