

Feb. 12, 1935.

F. GRAY

1,990,544

ELECTROOPTICAL SYSTEM

Filed March 25, 1930

2 Sheets-Sheet 1

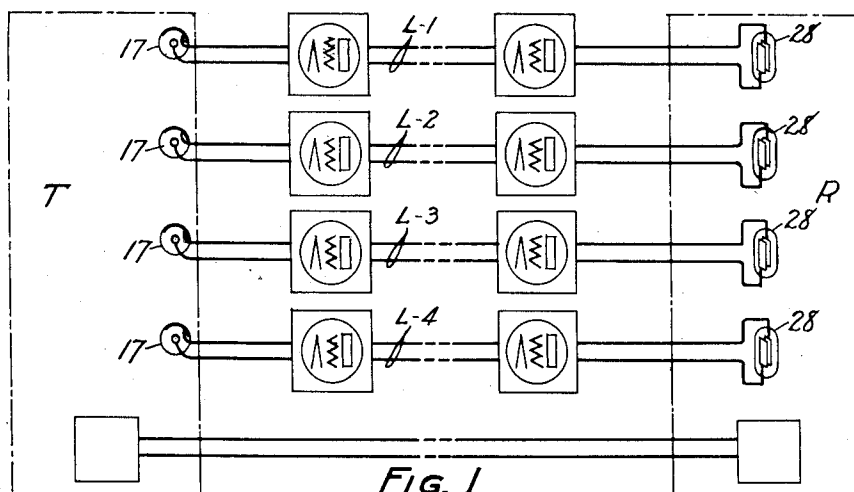


Fig. 1

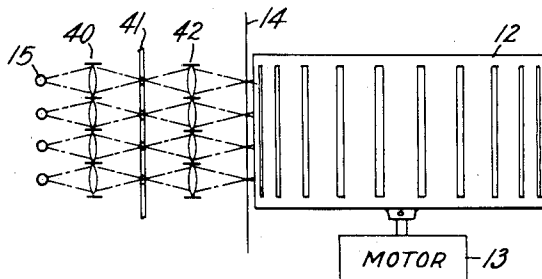


Fig. 6

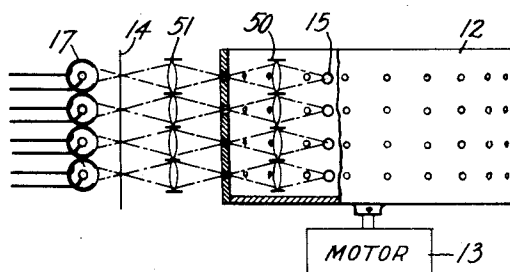


Fig. 7

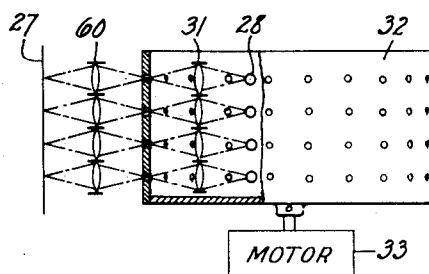


Fig. 8

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FIG. 2

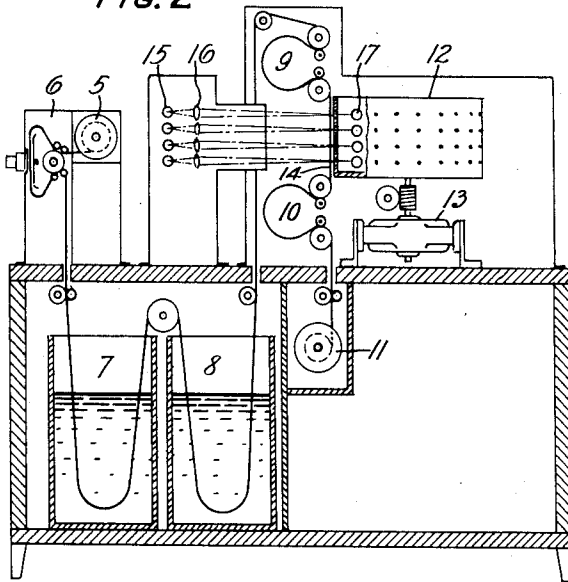


FIG. 5



FIG. 3

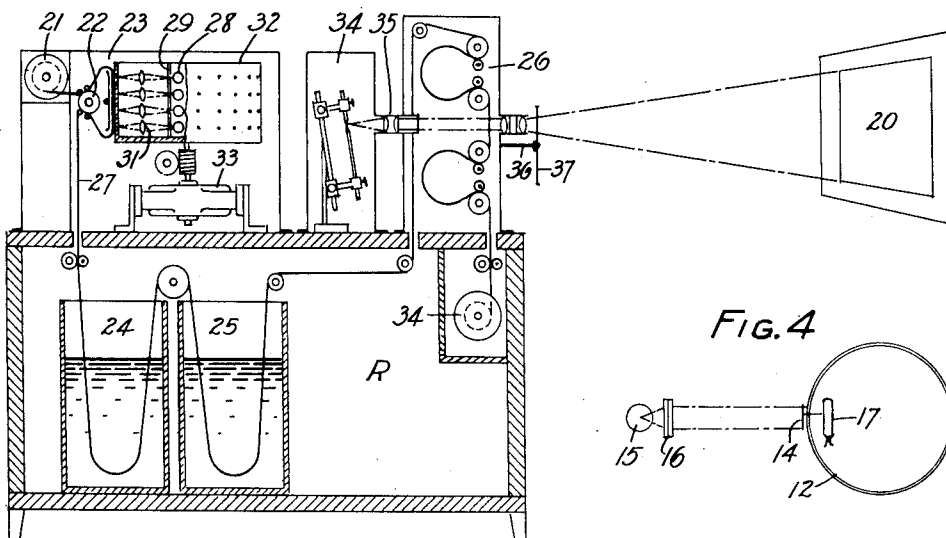
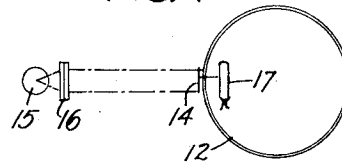


FIG. 4



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1,990,544

ELECTROOPTICAL SYSTEM

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19 Claims. (Cl. 178—6)

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

An object of the invention is to provide an improved television system for the production of images of field of large size, electrical transmission taking place over a plurality of simultaneously operating channels.

Prior to this invention it had been proposed to accomplish the television of extended scenes by taking a motion picture of the scene, immediately developing the film, scanning the film to produce image currents, exposing another film at the receiver, immediately developing this film, and projecting the motion picture on a viewing screen. It had further been proposed to accomplish the electrical transmission by a plurality of simultaneously operating channels in order to make the system adaptable for use in the existing commercial telephone plant.

This invention goes further by providing a new and simplified system. In accordance with a preferred form of the invention the developed film at the transmitter is moved at a uniform rate past a revolving scanning drum provided with a plurality of rows of apertures. For each row of apertures there is a photoelectric cell and associated transmission channel. As the film moves past a row of apertures, it is scanned in a series of parallel oblique elemental lines so separated that the unscanned surface may be scanned by the other rows of apertures. The rows of apertures may be separated any suitable distance but preferably such a distance that the same lines of adjacent frames are scanned by different rows of apertures. A motion picture film blank at the receiver is also moved at a uniform rate past a similar drum for exposing the blank in accordance with the incoming image currents.

In one of the arrangements selected for illustrating the invention, the optical arrangement is such that the films travel close to the drums. In a modified arrangement the mechanical difficulties inherent in the close traveling system are removed by modifying the optical system to permit of appreciable separation between the films and the drums.

The invention will now be described more in detail having reference to the accompanying drawings.

Fig. 1 is a schematic representation of a multi-channel image producing system.

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

Fig. 4 is a top view of the scanning drum and closely associated parts of Fig. 2.

Fig. 5 shows an elongated light source.

Fig. 6 is a scanning drum with slits inside of apertures.

Figs. 7 and 8 show transmitting and receiving optical systems respectively in which the films are widely separated from the scanning drums.

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 transmission channels. As illustrated, four channels L—1, L—2, L—3 and L—4 are employed. Each of these channels may comprise a physical transmission line, a carrier channel, a radio link or combinations thereof. Each electrical channel originates in a photoelectric cell and terminates in a variable source of light at the receiver.

Transmitting apparatus T as illustrated in Fig. 2 comprises means for exposing a motion picture film in accordance with the scene an image which is to be produced at the receiver, immediately thereafter developing and fixing the film and then scanning the film to produce image currents. Unexposed film on reel 5 is fed through an ordinary motion picture camera 6 down to a developing tank 7 and a fixing tank 8 then up over guide wheels 9 and 10 and finally down to the take up reel 11. Driving mechanisms for moving the film are suitably interconnected mechanically or electrically so that the exposing, developing and scanning constitutes a continuous operation. The film, of course, moves through the motion picture camera 6 with a step-by-step motion for the exposure of successive frames. The motion through the tanks 7 and 8 is preferably at a uniform rate as is also that between the guide wheels 9 and 10 where the scanning of the film for producing image currents takes place.

In the arrangement of Fig. 2, four elemental lines of the film are scanned simultaneously. A drum 12 rotated at a uniform rate by motor 13 is pierced with four equally spaced rows of small apertures for scanning the film 14. Transverse strips of the film opposite the four rows of apertures are illuminated by light from sources 15 focused by lenses 16. Light which passes through the apertures energizes photoelectric cells 17 to produce the image currents for the several channels, each row of apertures controlling one of the transmission channels. The distance between apertures around the drum is equal

to the width of a picture frame across the film. As the film moves past a row of apertures, the latter scan the film in a series of parallel and well separated oblique elemental lines. The film moving mechanism is geared to the rotating drum in such a manner that it will give a ratio of velocity of film to velocity of apertures that will just separate the centers of strips scanned by succeeding apertures of the same row by a distance equal to four times the desired separation of the centers of adjacent scanning strips across the film. In other words, the ratio of film speed to aperture speed is such that in the series of strips scanned across the film, succeeding strips are scanned in consecutive order by an aperture of row 1, an aperture of row 2, an aperture of row 3 and an aperture of row 4. As the four apertures move across the four illuminated strips of the film 14, the varying light entering the four photoelectric cells 17 produce four image currents which are transmitted over channels L—1, L—2, L—3 and L—4. Each picture frame therefore takes part in the production of image currents in each of the four transmission channels, there being more scanning lines per frame than there are transmission channels.

The distance between rows of apertures in the drum 12 preferably differs considerably from the length of a frame along the film in order that any imperfections of the drum or mechanism producing the continuous motions may cause errors at different parts of succeeding frames instead of always causing them at the same place, as would be the case if the distance between the rows of apertures in the drum 12 were equal to the length of a frame along the film. This distance is preferably less than the length of a frame along the film, although not necessarily so. The speed with which the film moves should be about equal to the length of 16 picture frames per second to permit the transmitted pictures to be produced at the receiving station in the usual manner. Furthermore, the ratio of the aperture speed to the film speed should not be an exact multiple of the ratio of the distance between apertures around the cylinder to the distance between corresponding points of two consecutive frames on the film in order that a row of apertures may scan different parts of succeeding frames. If the first ratio is not an exact multiple of the second ratio, a row of apertures will scan different parts of succeeding frames and any inequalities of the channels will thus tend to be smoothed out in the projected moving picture at the receiving station.

A top view of the scanning drum 12 and the associated optical apparatus is shown in Fig. 4. Film 14 is shown in cross section. Light from a point source 15 is guided by a double cylindrical lens 16 to illuminate a transverse elemental strip of the film 14. As the apertures of the drum 12 move across the different illuminated areas, light passing through the apertures enter the elongated photoelectric cells 17 to produce image currents.

At the receiver, the apparatus R makes possible the exposure of a motion picture film, the developing and fixing of the film and its projection at the proper rate to produce a motion picture on the screen 20 of Fig. 3. A supply of unexposed film on reel 21 is fed by suitable driving mechanism 22 through an exposing chamber 23, after which it passes through a developing tank 24 and a fixing tank 25 to a motion picture pro-

jector 26. The exposed film is stored on take up reel 34.

Four elemental strips of the film 27 are exposed simultaneously in accordance with the image currents received over the four transmission channels L—1, L—2, L—3 and L—4. The image currents from these channels are impressed upon glow discharge devices 28 which produce light of an intensity proportional to the respective incoming image currents in the several channels. Elongated apertures in screens 29 are illuminated by light sources 28. An enlarged showing of one light source 28 and one screen 29 with its elongated aperture 30 is shown in Fig. 5. An image of each aperture 30 is focused by lenses 31 on the inside surface of scanning drum 32 which is provided with four rows of apertures corresponding to the apertures in drum 12 at the transmitting station. The images of the apertures 30 coincide with the rows of apertures in the drum 32. The drum 32 is rotated by motor 33. As the drum 32 rotates, four beams of light passing through an aperture in each row of apertures traverses the film 27 transversely to expose four elemental strips corresponding to the four strips being scanned at the transmitter. Helium glow discharge lamps are preferably used for the sources 28 because of the high actinic value of the light produced. Other devices for producing light of varying intensities may be employed such as Kerr cells with crossed Nicol prisms or vibrating light valves.

The exposed film is developed in tank 24 and fixed in tank 25 after which it is illuminated by light from the arc 34, directed by lens 35 and imaged by lens 36 upon the screen 20. By means of the intermittently moved film and the ordinary interrupter disc 37 of the motion picture projector moving pictures are produced on the screen 20.

Scanning drums 12 and 32 with the associated film driving mechanisms are driven in synchronism and phase by motors 13 and 33. Any suitable synchronizing system may be used. A suitable system for this purpose is disclosed in Patent No. 1,763,909 of H. M. Stoller and E. R. Morton, patented June 17, 1930.

A modified scanning arrangement is shown in Fig. 6 and may be substituted for the scanning drum 12 and the associated optical system. In this arrangement the light from sources 15 is directed by lenses 40 to illuminate elongated apertures in screen 41. Lenses 42 then form sharp images of the apertures in screen 41 on the film 14 and the scanning drum 12 is provided with slots instead of rows of apertures. Photoelectric cells 17 are placed within the drum to receive light from the several illuminated strips on the film as the several slots pass transversely across the film.

In the arrangement of Figs. 7 and 8, which are further modifications of this invention, the film is placed at a distance from the surface of the scanning drums. The arrangement of Fig. 7 is suitable for use at the transmitter, while that of Fig. 8 is for use at the receiver. The scanning drums are the same as those of Figs. 2 and 3 and are driven by motors 13 and 33 respectively.

At the transmitter, the light sources for illuminating the film are located within the drums 12. Lenses 50 illuminate strips inside the drum coinciding with the rows of apertures so that as the drum rotates, light from different portions of these strips may pass through the several

apertures. Images of these apertures are formed by lenses 51 to illuminate moving spots on the film 14, light from which passes into the photo-electric cells 17.

At the receiver, light from sources 28 is focused by lenses 31 to illuminate strips inside the drum 32 coinciding with the rows of apertures. Lenses 60 then produce images of the light passing through the several apertures in the drum 32 to expose the receiving film 27. The receiving drum is driven by motor 33.

An advantage of the arrangements of Figs. 7 and 8 is in the ease of maintenance, due to the separation of two relatively fast moving parts by an appreciable distance. This is affected by the use of more lenses, which however are stationary elements.

In each of the arrangements illustrated it may be advantageous to use a single lens for the four optical channels, instead of four separate lenses, one for each channel. Also a single light source, instead of four, at the transmitter may sometimes be preferable.

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

What is claimed is:

1. In a television system, a motion picture film having a succession of frames, a plurality of sources of light, a plurality of lenses directing light from said sources respectively to illuminate a plurality of separated elemental strips across said film, a drum on the opposite side of said film having a plurality of rows of apertures, a row being located opposite each illuminated strip, a light sensitive cell for each row of apertures for receiving light from the film through the apertures, and means to rotate said drum and move said film with respect to said light sources to scan said film.

2. In a television system, a motion picture film having a succession of frames, a plurality of sources of light, a plurality of lenses directing light from said sources respectively to illuminate a plurality of separated elemental strips across said film, a drum on the opposite side of said film having a plurality of rows of apertures, a row being located opposite each illuminated strip and the separation between the rows being materially different from the distance between like points in adjacent frames, a light sensitive cell for each row of apertures for receiving light from the film through the apertures, and means to rotate said drum and move said film with respect to said light sources to scan said film.

3. In a television system, a motion picture film having a succession of frames, a plurality of sources of light, a plurality of lenses directing light from said sources respectively to illuminate a plurality of separated elemental strips across said film, a drum on the opposite side of said film having a plurality of rows of apertures, a row being located opposite each illuminated strip, a light sensitive cell for each row of apertures for receiving light from the film through the apertures, and means to rotate said drum and move said film with respect to said light sources to scan said film, the ratio of speed of aperture movement to width of frame differing from an exact multiple of the ratio of speed of film move-

ment to the distance between like points of adjacent frames.

4. In a television system, a motion picture film having a succession of frames, a plurality of sources of light, a plurality of lenses directing light from said sources respectively to illuminate a plurality of separated elemental strips across said film, a drum on the opposite side of said film having a plurality of slit apertures adapted to be moved across said illuminated strips, a light sensitive cell for each illuminated strip for receiving light from the film through the slit apertures, and means to rotate said drum and move said film with respect to said light sources to scan said film.

5. In a television system, a motion picture film having a succession of frames, a scanning drum having a plurality of rows of apertures, a plurality of light sources inside said drum for illuminating portions respectively of the inside of said drum in the paths of said apertures, a plurality of lenses for imaging respectively an aperture of each row on said motion picture film, a plurality of light sensitive devices energized by the light from the illuminated portions of said film, and means to rotate said drum and move said film with respect to said light sources to scan said film.

6. In a television system, a plurality of sources of light controlled by image currents incoming from a plurality of transmission channels, a light sensitive motion picture film, a drum adjacent to said film having a plurality of rows of apertures one for each of said plurality of light sources, a plurality of lenses for directing light from said sources respectively through said apertures to expose said film, and means to rotate said drum and move said film with respect to said light sources both continuously.

7. In a television system, a plurality of sources of light controlled by image currents incoming from a plurality of transmission channels, a light sensitive motion picture film, a drum adjacent to said film having a plurality of rows of apertures one for each of said plurality of light sources respectively, the separation between said rows being materially different from the distance between like points of adjacent frames of said motion picture film, a plurality of lenses for directing light from said sources through said apertures to expose said film, and means to rotate said drum and move said film in a lengthwise direction with respect to said light sources both continuously.

8. In a television system, a plurality of sources of light controlled by image currents incoming from a plurality of transmission channels, a light sensitive motion picture film, a drum adjacent to said film having a plurality of rows of apertures one for each of said plurality of light sources respectively, a plurality of lenses for directing light from said sources through said apertures to expose said film, and means to rotate said drum and move said film with respect to said light sources both continuously, the ratio of speed of aperture movement to width of frame of said motion picture film differing from an exact multiple of the ratio of the speed of film movement to the distance between like points of adjacent frames.

9. In a television system, a plurality of sources of light controlled by image currents incoming from a plurality of transmission channels, a light sensitive motion picture film, a drum adjacent to said film having a plurality of rows of apertures one for each of said plurality of light

sources, lens means for directing light from said sources through said apertures to expose said film, and means to rotate said drum and move said film with respect to said light sources both continuously.

- 5 10. In a television system, a motion picture film, means for scanning simultaneously a plurality of elemental lines across said film, each line of said simultaneous plurality of elemental lines scanned by said means being separated from each other line of said simultaneous plurality of elemental lines scanned by said means, means for

repeating said scannings in time succession, and means for moving said film continuously in a lengthwise direction to cause the entire picture surface to be scanned by said scanning means over a series of frames which extend along the film a distance more than twice that between the most widely separated simultaneously scanned lines whereby the gaps between the separated simultaneously scanned lines are filled up by succeeding scannings.

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