

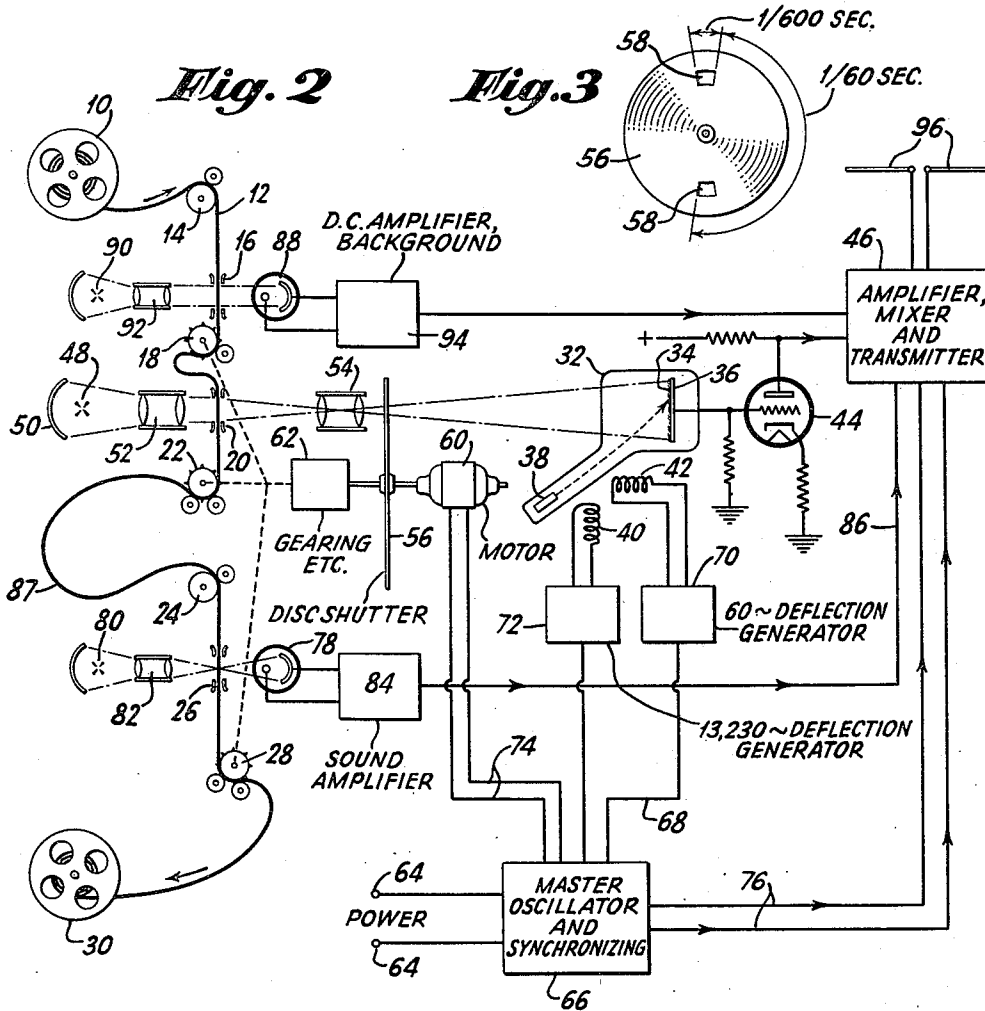
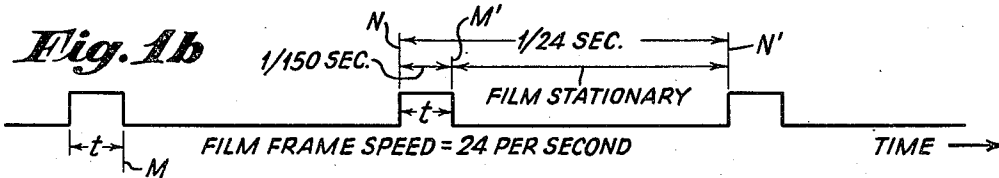
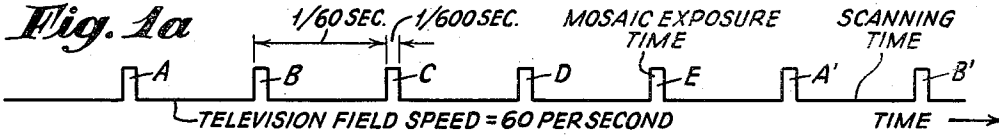
Dec. 1, 1942.

S. W. SEELEY

2,303,960

MOTION PICTURE PROJECTOR FOR TELEVISION USE

Filed Aug. 22, 1939



INVENTOR.
STUART W. SEELEY

BY

H. B. Grover
ATTORNEY.

UNITED STATES PATENT OFFICE

2,303,960

MOTION PICTURE PROJECTOR FOR
TELEVISION USEStuart W. Seeley, Roslyn Heights, N. Y., assignor
to Radio Corporation of America, a corporation
of Delaware

Application August 22, 1939, Serial No. 291,309

6 Claims. (Cl. 178—7.2)

This invention relates to motion picture projectors particularly of the type used in television systems where the subject matter transmitted by television is derived from a moving picture film. More particularly, the invention relates to the method of and means for projecting light images of the subject matter contained on a film upon the television transmitting tube and moving the film in such a manner and at such a speed that a regular intermittent motion may be imparted to the film.

In present television systems the field frequency is at the rate of 60 frames per second, this number being chosen in view of the fact that it affords convenient synchronizing with local power distribution systems since 60 cycle alternating current is normally used for power and lighting. In film projection the film is ordinarily operated at a rate of 24 frames per second and when the film is shown at this rate the apparent movement of the subject matter contained on the film is normal since films are normally exposed at the rate of 24 frames per second. In order that the speed of movement of the subject matter contained on the film may appear normal it is, of course, necessary that the film be moved at a rate of 24 frames per second while the television fields are actually transmitted at the rate of 60 per second.

In previously used projection devices where the subject matter of the film is to be transmitted by a television system, a projector is provided in which the intermittent motion which is imparted to the film is not regular but instead adjacent film frames are maintained stationary for different periods of time between the successive "pull-downs." It has been customary in such machines to cause alternate frames, for instance the odd frames, to remain stationary substantially 50% longer than the remaining or even frames. When such a system is used the subject matter contained on alternate frames (1, 3, 5, 7 etc.) is transmitted over the television system for three television fields whereas the remaining alternate frames (2, 4, 6, 8 etc.) are transmitted for a time period equal to two television fields. Therefore, each two film frames represents five television fields so that the film is shown at its proper rate of speed. Considerable ingenuity and alteration of design of a standard motion picture machine is necessary in order that the 3-2 ratio of film movement may be imparted to the film, and an example of such a device is shown in the application of A. V. Bedford, Serial No. 236,031. (RCA Docket 15,737.)

Furthermore, in television systems where the subject matter transmitted is derived from a moving picture film the mosaic or light responsive electrode upon which the optical image is projected is scanned by a cathode ray beam in substantially complete darkness. The scanning operation removes the charge image which is built up on the mosaic and accordingly produces the picture signals, the next succeeding charge image being produced by a very short "exposure" or projection of a film image on the mosaic or light responsive electrode during the time that the scanning cathode ray beam is returned in a vertical direction to the starting position for another scanning cycle. Since each scanning cycle occupies $\frac{1}{60}$ of a second these exposures or successive projections of film images are, of course, made at a rate of 60 per second. Of the total time of $\frac{1}{60}$ of a second about (not over) 10% of this period is devoted to vertically returning the cathode ray beam to the initial starting point. Accordingly, each film frame image is projected on the mosaic of the transmitting tube for a period equal to approximately $\frac{1}{600}$ of a second while the mosaic is actually scanned during a period of time equal to $\frac{1}{600}$ of a second. In previous systems, as explained above, the film has been maintained stationary for a length of time necessary to permit three exposures to be made during the showing of one film frame whereas the film is maintained stationary for the next succeeding film frame for a period of time sufficient only to permit two exposures to be made. Successive film frames in previously used systems are stationary, therefore, for periods of time equal to $\frac{2}{60}$ of a second and $\frac{3}{60}$ of a second (less the length of time required to move the film one frame).

In the present system a method and means has been devised whereby the length of time that each successive film frame is stationary in the projector is uniform and constant and furthermore, the length of time consumed by the "pull-down" period (or actual movement of the film at the film gate) for each film frame is also fixed and constant. In order to exercise the operation where the film is shown by television the length of time which may be devoted to actually moving the film during the "pull-down" period must be reduced to less than a certain predetermined maximum length of time as will be explained later.

It is therefore one purpose of the present invention to provide a film projecting device which may be used in connection with the television

transmitting system in which the film is moved intermittently and in which the intermittent motion is regular.

Another purpose of the present invention resides in the provision of a method and means whereby motion picture film which is to be shown at 24 frames per second may be used in connection with a television system wherein the fields are transmitted at the rate of 60 per second with means whereby the film may be moved intermittently and wherein the intermittent motion permits each successive film frame to remain stationary for exactly the same length of time.

Still another purpose of the present invention resides in the provision of a method and means for transmitting by television the subject matter contained on a motion picture film without the necessity of providing an irregular intermittent motion to the moving picture film.

Still further advantages of the present invention will become more apparent to those skilled in the art from a reading of the following specification and claims, particularly when considered with respect to the drawing wherein:

Figure 1a represents graphically the ratio between the exposure time and the scanning time in a television transmitting device;

Figure 1b represents schematically the time ratio between stationary and moving periods of the motion picture film which is necessary in order that the purposes of the present invention may be accomplished;

Figure 2 shows schematically a motion picture projector operating in accordance with the present invention together with the associated television transmitting system, and

Figure 3 represents a plan view of the disc shutter which is used in the motion picture projector.

Referring now to the drawing in Figure 2 is shown a reel 10 from which the film to be shown by television is derived. The film 12 is passed over an idler roller 14 and passes through a film gate 16, the purpose for which will be explained later. The film is drawn through the gate 16 at a uniform and constant rate of speed by means of the continuously rotating sprocket wheel 18. The film then passes through the film gate 20 in an intermittent manner as determined by the intermittent rotation of the sprocket wheel 22. The film then proceeds over an additional idler roller 24 and passes through still another film gate 26 at a uniform and constant rate of speed as determined by the continuously rotating sprocket wheel 28. The film finally is wound up on the take-up spool 30.

The figure also shows a television transmitting tube 32 which includes a light responsive mosaic or electrode 34 with which is associated a signal plate 36. Within the cathode ray tube 32 is an electron gun structure 38 for producing a beam of electrons, the beam of electrons being deflected in horizontal and vertical directions by means of the deflecting coils 40 and 42 respectively. These coils, by reason of their cyclically varying energization, cause the cathode ray beam to systematically scan the light responsive electrode 34 in a regular systematic manner. The output from the television transmitting tube is derived from the signal plate 36 and is supplied to a preamplifier tube 44. The output from the amplifier tube is then fed to an additional amplifier mixer and transmitting device shown schematically at 46.

With an optical image is projected upon the

light responsive electrode 34 a charge image is produced thereon in accordance with the intensity of the light image and as the cathode ray beam traverses the light responsive electrode these charges are removed and a series of picture signals are accordingly developed. After the charge images have been entirely removed from the light responsive electrode another light image is projected on the electrode 34 for a short space of time during which time the cathode ray beam is returned in a vertical direction to the initial starting point for the next successive scanning cycle and during the scanning of the light responsive electrode no light is permitted to strike the electrode.

For projecting the light images of the motion picture film frames on the electrode 34 a source of light 48 is provided with which is associated a reflector 50. The light from the source is directed upon the film 12 which is present in the film gate 20 by means of condensing lens 52 and the light which is permitted to pass through the film is focused upon the light responsive electrode 34 by means of the lens system 54. A disc shutter 56 is positioned in the optical axis of the projector and is generally located between the focusing lens 54 and the cathode ray television transmitting tube 32. This shutter is shown in Figure 3 and normally comprises an opaque disc in which one or more apertures 58 are provided near the periphery thereof.

Since the television fields are transmitted at the rate of 60 per second the shutter speed is so arranged that the light images are projected on the light responsive electrode 34 at the rate of 60 images per second, these images being actually projected on the light responsive electrode for only the time period between each successive transmission of the separate television fields, i. e., between each successive scanning operation. For rotating the disc a motor 60 is provided and if the motor 60 operates at a rate of 1800 R. P. M. the disc 56 will then be provided with two apertures 58. As shown in Figure 3 the length of time consumed during one-half revolution of the disc will then be $\frac{1}{60}$ of a second and since the vertical return time for the cathode ray beam occupies a period not in excess of $\frac{1}{16}$ of a complete field cycle the aperture 58 have an arcuate dimension of an amount not greater than the equivalent $\frac{1}{600}$ of a second on the shutter disc. The disc, of course, must be properly phased with the deflection of the cathode ray beam in order that the apertures in the disc are in alignment with the optical axis of the projector only during the time that the cathode ray beam is being returned in a vertical direction to begin another field scanning cycle.

In order that the film 12 may be moved in synchronism with the operation of the television transmitting tube and in synchronism with the rotation of the shutter disc 56, the film driving sprockets 18, 22 and 28 are mechanically connected to the motor 60 by means of a gear box 62. This gear box contains gearing such that the sprocket wheels 18 and 28 will move the film at a constant rate of 24 frames per second and means are also provided in the gear box 62 whereby regular intermittent motion will be imparted to the sprocket wheel 22 such that the film will be moved in a regular intermittent manner, the film frames being moved through the gate 20 at the rate of 24 per second.

Power for the projector and transmitting device is supplied to the terminals 64 to which are

connected the master oscillator and synchronizing device 66. This master oscillator supplies impulses at a rate of 60 per second which are supplied by means of conductor 68 to the 60-cycle vertical or field deflection generator 70 which operates through the deflecting coil or unit 42 to cause the cathode ray beam to be deflected vertically at a rate of 60 deflections per second. The wave form of the energy supplied to the deflecting unit 42 is generally of saw-tooth wave form or some modification of a saw-tooth wave form. The master oscillator also supplies impulses of a frequency of 13,230 impulses per second to the horizontal or line deflection generator 72 which operates to generate the proper wave form for energizing the deflecting coil or unit 40 which in turn imparts the proper horizontal deflection to the cathode ray beam in order to scan each line of the television field. Energy is also supplied to the driving motor 60 by means of conductors 74 for regulating the speed of the motor 60 the frequency of this energy being in proper synchronism and phase relationship with respect to the impulses which are supplied to the line and frame deflection generators 72 and 70 respectively.

Since the television receiver must be accurately synchronized with the operation of the television transmitter, synchronizing impulses must be transmitted with the picture signals and accordingly, impulses from the master oscillator and synchronizing device 66 are supplied to the amplifier mixer and transmitter 46 by means of conductors 76. These synchronizing signals are generally transmitted at the end of each line scan and at the end of each field scan, i. e., during the horizontal and vertical return of the scanning cathode ray beam.

In order that the sound which is recorded at the sound track of the film 12 may accompany the visual subject matter derived from the film, a light responsive cell 78 is provided. Light derived from a source 80 is projected upon the cell through the sound track of the film 12. An optical system 82 is provided in order to properly focus the light from the source 80 upon the sound track of the film. Since the film 12 is moved through the film gate 26 at a uniform and constant rate of speed by means of the rotating sprocket 28, the recorded sound which is to accompany the film action is translated into a signal series by means of the photo-cell 78. The energy from the photo-cell or light responsive device 78 is supplied to a sound amplifier 84 in order that the signal level may be properly increased. Energy from the sound amplifier 84 is then supplied to the transmitter 46 by means of conductor 86 for ultimate transmission. Inasmuch as the film must move continuously and at a constant rate of speed in order that the sound accompanying the film action will be properly reproduced, and in view of the fact that the film movement at the film gate 20 is intermittent, some film spacing between the film gate 20 and the sound gate 26 must be provided. Normally this spacing is approximately 24 frames and accordingly the loop of film 87 is of such a size that proper film displacement will be provided between the two film gates 20 and 26. The size of the loop 87 is, of course, determined at the time the film is initially threaded in the projector.

In order to control the background or average signal level of the television signals as transmitted, some means must be provided for vary-

ing the signal level in accordance with the average overall brightness of the subject matter of the film. Accordingly, a light responsive device 88 is provided, the device being associated with the film gate 16. Light from a source 90 is projected through an optical system 92 and in turn projected through the film 12 onto the light responsive device or photo-cell 88. The cross-sectional area of the light beam which is projected on the film at the film gate 16 is approximately equivalent to the area of a film frame. As the film moves continuously and at a uniform rate through the film gate 16 the amount of light which is permitted to strike the light responsive cell 88 is determined by the average brilliance of the film frames which, of course, is determined by the average translucency or transparency of the film per se. Signal energy from the light responsive film 88 is supplied to an amplifier 94, the output of which is connected to the transmitter 46. The transmitter 46, in accordance with known television practice, utilizes the synchronizing signals, the picture signals and the sound signals to modulate carrier waves in order that the energy may be transmitted by means of an antenna arrangement 96.

In Figure 1a is shown a repetition of several television fields. These fields are indicated as a function of time and, as represented in the drawing, each field cycle occupies $\frac{1}{60}$ of a second. Of this cycle, as explained above, not over 10% or $\frac{1}{600}$ of a second is utilized for the vertical return of the scanning cathode ray beam which return period coincides with the time that the light image from the film is projected on the light responsive electrode 34 and is represented by the portions A, B, C, etc. Between each of the areas A, B, C, etc. representing the mosaic exposure time is a time period of at least $\frac{1}{600}$ of a second which is actually the field scanning time of the light responsive mosaic 34.

Properly related to Figure 1a is Figure 1b which shows the movement which must be imparted to the film 12 in order that 60 television fields may be transmitted from a film operating at 24 frames per second. One film frame cycle as indicated in the figure occupies a time of $\frac{1}{24}$ of a second, the film being moved during a portion of this cycle. Since the exposure of the television transmitting tube mosaic 34 must occur while the film is stationary in the film gate 20, proper synchronized relationship must exist between the motion of the film and the operation of the television transmitting tube as explained above. Furthermore, if the length of time that each film frame remains stationary is to be constant and uniform for each film frame, then the period or length of time that each film frame is stationary must be sufficient to permit a maximum of three exposures on the light responsive electrode 34. If the "pull-down" time for the film, that is, the time during which the film is actually in motion at the film gate 20, is represented by t , then for one film frame three exposures, A, B and C must be made between two adjacent "pull-down" periods. While the film is stationary from the time indicated at M until the time indicated at N the exposures represented at A, B and C of the same film frame must be made. Between the exposures C and D the film is moved or pulled down one film frame and during the next succeeding stationary period of the film between the times indicated at M' and N' two exposures are made of that film frame and

these exposures are represented at D and E. The cycle is then completed and the film is moved during the time t between exposures E and A' so that the next succeeding film frame will be in position to supply three exposures to the light responsive electrode 34. Accordingly, it may be seen that five exposures of the light responsive electrode 34 are made for each two successive film frames.

If the "pull-down" time is to be made uniform for each film frame and if the length of time that each film frame remains stationary in the film gate 20 is to be constant, then the length of time consumed by the stationary period M—N must equal two television field cycles plus one exposure period or at least $\frac{2}{600}$ of a second. Since the length of time for each film frame cycle is fixed at $\frac{1}{24}$ of a second, it follows that the "pull-down" time for each film frame must not exceed $\frac{1}{24}$ of a second minus $\frac{2}{600}$ of a second or $\frac{1}{150}$ of a second. Accordingly, it will be seen that if a moving picture film is supplied with a regular intermittent motion wherein the "pull-down" time is not in excess of $\frac{1}{150}$ of a second, proper coordination between television field speed and film frame speed can then be accomplished. It is, therefore, only necessary that the film projector be capable of operating at such a "pull-down" speed that the successive film frames are not in motion in the film gate for a time period in excess of $\frac{1}{150}$ of a second in order that regular intermittent film motion may be imparted to the film when used as a source of subject matter for a television program. Expressed in percentage, the pull-down time must not exceed 16% of the time for each film frame cycle and the film must be stationary in the film gate for at least 84% of the time for each film frame cycle. These percentages are based on an exposure time of $\frac{1}{600}$ second but if the exposure time is slightly reduced, as it may be, the pull-down time may be increased to about 17.5 percent of the film frame cycle.

It may be seen from the above that when a film projector is operated in accordance with this invention no special and complex irregular intermittent motion need be provided and accordingly, machines of the more usual design may be used.

It is to be understood that the present invention is equally adaptable to the showing of 16 and 35 mm. films and furthermore, it is to be understood that such a film projecting device may be used with any type of television transmitting system wherein the television field frequency is at the rate of 60 fields per second.

Furthermore, even though a more or less specific form of television transmitting tube and deflecting mechanism is shown and described herein, it is to be understood that various other transmitting tubes and deflecting systems could as well be used.

Various other modifications and alterations may become apparent to those skilled in the art and it is desired that any and all modifications be considered in the purview of the present invention except as limited by the hereinafter appended claims.

I claim:

1. A motion picture projector for projecting light images of motion picture film frames on the light responsive electrode of a television image transmitting tube in which the film is moved at a uniform intermittent rate of approxi-

mately 24 frames per second while the images are projected on the television image transmitting tube at a uniform rate of approximately 60 images per second, and in which three optical images of alternate film frames and two optical images of the remaining film frames are projected on the light responsive electrode of the television image transmitting tube, which includes means for intermittently moving the film through the projector at a uniform rate of approximately 24 frames per second, a shutter positioned in the optical projection path for permitting approximately 60 images per second to be projected on the light responsive electrode, and means for synchronizing and phasing the operation of the shutter with the operation of the said means for intermittently moving the film, the interval during which the film is actually in motion in the film gate of the projector being so reduced that each frame of the film is stationary for a substantially uniform and constant length of time and for a time period sufficient to permit three optical images of alternate film frames and two optical images of the remaining film frames to be projected on the television image transmitting tube at the uniform rate of approximately 60 image projections per second, each image projection occupying an interval of time of not more than approximately $\frac{1}{600}$ of a second.

2. A motion picture projector for projecting light images of motion picture film frames on the light responsive electrode of a television image transmitting tube in which the film is moved at a uniform intermittent rate of approximately 24 frames per second while the images are projected on the light responsive electrode at a uniform rate of approximately 60 images per second, and in which three optical images of certain film frames and two optical images of each of the remaining film frames are projected on the transmitting tube which includes means for intermittently moving the film through the projector at a uniform intermittent rate of approximately 24 frames per second, a shutter positioned in the optical projection path for permitting approximately 60 images per second to be projected on the light responsive electrode, means for synchronizing the speed of operation of the shutter with the speed of operation of the means for intermittently moving the film and for maintaining a predetermined phase relationship therebetween, the interval during which each frame of the film is stationary being uniform and of sufficient duration to permit three optical images of alternate film frames to be projected on the light responsive electrode at the rate of approximately 60 uniformly spaced projections per second, each projection occupying an interval of time of less than $\frac{1}{600}$ of a second.

3. A motion picture projector including a shutter mechanism for projecting light images of individual motion picture film frames on the light responsive electrode of a television image transmitting tube in which the film is moved at a uniform intermittent rate of approximately 24 frames per second while the images are projected on the light responsive electrode at a rate of approximately 60 equally spaced images per second, and in which three optical images of alternate film frames and two optical images of the remaining film frames are projected on the light responsive electrode of the transmitting tube which includes means for intermittently moving

the film through the projector at a uniform rate of approximately 24 frames per second, a light shutter positioned in the optical projection path for permitting approximately 60 light images per second to be projected on the light responsive electrode, and means for synchronizing the speed of operation of the shutter and the speed of operation of the projector, the film pull-down time and the phase relationship of the shutter to the projector being such that each individual frame of the film is stationary for a time period sufficient to permit three optical images of alternate film frames and two optical images of the remaining film frames to be projected on the light responsive electrode at the rate of approximately 60 equally spaced images per second, each projection occupying an interval of time of approximately $\frac{1}{600}$ of a second.

4. A motion picture projector in which the film frame speed is F frames per second for projecting optical images of the individual film frames and of a predetermined uniform duration of E_s seconds onto the light responsive electrode of a television image transmitting tube at a rate of N_s uniformly spaced images per second where N_s is greater than F and does not bear an integer relation to F and in which a maximum of N_r optical images of any of the film frames are projected on the light responsive electrode of the television image transmitting tube comprising means for intermittently moving the film through the projector at the uniform rate of F frames per second, the interval during which the film is stationary being equal to or greater than

$$\frac{N_r - 1}{N_s} + E_s$$

a shutter positioned in the optical projection path for permitting N_s optical images per second to be projected on the light responsive electrode, and means for synchronizing and phasing the operation of the shutter with the operation of the projector so that N_r optical images of any film frame may be projected on the light responsive electrode of the television image transmitting tube while that film frame is stationary in the projector.

5. A motion picture projector in which the film frame speed is F frames per second for projecting optical images of the individual film frames and of a predetermined uniform duration of E_s seconds onto the light responsive electrode of a television image transmitting tube at a rate of N_s uniformly spaced images per second where N_s is greater than F and does not bear an integer relation to F and in which a maximum of N_r optical images of any of the film frames are projected on the light responsive electrode of the television image transmitting tube which includes means for intermittently moving the film through the projector at the uniform rate of F frames per second, the interval during which the film is actually in motion being equal to or less than

$$\frac{1}{F} - N_r - 1 + E_s$$

a shutter positioned in the optical projection path for permitting N_s optical images per second to be projected on the light responsive electrode, and means for synchronizing and phasing the operation of the shutter with the operation of the projector so that N_r optical images of any film frame may be projected on the light responsive electrode of the television image transmitting tube between successive periods of motion of the film in the projector.

6. The method of operating a motion picture projector for projecting optical images having a predetermined uniform duration of the individual film frames onto a television image transmitting tube in which the television field speed is greater than the film frame speed and does not bear an integer relation to the film frame speed, which comprises the steps of intermittently moving the film through the projector at a uniform rate corresponding to the film frame speed, the length of time that each film frame is stationary in the film gate being equal or greater than the time duration of each optical image projection plus the product of the time duration of a television field cycle times one less than the maximum number of television fields per film frame.

STUART W. SEELEY.