Sept. 14, 1943. E. W. KELLOGG 2,329,624

TELEVISION RECORDING APPARATUS

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FIG. 1.

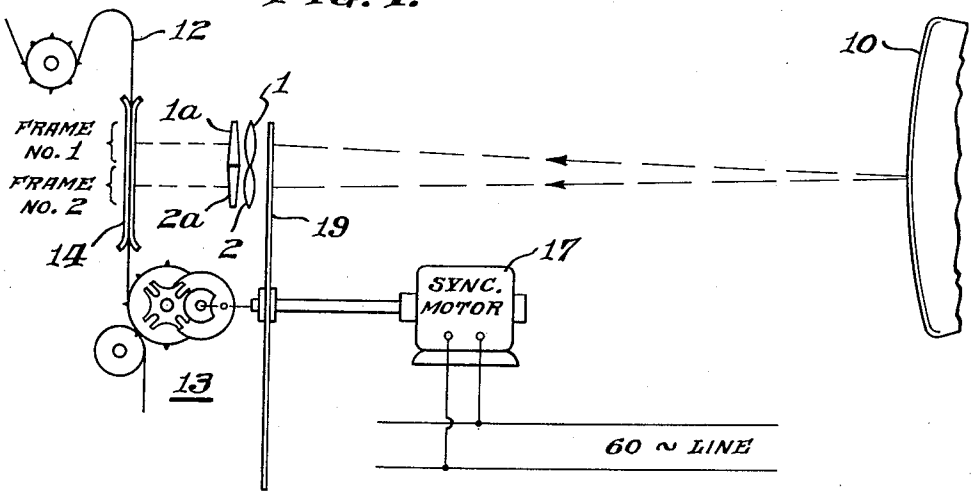

FIG. 2.

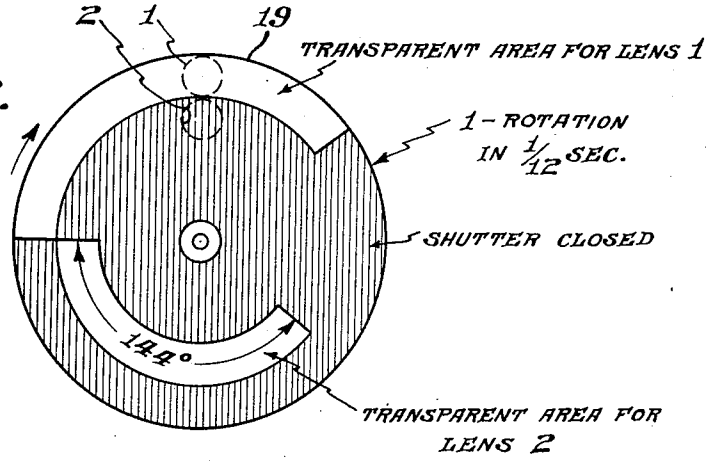

FIG. 3.

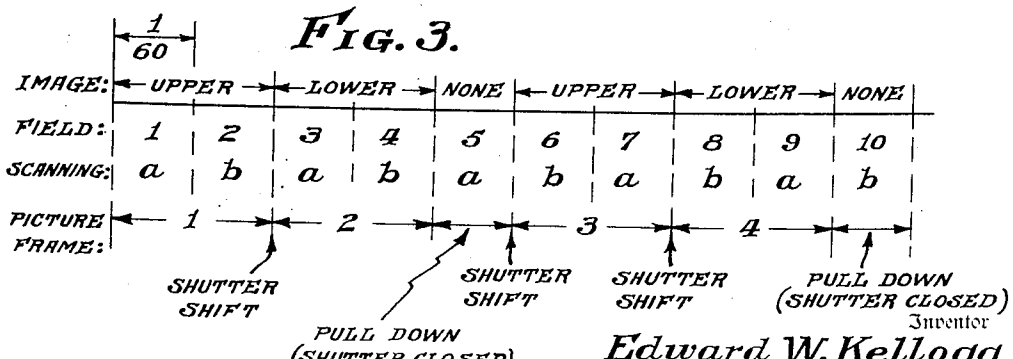

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FIG. 4.

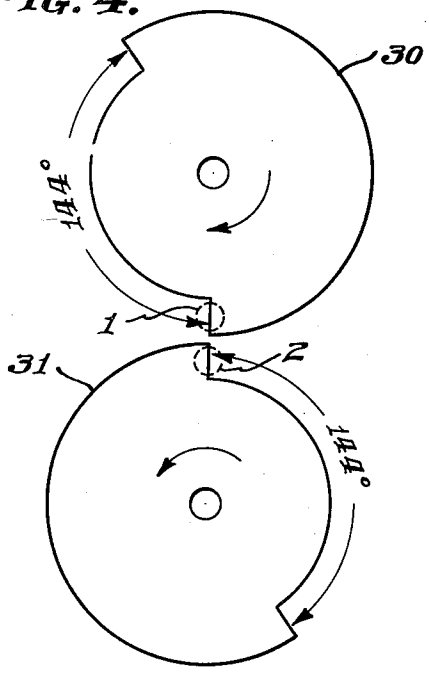


FIG. 6.

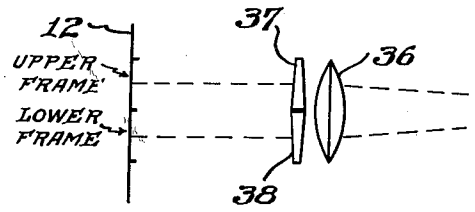


FIG. 7.

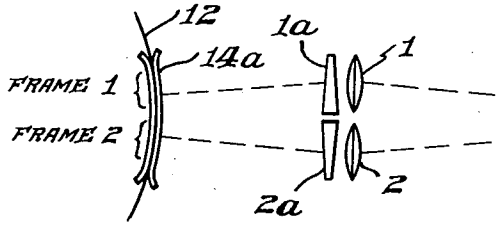


FIG. 5.

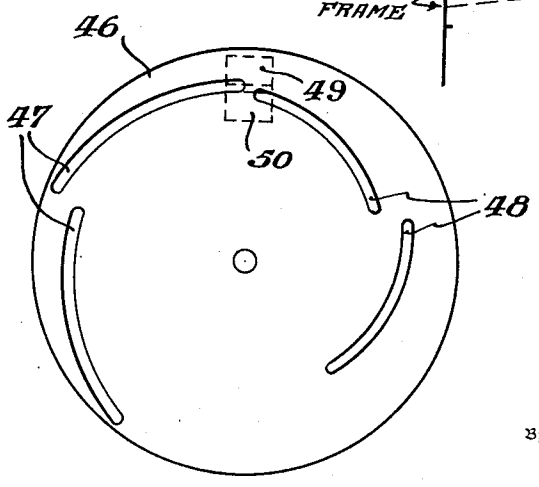
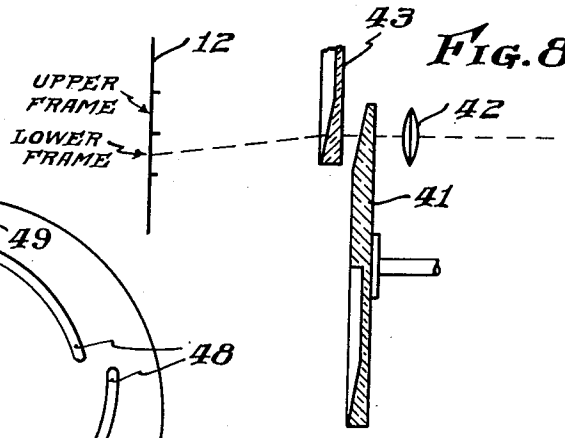


FIG. 8.



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Patented Sept. 14, 1943

2,329,624

UNITED STATES PATENT OFFICE

2,329,624

TELEVISION RECORDING APPARATUS

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Application January 31, 1941, Serial No. 376,883

7 Claims. (Cl. 178—6.7)

My invention relates to picture recording apparatus and particularly to means for recording television pictures occurring at a certain frame frequency on moving picture film which is being moved at a different frame frequency.

For record purposes, it is desirable to make a motion picture of studio scenes which are being transmitted from a television transmitter. The obvious way of doing this is to photograph the scene directly, but such procedure is undesirable since a recording camera cannot be located in the same place as the television camera (i. e., cannot occupy the same space) and, as a practical matter, cannot be used for many scenes during the television transmission. Moreover, such a method would not afford a record of the actual television transmission.

Also, it is desirable to provide some method of recording which is less expensive than photographing the scene directly with the aid of a special group of motion picture technicians.

The picture being transmitted can be recorded by focusing a motion picture camera on the end of a cathode ray receiver tube, such as a monitor tube or a cathode ray tube of the projector type at the transmitter, providing the frame frequencies of the television picture and motion picture camera are the same and the camera is actually synchronized with the scanning of the picture image.

Obviously, it is desirable to have the pictures recorded at a standard frame frequency, 24 per second for example, so that they may be projected later in a standard projector. Television pictures, however, should be transmitted at a frequency which is equal to or which is a submultiple of the power line frequency. In the United States, the standard power line frequency is 60 cycles per second and, accordingly, it is preferred television practice to transmit pictures having a frame frequency of 30 per second. Preferably, double "interlaced" scanning is employed whereby the field frequency or frequency of vertical deflection of the scanning beam is double the frame frequency, or in the example given, 60 per second. With interlaced scanning, the vertical spacing of the sweeps of the scanning beam is twice the line spacing, so that the entire height of the picture is covered in a single vertical deflection cycle, but with only half of the required number of lines. The scanning beam then begins over again and scans another series of lines, displaced below the first set by one line pitch. The complete scanning of the picture is thus accomplished in two half-scanning operations or "fields," which I shall call (*a*) and (*b*) half-scannings or fields.

It is obvious (in view of the foregoing, and the fact that the brightness of a given portion of the television screen dies down very quickly after the passage of the scanning beam) that to obtain a satisfactory photograph of the televised picture requires that the camera be open for exactly two fields or half scannings. If there is any departure from this exact timing, there will be either an overlap or a gap, with consequent doubly exposed streak across the picture or else a streak wherein half of the lines are missing. Since the camera shutter timing with sufficient accuracy to avoid a serious picture defect is difficult, if not impossible, it is desirable to begin and terminate the camera shutter opening at the time that the scanning beam is making its vertical return. There is at this stage an interval of 1/600 second when no scanning is being done, which is sufficient, with a suitably designed shutter arrangement, to open or close a camera aperture. Moreover, any imperfection in timing, if it occurs at this time, will mar only the very edge of the picture, which would not be noticeable or could be cut off from the subsequently projected motion picture.

It is, accordingly, one of the objects of my invention to provide means for making a motion picture of a television image, wherein the opening of the camera begins with the start of a scanning field and ends with the completion of the next succeeding scanning field. The necessary synchronization for this purpose can be obtained by driving the camera by means of a synchronous motor operated from the same 60 cycle power supply that controls the vertical deflections of the scanning beam, a phase or "framing" adjustment being provided, as is common in motion picture equipment.

Were each pair of television "fields" photographed to make one picture on the film, there would result 30 pictures per second, whereas only 24 pictures are desired. Moreover, only 1/600 second would be available to pull the film down in the camera between pictures. I, therefore, omit the photographing of one field or half-scanning in every five. This reduces the number of photographs to 24 per second, and provides an interval of 1/60 second for moving the film.

It is, accordingly, a further object of my invention to provide an improved method of and means for recording at one frame frequency, such as 24 per second, television pictures which are

being produced at a different frame frequency, such as 30 per second.

In practicing a preferred embodiment of my invention, I employ an intermittent movement in my camera which pulls down two film frames at a time. I photograph two picture fields on one frame of film, next shift the television picture to the other film frame by suitable shutter and/or optical means, photograph two picture fields on this frame and then pull down the film another two frames during the following picture field. In this way there is obtained a reasonable time for the film pull down, there being 1/60 second available for pulling down two frames. Thus, by employing the present invention there is no need to pull a film frame into position between the end of one scanning and the start of the next scanning, that is, during the return line period which is about 1/600 second. The required fast shift during a return line period preferably is accomplished by means of a continuously rotating shutter and optical combination or the like while the film is stationary, which shift can, without mechanical difficulty, be made in a very brief interval.

The invention will be better understood from the following description taken in connection with the accompanying drawings in which

Figure 1 is a view of apparatus illustrating one embodiment of my invention,

Figure 2 is a view of a shutter disc included in the apparatus shown in Fig. 1,

Figure 3 is a diagram illustrating the time relations employed in practicing a specific embodiment of my invention,

Figures 4 and 5 are views of another shutter design which may be used in the apparatus of Fig. 1, and

Figures 6 to 8 are views illustrating other embodiments of my invention.

Referring to Fig. 1, there is indicated at 10 a cathode ray tube upon the end of which there appears a television picture which is to be recorded on movie film indicated at 12. This television picture may be recorded by a camera comprising an intermittent mechanism 13 which pulls the film 12 through a film gate 14 at the rate, for example, of twenty-four picture frames per second, two frames at a time. The intermittent mechanism 13 may be driven by a synchronous motor 17 operated from the same power line that is supplying power to the television receiver.

The camera optical system preferably is so designed that the image of the television picture is split, that is, identical images are formed on the two film frames in the absence of the shutter, indicated at 19, which is normally used for shifting the image from one frame to the next. Various shutter and optical designs may be employed as will be explained hereinafter.

In the example shown in Fig. 1, two lenses or lens systems 1 and 2 are employed, the lens 1 forming the television picture image on frame No. 1 and the lens 2 forming this image on the frame No. 2. Prisms 1*a* and 2*a* may be combined with lenses 1 and 2, respectively, for the purpose of projecting the picture images normal to the film whereby any appreciable keystoning of the picture is avoided, and the desired separation of the two images produced.

The shutter 19 is mounted on the shaft of motor 17 which operates at 720 R. P. M., in the example being described, to rotate the shutter once every $\frac{1}{12}$ second. As shown in Fig. 2, the shutter 19 may comprise a transparent disc having two transparent arcuate portions which rotate successively past the lenses 1 and 2 as indicated by the legends. The remaining shaded portion of the disc is opaque. It is evident that, as the shutter disc 19 is rotated, the light to one lens is intercepted while light is passing through the other lens. During the film pull-down the light to both lenses is intercepted as indicated in Fig. 2 by the legend "Shutter closed."

The time relations of the television picture, the shutter and the intermittent mechanism will be better understood by referring to Fig. 3.

In Fig. 3 there are shown the time relations for the specific case where an interlaced television picture having a frame frequency of 30 per second and a field frequency of 60 per second is recorded on moving picture film being pulled through the film gate at 24 frames per second, two frames at a time.

Referring to Fig. 3, the fluorescent screen on the end of tube 10 is scanned twice while the transparent area of shutter 19 rotates past lens 1 and the first two fields are recorded on frame No. 1 of the film 12, this taking place in $\frac{1}{30}$ second. The shutter 19 then shifts the image to frame No. 2 of the film, and fields 3 and 4 are recorded on this frame. Next another two frames of the film are pulled down during field number 5 and during the time that the completely opaque sector of the shutter disc 19 (marked "Shutter closed" in Fig. 2) is rotating past the lenses 1 and 2. The cycle is then repeated.

It is important that the separation of the two images be exactly one picture frame, as determined by the perforations, or in the case of ordinary 35 mm. film, four times the sprocket perforation pitch, since in reproduction the film moves by four sprocket holes each time a picture is projected. An adjustment of the image separation should be provided. Such an adjustment can be had either by changing the vertical spacing of the lenses (if two lenses are used) or by moving the prisms toward or away from the film. A convenient arrangement for visually comparing the image separation with the perforation pitch is also desirable, in order to obviate the necessity of carrying out a photographic test. If the image spacing corresponds to four times the sprocket hole pitch at the time the picture is taken, subsequent film shrinkage will do no harm.

It may be noted that during the film pull-down, light may be prevented from reaching the film 12 by cutting off or blocking the cathode ray of the cathode ray tube 10 instead of by utilizing a completely opaque sector of the shutter disc 19.

It will be understood that the invention is not limited to the mechanism and optical system illustrated in Figs. 1 and 2 for obtaining the desired sequence of operation. For example, in place of the shutter 19 there may be substituted a shutter of the type illustrated in Fig. 4. In this arrangement two shutter discs 30 and 31 are rotated in a fixed time relation by means of a suitable gear drive (not shown), the shutter disc 30 being positioned to intercept periodically the light reaching the lens 1 and the shutter disc 31 being positioned to intercept periodically the light reaching the lens 2. The shutter discs 30 and 31 are driven by the motor 17 (Fig. 1) at the proper speed to give the sequence of operation previously described. It is obvious that the plane of the shutter or shutters might be located close to the film instead of close to the lenses. If the shutter is close to the film, it does not need to uncover the entire picture area at one time, par-

ticularly if the television screen is one which does not have much persistence. It is sufficient if the opening in the shutter uncovers that portion of the picture which is, at the moment, being scanned. This makes it possible to use a single shutter **46** with spiral slots **47** and **48** as shown in Fig. 5, which can be designed to have adequate mechanical strength without resorting to a transparent support. The two film frames are indicated by the dotted lines at **49** and **50**.

As illustrated in Fig. 6, a single lens **36** in combination with two prisms **37** and **38** may be utilized to split the image in place of the two lens combination shown in Fig. 1.

Also, as illustrated in Fig. 7, it may be found desirable to pass the film **12** through a curved film gate **14***a* instead of through a straight film gate in order to reduce any tendency towards keystoning of the picture.

It may also be pointed out that the combination of shutter and optical systems previously described may be replaced, as illustrated in Fig. 8, by a rotatable transparent disc **41** which has its edge beveled through 144° of the disc circumference to form a prism which projects onto one film frame the image formed by a lens **42** and which has the next 144° of circumference of the disc beveled so that when it rotates in front of the lens **42** it directs a picture image onto the other film frame. In the case just described, the disc **41** is rotated at the same speed as that employed for the shutter disc **19** in the embodiment of Fig. 1 and the sequence of operation is the same as that described for Fig. 1. In this embodiment, what formerly was a "shutter shift" is, of course, an "optical shift." Owing to the finite size of the rotating prism, the outwardly tapered portion of the prism would produce the additional effect of a convex cylinder, while the inwardly tapered portion, shown at the bottom in Fig. 8, would have the effect of a concave cylinder. These would defocus the picture, but this difficulty can be largely overcome by dividing the necessary prism effect between the disc **41** and a second disc **43**, in which the cylindrical lens effects would largely neutralize each other. The two discs **41** and **43** are similar.

From the foregoing, it will be apparent that I have provided, as a specific example of the invention, a method and means for copying a 30 frame interlaced television picture onto a moving picture film for projection at 24 frames per second in which the sequence of operation is such that sufficient time is provided for film pull-down without resorting to very expensive or impractical mechanical designs.

I claim as my invention:

1. The method of recording television pictures on a film which comprises pulling down two frames of said film, projecting the picture image upon one of said frames, shifting said image while said film is stationary and projecting it upon the other of said frames, and repeating said sequence of operation.

2. The method of recording an interlaced picture upon a film which comprises pulling down a plurality of frames of said film, exposing each of said frames successively to a plurality of picture fields before the film is further advanced, and again pulling down a plurality of frames of said film during a succeeding picture field.

3. The method of recording an interlaced picture upon a film which comprises pulling down two frames of said film, exposing only one of said frames to two picture fields, exposing the other of said frames to the next two picture fields before the film is further advanced, and again pulling down two frames of said film during the next occurring picture field.

4. Apparatus for recording on a film television pictures occurring at a certain picture field rate which comprises means for pulling down said film a plurality of frames during one picture field, and means for exposing said frames successively to the television picture before the next pull-down and in a fixed time relation to said field rate.

5. Apparatus for recording television pictures on a film which comprises means for pulling down said film a plurality of frames, and means for exposing said frames successively to the television picture before the next pull-down, said last means comprising a continuously rotating element.

6. Apparatus for recording television pictures on a film which comprises means for pulling down said film a plurality of frames, means for projecting an image of the picture to be recorded upon each of said frames, and means comprising a shutter for shifting said image from one of said frames to another of said frames before the film is again advanced.

7. Apparatus for recording interlaced television pictures on a film which comprises means for pulling down said film two frames at a time, and means for exposing each of said frames successively to two television picture fields before the next pull-down, said pull-down means being timed to again pull down two frames of said film during the next picture field.

EDWARD W. KELLOGG.