Sept. 9, 1930. J. W. HORTON 1,775,241

ELECTROOPTICAL SYSTEM

Filed May 25, 1929 2 Sheets-Sheet 1

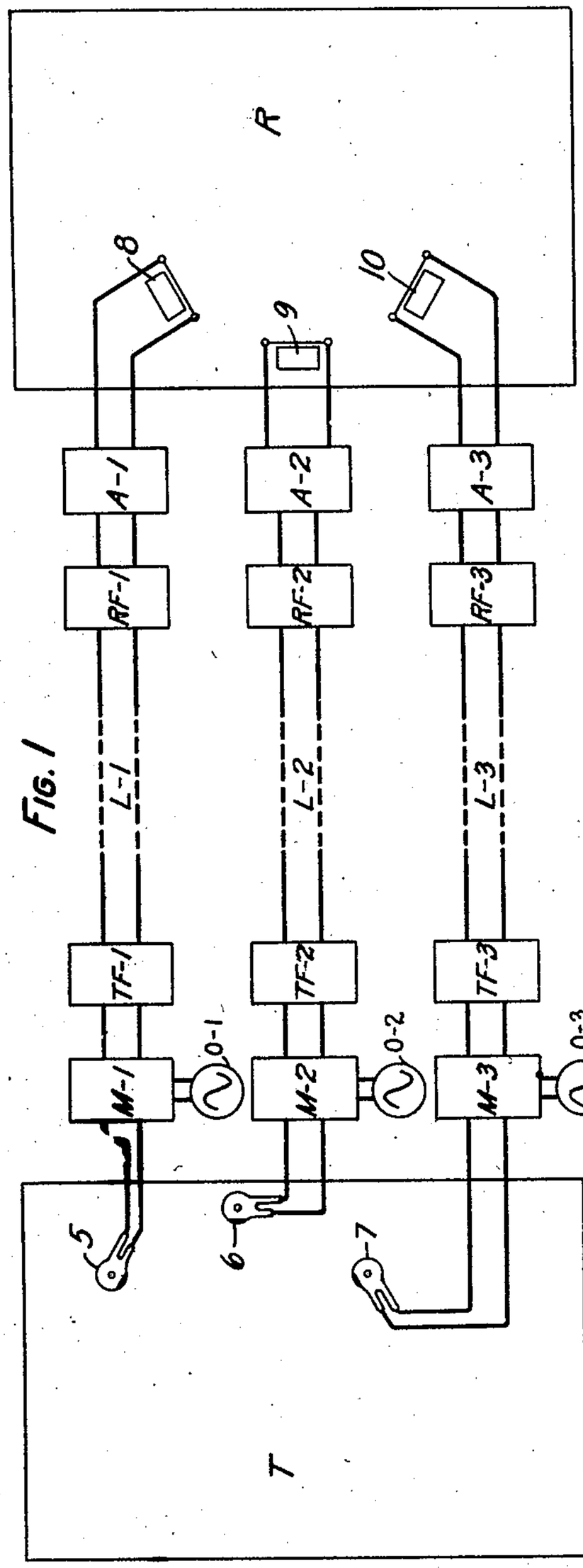


FIG. 1

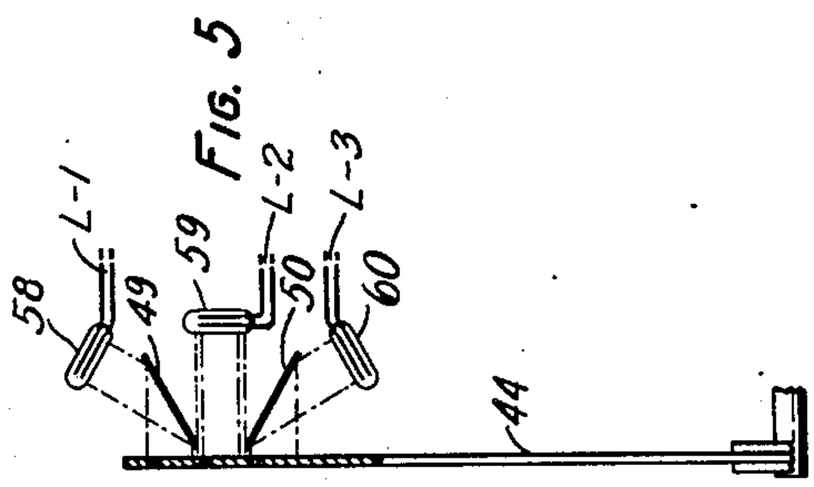


FIG. 5

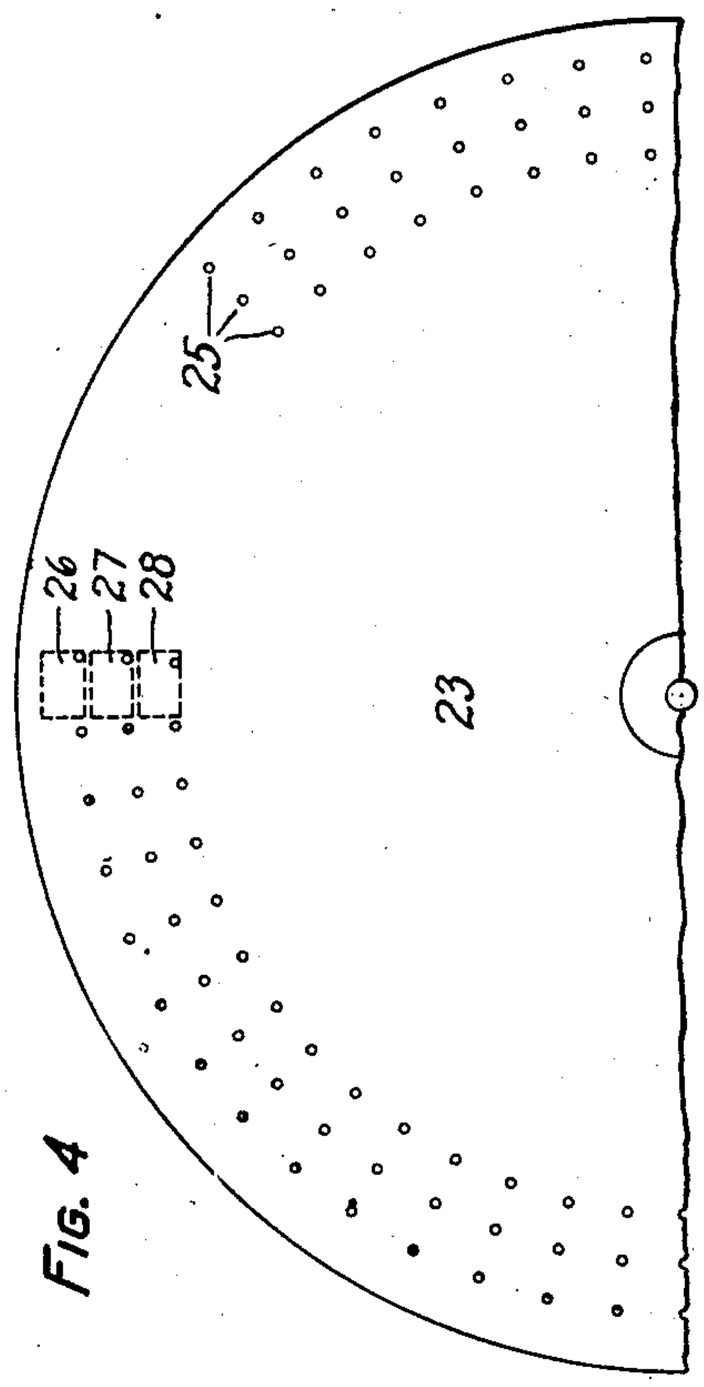


FIG. 4

INVENTOR
J. W. HORTON
BY C. C. Sprague.
ATTORNEY

Sept. 9, 1930. J. W. HORTON 1,775,241

ELECTROOPTICAL SYSTEM

Filed May 25, 1929 2 Sheets-Sheet 2

FIG. 2

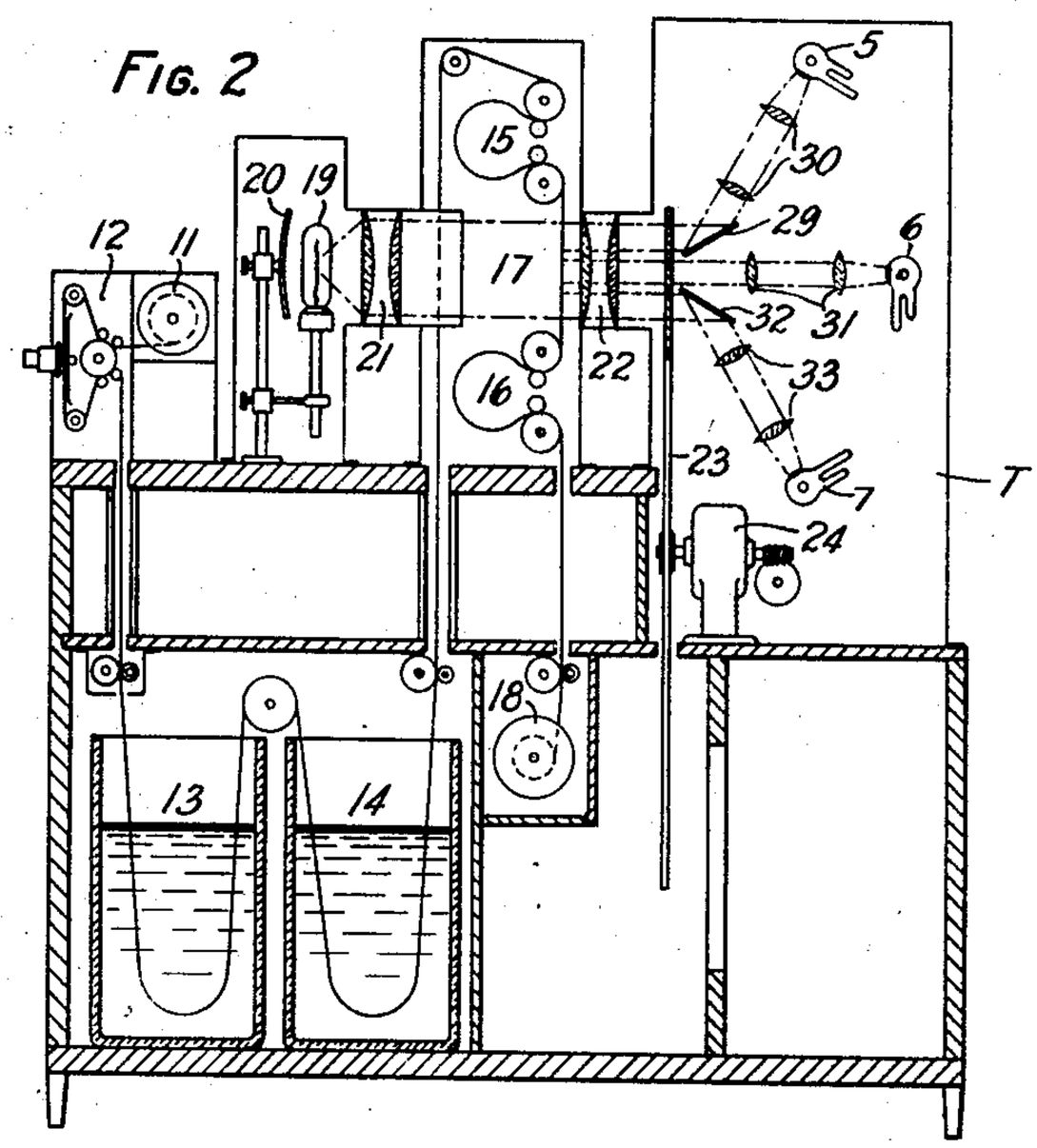
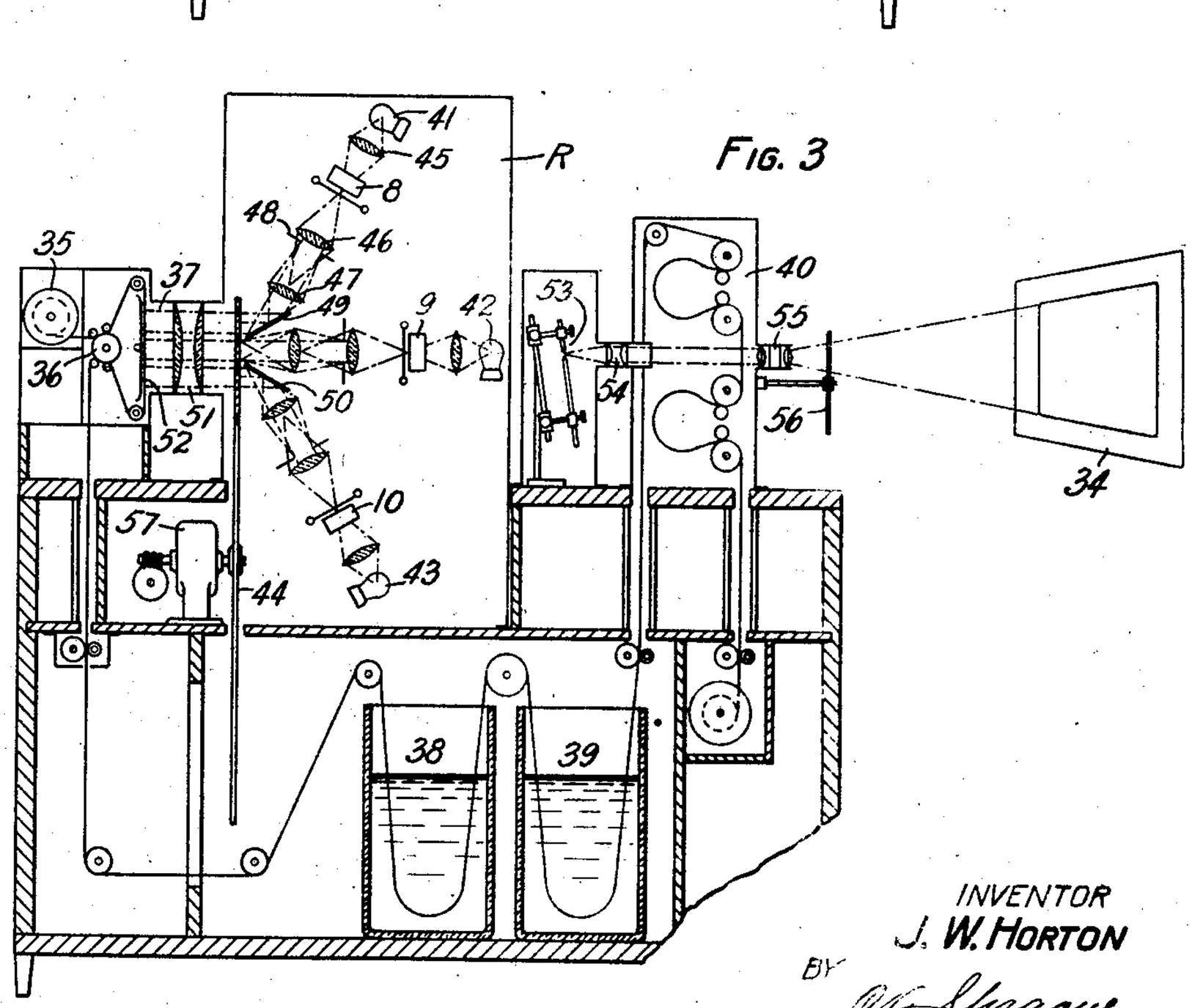


FIG. 3



INVENTOR
J. W. HORTON
BY
O. A. Sprague.
ATTORNEY

Patented Sept. 9, 1930

1,775,241

UNITED STATES PATENT OFFICE

JOSEPH W. HORTON, OF CAMBRIDGE, MASSACHUSETTS, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

ELECTROOPTICAL SYSTEM

Application filed May 25, 1929. Serial No. 365,855.

This invention relates to electro-optical systems and more particularly to television systems.

An object of the present invention is to provide an improved television system especially adapted to the viewing of extended scenes such as, for example, a ball game or a street scene where the field scanned is partly or wholly at a distance from the scanning mechanism. A more limited object of the invention is to provide a new and improved apparatus for electrically duplicating motion picture films.

Prior to this invention it had been proposed to accomplish the television of an extended scene by taking a motion picture of the field of view, developing and scanning the exposed film, transmitting electrical currents representative of the scanning to a receiving station, exposing and developing another motion picture film at the receiver for projection on a screen, all in one continuous process, so that the delay introduced by the record making becomes a negligible time factor. According to the present invention, the electrical transmission of separate portions of such a film simultaneously over a plurality of transmission channels is accomplished, thereby making possible the use of a simplified type of transmission channel and one which is readily available in the commercial telephone plant.

A feature of the invention is the storing of signals received from a plurality of simultaneously operating transmission channels to control the projection of successive images for the proper intervals to produce motion pictures at the receiver.

Another feature of the invention is the simultaneous scanning of a plurality of frames of the developed film to produce image currents for transmission over an equal number of transmission channels for exposing a like number of frames of a motion picture film blank at the receiver. In the example of practice selected for illustrating the invention, scanning discs are employed having a plurality of sets of spirally arranged apertures equal to the number of frames to be scanned simultaneously. Light valves preferably are used at the receiver but discharge lamps are also suitable.

The feature of motion picture film production by the simultaneous scanning of a plurality of frames is not confined to television systems.

A more detailed description of the invention will now be given having reference to the accompanying drawings.

Fig. 1 is a schematic circuit diagram of a system embodying this invention.

Figs. 2 and 3 show details respectively of the transmitting and receiving apparatus of Fig. 1.

Fig. 4 is a side view of the scanning disc used both at the transmitter and receiver.

Fig. 5 is an alternative light control arrangement for use at the receiver.

Identical elements in the several figures are identified by like reference characters.

Referring now to Fig. 1 transmitting apparatus T is associated with receiving apparatus R by a plurality of separate electrical transmission channels. In the arrangement illustrated three channels, L^1, L^2 and L^3 are employed. Each of these channels may comprise a physical transmission line, a carrier channel, or a radio link or combinations thereof. Each electrical channel originates in a photoelectric cell at the transmitter and terminates in a light valve at the receiver.

Transmitting apparatus T, as illustrated in Fig. 2, comprises means for exposing a motion picture film in accordance with a scene, an image of which is to be produced at the receiver, immediately thereafter developing and fixing the film, and then scanning the film to produce image currents. The unexposed film on reel 11 is fed through an ordinary motion picture camera 12 down to a developing tank 13 and a fixing tank 14, then up over guide wheels 15 and 16 between which it is exposed to the scanning light beam 17, and finally down to the take-up reel 18. The driving mechanisms for moving the film are suitably interconnected mechanically or electrically so that the exposing, developing and scanning constitute a continuous operation. The film, of course, moves through the motion picture camera 12 in a step by step mo-

tion for the exposure of successive frames. The motion through the tanks 13 and 14 is preferably at a uniform rate. The motion across the scanning beam 17 however, is intermittent, groups of three frames each being scanned simultaneously.

The source of light for the scanning beam 17 is lamp 19 backed by reflector 20 and directed to the film by the lens system 21. An image of each group of three frames is formed by the lens system 22 upon the left-hand face of scanning disc 23. The disc 23 is driven by suitable motor 24 at a speed suitably related to that of the film moving mechanism.

The disc 23 is illustrated more in detail in Fig. 4 and comprises three sets of spirally arranged scanning apertures 25. Each set of apertures is used to scan a separate frame of the group of three frames exposed simultaneously to the scanning beam 17. These frames are represented in Fig. 4 by the dotted rectangles 26, 27 and 28.

The light passing through the apertures of the outer spiral after reflection by mirror 29 is directed by lens system 30 to photoelectric cell 5. The light from the apertures of the middle spiral is directed by the lens system 31 to photoelectric cell 6. Light from the apertures of the inner spiral is reflected by mirror 32 and directed by the lens system 33 to photoelectric cell 7. Thus each separate frame of a group of three frames is scanned simultaneously and produces image currents in each of the separate channels L^1, L^2 and L^3.

A blank space is left between the first and last apertures of each spiral to prevent the passage of light to the photoelectric cells 5, 6 and 7 while the film is moving across the light beam 17 between group scannings. During the operation of the transmitting apparatus T the exposure of a frame in the motion picture camera 12 takes one-third of the time that is devoted to the scanning of each frame for the production of image currents.

At the receiver the apparatus R provides for the exposure of a motion picture film, the development and fixing of the film and its projection at the proper rate to produce a motion picture on the screen 34 of Fig. 3. A supply of unexposed film on reel 35 is fed by suitable driving mechanism 36 through an exposing chamber 37 after which it is passed through developing tank 38 and fixing tank 39 to a motion picture projector 40. Three frames are exposed simultaneously in accordance with the image currents received over the three transmission channels L^1, L^2 and L^3. The image currents from channels L^1, L^2 and L^3 respectively are impressed upon light valves 8, 9 and 10 respectively, to control the intensity of the light from sources 41, 42 and 43 respectively, illuminating at any instant rectangular areas of scanning disc 44, each of these areas corresponding to one frame of a group of three frames which are exposed simultaneously. The scanning disc 44 is identical with the scanning disc 23 illustrated in Fig. 4. The illuminated rectangle produced by light from source 41 corresponds to the outer spiral of apertures of disc 44, that produced by source 42 to the middle spiral and that produced by source 43 to the inner spiral. The light from source 41 is focused by lens 45 on the aperture of light valve 8. Lens 46 focusses an image of the light valve aperture in a plane in the vicinity of lens 47 which in turn produces an image of an aperture in screen 48 upon the right-hand face of disc 44 after reflection by mirror 49. The lens system for directing the light from sources 42 and 43 is identical with that just described except that no reflecting mirror is used with the source 42 and mirror 50 is used with the source 43. An image of that portion of the left-hand face of scanning disc 44 which is illuminated on its right-hand face is formed by lens system 51 upon that portion of the film 52 at that time in the exposing chamber 37. As the disc 44 rotates, the light passing through the several apertures, causes each elemental area of the film to be exposed to the proper degree to produce an image after development.

The exposed film is developed in tank 38 and fixed in tank 39, after which it is exposed to light from the arm 53 directed by lens 54 and imaged by lens 55 upon the screen 34. By means of the intermittently moved film and ordinary interrupter disc 56 of the motion picture projector 40, a motion picture is produced on the screen 34.

Any suitable electrical transmission channel may be used between the photoelectric cell and the light valve. As illustrated in Fig. 1 a carrier system is employed. The image currents from photoelectric cell 5 are used to modulate in modulator M^1 carrier currents from source O^1. These modulated carrier currents are transmitted through transmitting filter TF^1 over line L^1 to receiving filter RF^1 and amplifier A^1 from the output of which they are impressed upon light valve 8. Similar apparatus is used in the other channels. A channel of this kind is disclosed in Patent No. 1,606,227 issued November 9, 1926, to Horton, Ives and Long.

Scanning disc 44 is driven by motor 57, the speed of which bears a certain fixed relationship to the film driving mechanisms and also to the speed of the motor 24 at the transmitting station. Any suitable synchronizing system may be used. Preferably the speed of the film moving mechanisms is controlled by the speed of the motors 24 and 57 and means are provided to maintain the motors 24 and 57 in synchronism. A suitable synchronizing system for this purpose is disclosed in

Patent No. 1,763,909, of H. M. Stoller and E. R. Morton, issued June 17, 1930.

A light valve suitable for use in this system is disclosed in Patent No. 1,667,805 issued May 1, 1928, to H. E. Ives.

An alternative arrangement for variably illuminating the right-hand face of scanning disc 44 in accordance with received image currents is illustrated in Fig. 5. In place of light valves 8, 9 and 10, controlling the light from steady sources 41, 42 and 43 respectively, discharge lamps 58, 59 and 60 are employed. These lamps are energized by image currents from channels L^1, L^2 and L^3 respectively. The discharge lamps 58, 59 and 60 should produce light having a good actinic characteristic.

While three channels only are illustrated in the drawing, a larger number of channels may be employed if the results to be obtained warrant such increase. It is to be understood that various modifications of the specific systems disclosed come within the purview of this invention, the scope of which is defined in the appended claims.

What is claimed is:

1. A system for producing successive images of a field in which the objects may be moving or changing, comprising means for successively impressing views of the field upon a record, means controlled simultaneously by separate portions of said record and operating simultaneously with said first means for producing said images, and means to maintain a fixed motional relation between said recording means and said image producing means.

2. Means for scanning a field to set up television image currents comprising a photographic film, means for impressing successive views of the field upon said film to produce frames, driving means therefor, means for developing said film, means for scanning simultaneously a plurality of developed frames, means for driving said scanning means, and means for maintaining a fixed motional relation between both said driving means.

3. In a system for electrically producing motion picture film, means to scan simultaneously a plurality of frames of a motion picture film, means to transmit currents representative of said scannings over separate transmission channels respectively, and means to produce another motion picture film in accordance with the transmitted currents substantially like the originally scanned film.

4. A system for producing successive images at a rate sufficient to produce a motion picture of a field in which the objects may be moving or changing, comprising a plurality of transmission channels, means for storing signals representative of said images, certain of which signals are received from each channel and at a rate slower than that required for viewing, and means for producing in accordance with said stored signals successive images in proper sequence and at the proper rate to produce a motion picture of said field.

5. A system for producing successive images at a rate sufficient to produce a motion picture of a field in which the objects may be moving or changing, comprising a plurality of transmission channels, means for storing signals representative of said images, certain of which signals are received from each channel and at a rate slower than that required for viewing, means for producing in accordance with said stored signals successive images in proper sequence and at the proper rate to produce a motion picture of said field, and means for maintaining a fixed relationship between said signal storing and said image producing means.

6. A television system comprising a plurality of transmission channels for sequences of signals representative of successive images of a scene, a plurality of sequences being transmitted simultaneously over said plurality of channels respectively, means for storing each sequence at a rate slower than that required for viewing successive images of a motion picture, and means for producing in accordance with said stored signals successive images in proper sequence and at the proper rate to produce a motion picture of said scene.

7. A television system comprising a plurality of transmission channels for sequences of signals representative of successive images of a scene, a plurality of sequences being transmitted simultaneously over said plurality of channels respectively, means for storing each sequence at a rate slower than that required for viewing successive images of a motion picture, means for producing in accordance with said stored signals successive images in proper sequence and at the proper rate to produce a motion picture of said scene, and means for maintaining a fixed relationship between said signal storing and said image producing means.

8. In a television system, a plurality of transmission channels for image currents, a flexible recording member, means for recording upon said member signals representative of images under the control of currents received simultaneously over said plurality of channels, means for producing successive images from said record at such a rate that successive images follow each other within the time interval of persistence of vision, and means to maintain at constant value the average length of recording member between said recording means and said image producing means.

9. In a television system, means to produce image currents corresponding to successive aspects of an object field, means comprising a

plurality of simultaneously operating transmission channels for the transmission of said currents, a motion picture film blank, means to expose said film under the control of the image currents of said channels to produce successive frames corresponding to said successive aspects, means to develop said film, means to produce successive images of a motion picture, and means to maintain a fixed time relationship between said exposing, developing, and image producing means.

10. In a system for electrically producing motion picture film, means to scan simultaneously a plurality of frames of a motion picture film, and means to produce image currents representive of said scannings.

11. In a system for electrically producing motion picture film, a scanning disc having a plurality of sets of scanning apertures for simultaneously scanning a plurality of frames of a motion picture film, means to transmit image currents representative of said scannings over separate transmission channels respectively, a plurality of light controlling devices controlled by the image currents from said transmission channels, and another similar scanning disc for controlling light from said devices to produce another motion picture film like the originally scanned film.

12. Means for scanning a field to set up television image currents comprising a photographic film, means for impressing successive views of the field upon said film to produce frames, driving means therefor, means for developing said film, a scanning disc having a plurality of sets of spirally arranged apertures for scanning simultaneously a plurality of developed frames, means for driving said scanning disc, and means for maintaining a fixed motional relation between both said driving means.

13. A method of television which comprises receiving complete sets of image impulses representing complete scannings respectively at the transmitter, simultaneously storing signals representative of impulses of a plurality of said sets, the period of storage of complete sets of impulses being greater than the period of persistence of vision, and at once producing in accordance with said stored signals successive images one for each set of signals, the period required for the production of each image being no greater than the period of persistence.

14. In a television system, a plurality of transmission channels, means for storing signals received simultaneously over said channels, and means controlled by said stored signals for projecting successive images at the proper intervals to produce motion pictures.

In witness whereof, I hereunto subscribe my name this 21st day of May, 1929.

JOSEPH W. HORTON.