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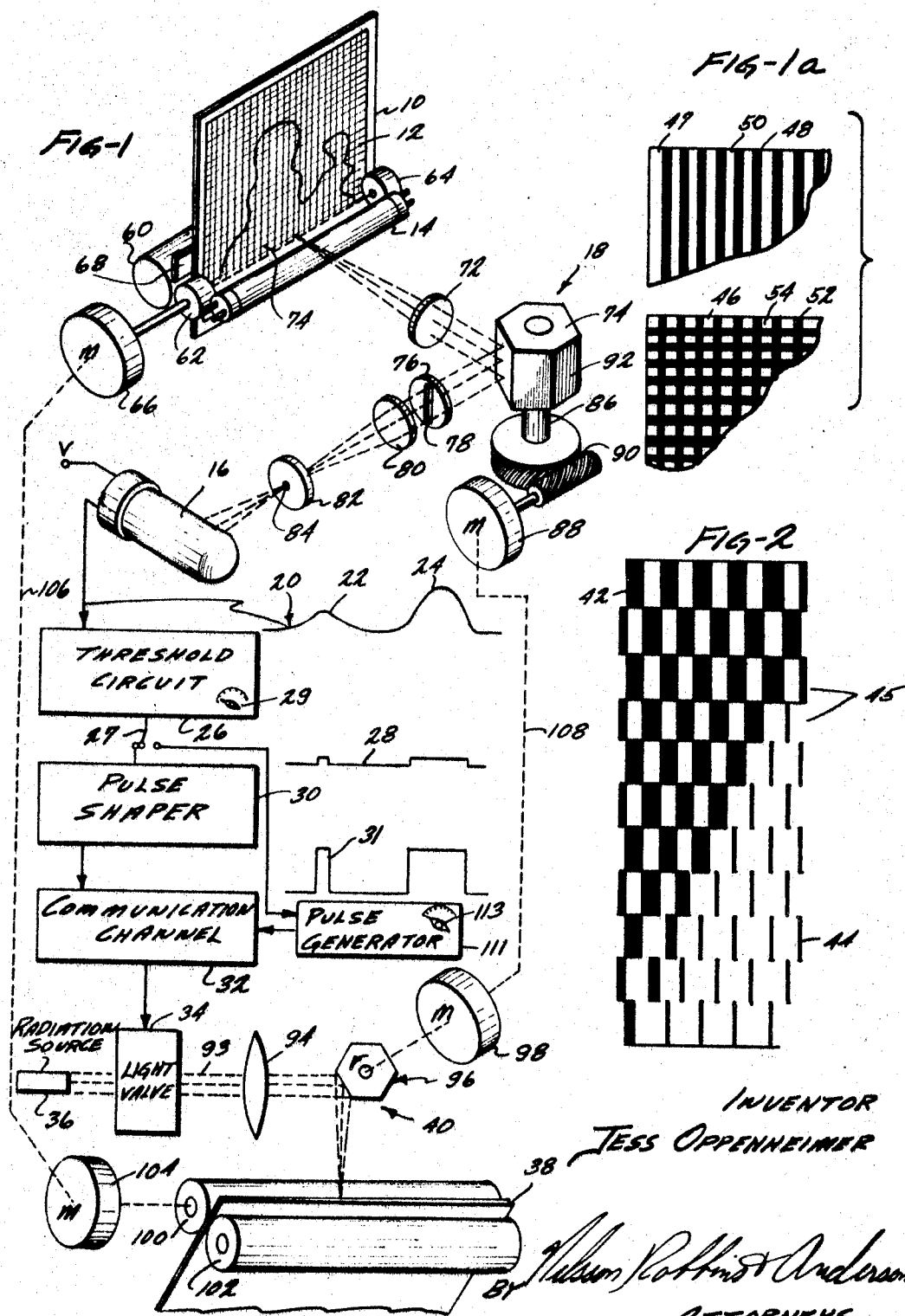
J. OPPENHEIMER

3,461,229

ELECTRO-OPTICAL REPRODUCTION METHOD

Filed Aug. 17, 1965

2 Sheets-Sheet 1



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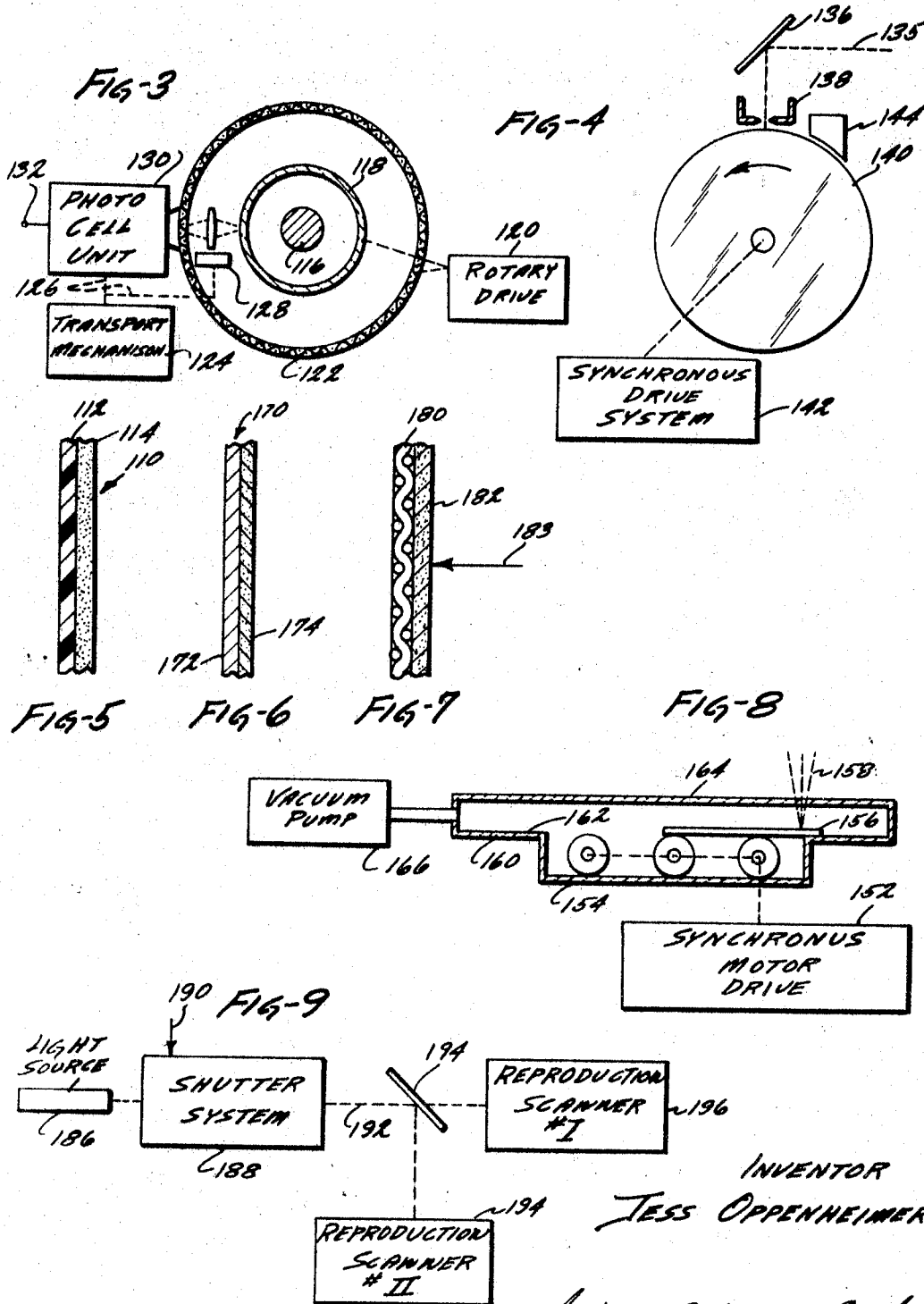
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2 Sheets-Sheet 2



INVENTOR
JESS OPPENHEIMER

BY *William Robbins & Associates*

ATTORNEYS

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ELECTRO-OPTICAL REPRODUCTION METHOD

Jess Oppenheimer, 549 Morena Ave.,
Los Angeles, Calif. 90049

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11 Claims

ABSTRACT OF THE DISCLOSURE

Apparatus for rapidly converting continuous-tone images into representative half-tone images by scanning through a screen to dissect the image into elemental dots. A recording beam may fuse thermoplastic ink, etch a metal plate, or burn a stencil.

The present invention relates to a system of image reproduction, and more particularly to an improved reproduction system in which variable-tone images, including a grey range, may be resolved into representative half-tone images as for printing in a single tone or color.

The half-tone process is widely used in the printing arts to produce a single-tone black and white image for example, that visually appears as the continuous-tone original. Specifically, a photograph including a wide range of grey tones may be dissected by the half-tone process into dots or other incremental areas, of a single tone, the density and size of which vary to represent gradations in the grey scale on the photograph. The half-tone image can thus be printed, using a single color or tone to represent shades of grey as well as black.

Although the half-tone process is widely employed in the printing arts, its use has been primarily restricted to volume production and relatively expensive printing operations. Traditionally, this method of printing has required a half-tone metal plate, made by rather expensive engraving techniques. Various techniques also have been proposed for making half-tone plates for less expensive printing systems; however, generally these have not been completely satisfactory and have not come into widespread use. Therefore, a considerable need exists for a system capable of producing less-expensive half-tone printing plates, and for producing half-tone images that may be adapted for use in inexpensive reproduction apparatus, as copiers, planographic printers, and the like.

Accordingly, it is an object of the present invention to provide an improved economical reproduction system capable of rapidly converting continuous-tone images into representative half-tone images.

Another object of the present invention is to provide a system of dissecting a continuous-tone image, e.g. a photographic representation, into a single-tone image, e.g. a uniform-tone black on white image, in which system the size of the images may be conveniently altered.

Still one other object of the present invention is to provide an improved system for engraving half-tone images into metallic plates for printing or other purposes.

A further object of the present invention is to provide an improved and economical system for producing printing masters incorporating half-tones for convenient and effective use in certain forms of economical printers and copiers.

Still a further object of the present invention is to provide an improved system for printing half-tone images on a medium, without the necessity of a printing plate or master.

Still another object of the present invention is to provide an improved means for resolving continuous-tone images into half-tone images by scan sensing a continuous-

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tone image through a screen to develop an electrical signal which may be modified and treated to reproduce the half-tone image by scan reconstructing the elemental areas.

Briefly, these and other objects and advantages of the present invention are achieved in accordance with the embodiments disclosed herein which include means for presenting a tonal light image, means for dissecting such an image into a pattern of elemental areas, and means for scanning the elemental areas to provide an electrical signal that may be developed to control a composing means which constructs the half-tone representative image.

Further details of the several novel features of the present invention, and the operation of various embodiments thereof, as well as additional objects and advantages of the invention will become apparent from a consideration of the following description taken in conjunction with the accompanying drawings representative of structure which is here presented by way of illustrative example only; and in which:

FIGURE 1 is a diagrammatic representation of a system constructed in accordance with the principles of the present invention;

FIGURE 1a is a somewhat diagrammatic plan representation of elements which may be employed in the system of FIGURE 1;

FIGURE 2 is a fragmentary enlarged, somewhat idealized diagram illustrating one manner in which images may be formed by the system of FIGURE 1;

FIGURE 3 is a diagrammatic representation of an alternative structure for a portion of the system of FIGURE 1;

FIGURE 4 is a diagrammatic representation of another alternative structure for a portion of the system of FIGURE 1;

FIGURE 5 is a sectional view of a medium that may be employed in a system of the present invention;

FIGURE 6 is a sectional view of another medium that may be employed in a system of the present invention;

FIGURE 7 is a sectional view of still another medium which may be employed in a system of the present invention;

FIGURE 8 is a diagrammatic representation of still another alternative form of a portion of the system of FIGURE 1; and

FIGURE 9 is a diagrammatic representation of still one further alternative structure which may be employed as a portion of the system of FIGURE 1.

Preliminary to considering the structure presented as illustrative of the present invention, it is important to appreciate the effect of a line screen, as used in the printing arts to convert continuous-tone images or photographs into half-tone representations. In accordance with somewhat conventional practice, various forms of screens for that purpose are made to include opaque lines defining open areas and are placed over a photographic image to dissect it into a dot pattern. The resulting division of the continuous-tone image into a composite of incremental dot areas is somewhat apparent; however, the production of varying dot size and density accomplished from the dissection may require further consideration and analysis. The illumination over each of the incremental areas in a line screen is non-uniform because of the penumbral shadows of the adjacent screen lines. That is, considering an incremental area of the image exposed through an individual screen aperture, full illumination reaches only the central point in the incremental area. More specifically, the center of the incremental area may be considered as fully illuminated, while the primary and secondary shadows cast by the screen surrounding the incremental area reduce the intensity of the illumination at locations

removed from the center. This variation in intensity of illumination can be visualized over the area of a rectangular opening as somewhat related to the physical form of a pyramid. The illumination is most intense at the very center of the area and diminishes outwardly therefrom as a result of the penumbral shadow cast by the screen. The peak light intensity of the different incremental areas depends upon the location on the grey scale of the area. Therefore, a physical graphic representation of the light image intensity from the screen area (highly magnified) would resemble an array of pyramids of different heights according to the location on the grey scale of the supporting incremental area. This variation in illumination over incremental areas provided by the line screen is utilized in the printing arts to photographically produce half-tone images by arresting development of a photographic image exposed through a line screen, when dots just appear. Pursuing the physical-representation example, it is as though the pyramids were shaved off at some plane, their sectional surfaces in that plane providing a half-tone representation of the original image. The half-tone image may then be engraved into a metal plate to print half-tone images. The photographic and chemical techniques and apparatus previously employed to produce the engraved metal plates have in the past necessitated considerable skill and expense.

In addition to the line screens described above to obtain a half-tone image, screens of variable density have also been developed for this purpose. The present invention contemplates the incorporation of various screens, and both these types as well as others might be employed to practice the invention.

The present system employs line screen dissection in a novel manner to accomplish unexpected results in image translation. In one form, this system employs a scan sensing apparatus, to sequentially resolve each incremental area (provided by the line screen) into a variable-intensity electrical signal. Manipulation of the electrical signal in accordance herewith then produces a pulse-width modulated signal in which each incremental area represented in the image is manifest by a uniform-amplitude pulse, the width of which indicates a level on the grey scale. The pulse signal may then be variously employed to accomplish the half-tone image on any of a variety of mediums. Specifically, for example, the representative pulse signal may control a scanning beam of electro-magnetic energy to melt a thermo-plastic ink and thereby print on a sheet of paper. Other exemplary applications include etching metal by evaporation in a vacuum to form an engraved plate and burning opaque material from a support screen to produce a master for use in an ink-transmissive printing system, as in mimeograph apparatus.

Considering the system of the present invention as represented in FIGURE 1, a photographic image carried on a plate 10 is partially obstructed by a screen 12 which resolves the image into an array of elemental areas. The line screen 12 is held immediately in front of the plate 10 and can be set apart by a certain distance, as by a spacer, so that light rays forming the image pass through the line screen as dots of varying light intensity, or a variable density contact screen can be used.

Illumination as from fluorescent lamps 14 (only one shown) produces the light image in dot form through the apertures in the screen 12 as elemental areas which are sequentially sensed by a photomultiplier tube 16 by means of a scanner 18. In general, the scanner 18 senses the light image in a raster pattern, so that each incremental area is scanned, the light from it being projected to the tube 16 for conversion into a representative electrical signal. As a result of the penumbral effect attendant the use of the line screen, as explained, the light sensed from each incremental area of the image varies (relative to time) somewhat parabolically as the individual elemental area is scanned. The peak amplitude of the parabol depends upon the location of the incremental area

on the grey scale. More specifically, a representation of the output from the tube 16 is shown as a somewhat idealized signal form 20 incorporating two somewhat parabolic spikes 22 and 24. The spikes are of similar width; however, the amplitude of the spike 24 is considerably greater than that of the spike 22, indicating a lighter area reflecting more-intense light.

The parabolic form of the spikes 22 and 24 results from the penumbral or variable density effect of the screen 12 on the incremental areas of the image carried on the plate 10. That is, the light reflected across the space of an elemental area varies from substantially no light directly below the center of a screen line, to a peak intensity at the opening center, then drops back a low level.

The peak amplitude (peak light intensity) of the spikes 22 and 24 is determined by the level of light intensity from the incremental area, i.e. the level of the area on the grey scale. Specifically, the spike 22 represents an area that is relatively close to black on the grey scale, while the spike 24 manifests higher light intensity and thus represents an area that is near white.

In the operation of the reproducing part of the system, the signal form 22 is applied to a threshold circuit 26 which may, in practice, comprise a well-known Schmidt trigger circuit and which functions to develop a two-state output signal representation 28, containing uniform-amplitude pulses. The width of the pulses is related to the peak amplitudes of the spikes 22 and 24 because of the relative slope of the leading and trailing edges of the spikes.

The system of FIGURE 1 may be operated in two different modes. In the first mode, the dot areas are only considered once, during a single scanning of the light image. The parabolic spikes 22 and 24, in sequence control a reproduction system according to their size by providing variable-width pulses to compose representatively sized dots.

In the second mode of operation of the system, the image is scanned several times to classify the dot areas. For example, the first scanning may only reproduce the clear white dots or areas, the second scanning supplying the slightly grey dots, and so on through the grey scale.

The single scanning, first mode of operation will be considered initially in which mode a switch 27 is moved to the left, connecting the threshold circuit 26 to a pulse shaper 30. Also, a control switch 29 as well-known in the prior art to control the threshold level of the circuit 26, is set somewhat low.

The pulses from the threshold circuit 26 are amplified and shaped by a circuit 30, to a form 31, then applied through a communication channel 32 (which may comprise a single conductor) to a light valve 34, which may for example comprise a Kerr cell. The valve 34 is operated to be either open or closed depending upon the two-state signal (pulse or no pulse) received from the communication channel 32. That is, when the applied signal is in a high state, the valve 34 is open to pass radiation from a source 36. Otherwise, the valve is closed to obstruct or divert the radiation.

The intermittent beam of radiation passed through the valve 34 is scanned onto a medium 38 by a scanner 40 operated in synchronism with the scanner 18, to reconstruct the original image in a half-tone pattern. The reconstruction of the image to represent a range of grey from the original is illustrated negatively in the diagram of FIGURE 2. Areas of the image which are near white on the grey scale produce larger areas 42 in the reconstructed image pattern while darker areas produce small areas 44. That is, assuming a somewhat idealized line-like light beam of narrow-slit formation is keyed on and off by the valve 34 while being scanned across each of the horizontal lines 45, the exposure patterns indicated in FIGURE 2 may be produced. When the beam is on, dwell areas indicated in black are exposed to develop the desired half-tone image. Of course, the production of the black and white areas may be reversed or phase in-

verted (as by adding an amplifier to the channel 32) depending upon the nature of the medium 38 and the intended function of the impinging radiation on the medium 38.

In view of the above general preliminary explanation, a detailed understanding of the system of FIGURE 1 may now best be accomplished by considering an assumed image conversion, and introducing other detail components of the system as the explanation of the operation proceeds. In this regard, it is important to appreciate the initial dissection of the image into a light image of elemental areas of variable intensity which can be scanned to resolve the image into a continuous single-channel signal that in turn may be manipulated to a form that will reconstruct the image in a half-tone or dot-pattern form. Several different forms of screens may be employed for such image dissection, two examples of which are shown in FIGURE 1a. The screens may be formed variously, employing different materials and patterns. In FIGURE 1a a screen 47 is illustrated which provides a line pattern, while the screen 46 provides a dot pattern. In the screen 47 opaque vertical lines 48 separate light-transmissive lines 50. In the screen 46, crossing opaque lines 52 define transparent dots or rectangles 54. The patterns of the screens may also take the form of circular areas (either in regular array or random) checkerboard patterns and so on. The size of the line rulings may also vary, however, between 65 lines per inch and 200 lines per inch will normally accomplish the desired results. The structure of the screens bearing various patterns may take the form of ruled lines on a glass plate or may be lines provided between two glass plates as well known in the printing arts. Various techniques for producing these screens as well as variable density screens are well-known and may be readily adapted to the practice of the present invention.

The screen 12 is positioned in proper relation to the image-bearing plate 10 and so held between a backup roller 60 and a pair of mechanically interconnected front rollers 62 and 64, which are driven by a synchronous motor 66. The plate 10 is also supported by a holder 68 so as to provide a flat unobstructed horizontal surface 70 of the screen and plate, for scanning, above the lamp 14.

Assuming the operation of the single-scan mode, to reproduce the original continuous image from the plate 10, the illumination from the lamp 14 results in a reflected light image from the plate 10, through the screen 12 composed of incremental discrete areas. These incremental discrete areas are scanned in a raster fashion, e.g. sequentially across one horizontal line after another, moving from top to bottom, to be resolved into a single channel signal representative of reflected light intensity.

The horizontal line-at-a-time scanning of the elemental areas results from the motor 66 driving the plate 10 upward through the rollers 62 and 64 mating with the roller 60. In this regard, a stepping motor may be employed to maintain the scanning horizontal across the plate 10, or a continuous drive motor will provide a slant line raster, analogous to that of the television arts. In using a slant line scanning pattern, the screen 47 avoids dwelling on a horizontal line in scan sensing.

In scanning the horizontal line to sequentially consider discrete areas, light from incremental areas on the plate 10 passes through an aperture in the screen 12, through an objective lens 72 to then impinge upon the faces of a poly-surface mirror 74 for reflection through an optical mask 76 (having a selective vertical slit or aperture 78) a collimating lens 80, and another mask 82 (having a central aperture 84). The mirror 74 in the sensing scanner 18 is carried on a shaft 86 and is revolved continuously by a synchronous motor 88 through a gearing mechanism 90. As each mirror face 92 of the mirror 74 in sequence swings through a forward stroke, the individual elemental areas in a line on the plate 10 are reflected from a mirror face in turn to be sensed and resolved into the desired light signal at the multiplier tube 16. At the conclusion

of such a scanning stroke, the plate 10 and the screen 12 are elevated so that the next mirror face scan senses a next-lower horizontal line of elemental areas. The resulting light signal is represented somewhat idealized by the signal form 20, and is similar in shape after conversion to an electrical signal by the photomultiplier tube 16.

The application of the electrical output of the photomultiplier tube 16 to the threshold circuit 26 resolves the spikes 22 and 24 into uniform-amplitude pulses to present a two-amplitude signal which is in a high state when the input is above a predetermined level of amplitude and which is otherwise in a low, or reference-level state. The signal representation 28 is illustrative of the output from the threshold circuit 26 which is amplified by the pulse shaper 30 and may also be clipped and clamped using any of several available well-known techniques to produce a desired output signal.

The communication channel 32 as previously indicated may comprise simply a single wire or line of communication; however, the channel might also comprise a radio link or various other facilities for transmitting width-modulated pulses to the light valve 34.

Various forms of light cells or shutters usable as the valve 34 are well known in the prior art, one form being the Kerr cell, an electro-optical shutter that utilizes the phenomenon that a plate of glass as well as various fluids become doubly refracting when submitted to a strong electrical field. By using that phenomenon in conjunction with polarizing plates, an effective light valve may be provided for control by an electrical signal.

The valve 34 passes a beam 93 of radiation from a source 36 during intervals when the input signal is in a high state, i.e. during the period of the pulses 31 as previously considered. The radiation source 36 may comprise any of several different structures including lasers, infra-red light sources, or various other types of electromagnetic radiation sources depending upon the application of the system. The beam 93 intermittently passed by the cell 34 is concentrated by a lens 94 and reflected by a multisided mirror 96 driven by a motor 98 similar to the sensing scanner, to accomplish a repeated line scanning movement by the beam. The scanning line beam 93 is formed by the valve 34 and is concentrated on a medium 38 that is advanced between a drive roller 100 and an idler roller 102 to reconstruct the image line-by-line in half tones by action of the energy beam.

To accomplish the line-by-line reconstruction, the roller 100 is driven by a motor 104 in synchronism with the motor 66 by any of a variety of techniques well known in the prior art as indicated by a dashed-line connecting link 106. Similarly, the motor 98 in the scanner 40 is synchronized with the motor 88 in the scanner 18 as also indicated by a dashed-line coupling 108. Therefore, the intermittent reconstructing beam impinging upon the medium 38 is synchronized with the sensing of the image to reproduce the image by elemental exposures having a duration coinciding to the location on the grey scale of the elemental area being copied. If the medium 38 constitutes a negative representation, the image developed will be as shown in FIGURE 2. That is, areas approaching white on the grey scale are substantially filled by black areas 42 while areas approaching black on the grey scale contain only small black areas 44, presenting considerable white. Thus, after each line is composed in this manner, the medium 38 is raised between the rollers 100 and 102 sufficiently for another line 45 to be similarly composed of black areas, the width of which varies as the degree of grey to be represented, as shown somewhat idealized in FIGURE 2. Thus, a negative image representation is produced. Alternatively, a positive image may be created as indicated by means of a phase inversion stage to reverse the operation of the light valve 34 from that previously described. Of course, the particular mode of operation

will depend upon the particular medium 38 and the desired operation thereon by the beam 93.

Somewhat related to the medium 38 to be used is the matter of the mode of operation for the system. As indicated, operation in the mode described above involves a single scanning of the light image to develop individual pulses representative of image areas which control the reconstruction of the image. In another mode of operation, each scanning of the light image quantizes the image areas within a particular range on the grey scale and produces representative signals which recombine the image in multiple scans.

In the second mode of operation, the switch 27 is positioned to the left, connecting the threshold circuit 26 through a pulse generator 111 to the communication channel 32. The threshold level of the circuit 26 is then set very high by adjustment of the control knob 29. The control knob 113 of the pulse generator 111 is set to provide a long-duration pulse output. In this regard the generator may comprise simply a variable time-interval monostable multivibrator.

With the controls set in this manner, only the highest amplitude pulses, representing very light areas (spike 24) trigger the threshold circuit 26 to provide an output which in turn drives the pulse generator 111 to provide a long-interval pulse. The pulses so produced are transmitted and control the light valve 34 as described above to produce a large representative area on the medium 38.

At the completion of the first scanning, the threshold of the circuit 26 is set at a lower level and the duration of the pulse generator 111 is set for a shorter period. As a result, areas above a lower level on the grey scale are sensed, connected to pulses of shorter duration which control a shorter dwell time of the beam 93 on the medium 38. Of course, areas struck by the beam 93 during the prior scanning are struck again, however, such repeat exposure is not important as the medium is either black or white.

At the completion of the second scanning, another scanning follows adjustment of the threshold level and pulse duration, which may be followed by several additional scanings. Thus, darker and darker elemental areas are sensed and composed on the medium 38. The number of times the light image is scanned depends upon desired fidelity because the grey scale is essentially being quantized into a number of levels, coinciding to the number of separate scanings.

The choice of mode of operation depends on the requirements of the system, its application, and the medium 38. For example, in one form of the medium 38, a coated paper may be employed in which a heat-sensitive white surface is removed or altered by the heat of infra-red radiation comprising the beam 93. That is, a normally white sheet for example may be scanned by the beam from the source 36 with the result that the sheet is heat blackened in the areas upon which the beam impinges. Such an arrangement requires a positively-keyed beam. In such a system, by controlling the sweeps afforded by the synchronizing motors, and the various other aspects of the system, an image can easily be enlarged or reduced during the process of reproduction and resolution to half-tone representation. Of course, this consideration depends entirely upon the relative sizes of the sensing and reproducing rasters which are readily controllable within limits for various systems.

In another application of the system the medium 38 may comprise a sheet 110 as shown in FIGURE 5 including a layer of paper 112 having a coating 114 of heat-sensitive ink disposed uniformly thereon. In the operation to set an image on the sheet 110 the electrical signal as described with reference to FIGURE 1, to control the radiation beam 93 is phase inverted so that generally-light areas indicate beam dwell spaces. That is, the electrical signal employed to control the valve 34 in FIGURE 1 is simply phase inverted as by the addition of an

odd number of amplifier stages in the channel 32, as very well-known in the prior art. Therefore, the beam of radiant energy impinges upon the coating 114 in areas where black is desired. The form of the sheet 110 is generally well known in the prior art and areas of the coating 114 which are subjected to radiant heat of the beam 93 melt and are thereby affixed to the paper 112. After such heat treatment of the sheet 110, the unmelted ink is removed from the paper by various techniques. The unmelted ink in the particle coating 114 may be held on the paper 112 by static electricity which is neutralized after heat treating to release ink particles from areas which are to be preserved white.

Of course, this technique can also be used for indirect printing where, for example, the melted ink is on a plate of glass, and is deposited therefrom onto paper or other medium.

In a system which employs the sheet 110 as a reproduction medium, a relatively compact apparatus may be desired for utilization as in a copy machine with half-tone capability. A relatively simple scan sensing structure and a similarly-simple scan reproducing system may be desired in such applications, as illustratively represented in FIGURES 3 and 4 respectively.

The scan sensing apparatus as shown in FIGURE 3 includes an elongated fluorescent lamp concentrically mounted within a rotatable glass cylinder 118 upon which a light-transmissive form of the image to be copied is mounted. The cylinder 118 is rotatably driven by a drive 120 along with a dot-pattern screen 122 also formed as a cylinder and concentric to the cylinder 118. Rotation of the cylinder 118 and the screen 122 provides the movement to resolve each line of an image into a plurality of dots. The image is resolved into lines by a transport mechanism 124 which may comprise a step motor with a linear slide rule output coupled as indicated by the lines 126 to drive a lens unit 128 and a photocell unit 130 parallel the axis of the cylinder 118. The transport mechanism 124 is synchronized with the rotary drive 120 so that upon each completed revolution of the cylinder 118 the transport mechanism 124 advances the photocell 130 and the lens mount 128 one position to scan the next line of the light image. As a result, the image placed on the glass cylinder 118 is transformed to a light image by the lamp 116, which is scanned by the lens unit 128 for resolution into a light signal somewhat analogous to a video signal. That signal is then chopped by the structure of the screen 122 into elemental intermittent representations as described with reference to FIGURE 1. Therefore, the signal passing through the apertures in the screen 122 (to be sensed by the photocell 130) is segmented to contain the effect of penumbral shadows or other screen dissection as explained above. The photocell unit 130 then provides a representative electrical signal at a terminal 132 that is similar to the signal previously described with reference to FIGURE 1, and that may be applied to a threshold circuit to accomplish width-modulated pulses.

The utilization of the signal developed from the structure of FIGURE 3 to compose a representative image may be accomplished by another rotary-scan structure as shown in FIGURE 4, which may employ the principles of xerographic reproduction. That is, the radiation source as disclosed in FIGURE 1 may provide an intermittent beam 135 (as described) to a scanning mirror 136 for accomplishing the reproduced image xerographically, for example as disclosed in United States Patent 3,099,943. More specifically, the beam is reflected from the mirror 136 to pass through a slotted light shield 138, and impinged upon a drum 140 driven by a drive system 142 synchronized to the scan sensing drive system. In accordance with the teachings of the above identified patent, a corona charging device 144 accomplishes the xerographic charging operation. Specifically, as the drum 140 is rotated, the corona charging device 144 applies a uniform electro-static charge over a photoconductive layer on the

drum 140. The electro-static charge is then selectively dissipated in part by the radiant energy of the beam scanning through the shield 138. In this regard, it is to be noted, that as previously described, the beam is not intensity modulated; however, it is duration modulated to accomplish the dot pattern as repeatedly emphasized here throughout. At the conclusion of the scanning operation the desired image is statically registered on the surface of the drum 140. Therefore, the image may be readily reproduced on paper or other medium as known in a black and white form; however, having good half-tone capabilities as a result of the dot pattern and the electrical signal operations.

The medium employed in systems hereof may take many other forms depending upon the result desired. For example, the system may be employed to remove material in a dot or half-tone pattern to provide an engraved printing plate or other dimensioned article. In general, the apparatus for engraving metal may be substantially as shown in FIGURE 1 with the alternate structure as disclosed in FIGURE 8 at the composition station, wherein the synchronous motor 104 is replaced by a synchronous drive 152 revolving a series of rollers 154 that transport a metallic plate 156 relative a scanning beam 158 intermittently providing high energy radiation to evaporate metal from the plate 156. In this regard, the rollers 154 are fixed in a sealed chamber 160 provided with shelves 162 for receiving the plate 156. The upper portion of the chamber 160 comprises a panel 164 of glass or other material which is transparent to the beam 158. The interior of the chamber 160 is then connected to a vacuum pump 166 which functions to maintain a partial vacuum inside the chamber. As a result, the radiation beam 158 is effective to evaporate metal from the plate 156 etching the half-tone image into the plate in accordance with the patterns as described above. In this regard, in some instances it may be desirable to provide the plate 156 in a laminated form including two different metals having different temperature characteristics. For example, a plate 170 as shown in FIGURE 6 includes layers 172 and 174 of different metals laminated together in a composite. The metal forming the layer 174 has a low melting point and is evaporated with relatively little energy while that of the layer 172 requires more energy for melting and therefore provides firm backing after etching off energy removable material.

With regard to the removal of material to define an image, several other applications for the present invention exist, one example of which is the production of printing masters as for use in mimeographing and relative low-cost printing arts. For example, FIGURE 7 shows a medium including a fine screen 180 of generally-transparent synthetic fibers carrying a layer 182 of carbon particles bonded together by a heat-sensitive binder. Upon exposure to a beam of radiation of sufficient energy formed as in the structure of FIGURE 1, and as indicated by an arrow 183, the carbon particles in the layer 182 are "burned out" or released by destruction of the binder. Yet, the screen 180, being generally transparent does not absorb sufficient energy to be affected. As a result, areas in an image are removed leaving the open screen 180 through which ink may flow for reproducing copies with half-tone characteristics by traditional mimeographing techniques.

It is thus apparent that the system hereof may be employed in a wide variety of applications depending upon the desired end results. Furthermore, the system may be variously combined to accomplish such results as color reproductions, or virtually any application in which resolution of an image including a grey tone scale is desired. Still further, the system hereof has capability for simultaneous multiple production. In this regard, as shown in FIGURE 9, a source 186 of radiation is applied to a light valve or shutter system 188, a previously described form of which may include a Kerr cell and which

is keyed in accordance with a signal from the communication channel 32, as shown in FIGURE 1 which is applied to a conductor 190. As a result, a beam 192 emerges from the shutter system 188 to impinge upon a beam splitter 194 dividing the keyed beam for application to a first reproduction scanner 196 and a second reproduction scanner 194. Of course, the reproduction scanners 196 and 194 may take any of a variety of forms, as disclosed above. However, it is noteworthy that by splitting the energy signal, a plurality of reproduction operations may proceed simultaneously to develop the desired half-tone images on a plurality of different mediums.

The important features of the invention generally result from the flexibility afforded in treating and transmitting a single-channel signal and from the effect of scan sensing a screened image to accomplish such a signal which can be resolved to half-tone representation. A number of features are readily apparent from the structures considered herein; however, the invention is not to be understood as limited to such structures which are described as merely illustrative. Rather, the system of the present invention shall be determined in accordance with the claims set forth below.

What is claimed is:

1. In combination:

means for presenting a tonal light image;

sensing means for scanning said tonal light image to dissect said image into a single-channel signal; and

means interposing an opaque screen pattern between said tonal light image and said means for scanning whereby said single-channel signal manifests elemental areas of said image and shadows cast on said tonal light image by said opaque screen pattern.

2. In combination:

means for providing a surfacial tonal light image;

means for dissecting said image by scanning whereby to provide a representative electrical signal;

means for providing an open-screen opaque pattern between said light image and said means for dissecting, whereby to resolve said representative signal into dot-sequential signals indicative of elemental areas of said image and shadows cast on said tonal light image by said opaque screen pattern;

means for reproducing said image by controlling a beam scanning over a reproduction medium in accordance with said representative electrical signal.

3. In combination:

means for providing a surfacial tonal light image;

means for providing an open-screen pattern in front of said tonal light image to dissect said image into elemental areas and provide shadows thereon;

means for scanning said elemental areas in sequence, including means to provide representative two-state electrical signals; and

means for reproducing said image by controlling a beam scanning over a reproduction medium in accordance with said representative electrical signal.

4. A combination according to claim 3 wherein said means for reproducing comprises means for providing a high-intensity light beam and means for controlling the dwell time of said beam on said medium in accordance with said electrical signal.

5. A combination according to claim 3 wherein said means for scanning comprises a photo-electric means means for exposing said photo-electric means to said elemental areas in a raster sequence to provide an electrical photo-signal, and means for thresholding said photo-signal to provide said two-state electrical signal.

6. A combination according to claim 5 wherein said means for reproducing comprises means for providing a high-intensity light beam and means for controlling the dwell time of said beam on said medium in accordance with said electrical signal.

7. A combination according to claim 3 wherein said

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means for scanning comprises means for quantizing said elemental areas at discrete levels.

8. A combination according to claim 3 wherein said means for scanning produces a single dot-sequential signal representative of said image.

9. A process for reproducing an image on a medium with tonal appearance in a single tone, comprising:
 providing a light image of said image;
 dissecting said light image into elemental areas a portion of which carry a penumbral shadow;
 scan sensing said elemental areas in sequence to provide an electrical signal representative thereof; and
 removing a thickness of said medium in a scanning pattern in accordance with a predetermined threshold level of said electrical signal.

10. A system for reducing a tonal image to a representation thereof which is manifest on a medium in a single tone, comprising:

means for providing a light image of said image;
 means for dissecting said light image into a plurality of incremental areas with penumbral shadows;
 means for scanning said incremental areas in sequence to provide an electrical signal representative thereof;
 means for providing a beam of radiation in accordance with a predetermined level of amplitude of said electrical signal; and
 means for scanning said medium with said beam of radiation in accordance with said sequence to provide a representation thereon.

11. A system for reducing a tonal image to a represen-

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tation thereof which is manifest on a medium in a single tone, comprising:

providing a light image of said image;
 dissecting said light image into a plurality of incremental areas with penumbral shadows;
 scanning said incremental areas in sequence to provide an electrical representative thereof;
 providing a beam of radiation in accordance with the predetermined level of amplitude of said electrical signal; and
 scanning said medium with said beam of radiation in accordance with said sequence to provide a representation thereon.

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RICHARD MURRAY, Primary Examiner

H. W. BRITTON, Assistant Examiner

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