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SECURITY DOCUMENT MANUFACTURING METHOD USING HALFTONE DOTS THAT CONTAIN MICROSCOPIC IMAGES

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By

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Assigned To

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TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT I, Huver Hu, have invented a new and useful security document manufacturing method using halftone dots that contain microscopic images of which the following is a specification:

SECURITY DOCUMENT MANUFACTURING METHOD USING HALFTONE DOTS THAT CONTAIN MICROSCOPIC IMAGES

REFERENCES:

PUBLICATIONS CITED

1. PostScript Language Reference Manual, 2nd Ed., Adobe Systems Inc., Addison-Wesley, Reading, Massachusetts, 1990.

2. PostScript Language Supplement, Language Level 3 Specification and Adobe PostScript 3 Version 3010 Product Supplement, Adobe Systems Inc., San Jose, California, 1997.

3. PostScript Screening: Adobe Accurate Screens, Peter Fink, Adobe Press, Mountain View, California, 1992.

4. Fundamentals of Interactive Computer Graphics, Foley and Van Dam, Addison-Wesley, Reading, Massachusetts, 1982.

5. Anti-Counterfeiting Features of Artistic Screening, V. Ostromoukhov, N. Rudaz, Amidror, P. Emmel, R.D. Hersch; Int. Symposium on Advanced Imaging and Network Technologies, Conf. Holographic and Diffractive Techniques, October 1996, Berlin, SPIE Vol. 2951, 126-133.

6. MECCA III Integrated Electronic Publishing System User's Guide, Vol 1-4, Amgraf, Inc., Kansas City, MO, 1997.

U.S. PATENT DOCUMENTS CITED

5,166,809	11/1992	Surbrook	358/456
4,227,720	10/1980	Mowry, et al.	283/094
5,788,285	08/1998	Wicker	283/093
5,853,197	12/1998	Mowry, et al.	283/093
5,340,159	08/1994	Mowry	283/093
5,710,636	01/1998	Curry	358/298
6,198,545	03/2001	Ostromoukhov, et al.	358/459
4,600,666	07/1986	Zink	430/006

ABSTRACT OF THE DISCLOSURE

The inventive device includes a method to capture any user-selected image such as a corporate logo, a photograph, or a key word or phrase, and to convert that image into a microscopic halftone dot with tonal variation features (referred to as "logodots"), and to allow the use of these "logodots" as a substitution for conventional square, round, elliptical, diamond and/or other shaped dots typically used in normal commercial printing. Through this invention, all or selected graphical elements of a printed image can be rendered in "logodots" that can be verified with a magnifying device. When compared to conventional halftone dots, “logodots” are much more difficult to faithfully copy using commercial photocopiers and scanners, resulting in pronounced “streaking” patterns in the resultant copy. When a security document design is made that consists of a combination of areas rendered with "logodots" adjacent to areas that are rendered with conventional halftone dots, these apparently slight differences become more prominent. This phenomenon provides an economical method for the commercial manufacture of printed security documents that are self-canceling when they are photocopied and/or scanned. Through this invention an economical, graphical manufacturing technique is provided for printing security documents such as checks, certificates, transcripts, and other objects having monetary or intrinsic value.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to user-definable custom halftone dots (hereinafter referred to as "logodots"), for use in the manufacturing of printed materials and more specifically it relates to a printing technique using microscopic images for providing an economical, graphical method to create and manufacture security documents such as checks, certificates, transcripts, and other objects having monetary or intrinsic value.

Description of the Prior Art

It can be appreciated that halftone screening dots have been in use for years to enable the printing of continuous tone images. To print various tones of color on paper with printing presses and ink or toner, the area of color must be converted to halftone dots (or lines) of an appropriate radius or thickness, with the (normally white) base paper (or other substrate) color showing through. Close examination of almost any commercially printed document will reveal these halftone dots. The inventors of halftone screening have strived to develop methods to generate halftone dots that are free from artifacts, and that render printed images which are as faithful as possible to the original continuous tone (unscreened) models, and do so under the most extreme printing environments on the widest range of substrates. Typically, conventional halftone dots are shaped as solid squares, filled circles or ellipses, filled diamond shapes, and/or solid lines, and they are used to print everything from newspapers and magazines to elaborate security documents such as checks and certificates.

Within established practices of printing halftone images on bi-level digital imaging devices, two common techniques exist: halftone dot, and dither matrix (or dither array). The invention described herein is based on the use of the halftone dot, where a spot cell of some number of pixels is used. For printing densities between 0% (all pixels white) and 100% (all pixels black), the pixels in the cell are to "turn on" (set as black), such that more and more "black pixels" appear as the density value progresses toward 100%. Examples of this technique are shown in U.S. Patent No. 5,166,809. One such established practice is exemplified by PostScript (references [1-3]), a Page Description Language developed by Adobe Systems Incorporated located in San Jose, California. PostScript uses the Euclidian composite dot spot function as detailed in reference [3]. PostScript is commonly utilized in the graphic arts industry for creating printable images, master films, negatives, and the printing plates used with conventional and digital printing presses.

In the past, there have been several patented techniques describing methods to utilize conventional halftone dots to manufacture and print documents that are graphically resistant to counterfeiting with photocopiers, digital scanners, and desktop publishing equipment. These techniques are based on the fact that the human eye is less sensitive than optical machines to small variations in the color density of printed areas on a paper (or other similar substrate) document. The human eye does not detect these slight variations whereas the optical scanner or photocopier does. The variations tend to become much more pronounced in the copy or reproduction, and ruin the evenness of the image. By designing a security document with a camouflage background image that consists of certain areas having one variation in tone, and other foreground areas (often a cancellation phrase or warning word such as "VOID") having a slightly different tone, the copy or reproduction becomes obvious.

The graphical halftone screen anti-counterfeiting techniques used in the past have consisted of tone variations including "big dots and little dots" as shown in U.S. Patent No. 4,227,720, "dotted lines and solid lines" as shown in U.S. Patent No. 5,788,285, juxtapositions of dot screens and line screens at varying angles as shown in U.S. Patent No. 5,853,197, and graduated tone dot screens (from light to dark) in both background and foreground as shown in U.S. Patent No. 5,340,159.

The problem with using only conventional halftone dots for security documents today is that scanning and photocopying equipment have improved, especially in the case of color copiers, and subtle tone variations are no longer as effective. New color copiers compensate for these subtle variations with remarkable results, producing near-perfect copies that cannot easily be identified as copies.

An effective technique to add graphical security to a printed document is known as "microtext", whereby words or phrases are printed in very small letterforms that can barely be perceived with the naked eye. These tiny letters are too small to be accurately copied by most of the available scanners and photocopiers. The resulting copy yields a "blot" instead of a legible letterform, and a string of letters or words often copy as a fuzzy line.

Although microtext is a valuable technique for document validation, there are some problems to consider. The person doing the document validation must know where on the document to look for microtext, and a magnifying glass or printer's loupe of 8X or higher power must be available to examine the document. In addition, when creating the document containing microtext, each letterform in a microtext string is treated as an individual graphical element that must be processed by a Raster Image Processor (RIP) or other character forming technique, then that subset of the composite image reduced to halftone dots. The processing overhead to compose and output large quantities of microtext can be a significant and time-consuming.

Inserting a human readable pattern within a halftone cell is the invention described by Curry in U.S. Patent No. 5,710,636, however, the method, application, flexibility, extensibility, and end result differ substantially from the invention described herein. Curry describes a specially stylized set of halftone cells consisting of segments of letterforms, that when positioned and rotated like “building blocks”, create hidden messages within a toned area.

The invention described herein also differs substantially from other published digital image half-toning techniques that apply only to raster bitmaps. One such invention is described in U.S. Patent No. 6,198,545 and "Artistic Screening" (see references), wherein a halftone image is analyzed, and density variations then replaced by pre-designed screen elements, or replaced by new in-between element shapes computed by interpolating between the two nearest known replacement shapes. With “Artistic Screening”, the composite image is screened in one pass, and the entire image as a whole is treated as a single grayscale raster bitmap. The screening process applies universally to the entire composite, or to selected masked areas that are also grayscale raster bitmaps. Similar digital image filtering effects are found in many desktop publishing photographic editing programs such as Adobe System’s Photoshop software. In addition to these digital techniques, mechanical film-based optical filters and contact screens as described in U.S. Patent No. 4,600,666 have been utilized for many years to achieve the same end result, again applying one half-toning effect to an entire composite image.

In contrast, the “logodot” created through the invention described herein is functionally no different from conventional printing dots, therefore it can be readily used for any graphical element, such as lines, areas, and textual typefaces, not just grayscale raster bitmaps. Different graphical elements within a composite image can be assigned to different “logodots”. Furthermore, once a graphical element within a composite image is assigned a “logodot”, it can be printed at any size, for any fixed density or a range of densities, at any desired screen angle, at many coarse-to-fine line frequencies, without re-computation as required by other techniques.

Although not all user-selected images can be used to construct a halftone dot that performs well throughout the full density range, there usually is a limited range where the custom dot is acceptable. The invented methods provide the capability for well-chosen bitmaps containing finely detailed pixel formations to be printed with high resolution devices so that photocopying or optical scanning machines would not be able to resolve the microscopic details. The loss of fidelity that occurs during the copying (or scanning) process is one basis for the security benefit of the present invention.

Also, a mixture of “logodots” or custom and standard halftone dots can be used together within a composite image, and when their densities are set to similar gray levels, the human visual perception blends them together and gives the perception of a uniform density spread. However, when sampled (seen) by a photocopier or scanner, the custom dots "pop out" resulting in a lighter or darker gray (or color) value being rendered. This provides a cost-effective way to "embed" hidden warnings, phrases, images, logos or other graphical elements to self-cancel the counterfeit copy.

There are many non-graphical techniques to incorporate security into a printed document, however, these usually contribute substantial added expense to the manufacturing process. Some of the most common protective techniques are to use special inks (e.g. fluorescent), special papers (e.g. embedded filaments), chemical additives (e.g. magnetic or thermochromic reactive coatings), affixed devices (e.g. holograms), pre-treatments such as watermarks, and post treatments such as embossing. While there are compelling reasons to utilize many of these techniques, the addition of security features via purely graphical techniques can be done much more economically, without a major change in the traditional print manufacturing processes. Although non-graphical techniques and devices may be suitable for the particular purpose to which they address, they are not as suitable for providing an economical, graphical method to create and manufacture security documents.

In these respects, the security document manufacturing method using microscopic images embedded in halftone dots, according to the present invention, substantially departs from the conventional concepts and designs of the prior art, and in so doing presents an apparatus that includes an economical, graphical method to create and manufacture security documents such as checks, certificates, transcripts, and other documents having monetary or intrinsic value.

SUMMARY OF THE INVENTION

The general purpose of the present invention, which will be described subsequently in greater detail, is to provide a new security document manufacturing method using custom halftone dots (“logodots”) that contain microscopic images that are inserted during the document’s or printed object’s creation and/or composition. In view of the foregoing disadvantages inherent in the known types and uses of conventional halftone dots now present in the prior art, the present invention describes a new manufacturing method that can be used as an economical, graphical alternative to create and print security documents such as checks, certificates, transcripts, and other documents having monetary or intrinsic value.

The invention has many of the advantages of the prior art mentioned heretofore, and many novel features, that result in a new security document manufacturing method which is not anticipated, rendered obvious, suggested, or even implied by any of the prior art of employing conventional halftone dots, either alone or in any combination thereof.

This invention describes (a) a method to digitally capture any user-selected image such as a corporate logo, a photograph, or a key word or phrase, and to convert that image into a microscopic “logodot”, and in doing so specify the white-to-black transition characteristics (illumination ranking) of the “logodot” so that it can be utilized by conventional printing devices to represent graphical images with halftone densities ranging smoothly from zero to 100%, (b) a method to automatically generate printing device-specific instructions to output the “logodot” as a suitable substitute for conventional halftone dots, and (c) a method to save various collections of custom dot designs as libraries, and (d) a method to refer to custom dots by name and assign the “logodot” to any graphical element within a composite image or graphical design, and (e) a method to utilize the above invention for the protection of security documents (or other printed objects) by causing a replication to be visually obvious and/or self-canceling.

The present invention generally comprises a method to capture any user-selected image such as a corporate logo, a photograph, or a key word or phrase, and to convert that image into a microscopic halftone dot with tonal variation features, and to allow the use of these "logodots" as a substitute for the conventional square, round, elliptical, diamond and/or other shaped dots typically used in normal commercial printing. Through this invention, all or selected areas of a printed image can be rendered in "logodots" that can be verified with a magnifying device.

When compared to conventional halftone dots, “logodots” are much more difficult to faithfully copy using commercial photocopiers and scanners. The primary reason for this is that the microscopic image embedded within the “logodot” is too small to be accurately resolved by all but the highest resolution scanning devices. More typically, the microscopic image completely disappears and only a “blot” comes through the copying or scanning process. Another reason that the “logodots” do not successfully photocopy or scan is due to the unique arrangement of the pixels that make up the microscopic image within the “logodot”. For a given tonal density (e.g. 40%), the same number of pixels within a custom halftone “logodot” cell are illuminated (set to black) as for a conventional 40% halftone dot cell. Although the pixel count is the same, the fact that the pixels are arranged into a non-conventional microscopic image causes the “logodot” to have reflective and/or transmissive properties that are slightly different than the reflective and/or transmissive properties of conventional halftone (e.g. round) dots. Another reason that contributes to the difficulty in photocopying and scanning of “logodots” is due to the implied overlay grid that occurs from digital copier and scanner devices. The grid effectively causes the scanner to “sample” small regularly-spaced rectangular areas of the printed document for their reflective and/or transmissive density values. Since the “logodots” are much more graphically complex than conventional halftone dots, there is an increased likelihood of significant variations in the density readings of a series of contiguous grid samples, resulting in pronounced “streaking” patterns in the resultant copy.

For the above stated reasons, when a security document design is made that consists of a combination of areas rendered with "logodots" adjacent to areas that are rendered with conventional halftone dots, these apparently slight differences become more prominent when a photocopy is made or the original document is scanned. This phenomenon provides an economical method for the commercial manufacture of printed security documents that are self-canceling when they are photocopied and/or scanned.

There has thus been outlined, rather broadly, the more important features of the invention in order that the detailed description thereof may be better understood, and in order that the present contribution to the art may be better appreciated. There are additional features of the invention that will be described hereinafter.

In this respect, before explaining at least one embodiment of the invention in detail, it is to be understood that the invention is not limited in its application to the details of construction and to the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced and carried out in various ways. Also, it is to be understood that the phraseology and terminology employed herein are for the purpose of the description and should not be regarded as limiting.

A primary object of the invention is to provide a method whereby user-selected image(s) can be converted to a “logodot” that contains a microscopic embedded image.

Another object is to provide a method to automatically generate printing device-specific instructions to output the “logodot” as a suitable substitute for conventional halftone dots.

Another object of the present invention is to provide a security document manufacturing method using microscopic images that will overcome the shortcomings of the prior art devices.

Another object of the present invention is to provide a new security document manufacturing method using microscopic images for providing an economical, graphical method to create and print security documents such as checks, certificates, transcripts, and other documents having monetary or intrinsic value.

Another object is to provide a security document manufacturing method using microscopic images that will allow these microscopic halftone dots to be used in combination with conventional halftone dots for rendering any graphical object, e.g.. photographs, raster images, logos, symbols, text and typefaces, rules and lines, circles, arcs, splines, colored areas, borders, pantographs, patterns, and any other graphical element found or used in a commercially designed security document.

Another object is to provide a security document manufacturing method using microscopic images that will automatically adjust the tonal density from white-to-black and all variations of gray level between black and white dynamically according to the attributes of the graphical element or the wishes of the graphical designer.

Another object is to provide a security document manufacturing method using microscopic images that will provide a simple procedure to create and employ the “logodot”, and an efficient method to output graphical images that contain the “logodot”.

Another object is to provide a simple method to develop libraries of custom dot designs.

Another object is to provide a simple method to name each custom dot design and refer to the custom dot by name when linking it to a graphical element within a composite image.

Other objects and advantages of the present invention will become obvious to the reader and it is intended that these objects and advantages are to be within the scope of the present invention.

To the accomplishment of the above and related objects, this invention may be embodied in the form illustrated in the accompanying drawings, attention being called to the fact, however, that the drawings are illustrative only, and that changes may be made in the specific construction illustrated.

BRIEF DESCRIPTION OF THE DRAWINGS

Various other objects, features and attendant advantages of the present invention will become fully appreciated as the same becomes better understood when considered in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the several views, and wherein:

FIG. 1 shows examples of conventional halftone dot and line screens.

FIG. 2 shows examples of custom halftone dot (“logodot”) screens.

FIG. 3 shows enlarged examples of microtext before and after a photocopy.

FIG. 4 shows an example of custom halftone dots (“logodots”) at various screen angles.

FIG. 5a shows side-by-side examples of conventional and custom halftone dot (“logodot”) screens with 40% density at several line frequencies.

FIG. 5b shows a photocopy of the FIG. 5a specimen.

FIG. 6a-6d shows custom halftone dots (“logodots”) assigned to individual graphical elements that may be used within a composite image.

FIG. 7 shows a composite graphic image with a variety of conventional halftone dots and custom halftone dots (“logodots”).

FIG. 8a shows a security document design with a combination of conventional halftone dots and custom halftone dots (“logodots”).

FIG. 8b shows a photocopy of the FIG. 8a specimen.

FIG. 9 shows the DotMaker program user interface.

FIG. 10 shows the pixel illumination ranking order for a custom halftone dot (“logodot”).

FIG. 11 shows the formula for the Euclidian composite dot spot function.

FIG. 12 shows custom halftone dot (“logodot”) illumination through a range of 0% to 100%.

FIG. 13 shows examples of a multi-seed custom halftone dot (“logodot”).

FIG. 14 shows the Custom Dot Library user interface.

DETAILED DESCRIPTION OF THE INVENTION

Turning now descriptively to the drawings, in which similar reference characters denote similar elements throughout the several views, the attached figures illustrate a security document manufacturing method using halftone dots that contain microscopic images. FIG. 1 shows the most common halftone dot shapes in general use today. In contrast, FIG. 2 shows samples of “logodots” created using the invention described herein. Please note that in the drawings, halftone dots are printed at a large size for illustrative purposes.

FIG. 2 also illustrates that the invention includes a method to capture any user-selected image such as a corporate logo, a photograph, or a key word or phrase, and to convert that image into a microscopic halftone dot with tonal variation features ("logodots"), and to allow the use of these "logodots" as a substitution for conventional square, round, elliptical, diamond and/or other shaped dots typically used in normal commercial printing.

FIG. 3 illustrates the effectiveness of “microtext” as a method to detect a copy. FIG. 3 shows a specimen of a security document that includes microtext letterforms that are printed at a size of one-half point or smaller. In general, a magnifying glass is required to read microtext. When photocopied, the microtext cannot be resolved and the resultant “blotting” renders the text illegible. “Logodots” that contain microscopic images also exhibit the same kind of distortion when photocopied or scanned.

FIG. 4 illustrates the fact that “logodots” can be output at any arbitrary screen angle, the same as conventional halftone dots. The screen angle of foreground and background elements can be controlled when designing a security document.

FIG. 5a shows examples of both conventional and “logodots” of a 40% density side-by-side, at several screening frequencies, to illustrate the fact that the halftone dots can be substituted as desired. FIG. 5b shows the results of a photocopy of the illustration in FIG. 5a, whereby the conventional dot retains its clarity and fidelity while the custom dot distorts and darkens.

Through this invention, as shown in FIG. 6a-6d, all or selected areas of a printed image can be rendered in "logodots" containing microscopic images that can be verified with a magnifying device, including photographs, raster images, logos, symbols, text and typefaces, rules and lines, circles, arcs, splines, colored areas, borders, pantographs, patterns, and any other graphical element found or used in a commercially designed security document. In addition, any conventional halftone dot or “logodot” can be assigned to any graphical element, so that a given document can have a blend of many conventional and/or “logodots”. As shown in FIG. 7, a graphic designer is able to use his skill to select the best utilization of “logodots” depending on the requirements of the project.

As shown in FIG. 8a-8b, when compared to conventional halftone dots, “logodots” are much more difficult to faithfully copy using commercial photocopiers and scanners. The primary reason for this is that the microscopic image embedded within the “logodot” is too small to be accurately resolved by all but the highest resolution scanning devices. More typically, the microscopic image completely distorts and only a “blot” results from the copying or scanning process.

Another reason that the “logodots” do not successfully reproduce via photocopier or scanner is due to the unique arrangement of the pixels that make up the microscopic image within the “logodot”. For a given tonal density (e.g. 40%), the same number of pixels within a “logodot” cell are illuminated (set to black) as for a conventional 40% halftone dot cell. Although the pixel count is the same, the fact that the pixels are arranged into a non-conventional microscopic image causes the “logodot” to have reflective and/or transmissive properties that are slightly different than the reflective and/or transmissive properties of conventional halftone (e.g. round) dots. Another reason that contributes to the difficulty in photocopying and scanning of “logodots” is due to the implied overlay grid that occurs from digital copier and scanner devices. The grid effectively causes the scanner to “sample” small regularly-spaced rectangular areas of the printed document for their reflective and/or transmissive density values. Since the “logodots” are much more graphically complex than conventional halftone dots, there is an increased likelihood of significant variations in the density readings of a series of contiguous grid samples, resulting in pronounced “streaking” patterns in the resultant copy.

For the above stated reasons, when a security document design is made that consists of a combination of areas rendered with "logodots" adjacent to areas that are rendered with conventional halftone dots, these apparently slight differences become more prominent when a photocopy is made or the original document is scanned. This phenomenon provides an economical method for the commercial manufacture of printed security documents that are self-canceling when they are photocopied and/or scanned.

This invention describes (a) a method to digitally capture any user-selected image such as a corporate logo, a photograph, or a key word or phrase, and to convert that image into a microscopic “logodot”, and in doing so specify the white-to-black transition characteristics (illumination ranking) of the “logodot” so that it can be utilized by conventional printing devices to represent graphical images with halftone densities ranging incrementally from zero to 100%, (b) a method to automatically generate printing device-specific instructions to output the “logodot” as a suitable substitute for conventional halftone dots, and (c) a method to save various collections of custom dot designs as libraries, and (d) a method to refer to custom dots by name and assign the “logodot” to any graphical element within a composite image or graphical design, and (e) a method to utilize the above invention for the protection of security documents (or other printed objects) by causing a replication to be visually obvious and/or self-canceling.

Description of the Invented Process

Herein described is a variation of the invented method to digitally capture, visualize, and specify the white-to-black transition characteristics of a dot. The inventor developed a software program (called DotMaker) that demonstrates and simplifies the process of creating “logodots” for PostScript imaging devices. The user interface to the DotMaker program is shown as FIG. 9.

The PostScript language provides for a halftone Spot Function (reference [3]), a procedure written in the PostScript language that, when invoked by the PostScript RIP, is to provide the "ranking values" for all pixels in the cell. These ranking values determine how the pixels in the spot cell are to turn on: the higher the value, the sooner that pixel turns on. The invention described herein makes use of a visual "seed image" and an interpretive process (as opposed to a formula) to dynamically re-program the Spot Function, so that the pixel ranking values are determined by the relative white to gray to black transitions of pixels and their relative locations within the reference "seed image", as shown in FIG. 10. The Spot Function is solely responsible for the pixel growth pattern within the cell. In existing practice, to control pixel illumination, almost all of the prior art has dealt exclusively around the use of mathematical procedures to determine the pixel ranking values, such as the Euclidian algorithm to generate the "round dot" published by Adobe Systems, Inc. and illustrated as FIG. 11.

An enlargement showing how a “logodot” progresses from 0% (white) to 100% (black) by pixel ranking order illumination appears as FIG. 12. Although not all user-selected images can be used to construct a halftone dot that performs well throughout the full density range, there usually is a limited range where the custom dot is visually acceptable. The “logodot” example in FIG. 12 is legible from approximately 10% to 60% density, which makes it suitable for a number of background/foreground applications.

The widely used offset printing process, and many other conventional and digital printing techniques, depend on the phenomenon of halftone dot screening to render lighter shades of colors with a single ink. With a single color of ink, tones are achieved by screening the desired area into regularly spaced dots of smaller size for lighter tones, and larger size dots for darker tones. Solid colored areas do not need or use halftone dots.

Through the halftone screening process, a broad range of tones from almost white to almost solid color are possible, all from a single ink color. Prior art and invention have established that the most consistently perfect printed results on the widest range of substrates are obtained with so-called "conventional dot screens", generally round, square, elliptical, or diamond shaped dots, as well as line screens composed of parallel line shapes. In the present invention described herein, a method is described whereby the "conventional dot screens" can be selectively replaced on an item-by-item basis with "custom dot screens" that are uniquely designed and shaped. While this may not be desirable for all printing applications, the ability to selectively include custom screened graphical elements into a composed image has the benefit of making the printed document or object difficult to copy, and therefore resistant to counterfeiting.

Halftone dots are successful in visually representing tones and images on a printed object because the human eye merges the dots into a perceived continuous tone. This occurs because the dots are typically very small, and only obvious if the printed document or object is enlarged or magnified. This invention reveals a method to insert a microscopic image into each “logodot”, allowing the user to continue the prepress design and composition functions as before. The printed document or object appears to the naked human eye the same as a conventionally produced product. However, when the printed document or object is photocopied or scanned, the “logodots” that contain the microscopic images are either reproduced lighter or darker than conventional halftone dots of the same relative density or darkness. The reproducibility variation between the two dot technologies can be purposely taken advantage of to create graphic designs that are self-canceling when photocopied or scanned.

In the present invention described herein, there is also described a method to take any user-selected image such as a corporate logo, a photograph, or a key word or phrase, and convert that image into a custom halftone screen dot. Further described is a method to control the "growth" of the “logodot” (containing the microscopic image) with tonal variation features so that it can successfully be used from very light to very dark areas of the printed document or object. Further described is a method to cause the custom dot image to consist of one or more images which evolve from 0% white to the first image then to the second then to the next and so forth until the dot density reaches 100% black. Further described is a method to save the custom dot design file by name so that it can be referenced for inclusion in a composition, or so that it can be later revised or copied. Further described is a method to connect the custom dot to a graphical design system so that master images, films, negatives, and/or printing plates can be produced that have selected components rendered in “logodots”.

The invented method also has applicability in the manufacture of secure labels, decals, tags, identification cards, packages, and other printed products. In addition, the invented method has value for artistic design beyond the utility of security document protection. The ability to include one's corporate logo or self-portrait as a microscopic image within a printed document or object has the appeal of added personalization or validation. The ability to name and recall the “logodots” is the foundation for building libraries of custom dot designs for various commercial, industrial, and artistic purposes.

Description of the DotMaker Program

As shown in FIG. 9, the DotMaker program takes a rectangular, digital bitmap as a "seed image", and converts it to a printing spot: (a.) The seed image is placed in a square cell, whose side length (in terms of number of pixels) is the larger of the 2 sides of the image. For practical purposes, the current implementation limits the seed image to be no more than 255 pixels on either side. While increasing the number of pixels has the benefit of adding detail to the microscopic image, a lower line frequency must be specified in order for every pixel within the custom dot to be displayed. The following table shows the relationship between pixel count and screen frequency for a custom dot imaged on a device that has 2540 dots-per inch (DPI):

Pixel Matrix in “logodot”	Ideal Screen Frequency in lines-per inch (LPI)
16 x 16	158.750
19 x 19	133.684
25 x 25	101.600
32 x 32	79.375
64 x 64	39.688
127 x 127	20.000
254 x 254	10.000

Any size pixel matrix can be used from 2 x 2 to 255 x 255. For screen frequencies other than the ideal, PostScript automatically inserts or removes pixels from within the custom halftone cell to output the specified lineage. (b.) If the image is gray-scale, each pixel's darkness value is used as the "pixel ranking values" for the spot cell, where black corresponds to the highest ranking value, and white the lowest. These ranking values therefore reside inside the limit between zero and the highest value that each pixel size in the image can accommodate. For images stored with one byte per pixel, the limit is 255. (c.) If the image is color, it is converted to gray-scale by using the commonly known Red Green Blue (RGB) color to Luminance calculation, e.g.:

$$\text{Luma} = 0.30R + 0.59G + 0.11B$$

as used in RGB-to-YIQ conversion shown in reference [4], then treated as a gray-scale image. (d.) If the image is bi-level "black and white", a "growth center" can be provided by the user, the distance to this center from each black pixel in the image is computed, and used as that pixel's ranking value: the smaller the distance, the higher the ranking value. All white pixels have their ranking value set to the lowest value (zero, in the sample implementation). Therefore, the spot will grow from nothing (0% density), to the original image, and on to all black (at 100% density), around the given center in the cell. Two small variations from this "circular fan-out distance ranking" are available to the user: use only the distance along the x axis, or only the distance along the y axis.

One other variation is that the user can load 2 or more "seed images", each corresponding to a particular density step between 0% and 100%, where the second and subsequent image(s) correspond(s) to an overall higher density than the first. The spot will therefore grow from 0% density to the first image, on to the combined image, on to the subsequent image(s), and finally to 100% density beyond the last image, as shown in FIG. 13. The current implementation requires each of the multiple images to be bi-level (black and white): additional black pixels in the second and subsequent images are ranked by their adjacency to the pixels (already ranked) in the previous images, so that pixel ranking value coherence is maintained. (e.) The user can then save the pixel ranking values, along with other identifying and tracking information, to a named file.

The ranking methods described above are as implemented in the demonstration program DotMaker. These methods should in no way be construed as the only method for ranking pixels within a halftone cell. Other ranking methods may be employed to cause different white-to-black (including white-to-black-to-white-to-black and the inverse) progressions from the same “seed images”, and they should be considered as part of the invention herein.

The invented program allows the user to save and refer to custom dots by name and assign screening attributes to any graphical element in a document layout. Custom dot designs are given a unique name and collected in a Custom Dot Library shown in FIG. 14, which can be utilized by the MECCA III and MECCA 2000 Integrated Electronic Publishing Systems manufactured by Amgraf, Inc., located in Kansas City, Missouri (reference [6]). A graphic designer using a MECCA 2000 system can assign any custom dot name to any graphical element (except Bar Codes), thereby simplifying the inclusion of custom dots within a security document design. When a user specifies the use of a custom dot, the screening frequency and dot angle may also be specified, in exactly the same way and meaning as with conventional dots, to control dot size and rotation. To graphic art and printing industry professionals, specifying such a “logodot” is no different from using a conventional halftone dot.

To support this invention, Amgraf, Inc.'s PostScript file generation program, called "typdrv", was enhanced to output (for each custom dot) a PostScript array comprised of the dot's pixel ranking values, and an accompanying PostScript Spot Function which, when activated by the PostScript RIP, scales and maps the pixel ranking values to the range of -1 to +1 as required by the PostScript language.

The procedure to follow in order to create a security document that contains the invention's custom dots is as follows: (a.) The designer captures a "seed" image to use as the "logodot". The image can be scanned from a hard-copy of the image or obtained via a digital camera or other means. The image then is reduced to a rectangular "bit-map" with an overall pixel count not to exceed 255 x 255 pixels. (b.) Using standard desktop publishing pixel editing software, the bit-map is edited to indicate the preference for progressive illumination of the pixels from white to black, by making the most prominent pixels black, the least prominent pixels white, and the order of tonal variation across the dark to light spectrum in various shades of gray. (c.) The resultant "seed" image is saved from the pixel editor program then loaded into the "DotMaker" program, named, and processed into a "logodot" consisting of illumination ranking instructions. (d.) The code set is stored in a Custom Dot Library on a MECCA 2000 System. (e.) A MECCA 2000 user creates or opens a design file for a security document and assigns various custom dot names (and screening attributes) to various graphical elements such as photographs, text and typefaces, rules and lines, circles, arcs, splines, colored areas, borders, pantographs, patterns, and logos. (f.) The MECCA 2000 user selects the "Output" menu and sends the composite image to a PostScript imaging device to create printing plates, negatives, and/or films which contain the "logodot".

As to a further discussion of the manner of usage and operation of the present invention, the same should be apparent from the above description. Accordingly, no further discussion relating to the manner of usage and operation will be provided.

With respect to the above description then, it is to be realized that the optimum relationships for the parts of the invention, to include variations in software, systems, materials, shape, form, function and manner of operation, assembly and use, are deemed readily apparent and obvious to one skilled in the art, and all equivalent relationships to those illustrated in the drawings and described in the specification are intended to be encompassed by the present invention. It is understood that the practical DPI resolution of imaging, scanning, copying, and printing devices will continue to increase in the future, resulting in higher screen frequencies for both conventional halftone dots and “logodots”.

Therefore, the foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described, and accordingly, all suitable modifications and equivalents may be resorted to, falling within the scope of the invention.