

Sept. 2, 1941.

C. F. MATTKE

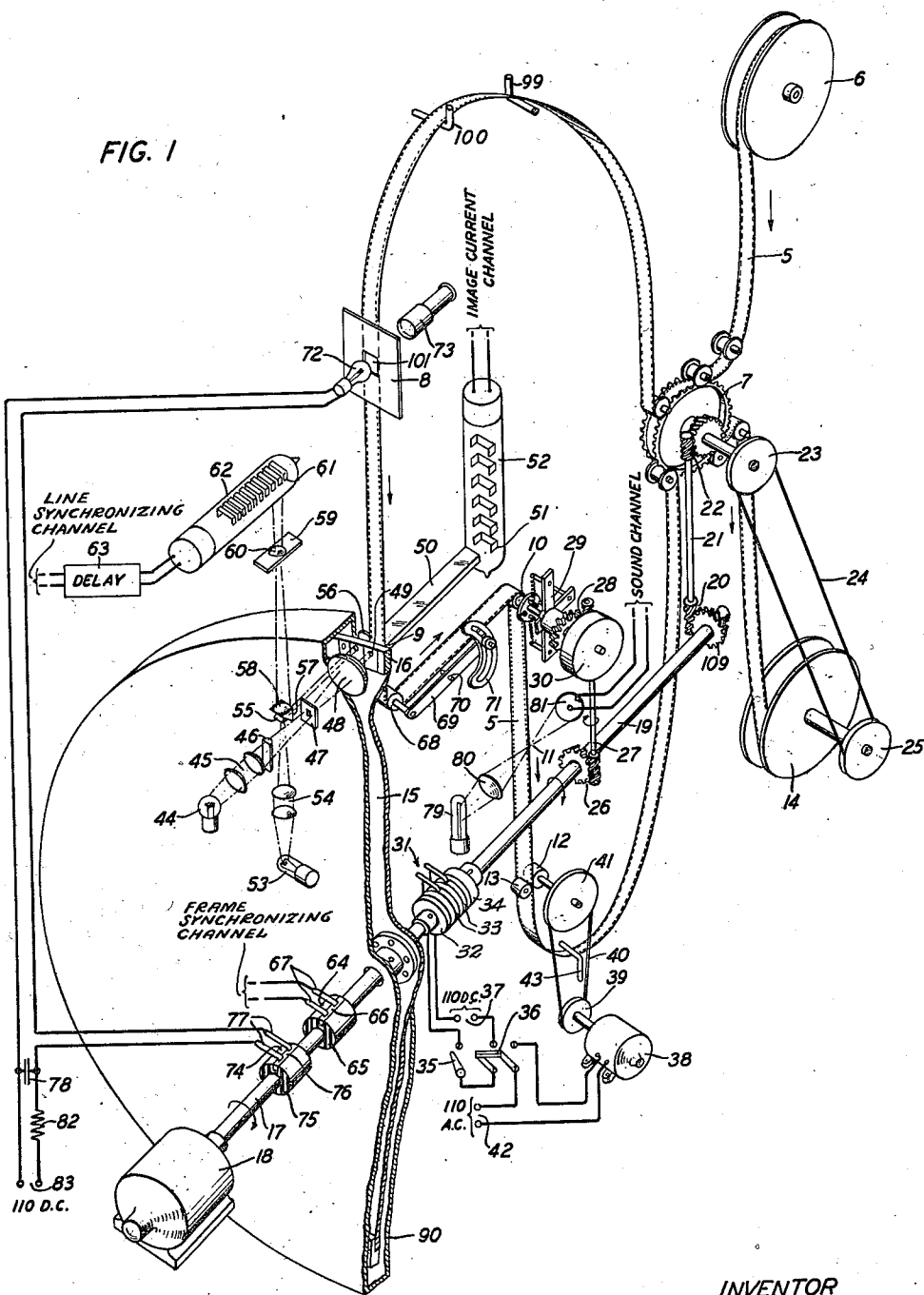
2,254,614

ELECTRO-OPTICAL SCANNING SYSTEM

Filed Oct. 15, 1937

5 Sheets-Sheet 1

FIG. 1



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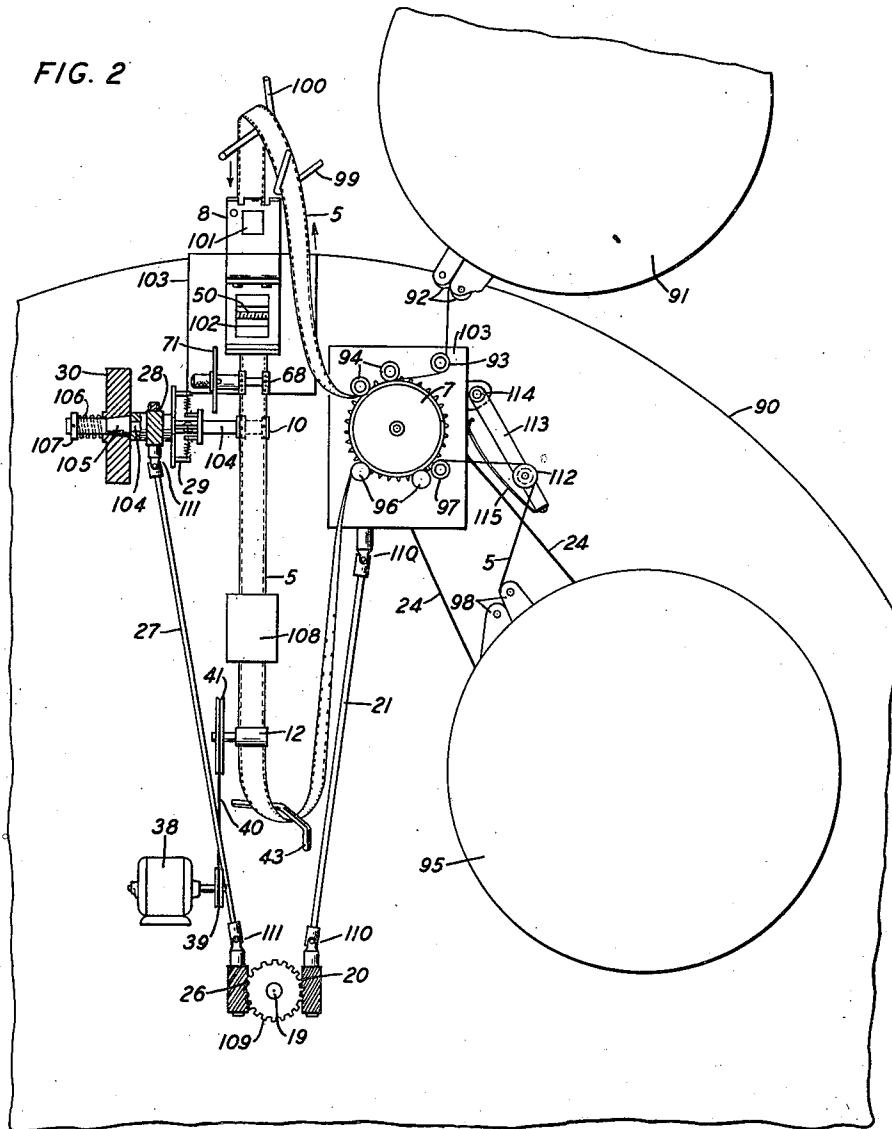
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5 Sheets-Sheet 2

FIG. 2



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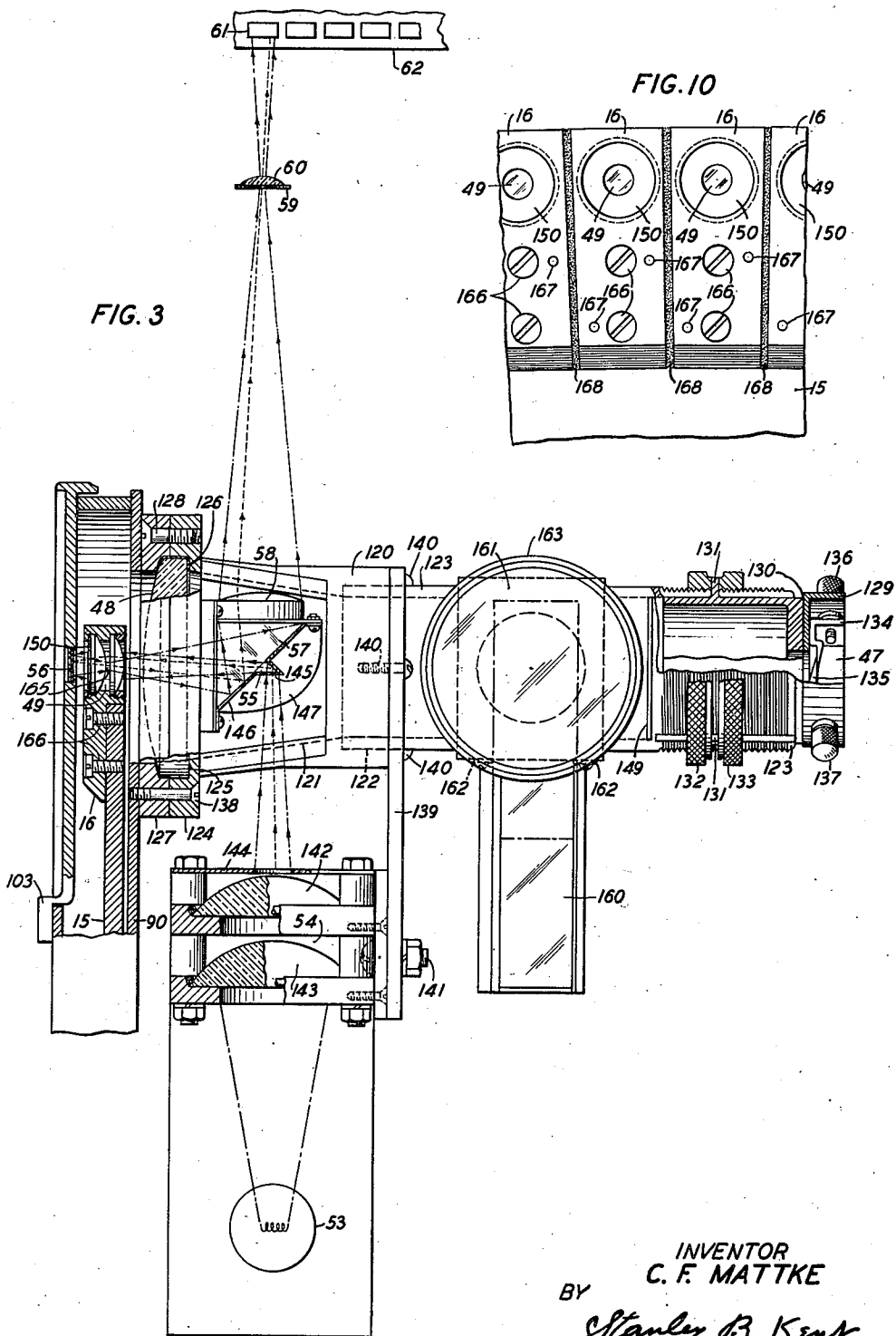
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ELECTRO-OPTICAL SCANNING SYSTEM

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5 Sheets-Sheet 3



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ELECTRO-OPTICAL SCANNING SYSTEM

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5 Sheets-Sheet 4

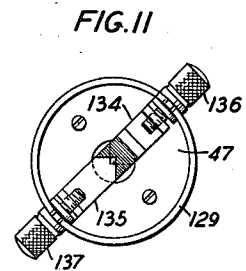
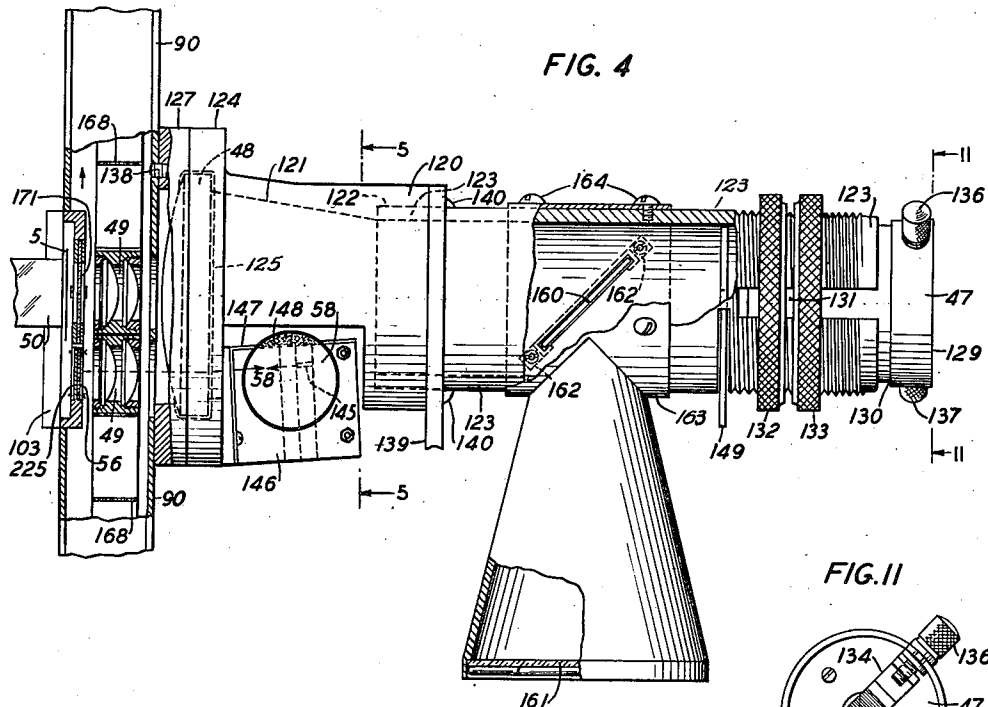
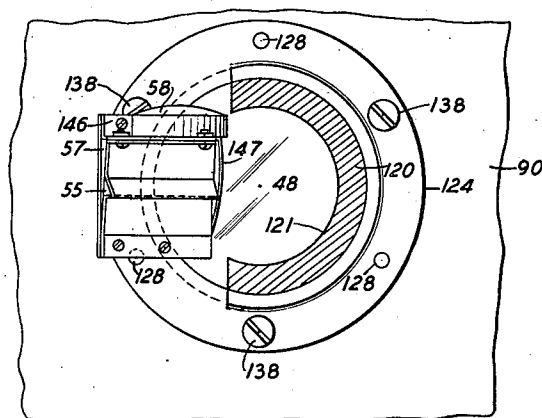


FIG. 5



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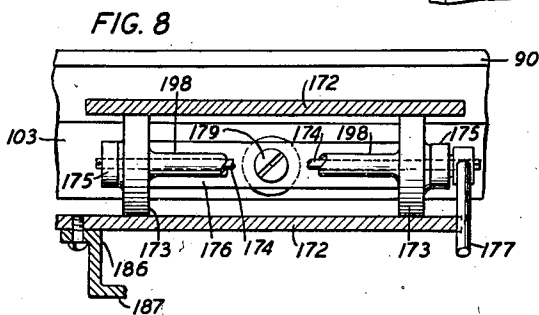
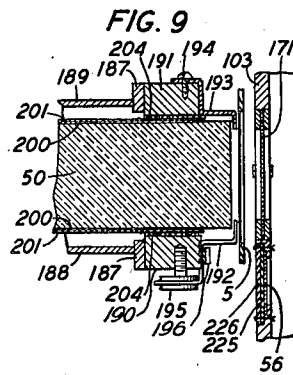
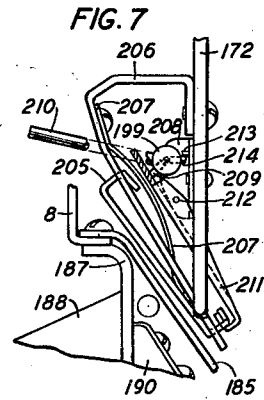
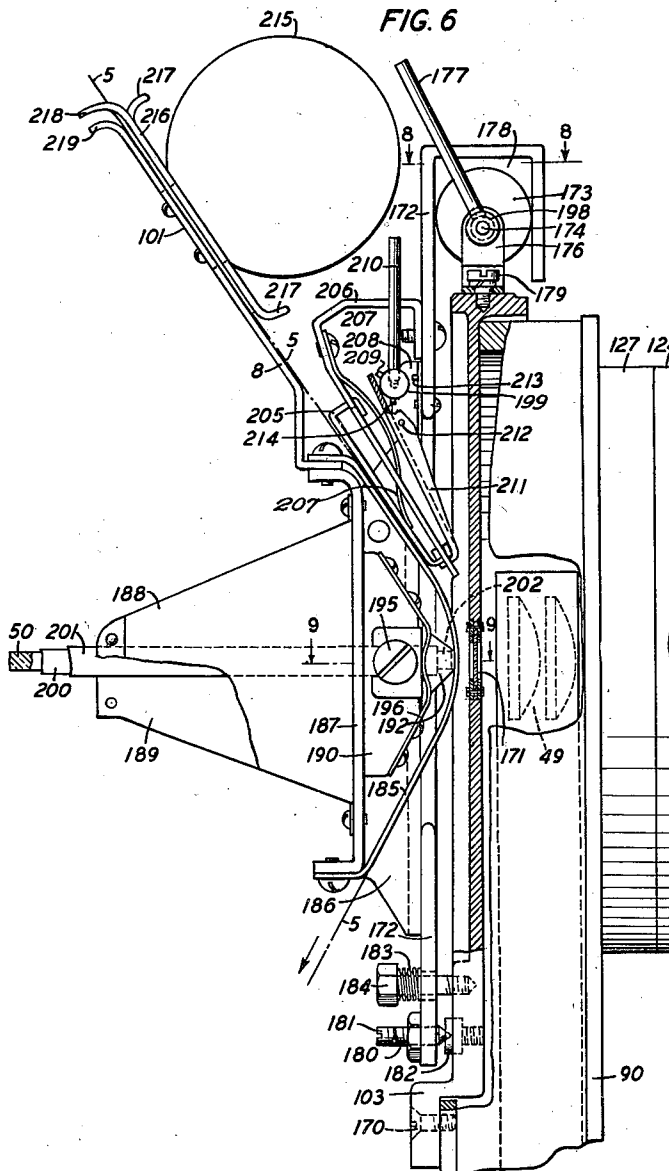
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ELECTRO-OPTICAL SCANNING SYSTEM

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5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE

2,254,614

ELECTRO-OPTICAL SCANNING SYSTEM

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8 Claims. (Cl. 178—69.5)

This invention relates to electro-optical systems and more particularly to method and means for effecting television.

An object of the invention is to provide improved television equipment.

In an example of practice illustrative of the invention, scanning of continuously moving motion picture film is effected by means of a rotating scanning disc carrying a ring of lenses. A compact optical unit is employed for producing the picture scanning light beam and the synchronizing light pulses. The synchronizing pulses are produced by light directed through a lens and reflected back through the same lens just prior to the time when that same lens starts to scan a line of the picture. The optical unit is securely bolted to the protecting casing surrounding the disc and comprises a collimating lens, an adjustable aperture, and an annular stop in the picture channel and a double prism with aperture and an objective lens for the synchronizing channel, the optical axis of the synchronizing channel being twice turned through 90 degrees while the optical axis of the picture channel is rectilinear. The film in its travel is caused to coincide with the plane of the principal foci of the disc lenses at the line of scanning and the picture scanning head is adjustable to effect proper positioning of the film. Framing indicating means is provided so that the operator may know by observation when a selected lens is scanning a given line of the picture. This framing indicating means comprises a frame observation gate through which the film passes, a flashing neon lamp for illuminating the portion of the film within this gate at the instant when the lens which is to scan the first line of a frame starts to scan a line, and a telescope for observing the observation gate, the observation gate being so positioned with respect to the scanning lenses that the distance along the film from the point of scanning to the edge of the observation gate where the film leaves the gate is an integral number of picture frames. The pressure pads which bear against the film to hold it close to the film guides in the scanning gate are releasable to facilitate threading the film through the gate. The main film sprocket which draws the film from the supply reel and feeds it to the take-up reel, and the scanning sprocket which pulls the film through the scanning gate, are driven through shafting and gears from a magnetic clutch on the end of the disc shaft. A flywheel on the scanning sprocket shaft is driven through

a friction coupling in order to relieve strains on the mechanism when the magnetic clutch is suddenly engaged. The film is pulled through the sound reproducing head by motor-driven friction rollers, the motor circuit being interlocked with the clutch circuit so that the clutch cannot be energized unless the motor circuit has been previously set to energize the motor. The light pulses which are produced by the synchronizing optical unit are directed to an electron multiplier which produces corresponding electrical impulses which may be used to control the line sweep circuit of a cathode ray tube television receiver. Since any given lens produces the synchronizing impulse a fraction of a scanning line period before that lens starts to scan a line, a delay network is inserted in the synchronizing channel.

A more detailed description of the invention follows having reference to the accompanying drawings, of which

Fig. 1 is a schematic drawing of film scanning equipment embodying this invention;

Fig. 2 is an elevation of such film scanning equipment looking toward the scanning disc from the film side with certain parts cut away or left out;

Fig. 3 is an elevation of the optical unit of this invention, partially in section, and including a portion of the scanning disc and housing;

Fig. 4 is a plan of the optical unit of Fig. 3;

Fig. 5 is a cross-section of the optical unit of Fig. 4 looking in the direction of the arrows 5;

Fig. 6 is an elevation, partly in section, of the picture scanning gate showing the adjustable focussing mechanism and the releasable pressure pad;

Fig. 7 is a fragment of Fig. 6 showing the pressure pad in released position;

Fig. 8 is a cross-section of a portion of the mechanism of Fig. 6 looking in the direction of the arrows 8;

Fig. 9 is a cross-section of Fig. 6 looking in the direction of the arrows 9;

Fig. 10 is a face view of a fragment of the scanning disc showing the mounting of the disc lens holders; and

Fig. 11 is an end view of the optical unit looking toward the adjustable aperture.

The same reference characters are used to indicate identical elements in the several figures of the drawings.

Referring now to Fig. 1, film 5 which is to be scanned is drawn from supply reel 6 by film feed

sprocket 7. The film 5 as it comes from sprocket 7 is drawn through framing indicating gate 8 and scanning position 9 by scanning sprocket 10. The film 5 as it comes from the scanning sprocket 10 is drawn through the sound scanning position 11 by a pair of motor driven steel friction rollers 12 and 13 which keep the film taut between sprocket 10 and rollers 12 and 13. The film 5 as it comes from rollers 12 and 13 is fed by feed sprocket 7 to film take-up reel 14.

Elemental linear transverse portions of film 5 are scanned at the position 9 by a moving spot of light produced by means including rotating scanning disc 15. The outer edge of disc 15 carries 240 lens holders 16 each provided with a pair of plano-convex scanning lenses. These lenses are all at the same radial distance from the center of the disc 15. The disc 15 is mounted on a shaft 17 which is driven by a motor 18 in the direction indicated by the arrow. The speed of motor 18 may be controlled by the same tuning fork (not shown) as is used to determine electrical frequencies in other elements of the television system.

The film feed sprocket 7 is driven from shaft 19 through gear and pinion 20, shaft 21, and gear and pinion 22. The film take-up reel 14 is belt driven from pulley 23 on the shaft of feed sprocket 7 by belt 24 driving pulley 25.

The scanning sprocket 10 is also driven from shaft 19 through gear and pinion 26, shaft 27, and gear and pinion 28. The gear of gear and pinion 28 is coupled to the shaft of scanning sprocket 10 by flexible coupling 29 of well-known design. Also mounted on the shaft of scanning sprocket 10 is a heavy flywheel 30. This flywheel 30 is driven by friction with the shaft of sprocket 10, the shaft being provided with a conical axle against which a conical bearing in flywheel 30 is pressed by means of a spring (shown in Fig. 2).

The shaft 19 is driven from shaft 17 through magnetic clutch 31. This clutch 31 comprises portion 32 which is rigidly secured to shaft 17 and an armature 34 flexibly connected to shaft 19 in fixed angular relationship with shaft 19 but longitudinally movable to engage the portion 32 on shaft 17. The portion 32 comprises an electromagnet energizable through slip rings 33. The energization of clutch 31 is controlled jointly by a single-pole single-throw switch 35 and the left-hand blade of double-pole single-throw switch 36. The energizing current is obtained from a 110-volt source of direct current (not shown) connected to terminals 37.

The friction roller 12 is belt driven by constant speed motor 38 through pulley 39, belt 40, and pulley 41. The friction roller 13 is spring pressed against the film 5 where it runs over roller 12. This pressure is sufficient to pull the film through the sound gate but not sufficient to injure the film even though the motor 38 is running and turning the roller 12 while the film is stationary due to the clutch 31 being deenergized. The function of the rollers 12 and 13 is to pull through the sound head any film which has passed by the scanning sprocket 10 and as rapidly as it passes by said sprocket. The motor 38 is energized from a 110-volt source of alternating current (not shown) connected to terminals 42 through the right-hand blade of switch 36. The motor 38 normally runs so that there is a slight slippage in the forward direction between the roller 12 and the film 5.

The energizing circuits of magnetic clutch 31 and sound motor 38 are interlocked through

switches 35 and 36 so the clutch 31 cannot be energized unless motor 38 is running or is ready to start running as soon as the clutch is energized. If this were not so and clutch 31 were energized before motor 38, scanning sprocket 10 would pile up film ahead of the sound head which rollers 12 and 13 would not take away and film feed sprocket 7 in trying to take film away from rollers 12 and 13 would place such a strain on the film that it would break at guide pin 43. If switch 35 alone is closed the clutch 31 is not energized because its energizing circuit is still open at the left-hand blade of switch 36. If switch 36 is now closed both the clutch 31 and motor 38 are energized simultaneously and normal operation occurs. If switch 36 alone is closed the motor 38 is energized through the right-hand blade and the energizing circuit of clutch 31 is partially completed through the left-hand blade of switch 36. The motor 38 and friction roller 12 start running but no injury to the film results as hereinbefore pointed out. As soon as switch 35 is closed clutch 31 is energized, film is fed to the sound head by sprocket 10 and taken away from the sound head by sprocket 7 and normal operation occurs. Injury to the film and improper operation of the film moving mechanism are prevented by this interlocking circuit.

The picture line scanning optical system comprises a source of light 44, a spherical lens unit 45, a cylindrical lens 46, an aperture member 47, a collimating lens 48, disc lens units 49 and a highly efficient light conductor 50. This optical system has rectilinear axes which are at right angles to the plane of the disc 15 and film 5 at the picture scanning position 9. An image of the aperture in member 47 is formed at the principal focus of each disc lens unit 49 while such unit is in the beam of collimating lens 48 formed by light rays from the source 44. As the disc 15 rotates this image moves across the portion of the film 5 in the scanning gate. The diverging rays from this image, controlled in intensity by the tone values of the scanned portions of the film 5, are gathered by the light conductor 50 and impressed upon the light sensitive cathode 51 of multistage electron multiplier 52, the output circuit of which is connected to a suitable image current channel. The multiplier 52, shown conventionally, may be of any suitable type known to the art.

The synchronizing optical system comprises a source of light 53, a condensing lens unit 54, a small reflecting prism 55 provided with an elongated aperture adjacent to its incident face, one edge of collimating lens 48 and disc lens unit 49 which is next on the left of the effective line scanning lens unit as viewed in Fig. 1, a plane mirror 56 to direct light rays from disc lens unit 49 back through the same lens unit and collimating lens 48, large reflecting prism 57, objective lens 58, aperture plate 59 and lens 60. The optical axis of this synchronizing lens system is twice turned through 90 degrees, once by prism 55 and again by prism 57. Each disc lens unit 49 during the course of its movement through the light beam from source 53 forms an image of the aperture on the incident face of prism 55 by light rays reflected by the mirror 56 in the neighborhood of its own optical center and lens 58 forms an image of this image at the aperture plate 59. As this second image at plate 59 sweeps across the aperture in plate 59 the diverging rays passing through the aperture are gathered by lens 60 and directed to the light sensitive cathode 61 of synchronizing multistage electron multiplier

62, the output circuit of which is connected through delay circuit 63 to a suitable picture line synchronizing channel. Multiplier 62, also shown conventionally, may be of any suitable type known to the art.

Since the image on aperture plate 59 sweeps across the aperture very rapidly during normal scanning of the film an electrical impulse of short duration is produced by the multiplier 62 as each disc lens unit 49 becomes effective to produce a line synchronizing pulse shortly before it starts the scanning of a picture line. The delay network 63 delays this impulse in time so that it is available in the synchronizing channel just before the line scanning begins. In a specific embodiment of the invention herein disclosed this delay is less than the time required to scan one picture line. In other words, the disc lens unit producing the synchronizing pulse is adjacent to, but following with reference to the direction of rotation of the disc, the disc lens unit then effective in scanning a picture line. This is made possible by the arrangement of the optical elements in a compact unitary structure and utilizing reflected rays in the synchronizing optical channel.

The delay network 63 effects the major portion of the phase shift of the synchronizing impulses with respect to the image current. Further adjustment of this phase relationship is effected by adjustment of aperture plate 59 to vary the position of the aperture along the path of the moving synchronizing image.

Frame synchronizing impulses are controlled by circuit closer 64 which comprises an insulating collar 65 rigidly secured to shaft 17 and provided with a metallic contact bar 66 which conductively connects brushes 67 once during each revolution of the disc 15. The conductors connected to brushes 67 lead to a suitable frame synchronizing channel wherein an impulse of current occurs each time brushes 67 contact bar 66. Brushes 67 and bar 66 are so positioned that the frame scanning impulse occurs just before one of the disc lens units 49 starts to scan a picture line. If this impulse is used to control the frame sweep circuit of a cathode ray television receiver the disc lens unit about to start scanning will scan what will appear as the first line of the received picture. Such disc lens unit will hereinafter be called "disc lens No. 1."

In order, therefore, that the picture produced at the cathode ray receiver shall correspond to a complete frame of the motion picture film 5 it is necessary that disc lens No. 1 scan the leading edge of each frame or preferably the trailing edge of the blank space between frames. An adjustable framing device is therefore provided comprising a roller 68 carried on an arm 69 which is rotatable around a pivot 70. This arm 69 may be fashioned in any desired position by a nut on a threaded stud which extends through a circular slot in fixed support 71. Roller 68 engages a loop in film 5 between scanning sprocket 10 and picture scanning position 9. By rotating arm 69 the length of film between sprocket 10 and scanning position 9 may be changed so that disc lens No. 1 will scan the leading edge of each frame after the energization of clutch 31 which energization starts the motion of the film 5. The received picture then will be in frame at the cathode ray receiver.

It is desirable that the operator at the transmitter shall be able to ascertain when the adjustment is such that the picture will be in frame

without reference to the picture at the receiver. A framing indicating device is therefore provided which comprises the framing indicating gate 8 intermittently illuminated by neon lamp 72 and observed preferably through telescope 73. The neon lamp 72 is energized once during each revolution of the disc 15 by circuit closer 74 which comprises an insulating collar 75 rigidly secured to shaft 17 and provided with a metallic contact bar 76 which conductively connects brushes 77 once during each revolution of disc 15. The circuit closer 74 completes an energizing circuit for neon lamp 72 through condenser 78 which condenser is charged through resistance 82 by current from a 110-volt source of direct current (not shown) connected to terminals 83. This circuit is closed when disc lens No. 1 starts to scan a picture line and the observing gate 8 is so positioned with respect to the scanning position 9 that a full frame of the film 5 is in the gate 8 when the leading edge of a frame is being scanned by disc lens No. 1. If the operator after energizing clutch 31 to start the film in motion adjusts the roller 68 until a full film frame is seen in film gate 8 when looking through telescope 73, he will know that the image currents and both the line and frame synchronizing impulses are in proper phase relationship to produce an image in full frame at the receiver.

This framing indicating device may have other adjustments than that just described depending upon the angular position of circuit closer 74 with respect to disc lens No. 1 and the length of film between observing gate 8 and scanning position 9. For one such alternative adjustment, for example, an indicator pointer is placed on one side of the observing gate 8 intermediate the top and bottom of the gate, the position of the scanning gate being such that when a full frame of the film is in the gate and the scanning mechanism adjusted so that disc lens No. 1 is scanning the leading edge of another frame, this indicator points to the middle of the frame in the gate. The circuit closer 74 is adjusted to cause neon lamp 72 to flash after disc 15 has turned a half revolution beyond the scanning position of disc lens No. 1. With this adjustment the operator will know that the framing mechanism is properly set to produce images in full frame, if he sees in the observing gate 8 portions of two adjacent frames with the indicator pointing to the leading edge of the incoming frame. The use of such an indicator pointer appears to make possible more rapid framing.

The sound head is of well-known design and is represented schematically by light source 79, objective lens 80 and photoelectric cell 81. The lens 80 forms an image of the light source 79 or an image of an aperture illuminated by such light source at the sound track on film 5 and the transmitted rays energize the photoelectric cell 81. The output current of cell 81 is connected to a suitable sound channel. The length of film between the picture scanning position 9 and the sound scanning position 11 is approximately the same as that between the picture taking position and the sound recording position in the sound camera used in making the film 5. In the adjustment of framing roller 68 this length of film may vary by as much as half a frame length. Such variation has a negligible effect upon the synchronization of the reproduced picture and accompanying sound effects.

The arrangement of certain portions of the equipment schematically illustrated in Fig. 1 is

further shown in Fig. 2 which is a view in elevation of certain parts of the equipment looking toward the scanning disc from the film side of the disc. The scanning disc 15 rotates within a sheet-iron housing 90 which is rigidly secured to suitable framework (not shown) including the bearings of the shafts 17 and 19 and the main driving motor 18. The film supply reel 6 is mounted in housing 91, the film feeding out between guide rollers 92 and under guide roller 93 to the upper side of film feed sprocket 7, against which it is held by rollers 94. The take-up reel 14 is mounted in housing 95, the film feeding into this housing from the lower side of film feed sprocket 7 against which it is held by rollers 96 over guide rollers 97 and 112 and between guide rollers 98.

The roller 112 is mounted on an arm 113 pivoted on a pin 114. A spring 115 secured to the movable end of arm 113 bears on the edge of casting 103 and tends to push the arm 113 upward. The loop of film between film feed sprocket 7 and rollers 98 is thus of variable length. This variable loop is provided to prevent injury to the film 5 when it is quickly started upon the energization of magnetic clutch 31. Since the take-up reel 14 is belt-driven from the shaft of sprocket 7, the belt tension being such that there is some slippage, there is a tendency for the reel 14 to come up to speed more slowly than film 5 is fed from sprocket 7 and then with heavy reels to overrun the supply speed of the film sufficiently to break the film unless the strain is eased by shortening of the loop against the pressure of spring 115. The friction between the spring 115 and the bearing surface on casting 103 is sufficient to overcome any tendency to oscillate.

As the film feeds from the upper side of sprocket 7 it passes over two guide pins 99 and 100 whereby the plane of the film is turned through 90 degrees and the direction of movement reversed from upward to downward as shown by the arrows. After leaving pin 100 the film passes into framing indicating gate 8 where it may be observed in aperture 101 which is an opening the size of a motion picture frame. The neon lamp 72 which is positioned back of this aperture and the observing telescope 73 which is positioned in front thereof are not shown in this view. Immediately below gate 8 is the picture scanning gate housing 102 which is located at picture scanning position 9. This housing 102 and the framing indicating gate 8 are secured to a supporting casting 103 which is bolted to the disc housing 90. The light conductor 50 is shown in cross-section.

As the film passes from the picture scanning gate housing 102 it passes over framing roller 68 to scanning sprocket 10. In Fig. 2 framing roller 68 with its supporting mechanisms is shown somewhat above its normal position behind scanning sprocket 10 for clearness of illustration. Film sprocket 10 is rigidly secured to shaft 104 which extends through and serves as an axle for the gear of gear and pinion 28 and the driving portion of flexible coupling 29. The flywheel 30 has a conical bearing which is journaled on conical axle 105 secured on the end of shaft 104. Flywheel 30 is forced against the axle 105 by a coiled spring 106, the outer end of which is held by collar 107, also rigidly secured to the shaft 104. This friction coupling between the flywheel 30 and the shaft 104 permits the flywheel to come up to speed slowly

when the shaft is started rapidly and thus obviates destructive strains being placed on the mechanism when the film is started rapidly as in normal operation.

Sound head 108 located at the sound scanning position 11 is merely indicated by a block.

The gears of gears and pinions 20 and 26 of Fig. 1 are preferably constructed as a single gear 109 as shown in Fig. 2, the respective pinions meshing with this gear on opposite sides thereof. Space is thereby conserved and the equipment can be made more compact.

The shafts 21 and 27 are provided with universal couplings 110 and 111, respectively.

Further details of the compact unitary optical arrangement for picture line scanning and synchronizing light pulse production are shown in Figs. 3, 4 and 5. Source of light 53, condensing lens unit 54, aperture plate 59, lens 60 and light sensitive cathode 61 of electron multiplier 62 are omitted from Fig. 4. This compact arrangement of the optical elements makes it possible to use each disc lens unit 49 during operation to first produce a synchronizing pulse and then, within less than a line scanning period, to start the scanning of a line. The delay necessary in the synchronizing channel is reduced to a minimum without introducing deleterious interference between the picture scanning optical channel and the synchronizing optical channel.

This unitary optical arrangement comprises a casting 120 having a conical bore 121 at one end and a cylindrical bore 122 at the other. Within the cylindrical bore 122 a circular tube 123 is inserted in any suitable manner, as by "sweating." At the larger end of the casting 120 a flange 124 is provided. A cylindrical recess 125 is provided in the open end of flange 124 which constitutes a seat for collimating lens 48, a soft paper gasket 126 being placed between the lens and its seat. A ring 127 fastened to the face of flange 124 by three screws 128 retains the lens 48 in fixed position. The gasket 126 also extends between the ring 127 and the lens 48.

At the open end of the tube 123 the aperture member 47 is located. This member 47 comprises a cup-shaped member 129 secured to another cup-shaped member 130, bottom to bottom. There are central apertures in the bottoms of both cup-shaped members 129 and 130. The sides of member 130 slide inside of tube 123. Three lugs 131 extend from the sides of member 130 and enter corresponding slots in the end of tube 123. Member 130 may be moved longitudinally with respect to tube 123 by knurled, internally threaded rings 132 and 133 which cooperate with the threads on tube 123. The lugs 131 may be clamped between rings 132 and 133 to maintain a fixed relationship between member 130 and tube 123. Within the cup-shaped member 129 are two adjustable jaws 134 and 135, controlled by knurled screws 136 and 137, respectively. Jaws 134 and 135 are provided with overlapping V-shaped notches as shown in Fig. 11. A square aperture is formed between jaws 134 and 135. The size of this aperture, as well as its position transversely of tube 123, are determined by the position of jaws 134 and 135. The aperture in member 47 is thus adjusted to proper size and positioned in the axis of collimating lens 48 by the adjustment of screws 136 and 137 while it is positioned at the principal focus of lens 48 by the adjustment of rings 132 and 133. By changing the angle of the V-shaped notches in jaws 134 and 135 other shapes of apertures may be obtained.

This unitary optical arrangement is bolted to the disc housing 90 by screws 138 passing through flange 124 and ring 127 into the side of housing 90. A hole is cut in housing 90 about the same size as the hole in the ring 127. The optical axis of collimating lens 48 is approximately the same distance from the center of disc 15 as are the optical axes of disc lens units 49.

The synchronizing light source 53 and condensing lens unit 54 are supported from casting 120 by bracket 139 which is bolted to the end of casting 120 by studs 140 and to the condensing lens unit 54 by bolt 141. The condensing lens unit 54 comprises two plano-convex lenses 142 and 143 and a stop 144. Stop 144 has a circular aperture so as to limit the divergence of the beam passing through aperture 145 on the incident face of small prism 55 to prevent interference with the picture scanning beam.

Prisms 55 and 57 and lens 58 are mounted in a holder 146 which is bolted to the flange 124 of casting 120. The prism 55 is cemented to prism 57 by Canada balsam so that light rays are not deviated in passing through the adjacent faces of these prisms. The prisms 55 and 57 are set at an angle, as shown in Figs. 4 and 5, to compensate for the bending of the optical axes of disc lens units 49 as they pass through the edge of collimating lens 48. In order to provide space for the prism holder 146, a portion of the casting 120 is cut away. As a further means of preventing interference between the picture scanning and synchronizing optical channels, an opaque screen 147 is provided adjacent to one of the ends of prisms 55 and 57 and portion 148 of lens 58 which extends beyond screen 147 is painted black.

In a hole in the disc housing 90 opposite collimating lens 48 is a casting 103 which supports the picture scanning gate and the synchronizing mirror 56. This casting is secured to the housing 90 by screws. The picture scanning gate guides the film 5 and holds one end of the light conductor 50 in the position shown in Fig. 4. A piece of transparent glass is placed over an opening in casting 103 between the film 5 and disc lens units 49 to permit the picture scanning rays to reach the film 5 without leaving a physical opening in the disc housing.

The inside surfaces of casting 120 and tube 123 are painted black to minimize reflection. The picture scanning beam is prevented from impinging on these surfaces by a removable stop 149 which is inserted in a transverse slot in the side of tube 123 between the aperture in member 47 and collimating lens 48. The aperture in this stop 149 is large enough to so fill collimating lens 48 with light rays from the aperture in member 47 that disc lens units 49 are completely filled with light when in the picture line scanning position. Each lens disc unit 49 is provided with a stop 150, the aperture in which is about one-half the diameter of the lens of this unit. By stopping down these lenses a more uniform size of scanning spot is obtained since small variations in the distance between the emulsion of film 5 and the disc lens units 49 have less effect on the size of the scanning spot.

In order to facilitate adjustment of the picture scanning optical system, movable mirror 160 and a ground glass screen 161 are provided. This mirror 160 may be slid up between guides 162 to intercept the light beam from the aperture in member 47 and direct it to screen 161. The size and location of the spot on screen 161 give an

indication of the size and position of the spot which will be formed on collimating lens 48 when the mirror is lowered out of the path of the beam. The screen 161 and mirror 160 are mounted in a housing 163 which is secured to tube 123 by screws 164.

In operation, the aperture in member 47 is illuminated by light rays from source 44, the source being imaged on the aperture by lenses 45 and 46, as shown in Fig. 1. The cylindrical lens 46 is used because the light source 44 is longer in the horizontal direction than in the vertical. By using lens 46 the image is substantially compressed in a horizontal direction, resulting in a more intense illumination of the aperture in member 47. The rays passing through the aperture in member 47 and through the aperture in stop 149 are collimated by lens 48. As the disc lens units 49 travel across this beam the rays passing through units 49 are brought to a focus in the plane of the principal foci of these units which is in the plane of the emulsion of film 5 for minimum size of scanning spot. By this arrangement a reduced image of the aperture in member 47 is formed on the film 5 at the scanning position 9. This spot travels transversely across the film 5 as each lens disc unit 49 becomes effective for picture line scanning. At the same time a beam of light from synchronizing source 53 is condensed on aperture 145 by condensing lens unit 54. The rays which pass through aperture 145, form, after reflection by small prism 55, passage through the edge of collimating lens 48 and reflection by mirror 56, an image 165 of the aperture 145 at approximately the center of disc lens unit 49 following the lens disc unit then effective for picture line scanning. The rays passing from the image 165 are reflected by large prism 57 to lens 58 which lens forms an image of image 165 at aperture plate 59. As disc lens unit 49, which is effective for producing the synchronizing pulse, moves with the disc 15 following the lens unit 49 which is effective for picture scanning, the synchronizing image on aperture plate 59 moves upward perpendicularly to the plane of the paper in Fig. 3. When it crosses the aperture in plate 59 a pulse of light energizes cathode 61 of electron multiplier 62 to produce an electrical synchronizing impulse. The aperture in plate 59 is so positioned that this impulse occurs when the picture line then being scanned is about half scanned.

In Fig. 3 the boundary rays of the synchronizing light beams are indicated by dot and dash lines. The path of one typical ray passing through the center of aperture 145 and, therefore, the center of image 165 is indicated by dotted lines. The arrows on these ray lines indicate the direction of propagation of the rays. The optical axis of one of the disc lens units 49 in one position showing how it is bent in passing through the edge of collimating lens 48 is indicated by the dotted line with arrows in Fig. 4. This compact unitary optical arrangement makes it possible to use the same disc lens unit 49 for producing a synchronizing pulse and later scanning a picture line the reproduction of which is partially controlled by said synchronizing pulse. This result is effected with negligible interference between the picture line scanning and synchronizing optical systems and requires delaying the synchronizing electrical impulses less than the period required for scanning a picture line.

The lens holders 16 for disc lens units 49 are

L-shaped members in section, as shown in Fig. 3. The two plano-convex lenses of each lens unit 49 are seated in a hole which extends lengthwise through the shorter leg of lens holder 16. The longer leg is bolted to the outer edge of disc 15 by machine screws 166 and accurately positioned by pins 167. The relative positions of the lens holders 16 on the face of disc 15 are shown in Fig. 10. The space 168 between the holders 16, after they have been mounted on the disc 15, is filled with "Krackno" in order to prevent light from lens 48 passing between holders 16 to the film 5 and light conductor 50 and also to minimize air friction when the disc 15 is rotating in the housing 90. Only one lens holder 16 is shown in Fig. 3 for clearness of illustration.

Further details of the picture scanning gate are illustrated in Figs. 6, 7, 8 and 9. The casting 103 is shown secured to housing 90 by machine screws 170, one only of which is shown. The relative location of one disc lens unit 49 and the boundaries of the other disc lens units are indicated by dotted lines within the housing 90. Lens ring 127 and a portion of the flange 124 of casting 120 is shown attached to the opposite side of housing 90. Within the aperture in casting 103, through which the picture is scanned, a piece of transparent glass 171 is secured.

The picture scanning gate comprises an adjustable plate 172, the upper end of which is bent to form a channel which fits over two eccentric cylindrical cams 173. These cams are integral with an axle 198 extending therebetween, which axle is mounted on and secured to a shaft 174, which is supported by bearings 175 in the legs of a shallow U-shaped member 176. The shaft 174 with the cams 173 may be rotated by the lever 177, which is secured to the end of shaft 174. The plate 172 with cams 173 and their mounting elements constitutes an adjustable support 178 for the film gate and associated elements. This support 178 is mounted on casting 103 by a three-point suspension. One point of this suspension is the machine screw 179, which passes through a hole in the base of U-shaped member 176, into a threaded hole in casting 103. The other two points of suspension are pivot screws 180 and 181 located near the sides and at the lower end of plate 172, the conical pivot ends of which seat in recesses in screws 182 set in casting 103. The upper portion of pivot screw 180 is broken away in order to show pivot screw 181 situated behind it. The pivot screws 180 and 181 are held in their seats by coiled spring 183 and machine screw 184. The screw 184 passes through a hole in plate 172 and is threaded into a hole in casting 103.

In order to allow space for threading the film 5 over the curved film guide 185, a portion of plate 172 is cut away. At the rear of plate 172 there is secured a lip 186 which is integral with plate 187. Plate 187 serves as a support for the framing indicating gate 8, the film guide 185, the guide wings 188 and 189 for light conductor 50, and the guide and support blocks 190 and 191, which in turn support jaws 192 and 193 respectively for determining the transverse portion of film 5 which is scanned. Jaw 193 is secured to block 191 in fixed position by screw 194. Jaw 192 is adjustable by means of screw 195 and is held against block 190 by spring 196. The adjustment of jaw 192 determines where the scanning of the picture line begins and so makes it possible to vary the period between line scan- nings.

The light conductor 50 is wrapped in black paper 200 and inserted in a copper tube 201 of rectangular cross-section. The end 202 of light conductor 50 which is nearer the film 5 extends beyond the copper tube 201 and paper 200, as indicated by dotted lines in Fig. 6. The corresponding end of the copper tube 201 is inserted between support blocks 190 and 191, a felt pad 204 being provided between the support blocks and the tube. The clearance between the support blocks and the tube is such that the tube may be easily removed if desired.

It is thus seen that the film 5 which is threaded and runs over film guide 185 may be moved toward or away from disc lens units 49 by rotating cam handle 177 and cams 173, thereby moving plate 172 around the points of pivot screws 180 and 181. The emulsion on the film 5 may thus be brought into coincidence with the principal foci of disc lens units 49. By adjusting pivot screws 180 and 181 the plane of the film 5 at the scanning position 9 may be positioned parallel to the path of the principal foci of disc lens units 49 as the disc 15 rotates. The picture scanning spot, therefore, remains of constant size at the film emulsion as the spot travels across the film 5 during normal scanning operation.

The film 5 is held against the upper part of the film guide 185 by releasable pressure pad 205, the film being drawn against the lower part of film guide 185 by film sprocket 10, which pulls the film through the picture scanning gate over framing roller 68. This pad 205 is supported from plate 172 by bracket 206. The operating mechanism for pad 205 includes a spring 207 which exerts pressure on the back side of pad 205, tending to force it against the film guide 185. The rotatable shaft 199 supported in a bearing member 208 secured to plate 172 is provided with a pin 209 which when the shaft is rotated in a counter-clockwise direction by handle 210 forces down the left-hand end of lever 211, which is pivoted at point 212. The right-hand end of lever 211, by means of a hooked connection with pressure pad 205, pulls the pad away from the film guide 185 against the pressure of spring 207. The pad 205 is shown in retracted position in Fig. 7. The shaft 199 is stopped in the releasing position by stop-pin 214 contacting with stop 213.

The housing 215 for neon lamp 72 is secured to frame indicating gate 8, a film guide plate 216 being located between the housing 215 and the gate 8. This plate 216 has turned-up portions 217 above the film and a turned-down portion 218 on either side of the film 5 to guide the film centrally in the gate. The gate 8 also has a turned-down portion 219 below the film where the film enters the gate. The aperture in the gate 8, which is the size of a film picture frame, is indicated by dotted lines.

The mounting of the synchronizing mirror 56 is further illustrated in Fig. 9. This mirror 56 backed by a piece of soft cardboard 226 and a metallic plate 225 fits into an aperture in casting 103. Plate 225 is fastened to the casting 103 with screws. By removing the plate 225, the mirror 56 may easily be removed and cleaned.

In a specific embodiment of the invention which has been operating satisfactorily in a television system producing images from ordinary sound motion picture film at the rate of twenty-four frames per second, scanning disc 15 carries 240 lens disc units 49 on $\frac{7}{8}$ inch centers. The centers of the disc lens units 49, therefore, are approxi-

mately $33\frac{1}{2}$ inches from the center of the disc 15, the disc diameter without the lens holders 16 being slightly less than 66 inches. The lenses of the lens disc units 49 are slightly less than $\frac{3}{4}$ inch in diameter and are stopped down to $\frac{3}{8}$ inch. The relative dimensions of the apparatus elements are shown rather accurately in Figs. 3 to 11, inclusive, certain of the elements being exaggerated in size for the sake of clearness. For best results the aperture in aperture member 47 is a square 30 mils on each side and the image of the aperture formed at the emulsion of film 5 is a square 3 mils on each side. The synchronizing aperture 145 on small prism 55 is a rectangle $\frac{1}{8}$ inch by $\frac{3}{8}$ inch. Disc 15 rotates twenty-four times per second producing 5,760 line synchronizing light pulses per second. Since each synchronizing pulse is produced prior to the time when it is used to initiate a line scanning at the receiver by a period less than one-half of a line scanning period it is only necessary to delay the electrical synchronizing impulses less than 1 divided by 11,520 parts of a second. Because of the novel construction of the unitary optical arrangement of this invention, such a small delay is made possible without introducing troublesome interference between the picture line scanning and synchronizing optical channels.

What is claimed is:

1. An optical device for producing recurring impulses of radiant energy of short duration, comprising a source of light, means to illuminate a small aperture, a movable lens, a reflector in the path of light rays from said aperture through said lens for reflecting rays back through said lens, said aperture, lens and reflector being so located that an image of said aperture is formed outside the plane of said aperture by reflected rays, means to move said lens past said aperture and reflector periodically, and means to utilize the rays from said image only while said lens is traversing a small portion of its path between said aperture and reflector.

2. A synchronizing optical system for television comprising a rotatable television scanning disc having a circle of lens-equipped apertures, an aperture so located that the axes of the lenses on the disc pass therethrough as the disc rotates and at a point on the axis outside the principal focus, a plane mirror parallel to the plane of the disc also intercepted by the axes of said lenses when the axes intercept said aperture on the side of the disc opposite to said aperture and in the neighborhood of the principal foci of said lenses, a second aperture, and means to form an image at said second aperture of the image of said first aperture formed by said lenses with rays from any lens reflected back through the same lens.

3. A scanning system comprising a rotating disc carrying a plurality of lenses angularly spaced around said disc, an optical system on a rectilinear axis comprising a source of light for directing image scanning light through said lenses in succession, and another optical system comprising a second source of light having axes in part parallel to the axis of said image scanning optical system and in part transverse thereto also directing light through said lenses in succession.

4. A method of effecting proper framing of television images which comprises scanning an object field in a succession of elemental areas, introducing a succession of views of the object into the object field, observing a view while occupying an observing area outside the object field,

illuminating the view to be observed by a flash of light occurring when a given elemental area of the object field is being scanned and so spacing the observed view and the scanned view physically that at the instant the flash occurs the elemental area of the observed view corresponding to the given elemental area being scanned of the scanned view occupies the same relative position in the observed field as the scanned elemental area occupies in the scanned field.

5. A scanning arrangement for television for motion picture film comprising a scanning gate, a frame-viewing gate, means to illuminate the film in said viewing gate at the instant that a given elemental area is being scanned in the scanning gate, means to drive the film through both gates with a fixed length of film between said gates, means to position said scanning gate and said film gate so that when said given elemental area is being scanned and the flash of light occurs the corresponding elemental area of the frame in the viewing gate occupies the corresponding position in the viewing gate, and means to adjust the length of film between the driving means and said gates so that a full frame appears in the viewing gate when the flash occurs.

6. An optical device comprising a tubular support, a collimating lens seated in one end of said support, an aperture forming member at the other end of said support, means to position said aperture at the principal focus of said collimating lens, a pair of reflecting prisms of unequal size having a non-reflecting face of the smaller prism cemented to the reflecting face of the larger prism, and the reflecting faces positioned at right angles to one another, means to mount said prisms in an opening in the side of said tubular support adjacent one edge of said collimating lens so that a light ray incident on the reflecting face of said smaller prism at an angle of incidence of 45 degrees is reflected through the cemented portions of said prisms to the face of said collimating lens near one edge thereof, and means in said tubular support to prevent light rays entering through said aperture from impinging upon said prisms.

7. An optical device comprising a tubular support, a collimating lens seated in one end of said support, an aperture forming member at the other end of said support, means to position said aperture at the principal focus of said collimating lens, a pair of reflecting prisms of unequal size having a non-reflecting face of the smaller prism cemented to the reflecting face of the larger prism, and the reflecting faces positioned at right angles to one another, means to mount said prisms in an opening in the side of said tubular support adjacent one edge of said collimating lens so that a light ray incident on the reflecting face of said smaller prism at an angle of incidence of 45 degrees is reflected through the cemented portions of said prisms to the face of said collimating lens near one edge thereof, means in said tubular support to prevent light rays entering said aperture from impinging upon said prisms, and means to move a succession of lenses past said collimating lens, said movable lenses being of such size and so positioned that in pairs they receive at given positions light rays simultaneously from said collimating lens, the rays passing to one lens of said pair from said aperture and the rays passing to the other lens of said pair from said smaller prism.

8. A framing indicating device for a motion

picture scanner comprising a rotatable scanning disc having a plurality of scanning apertures, means to move a motion picture film past said disc so that one frame of said film is completely scanned for each revolution of said disc, a viewing gate positioned a fixed distance from said scanning position measured along said film, means to illuminate the film in said viewing gate

at the instant that a given aperture is effective for scanning, and means in said gate which coincides with a characteristic mark on each frame of the film at the instant when said viewing gate is illuminated and the film is in frame for scanning.

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