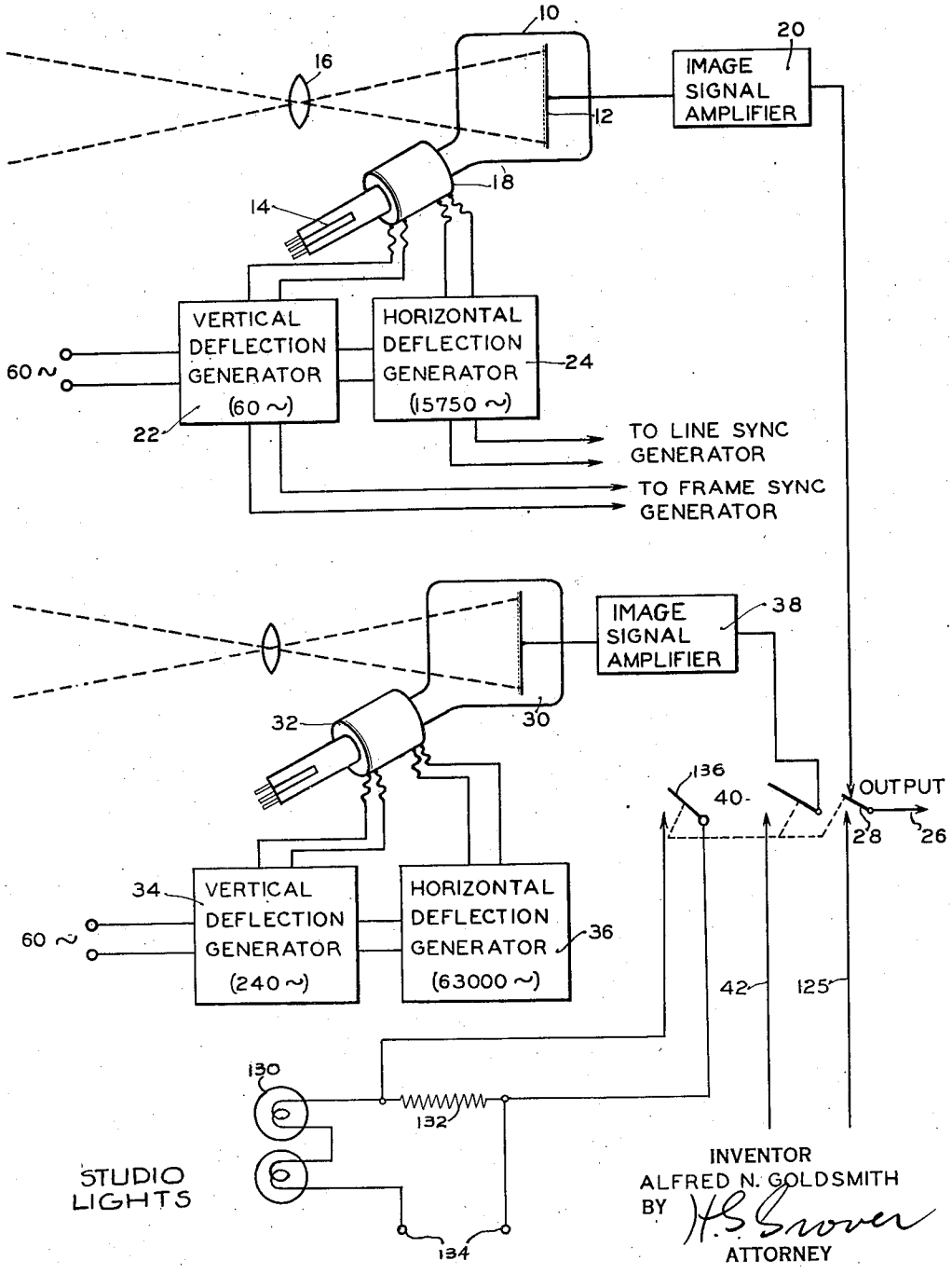
Aug. 14, 1945. A. N. GOLDSMITH 2,381,901

TELEVISION TRANSMITTING SYSTEM

Filed Aug. 26, 1942 2 Sheets-Sheet 1

Fig. 1A.



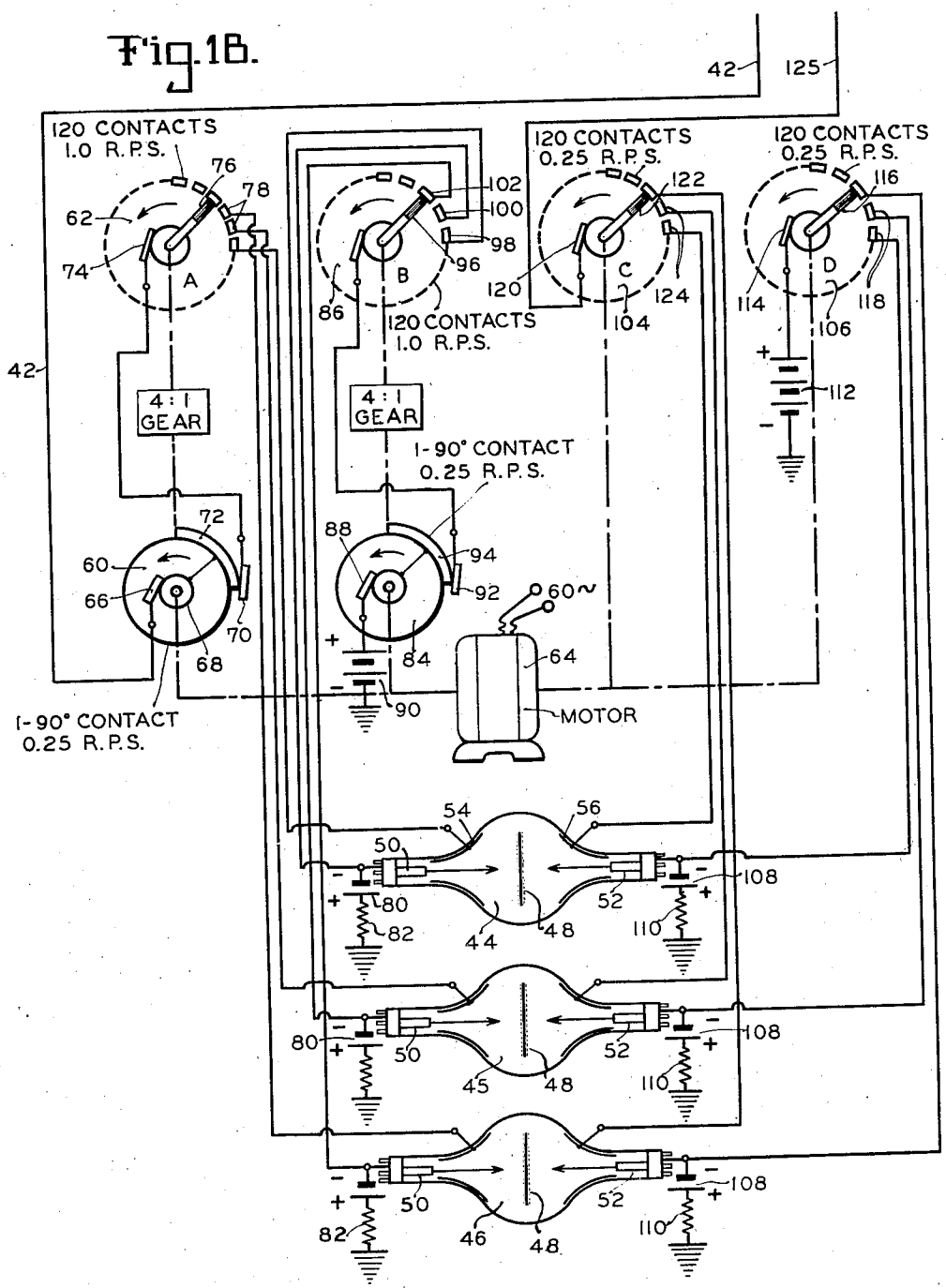
INVENTOR
ALFRED N. GOLDSMITH
BY H. S. Snover
ATTORNEY

Aug. 14, 1945. A. N. GOLDSMITH 2,381,901

TELEVISION TRANSMITTING SYSTEM

Filed Aug. 26, 1942 2 Sheets-Sheet 2

Fig. 1B.



INVENTOR
ALFRED N. GOLDSMITH
BY H. S. Grover
ATTORNEY

Patented Aug. 14, 1945 2,381,901

UNITED STATES PATENT OFFICE

2,381,901

TELEVISION TRANSMITTING SYSTEM

Alfred N. Goldsmith, New York, N. Y.

Application August 26, 1942, Serial No. 456,133

20 Claims. (Cl. 178—6.8)

This invention relates to an improvement in television transmitters and, more particularly, to a system wherein it is possible to present television images in slow motion.

The use of slow motion in television is highly desirable but has heretofore been impossible, since no practical arrangement has been devised where it is possible to present television images in slow motion, particularly where the subject matter is obtained from direct pick-up.

Slow motion in the moving picture field is relatively simple, since it entails merely the operation of a camera at a relatively high rate of speed to expose successive frames of a film in rapid succession, the film after processing and printing being run through a projector at normal projection rates with the result that the subject matter photographed, together with the apparent motion, is shown in "slow motion" so that the actual time elapse has been increased several fold.

Slow motion in television is, therefore, conveniently possible where a film intermediate may be used, since the film technique of slow motion may be employed. However, slow motion in television, from the standpoint of direct pick-up, is not equally simple and necessarily entails the use of an appropriate assembly of apparatus. Naturally, some relatively long-term picture storage means must be provided, since the subject matter per se cannot be slowed down; and where the subject matter being transmitted is derived from direct pick-up, special means are provided whereby electrical replicas of a series of successive television frames may be stored or retained for a predetermined length of time in order that they may be subsequently immediately, or shortly subsequently used to produce images on the screens of the various television receiving apparatus.

The present invention accomplishes slow motion without the use of an intermediate film, and provides means whereby it becomes possible at any particular desired instant to portray in slow motion a certain occurrence even though the subject matter is being immediately televized, and the television images are derived from direct pick-up.

Such a television system is highly desirable at races or other competitive or sporting events to observe in detail an action which transpires in a relatively short length of time or for various other purposes familiar to those skilled in the art. It is, therefore, one purpose of the present invention to provide a slow motion television transmitting system whereby the actual rate of movement of persons or objects is reduced in some predetermined selectable ratio.

Another purpose of the present invention resides in the provision of a slow motion television transmitting system for transmitting television images for a predetermined period of time, the slow motion interval being preceded or followed as may be desired by either normal motion or slow motion pictures.

A still further purpose of the present invention resides in the provision of means for transmitting television images in slow motion wherein the movement following the slow motion interval is immediately portrayed in normal motion with an omission of only part of the normal motion which transpired during the time of presentation of the slow motion images.

Still another purpose of the present invention resides in the provision of a slow motion television transmitting system wherein movements of persons or things may be portrayed in slow motion during a predetermined interval with further means whereby a succession of adjacent intervals of substantially the same duration may be presented in slow motion form.

Still another purpose of the present invention resides in the provision of a plurality of television image storing devices whereby electrical replicas of the motion may be retained for a predetermined length of time for subsequent use in presenting slow motion television images.

A further purpose of the invention is to provide means for appropriately changing the intensity or character of the illumination of the televized scene during the slow motion pick-up period.

Still other purposes and advantages will become more apparent to those skilled in the art from the following detailed description, particularly when considered in connection with the drawings wherein:

Figures 1*a* and 1*b* represent, by way of example, one embodiment of the present invention.

In order that true slow motion television images may be presented it is naturally necessary to scan the subject matter or an image of the subject matter at an increased scanning rate to thereby produce image or video signals representative of a relatively large number of individual and sequential images of the particular subject matter. In normal television transmission practice the subject matter to be transmitted, or an image thereof, is scanned at a predetermined rate to thereby produce image signals which, after transmission to the receiver, are utilized to produce television images. Accord-

ingly, in the present slow motion television system two separate television pick-up cameras are utilized, one of which is operated at normal picture transmission speed, and the other of which is operated at a higher rate of speed, preferably at some multiple of the operation of the normal television pick-up or camera unit.

Referring now to the drawings, there is shown a conventional television image pick-up or camera tube 10 having a mosaic electrode 12, including a light sensitive surface and a signal plate and wherein an electron gun structure 14 is also provided to develop a scanning electron beam. Associated with the pick-up or camera tube is a lens system 16 for projecting optical images of the subject matter to be televized upon the mosaic electrode 12. The electron gun structure 14 when subjected to proper operating potentials develops a cathode ray beam which when deflected in mutually perpendicular directions by means of the deflecting coil 18 is caused to scan the surface of the mosaic electrode 12 to produce image or video signals which are applied to an image signal amplifier 20. For deflecting the cathode ray beam in both horizontal and vertical directions a vertical deflection generator 22 is provided, as is also a horizontal deflection generator 24. The vertical deflection generator is supplied with timing impulses in order that the deflection frequency may be maintained constant and, in order that the proper ratio of deflection rates may be maintained, frequency dividers or multipliers are generally interposed between the vertical and horizontal deflection generators.

In order to facilitate in describing the operation of the present invention it will be assumed, by way of example, that the normal operating frequency of the normal speed television pick-up or camera tube 10 is at 60 fields per second and at 15,750 lines per second (that is at the rate of 30 double interlaced 525 line pictures per second). Accordingly, the voltage variations supplied by the vertical deflection generator 22 will vary in wave form at the rate of 60 cycles per second, whereas the horizontal deflection generator 24 will produce voltage variations having a frequency of 15,750 cycles per second. Energy from both of these deflection generators is then applied to the deflecting coil 18 in order to deflect the cathode ray beam in mutually perpendicular directions at the desired rates in order that the mosaic electrode may be scanned to produce image signals. The image signals after amplification are then available at the output terminal 26, provided switch 28 is in the position as shown in the drawings.

For the purpose of this description it will be assumed that the retardation ratio is 4 to 1, and on this assumption the television pick-up or camera tube that is used for the production of slow motion television images will operate at exactly four times the speed of the normal television pick-up or camera tube. A second television camera tube 30 is, therefore, provided which is similar to tube 10. The tube also has associated therewith a deflecting coil 32, and the deflecting coil is supplied with energy from an associated vertical deflection generator 34 and horizontal deflection generator 36. The vertical deflection generator is controlled to operate at 240 cycles per second (assuming a 4 to 1 retardation ratio), while the horizontal deflection generator is controlled to operate at 63,000 cycles per second. When energy from these two deflection generators is supplied to the deflecting coil 32 of tube 30 the cathode ray beam will be caused to scan the mosaic electrode at a line frequency of 63,000 lines per second and a field frequency of 240 fields per second. It is convenient to operate the timings of deflection generators 34 and 36 as multiples of those of the respective generators 22 and 24 by the interposition of suitable frequency multipliers therebetween.

Scanning of the mosaic electrode in tube 30 produces image or video signals which are amplified by the picture signal amplifier 38. Inasmuch as the scanning rate in tube 30 is assumed to be four times the scanning rate in tube 10 then the generated image signals will have a top frequency of the order of four times the top frequency of the image signals generated by the camera tube 10. The image signal amplifier 38 must, therefore, be of exceptionally wide band width in order that an extreme range of image signals may be amplified thereby with the proper degree of fidelity. The image signals after appropriate amplification are then impressed upon conductor 42 by way of switch 40.

The switches 40 and 28 are mechanically connected together so that when slow motion television images are desired both of the switches are simultaneously operated to close switch 40 and to thereby apply image signals to the slow motion storage network and to also position switch 28 such that the image signals derived from the slow motion storage circuit may be made available at the output terminal 26. The image signals available from the terminal 26, either as derived directly from pick-up or camera tube 10 or indirectly from the slow motion pick-up or camera tube 30, are then subjected to further amplification and have combined therewith line and frame synchronizing signals which are supplied by a line or frame synchronizing generator (not shown). To control the line and frame synchronzing generator energy may be applied thereto from the vertical and horizontal deflection generators 22 and 24, respectively. After the synchronizing signals have been combined with the image signals the composite series of signals may then be used to modulate a radio frequency carrier for radio transmission to television receivers.

When slow motion television signals are passed from conductor 125 to output terminal 26, either stored synchronzing signals associated with the image signals may be transmitted (as will generally be most convenient), or alternatively new synchronizing signals from generators 22 and 24 may be added to the slow motion image signals for the transmission.

In addition to assuming, by way of example, that the retardation factor is taken as four, it will be assumed also that normal action for a time duration of one second will be expanded into four seconds of slow motion television. In other words, movement which transpires in an interval of one second is presented in slow motion having a duration of four seconds.

For storing the very rapidly produced image signals a plurality of storage tubes are provided three of which are shown at 44, 45 and 46. The specific construction of these storage tubes will not be discussed in detail, since a description of such a tube is to be found in the publication "Television" by Zworykin and Morton (John Wiley & Sons, Inc., 1940) on pages 326 and 327. The tubes, however, include a double sided mosaic electrode 48 and two gun structures 50 and 52. The gun structures are arranged to scan opposite

sides of the mosaic 48 and when a modulated cathode ray beam is caused to impinge upon one side of the mosaic an electrostatic charge image will be produced thereon which may be removed by the electron gun structure in the opposite end of the tube. Image signals are, therefore, applied to the second anode 54 of tube 44, for example, with the result that the individual elements of the mosaic electrode 48 will assume a potential which is dependent upon the instantaneous potential of the second anode. For storing the charge image on the mosaic 48 the cathode ray beam generated by the gun structure 50 is naturally used. When the scanning action is completed a potential variation will exist over the mosaic which is a result of the voltage variation applied to the second anode 54. When the opposite side of the mosaic 48 is scanned by the cathode ray beam produced by the gun structure 52 signals may be derived from the second anode 56 associated with this cathode ray beam. The potential variations which exist on the mosaic electrode 48 are, therefore, transformed into a signal which may be collected from the second anode 56 when the mosaic is scanned by the cathode ray beam. Naturally, a deflecting means is associated with each gun structure, but such means has been omitted in the drawings for simplicity.

If, as above assumed, a time duration of one second is to be expanded into four seconds of slow motion television, then 120 storage tubes will be required. Each storage tube is capable of retaining a complete television frame including two field scansion cycles. This is on the basis that a 2 to 1 interlace scanning system is employed as is standard television practice. When interlaced scanning is employed two successive television fields are required to complete a television frame and an electrostatic charge image of a complete television frame (including two fields) may be deposited upon each storage tube. The charges representing each of the two fields may be removed in succession by the cathode ray beam produced by the gun structure 52 when the mosaic electrode 48 of the storage tube is scanned by an interlaced pattern. When no interlacing is employed then naturally a number of storage tubes must be employed corresponding to the number of fields or frames which are scanned by the slow motion television camera during the interval at which slow motion images are to be presented.

In order that the individual image signals as produced by the slow motion television pick-up tube 30 may be successively applied to the storage tubes so that the images may be retained for a predetermined length of time, some switching arrangement must naturally be employed. Likewise, a similar switching arrangement, operating in synchronism with the normal motion pick-up or camera tubes, must also be employed for removing the stored signals.

For applying the image signals from the slow motion camera tube 30 to the storage tubes in succession a timer 60 and a commutator 62 are provided. Both the timer and the commutator are driven by a synchronous motor which derives its energy from a 60-cycle power source synchronized with the vertical deflection voltage variations for controlling the scanning cathode ray beam in the television camera tube 10. This motor may conveniently be provided with a manually or otherwise rotatable stator so that the phasing of the operation of the timer 60 and the commutator 62 may be accurately controlled in relation to the individual image scannings. The timer 60 is arranged to rotate at 0.25 revolution per second, whereas the distributor 62 is arranged to operate at 1.0 revolution per second. The timer is provided with a brush contact 66 which cooperates with a ring contact 68, and the timer also includes a brush contact 70 which cooperates with a quadrant contact or sector 72. The quadrant contact or sector 72 extends ninety degrees around the periphery of the timer on the assumption that a retardation factor of 4 is chosen.

The commutator 62 includes a brush and ring contact arrangement 74 for applying current to the contact arm 76. Around the periphery of the commutator are arranged a plurality of contact segments 78 corresponding in number to the number of storage tubes. In the example above assumed, 120 contact terminals will be positioned around the distributor for cooperation with the rotating arm 76.

When the switch 40 is in a closed position image signals from the slow motion camera tube 30 will then be applied over the conductor 42 to the brush and ring contact 66 and 68 and to the quadrant conductor 72. Since the timer makes 0.25 revolution per second, the brush 70 will be in contact with the quadrant 72 for a duration of time equivalent to one second, while the circuit will be interrupted for the next succeeding three second interval. During the second that the brush 70 is in contact with the conducting segment 72 the arm 76 will make one complete revolution over the 120 contacts 78 which are in turn connected individually to the 120 storage tubes 44, 45, 46, etc. Picture signals representative of each successive television frame as derived from the slow motion camera tube 30 will, therefore, be applied in succession to the second anode 54 of each of the storage tubes to thereby produce an electrostatic charge image on the associated mosaic electrode 48.

Naturally, it is desirable that the cathode ray beam generated by the gun structure 50 be initiated only during the interval that a charge image is to be placed on the associated mosaic electrode. This interval for any particular storage tube will occupy $\frac{1}{120}$ of a second. In order to render the electron gun structure 50 inoperative a biasing potential source 80 is provided, the potential source being connected between the control electrode of the gun structure 50 and the ground by way of resistance 82. The potential supplied by the battery 80 is sufficiently negative to bias the cathode ray beam to cut-off, but in order that the cathode ray beam may be generated during, and only during, the desired interval, a second timer 84 and commutator 86 are provided, the timer 84 being substantially identical to the timer 60 and the commutator 86 being substantially identical to the commutator 62. For convenience of construction and operation, the elements 60, 62, 84, and 86 may be parts of a unitary assembly which includes also the below described similar elements 104 and 106. The brush contact 88 of the timer 84 has connected thereto the positive potential source 90, the negative terminal of the potential source being connected to ground. When the brush contact 92 is in contact with the segment 94 a positive potential will then be applied to the contact arm 96 so that positive control impulses may be applied successively to the control electrodes of the storage tubes 44, 45, 46, etc., by way of commutator contacts 98, 100, 102, etc. The action of the timer 84 and distributor 86, therefore, applies a positive potential to the control electrode of the

electron gun structure 50 in the storage tubes during the proper interval and at the proper instant in order that image signals from the slow motion television camera tube 30 may be effective when applied to the second anode 54 to store a potential or electrostatic charge image on the mosaic 48 of each of the storage tubes representative of the separate television frames as they occur in succession.

A somewhat similar commutating arrangement is also provided for removing the charge image representing successive television frames, the removal of the charge images occurring at a slower rate in order to produce the illusion of slow motion. Naturally, the charge image on the plurality of storage tubes must be removed in the proper sequence, and for this purpose commutators 104 and 106 are provided. These commutators are similar in construction to commutators 62 and 86, but the commutators 104 and 106 rotate at a speed of 0.25 revolution per second or, in other words, one fourth the speed of revolution of the commutators 62 and 86.

In order that the electrostatic charge image which is produced on the mosaic electrode 48 of each of the storage tubes may be retained it is necessary that no cathode ray beam be permitted to strike the mosaic electrode. Accordingly, a bias potential source 108 is provided and is connected between the control electrode of the electron gun structure 52 and ground by way of resistance 110. The potential of the source 108 is sufficient to normally block or prevent the formation of a cathode ray beam by the gun structure 52. For permitting the production of a cathode ray beam by the gun structure 52 the commutator 106 is used in conjunction with a source of potential 112. The negative terminal of the battery 112 is connected to ground, whereas the positive terminal is connected to brush and ring contact 114 for applying a positive potential to the contact arm 116.

The contact arm cooperates with the 120 peripheral contacts 118 to apply positive potential to the control electrodes of the gun structure 52 in order that a cathode ray beam may be produced by the gun structure 52 in each of the storage tubes 44, 45, 46, etc., in sequence and in proper succession.

It is possible to derive the individual cut-off biasses of the tubes 44, 45, 46, etc., from a common source through individual high impedances beyond which the activating voltage may be briefly applied as described. Numerous equivalent circuit modifications fall within the scope of this invention.

When the mosaic electrode 48 is scanned by a cathode ray beam produced by the gun structure 52, image signals may be derived from the second anode 56 representing one complete television frame or two interlaced scanning cycles.

The commutator 104 includes a brush and ring contact assembly 120 and a switch arm 122. The switch arm cooperates with the 120 peripheral contacts 124, the contacts being individually connected to the second anode of the gun structure 52 of each of the storage tubes 44, 45. 46, etc. Since the commutator arm 122 makes one revolution in four seconds, picture signals from the second anode 56 of each of the storage tubes are collected in sequence and in succession and are applied by way of brush and ring contact 120 to the conductor 125. The conductor 125 is then arranged to cooperate with switch 128 for applying slow motion television image signals to the output terminal 26.

From the above it may be seen, therefore, that motion which normally requires only one second to transpire may be presented on the screen of a television receiver so as to occupy a time duration of four seconds, the presentation of the television image at the receiver occurring at the usual and normal television operating speed. It is, therefore, unnecessary to make any changes whatsoever in the television receiver, all of the apparatus required for producing slow motion television images being located at the television transmitter.

When it is desired to present in slow motion any particular event or motion, it is only necessary to operate switches 40 and 28 (which are mechanically connected together) so that slow motion television images produced by the camera tube 30 may be stored on the storage tubes 44, 45, 46, etc., for a one second time interval, the stored images being removed during substantially that second and for the next succeeding three seconds (and generally with the loss of only a single initial frame).

All of the commutators as well as the timers are indicated as operating from a single driving motor 64, and such an arrangement is preferably in order to maintain proper synchronous and relative phasal conditions. Since the presentation, of slow motion images begins substantially immediately upon operation of switches 40 and 28, it is actually desirable in practice to delay the scanning of the mosaic electrode in the first storage tube until after an image representing the first complete television frame in slow motion is stored thereon. The operation of the commutators 104 and 106 should, therefore, be so phased that a short time interval is permitted to elapse, this time interval being not less than $\frac{1}{120}$ of a second. If synchronizing signals are to be supplied as indicated above, then in order to maintain proper synchronous operation it would be desirable to delay the presentation of slow motion images for one complete normal television field or $\frac{1}{60}$ of a second. During this interval potentials representative of two frames of slow mo' on television will be stored on two of the storage tubes at which time the transmission of the stored images commences. If switches 40 and 28 are maintained closed or in the slow motion television position then a succession of slow motion events may be indicated, the action of each fourth second being split to occupy a continuous time interval. Naturally, the movement which transpires during the three seconds between slow motion intervals will be completely lost. However, this will scarcely ever be detrimental, particularly if the particular time interval is wisely chosen during which slow motion television images are presented.

Theoretically and in the absence of any ameliorating factors at least four times the light intensity on the televized scene would be necessary for the production of slow motion television images, since the scanning rate is increased four fold. This requirement for additional light intensity may be compensated for by utilizing a faster lens associated with the slow motion television pick-up tube 30, or a more sensitive mosaic electrode could be used. In the absence of either of these compensatory measures, switching means could be arranged to operate in conjunction with switches 40 and 28 for increasing the illumination

in the television studio during the interval that slow motion is desired. Thus, for example, the voltage impressed on a bank of studio incandescent lamps may be momentarily increased sufficiently during the slow motion pick-up period, and without appreciable reduction in the total operating life of the lamps. An arrangement for providing the increased illumination is shown, by way of example, in Figure 1a where one or more studio light sources 130 (preferably of the incandescent type) are connected in series with a resistor 132. The series combination is energized from an appropriate potential source connected to terminals 134. A switch 136 is connected in parallel with the resistor 132 so that when the switch is closed, the studio lights 130 are over-excited during the interval of operation of slow motion television camera tube 30, and this over-excitation results in an increased illumination in the studio. The switch 136 is mechanically or electrically associated with the switches 28 and 40. In order to avoid waste of power, the resistor 132 may be replaced by another light source.

Momentary over-excitation of the studio lights during the slow motion interval will produce considerable increase in light intensity, and in order that the sudden and relatively intense increase in illumination may not affect persons being televized, it is also possible to employ ultra-violet light or infra-red light for the increased illumination, assuming, of course, an appropriately color responsive mosaic electrode is incorporated in the slow motion television camera tube 30. If the mosaic electrode in tube 30 were constructed to be exceedingly responsive in the ultra-violet spectrum, whereas the mosiac in the normal camera tube 10 had a spectral response similar to that of the human eye, then no switching arrangement would in fact be necessary since the ultra-violet light sources could be left on continuously without in any way affording any discomfort in so far as persons being televized is concerned and without interfering with the illumination in so far as the normal camera tube 10 is concerned. The relatively intense ultra-violet illumination would be sufficient to permit operation of the slow motion camera tube 30.

It is possible materially to simplify the slow motion circuit arrangement described above and to reduce the scanning speed in the normal camera tube 10 if each television frame from the slow motion camera tube 30 is applied simultaneously to four of the storage tubes so that the same electrostatic charge image is deposited on groups of four of the storage tubes simultaneously. The same image could then be scanned as described above at the normal rate to produce an apparent slowness of motion. Such a system, although physically simpler in so far as scanning and switching is concerned, is not so desirable, since the resultant images may be jerky in their motion and not have an apparently smooth reproduction as is the case where multiple speed scanning as previously described herein is employed. Where each television frame image in slow motion is stored on four storage tubes, the same detail of movement can not possibly to presented as will be the case if a system such as shown and described above is employed.

Although timers and commutators of a mechanical nature are shown and described herein, it is to be understood that electronic switching means could as well be employed for accomplishing the same purpose. Mechanical switching arrangements have merely been shown in order to simplify the drawings and explanations thereof and in order to present readily a complete and understandable description of the operation of the slow motion television system. Furthermore, it is to be understood that various types of television camera tubes may be used, and that it is not necessary to use the particular form of electron storage type specifically indicated in the drawings. Furthermore, various types of storage tubes may be used, the ones shown being merely representative of various tubes that could be employed.

Various other alterations and modifications may be made in the present invention, and it is desired that any and all such modifications be considered within the purview of the present invention except as limited by the hereinafter appended claims.

Having now described my invention, what I claim is:

1. A slow motion television transmitting system comprising a television camera tube including a target electrode, means to generate a cathode ray beam, means to deflect the cathode ray beam in mutually perpendicular directions to scan the target electrode at a predetermined rate to produce image signals, a plurality of storage tubes each including a storage electrode, means to store the produced image signals on the storage electrodes of said tubes as electrostatic charges and means to remove the stored image signals at a rate that is slow as compared to their originally produced rate.

2. A slow motion television transmitting system comprising a television camera tube including a light-sensitive target electrode, means to produce an electrostatic charge image of a scene to be transmitted on the target electrode, means to generate a cathode ray beam, means to deflect the cathode ray beam in mutually perpendicular directions to scan the target electrode at a predetermined rate to produce image signals, a plurality of storage tubes each including a storage electrode, means to sequentially store the produced image signals on the storage electrodes of said tubes as electrostatic charge image replicas of the image scanned in the pick-up tube, and means to sequentially remove the stored image signals at a rate that is slow as compared to their originally produced and stored rate.

3. A slow motion television transmitting system comprising a television camera tube having a target electrode, means to generate a cathode ray beam in said tube, means to deflect the cathode ray beam in horizontal and vertical directions to scan the target electrode to produce image signals, a plurality of storage tubes each including a storage electrode, means including a switching arrangement to successively store the image signals produced during a whole number of vertical deflection cycles on a separate storage tube, and means including a second switching arrangement to remove the stored image signals in succession at a rate slow as compared with the rate at which they were originally produced.

4. A slow motion television transmitting system comprising a television camera tube having a light-sensitive target electrode, means to generate a cathode ray beam in said tube, means to deflect the cathode ray beam in horizontal and vertical directions to scan said target electrode to produce image signals corresponding to each television line and frame, a plurality of storage tubes each including an electron storage

electrode, means including a switching arrangement to sequentially store the produced image signals representative of each television frame on a separate storage tube, and means including a second switching arrangement to remove the stored image signals in succession at a rate slow as compared with the rate at which they were originally produced and stored.

5. A slow motion television transmitting system comprising a television camera tube having a light-sensitive target electrode, means to generate a cathode ray beam in said tube, means to deflect the cathode ray beam in horizontal and vertical directions at different rates to scan said target electrode to produce image signals corresponding to each television line and frame in accordance with the horizontal and vertical deflections of the cathode ray beam, a plurality of storage tubes each including an electron storage electrode, means including a switching arrangement operable to sequentially store the produced image signals representative of each television frame at the horizontal and vertical deflection rates on a separate storage tube, means including a second switching arrangement operable to successively remove the stored image signals at a rate slow as compared with the rate at which they were originally produced and stored, the rate of storage bearing a whole number multiple ratio to the removal rate, and means to transmit the removed image signals whereby slow motion television images may be produced.

6. A slow motion television transmitting system comprising a first and a second television transmitting camera tube, each including a target electrode and means for developing a cathode ray beam, means to deflect the developed cathode ray beam in the first camera tube to scan its target electrode at a first predetermined rate to produce image signals, means to deflect the developed cathode ray beam in said second camera tube to scan its target electrode at a second predetermined rate to produce image signals, the said second scanning rate being considerably faster than the said first scanning rate, means to directly transmit the image signals produced by said first camera tube, a series of television image storage tubes, means to store in said storage tubes the image signals produced by said second camera tube at their rate of production, and means to remove and transmit the stored image signals at a rate corresponding to the rate of transmission of said image signals from said first camera tube.

7. A slow motion television transmitting system comprising a first and a second television transmitting camera tube, each including a light responsive target electrode, means for developing a cathode ray beam in each of said tubes, means to deflect the developed cathode ray beam in the first camera tube to scan its target electrode at a first predetermined rate to produce picture signals, means to deflect the developed cathode ray beam in said second camera tube to scan its target electrode at a second predetermined rate to produce picture signals, the said second scanning rate being considerably faster than the said first scanning rate and bearing a whole number ratio with respect thereto, means to transmit the image signals produced by said first camera tube at their rate of production, a series of television image storage tubes, means to sequentially store the image signals produced by said second camera tube as charge images in said storage tubes at their rate of production, and means to sequentially remove and transmit the stored image signals at a rate corresponding to the rate of transmission of the image signals from said first camera tube.

8. A slow motion television transmitting system comprising a first and second television camera tube, each including a target electrode and means to develope a cathode ray beam, means to deflect the developed cathode ray beam in said first camera tube at a predetermined normal rate to produce image signals, means to deflect the developed cathode ray beam in said second camera tube at a rate considerably in excess of the normal rate to produce image signals, a plurality of electrostatic charge storage tubes, means including a switching arrangement for storing in said storage tubes image signals produced over a predetermined length of time by said second camera tube, and means including a second switching arrangement for removing the stored image signals at the said predetermined normal rate.

9. A slow motion television transmitting system comprising a first and second television camera tube, each including a target electrode and means to develop a cathode ray beam, means to deflect the developed cathode ray beam in said first camera tube at a predetermined normal rate to produce image signals, means to deflect the developed cathode ray beam in said second camera tube to develop image signals, the rate of deflection in said second tube being at a rate considerably in excess of the rate of deflection in said first camera tube, a plurality of electrostatic charge storage tubes, means including a switching arrangement for storing image signals produced by said second camera tube over a predetermined length of time upon said storage tubes, and means including a second switching arrangement for removing the stored image signals at a slower rate corresponding to the rate at which image signals are produced by said first camera tube.

10. A slow motion television transmitting system comprising a first and second television camera tube, each including a target electrode and means to develop a cathode ray beam, means to deflect the developed cathode ray beam in said first camera tube at a predetermined normal rate to produce image signals, means to deflect the developed cathode ray beam in said second camera tube to develop image signals, the rate of deflection in said second tube being at a higher rate and bearing a multiple relationship to the said predetermined normal rate of deflection, a plurality of electrostatic charge storage tubes each including a storage electrode, means including a switching arrangement for sequentially storing image signals produced by said second camera tube over a predetermined length of time on the storage electrodes in said storage tubes, means including a second switching arrangement for sequentially removing the stored image signals from the storage electrodes at the said predetermined normal rate, and means to transmit the removed image signals.

11. The method of transmitting a plurality of optical images which comprises the steps of sequentially converting, at a predetermined rate, the plurality of optical images into a plurality of separate electrostatic charge images, and subsequently sequentially converting, at a different predetermined rate, the separate electrostatic charge images into a series of image signals.

12. The method of transmitting a plurality of

optical images which comprises the steps of sequentially converting, at a predetermined rate, the plurality of optical images into a plurality of separate electrostatic charge images, and subsequently sequentially converting, at a slower rate, the separate electrostatic charge images into a series of image signals.

13. The method of transmitting optical images by television which comprises the steps of generating a series of image signals from the optical images, converting the series of image signals into a series of separate electrostatic charge images, retaining the electrostatic charge images for predetermined time intervals, and reconverting the separate electrostatic charge images into another series of image signals.

14. A television transmitting system including a plurality of charge storage electrodes, means to produce sequentially a series of electrostatic charge images on said storage electrodes from a series of visual representations, the charge distribution of the charge images corresponding to the characteristics of the elemental areas of the visual representations, and means to subsequently sequentially scan the storage electrodes to produce a series of electrical potential variations from the electrostatic charge images.

15. A television transmitting system including a plurality of charge storage electrodes of mosaic construction capable of retaining a plurality of separate electrostatic charges on elemental areas of each electrode, means to sequentially produce an electrostatic charge image on each electrode at a predetermined rate from a succession of optical images, and means to subsequently and sequentially convert the electrostatic charge images into a series of image signals at a different rate.

16. A television transmitting system including means to convert a series of optical images into a series of image signals, a plurality of electrostatic charge storage electrodes, means to sequentially produce a series of electrostatic charge images on the storage electrodes in response to the produced series of image signals, and means to subsequently and sequentially scan the charge storage electrodes to produce another series of image signals from the electrostatic charge images.

17. A television transmitting system including means to convert a series of optical images into a series of image signals, a plurality of electrostatic charge storage electrodes, means to sequentially produce at one predetermined rate a series of electrostatic charge images on the storage electrodes in response to the produced series of image signals, and means to subsequently and sequentially scan the charge storage electrodes at a slower predetermined rate to produce another series of image signals from the electrostatic charge images so that slow motion effects result from the last named series of image signals.

18. A television transmitting system comprising a first television camera tube for converting optical images of a subject matter into a series of image signals at one predetermined rate, a second television camera tube for converting optical images of the subject matter into a series of image signals at a different predetermined rate, means to transmit directly the image signals produced by said first camera tube, a series of television image signal storage tubes, means to store in said storage tubes the image signals produced by said second camera tube at their rate of production, means to remove and transmit the stored image signals at a rate corresponding to the rate of transmission of the image signals from said first camera tube, means to illuminate the subject matter, and means to alter the illumination of the subject matter during periods of operation of said second camera tube.

19. A slow motion television transmitting system comprising a first television camera tube for generating image signals at a predetermined rate corresponding to the subject matter to be transmitted, a second television camera tube for generating image signals at a second predetermined rate corresponding to the subject matter to be transmitted, said second predetermined rate being considerably faster than said first predetermined rate and bearing a whole number ratio with respect thereto, means to transmit the image signals generated by said first camera tube at their rate of production, a series of television image signal storage tubes, means to sequentially store the image signals produced by said second camera tube as charge images in said storage tubes at their rate of production, means to subsequently and sequentially remove and transmit the stored image signals at a rate corresponding to the rate of transmission of the image signals from said first camera tube, means to illuminate the subject matter to be televised, and means to enhance the illumination during periods of operation of said second television camera tube.

20. A slow motion television transmitting system comprising a first and second television camera tube, each operative to scan an optical image of the subject matter to be transmitted to produce image signals, the rate of scanning in said second camera tube being considerably in excess of the rate of scanning in said first camera tube and bearing an integer relationship thereto, a series of television image signal storage tubes, means to sequentially store the image signals produced by said second camera tube as charge images in said storage tubes at their rate of production, means to subsequently and sequentially convert the charge images into a series of image signals, the rate of conversion corresponding to the scanning rate of said first television camera tube, switch means selective to directly transmit image signals produced by said first camera tube or to store and subsequently transmit image signals produced by said second television camera tube, means to illuminate the subject matter to be televised, and a switching device associated with said switch means for increasing the illumination of the subject matter to be televised when said second television camera tube is in operation to produce image signals.

ALFRED N. GOLDSMITH.