

April 9, 1940.

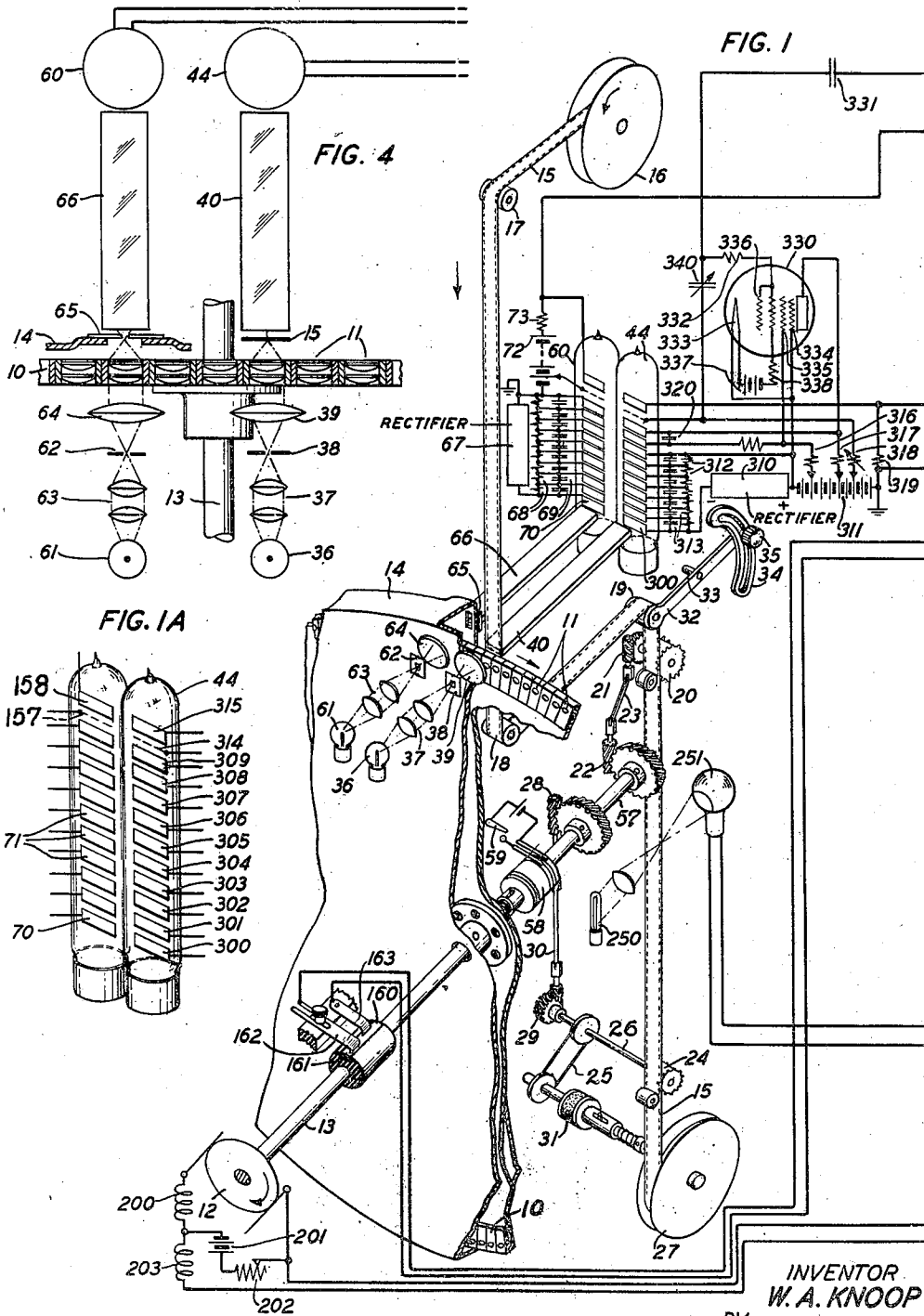
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2,196,867

TELEVISION IMAGE PRODUCING SYSTEM

Filed Oct. 1, 1937

4 Sheets-Sheet 1



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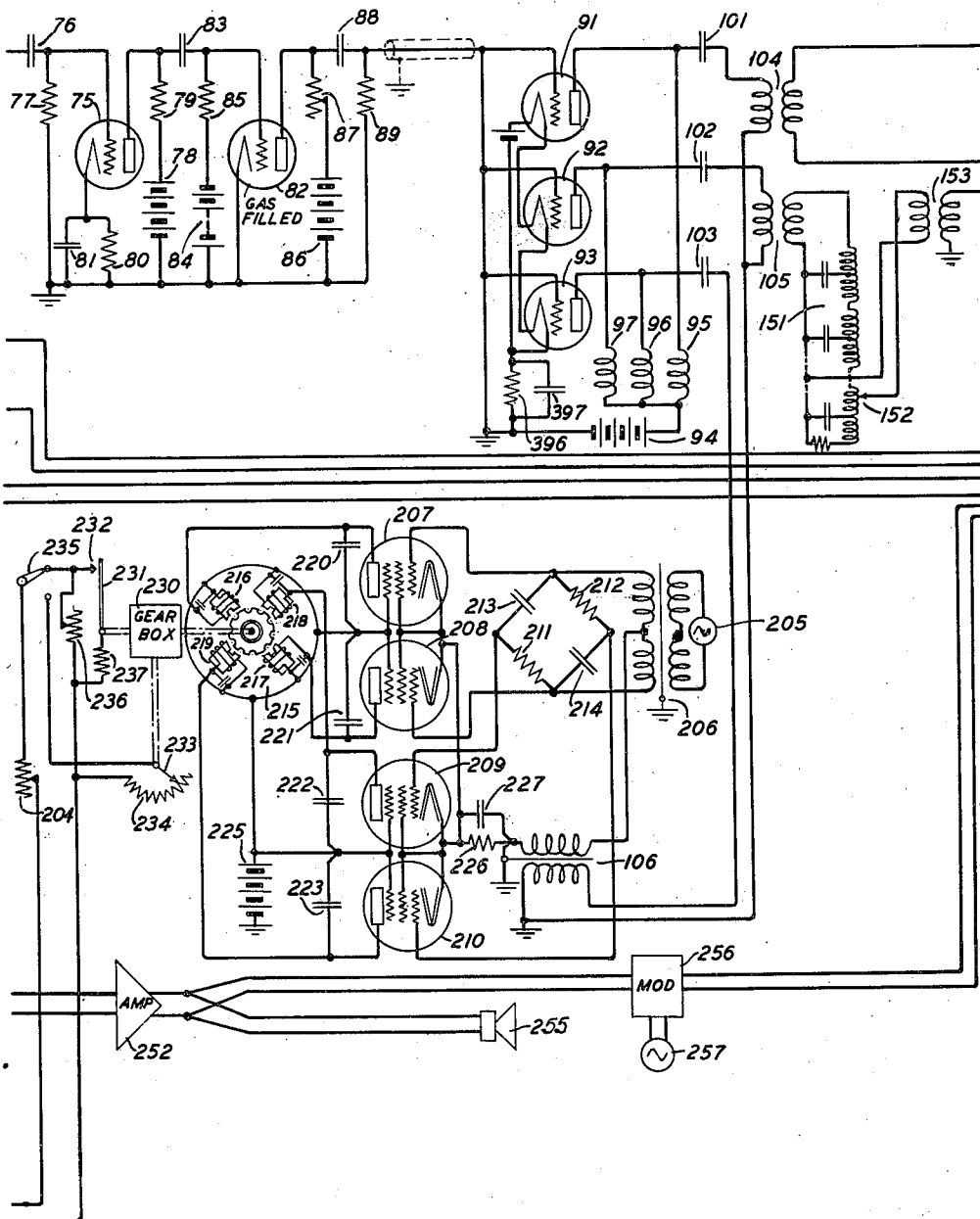
2,196,867

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FIG. 2



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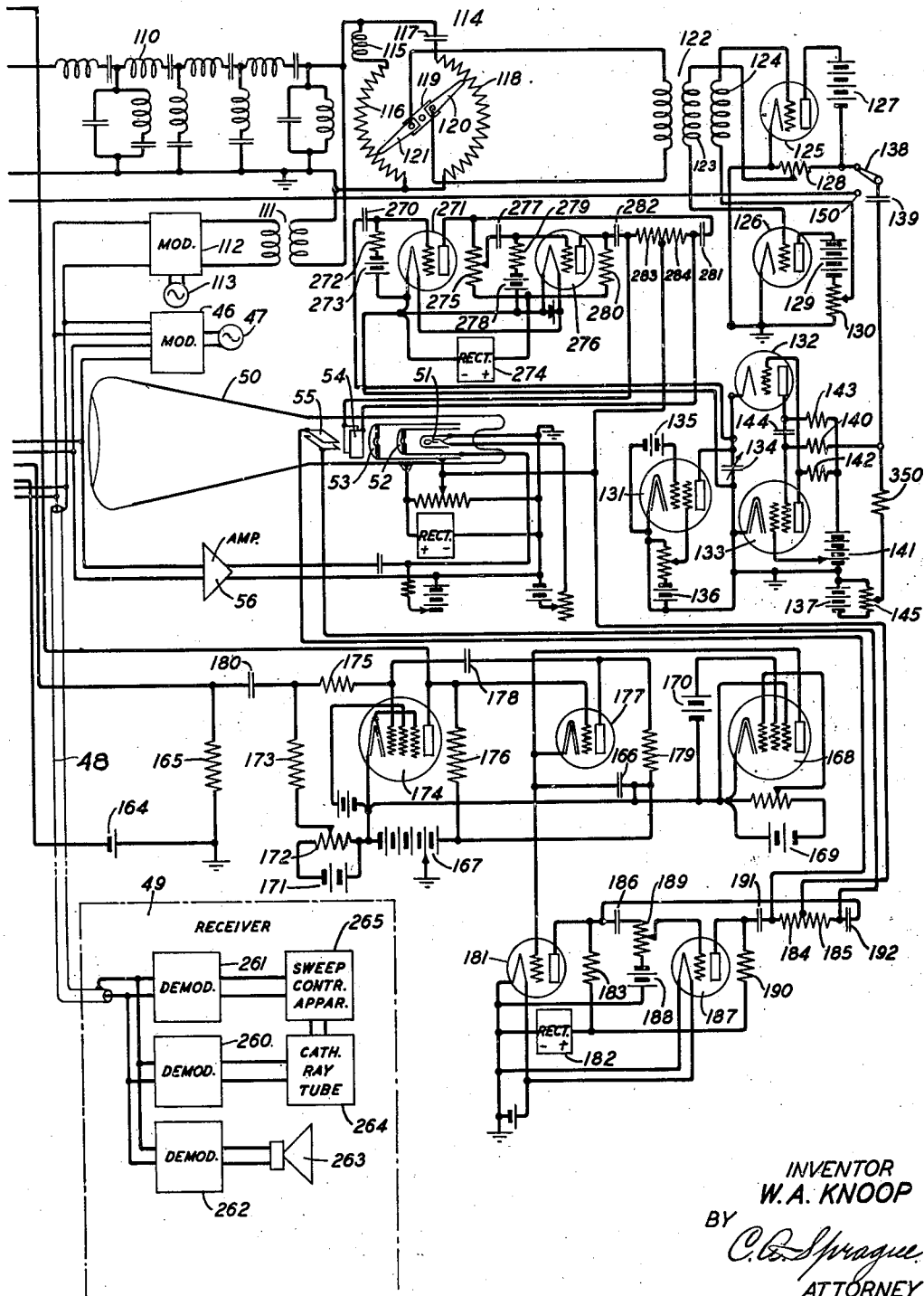
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TELEVISION IMAGE PRODUCING SYSTEM

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FIG. 3



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FIG. 5

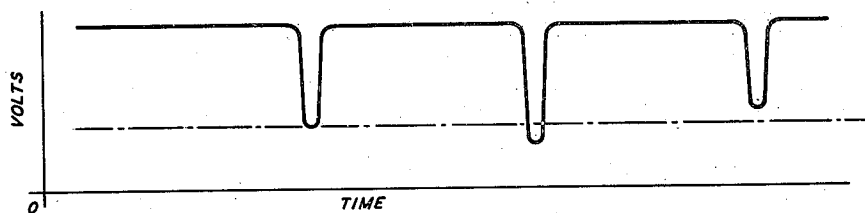


FIG. 6

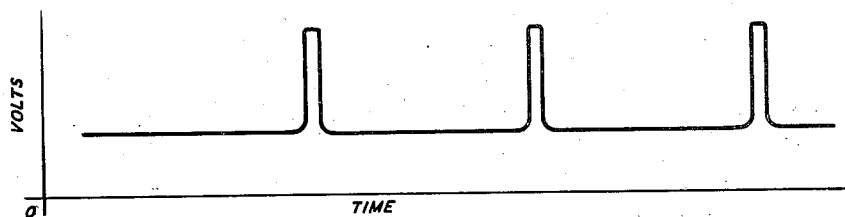


FIG. 7

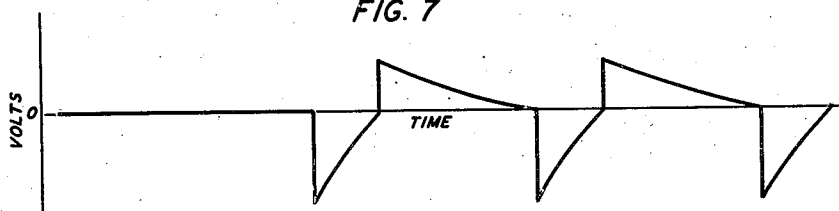
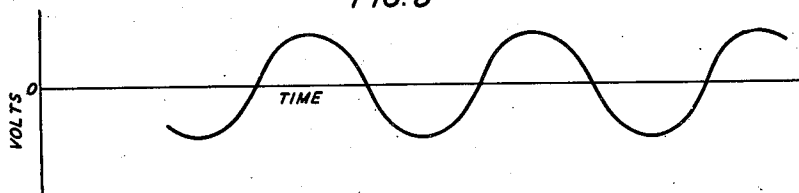


FIG. 8



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2,196,867

TELEVISION IMAGE PRODUCING SYSTEM

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Application October 1, 1937, Serial No. 166,728

24 Claims. (Cl. 178-5.6)

This invention relates to television image producing systems and particularly to a system for producing television images together with the accompanying sound effects from sound motion picture films.

In accordance with an embodiment of the invention shown and described herein for the purpose of illustration, a large rotating disc carrying lenses arranged along a circular path near its periphery directs a light beam from a fixed source to the elemental areas in succession along a linear path of a motion picture film. The motion picture film is moved continuously in a direction perpendicular to the direction of scanning of the elemental areas along a linear path so that successive lenses illuminate or scan the elemental areas along successive parallel lines. The disc is enclosed in a housing to reduce wind resistance and also to prevent accidental contact with the disc while in motion. As the film moves past the scanning position it is spaced only a short distance from the disc housing and moreover the lenses in the disc have a short focal length so as to illuminate a small area of the film at a time. Light from the successively illuminated elemental areas of the film is directed by means of a rectangular cross-sectioned light tunnel of glass or, preferably, of a material known as "pontalite" to the primary cathode of an electron multiplier.

A short time prior to the time that a certain lens of the scanning disc commences scanning a line of the picture film, two or three line scanning periods, for example, light is directed through the lens and through an adjustable aperture upon a light sensitive cathode of a second electron multiplier for generating a synchronizing impulse. Due to imperfections in the scanning disc lenses or to dust on the lenses, the light transmission ability of the lenses may vary somewhat and thus cause the amplitude of the synchronizing impulses generated by the electron multiplier to vary. Therefore, the synchronizing impulses generated by the electron multiplier are impressed upon an amplifier which limits the amplitude of the impulses to a constant value. This amplifier also reverses the phase of the impulses which are supplied to the grid-cathode circuit of a gas-filled triode. To the anode circuit of the gas-filled tube is connected a circuit including a condenser which is charged through a resistive element. The condenser is periodically discharged by the gas-filled tube due to the synchronizing impulses impressed upon its input circuit. There are thus

produced across the resistive element of the condenser charging-discharging circuit a voltage wave having a fundamental frequency equal to the line scanning frequency and having a constant peak amplitude. The fundamental frequency component of the wave produced by the alternate charging and discharging of the condenser has a greater amplitude than that of the wave impressed upon the input circuit of the gas-filled tube. The resistive element is connected across the input circuits of three three-electrode vacuum tubes connected in parallel, the output circuits of said tubes being connected to different output transformers respectively. One output transformer is connected to a band-pass filter to produce a sine wave current of constant amplitude and having a frequency equal to the line scanning frequency. A second transformer is connected to an adjustable delay network which delays the impulse for an interval equal to the interval between the time that a synchronizing impulse is generated by light directed through a certain lens of the scanning disc upon the synchronizing electron multiplier and the time that the first elemental area of a line of the picture film is scanned by light directed through that lens. The third transformer is connected to a circuit for maintaining the scanning disc driving motor at a constant speed.

For transmission to a distant station, carrier transmission over a coaxial cable is employed, the television image current, the line frequency alternating current and the sound current produced by scanning the sound track of the motion picture film being transmitted over different carrier channels, respectively. The output of the electron multiplier for generating the television image current is connected directly to the image current modulator without the use of alternating current amplification, so that the direct and very low frequency alternating components, corresponding to the average picture tone value as well as the higher frequency components of the image current are transmitted. At the receiving station the carrier modulated image current, after demodulation, is applied to the control electrodes of a cathode ray image producing device. The sine wave synchronizing current of line scanning frequency, after demodulation, is employed for producing a sawtooth wave for controlling the high frequency deflection of the cathode beam. A subharmonic generator controlled by the line frequency current may be employed for generating a frame frequency current which, in turn, controls the

production of a saw-tooth wave for controlling the low frequency deflection of the cathode beam. The carrier modulated sound current, after demodulation, is impressed upon a loud-speaker.

A cathode ray image producing apparatus is also provided at the transmitter for monitoring purposes. The control electrodes of the cathode ray tube may be connected to the output circuit of a demodulator, the input circuit of which is connected to the source of carrier modulated image current. However, it is not essential that the image produced by the monitoring receiver should have the correct average tone value. Therefore, the control electrodes of the monitoring cathode ray tube may be connected to the output circuit of an alternating current amplifier, the input of which is supplied with current from the image scanning electron multiplier. The high frequency deflection of the cathode beam may be controlled either by the sine wave synchronizing current or by the delayed synchronizing impulse current. The use of the latter has the advantage that the image current impulse corresponding to the first scanned elemental area of a line and the synchronizing impulse for returning the cathode beam to its initial line scanning position are always accurately in synchronism and do not vary in phase due to inaccuracies in the positioning of the lenses of the scanning disc. When the sine wave is to be used for controlling the high frequency deflection of the cathode beam, it is utilized for controlling the generation of a square-topped wave and the latter, in turn, is utilized for controlling the production of a saw-tooth wave which is impressed upon the high frequency deflecting plates of the cathode ray tube. When the impulse wave is employed for controlling the high frequency deflection of the cathode ray beam, it directly controls the production of the saw-tooth wave which is impressed upon the high frequency deflecting plates.

For controlling the low frequency deflection of the cathode ray image producing tube, a voltage impulse is generated once per revolution of the scanning disc by a circuit closed through an insulated conducting segment of the scanning disc drive shaft. These impulses control a vacuum tube circuit for quickly charging a condenser which has been previously discharged at a constant rate. The voltage across this condenser is amplified by a vacuum tube circuit connected to the low frequency deflecting plates for causing the potential on one plate to increase while that on the other plate decreases and vice versa. These impulses are also utilized for causing the multiplying power of the image electron multiplier to be periodically greatly reduced, thus causing the transmission of current corresponding to "black" tone value at the end of each picture frame. This results in "blanking out" the low frequency return sweep of the cathode beam of the receiver in going from the last line to the first line of the image.

The invention may be better understood from the following description with reference to the accompanying drawings, in which

Figs. 1, 2 and 3, if placed side by side in order with Fig. 1 to the left, constitute a schematic showing of a complete television system, Fig. 1 showing a portion of the apparatus in perspective;

Fig. 1—A is a schematic view of a portion of the apparatus shown on Fig. 1;

Fig. 4 is an enlarged plan view, partly in section, of a portion of the apparatus shown in Fig. 1; and

Figs. 5 to 8, inclusive, are curves which will be referred to in explaining the operation of the system.

Referring to the drawings, the metallic scanning disc 10, about six feet in diameter and carrying 240 equally spaced compound scanning lenses 11 arranged along a circular path near the periphery of the disc, is driven at a rate of 24 revolutions per second by a 10 horsepower direct current motor 12 through a shaft 13. Since the lenses in succession scan the field along successive substantially straight linear paths, 5760 lines are scanned per second. The disc is enclosed in a casing 14 to avoid accidental contact with the disc and also to reduce air resistance. The sound motion picture film 15 which is to be scanned to produce a television image current and a current corresponding to the accompanying sound effects is fed from the storage reel 16 over roller 17 past a light transmitting aperture in housing 14 through which the picture portions of the film are scanned, past rollers 18 and 19 to the sprocket wheel 20 which continually unwinds the film from the storage reel 16 at the rate of one frame for each rotation of the scanning disc. The sprocket wheel is mechanically connected to the shaft 57 through gears 21, 22 and the universal connection 23. The shaft 57 may be connected to the shaft 13 at a desired time, preferably after the disc 10 has been brought to speed, by means of the electromagnetic clutch 58 the winding of which may be energized by the closure of switch 59. The film then moves through the sound pick-up apparatus, the film being driven by sprocket 24 which is connected to the shaft 57 by the gears 28 and 29 and the universal coupling 30. The film is then wound up upon a storage reel 27 which is driven through friction clutch 31 and belt drive 25 from shaft 26 which connects the sprocket wheel 24 with the gears 29. The roller 19 is mounted upon an arm 32 at one end thereof, which arm is movable about a fulcrum 33. The other end of arm 32 may be secured to support 34 by a thumb screw 35. By adjusting the arm 32, the position of the film 15 may be adjusted so that a certain lens of the scanning disc will scan the first line of the frame of a motion picture film. This adjustment is necessary so that the "frame" or low frequency synchronizing impulses, which are generated once per revolution of the scanning disc when the disc is in a certain position, may occur between the scanning of successive picture frames.

For scanning the motion picture film light from source 36 after passing through lenses 37 is directed in a convergent beam upon an aperture .03 inch square in aperture plate 38. The divergent beam transmitted through the aperture in plate 38 reaching the collimating lens 39 is transmitted thence in a beam of parallel rays through which the lenses 11 of the scanning disc pass in succession. Each compound lens 11 of the scanning disc comprising two plano-convex lenses mounted as shown in Fig. 4, has a short focal length and produces an image .003 inch square of the aperture in plate 38 upon the film 15 which moves in close proximity to the housing 14. As the disc rotates, the light beam projected by one lens will trace a path .003 inch wide across the film, the light beam projected by the next lens will trace a contiguous .003 inch

wide path, etc. The light beam transmitted through the film 15, which will be modulated in accordance with the tone values of successively illuminated elemental areas, reaches one end of a light conducting tube or light tunnel 40, this end of the light tunnel being positioned close to the portion of the film which is being illuminated. The light conducting tube may be made of a material such as glass or quartz, but is preferably made of a material known as "pontalite", which is not brittle and which is a better light conductor than glass. The width of the light conductor in the direction of the scanning lines is $\frac{1}{8}$ inch and its thickness is $\frac{1}{16}$ inch. An electron multiplier 44 of the type disclosed in U. S. Patent No. 2,160,796, granted to G. K. Teal, May 30, 1939, for example, is positioned adjacent to the opposite end of the light tunnel, so that the light emerging from the light tunnel will reach the primary cathode 300 thereof. The electron multiplier plates 300 to 309, inclusive, are connected to a suitable source of electromotive force such as the rectifier 310 and battery 311, such that each secondary cathode is operated at a positive potential with respect to that of the primary cathode and such that the potential applied to each secondary cathode is greater than that applied to the next preceding secondary cathode, as shown and described in said Teal patent, supra. The rectifier is shunted by the voltage dividing resistive elements 312 in series each shunted by a small condenser 313. The positive terminal of the rectifier 310 is connected to the negative terminal of battery 311, the positive terminal of the battery being grounded. Different points of battery 311 are connected to secondary electrodes 308 and 309, grid 314, and anode 315 through different resistive elements 316, 317, 318 and 319, respectively. A condenser 320 connects electrodes 308 and 309. The image current in the anode circuit of the electron multiplier 44 flows through the resistive element 319 which is connected directly to the input circuit of modulator 46, the latter being supplied with a carrier current from source 47. The modulated carrier current from modulator 46 is transmitted over a suitable transmission line such as the coaxial conductor cable 48, to the receiver 49 at a distant station. While a single modulator 46 is shown, double modulation is preferably employed.

The opening in casing 14 through which the scanning light beam from source 36 passes is so dimensioned that the light beam is cut off for a short period at the end of each scanning line. As a result the cathode ray beam of the receiver will be extinguished or reduced in intensity during the return sweep of the cathode beam occurring between scanning lines.

There is also provided an image producing receiving apparatus comprising a cathode ray tube 50 of the type disclosed in U. S. Patent No. 2,169,179, granted to F. Gray, August 8, 1939, which may be used for monitoring purposes. The tube 50 is provided with a cathode 51, a grid 52, an anode 53, high frequency deflecting plates 54 and low frequency deflecting plates 55. While the carrier modulated image current from source 46 may be demodulated and the demodulated current supplied to the grid-cathode circuit of tube 50, for monitoring purposes it is satisfactory to amplify the image current by an alternating current amplifier 56, thereby suppressing the direct component of the image current. The output

of amplifier 56 is impressed upon the grid-cathode circuit of cathode ray tube 50.

The electron multiplier 60 is provided for generating synchronizing impulses, one for each scanning line, under control of light transmitted through the scanning disc lenses. Light from source 61 is focussed by lenses 63 upon the screen 62 having a narrow light transmitting aperture therein. The collimating lens 64 directs the beam in parallel rays upon the scanning disc and each scanning disc lens 11 directs the beam through a narrow slot in the adjustable screen 65 upon one end of a light conducting tube 66, similar to the tube 40. The other end of the light tunnel is adjacent to the primary cathode 70 of the electron multiplier 60. A rectifier 67, energized from a 60-cycle power source, supplies current at 1350 volts to the series connected resistive elements 68 across which condenser 69 of small capacity are connected. The negative terminal of the rectifier is connected to the primary cathode of the electron multiplier. The secondary cathodes 71 of the electron multiplier are all supplied with voltage from the rectifier 67. This is contrary to the usual television practice when using electron multipliers for generating television signals. The arrangement shown gives good regulation because the electron current is being delivered over extremely short periods of time compared with the line scanning period and the condensers 69 do not have time to discharge appreciably. Battery 72 supplies potential to the screen grid 157 and to the anode 158 of tube 60, the anode current flowing through resistive element 73. The output circuit of the electron multiplier is connected to an amplifier comprising thermionic tube 75 through a condenser 76 by a lead from the resistive element 73, one of the input terminals of the amplifier and the positive terminal of rectifier 67 being grounded. If desired, the screen grid 157 and the anode 158 of the electron multiplier may also be supplied with potential from the rectifier 67. The amplifier includes a resistive element 77 of .5 megohm connected in its input circuit and anode current is supplied by battery 78 of 200 volts flowing through resistive element 79 of .01 megohm. Anode current flowing through resistive element 80 of 2500 ohms biases the grid of the tube with respect to the cathode so as to cut off the peaks of the impulses produced by the electron multiplier 60 and thus limit the impulses to a constant amplitude, the resistive element 80 being shunted by a 50 microfarad condenser 81.

The output circuit of amplifier tube 75 is connected to the input circuit of the three-electrode gas-filled tube 82, through condenser element 83 of .02 microfarad. Across the input circuit is connected the grid biasing battery 84 and resistive element 85 of .25 megohm in series. Anode potential is supplied to tube 82 by battery 86 of 135 volts, which is connected to the anode through variable resistive element 87 having a maximum value of .1 megohm. Also connected across the output circuit of tube 82 are a condenser 88 of .0005 microfarad and a resistive element 89 of 50,000 ohms. The condenser 88 is charged by current from battery 86 and quickly discharged through the anode circuit of gas-filled tube 82 when a synchronizing impulse is impressed upon its grid.

Across the resistive element 89 of the condenser charging-discharging circuit are connected the input circuits of three power amplifier tubes 91, 75

92 and 93 connected in parallel. Anode current is supplied to the tubes by battery or rectifier 94 of 450 volts, the positive terminal of which is connected to the anodes of tubes 91, 92 and 93 through choke coils 95, 96 and 97, respectively. The resistive element 396 shunted by condenser 397 connected in the anode-cathode circuits of the tubes, supplies biasing potential to the grids thereof. The output circuits of tubes 91, 92 and 93 are connected through condensers 101, 102 and 103, respectively, to the primary windings of transformers 104, 105 and 106, respectively. The secondary winding of transformer 104 is connected to the input circuit of band-pass filter 110 for transmitting the fundamental frequency of 5760 cycles of the synchronizing wave and the output circuit of the filter 110 is connected through a transformer 111 to the input circuit of modulator 112, which is supplied with carrier current from source 113. The carrier modulated synchronizing current from modulator 112 is transmitted over the coaxial conductor cable 48 to the distant receiver 49.

The 5760 cycle sine wave current from the output circuit of filter 110 may also be utilized for controlling the high frequency deflection of the cathode beam of tube 50. For this purpose the output of filter 110 is connected to the adjustable phase shifter 114 having the two parallel branches, one consisting of inductive element 115 and resistive element 116 and the other consisting of capacitive element 117 and resistive element 118. The phase of the current transmitted by the phase shifter may be varied by turning the arm 119 about its axis, this arm carrying a brush 120 in slidable engagement with resistive element 118 and brush 121 in slidable engagement with resistive element 116. The brushes 120 and 121 are connected, respectively, to the terminals of the primary winding of transformer 122 having two secondary windings 123 and 124. The impedance looking into the primary winding of transformer 122 is preferably high compared with the resistance of element 118. The resistance of elements 116 and 118 are each made equal to the square root of the ratio of the inductance of element 115 to the capacity of condenser 117. Under these conditions the impedance looking into the network from filter 110 will be a constant resistance. The windings 123 and 124 are connected to a circuit comprising vacuum tubes 125 and 126 for converting the impressed sine wave into a square-topped wave. A battery 127 and a resistive element 128 are connected in the anode circuit of the vacuum tube 125 and a battery 129 and a resistive element 130 are connected in the anode circuit of tube 126. One terminal of transformer winding 123 is connected to the grid of tube 126 and the other terminal through an adjustable contact to resistive element 128. One terminal of winding 124 is connected to the grid of tube 125 and the other terminal is connected through an adjustable contact to resistive element 130. The cathodes of tubes 125 and 126 are conductively connected. The circuit arrangement is such that when current flows in the anode circuit of one of the tubes 125, for example, the other tube 126 becomes blocked because of the negative bias applied to its grid due to the drop across the portion of resistive element 128 which is connected to the input circuit of tube 126. The transformer windings 123 and 124 apply potentials to the input circuits of tubes 125 and 126 necessary to unblock one tube

and, as a result, to block the other tube. The transformer windings are connected to the input circuits so that, when a small negative signal voltage is applied to the grid of the unblocked tube, a corresponding positive voltage is applied to the grid of the blocked tube. When this voltage reaches a certain amplitude, the tubes are caused to reverse condition, the unblocked tube being blocked and the blocked tube being unblocked. As a result, square-topped voltage impulses, one for each cycle of the 5760 cycle alternating current from the output of filter 110 are produced across the resistive element 128.

The circuit comprising vacuum tubes 131, 132 and 133 is controlled by the square-topped wave to produce across the .0005 microfarad variable condenser 134 a saw-tooth voltage wave which is utilized to control the high frequency deflection of the cathode beam produced in tube 50 at the line scanning frequency of 5760 cycles. The two grids of tube 131 are biased by batteries 135 and 136, respectively to potentials such that the anode current remains constant over a wide range of anode potentials. The condenser 134, after having been charged, is thus discharged at a substantially constant rate through the anode-cathode circuit of tube 131.

The circuit comprising tubes 132 and 133 is provided for periodically quickly charging condenser 134 through the anode circuit of tube 132 at the beginning of the square-topped impulse produced across the resistive element 128. With the switch 138 in the position shown in the drawing, when the tube 125 commences to draw current, a negative impulse is applied to the grid of tube 133 through a circuit comprising condenser 139 and resistive element 140. As a result, the flow of anode current from battery 141 through resistive element 142 is reduced and the grid of tube 132 becomes more positive. Consequently, anode current from battery 141 is caused to flow through the resistive element 143, through the anode-cathode circuit of tube 132 and through condenser 134 to quickly charge the condenser. The charging of condenser 134 is accelerated due to the connection from the anode of tube 132 to the grid of tube 133 through condenser 144 of .0005 microfarad. When a negative impulse is applied to the grid of tube 133 the anode of tube 132 becomes more negative, and this negative impulse is applied to the grid of tube 133. The positive impulse applied to the grid of tube 132 is thus increased. The battery 137 supplies grid potential to the grid of tube 133 through resistive elements 140 and 350, this potential being made variable by the potentiometer 145.

The potential across condenser 134 is impressed through condenser 270 across the grid-cathode circuit of vacuum tube 271 which is biased through resistive element 272 by battery 273. Anode current from the rectifier 274, energized from a 60-cycle power source, is supplied to the anode circuit of tube 271 through resistive element 275 of 10,000 ohms. A portion of the resistive element 275, having about $\frac{1}{10}$ of the total resistance of this element, is connected across the input circuit of vacuum tube 276 through condenser 277, having the same capacity as condenser 270. The grid-cathode circuit of tube 276 is biased by battery 278, the same as battery 273, through resistive element 279 of the same value as resistive element 272. Anode current is supplied to the anode circuit of tube 276 by rectifier 274 through resistive element 289 of 10,000 ohms. The tubes 271 and 276 are of the same type, each

having an amplification factor of about 10. As the condenser 134 discharges, the potential at the anode of tube 271 increases with respect to ground at a certain rate and the potential at the anode of tube 276 decreases with respect to ground at the same rate. The anode of tube 271 is connected through condenser 281 to one of deflection plates 54 and the anode of tube 276 is connected through condenser 282 to the other of deflecting plates 54. Across the deflecting plates 54 are connected two 10-megohm resistive elements 283 and 284 in series, the common terminals of the resistive elements being connected to the anode 53 of cathode ray tube 50.

There is thus applied across the deflector plates 54 a saw-tooth voltage wave similar to the voltage wave produced across condenser 134 but amplified. The potentials applied to the plates 54 are balanced with respect to the anode 53, the potential of one plate 54 increasing while that of the other plate 54 is decreasing with respect to the potential of the anode 53. Loss of focus of the cathode beam is thus avoided. The 60-cycle and 120-cycle components of the current from the rectifier 274 are amplified by the tube 276 and impressed upon one of the high frequency deflector plates 54. This results in a scarcely noticeable irregularity in the edges of the image produced by the cathode ray tube. The advantage of the arrangement shown is that the resistance of the portion of resistive element 275 connected to the input of tube 276 is small compared to the grid-cathode impedance of the tube 276 even at some of the higher harmonic frequencies of the 5760 cycle saw-tooth wave. If this were not the case, the saw-tooth wave would be rounded at one peak and sharpened at the other due to the suppression and phase shifting of high frequency components, and the image would appear too bright at one edge and too dark at the other edge.

When the switch 138 is moved to close a circuit to contact 150, a circuit is completed from transformer 105 through a delay network 151 which may be varied in steps by the variable connection 152, through transformer 153 to the contact 150 and thence through switch 138, condenser 139 and resistive element 140 to the grid of tube 133. The cathode of tube 133 and one terminal of the secondary winding of transformer 153 are grounded.

For setting up low frequency synchronizing impulses at the frame scanning rate of 24 per second, there is provided on the scanning disc drive shaft 13, a commutator comprising a conducting segment 160 imbedded in insulating material designated by the numeral 161. For a short period during each revolution of the scanning disc, the brushes 162 and 163 complete a circuit including 9-volt battery 164 and resistive element 165 of 2 megohms. The condenser 180 of .1 microfarad is normally charged due to voltage applied to it from a portion of battery 167 and battery 171 through a circuit including potentiometer 172, resistive element 173 of 2 megohms and resistive element 165 of 2 megohms. When the battery 164 is connected across resistive element 165 by the conducting segment 160, condenser 180 is partially discharged and, as a result, a negative impulse is impressed upon the control grid of vacuum tube 174 through resistive element 175 of 1 megohm. The anode current from source 167 flowing through resistive element 176 and the anode-cathode circuit of tube 174 is thus decreased. The resistive element 176 and battery 167 being

connected across the control grid-cathode circuit of vacuum tube 177 through condenser 166, a positive impulse is impressed upon the control grid of tube 177 due to the decrease in anode current in the tube 174. The tube 177 consequently draws anode current and the condenser 166 of .04 microfarad is charged by current from battery 167 through the anode-cathode circuit of tube 177, including resistive element 179 of 2000 ohms. The anode of tube 177 is connected through condenser 178 to the control grid of tube 174 to feed back a negative impulse to the control grid of tube 174 to accelerate the action of the circuit in charging condenser 166. The condenser, after being charged, is discharged at a constant rate through the anode-cathode circuit of the vacuum tube 168 to which the condenser is connected, the grids of the tube 168 being biased by batteries 169 and 170 to give a substantially constant anode current over a wide range of anode potentials. The plate of condenser 166 which becomes charged positively with respect to its other plate is connected to the control grid of vacuum tube 181, the cathode of the tube being grounded. The grounding of battery 167 near its positive end and the grounding of the cathode of tube 181 results in the cathode of tube 181 being positive with respect to the positively charged plate of condenser 166 and the grid circuit of tube 181 thus draws no current. As condenser 166 becomes discharged, the anode current from rectifier 182 of 1500 volts, energized from a 60-cycle power source, flowing through resistive element 183 of 10,000 ohms decreases. Across the resistive element 183 and rectifier 182 are connected in series condenser 186 of 1 microfarad, resistive element 189 of 10 megohms and battery 188 of 67 volts. The grid-cathode circuit of vacuum tube 187 is connected across a circuit consisting of a portion of resistive element 189 of 0.1 megohm and battery 188. Anode current is supplied to tube 187 from rectifier 182 through resistive element 190. The anode of tube 181 is connected through condenser 192 to one of the low frequency deflector plates 55 and the anode of tube 187 is connected through condenser 191 to the other of the deflecting plates 55. Across the plates 55 are connected two 10 megohm resistive elements 184 and 185 in series, the common terminal of the resistive elements being connected to the anode 53 of cathode ray tube 50.

There is thus applied across the deflector plates 55 a saw-toothed voltage wave similar to the wave produced across condenser 166 but amplified. The shunting effect of the grid-cathode impedance of tube 187 at the higher harmonics of the 24-cycle saw-tooth wave is insufficient to appreciably distort the wave. It is important that the amplitude of the 60-cycle and 120-cycle components from rectifier 182 impressed upon the input circuit of tube 187 be of very low value because the presence of a 60-cycle or 120-cycle voltage component across low frequency deflecting plates 55 would cause the spacing of the scanning lines at a given portion of the image to alternately increase and decrease. The amplitude of the 60-cycle and 120-cycle components with respect to ground potential is less at the anode of tube 181 than it is at some point along resistive element 183 closer to the positive terminal of rectifier 182. The amplitude of the 60-cycle and 120-cycle components across the portion of resistive element 189 connected across the input of tube 187 is about one-tenth of its amplitude at the anode of tube 181, and, although tube 187, as well as tube 181, has an amplification factor of 10, the poten-

tial of the 60-cycle component at the anode of tube 187 is small.

The positive impulse produced at the anode of vacuum tube 174 due to the closure of a circuit through contact 160 is also impressed upon the control grid 336 of tube 330 through blocking condenser 331 and resistive element 332 to cause a large decrease in the sensitivity of electron multiplier 44 at the end of the scanning of each picture frame. As a result the image current flowing through resistive element 319 is greatly reduced for a short period between the scanning periods of succeeding frames and the cathode ray beam of the image producing tube is extinguished or substantially extinguished during this period. The cathode 333 and grid 334 are connected to the negative terminal of battery 311, the grid 335 is positively biased by a portion of battery 311 and the grid 336 is negatively biased by battery 337 through resistive element 338. The tube 330 normally draws no anode current. When a positive impulse is impressed upon grid 336 from tube 174, current from a portion of battery 311 flows through resistive element 317 and the anode-cathode circuit of tube 330. As a result, the potential applied to electrodes 308 and 309 decreases almost to the potential of electrode 307. The multiplying power of electrodes 308 and 309 is thus greatly reduced and the current flowing through resistive element 319 is greatly decreased. Due to the capacity between the anode 315 and the leads from electrodes 308 and 309, a spurious negative impulse was found to be set up at the anode 315 due to decrease in potential of plates 308 and 309 caused by the impulse from tube 174. This spurious impulse is neutralized by a positive impulse from tube 174 impressed upon the grid 314 through neutralizing condenser 340.

The end portion of brush 162 is slotted and secured to the insulating block 360 by means of a thumb screw 361 thus making brush 162 adjustable. Successive frames of the motion picture film 15 may overlap somewhat or there may be a blank interval or frame line between the bottom line of one frame and the top line of the next frame which may be designated as underlap. For example, the maximum overlap or underlap, as the case may be, may be the width of five scanning lines. In this case the brush is preferably adjusted so that a circuit is closed through the brushes 162 and 163 and the conducting segment 160 for a period equal to the time required for scanning five scanning lines. The image current is thus reduced to a low value or zero so that the overlap or underlap portions of the film will not be produced at the receiver.

The 10 horsepower direct current driving motor 12 has a series field winding 200, which is energized by current from source 201 through a starting resistive element 202, and a shunt field winding 203. The speed of the motor may be controlled by manually adjusting the variable resistive element 204 to control the current in the shunt field winding.

It is desirable to maintain the motor at a substantially constant speed for the following reasons: Phase equalizers, not shown in the drawing, are employed for eliminating phase distortion of the television image current over the required frequency range when the pictures are scanned at the rate of 5760 lines per second. The equalizers are not designed for operating over the increased frequency range which would need to be transmitted if the speed of the disc were increased by a substantial amount. The television

current transmission channel is designed to transmit a certain frequency band and if the speed of the scanning disc is increased substantially above 24 revolutions per second, the frequency range required for image production may extend beyond the range which the transmission channel is designed to transmit. Moreover, if the speed of the scanning disc varied appreciably, the frequency of, and therefore the propagation velocity of, the transmitted synchronizing current would vary sufficiently to cause the image at the receiver to move out of frame. The motor 12 is therefore maintained at a substantially constant speed ($24 \pm .01$ revolutions per second) under control of current from the tuning fork-controlled oscillator 205, generating constant frequency current of 5760 cycles, supplied to the primary winding of transformer 206 and current, the frequency of which is controlled in accordance with the speed of scanning disc 14, supplied to the primary winding of transformer 106, the frequency of this current being 5760 ± 2.3 cycles. The vacuum tubes 207 and 208 with their associated circuits constitute a balanced modulator and vacuum tubes 209 and 210 with their associated circuits constitute a second balanced modulator. The variable frequency source is applied to the input circuits of tubes 207, 208, 209 and 210 in phase. The voltage of constant frequency source 205 is applied to the input circuits of tubes 207 and 208 in phase opposition. The bridge circuit comprising resistive elements 211 and 212, each of .1 megohm, and the condensers 213 and 214 each of .0003 microfarad is employed for shifting the phase of the voltage from source 205 applied to the input circuits of tubes 209 and 210, so that the voltages from source 205 applied to tubes 209 and 210, respectively, will be 180 degrees out of phase with respect to each other but 90 degrees out of phase with respect to the voltages from source 205 applied to tubes 207 and 208. The four-phase synchronous motor 215 having stator windings 216, 217, 218 and 219, is driven by the difference frequency output currents from modulator tubes 207, 208, 209 and 210 in one direction or the other, depending upon whether the frequency of the current from transformer 106 is higher or lower than that of the constant frequency source 205. The higher frequency components of the modulated currents are shunted out by the 2-microfarad condensers 220, 221, 222 and 223. Anode potential for tubes 207, 208, 209 and 210 is provided by grounded battery 225 and the potential drop across the 1000-ohm resistive element 226 shunted by the 2-microfarad condenser 227, connected in the anode-cathode circuits provides biasing potential for the grids of tubes 207 to 210 inclusive.

The motor 215 drives, through suitable speed-reducing gears 230, a shaft carrying contact arm 231 for opening or closing contact 232 in accordance with the direction of rotation of the motor 215, and a shaft carrying an arm 233 for continuously varying the resistance of variable resistive element 234 in one direction or the other in accordance with the direction of rotation of motor 215. When the switch 235 is closed to its upper contact, as shown in the drawing, the manually adjustable resistive element 236 is connected in circuit with the shunt field winding 203 of motor 12 and, when the contact 232 is closed, the resistive element 237 shunts the resistive element 236. Thus when the motor 12 is moving too fast and the frequency of the current supplied to transformer 106 is greater than 5760

cycles, the motor 215 rotates in a direction to close contact 232 and thus cause the speed of motor 12 to decrease and vice versa. With this arrangement the scanning disc motor was found to hunt at a low frequency of about 1.5 cycles per second. This hunting can be eliminated by throwing the switch 235 to its lower position to connect the variable resistive element 234 in series with the shunt field winding 203. With this arrangement, when the speed of motor 12 is too high, the motor 215 will run in a direction to decrease the resistance of resistive element 234, causing motor 12 to slow down, and vice versa.

The sound track of the motion picture film 15 is scanned by the usual sound pick-up apparatus comprising a light source 250 and a photoelectric cell 251. The photoelectric cell is connected through amplifier 252 to a monitoring loudspeaker 255. The output of amplifier 252 is also connected to a modulator 256 supplied with carrier current from source 257 and the output of the modulator is transmitted over the coaxial conductor cable 48 to the distant receiver 49.

At the distant receiver 49, there are provided apparatus 260 for demodulating the image modulated carrier current from modulator 46, apparatus 261 for demodulating the synchronizing modulated carrier current from modulator 112 and the apparatus 262 for demodulating the sound modulated carrier current from modulator 256. The sound current from demodulator 262 is supplied to a loudspeaker 263 and the image current from demodulator 260 is supplied to the appropriate electrodes of cathode ray tube 264. The beam deflecting electrodes of the cathode ray tube are controlled by apparatus 265, which in turn is controlled by the synchronizing current from demodulator 261. The sweep control apparatus 265 may include a subharmonic generator for deriving a 24-cycle low frequency synchronizing current from the 5760 cycle high frequency synchronizing current and saw-tooth wave generators similar to those employed for controlling the potentials impressed upon the deflector plates 54 and 55 of the cathode ray image producing device 50.

The curves of Figs. 5 to 8 inclusive, depict the type of wave produced under control of the light beam from source 61 directed upon the electron multiplier 60.

Fig. 5 shows the type of synchronizing impulses produced across the resistive element 73 and impressed upon the grid of amplifier 75. These impulses are of non-uniform amplitude due to differences in light transmitting ability of different lenses, respectively, and, while not apparent from the drawing, are slightly irregular in occurrence due to slight irregularities in the positioning of lens 11.

Fig. 6 shows the constant amplitude impulses measured across the circuit consisting of resistive element 79 and battery 78 in series.

Fig. 7 shows the voltage wave produced across the resistive element 89 due to the alternate charging and discharging of condenser 88.

Fig. 8 shows the sine wave alternating voltage measured across the output of filter 110.

To obtain a small image of the illuminated aperture 38 upon the film 15, scanning disc lenses 11 having a short focal length are employed and the film is positioned to move in close proximity to the housing 14. It is impossible with this arrangement to direct light from another source 61 through a certain lens, at the time that it is in position to commence the scanning of a linear

portion of a picture frame, to an electron multiplier 60 to set up synchronizing impulses for controlling the deflection of the cathode beam of cathode ray tube 50 to return the cathode beam to position for commencing the scanning of a line. In the system described, light from source 61 is directed through a certain lens 11 prior to the time that said lens commences the scanning of a linear portion of a picture frame. With this arrangement, due to slight irregularities in the positioning of the lenses 11, there would be expected to occur phase variations between the time of commencement of scanning of a line and the time of production of a synchronizing impulse, thus causing the return sweep of the cathode beam of tube 50 to occur too soon at times and too late at other times with respect to the occurrence of the image current impulses corresponding to the first scanned elemental areas of the linear portion of the picture. To avoid such an occurrence, the delay network 151 is provided and the aperture plate 65 is made adjustable. In setting up the system for operation, such a number of delay sections of network 151 are connected in circuit that the time delay introduced by the network is approximately equal to the time which elapses between the time of producing a synchronizing impulse by a certain lens 11 and the time of commencement of scanning of the picture frame by said lens. For example, if this interval is equal to the time required for scanning three lines of the picture frame, the network is adjusted to give a delay of approximately $\frac{3}{5760}$ second. It can be determined by observing the image produced by the cathode ray tube 50 (the switch 138 closing the circuit to contact 150) whether the delay introduced is too large or too small. If the delay introduced is too small, an accurate adjustment can be made by moving the aperture plate 65 in the direction of movement of the lenses 11, and vice versa. When this adjustment has been made, the time delay introduced by network 151 will be equal to the interval between the production of a synchronizing impulse by a certain lens and the time of commencement of scanning a linear portion of the picture frame by said lens. When the sine wave synchronizing current from filter 110 is employed for controlling the high frequency deflection of the cathode beam of the image producing device 50 (switch 138 being in the position shown) the phase shifter 114 is adjusted to bring the image current and the high frequency deflecting impulses into proper time relationship.

If desired, the synchronizing impulses from the secondary of transformer 153 may be transmitted to the distant receiver 49, instead of the sine wave current from filter 110 for controlling the high frequency deflection of the cathode beam of the image producing device at that station. In that case, it may be found necessary to introduce an additional delay in the image current channel or the synchronizing channel to compensate for differences of delay in the transmission of the synchronizing and television currents, respectively, by the respective channels. Moreover, if desired, high amplitude synchronizing impulses of brief duration, such as those produced in the output circuit of amplifier tube 75, may be transmitted along with the television current during periods corresponding to brief intervals of interruption of scanning between successive scanning lines for controlling synchronism.

What is claimed is:

1. Television apparatus comprising means including a rotatable scanning device carrying a plurality of light directing elements for scanning the elemental areas in succession along successive parallel lines of a field of view to produce a television image current, means including said scanning device for generating synchronizing impulses in succession under control of light received from successive light directing elements, each light directing element controlling the production of a synchronizing impulse a certain period prior to the time of commencement of scanning a linear portion of the field of view by said light directing element, and electrical delay means for delaying each of said synchronizing impulses for a period equal to said first-mentioned period.

2. In a television system, means including a light source and a rotatable scanning disc having mounted thereon a plurality of light directing lenses for illuminating the elemental areas in succession along successive parallel lines of a motion picture film, light sensitive electric means for receiving light from the illuminated elemental areas to produce a television image current, a second light sensitive electric means, a second light source from which light is directed through said lenses in succession to said second light sensitive means to produce electric synchronizing impulses, means for delaying the transmission of said impulses, and an adjustable member having an aperture therein positioned in the light path between said second light source and said second light sensitive means, said member being adjusted to a position such that the delay occurring between the time that a synchronizing impulse is generated by light transmitted through a certain lens and the time of commencement of scanning of a linear portion of the motion picture film frame by light directed through said lens is compensated for by the delay introduced by said delay means.

3. In a television system, a rotatable disc having mounted thereon a plurality of lenses, means comprising said rotatable disc for scanning a field of view along successive linear paths to produce a television image current, means for generating synchronizing impulses comprising means for directing light through said lenses in succession, light being directed through each lens prior to the time that said lens is utilized for scanning, and means for compensating for irregularities in the positioning of said lenses comprising means for delaying the transmission of each synchronizing impulse to compensate for the time elapsing between the time of generation of an impulse under control of light transmitted through a certain lens and the time of commencement of scanning of a linear portion of the field of view by said lens.

4. In the method of television image transmission in which the line deflection of a cathode ray beam of an image producing device is under control of synchronizing impulses generated at a transmitter and in which the synchronizing impulse for returning the cathode beam to the position for commencement of scanning of a certain line is generated at the transmitter at least a considerable portion of a line scanning period prior to the commencement of scanning of said line at the transmitter, the step of delaying the transmission of the synchronizing impulse to compensate for the time interval occurring be-

tween the generation of the synchronizing impulse and the time of commencement of scanning said line at the transmitter, thereby compensating for variations in the intervals between successively generated synchronizing impulses.

5. The method of image transmission which comprises the steps of deflecting a cathode ray beam of an image producing device under control of synchronizing impulses, scanning a field of view line by line to produce an image current, generating a synchronizing impulse for returning the cathode beam to the position for commencement of scanning of a certain line prior to the commencement of scanning of said line at the transmitter by a period equal to at least a considerable portion of a line scanning period and delaying the transmission of the synchronizing impulses to compensate for variations in the periods between successively generated synchronizing impulses.

6. In a television system, means including a rotatable scanning device having a plurality of light transmitting apertures for scanning a field of view, a motor for driving said rotatable scanning device, a light sensitive electric device, means for directing light through said apertures in succession to said light sensitive electric device to produce current impulses in succession, a source of constant frequency alternating current, and means responsive jointly to said current impulses and said constant frequency alternating current for controlling the speed of said motor.

7. In a television system, means including a rotatable scanning device having a plurality of light transmitting lenses for scanning a field of view, a motor for driving said rotatable scanning device, a source of light, a light sensitive electric device controlled by light from said source directed through said lenses in succession for generating current impulses in succession, said impulses varying in amplitude somewhat due to variations in the light transmission ability of said lenses, means for converting said current impulses into recurrent current impulses of fixed amplitude, an independent source of constant frequency alternating current, and means responsive jointly to said fixed amplitude current impulses and to current from said source of constant frequency current for maintaining the speed of said driving motor substantially constant.

8. In a television system, apparatus for scanning a field of view, means for generating synchronizing impulses in succession at a rate determined by the speed of scanning the field of view, said impulses varying somewhat in amplitude, means for converting said synchronizing impulses into a sine wave alternating current of substantially constant amplitude, image producing apparatus, and means under control of said alternating current for maintaining said image scanning and said image producing apparatus in synchronism.

9. A television system comprising means including a rotatable lens disc for scanning a field of view to produce a television image current, image producing apparatus under control of said image current, an electron multiplier, means for directing light through the lenses in said disc in succession to said electron multiplier to produce recurring synchronizing impulses, the amplitude of which may vary due to variations in the amount of light transmitted to said electron multiplier by different lenses respectively, means for amplifying said impulses, a circuit comprising a condenser, a resistive element and a source of

current for charging said condenser, a gas-filled electric discharge device controlled by said amplified impulses for periodically discharging said condenser, means for amplifying said condenser charging and discharging current, a filter for transmitting only the fundamental frequency of the current from said last-mentioned amplifier, thereby producing a constant amplitude sine wave alternating current, and means controlled by said alternating current for maintaining the production of the image in synchronism with the scanning of the field of view.

10. In combination, means for scanning the elemental areas of a field of view line by line to produce an image current, a light sensitive electric device, means for directing a light beam upon said device, for a period which is short compared to a line scanning period, prior to the time of commencement of scanning of a predetermined line of the field of view, a cathode ray image producing device, and means for controlling the deflection of the cathode ray beam of said image producing device, said last-mentioned means comprising means for producing under control of said light sensitive device electric synchronizing impulses, and means for delaying said impulses for a period to compensate for the interval which occurs between the time that said light beam activates said light sensitive device and the time of commencement of scanning of said line.

11. In combination, an electron multiplier having a primary cathode, a plurality of secondary cathodes and an anode, an output circuit therefor, means for directing light of varying intensity upon said primary cathode to produce current of varying amplitude in said output circuit, a circuit having a normally high impedance connected between two of said secondary cathodes, and means for periodically reducing the impedance of said circuit to decrease the sensitivity of said electron multiplier.

12. In combination, an electron multiplier having a plurality of electrodes comprising a primary cathode, a plurality of secondary cathodes and an anode, an output circuit therefor connected between said anode and one of said secondary cathodes, means for applying biasing potentials to said electrodes, an electric discharge device having an anode, a cathode and a control electrode, means for connecting said last-mentioned cathode to one of said secondary cathodes, means for connecting said last-named anode to another of said secondary cathodes, means for negatively biasing the control electrode with respect to the cathode of said electric discharge device to prevent the flow of anode current, and means for periodically applying an impulse to said control electrode-cathode circuit to reduce the anode-cathode impedance of said electric discharge device thereby greatly reducing the sensitivity of said electron multiplier.

13. In combination, an electron multiplier having a plurality of electrodes comprising a primary cathode, an anode and a plurality of secondary cathodes at different positions respectively, between said primary cathode and said anode, means for applying to each of said secondary cathodes and to said anode a positive potential with respect to the potential of said primary cathode, the potential applied to each secondary cathode and to said anode being greater than the potential applied to the next preceding cathode, means for producing periodically recurring voltage impulses, and means under control

of said impulses for reducing the potential difference between two of said secondary cathodes.

14. In a television system, means including a light sensitive electronic device for setting up an image current having amplitude variations corresponding to the tone values of elemental areas in succession of a field of view, an image of which is to be produced, means for producing periodically recurring voltage impulses, and means under control of said impulses for periodically reducing the sensitivity of said electronic device to reduce the amplitude of said image current.

15. In a television system, means including a light sensitive electronic device for setting up a unidirectional image current having amplitude variations corresponding to the tone values of elemental areas in succession of a field of view, an image of which is to be produced, means for producing periodically recurring voltage impulses, and means under control of said impulses for periodically reducing the sensitivity of said electronic device to reduce the amplitude of said image current.

16. A television system comprising means including a light sensitive electric device for setting up a unidirectional image current having amplitude variations corresponding to the tone values of elemental areas in succession of a field of view, an image of which is to be produced, means including a cathode ray device under control of said image current for setting up an image, said device including means for producing a cathode ray beam, means for producing periodically recurring voltage impulses, means under control of said impulses for controlling in part at least the deflection of said cathode ray beam, and means under control of said impulses for periodically changing the sensitivity of said light sensitive electric device to change correspondingly the amplitude of said image current.

17. A television system comprising means at a transmitting station for scanning the elemental areas in succession along successive linear paths of a field of view to set up a television image current, a cathode ray image producing device at a receiving station under control of said image current for setting up an image of said field of view including means for producing a cathode beam and means for deflecting the beam at a substantially uniform rate from a first side of the image field to the second side and more rapidly from the second side back to the first side, means for producing a continuous substantially sine wave constant amplitude current at said transmitting station for transmission to said receiving station for controlling said deflecting means, and means for causing a reduction in the amplitude of said image current for a brief period between the scanings of successive lines to obliterate the cathode ray beam during its return movement from the end of one line to the beginning of the next line.

18. The combination with television scanning apparatus comprising means for continuously moving a motion picture film at a uniform rate and means for scanning all portions of said film in transverse elemental lines while it is moving to set up image currents representative of the scanned lines, of means for generating electrical synchronizing impulses and means under control of said impulses for substantially suppressing such portions of said current as are not already substantially zero between the scanning of successive frames for at least several line scanning periods.

19. The combination of claim 18 in which said scanning means comprises an electron multiplier for setting up the image current and said suppressing means comprises means for applying a periodic voltage to said multiplier under control of said synchronizing impulses.

20. In combination, an electron multiplier having a primary cathode, a plurality of secondary cathodes and an anode, an output circuit therefor, and means for applying a varying potential to at least one of said secondary cathodes with respect to said primary cathode for controlling the current in said output circuit.

21. In combination, a light sensitive electron multiplier tube, means for causing light to impinge upon said tube intermittently for generating electrical impulses, a gas-filled electric discharge device having a control circuit and an anode circuit and means for impressing said impulses upon said control circuit for causing current to flow in said anode circuit.

22. A signaling system comprising a light sensitive electron multiplier tube, an output circuit therefor, means for directing a modulated light beam upon said tube to produce a unidirectional signaling current in said output circuit, means for modulating alternating carrier current in accordance with variations of said unidirectional current, and means for directly conductively con-

necting said output circuit to said modulating means.

23. A television system comprising means including a movable scanning device having light directing apertures through which light is directed for scanning a field of view to produce a television image current, image producing apparatus under control of said image current, a light sensitive electronic device, means for directing light through the apertures in said scanning device in succession to said light sensitive device to produce recurring synchronizing impulses the amplitude of which may vary, means under control of said synchronizing impulses for producing a constant amplitude sine wave alternating current, and means controlled by said alternating current for maintaining the production of the image in synchronism with the scanning of the field of view.

24. In combination, means including a light source and a light sensitive device for generating recurring electric impulses the amplitude of which may vary, a condenser, means under control of said impulses for causing said condenser to be charged and discharged alternately, and means under control of said condenser charging-discharging current for producing a constant amplitude sine wave alternating current.

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