

Aug. 3, 1937.

G. W. WALTON

2,089,155

SCANNING DEVICE AND METHOD

Filed Oct. 19, 1929

Fig. 1.

a	x	b
c		d
e	x	f
g		h

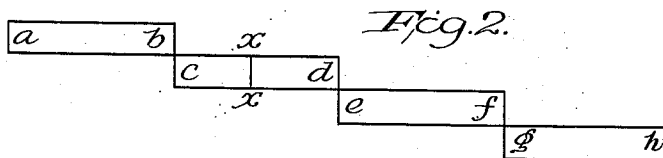


Fig. 2.

Fig. 4.

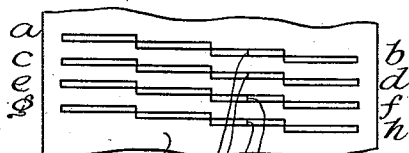
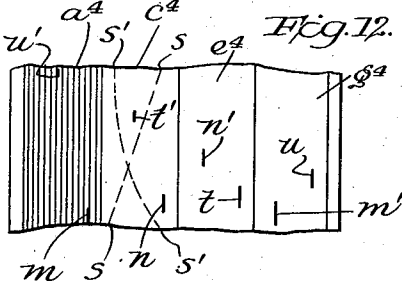
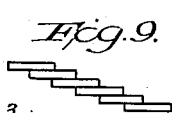
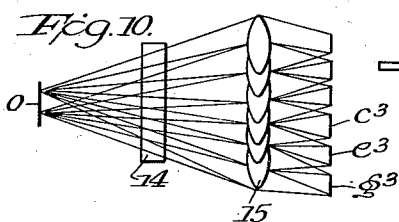
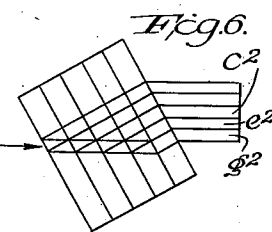
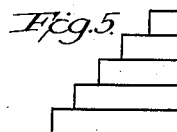
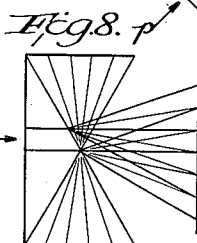
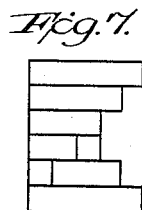
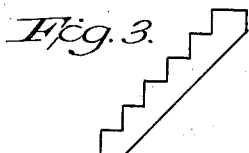


Fig. 11.

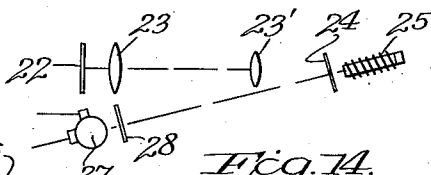


Fig. 14.

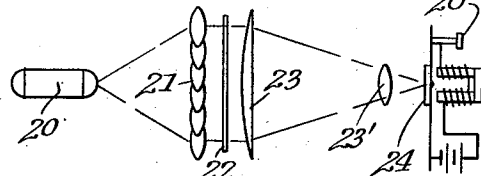


Fig. 13.

Inventor

G. W. Walton.

By *Ernestman, Darby, & Ernestman*
Attorneys

UNITED STATES PATENT OFFICE

2,089,155

SCANNING DEVICE AND METHOD

George William Walton, London, England, assignor to Scophony Limited, London, England, a company of Great Britain

Application October 19, 1929, Serial No. 400,883
In Great Britain October 25, 1928

17 Claims. (Cl. 178—7.6)

This invention relates to apparatus for television, facsimile telegraphy and for recording and reproducing pictures whereby the elements composing the scene, image or picture are formed or arranged in a novel and convenient manner.

The human eye, because of its construction, appreciates scenes or pictures as a two dimensional arrangement and hitherto all optical, television, picture transmitting, recording and reproducing apparatus have been constructed to form two dimensional images and pictures. Though an image or picture as presented to the eye must be two dimensional, it is not essential that intermediate images and pictures should be also of that type, in fact some other type may be more advantageous, particularly where intermediary apparatus is used between the eye and the image, picture or scene.

A picture may, for practical purposes, be regarded as composed of a large number of elemental areas, the detail within each of which is immaterial and the number of such elemental areas necessary to give the desired effect being dependent upon the degree of definition required. In a normal picture these elemental areas are, of course, arranged in two dimensions.

The present invention may be regarded broadly as concerned with the production from a normal two dimensional image or the like an image, referred to for convenience as a one dimensional image, which is representative of the two dimensional image but in which representations of all the elemental areas of the two dimensional image are simultaneously disposed so that they do not overlap one another. Thus the nature of the one dimensional image is such that all the elemental areas representative of the two dimensional image can be scanned in succession by sweeping the one dimensional image once, and in one direction, over a scanning aperture. The invention is also concerned with the reforming of normal two dimensional images from such one dimensional images.

The television and picture reproducing apparatus may be combined in one machine, thereby providing a complete form of popular amusement.

The invention will be now more particularly described making reference to the accompanying drawing, but it is in no way limited to the particular forms described or illustrated, since they are only given in order that the invention may be easily understood.

Fig. 1 shows diagrammatically a 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.

Fig. 13 is a diagrammatic view of a television apparatus using scanning, and

Fig. 14 is a view in side elevation thereof.

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 type. 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. The number of strips into which the image is divided in the drawing is purposely made very small for the sake of clearness of illustration. In practice the width of the strips (the vertical dimension of the strips in the drawing) is made equal to the width of the elemental areas into which the picture can be assumed to be divided to give the desired degree of definition. Each strip can therefore be regarded as a single row of elemental areas. After such sub-division all points lying on a line $x-x$ across a width can be represented by the line $x-x$ having an intensity which may be uniform or not so long as it is the average of the intensities of all points in it, and therefore each strip only requires definition in its length (that is, horizontally in the drawing). If the strips $a-b$ to $g-h$ are deployed as in Fig. 2, then as long as there is definition within the length a to h the image of Fig. 2 is equivalent to Fig. 1, for practical purposes, as it contains all the elements of Fig. 1. Fig. 2 can be regarded as a one dimensional arrangement of Fig. 1 which is two dimensional, and in this arrangement $x-x$ may be vanishingly short or infinitely long without affecting the efficacy of Fig. 2 as a picture or image.

The image of Fig. 2 may be derived from Fig. 1, or Fig. 1 from Fig. 2, 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 side view and Fig. 4 a plan. In Fig. 3 the vertical faces are mirrors. In Fig. 4 a pencil of light p having a depth covering all the reflecting surfaces, 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 g' , e' , c' do not overlap, so that if 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, the length of the light travel is different for each step of the reflector, but this may be remedied by 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, being a side view and Fig. 6 a plan view, as in Figs. 3 and 4. Light passing through the steps is laterally displaced by amounts dependent on the thickness of material traversed, so that the issuing sections g^2 , e^2 , c^2 , of the entering pencil p 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 focussing of an image.

Fig. 7 shows another form of echelon refractor, in side elevation, and Fig. 8 a view in plan thereof. This consists of prisms of increasing angles, each step giving a different angle of deviation, which if arranged in increasing order arrange the issuing light sections, as in Fig. 2.

Fig. 9 shows another stepped refractor in front elevation and Fig. 10 a view in plan thereof. The steps are lenticular in shape and staggered preferably in a direction at right angles to the optical axis of the system. An object or image at o , similar to Figure 1, is focussed in a vertical direction (perpendicular to the paper in Figure 10) at or near the entrant surface of the echelon device 13 by a cylindrical lens 14. Thus each lens of the echelon receives light from only one horizontal strip of the object and deployed line images of horizontal strips of object o are formed at g^3 , e^3 , c^3 , 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 Figures 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 Figures 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, prefer-

ably, but not essentially, of some regular order of displacement.

The line image of 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 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 this is accomplished 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 line image is formed by an echelon device in combination with a suitable lens system. Any convenient system of reels, rollers and guides may be provided to accommodate and traverse the record material i over the line image. Thus, the record material can be moved in the plane of the line image d , e , f , Figure 10 for example, in a direction perpendicular to the plane of the paper. If i moves upwards a number of line pictures $a-b$ to $g-h$ may be impressed intermittently, in which case the record would be much the same as a cinematograph film. If the pictures $a-b$ to $g-h$ are impressed successively without any movement of the scene or point in the scene, and the position and aspect of the apparatus relative to the scene is kept constant, then a point or elemental area k will appear in each picture in the same relative position, and as i moves upward the points k in each picture will lie in a line parallel to the direction of movement of i . The record material i need not move intermittently nor need the picture be exposed intermittently, for i can be given a movement preferably constant and along a straight line, and the point k will trace a line on the record, the intensity of the impression at any point of that line being proportional to the intensity of k at some particular moment. Such a line is obviously a continuous and true record of the point k and of that point only. The same also applies to every point in the line image.

Fig. 12 shows such a record, the sections a^1 , c^1 , e^1 , and g^1 being sections of the image, that is individual lines of the original two dimensional image or scene shown as $a-b$ to $g-h$ in Fig. 1, and for a condition of no movement in scene or apparatus the points in each section will trace a number of parallel lines, as shown in section a , only. Should a point in the scene move, say horizontally in Fig. 1, then during such movement, that point combined with the steady movement of the record, will trace a line which is no longer parallel to the direction of movement of the record. Assuming rectilinear direction and a constant speed of record, a point moving horizontally to the right in Fig. 1 at a constant speed in one direction will trace a straight line, such as $s-s$, in Fig. 12, and another point moving horizontally in an opposite direction at a decreasing speed will trace a curve $s'-s'$. A point moving vertically downwards in Fig. 1 at a constant speed will move from one line to another in succession and will, therefore, appear successively in adjacent sections a^1 , c^1 , e^1 , g^1 , of Fig. 12 as the short lines m , n , t , and u , which will lie in a straight line in the record and be all of the same length.

Another point moving vertically upward at an increasing speed will appear as the lines m' , n' , t' , and u' , which lie in a curve, m' being longest and the others of successively shorter lengths. Any other direction of movement of

a point in the scene will be recorded as a compound of vertical and horizontal movements. Within the limit of definition imposed by the number of lines into which a scene may be divided, that is the number of sections, such as a^1, c^1, e^1, g^1 , of Fig. 12, and that definition which the recording surface can satisfactorily accommodate, every point of the scene may be moving individually in different directions and paths, rectilinear curved or irregular, and at wholly different speeds increasing, decreasing, constant or irregular, and each point will simultaneously trace on the record a characteristic and individual pattern, and yet the different patterns will in no way interfere with each other, for should a line cross another on the record for instance, $s-s$, and $s'-s'$, Fig. 12, the point of crossing is a record at the moment when one point is obscured by the other in the scene being recorded.

A picture record as described may be said to record the position of a point in a scene in one dimension of the record and the other dimension corresponds to time, the whole recording change of position in time. It is preferable that the line image being recorded should be very narrow in the direction $x-x$ of Fig. 2 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 contain 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 and preferably the horizontal dimension of Fig. 1 which correspondingly reduces the length of Fig. 2. The limit to this reduction will be the ability of the surface to record the definition required which is the size of the grain of the emulsion if a photographic record is used. This reduction is also of advantage in television apparatus.

A natural colour record that is one multiple record say three colour, can be made, and would consist of three records side by side on the same surface. Excepting for the fact that the recorded image is a one dimensional instead of a two dimensional image, the recording and reproducing methods and apparatus may be the same as in known natural colour recording and reproducing.

In reproducing a picture record of the kind shown in Fig. 12 by projection, devices similar to those described in connection with Figs. 3 to 10 may be used inversely, the record being traversed and suitably illuminated so that a reconstructed two dimensional picture will be thrown on a screen disposed to receive it.

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 Fig. 12. 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.

The line image and the echelon devices may also be used in systems of television, facsimile telegraphy and the like, in which scanning is employed. The one dimensional image is preferably scanned, in which case the scanning device may be very simple and compact. Any of the known means of optical scanning may be employed, or a mechanically oscillated photo-electric cell. Whichever are used, they are very much simplified as only one dimensional scanning is required. In facsimile telegraphy, it is preferred that a one dimensional picture be made, for instance, on strip photographic film, which is then traversed between a source of light and a light sensitive device. Since a one dimensional image is both transmitted and received, no means of synchronization are required for traverse may be at any rate at both transmitter and receiver and independent. This will be readily appreciated from the fact that a one dimensional picture is the same as an ordinary picture in that it can be enlarged or reduced without losing any of its value as a picture. In the receiving instrument, a photographically sensitive tape is traversed at any convenient speed through a ray of light, the intensity of which is electrically controlled by the transmitted impulses. The line picture so received may at any time be readily converted into a two dimensional image by means of the echelon device, and a two dimensional picture made.

A preferred arrangement of television apparatus using scanning consists of a mirror oscillated by an electromagnet having a make and break contact, similar to the type used in electric bells and buzzers. The arrangement is shown in Fig. 13 in which 20 is a lens system, 21 the echelon device which forms a line image at 22, the light from the image being converged by lenses 23 and 23' on to the mirror 24, oscillated by electromagnet 25 which is supplied with interrupted electric current by a contact maker 26. Light reflected by mirror 24 is reflected on to a light sensitive cell 27, Fig. 14, before which is placed a stop 28 which has a slit of suitable width in it. By means of the oscillating mirror, points in the line image are reflected in regular succession onto the light sensitive cell. The receiver may be the same, except that the cell 27 is replaced by a source of light and an electrical means of controlling the intensity of light thrown on to the mirror, or a neon or similar lamp may be used in the well known manner. The frequency of the mirror oscillations may be controlled by mechanical tuning of the vibrating mechanism, such as varying the spring tension thereby forming a simple means of synchronization between transmitter and receiver.

The expression "static displacement", or "static optical displacement" in the claims, means such displacement or deployment as can be produced without motion of the optical device.

Subject matter disclosed but not claimed herein is claimed in the following applications comprising divisions hereof: application Serial No. 37,584, filed August 23, 1935, Motion picture records, and application Serial No. 115,048, filed December 9, 1936, improvements in Picture representation

and improvements in television and in the recording and reproducing of pictures.

I declare that what I claim and desire to secure by Letters Patent is:—

1. In a picture reproduction system, means for forming, from an object, an image composed of line elements of the object deployed so that they do not overlap one another, for use in television, picture recording and reproduction and like purposes, said apparatus including an optical system comprising refractively acting transparent laminae arranged in staggered formation, each of said laminae having a plane edge surface, said plane surfaces of all laminae lying in the same plane, with the opposite edge surface of each laminae so arranged as to effect deployment.
2. Apparatus adapted to deploy a picture into the form of non-overlapping line elements for use in television, picture recording and reproduction and like purposes having an optical system comprising refractively acting transparent laminae, the planes of said laminae being parallel to the axis of said system, each of said laminae being in the form of a cylindrical lens having its axis of curvature substantially perpendicular to the said planes and said laminae being staggered relatively to one another in a direction substantially perpendicular to said axis.
3. Apparatus for television, picture recording and reproduction and the like purposes having an optical system comprising a plurality of refractively acting transparent laminae arranged contiguously and with one of their axes staggered in a single plane, said laminae being in the form of like cylindrical lenses arranged with their axes of curvature co-planar and displaced relatively to one another.
4. In a picture reproduction system, adapted to optically form from an object an image in which the representations of adjacent lines of said object are longitudinally displaced relatively to one another, including a stepped reflecting echelon device having a plurality of contiguous reflecting surfaces disposed parallel to one another and in different planes, means for casting an image of said object upon said device at an acute angle, and means for receiving a deployed line image of said object after reflection from said device.
5. In a picture reproduction system, optical means adapted to form from an object an image in which the representations of adjacent lines of said object are longitudinally displaced relatively to one another, said optical means including a stationary transparent solid refracting echelon device having a plurality of entrant type surfaces to which light from said object can enter said device and, associated with each of said entrant surfaces, an emergent type surface through which the light can emerge after refraction, one of said types of surfaces lying in different planes, and the surfaces of the other of said type of surfaces being in the same plane and bounded by common lines.
6. In a picture reproduction system, optical means adapted to form from an object an image in which the representations of adjacent lines of said object are longitudinally displaced relatively to one another, said optical means including a stationary solid transparent refracting echelon device having a plurality of entrant surfaces at which light from said object can enter said device and, associated with each of said entrant surfaces, an emergent surface through which said light can emerge after refraction, each of said

entrant and emergent surfaces lying in a different plane, and said entrant surfaces being in the same plane and bounded by common lines.

7. In a picture reproduction system, including optical means for viewing an object, said optical means comprising a plurality of stationary optical elements positioned and constituted to view different parts of said object and to simultaneously produce contiguous parallel line images having detail only along the line of said parts which are deployed to such an extent that they do not overlap one another viewed at least in a direction normal to the direction of said deployment, an apertured photo-sensitive device, means for producing relative motion between said deployed line images and said device and means for deriving from said device electrical signals for transmission, and means for forming said deployed line images in the neighborhood of said device.

8. Apparatus for picture reproduction including optical means for viewing an object, said optical means comprising a plurality of optical elements positioned and constituted to view different parts of said object and to simultaneously produce contiguous parallel line images having definition only along the line of said parts which are deployed to such an extent that they do not overlap one another viewed at least in a direction normal to the direction of said deployment, an apertured photo-sensitive device, means additional to said optical means for producing relative motion between said deployed line images and said device and means for deriving from said device electrical signals for transmission.

9. In a picture reproduction system, the method of producing an image of a picture in which image all picture elements composing the picture are arranged in a row, comprising forming images of lines of picture elements and producing static optical displacement of said images relative to one another in the direction of said lines, said images having definition only in the direction of said displacement.

10. In a picture reproduction system, means for forming an image of an object, said means including a plurality of stationary optical elements for distributing the light from the object in such a manner as to deploy the image laterally in a series of non-overlapping line areas having detail only along the line, and movable means for sweeping the lines successively across a predetermined point.

11. In a picture reproduction system for forming from an image of a picture in which image all lines of picture elements composing the picture are arranged in a row and have definition at least in the direction of said lines, a second image in which the lines of picture elements are arranged one beneath the other as in the original picture, a plurality of cylindrical lenses positioned and constituted to statically deploy the image laterally in a series of non-overlapping line areas.

12. Apparatus for forming, from an object, an image composed of non-overlapping deployed line elements for use in television, picture recording and reproduction and like purposes having an optical system comprising an optical device consisting of a plurality of optical laminae, the planes of the laminae being parallel to the axis of the system and the laminae being arranged contiguously and in staggered formation, each of said laminae being in the form of a cylindrical lens having its axis of curvature substantially perpendicular to the said planes and said laminae

being staggered relatively to one another in a direction substantially perpendicular to said axis, and a lens means associated optically with said device having optical power at least in a plane perpendicular to the planes of said laminae.

13. A system of reproducing pictures comprising successively viewing displaced portions of a moving line of modulated light and statically optically displacing successive portions of different positions of the line to position such portions in the same line.

14. In a picture reproduction system, means for developing a line of light, means for moving said line at right angles to itself, and static optical means for placing different portions of different lines of the light in a single line on a viewing screen.

15. A system of reproducing pictures comprising successively viewing displaced portions of a moving line of modulated light having definition

only in the direction of displacement and statically optically displacing successive portions of different positions of the line to position such portions in the same line.

16. In a picture reproduction system, means for developing a line of light having definition only along its length, means for moving said line at right angles to itself, and static optical means for placing different portions of different lines of the light in a single line on a viewing screen.

17. The method of reproducing pictures comprising producing picture modulated light, arranging the lines of the picture in laterally displaced rows and refractively acting on the displaced rows to arrange the picture in a series of lines which are contiguous to each other and the ends of which are bounded by the same straight lines.

GEORGE WILLIAM WALTON. 20