Nov. 26, 1935. B. F. LOFGREN 2,022,248

TELEVISION EQUIPMENT

Filed March 10, 1930

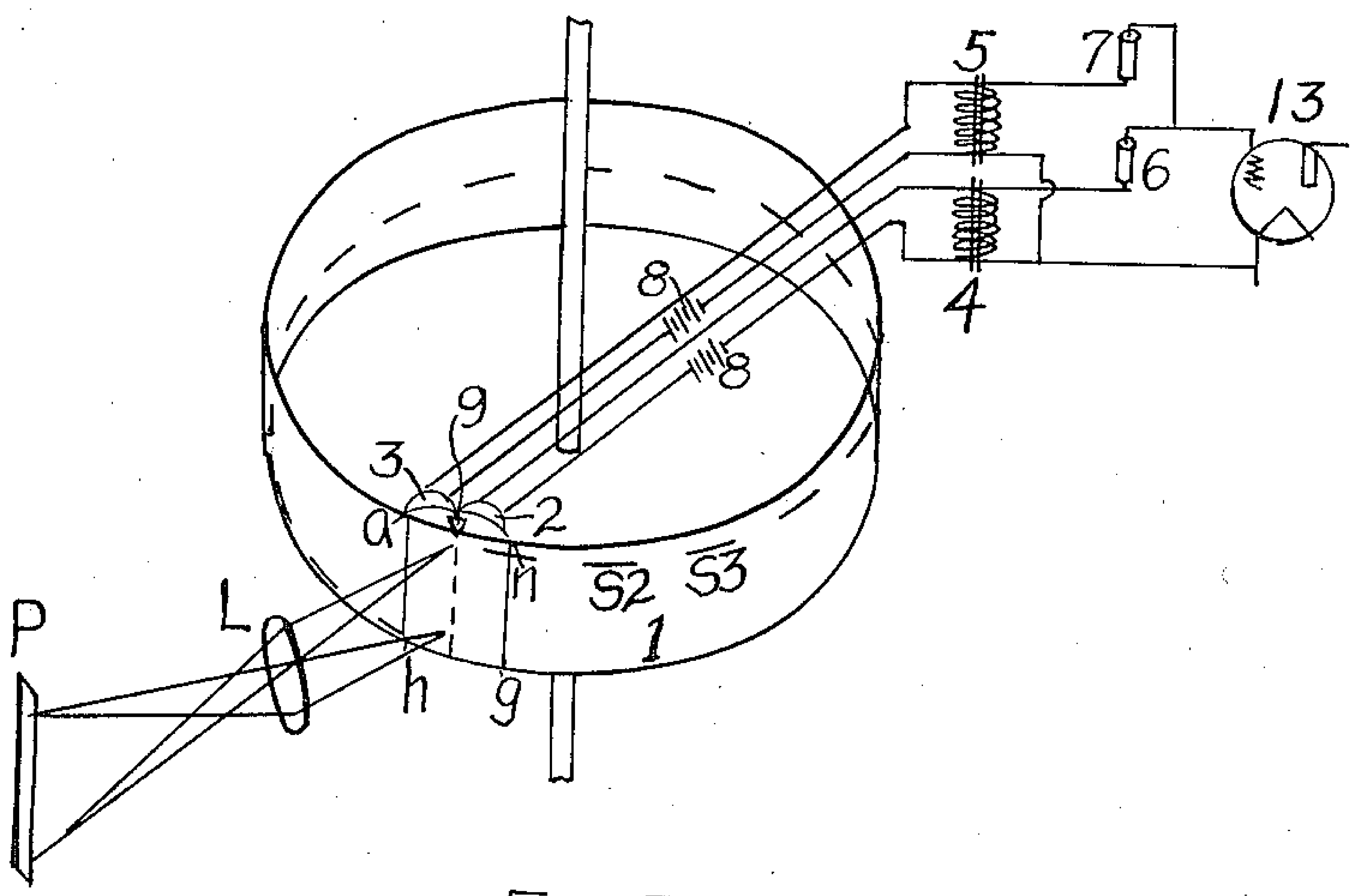

Fig I

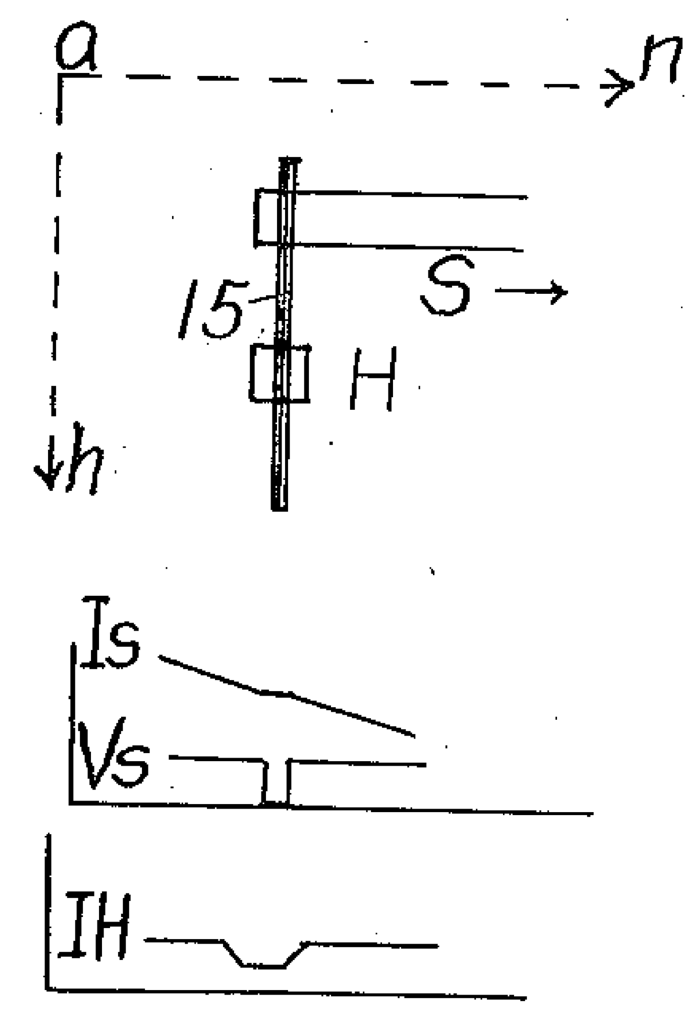

Fig IV

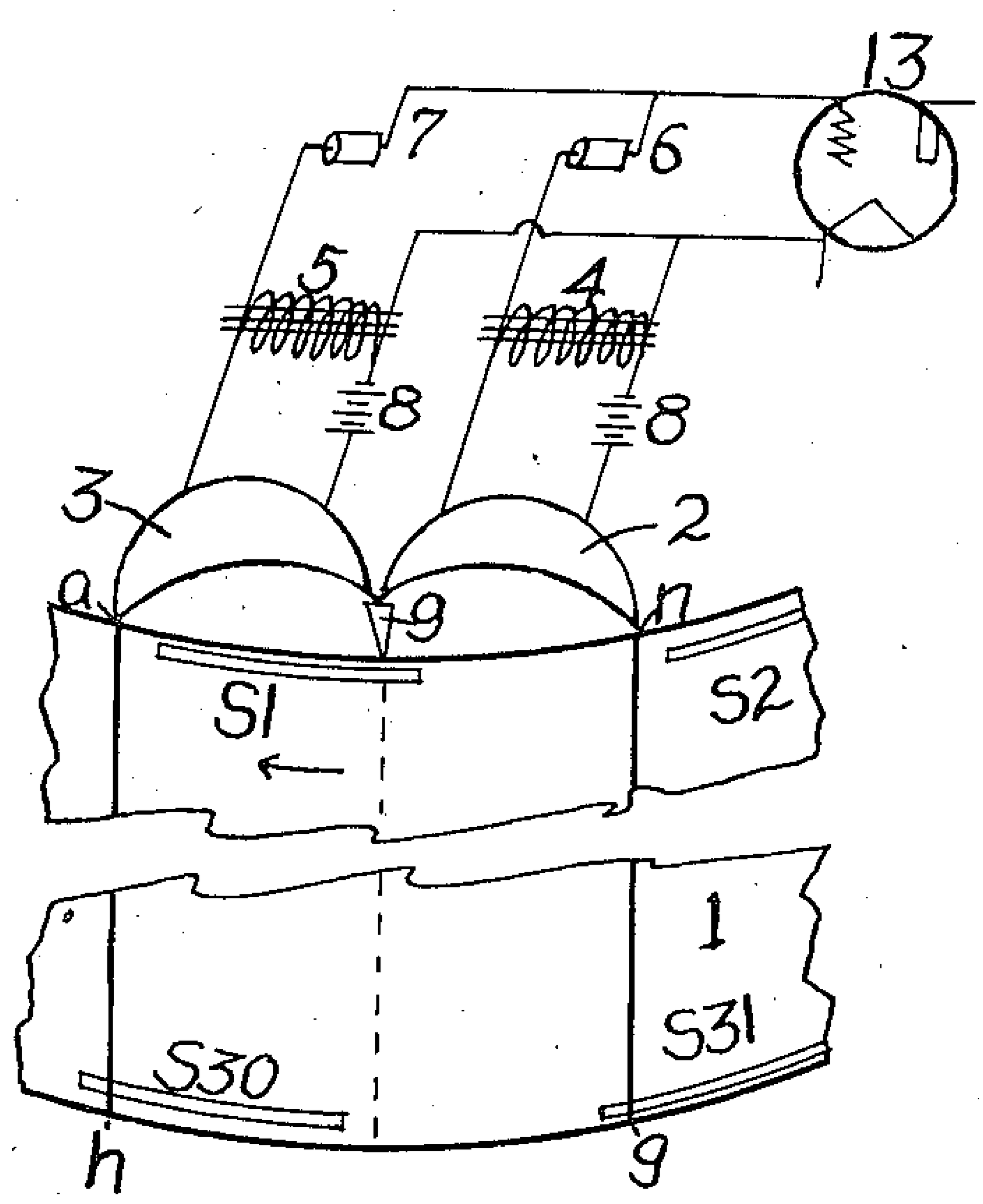

Fig II

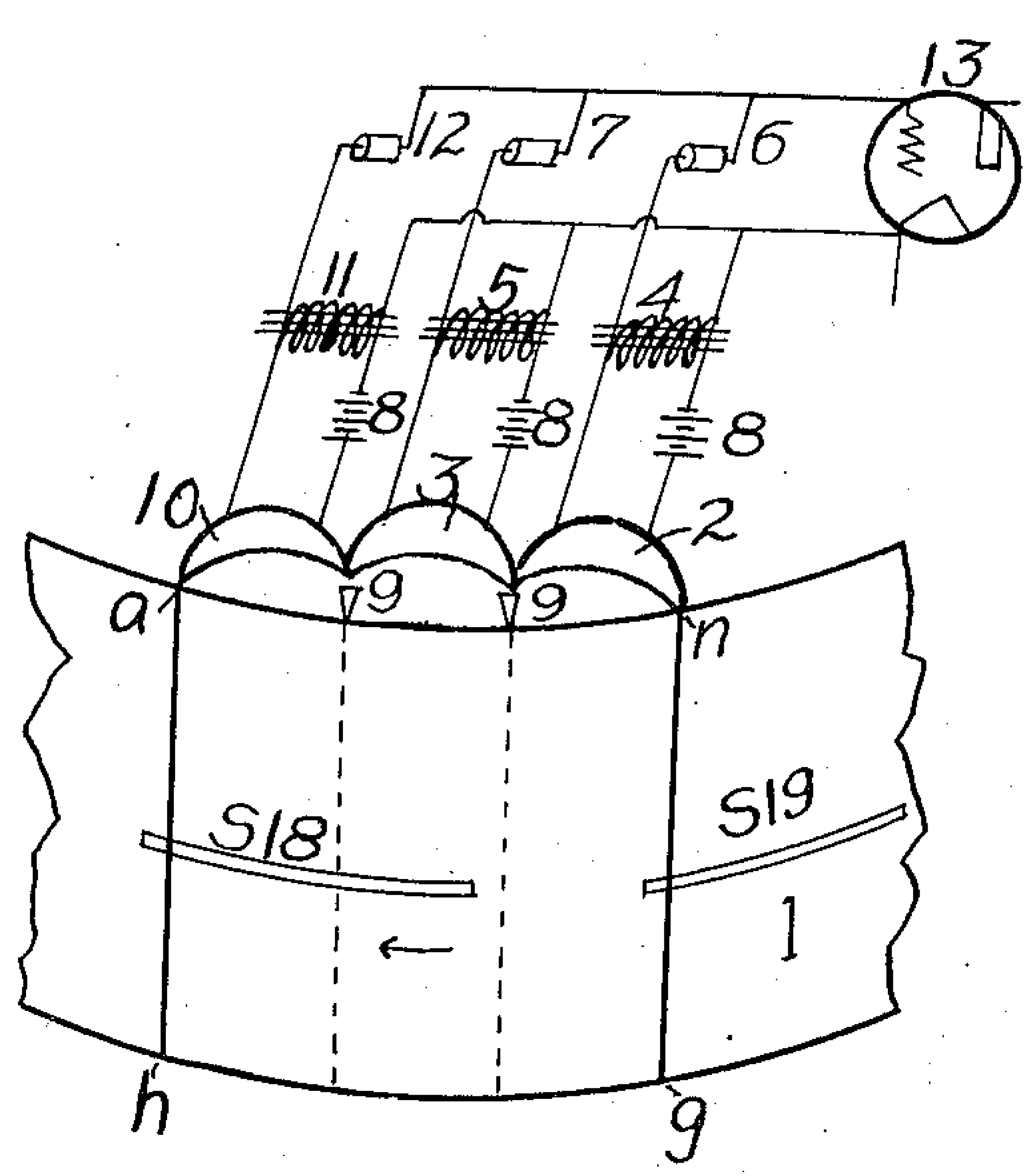

Fig III

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TELEVISION EQUIPMENT

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21 Claims. (Cl. 178—6)

This invention pertains to the art of transmitting pictures electrically and especially to television. The principal object of this invention is: means to analyze an object or an image as to light values and the production of corresponding electric values.

As is generally known the usual analysis of a picture for televtision is accomplished by passing a small aperture across an image of the picture in adjacent lines so that the light from small areas of the image pass in turn into a photoelectric cell to vary the resistance in an electric circuit, thus producing electric values proportionate to the light values of the picture. Other systems cause the image to move and the aperture to remain stationary; but all present systems analyze the picture by taking the light from fractional areas in turn of the image or picture. Thus the light values being used at any time is the sum of the light of all the points in that fractional area. Evidently this method can not respond to the fine points or lines of a picture and the reproduced picture will consequently be vague or diffused.

The present invention purposes to largely eliminate that effect by analyzing in a new manner hereinafter described.

The systems now known for analyzing a picture use the light from each small fractional area during its proportionate time only, to operate the photo-electric cell. And since the photo-electric circuit produces relatively small currents the electric values obtained are extremely small, necessitating great amplification. The present invention purposes to analyze the picture by a method which allows the light from each part of the picture to operate the photo-electric cell longer than its proportionate time and uses the accumulated light effect to produce instantaneous electric variations.

With these and other purposes and objects in view this invention consists in the novel apparatus and methods hereinafter described and particularly pointed out in the claims.

Fig. I is an illustration of the general scheme showing the analyzing apparatus.

Fig. II shows more in detail the image being analyzed where two photo-electric circuits are used.

Fig. III shows in detail the image being analyzed where three photo-electric circuits are used.

Fig. IV illustrates the electrical results obtained when using the usual method of analyzing as compared with the results when using the invention herein described.

Referring to the drawing and especially to Fig. I, the lens L focuses light from an object P to form an image *a—n—g—h* on a rotatable drum 1. The drum 1 contains a series of slits S1, S2, S3, etc. arranged in a broken spiral form of one turn, so that as the drum rotates the slits pass through the image in different lines. When a slit is in the image the light from a narrow strip of the image passes through the slit. Two or more photo-electric cells 2, 3, (10) are placed to receive the light which passes from the image through the slits, each cell receiving from its proportionate part of the image area. For the purpose of more accurately dividing the image area into sections a divider 9 (or dividers 9, 9 Fig. III) is placed between the photo-electric cells so that the light from any one point in the image will fall into only one cell. Each photo-electric cell is connected in an electrical circuit with a proper electromotive force and an inductance coil. Cell 2 is in circuit with a potential 8 and an inductance 4, while cell 3 is in circuit with a potential 8 and an inductance 5, so that any light which passes into a cell causes a proportionate current to flow through that particular circuit.

The slits are so arranged that the distance from one to the next is equal to the width of one section or division of the image, that is, the width of image which operates one cell.

Fig. II shows more clearly the relationship between the slits, image and cells where two cells are used. The distance between slits equals one half the image width and the length of the slits is minutely longer. It is readily seen that light can enter a cell through only one slit at any time. When any part of a slit is between the divider 9 and *a—h* the light from that part of the image passes into cell 3 and when any part of a slit is between the divider 9 and *n—g* the light from that part of the image passes into cell 2. As the drum 1 rotates each slit in turn admits the light from a narrow strip of each half image into its particular cell and then cuts the light out. But always while a slit is cutting light into one cell it, or another slit, is cutting light out of the other cell. The two cases are illustrated in Fig. II. At the top of the image S1 is cutting light into cell 3 and at the same time, is cutting light out of cell 2. As soon as S1 is out of the cell 2 half image S2 will begin to enter. In another case, shown at the bottom of the image, one slit, say S30 is cutting light out of cell 3 while S31 is cutting light into cell 2. Thus each part of the image in turn is cut into a cell and then cut out. But this increasing or decreasing light flux in a cell causes a proportionate increase or decrease in the electric current in that particular circuit. In the circuit with each photo-electric cell is an inductance coil so that any current in the circuit produces a magnetic field about the inductance coil and any change in current produces an electromotive force or potential across the coil; when the current is decreasing the potential is in one direction and when the current is increasing the potential is in the opposite direction. Each inductance coil is connected in another circuit containing a rectifying valve 6, 7 and in common a vacuum tube 13. These rectifying valves are so connected that only the coil in which the current is decreasing can pass its induced electromotive force to control the tube 13. Since the slits are cutting light out of only one cell at any time only one cell at a time has its force in the right direction to operate tube 13. Thus tube 13 is controlled at any instant by the potential across an inductance coil, which potential is proportional to the rate of decrease of current in that coil, which is proportional to the rate of decrease of light flux in that photo-electric cell, which is proportional to the light intensity at that particular spot in the image being cut out.

In the event that such high inductance coils are used that there is a considerable lag in the growth of the current where the light is increasing or in the event that such sensitive photo-electric cells are used that a wide variation in light flux entering is undesirable then more than two cells, with their dividers and electric circuits, can be used. In such a case there is a longer time after the cutting of light into a cell before the cutting out begins; in which time the current can become established thus accumulating the light effect in the circuit. At the cutting out of light there is no lag in the drop of current and a relatively high potential is obtained by an electromagnetic action in the coil similar to an induction coil at break of circuit.

Fig. III illustrates the arrangement for three photo-electric cells with their corresponding circuits. The distance between slits is equal to the width of one division of the image and the length of the slits equals the width of the image less one division.

When the image of a moving object is to be analyzed, such as a moving picture film or an object viewed from a moving airplane then the slits will be arranged to pass through the subject matter of the image in different lines. The positions of the slits on the rotating drum will depend upon the relative velocities of the slit and the moving object. However, one skilled in the art can properly arrange the slits to meet that situation, keeping in mind that the entire length of a slit must pass through the same line in the subject matter of the image.

A disc or belt containing slits might be used in place of the drum, but that would not require invention. Modifications in construction might be made without changing the principles of this invention. For example, a compound photo-electric cell might be used in place of a number of single cells and might also incorporate the dividers. The slits might be used in more than one turn on the drum by introducing suitable shutters or a switching device to connect only the desired number of cells at a time; or the slits might be in a stationary diaphragm and the image move, provided always that only one cell having one slit cutting light out, can operate vacuum tube 13 at any time. Larger openings might let light into a cell but a small cutting member cut the light out in narrow strips in turn. Yet all these variations in detail are within the principles of this invention.

One of the advantages of this invention over the usual analyzing device is illustrated in Fig. IV. A black line 15 in the image being analyzed is shown being crossed by the slit S as in this invention and by a hole H as in the usual method. As the slit S moves, the black line has no influence on the rate of cutting out light until the last end meets the black line. Instantly the rate of cutting drops to zero until the black line is passed, then the rate of cutting instantly is up proportional to the intensity of the light. Since the potential Vs is proportional to the rate of cutting out of light it follows the light intensity very closely. With the usual hole H passing the black line the resultant current IH falls gradually, does not quite reach zero then rises gradually, thus producing a fading or diffusing effect.

Another advantage of the present invention lies in the fact that an increase in the number of lines into which the image is cut will not reduce the potential values developed, since all the light must be cut in and then out once over the picture. But with the hole disc the resultant current depends on the area of the hole which is greatly reduced by increasing the number of holes.

This invention uses the light from each point of the image for a longer time than its proportionate time and accumulates the effect in a magnetic field about an inductance coil and the resultant is taken as an instantaneous potential as the light is cut out.

Thus the light intensities of infinitely small parts of the image, taken in turn, produce a correspondingly varying potential which controls tube 13. The current from this tube is amplified for transmission to a receiving station for picture reproduction or is used as a measure of the light values of the analyzed object.

Although a device pertaining to picture transmission is given as the principal object of this invention, yet there are elements in this invention which are useful for other purposes, such as photometry and color analysis.

Having described my invention, what I claim is:

1. The method of electro-optical scanning which comprises progressively and continuously varying the size of the region of a picture field from which light is utilized throughout the scanning operation, and utilizing the rate of change of size of said region to control the production of an electromotive force which continuously corresponds to the rate of change of light from said region.

2. Scanning apparatus comprising light sensitive electric means for receiving light modified by a picture field of view, and means for determining the region of said field from which light is at any instant received by said light sensitive means and for causing a progressive continuous change in the size of said region as the scanning proceeds throughout the complete scanning period.

3. Scanning apparatus comprising light sensitive electric means for receiving light modified by a picture field of view, and means for deter-

mining the region of said field from which light is received by said light sensitive means at each instant and for progressively and continuously varying the size of said region from which light is received by varying a portion only of the boundary of said region throughout the complete scanning period.

4. Television scanning apparatus comprising light sensitive electric means for receiving light modified by a picture field of view and rotatable apertured scanning means for determining the region of the field from which light is received by said light sensitive means and for progressively continuously varying the size of said region as the scanning proceeds throughout the complete scanning period.

5. Scanning apparatus comprising light sensitive electric means for receiving scanning light from a picture field of view, and means including a rotatable scanning element having rectangular shaped slots therein for respectively determining in succession regions of the field from which light is received by said light sensitive means and for progressively continuously causing the size of each of said regions to decrease from a maximum value to zero as the scanning proceeds throughout the complete scanning period.

6. In a scanning system, an electrical light sensitive device for receiving light rays from all points of a picture field of view and only from said field, scanning means for determining the region of the field from which the light is effective on said device at any given instant, means for changing the area of said region in a predetermined progressive continuous manner as the scanning proceeds throughout the complete scanning period, an inductance coil connected in series with said light sensitive device, and means to utilize the voltage generated across at least a portion of said coil.

7. Scanning apparatus comprising light sensitive electric means for receiving scanning light from a picture field of view, means to confine the light from one portion of the field to one portion of said light sensitive means and the light from another portion of the field to a second distinct portion of said light sensitive means, means for determining the regions of each of the portions of said field from which light is at any instant received by both portions of said light sensitive means and causing a progressive continuous change in the size of the said regions as the scanning proceeds throughout the complete scanning period and means for transmitting effective image currents controlled by only a single portion of said light sensitive means at any given time.

8. Scanning apparatus comprising a light sensitive electric means for receiving light from a field of view and only from said field, a movable scanning means having a plurality of elongated apertures for exposing to said light sensitive device entire elemental lines of said field successively upon movement thereof, the apertures being so arranged that light from only a single line is incident upon said light sensitive device at any given instant, means to move said scanning means to successively expose said elemental lines, and means for utilizing the current produced in the light sensitive device to control the production of image currents only when the effective area of an exposed elemental line is progressively changing in a single direction.

9. Scanning apparatus comprising means to form an image of an object to be scanned, a rotating scanning drum coincident in part with said image, elongated apertures in said drum of elemental line width and length at least equal to the length of an elemental line of said image, said apertures being arranged to scan elemental lines successively and being separated end to end by at least the length of an elemental line, a light sensitive electric device for receiving light from said image through said apertures, and means for utilizing the current produced in the light sensitive device to control the production of image currents only when corresponding ends of the apertures lie within the image area being scanned.

10. Scanning apparatus comprising a scanning drum, a plurality of elongated apertures arranged around the surface of said drum separated end to end by a distance equal to the length of an aperture and off-set across the drum so as to trace at least partially distinct paths as the drum rotates, a light sensitive electric device adapted to be energized by light incident thereon through a single aperture at any given instant, and means for utilizing the current produced in the light sensitive device to control the production of image currents only when the effective size of any aperture is progressively changing in the same direction due to rotation of the drum.

11. Scanning apparatus comprising a scanning drum, a plurality of elongated apertures arranged around the surface of said drum separated end to end by a distance equal to the length of an aperture and off-set across the drum so as to trace at least partially distinct paths as the drum rotates, a light sensitive electric device adapted to be energized by light incident thereon through a single aperture at any given instant, and means for utilizing the current produced in the light sensitive device to control the production of image currents only when the effective size of any aperture is progressively decreasing due to rotation of the drum.

12. Scanning apparatus comprising a scanning drum, means for rendering a limited area of said drum surface effective for scanning at any given instant, a plurality of light sensitive electric devices adjacent distinct portions of said limited area, a plurality of elongated apertures arranged around said drum in such a manner as to scan different elemental lines of said area, the length of said apertures being at least equal to the width of said area less the width of the narrowest distinct portion and the separation between apertures end to end being at least equal to the width of the widest distinct portion, and means for utilizing, to control the production of image currents, the current produced only in that light sensitive device corresponding to the distinct portion across which corresponding ends of the apertures are moving to progressively change the effective area in the same direction due to rotation of the drum.

13. Scanning apparatus comprising a scanning drum, means for rendering a limited area of said drum surface effective for scanning at any given instant, two light sensitive electric devices each adjacent to one-half of said limited area measured around the drum, a plurality of elongated apertures arranged around said drum in such a manner as to scan different elemental lines of said area, the length of each of said apertures as well as the separation between said aperture end to end being at least equal to one-half the width of said limited area, and means for utiliz-

ing, to control the production of image currents, the current produced only in that light sensitive device corresponding to that half of said limited area wherein the size of the aperture is progressively decreasing due to rotation of the drum.

14. Scanning apparatus comprising a scanning drum, means for rendering a limited area of said drum surface effective for scanning at any given instant, three light sensitive electric devices each adjacent to one-third of said limited area measured around the drum, a plurality of elongated apertures arranged around said drum in such a manner as to scan different elemental lines of said area, the length of each of said apertures being at least equal to two-thirds the width of said limited area and the separation between apertures end to end being at least equal to one-third the width of said limited area, and means for utilizing, to control the production of image currents, the current produced only in that light sensitive device corresponding to that third of said limited area wherein the size of the aperture is progressively decreasing due to rotation of the drum.

15. The method of scanning which comprises dividing the light from a picture field of view into successive regions, each having a maximum area corresponding to an extended portion of the field, utilizing the light from each region to control the production of an electromotive force, and progressively continuously changing the size of each region and said regions in succession as the scanning of said field proceeds throughout the scanning period to change the amount of light supplied from varying portions thereof to thereby vary said electromotive force.

16. The method of electro-optically scanning a non-uniform picture field which comprises progressively continuously varying the size of the region from which light is utilized by moving a boundary thereof, and continuously utilizing the light from said region as the scanning proceeds throughout the scanning period to control the production of an electromotive force which varies in accordance with the light tone values of said field at said boundary.

17. The method of electro-optically scanning a non-uniform picture field in elemental strips which comprises progressively continuously varying the size of the region within a strip from which light is utilized, said variation being produced by changing the position of a boundary of said region with respect to the field, repeating this process for successive elemental strips of the field, and utilizing the light from the field at such instant as the scanning proceeds during the complete scanning period to control the production of an electromotive force which varies in accordance with the light tone values of said field at said boundary.

18. The method of electro-optically scanning a non-uniform picture field in elemental strips which comprises progressively continuously varying the size of the region within a strip from which light is utilized, said variation being produced by changing the position of a boundary of said region with respect to the field, repeating this process for successive elemental strips of the field, and utilizing the light from said field at each instant as the scanning proceeds throughout the complete scanning period to set up a variable electromotive force.

19. Electro-optical apparatus comprising means for scanning a picture field along an elemental path of very great length compared with its width by progressively continuously varying the portion of the path from which light is utilized as the scanning proceeds throughout the complete scanning period, and means for utilizing the light from the path to set up a variable electromotive force.

20. Electro-optical apparatus comprising means for scanning a non-uniform picture field along an elemental path of very great length compared with its width including light sensitive means and means for causing said light sensitive means to receive light from a longitudinal portion of said path of progressively continuously varying length as the scanning proceeds throughout the complete scanning period to control the production of an electromotive force, and means for deriving from said electromotive force a second electromotive force which varies in accordance with the non-uniform characteristics of said field along said path.

21. Electro-optical apparatus comprising means for optically scanning a non-uniform picture field along a path of uniform width by restricting the useful light to a longitudinal section of said path of continuously progressively varying length as the scanning proceeds throughout the complete scanning period, and light sensitive electric means upon which said useful light impinges to set up an electromotive force having a component representative of the non-uniform characteristics of said field along said path.

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