United States Patent [19]

Marks

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[54] **COMPOUND SCREEN FOR OBJECT SCREENING**

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[52] **U.S. Cl.** ..... **96/116;** 96/1 R; 96/45

[51] **Int. Cl.**[2] **G03F 5/00;** G03G 16/00

[58] **Field of Search** ..... 96/47, 116, 45, 1 R

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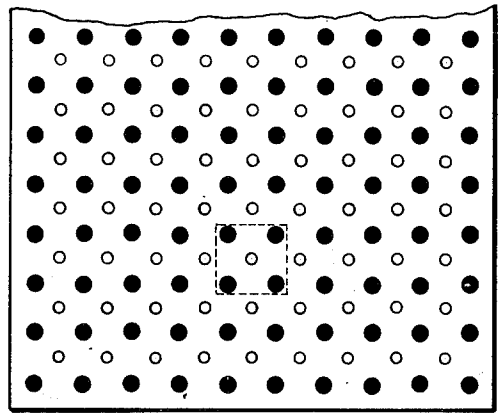
Primary Examiner—Norman G. Torchin

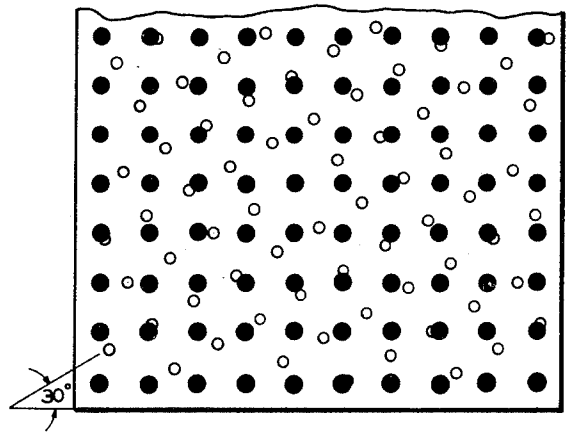
Assistant Examiner—Alfonso T. Suro Pico

[57] **ABSTRACT**

The present invention is directed towards a method for extending the range of high contrast electrophotographic imaging processes. This is accomplished by providing a compound document screen adapted to be used at the exposure station proximate to the image face of the document to be copied. The document screen consists of a clear transparent base member having a mixed dot pattern of substantially light absorbing dots and substantially light reflecting dots. The frequency of the like dots is such that the lens system employed in the electrophotographic process passes the fundamental spatial frequencies reflected from the screened original but attenuates the harmonic spatial frequencies. The developed image is found to consist of a plurality of halftone dots of varying sizes, the dot sizes varying in accordance with the screened output density reflected from the original document.

10 Claims, 4 Drawing Figures





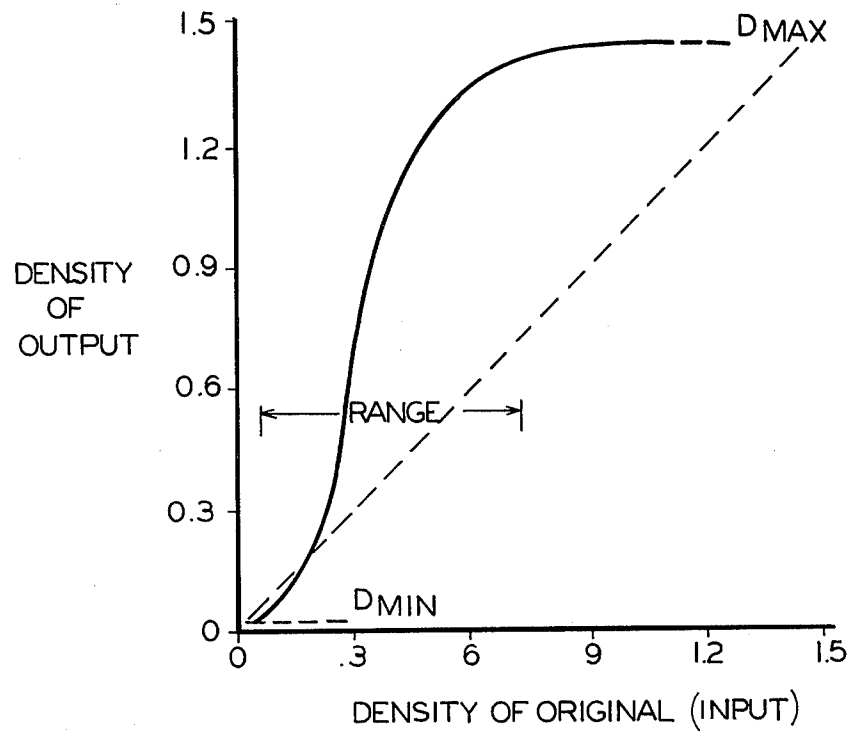

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DENSITY OF OUTPUT
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DENSITY OF ORIGINAL (INPUT)

FIG. 1

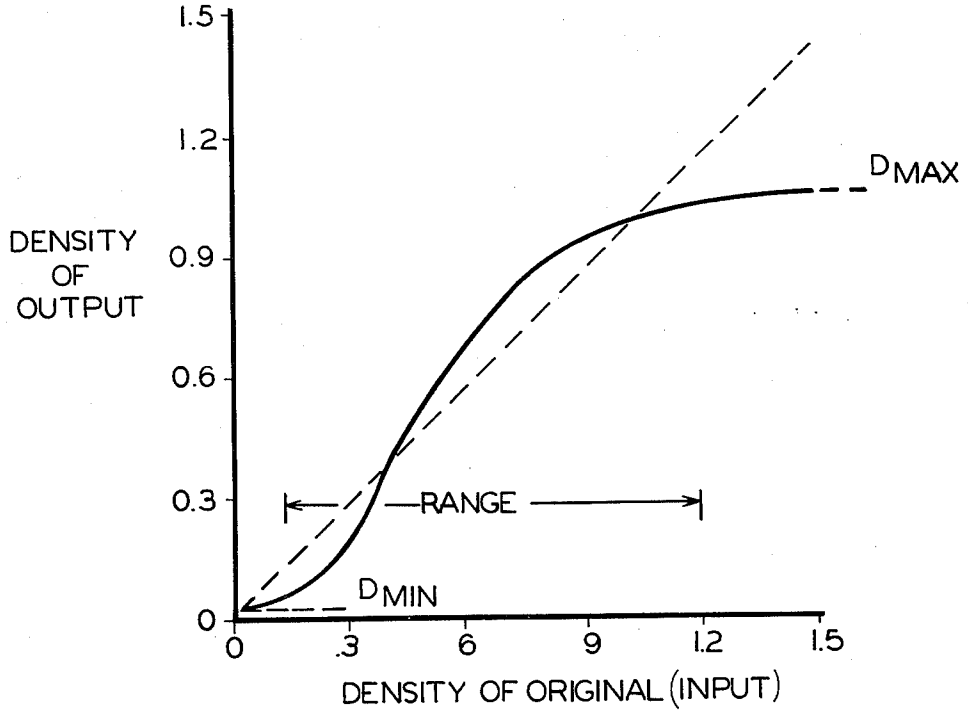

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DENSITY OF ORIGINAL (INPUT)

FIG. 2

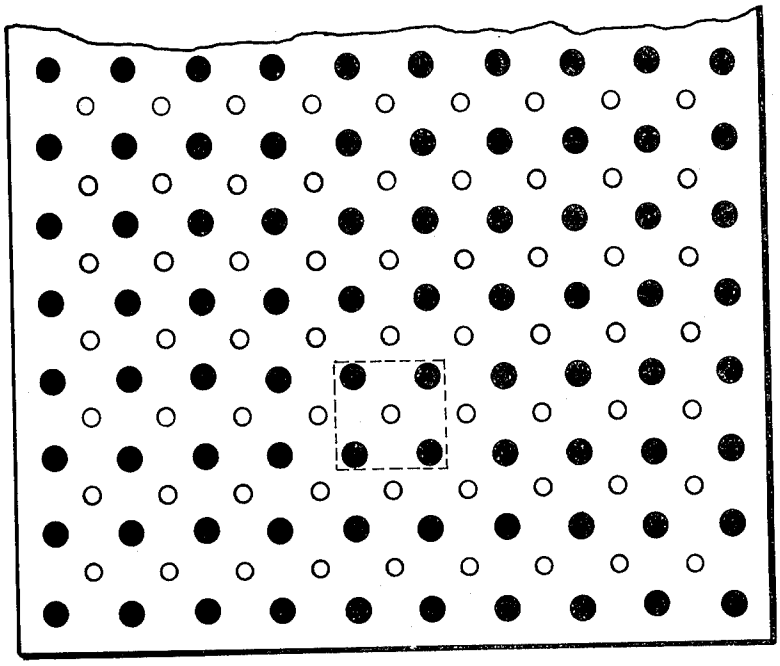


FIG. 3

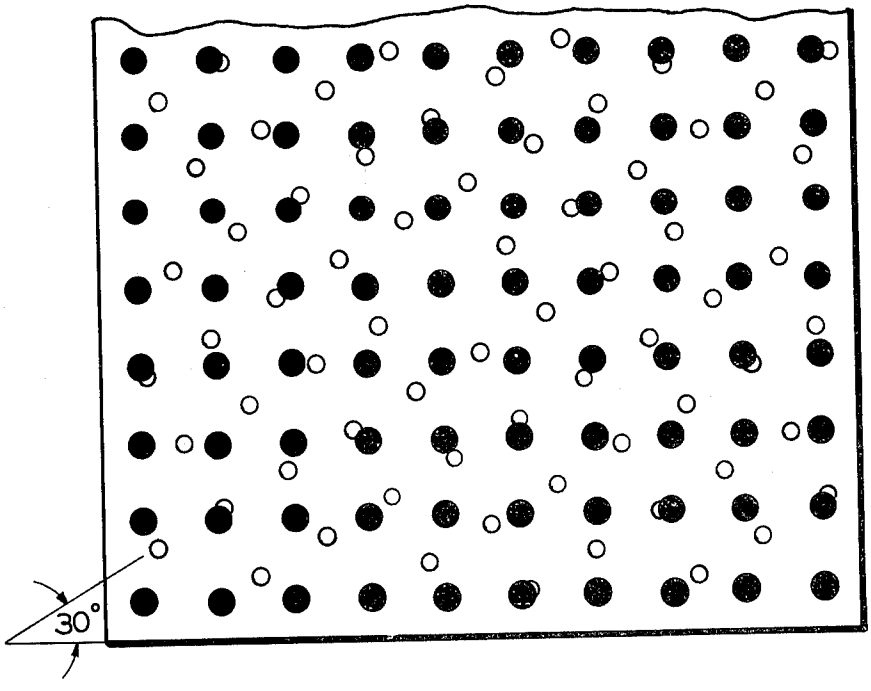


FIG. 4

COMPOUND SCREEN FOR OBJECT SCREENING

BACKGROUND OF THE INVENTION

The present invention relates to electrophotographic processes. More specifically, the present invention relates to halftone screening techniques for extending the range of relatively high contrast electrophotographic processes such as xerography.

In xerography, a special xerographic photoreceptor comprising a layer of photoconductive insulating material placed upon a conductive backing is used to support xerographic images. The photoreceptor may be formed in any shape. An image is formed by uniformly electrostatically charging the photoreceptive surface and then exposing it to a radiation pattern in the form of the image to be reproduced. This radiation selectively discharges areas of the photoreceptor forming an electrostatic charge pattern conforming to the radiation image. This radiation image is generally derived from an original document or other object which is illuminated and imaged on the photoreceptor through a lens.

The latent image on the photoconductive layer is then developed by contacting it with a finely divided electrostatically attractable material such as a resinous colored powder called a toner. The toner is held to the image areas by electrostatic charge fields on the layer. The toner is held proportionately to the charge field so that the greatest amount of material is deposited where the greatest charge field is located. Where there is a minimum charge there is little or no material deposited. Therefore, a toner image is produced to conform with the latent image previously placed on the photoreceptor. In reusable xerographic systems the toner is transferred to a sheet of paper or other support surface and suitably fixed thereto to form a permanent print. This fixing may take place by heat or vapor which fuses the toner to the support material to which it has been transferred.

The xerographic process produces excellent results for the reproduction of line copy, e.g., printed characters such as letters or numerals, but presents inherent difficulties where the copy to be reproduced comprises large solid dark areas of high density or a continuous tone image of varying density such as a photograph. At this point, a clear distinction is to be made between the problem of xerographic reproduction of dense solid areas of an original and accurate xerographic reproduction of density gradients in the highlight and shadow regions of continuous tone originals having areas of varying densities.

The former is a development problem associated primarily with an open cascade development system which problem has been largely overcome by employing specific development techniques or by altering the charge pattern present on large areas of contiguous charge on the photoreceptor, as hereinafter discussed. The latter is partially a development problem and partially a problem inherent in a high contrast and moderate range process such as xerography caused by the inability of a given photoreceptor to sense or appreciate, and consequently reproduce, small density gradients in the highlight and shadow areas of a continuous tone original such as a photograph. It is the solution of this latter problem by extending the range and improving the tone reproduction response of the xerographic process toward which the present invention is directed.

Various techniques have been proposed in the prior art to improve solid area cascade development in the xerographic process. Briefly, the problem of solid area development is due to electric field conditions in the regions of large contiguous areas of charge present on the photoreceptor. Xerographic development in these areas delineates only their outline, developing only in the areas where there is a differential in charge on the xerographic surface. Consequently, the centers of these areas of uniform high charge, being large solid areas of dark input, do not attract and hold xerographic toner, and thus appear white or very lightly toned on the transfer copy sheet.

Since the problem of solid area development is primarily associated with open cascade development systems, one solution to the problem has been the adoption of development techniques other than cascade such as the well known magnetic brush, powder cloud, or liquid development systems, or by the use of development electrodes as for example disclosed in U.S. Pat. No. **2,777,418** to Gundlach or U.S. Pat. No. **2,952,241** to Clark et al.

Another approach towards the solution of the problem of solid area development has been to break up the continuous charge pattern on the photoreceptor using mechanical, optical, or electrical techniques. For example, Carlson suggests in U.S. Pat. No. **2,599,542** that improved solid area coverage is obtained using an electrophotographic plate which has been etched to resemble a waffle-grid design, the depressions on the surface of which plate are filled with a photoconductive substance. Weigl in U.S. Pat. No. **3,248,216** teaches selective discharge of a charged electrostatic plate by contacting the plate with a conductive element such as a metallic gravure roller having a dot pattern provided by ridges or projections, followed by exposure of the semi-discharged plate to the image. Optical techniques for improving solid area coverage by breaking up the charge area on an electrophotographic plate involve exposing the plate after charging and prior to or subsequent to imaging to a screened light source. The screen may take the form of a line or comb screen or a grid or dot pattern. The plate is selectively discharged in those areas where the light passes through the screen but retains its charge in those areas blocked by the opaque areas in the screen. Examples of optical techniques for improving solid area coverage may be found in U.S. Pat. Nos. **2,598,732, 3,121,010, 3,212,888, 3,335,003,** and **3,535,036.**

The use of screens consisting of alternating opaque and transparent areas positioned between the object to be imaged and the photoreceptor has also been suggested in the prior art as a means for breaking up solid area images to allow uniform development. For example, Pendry in U.S. Pat. No. **3,152,528** teaches a document screen adapted to be superimposed over the document to be copied between the document and the lens system of a xerographic copy machine. The screen comprises a transparent base material having printed thereon a plurality of opaque dots or lines which serve to break up any dark or continuous tone areas present on the document to be copied. Typical of such screens, which have been in commercial use for the past several years, are those consisting of a pattern of reflecting dots on a transparent substrate. These dots cover about **30** percent of the area of the screen and are arranged

in a square array with a frequency of about 60–65 dots per inch.

Because of the improved solid area coverage in xerographic copies achieved by the above techniques in shadow and middle tone areas of an original such as a continuous tone photograph, the casual observer is impressed that the process has been sensitized to the point where it can "see" and consequently reproduce not only solid areas but also density gradients in the middle tone areas of the original. However, the use of such mechanical, electrical or optical discharge techniques, or of reflecting document screens wherein the opaque patterns of the screen appear faithfully reproduced on the solid areas of output copy, does not serve to extend the range of the process; that is, small density gradients in the highlight and shadow areas of the original are not shown as concomitant changes in density in the copy. Furthermore, the density of the toned areas of the copy is necessarily less than the maximum density achievable in the process because of the intermittent areas of discharge of the xerographic plate evidenced by small intermittent white areas in the copy.

The range of an electrophotographic system is usually defined in terms of the input exposures over which changes in output density can be observed. Range can be shown graphically using a tone reproduction curve (TRC) wherein input density expressed in terms of log $_{10}$ (100/Ro) is plotted against output density expressed in terms of log $_{10}$ (100/Rc), where Ro is the percent reflectivity of the original and Rc is the percent reflectivity of the copy. Thus, where the reflectivity approaches 100 percent (white areas), the density approaches 0 ($\log_{10}$ 100/100=0); where the reflectivity decreases, (black areas), the density increases. For example, at 10 percent reflectivity, the density is 1; at 1 percent reflectivity, the density is 2. A typical TRC of solid area xerography embodying a selenium photoreceptor plotted over a plurality of input densities is shown as the solid curve in FIG. 1. For the purposes of the present invention, the range is defined as the density differential on the abscissa axis between points where the slope of the S-shaped TRC is 0.5. The range of the system shown in FIG. 1 is about 0.6.

The TRC in FIG. 1 illustrates clearly why normal xerographic systems have a limited capability in reproducing pictorial originals. Opaque photographs typically have a density range in the order of about 1.5 (D max = 1.6: D min = 0.1) and simply cannot be accurately reproduced by a system with a range of 0.6. Varying the exposure above or below the point where the minimum output density occurs for an input density of zero serves merely to shift the TRC with no range extension and at the cost of sacrificing shadow or highlight information. In fact, range extension can be achieved only by "flattening" the TRC curve to approach as nearly as possible the dotted straight line of FIG. 1 which represents the optimum faithful reproduction of all densities.

Accordingly, it is an object of the present invention to provide a simple and economical means for improving the range capabilities of high contrast and moderate or low range electrophotographic processes.

A more specific object is to extend the range of input densities transmitted or reflected from an original document over which there is a change of output density in a copy made using a high contrast electrophotographic process such as xerography.

SUMMARY OF THE INVENTION

The foregoing and other objects of the invention are realized by providing a half tone compound document screen to be used proximate to an original document to be copied at the exposure station in an electrophotographic process. The halftone screen is constructed of a clear transparent substrate material having on at least one surface thereof a plurality of substantially opaque dots of uniform density, and is adapted to be positioned proximate to, preferably in contact with, the face of the document to be copied between the document face and lens system employed in the electrophotographic system. The dots present on the screen comprise a mixed or compound dot pattern of a plurality of substantially light-absorbing dots and a plurality of substantially light-reflecting dots. The frequency and array of these dots is such that light reflected by the screened original is modulated by the lens in accordance with the Modulation Transfer Function of the particular lens system employed such that the lens passes the fundamental spatial frequencies in the pattern and attenuates the harmonic spatial frequencies in the pattern. Spatial modulation of a continuous tone image on an original document by screening according to the present invention gives rise to an area modulated pattern of halftone dots in the copy. The copy image of a continuous tone black and white original is found to consist of a plurality of black halftone dots of varying sizes, the sizes of these dots varying in accordance with the screened output density in various areas of the original. Accordingly, minute changes in density in all areas of the original document, including highlight and shadow areas, are accurately recorded as minute changes in halftone dot size, thereby conveying the impression of accurate electrophotographic reproduction of density gradients and effectively extending the range of the electrophotographic process, as well as providing for solid area coverage.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a tone reproduction curve for a typical xerographic system embodying a selenium photoreceptor.

FIG. 2 is a tone reproduction curve for a xerographic system employing a selenium photoreceptor and embodying a document screen according to the present invention.

FIG. 3 is an enlarged view of a small area of suitable compound screen pattern of absorbing and reflecting opaque dots on a transparent substrate arranged in a body centered pattern.

FIG. 4 is an enlarged view of a small area of a compound transparent screen comprising a first screen containing absorbing opaque dots superimposed over a second screen containing reflecting dots arranged at a suitable angle to achieve randomization of the dot pattern.

DETAILED DESCRIPTION OF THE INVENTION

As indicated above, the present invention involves specific halftone screening techniques to extend the range of high contrast electrophotographic processes. The invention is specifically described as applied to the xerographic process but it should be understood that it is equally applicable to any electrophotographic process involving projection through a lens of an image reflected from a colored or black and white original doc-

ument onto a photosensitive member, such as the photoelectrophoretic process exemplified in U.S. Pat. No. **3,384,556,** the manifold imaging process exemplified in U.S. Pat. No. **3,707,368** and like processes.

The halftone screen used in the present invention comprises clear transparent support material having on at least one surface thereof a mixed dot pattern of appropriate frequency comprising a plurality of substantially opaque dots of uniform density, some of which dots are substantially light-absorbing and others of which are substantially light-reflecting. The term "dots" as used herein is intended not only to encompass dots in the classical sense such as the circular shapes depicted in FIGS. **3** and **4,** but also is intended to encompass areas of uniform density forming other geometrical shapes such as elipses, squares, triangles or polygons in general, inasmuch as any of these shapes proves operable in the present invention. The opacity of the dots should be sufficient to optically block out from the photosensitive member white or denser image information, or colored image information, contained on those areas of an original over which the dots are superimposed. The substantially light-absorbing dots, hereafter referred to as black dots, should be of such a density as to absorb more light of all wavelengths than is reflected. Conversely, the substantially light-reflecting dots, hereafter referred to as white dots, should be of such a density as to reflect more light of all wavelengths than is absorbed. Best results, in terms of range extension, are obtained where the black dots are at least **80** percent absorbing and the white dots at least **80** percent reflecting, with optimum results achieved as both values approach **100** percent. The base material supporting the dot patterns may comprise any clear transparent material such as glass or plastic. Clear films made from plastics, such as polyesters, methacrylate polymers or vinyl halide polymers and having a thickness of less than about **100** mils, are especially preferred because such screens can be used with both flat and curved platen electrophotographic machinery.

The frequency of the screen dot pattern is defined for the purposes of the present invention in terms of the average period of like dots present on a given linear or area measurement of screen surface. By the term "like dots" is meant dots of similar reflectivity or absorbancy, i.e., white dots or black dots. Frequency is the reciprocal of the average period of like dots and can be defined by the equation: $f = 1/P$, where P equals the average distance between the geometrical center of one like dot and its closest like dot neighbor of the total like dot population per linear or area measurement of screen surface. Thus, a screen having a like dot inch frequency of about **100,** or the equivalent like dot millimeter frequency of about **4,** would be a screen where the average distance between like dots present in **1** linear inch or linear millimeter, or **1** square inch or square millimeter where the dots are not in rectilinear array, would be about **0.01** inch or about **0.25** millimeter respectively.

As pointed out above, the frequency and array of the dot pattern present on the screen is determined by the frequency response function, specifically, the Modulation Transfer Function (MTF), of the particular lens system employed in the electrophotographic process. The relationship between spatial frequency and optical response function is discussed, inter alia, in "Optics: A Short Course for Engineers and Scientists," Charles S. Williams and Orville A. Becklund, John Wiley and Sons, New York, N.Y., **1972,** at pages **215** through **228.** For a given lens system MTF, the frequency of the dot pattern is too low if the dot pattern is accurately imaged by a properly focused lens, for in this case the aerial image of the dot pattern would be a square wave which according to conventional Fourier analysis comprises sine waves at the fundamental dot pattern frequency and many higher harmonics. Such a square wave aerial image produces only a single dot size on the photosensitive member rather than a variety of dot sizes for different input densities. Conversely, the frequency of the dot pattern is too high if the dot pattern is completely smeared by the lens, since in this case resolution of the dot pattern would be completely lost giving an unmodulated image and producing no dot pattern whatever on the photosensitive member. Lens systems common employed in most electrophotographic processes and in commercially available xerographic equipment begin to exhibit the desired modulation at a spatial like dot millimeter frequency of about **2,** or a like dot inch frequency of about **50,** and modulation may be lost completely at like dot millimeter frequencies ranging anywhere from about **6** to about **16,** or like dot inch frequencies of approximately **150** to **400,** depending on the quality of the lens. Thus, for the purposes of the present invention, halftone compound screens having a like dot inch frequency within the range of about **50** to **400** are generally suitable. Specifically, the MTF of lens systems commonly used in the xerographic process or in xerographic equipment is such that compound screens having a uniform like dot inch frequency within the range of about **70** to **150** are sufficient for appropriate image modulation such that the lens will pass the fundamental spatial frequencies and attenuate the harmonic spatial frequencies.

The fundamental and harmonic frequencies of the screen dot pattern mentioned above refer to the frequencies of sine waves required to synthesize the reflectivity patterns of like dots within the screen according to conventional Fourier analysis. Within the scope of this invention it should be appreciated that like dots may be positioned in any regular array or may occupy random positions with respect to other like dots. Examples of the regular array would be square, triangular, or hexagonal lattices, with the fundamental screen frequency defined by the basic periodicity of the array of like dots. The frequency is given by $f = 1/p$ where p is the average distance between like dots per rectilinear measurement of screen surface. In the random case, the fundamental frequency is substantially that defined where p is the average distance between on like dot and its closest like dot neighbor in the random array per area of screen surface. Although the like dots may occupy completely random positions in the random array, it has been found to be advantageous for like dots not to overlap. It should also be pointed out that it is not necessary that the frequency of the white dot pattern be identical to the frequency of the black dot pattern, nor is it necessary for the frequency to be uniform on all areas of screen surface, so long as the frequency of each like dot pattern is sufficient to achieve appropriate modulation within the modulation or frequency parameters specified above.

One embodiment of dot array is the body centered regular pattern shown in FIG. **3** which consists of a plu-

rality of square arrays of like dots surrounding a centrally positioned different dot. The square array in FIG. 3 is depicted in the area encompassed by the dot line which shows four black dots in square array with a white dot positioned at the intersection of black dot diagonals. Of course, the array may be equally described at another area as four white dots in a square array surrounding a centrally positioned black dot. Assuming the like dot inch frequency of the black and white dots of the compound screen of FIG. 3 to be **100**, this means for the purposes of the present invention that there is a repetitive two dimensional pattern of **100** black dots along each of two mutually perpendicular rectilinearly directed imaginary lines one inch long encompassing a common end dot and **100** white dots along each of two mutually perpendicular different rectilinearly directed imaginary lines also **1** inch long and encompassing a common end dot. Thus, **1** square inch of compound screen surface with a body centered like dot inch frequency of **100** would contain approximately **10,000** black dots and **10,000** white dots.

Although the body centered pattern of FIG. 3 is very desirable in terms of dot pattern spatial array, it is often a tedious and relatively expensive matter to prepare screens where the body centered pattern can be accurately reproduced throughout a large screen area, particularly a higher screen frequencies. Improper registration of the body centered pattern at various areas of the screen can give rise to an undesirable moire pattern which adversely affects the modulation of the dot pattern. Accordingly, a simpler realization of the compound screen is a random mixed dot pattern which may be achieved by orientating a black dot and white dot linear array at a suitable angle to achieve randomization and minimize moire. This is best accomplished by orientating a regular linear array of white dots at a suitable angle, such as about **30°** or about **60°**, with respect to a regular linear array of black dots. In this type of array, the relative spacing of black and white dots is not uniform as in the body centered pattern and, in fact, at various areas of screen surface some of the black and white dots will overlap. An example of a dot pattern formed by superimposing a linear black dot screen over a linear white dot screen orientated at an angle of **30°** is shown in FIG. **4.** As in the case of compound screens having a body centered pattern, the inch frequency of like dots in the orientated array should be within the range of about **50** to **400** for best results.

The mixed dot pattern forming the compound screen serves to extend the range of the electrophotographic process in both the highlight and shadow areas of a continuous tone original document, with the black dots modulating in the highlight areas of the original and the white dots modulating in the shadow areas of the original. Thus, the degree of range extension achieved in the highlight or shadow areas is controlled within certain limits as a function of the relative surface area of the compound screen containing black dots and white dots respectively. For example, a half-tone document screen of regular array and appropriate frequency, e.g., **100** dots per inch, consisting solely of black opaque dots covering about **30** percent of the screen surface was evaluated in the xerographic process using a black and white continuous tone photograph as the original document. After adjusting exposure to compensate for additional light absorption caused by the screen, it was found that range extension in the copy has been achieved only in the highlight areas of the original document, i.e., the low density end of the tone reproduction curve. Similarly, a half tone document screen consisting solely of white substantially opaque dots with a frequency of **100** dots per inch and coverage of about **30** percent gave range extension in the shadow areas of the original, i.e., the high density end of the TRC. It is thus evident, that with the mixed black and white dot patterns of the present invention, the dots of each gray scale color operate independently to achieve range extension at both ends of the TRC, thereby flattening the curve to more nearly approximate the ideal TRC represented by the dotted lines in FIGS. **1** and **2.** FIG. **2** depicts such a flattened curve. Note that the range has been extended to about **1.1** as opposed to the range of about **0.6** shown in FIG. **1.**

The relative proportion of the area of the compound screen covered by black or white dots may vary as a factor of the type of electrophotographic process in which the screen is to be used, the nature of the particular continuous tone document to be copied, and exposure limitations in the electrophotographic process. In general, it has been found that desirable results in terms of range extension in the xerographic process have been achieved using compound screens having from about **2** percent up to about **65** percent opaque area coverage, **1** to **64** percent of which opaque area coverage is provided by either black or white dots. As the black dot area increases above **1** percent, additional exposure in the form of increased document illumination or longer exposure time of the screened document is necessary to compensate for the absorbance of the screen. As the white dot area is increased above **1** percent, there is a corresponding lowering of the maximum output density in solid or dense areas of the copy. Thus, the composition of a screen to suit a particular process, apparatus or category of document may require some trial and error work within the parameters specified above on the part of the technician to achieve optimum results in terms of range extension.

For pictorial reproduction via the xerographic mode, screens having about **40** percent total opaque dot coverage, composed of about **30** percent black dots and **10** percent white dots have been found to be most satisfactory. Use of such a document screen requires approximately double the unscreened exposure to achieve accurate xerographic reproduction of the original. Where such a screen is to be used as a document screen with commercially available xerographic equipment, it may be necessary in some cases to modify the equipment to increase the exposure twofold either by providing additional exposure lamps, by using exposure lamps of higher lumen values, by slowing down the equipment to provide a longer exposure time of the document to the photosensitive member, or by combinations of these.

The halftone screen is designed for use proximate the original document at the exposure station in an electrophotographic process. By the term "proximate" is meant that the screen is used positioned either in direct contact with the image face of the original document or at a distance away from the image face within the focal capabilities of the lens, usually not greater than about one-fourth inch.

The compound screens of the present invention may be fabricated by printing, etching, dye transfer, photographic processes or other well-known techniques which are employed to prepare analogous screens used

in the graphic arts. The simplest and most effective procedure is to print directly onto the clear transparent base member by offset printing techniques using opaque black or white inks or pigments to provide the desired black and white dot patterns. The total percentage of opaque area coverage at a given frequency for a given area of screen may be established by controlling the size of the dots printed on the screens, i.e., the larger the fixed frequency dot size, the greater the area of dot coverage. The relative proportion of black and white dot area coverage can be controlled in the same manner. For example, to print a compound screen having a like dot inch frequency of about **100**, or a like dot millimeter frequency of about **4**, with a total opaque dot area coverage of **40** percent consisting of **20** percent black dots and **20** percent white dots, simple calculations indicate that each of the approximately **16** black and **16** white dots per square millimeter should be printed to occupy an area of about **0.0125** square millimeters per dot. To print a similar screen where the black dots account for about **30** percent screen opacity and the white dots account for about **10** percent screen opacity, each of the **16** black dots should be printed to occupy an area of about **0.019** square millimeters and each of the **16** white dots should be printed to occupy an area of about **0.006** square millimeters.

Compound screens having the body centered dot pattern similar to that shown in FIG. **3** may be printed on a clear transparent substrate by first applying dots of ink of one color to one side of the substrate, and subsequently applying dots of ink of the other color in proper spatial array to the same or opposite side of the substrate. alternatively, the body centered compound screen pattern may be provided by two separate sheets or layers of substrate with white dots printed on one sheet and black dots printed on the other sheet such that when the two sheets are superimposed and fixed in place, the body centered pattern of FIG. **3** is evident. The oriented compound screen pattern of FIG. **4** may be printed in a similar fashion by first printing dots of one color on one side of the substrate and subsequently printing dots of the other color on the same or opposite side of the substrate, care being taken to insure that the latter dots are printed orientated at suitable linear angles to minimize moire, e.g., angles of **30°** or **60°**, with respect to the former dots. With this technique, no specific care need be taken with regard to the relative spatial array between black and white dots. Alternatively, the black and white dots may be printed on separate sheets, and a compound screen formed by superimposing and orientating these sheets at appropriate linear dot angles, e.g., **30°** or **60°**. The laminated sheets may then be fixed in place such that relative movement of the sheets is prevented, followed by trimming to the desired screen dimensions.

As previously indicated, the compound half tone screen of the present invention is suitable for use in any electrophotographic imaging process, both color and black and white, and designed to be positioned proximate to, preferably adjacent and in substantial contact with, the image face of the original to be copied, and between the original and lens system employed in the electrophotographic process. The compound screens are particularly adapted to the xerographic process as half tone document screens used in contact with the image face of an opaque, colored or black and white original document such as a continuous tone photograph. Light illuminating the original passes through the transparent areas of the screen and is selectively reflected or absorbed by the opaque dot areas of the screen. The pattern of light reflected by the screened original is passed through a lens system and focused on a charged photoconductive plate. This spatial modulation of a continuous tone image on an original document gives rise, after xerographic development of the latent image formed on the plate, to an area modulated pattern of half-tone dots in the copy, said dots varying in size as a function of the screened output density in various areas of the original. In a black and white process, these dots are black; in a color process, these dots would be of appropriate color.

The dimensions of the compound screen should be sufficient to cover either the entire image area of the document or selective pictorial areas of the document. Thus, an **8 ½ × 11** inches opaque original photograph requires an **8 ½** inches by **11** inch compound screen. Other originals containing both pictorial and line copy require screens of dimensions sufficient to cover the pictorial copy only. When used with commercial xerographic equipment, the compound screen is simply positioned at the platen or exposure station and the original document placed over it. If desired, the glass platen of a xerographic apparatus may itself constitute the screen, having the appropriate dot pattern directly affixed thereto.

While the invention has been described with reference to the structure disclosed herein, it is not confined to the specific embodiment set forth, and this application is intended to cover such operative modifications or changes as may come within the scope of the following claims.

What is claimed is:

1. A compound document screen for extending the range of electrophotographic imaging processes and adapted for use proximate to the image face of an original document to be copied, said compound screen comprising:

a clear transparent substrate material having clear areas and bearing opaque areas;

said opaque areas comprising a repetitive pattern of substantially opaque mixed dots comprising substantially light absorbing like dots and substantially light reflecting like dots;

said like dots arranged with respect to other like dots at an average like dot inch frequency within the range of from about **50** to **400** dots.

2. The compound screen of claim **1** wherein the substrate material comprises a single sheet of clear transparent material having the substantially light absorbing like dots affixed to one side of said sheet and the substantially light reflecting like dots affixed to the same or opposite side of said sheet.

3. The compound screen of claim **1** wherein the substrate material comprises two superimposed sheets of clear transparent material having the substantially light absorbing like dots affixed to one of said superimposed sheets and the substantially light reflecting like dots affixed to the other of said sheets.

4. The compound screen of claim **1** wherein each of said like dot patterns is of substantially uniform frequency, like dots being arranged along generally rectilinearly directed lines with respect to other like dots.

5. The compound screen of claim **4** wherein said mixed dots are arranged in a body centered pattern.

6. The compound screen of claim 4 wherein the rectilinear arrays of substantially light absorbing like dots are disposed at an angle with respect to the rectilinear arrays of substantially light reflecting like dots, said angle being appropriate to minimize moire and provide optimum randomization of the mixed dot pattern.

7. The compound screen of claim 4 wherein the uniform like dot inch frequency is within the range of about 70 to 150.

8. The compound screen of claim 1 wherein said repetitive pattern of substantially opaque mixed dots occupies from about 2 to about 65 percent of the image area of the compound screen, said substantially light absorbing like dots constituting from about 1 to about 64 percent of said image area and said substantially light reflecting like dots correspondingly constituting from about 64 to about 1 percent of said image area.

9. The compound screen of claim 8 wherein the like dot inch frequency is within the range of about 70 to about 150.

10. The compound screen of claim 9 wherein the substantially light absorbing like dots constitute about 30 percent of said image area and said substantially light reflecting like dots constitute about 10 percent of said image area.

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