July 21, 1959 B. KAZAN 2,896,087

HALF-TONE IMAGE PRODUCTION

Filed May 3, 1954 3 Sheets-Sheet 1

Fig. 1.

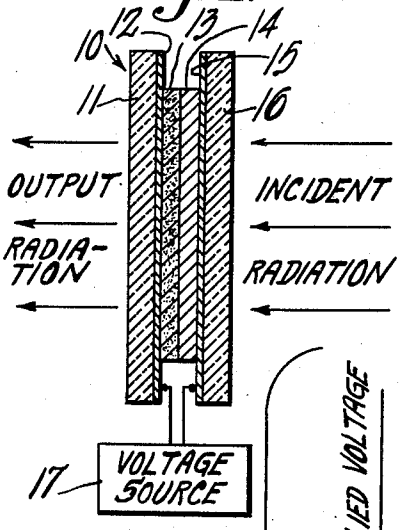


Fig. 2.

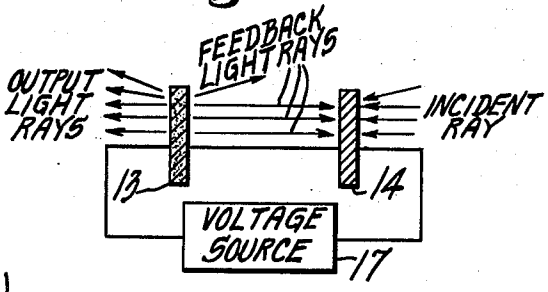
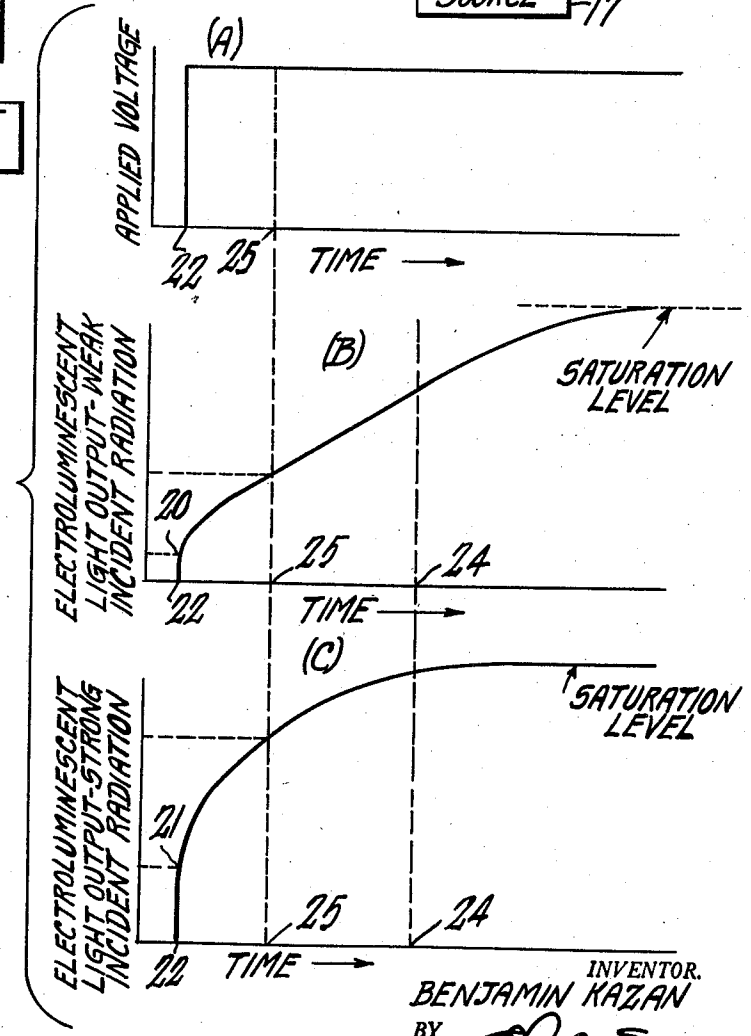


Fig. 3.



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July 21, 1959 B. KAZAN 2,896,087

HALF-TONE IMAGE PRODUCTION

Filed May 3, 1954 3 Sheets-Sheet 2

Fig. 4.

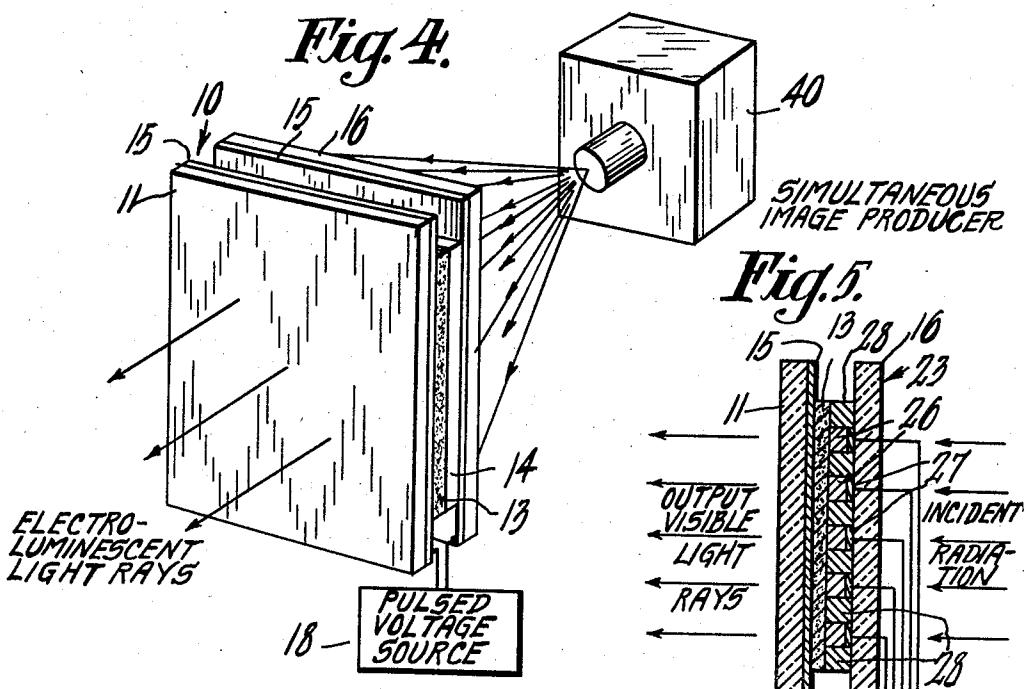
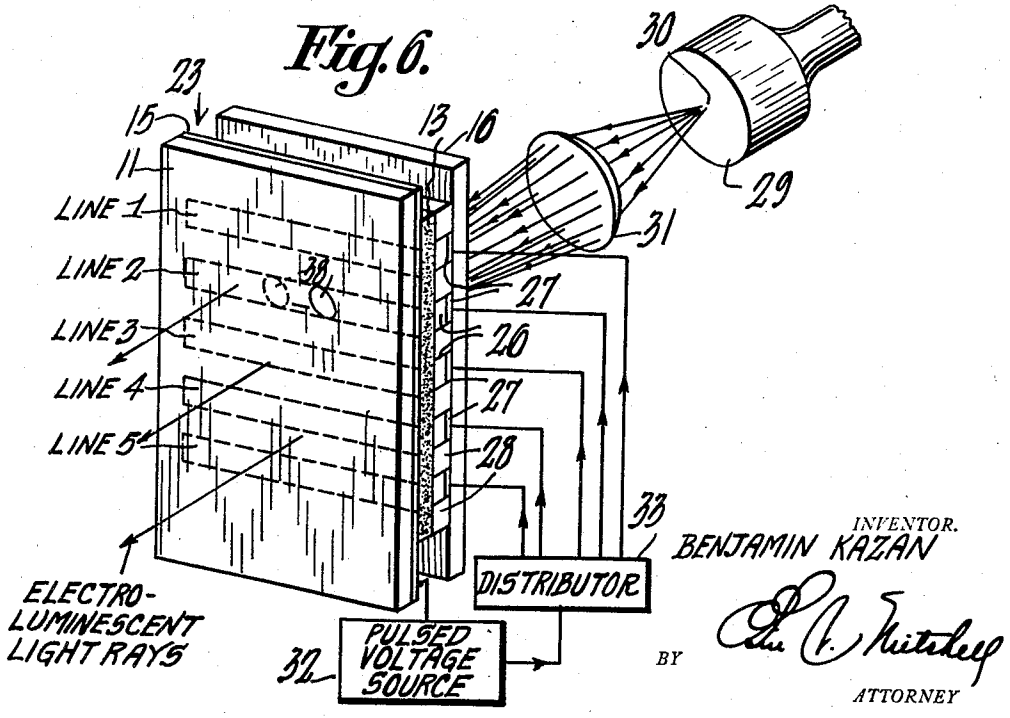


Fig. 5.

Fig. 6.



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July 21, 1959 B. KAZAN 2,896,087

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Filed May 3, 1954 3 Sheets-Sheet 3

Fig. 7.

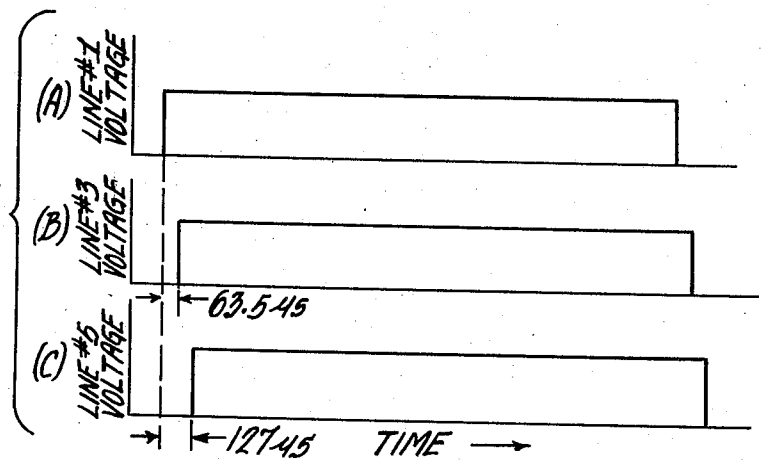
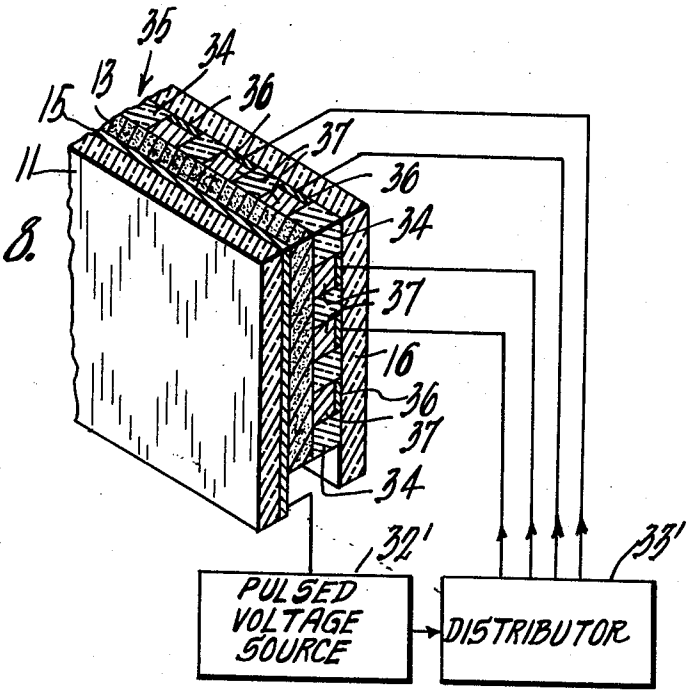


Fig. 8.



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2,896,087

HALF-TONE IMAGE PRODUCTION

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Application May 3, 1954, Serial No. 426,964

8 Claims. (Cl. 250—213)

This invention relates to radiant energy transducing apparatus and in particular to an electroluminescent-photoconductive apparatus for amplifying light.

Recently a method for amplifying light has been found which utilizes the principle of electroluminescence and photoconductivity. A device of this nature is described in detail in my copending application, Serial No. 315,694, filed October 20, 1952, and entitled, "Electroluminescent Device." It has been found that if an electroluminescent body is coupled with a photoconductive body and a voltage applied across said bodies, radiant energy impinging upon the photoconductive body will change its resistance whereupon the voltage drop across the electroluminescent body will change so that a corresponding amount of light output from the electroluminescent body is produced. In general, such types of devices may be classed either as regenerative or non-regenerative. The regenerative type depends upon the fact that when the electroluminescent body is excited, part of the light of luminescence is fed back to the photoconductive body resulting in an even smaller resistance of the latter, and consequently a greater voltage drop across the luminescent body. This, of course, means that the electroluminescent body is induced to produce even more light. This type of regenerative device is usually much more sensitive than a device of the non-regenerative type. If sufficient feed-back is permitted, a device of the regenerative type can be triggered on with a very small amount of input light, but the regenerative action will drive it to its saturation level.

Non-regenerative types, as may be supposed from the adjective used, do not employ feedback of light from the electroluminescent body to the photoconductive body to enhance the value of light output and hence its sensitivity. In non-regenerative types of devices or in devices with limited feedback there is an inherent advantage since the light output will then be a continuous function of the light input, and half-tones appearing in the light image to be amplified may be readily reproduced.

It would be very advantageous to combine the sensitivity of the highly regenerative type of device with the ability to produce half-tones which inheres in the other types.

According to the present invention highly regenerative types of such amplifiers are enabled to reproduce half-tones by applying the voltage supply to the electroluminescent-photoconductive device in such a manner that the regenerative effect is permitted to occur only for a limited time duration.

It is therefore an object of the present invention to enable a highly regenerative type of electroluminescent-photoconductive device to reproduce half-tones which exist in the radiation incident upon it.

It is a further object to provide an efficient and sensitive light amplifier which can reproduce half-tones of images to be amplified.

Still another object is to provide apparatus for amplifying a half-tone image.

Another object is to provide apparatus for amplifying a television image.

The invention will be described with reference to the drawings wherein:

Figure 1 shows one type of a regenerative electroluminescent-photoconductive device;

Figure 2 is an equivalent schematic representation of the operation of a device such as that shown in Figure 1;

Figure 3 is a set of curves representing the operation of the device shown in Figure 1 when the principles of the present invention are applied;

Figure 4 shows how the invention may be used to amplify a half-tone image each of whose elements are produced substantially simultaneously;

Figure 5 is an end elevation view of an electroluminescent device for sequentially producing an image in accordance with the present invention;

Figure 6 is a perspective view diagrammatically illustrating a system for sequentially producing an amplified television image in accordance with the present invention while utilizing the device of Figure 5;

Figure 7 is a set of curves illustrating the operation of the apparatus shown in Figure 6; and

Figure 8 is a diagrammatic representation of a system partly in block form, including a perspective view of an electroluminescent device having discrete elemental areas for sequentially producing an amplified television image in accordance with the present invention.

Referring to Figure 1, a regenerative electroluminescent-photoconductive device **10** is shown for the purpose of explaining the operation of this invention. The electroluminescent-photoconductive device **10** contains a transparent supporting plate **11** which has a TIC (transparent, iridescent conductive) coating **12** on one of its surfaces. The transparent conductive material may be of the type formed by deposition of the vapors of stannic chloride, water and methanol. A layer of electroluminescent phosphors **13** is placed into contact with TIC layer. The phosphors chosen may be of many varieties such as copper-activated zinc sulphide, zinc beryllium silicate and the like which are embedded in an appropriate light transmitting insulating material which may be a plastic, lacquer, wax, or a particular matrix material such as described in my previously mentioned application.

A layer **14** of a photoconductive material such as suitably activated cadmium sulphide is placed into contact with the phosphor layer **13**. Another TIC layer **15** is deposited upon another transparent supporting plate **16** and makes contact with the photoconductive layer **14**. Radiation is applied through the plate **16** and the transparent layer **15** to the photoconductive layer **14**. When this occurs, the resistance of the layer **14** will change as a function of the intensity of the incident radiation so that an applied voltage from the source **17** on the TIC strips **12** and **15**, has a smaller drop across layer **14** and a larger drop across the adjacent part of layer **13** causing it to luminesce. Part of the light from the electroluminescent layer **13** will pass out through TIC layer **12** and supporting plate **11** for observation, but a certain amount will be fed back to the photoconductive layer **14**. It is this feedback light which makes it difficult to reproduce half-tones in so-called regenerative type of electroluminescent-photoconductive device as will be explained below.

The frequency or pulse rate of the voltage utilized depends on the materials used and the light output desired and may range from 60 cycles to frequencies in the megacycles. When alternating voltage is applied to an electroluminescent device, there are two bursts of light during each voltage cycle. Thus, for the particular materials employed for the device, the frequency of the volt-

age must be at least sufficiently high so that the individual bursts of light cannot be seen by the eye. The magnitude of the voltage depends on the thickness of the cell and desired light output and may, for example, be between 200 and 1000 volts. The device is designed so that, in the unenergized condition, i.e. in the absence of incident radiation, the impedance of the photo-conductive layer **14** is considerably higher than that of the luminescent layer **13** so that a greater portion of the voltage drop appears across the former and the portion of the voltage across the latter is insufficient to produce appreciable luminescence. The ratio of the impedances of the layers at any particular source frequency to be used can be controlled by proper design of the thicknesses of the two layers for the types of materials used.

It might be well to explain the scope of the words "electroluminescent" and "photoconductive." "Electroluminescent" usually involves the production of visible radiation, but it should be understood that its radiation may be infra-red, ultraviolet, or other forms of detectable radiant energy. "Photoconductive" implies that the resistance or impedance, as the case may be, of the body varies in response to incident radiation which often is visible radiation. However, other forms of radiation may cause changes in the impedance. To mention a few, ultraviolet, infra-red, or X-rays will cause such impedance changes. For purposes of this application, however, it is necessary to have an electroluminescent-photoconductive device having a feedback action which results in attainment of the saturation level if the exciting or energizing voltage is maintained indefinitely. Such feedback is impossible unless that portion of the device on which the incident radiation falls is responsive to the radiation produced by the electroluminescent part of the device. For example, if the photoconductive portion were responsive to X-radiation and the electroluminescent portion produced visible light only, no feedback would occur.

It should also be understood such an electroluminescent-photoconductive device may be put to a variety of uses. If the incident radiation energy is less than the output radiation energy, the device may be viewed as an amplifier. If the opposite is the case, it is merely a transfer device or a reproducing apparatus. The device may also be a transducer if the photoconductive portion is responsive to types A and B of radiant energy, for example, whereas the electroluminescent body produces only type B radiation. In that case, if type A radiation falls on the photoconductive portion, a change in the voltage across the electroluminescent portion causes type B radiation to fall, in part, on the photoconductive portion which sets up a regenerative action, resulting in an enhanced output of type B radiation.

In Figure 2 this regenerative effect is shown in a simple form. A source of voltage **17**, which may be either A.-C. or D.-C. as will be explained below, is coupled across a photoconductive body **14** (corresponding to layer **14** of Figure 1) and electroluminescent body **13** (corresponding to layer **13** of Figure 1) in series. If the resistance of element **14** decreases, there will be a greater voltage drop across electroluminescent body **13**. This means greater light output by body **13**, part of which is fed back and falls on photoconductive element **14** causing an even greater voltage drop across body **13**, etc. Thus, in response to a relatively small input amount of light the regenerative effect between bodies **13** and **14** will continue to build up until the saturation level is reached whereupon the body **13** will exhibit a relatively high luminosity. However, saturation due to the regenerative effect will occur in response to many levels of light input, and the end result, in terms of light output, will be essentially either "blacks" or "whites" and no gradations in-between. A half-tone image is not easily possible under these circumstances.

As explained in my previously mentioned copending application, Serial No. 315,694, the feedback may be eliminated or controlled to a desired extent by interposing an opaque conductive material between the body **14** and the body **13** so that light from the latter is masked-off in so far as the body **14** is concerned. This may produce half-tones, but lowers the sensitivity compared to a similar device which employs feedback.

Figure 3 illustrates the germ of the present invention. Purely for explanation purposes, a rough analogy to a well known electronic circuit may be useful. The "super-regenerative" detector, widely used in some early radio broadcast receivers, is a device from which pertinent parallels may be drawn. As explained at page 456, et seq., of "Radio Engineering" by F. E. Terman (second edition, McGraw-Hill, 1937) a certain amount of feedback from the plate circuit to the input grid circuit of a tube permits oscillations to be built up upon the reception of an information signal. The build up is permitted to continue for only a short time before it is quenched. This results in a wave train of successive damped-out oscillatory wave pulses which occur at a low RF rate and whose envelope corresponds to the input signal. If the oscillations were permitted to build up to their maximum level without quenching, a constant output would be obtained and input signals could not be detected. With a highly regenerative type of photoconductive-electroluminescent device which is not quenched, all levels of light input, by the same token, would theoretically cause the same saturation value of light output and, therefore, only those photoconductive elements on which no light fell at all would be black. If, however, the voltage across the elements of the device is not applied steadily, but is externally cut off at a certain time or times, the mutual regenerative effect between the electroluminescent and photoconductive elements respectively will not attain its maximum, i.e., saturation, level. Up until the time that the applied voltage ceases, the various areas of the electroluminescent phosphor will produce an integrated amount of light output which is chiefly determined by the intensity of the incident light.

In curve A of Figure 3 the applied voltage begins at a point indicated by the numeral **22**. If the incident radiation is relatively weak, the electroluminescent light output will commence, as shown in the idealized curve B, by rapidly attaining a level **20** and ultimately reaching the saturation level as indicated. Curve C shows what happens when strong incident radiation is directed upon the photoconductive portion. Almost immediately a level **21**, which is considerably higher than the level **20** of curve B, is attained. From level **21** the curve rises to saturation level which it reaches much sooner than curve B. In both cases, assuming that the electroluminescent material is homogeneous, the saturation level will be represented by the same amount of output light. To prevent saturation level from being reached, the applied voltage shown in curve A may be cut off at a point in time marked by the vertical dashed line **25**. At point **25** it is to be noted that the area under the curve B up to that time is considerably less than the area under curve C. Thus, both the instantaneous and integrated light output at cutoff point **25** is considerably less for weak incident radiation than it is for strong incident radiation so that half-tones are produced. Once the applied voltage is cut off, it then remains off sufficiently long for conductivity of the photoconductor to decay and return the device to the condition indicated at point **22**.

Figure 4 shows how the apparatus illustrated in Figure 1 may be used to reproduce or intensify an image whose elements are simultaneously produced. An image producer **40** which may be, for example, a slide projector, motion picture apparatus, or the like, projects an image through the transparent plate **16** and the transparent coating **15** onto the photoconductive layer **14** reducing the latter's impedance or resistance as the case may be in accordance with the image intensity at a particular point. An electroluminescent layer **13** thus has a correspondingly greater voltage drop as a function of the applied

image. A source 18 of a pulsed voltage is connected across the layers 13 and 14 by way of the transparent conductive layers 12 and 15. This voltage, which may be either A.-C. or D.-C., is turned on substantially at the same time as the image is projected (or before, if desired), but is turned off before the regenerative effect described in connection with Figures 2 and 3 reaches its maximum value. For motion picture projection the applied voltage must be pulsed at least once each frame. If the duration of the time for projecting one frame is so long as to produce saturation of the device, it will be necessary to pulse the applied voltage several times during each frame to prevent saturation. Another determinant of the number of pulses required are the characteristics of the phosphor layer 13 and the photoconductive layer 14. If the voltage is properly applied in pulses, each pulse of the device 10 will function as described in connection with Figure 3 and thus the electroluminescent light rays visible to the observer through transparent plate 11 will contain half-tones if any such were in the projected image. If the applied voltage is A.-C., the pulsed voltage source 18 may contain some type of oscillator whose output is fed to a coincidence circuit which is operated to pass current only upon the application of a keying pulse such as might be obtained from multivibrators. In United States broadcast color television standards recently approved by the Federal Communications Commission, a "burst" of a subcarrier frequency is injected into the transmitted composite color video signal at a prescribed repetition rate. Circuits similar to the operation of such burst injectors could also be adapted for use with the present invention. To name a few, reference is made to the article beginning at page 204 of the January, 1954 Proceedings of the I. R. E. At page 209 of this article a block diagram is shown in which a gate pulse is applied to a gate to which the subcarrier is also applied. Only when they coincide does the gate pass the subcarrier. In a bulletin entitled, "Recent Developments in Color Synchronization, in the RCA Color Television System," published in February, 1950, by RCA circuitry is shown in Figure 13 thereof which may easily be adapted for use in the present system.

If D.-C. is used to energize the device, it is even possible to employ any of a number of conventional commutators or switches whose characteristics may depend upon the rate of projection of the simultaneously produced image. Multivibrators are a well-known class of circuits which can furnish a pulse as shown in curve A of Figure 3 at the desired repetition rate.

The invention in another of its forms can be used to reproduce or amplify an image each of whose elements is produced sequentially. In other words each element is individually scanned at a rapid rate, and because of the combined effect of persistence in the image producing means, and the retentivity of human vision, an entire image is apparent. A very common example of such an image is the one produced by conventional television receivers. In the latter the display means is a cathode ray tube whose cathode ray is an intensity modulated stream of electrons which is deflected laterally and vertically so that it impinges upon successive elements of a phosphorescent screen causing it to glow in response thereto.

Figure 5 shows a slight modification of the device shown in Figure 1 which may be useful in reproducing a sequentially produced television image. It is very similar to the apparatus shown in Figure 2 of my above-mentioned copending application. The essential difference is that the photoconductive part of the device is not a single, continuous coating or layer as in Figure 1, but is rather a number of discrete and independent units 26. Figure 5 is an end section of such a device. Parts similar to Figure 1 are similarly numbered. The photoconductive material is laid down in strips 26 extending from one side of the device to the other. One surface of the strips 26 is in contact with the electroluminescent layer 13. Also running sideways and in contact with each of the photoconductive strips 26 is a corresponding number of TIC strips 27. The TIC strips are also in contact with the supporting plate 16. To each of the TIC strips 27 a lead is attached which runs to a voltage source (not shown). The TIC layer 15 is also coupled to the last-named voltage source. Incident radiation is directed toward the TIC strips 27. Spacing each strip or line of photoconductive material from the other is a plurality of insulating members 28. These members 28 should also prevent light from sections of the electroluminescent layer 13 which are not in contact with the photoconductive strips from affecting the resistance of the photoconductive strips 26. This may be accomplished merely by using an opaque insulating material for the elements 28.

Figure 6 is a perspective and sectional view of the construction of the device of Figure 5 for reproducing or intensifying a television image for example. A kinescope 29 having a flying spot 30 generates a complete raster on its face plate which is optically transferred by means of lens 31 (symbolic of a complete optical system) onto successive ones of the TIC strips 27. The applied flying spot of light passes through the strips 27 onto a corresponding photoconductive strip 26 as the scansion of the television image is accomplished by the kinescope 29. For each line in the television raster there is preferably one strip 26 of photoconductive material in the device 23. As the intensity of the spot varies so does the impedance or resistance of each element of the photoconductive strips 26 which results in a fluctuation in the voltage applied across the corresponding element of the electroluminescent layer 13. To prevent the interaction between the photoconductive and electroluminescent layers from regenerating to the saturation level, the voltage from pulsed voltage source 32 is applied in a particular way by distributor 33.

Figure 7 will assist in understanding the application of voltage to the device 23. Let us assume that the spot 30 is on the topmost line of the television raster formed on kinescope 29, and is focused on an element of the topmost photoconductive strip 26. Just as the spot 30 begins scanning from one side, a voltage, as shown in curve A of Figure 7, is applied by way of the topmost of the TIC strips 27 to the topmost photoconductive strip 26. When scansion of the top line has been completed, the focused spot will move to, let us say, line 3. The focused spot will begin scanning the third line of the device 23 at approximately 63.5 microseconds after the commencement of scanning of line 1, and the voltage will be applied as shown in curve B of Figure 3. When the spot is focused upon line 5, the voltage as shown in curve C of Figure 7 will be applied 127 microseconds after the beginning of the scansion of line 1. Scanning will continue in this manner until each field is completed. With interlaced television scanning the odd lines are first scanned to produce a first field, and then the even lines are scanned to produce a second field, both fields together comprising one complete picture fame. It is desirable that the voltage applied to each TIC strip be maintained, in any event, not longer than the frame repetition rate which is 30 c.p.s. However, since the mutual regenerative effect existing between the electroluminescent and photoconductive elements may read saturation level long before this time, the voltage on each line should last for a time short of the saturation level time as explained in connection with Figure 3 above.

In Figure 6 one pulse of voltage is applied to each photoconductive strip 26 during the scanning of each line of the television image as explained in connection with Figure 7. It is possible to break up each photoconductive strip into a plurality of smaller units each of which corresponds to one or more picture elements. If the TIC material was similarly divided, the pulsed voltage can be applied in proper phase and individually to each photoconductive element along a horizontal line.

Thus no time differential exists between the start of the voltage pulse as applied to any one element of the line and the instant when the line element was illuminated by the spot as compared with any other element on the line.

Such a device **35** may be constructed as shown in Figure 8 which is a perspective and sectional view. As in the previous figures, similar parts are similarly numbered. A number of photoconductive elements **37** are positioned in rows from side to side in contact with the electroluminescent layer **13**. Each of the elements **37** is also attached to an individual TIC area or element **36**. A lead is taken from each of the TIC areas **36** and is coupled to a distributor **33'**. Separating each of the photoconductive elements **37** are a plurality of insulating elements **34** which are preferably opaque. In manufacture, the arrangement of the photoconductive elements **37** and the insulating elements **34** may be expedited by inserting the photoconductive material in the interstices of a mesh made of the opaque insulating material. The TIC elements **36** are also coupled to the supporting plate **16** which is transparent. The conductive coating **15** is coupled to a pulsed voltage source **32'**. The source **32'** is also coupled to distributor **33'**. The pulsed voltage from source **32'** has a duration determined chiefly by the time when the saturation level of the device **35** is reached. The pulses are applied consecutively to each of the photoconductive elements **37**. To achieve this in the case of television requires a relatively high frequency switching device or other type of device which will furnish pulses to the successive elements **37** in proper time relation. Ideally, each of the pulses should be applied to the elements **37** a moment before or at the instant the image spot is focused upon that particular element. The distributor **33'** may consist of a high frequency electronic commutator operating at a rate determined by the number of elements **37** used. If the number of elements **37** corresponded directly to the number of picture elements reproducible under the United States television standards, there would be approximately 200,000 of them in a frame consisting of two fields of approximately 100,000 elements apiece. Since there are 30 frames per second, this would entail a commutator having a frequency of about 6 mc. Such high frequency electronic commutators or samplers are well known in the art and numerous examples thereof may be found in the literature.

It is also possible to construct a delay line having a number of taps corresponding to the number of elements to be energized, through which a train of pulses is propagated.

It is to be understood that a device such as device **35** of Figure 8 could be employed for reproducing a simultaneous image as discussed in connection with Figure 4.

Having thus described the invention, what is claimed is:

1. A system for reproducing incident light radiation having a plurality of intensity gradations, comprising a regenerative electroluminescent photoconductive device having a photoconductive element and an electroluminescent element, electrically coupled in series relation, said photoconductive element having a variable impedance characteristic which is a function of the illumination thereon, means coupled to said device for applying an excitation voltage across said series-coupled elements whereby the voltages across said elements are in a ratio which is a function of the impedance ratio of said elements, means connected to control said excitation voltage in an on-and-off manner according to a predetermined time pattern, said pattern including an on-time having a duration less than the time required for said device to reach regeneration-induced illumination saturation, and having an off-time corresponding substantially to the conductivity decay time of said photoconductive element, whereby the illumination output of said electroluminescent element is a function of the intensity of the incident light radiation on said device.

2. A method of using a regenerative electroluminescent-photoconductive device for reproducing radiation incident thereupon which has a plurality of intensity gradations, comprising the steps of periodically applying a voltage across said device, cutting off said applied voltage before the saturation level of said device is attained, and reapplying said voltage after the end of the decay preiod of said device whereby said device produces light as a function of said intensity gradations.

3. A radiant energy transducing system including a regenerative electroluminescent-photoconductive device, said device comprising an electroluminescent body and a photoconductive body coupled to one another, said photoconductive body adapted to receive incident radiation, means for applying an electric field across both of said bodies, means for cutting off said applied electric field at predetermined points of time and causing said field to remain cut off for a time duration determined by the decay time of said device, said predetermined points being chosen to occur before the saturation level of said device is attained.

4. Apparatus for reproducing radiant energy images having a plurality of intensity gradations including a regenerative electroluminescent-photoconductive device which contains a body which luminesces in response to applied electrical energization and a charge receiving body coupled to said luminescent body, means for applying an electric field to said bodes, said radiant image being applied to said charge receiving body, and means for cutting off said applied electric field at a time before the saturation level of said device is reached and causing said field to remain cut off for a time duration determined by the decay time of said device whereupon said luminescent body reproduces said image having said plurality of intensity gradations.

5. Apparatus for amplifying an image each of whose elements is produced simultaneously, comprising in combination an electroluminescent-photoconductive device which contains a body which luminesces in response to applied electrical energization and a photoconductive body serially coupled thereto, said device further containing means for applying an electric field across said bodies, each of said image elements being applied to said photoconductive body whereupon each element of said image causes the resistance of a corresponding portion of said photoconductive body to vary as a function of the intensity of said image element, and means for cutting off said applied voltage for a period corresponding to the decay time of said device before said device reaches saturation level in such a fashion that each portion of the electroluminescent body is caused to luminesce as a function of the intensity of a corresponding image element.

6. Apparatus for reproducing an image each of whose elements is sequentially produced, said image possessing a plurality of intensity gradations, comprising in combination an electroluminescent-photoconductive device which contains a body which luminesces upon the application of an electric field thereto, a plurality of photoconductive bodies each of which is coupled to said luminescent body, means for applying each element of said image on successive portions of each of said plurality of photoconductive bodies, a source of voltage adapted to be coupled across each of said photoconductive bodies and said electroluminescent body, means for applying said voltage to each photoconductive body and to said electroluminescent body during the time when said image elements are being applied to said photoconductive bodies, and means for cutting off said applied voltage before said applied image elements cause each photoconductive body and said electroluminescent body to regenerate to saturation level for a time duration determined by the decay time factor of said device, said device thereby reproducing said image including said intensity gradations.

7. Apparatus for reproducing an image each of whose elements are sequentially produced, said image elements having a plurality of intensity gradations, comprising in combination an electroluminescent-photoconductive device which contains a body which luminesces upon the application of an electric field thereto, insulating means having a plurality of interstices coupled to said electroluminescent body, a plurality of photoconductive bodies each of which is located within one of said interstices, each of said photoconductive bodies being coupled to said electroluminescent body, means coupled to said electroluminescent body and adapted to be coupled to each of said photoconductive bodies for applying an electric field thereto, means for applying each of said sequentially produced image elements in predetermined sequence upon said plurality of photoconductive bodies, each of said photoconductive bodies and the portion of said electroluminescent body in proximity thereto thereupon becoming mutually regenerative, and means for removing said applied electric field from each of said photoconductive bodies and said proximate portion of said electroluminescent body before said regeneration reaches saturation level for a time duration corresponding substantially to the decay time of said device in such a fashion that said electroluminescent body reproduces said image having said intensity gradations.

8. Apparatus for producing an image each of whose elements is produced in sequence, said image elements having a plurality of intensity gradations, comprising in combination, an electroluminescent-photoconductive device containing a first transparent supporting plate, a transparent and electrically conductive layer disposed on

one of the faces of said supporting plate, a layer of electroluminescent phosphors mounted in contact with said transparent conductive layer, a second transparent supporting plate, a plurality of photoconductive bodies mounted in contact with said electroluminescent layer, a plurality of transparent conductive bodies, each of said last-named bodies being coupled to a corresponding one of said photoconductive bodies and to said second supporting plate, a plurality of opaque insulating bodies interposed between said photoconductive bodies, a plurality of conducting means each of which is coupled to one of said plurality of transparent conductive bodies, means coupled to said transparent conductive layer and adapted to be coupled to each of said plurality of conducting means in predetermined sequence for applying an electric field thereto, each of said photoconductive bodies and a portion of said electroluminescent layer in proximity thereto becoming mutually regenerative upon the application of said field, and means for removing said applied electric field from each of said photoconductive bodies and said proximate portion of said electroluminescent layer before said regeneration reaches saturation level.

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