March 22, 1938. G. W. WALTON 2,112,002

PICTURE RECORDING AND REPRODUCING SYSTEM

Original Filed Oct. 19, 1929

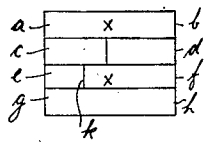


Fig. 1.

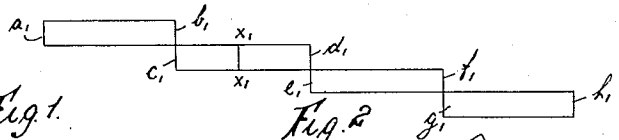


Fig. 2.



Fig. 3.

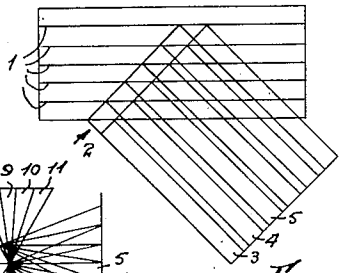


Fig. 4.

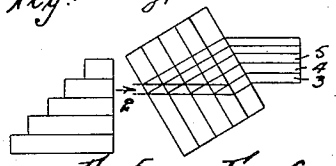


Fig. 5

Fig. 6.

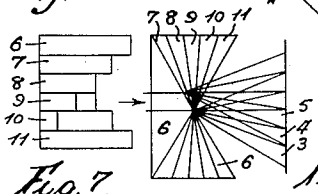


Fig. 7

Fig. 8.

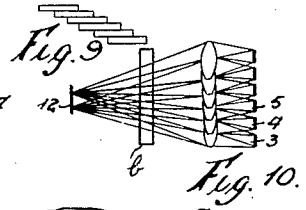


Fig. 9

Fig. 10.

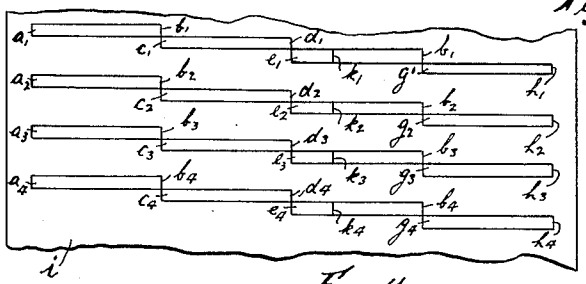


Fig. 11.

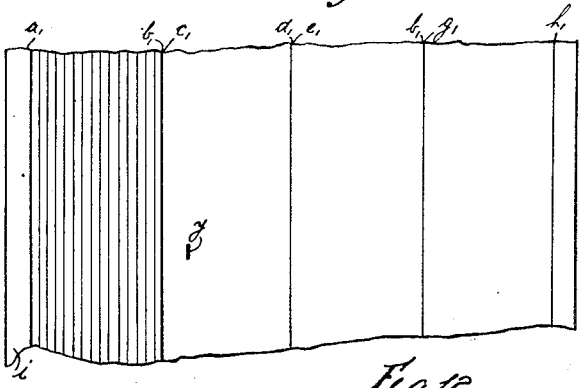
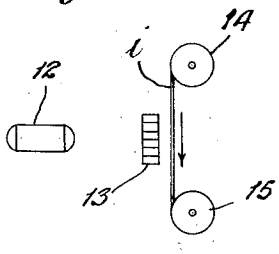


Fig. 12.

Fig. 14.



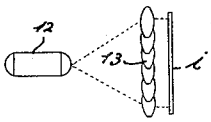


Fig. 13.

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PICTURE RECORDING AND REPRODUCING SYSTEM

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Original application October 19, 1929, Serial No. 400,883. Divided and this application December 9, 1936, Serial No. 115,048. In Great Britain October 25, 1928

2 Claims. (Cl. 88—16.6)

The present invention relates to picture recording and reproducing systems and is a division of the application for my Patent No. 2,089,155, issued August 3, 1937, for Scanning device and method.

In my above mentioned patent there are described methods and apparatus whereby a novel form of image, known as a stixograph, can be produced and the present invention relates to systems for producing picture records with the aid of the aforesaid methods and apparatus and to systems for reproducing such stixograph images on a screen.

If an ordinary picture be regarded as composed of a large number of elemental areas of a size depending upon the degree of definition required in an image and such that the detail within any of these areas can, for this degree of definition, be neglected, the novel form of image or stixograph with which the present invention is concerned is an image in which the elemental images, that is to say the images of the elemental areas of the object, are deployed in such a way that they do not overlap one another when viewed in a direction perpendicular to that of the deployment. Usually the picture can be regarded as divided into a number of strips, each composed of one single row of the aforesaid elemental areas, and in this case the elemental areas of each strip of the object are represented in the stixograph by elemental images in the same relative positions as the elemental areas in the object, but the images of the strips are longitudinally displaced relatively to one another by an amount such that no two strip images overlap one another when viewed in a direction perpendicular to the direction of deployment.

The invention will be described with reference to the accompanying drawing, which are given by way of example. In the drawing Fig. 1 is a diagrammatic two dimensional image illustrating the method employed to transform it into a one dimensional image,

Fig. 2 is a diagrammatic representation of a one dimensional image resulting from the transformation of the two dimensional image shown in Fig. 1,

Figs. 3 and 4 are views in side elevation and plan respectively of a reflecting echelon device for transforming a two dimensional image into a one dimensional image, or vice versa,

Figs. 5 and 6 are views in side elevation and plan respectively of a refracting echelon device,

Figs. 7 and 8 are similar views of a modified form of refracting echelon device,

Figs. 9 and 10 are similar views of a modified form of stepped refracting echelon device,

Figs. 11 and 12 are diagrammatic views showing the way in which records of animated scenes may be obtained, and

Figs. 13 and 14 are diagrammatic views, in elevation and plan, respectively, of apparatus for producing a one-dimensional cinematographic record.

Referring particularly to Figs. 1 and 2, Fig. 1 shows a two dimensional image, picture, scene or representation, which it is desired to transform into a one dimensional or stixograph type image. During the transformation, the picture is divided into any number of strips a—b to g—h the width and number of strips being decided by the degree of definition required. After such sub-division, all points lying on a line x—x across the width can be represented by the line x—x having an intensity which is the average of the intensities of all points in it, and therefore each strip only requires definition in its length. If the strips a—b to g—h in Fig. 1 are deployed as in Fig. 2 to form images a_1—b_1, c_1—d_1, e_1—f_1, g_1—h_1, then as long as there is definition within the length a_1 to h_1, the image a_1 to h_1 is equivalent of Fig. 1, for practical purposes, as it contains representations of all the elements of Fig. 1. For example the line x—x of Fig. 1 appears at x_1—x_1 in Fig. 2. Fig. 2 is a one dimensional arrangement of Fig. 1 which is two dimensional, and in this arrangement x_1—x_1 may be vanishingly short or infinitely long without affecting the efficacy of Fig. 2 as a picture or image so long as the density or brightness of x_1—x_1 in the image of Fig. 2 is representative of the average density or brightness of x—x in the original of Fig. 1.

The stixograph of Fig. 2 can be derived from the two dimensional image of Fig. 1, or vice versa, by means of an echelon device which may be reflecting, refracting or combined reflecting and refracting.

Figs. 3 and 4 show a reflecting echelon device, Fig. 3 being a view in side elevation and Fig. 4 a view in plan. In Fig. 3 the vertical faces 1 are mirrors. In Fig. 4 a pencil of light represented by arrow 2 having a depth covering all the reflecting surfaces 1, is thrown on to those surfaces at an angle, a section of the incident pencil being reflected by each surface. As each successive surface is further away than the preceding one, the sections of the pencil are reflected with lateral displacement, which by suitable size of steps, angle of incidence and width of pencil can be such that the reflected sections 3, 4, 5 do not

overlap. If, therefore, the cross section of the incident pencil is represented by Fig. 1, the cross section of the reflected light will be represented by Fig. 2.

With the type of reflector shown in Figs. 3 and 4, there is the disadvantage that the length of the light travel is different for each step of the reflector, but this may be remedied by a successive reflection from two or more stepped surfaces so arranged that the lateral displacements of the successive surfaces are preferably additive.

Fig. 5 shows a refracting echelon device in side elevation, Fig. 6 being a plan view of the same device. Light passing through the steps is laterally displaced by amounts dependent on the thickness of material traversed, so that the issuing sections 3, 4, 5 of the entering pencil *a* are deployed, as in Fig. 2. Refraction may take place in one or more stages, with the displacement of the successive stages additive, and further the stages may be arranged so that the length of path through the system is constant at all points, thereby facilitating the focusing of an image.

Fig. 7 shows another form of echelon refractor, in side elevation, Fig. 8 being a view in plan thereof. This refractor consists of a stack of prisms 6 to 11 of increasing angles, each step giving a different angle of deviation. If the prisms are arranged in increasing order as shown, they serve to arrange the issuing light sections (each section representing a strip of the object) as in Fig. 2.

Fig. 9 shows another stepped refractor in front elevation, Fig. 10 being a view in plan thereof. The steps are lenticular in shape and staggered preferably in a direction at right angles to the mean optical axis.

An object or image at 12, similar to Fig. 1, is focused in a vertical direction (perpendicular to the paper in Fig. 10) at or near the entrant surface of the echelon device by a cylindrical lens *b*. Thus each lens of the echelon received light from only one horizontal strip of the object and deployed line images of horizontal strips of object 12 are formed at 3, 4, 5, etc., these line images being focused by the echelon lenses only in a horizontal direction. It will be understood by those skilled in the art that in the case of Figs. 3 to 8 also suitable optical means are provided to insure that the one dimensional image is focused in the direction of deployment, that is to say, in planes parallel to the plane of the paper in Figs. 4, 6 and 8 and that an image is focused, at least in a direction perpendicular to that of deployment, in or about the entrant surface of an echelon device, so that each step or lamina deals only with one line of the two dimensional image.

There are numerous possible forms of echelon reflectors, refractors, and combinations, but the essential feature of each form is that there shall be definite steps in the device having linear or angular displacement between the steps, preferably, but not essentially, of some regular order of displacement.

The stixograph or one dimensional image of the type illustrated in Fig. 2 is of great practical utility, as by its use very compact records can be made of scenes or pictures, and, further, it is of even greater value in recording changing scenes, in that a truly continuous record may be made in contrast to the ordinary cinematograph record which is intermittent. The manner in which the stixograph image can be used in recording and reproducing pictures and changing scenes is shown in Figs. 11 and 12.

In Fig. 11 *i* is the record material, such as photographic film, plate or paper, on which a stixograph a_1—b_1, c_1—d_1, e_1—f_1, g_1—h_1 is focused. If after exposing the film to this image the film be moved upward, a second image a_2—b_2, c_2—d_2, e_2—f_2, g_2—h_2 can be produced and so on. This record is of the intermittent type and is therefore of the same character as and can be dealt with in a similar way to ordinary cinematograph films. It is with such truly continuous records that the present invention is concerned. Such a record differs from an ordinary cinematograph record only in that the individual pictures are one dimensional instead of two dimensional. If the pictures a_1—h_1, a_2—h_2 etc. are impressed successively without any movement of the scene or point in the scene, and if the position and aspect of the apparatus relative to the scene is kept constant, then a point k_1, representative of an elemental area at about point *k* in Fig. 1, will appear in each picture in the same relative position. As the film *i* moves the points k_1, k_2, k_3, k_4 in each picture will lie in a line parallel to the direction of movement of *i* and consequently the film *i* need not move intermittently nor need the picture be exposed intermittently, for the film *i* can be given a movement preferably constant and along a straight line, and the points k_1, k_2 etc. will trace a line on the record, the intensity of the impression at any point of that line being proportional to the intensity of point *k* of Fig. 1 at some particular moment. The density or brightness of such a line is obviously a continuous and true record of the density or brightness of the point *k* of Fig. 1 and of that point only. The same also applies to every other point in the line image.

Fig. 12 shows such a record, the sections a_1—b_1, c_1—d_1, e_1—f_1 and g_1—h_1 being representative of corresponding sections of the image, that is individual strips *a*—*b*, *c*—*d*, *e*—*f*, *g*—*h* respectively of the original two dimensional image or scene shown in Fig. 1, and each of the points or elemental areas in each section will trace a line parallel to the direction of movement of the film. Such lines are shown only in section in a_1—b_1. Thus each of the vertical lines of the stixograph record of Fig. 12 is a record of the brightness or density of one elemental area of the object. The vertical dimension is the time dimension and therefore if the elemental area in question remains of constant brightness then the line in Fig. 12 representing that elemental area will be of constant brightness or density. If the brightness of the elemental area changes then the brightness or density of the line will change correspondingly.

A picture record as described may be said to record the position of a point in a scene in one dimension of the record, the other dimension corresponding to time and the whole record recording change of position in time. It is preferable that the line image being recorded should be very narrow (in the direction of movement of the record) in order to improve the quality of the record and also to shorten it, for instance it may be a tenth of a millimetre wide, in which case three millimetres of length could obtain thirty line pictures. It may be said that there are more, for the record is continuous. Sixteen pictures per second are capable of recording scenes having ordinary movement from which it follows that the picture record need only move at a

rate of two to three millimetres per second. In contrast with the ordinary cinematograph film using one foot per second, there is great advantage and also apparatus for intermittent movement and exposure is not required.

In order that the record shall be of a convenient width, one dimension of the image may be reduced relative to the other. The reduced dimension is preferably the horizontal dimension of Fig. 1 and the horizontal length of Fig. 2 and the width of the film necessary for recording is thus correspondingly reduced. The limit to this reduction will be the ability of the surface to record the definition required which is determined by the size of the grain of the emulsion if a photographic record is used.

Apparatus for producing a record such as is shown in Fig. 12 is illustrated diagrammatically in Figs. 13 and 14. The stixograph is in this example produced with the aid of a device such as is shown in Fig. 10. In Figs. 13 and 14 a lens system performing the function of lens *b* in Fig. 10 is indicated at 12. The echelon 13 is constituted by thin cylindrical lenses arranged in a stack and staggered relatively to one another. The sixtograph image is formed on a film *i*, suitable means, represented diagrammatically by rollers 14 and 15, being provided for displacing the film continuously in the direction of the arrow.

The same apparatus as is shown in Figs. 13 and 14 can be used for reproducing from a record of the kind shown in Fig. 12, a light source being provided to the right of the film *i*.

As described, the picture record is in the form of a strip but this is by no means necessary for it may take the form of a disc similar to a gramophone record, again that of a cylinder or any other form which affords a surface on which a line image can be impressed whilst that surface is given a suitable traversing motion as described with reference to Figs. 13 and 14. The record may be transparent or opaque and during reproduction may be illuminated by light passing through the record and on to the optical system, or by light which is reflected by the record on to the optical system.

I claim:

1. In a system for picture recording and like purposes means for receiving and producing continuous motion of a photographically sensitive surface, optical means for dividing an object picture to be recorded into a line image formed of a series of line elements with corresponding ends of the line elements displaced from each other in a direction transverse of the direction of said motion, said optical means comprising a plurality of optical elements each having an entrant surface for receiving light from said object picture and an emergent surface from which light passes to said sensitive surface, means including a lens for focusing, at least in a direction transverse of the direction of said displacement of said line elements, an image of said object picture in the vicinity of said entrant surfaces and means for focusing, at least in a direction parallel to the direction of said displacement, a line image of said object picture upon said sensitive surface.

2. In a system for reproducing recorded pictures upon a screen, means for receiving and producing continuous motion of a photographic record to be reproduced, optical means for combining into a two-dimensional image upon said screen a line image upon said record formed of a series of line elements with corresponding ends of the line elements displaced from each other in a direction transverse of the direction of said motion, said optical means comprising a plurality of optical elements each having an entrant surface for receiving light from said record, an emergent surface from which light passes to said screen, and means for focusing, at least in a direction transverse of the direction of said displacement of said line elements, an image of said emergent surfaces upon said screen.

GEORGE WILLIAM WALTON.