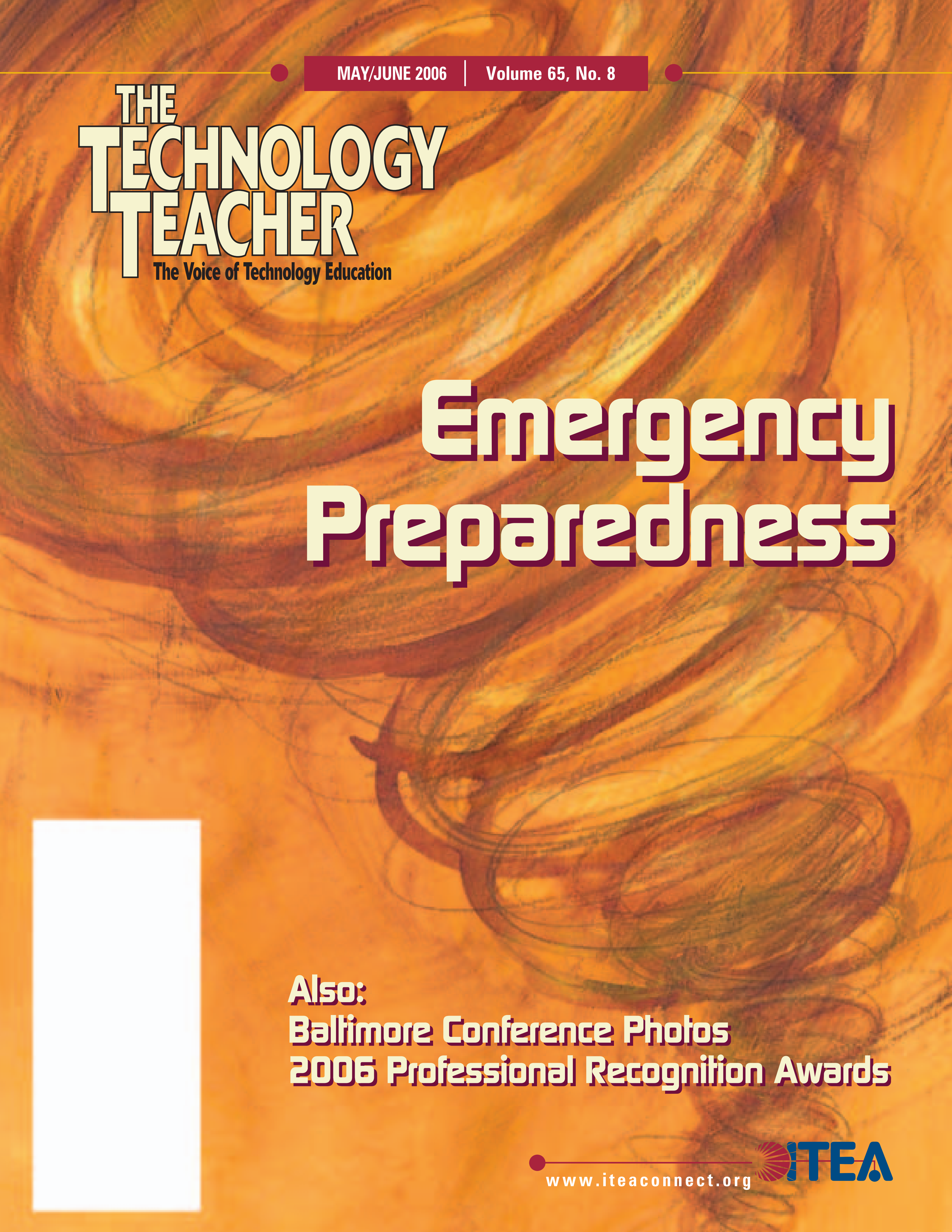
MAY/JUNE 2006 | Volume 65, No. 8

THE TECHNOLOGY TEACHER

The Voice of Technology Education



Emergency Preparedness

Also:

Baltimore Conference Photos

2006 Professional Recognition Awards

www.iteaconnect.org

ITEA

ITEA

MAY/JUNE 2006
Volume 65, No.8

ITEA is an affiliate of the American Association for the Advancement of Science.

The Technology Teacher, ISSN: 0746-3537, is published eight times a year (September through June with combined December/January and May/June issues) by the International Technology Education Association, 1914 Association Drive, Suite 201, Reston, VA 20191. Subscriptions are included in member dues. U.S. Library and nonmember subscriptions are $80; $90 outside the U.S. Single copies are $8.50 for members; $9.50 for nonmembers, plus shipping—domestic @ $6.00 and outside the U.S. @ $17.00 (surface).

E-mail: kdelapaz@iteaconnect.org
World Wide Web: www.iteaconnect.org

Advertising Sales:
ITEA Publications Department
703-860-2100
Fax: 703-860-0353

Subscription Claims
All subscription claims must be made within 60 days of the first day of the month appearing on the cover of the journal. For combined issues, claims will be honored within 60 days from the first day of the last month on the cover. *Because of repeated delivery problems outside the continental United States, journals will be shipped only at the customer's risk. ITEA will ship the subscription copy, but assumes no responsibility thereafter.*

The Technology Teacher is listed in the Educational Index and the Current Index to Journal in Education. Volumes are available on Microfiche from University Microfilm, P.O. Box 1346, Ann Arbor, MI 48106.

Change of Address
Send change of address notification promptly. Provide old mailing label and new address. Include zip + 4 code. Allow six weeks for change.

Postmaster
Send address change to: The Technology Teacher, Address Change, ITEA, 1914 Association Drive, Suite 201, Reston, VA 20191-1539. Periodicals postage paid at Herndon, VA and additional mailing offices.

PRINTED ON RECYCLED PAPER

THE TECHNOLOGY TEACHER

The Voice of Technology Education

TABLE OF CONTENTS

DEPARTMENTS

FEATURES

THE TECHNOLOGY TEACHER
The Voice of Technology Education

Editorial Policy
As the only national and international association dedicated solely to the development and improvement of technology education, ITEA seeks to provide an open forum for the free exchange of relevant ideas relating to technology education.

Materials appearing in the journal, including advertising, are expressions of the authors and do not necessarily reflect the official policy or the opinion of the association, its officers, or the ITEA Headquarters staff.

Referee Policy
All professional articles in *The Technology Teacher* are refereed, with the exception of selected association activities and reports, and invited articles. Refereed articles are reviewed and approved by the Editorial Board before publication in *The Technology Teacher*. Articles with bylines will be identified as either refereed or invited unless written by ITEA officers on association activities or policies.

To Submit Articles
All articles should be sent directly to the Editor-in-Chief, International Technology Education Association, 1914 Association Drive, Suite 201, Reston, VA 20191-1539.

Please submit articles and photographs via e-mail to kdelapaz@iteaconnect.org. Maximum length for manuscripts is eight pages. Manuscripts should be prepared following the style specified in the *Publications Manual of the American Psychological Association, Fifth Edition.*

Editorial guidelines and review policies are available by writing directly to ITEA or by visiting www.iteaconnect.org/F7.htm.

DEMYSTIFYING THE HALFTONING PROCESS: CONVENTIONAL, STOCHASTIC, AND HYBRID HALFTONE DOT STRUCTURES

FEATURE ARTICLE

Garth R. Oliver

Jerry J. Waite

Laypeople seldom consider what occurs when they click File>Print.

Introduction

Standard 17 of the *Standards for Technological Literacy* (*STL*) document states that "Students will develop an understanding of and be able to select and use information and communication technologies." Technology education teachers who expose their students to visual communication processes are often called upon to help them understand the appropriate use of conventional and contemporary halftone screening technologies when reproducing photographs using ink on paper. Halftoning technologies allow printed photographs to be composed of varying types of dots or spots that can contribute to, or detract from, the faithful and effective reproduction of photographs. Before students can select the most appropriate halftoning technology, they must understand the choices that are available. This article presents those choices.

The choice of halftoning technology depends upon inputs (original photographs), processes (graphic design, prepress, and printing technologies), and outputs (purpose of the printed product). Therefore, teaching halftoning processes helps technology teachers comply with *STL* Standard 17, Benchmark L: "Information and communications technologies include the inputs, processes, and outputs associated with sending and receiving information."

Conventional, stochastic, amplitude modulated (AM), frequency modulated (FM), dot shape, lines per inch (LPI), and dots per inch (DPI) are all terms associated with printing that describe the process of converting a continuous tone (CT) image into a halftone. Lay people seldom consider what occurs when they click File>Print. Instead, they simply want images and words that adequately convey their messages. Therefore, the processes their computers and printers use to convert halftones are of little or no concern. On the other hand, to remain competitive, printers are engaged in a never-ending quest to increase the aesthetic qualities and fidelity of printed reproductions. Since halftoning techniques strongly impact the appearance of printed reproductions, printing companies must carefully choose and implement the most efficacious processes available.

The introduction of computers into the printing process drastically changed the way the CT-to-halftone conversion occurs. Computers provided, at minimum, two things: 1) a simplification of the CT-to-halftone conversion process and 2) more precise control over the resultant image. Anyone who used a conventional process camera to make a halftone, used a Kodak Q-15 Halftone Calculator, or dot-etched a negative, knows this to be true.

Improved technology increases expectations. Both print buyers and producers demand the increased quality and fidelity afforded by new halftoning technologies. Therefore, graphics educators must learn and develop new ways to teach students when and how to utilize these technologies. This article demystifies three common halftoning processes.

Figure 1. Tonal differences in a halftone are an illusion.

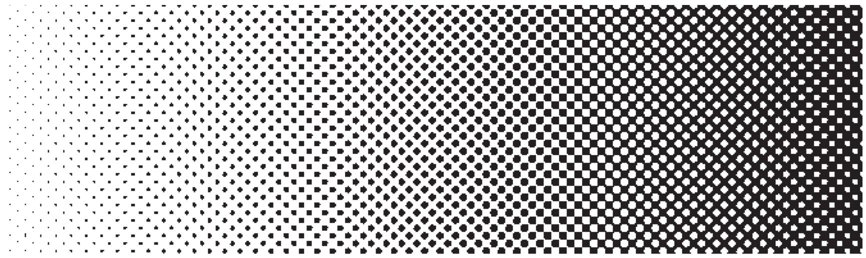


Figure 2. A range of tones reproduced using enlarged AM halftone dots.

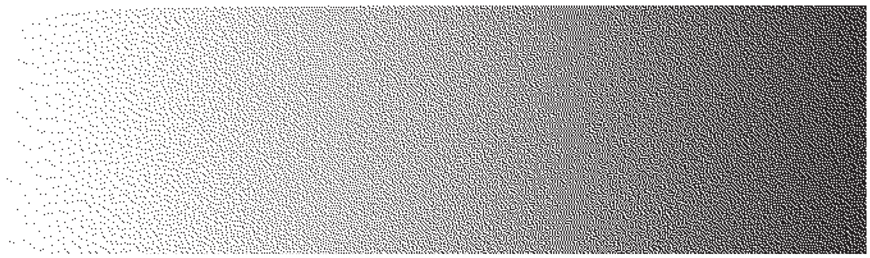


Figure 3. A range of tones reproduced using FM halftone dots.

How Halftoning Creates Tonal Difference

Tonal difference, shades of gray, and detail are interrelated terms used to explain a different shade or tint in one area of a photograph compared to that in another area. Figure 1 is a halftone reproduction of an original CT photograph that contained tonal differences (shades of gray) across the image. Without the detail resulting from these shades of gray, there would be no image. The image created by the halftone in Figure 1 is an illusion: the differences in tone are caused by dots of different size or frequency rather than by varying shades of black and white. A press either prints ink or leaves the substrate blank. When large-sized or a large number of halftone dots cover the substrate (paper), they absorb the reflected light and darken the page. Conversely, wherever there are small or few dots, light is reflected to the viewer so that the page appears light. To create detail, the total coverage of ink in a given area must be different than that in a neighboring area.

Screening Processes Defined

Halftones are created using three different techniques: conventional (AM), stochastic (FM), and hybrid. Each of these techniques can be used to create the illusion of shades of gray.

Conventional (AM) Screening

Conventional, or amplitude modulated (AM) screening, was patented by William Henry Fox Talbot in 1852. It uses varying-sized dots on a crisscross pattern similar to graph paper or grids in Adobe Photoshop®. As shown in Figure 2, the size of the dots in the grid pattern controls the intensity of the light reflected back from the substrate. In a highlight area of a halftone, small dots of ink absorb a small amount of light while allowing most of the light to reflect.

Conversely, in shadow areas, larger dots absorb more light so that very little light can reflect from the substrate. The viewer sees only the light that is reflected. Therefore, small dots result in light areas while large dots result in darker areas. The dots, if small enough, cannot be readily perceived by humans due to the poor ability of our eyes to resolve them.

AM screening, the primary method of halftone conversion for over 100 years, has both positive and negative characteristics. On the positive side, AM screening provides a particularly smooth transition from one mid-tone dot size to another. In addition, AM screening provides superior results when printing screen tints. However, AM highlight dots are sometimes so small that they disappear (drop) during the production cycle. At the dark end of the tonal scale, AM dots are very large, overlapped, and separated by very small unprinted areas. Human error in platemaking or the application of too much pressure or ink during the press run often causes the dots to grow so large that the small unprinted areas disappear (fill in). These phenomena at both ends of the tonal scale equate to diminished highlight and shadow detail.

Stochastic (FM) Screening

Stochastic screening, also known as frequency modulated (FM) screening, was invented in 1965 by Karl Scheuter at Technical University of Darmstadt in West Germany. Not until three decades later did computing power, PostScript interpreters, and image- and platesetters become robust enough to allow Scheuter's invention to be implemented (Balas & Lanzerotti, 2004). When FM screening is employed, the number (frequency) of dots, rather than dot size, controls the amount of the light reflected from the substrate (see Figure 3). In a highlight area of a halftone, a few same-sized dots absorb very little of the light. Therefore, most of the light is reflected. Conversely, in shadow areas, a greater frequency of dots absorbs more light, causing very little light to reflect from the substrate. As light is absorbed or reflected throughout the halftone, detail is produced by the varying frequency of dots.

If properly employed, FM screening techniques can increase the aesthetic qualities and fidelity of reproductions. FM techniques provide increased image detail due to smaller FM dots. In addition, the FM screening process eliminates moiré—an objectionable perceptual effect caused by the overlapped angles inherent in AM screening—and allows the expansion of the limited color palette (CMYK) traditionally used to minimize this pattern. In particular, FM technologies allow printers to effectively print hi-fidelity color reproductions in six or more colors. Additional colors dramatically increase the color gamut of printed images.

If the press is properly controlled and if the substrate is a smooth coated stock, FM highlight dots do not disappear and shadow dots do not fill in because all of the dots are the same size. On the other hand, if too much fountain solution is run on press, the fine microdots in the highlights can be easily washed away. Similarly, if a rough uncoated paper is used, the microdots can disappear between the fibers. In addition, too much plate-to-blanket or blanket-to-paper pressure can cause micro shadow dots to fill in. Thus, FM screening techniques require fine-tuned press operations.

"FM screening is still considered an emerging technology. It entails significant change to the printing mindset and has been subject to a very healthy dose of scrutiny over the years. It is well understood that FM screening eliminates screening moiré, screening rosettes, and delivers photographic quality while boosting fidelity and detail in the reproduction of images" (Blondale, 2003).

Hybrid Screening

Hybrid screening is a combination of AM and FM screening that utilizes the best qualities of each. In particular, most hybrid technologies retain the FM rendition of highlight and shadow dots. This allows fine detail provided by random clusters of microdots that are not confined to a grid pattern. On the other hand, AM screening typically provides a smoother transition of tone in the midtones. So, one approach to hybrid screening would be to utilize FM dots in the highlights and shadows while employing AM dots in the midtones.

Two approaches to hybrid screening include Hybrid FM (also known as Second Order FM) and Hybrid AM (also called XM). Hybrid FM screens grow the dot's length or change its shape depending on the screen design. Note the shape change in the Hybrid FM dot shown in Figure 4-1.

When Hybrid AM is employed, the size of the dots in the highlights and shadows are constrained to the size of the smallest printable dot on a particular press using a given substrate. For example, if the smallest dot a press can hold is a 10-micron dot, Hybrid AM techniques would utilize no dot smaller than 10 microns. To make a lighter area than the 10-micron dot produces, dots are removed from the grid. This prevents too-small dots from dropping on press while resulting in a lighter perceived tone. A similar process is employed in the shadows: no dots larger than the largest consistently printable shadow dots are used. To make a darker tone, specific areas are allowed to go solid. The midtones are produced with a conventional (AM) screening technique. A Hybrid AM screen is shown in Figure 4-2. Note the missing AM dots at each end of the tonal scale.

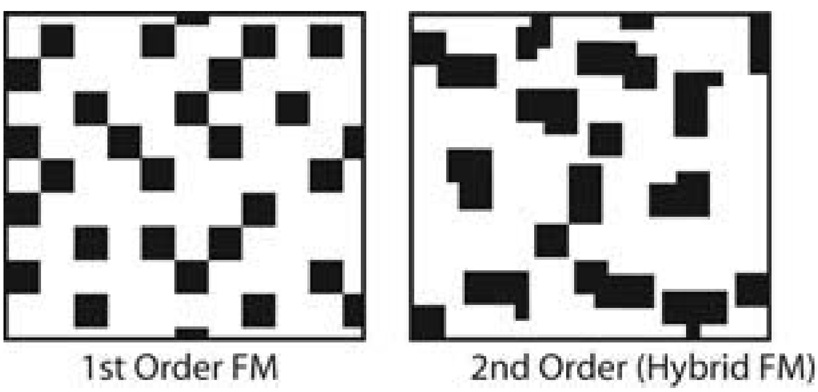


Figure 4-1. A comparison of first- and second-order FM dot shapes.

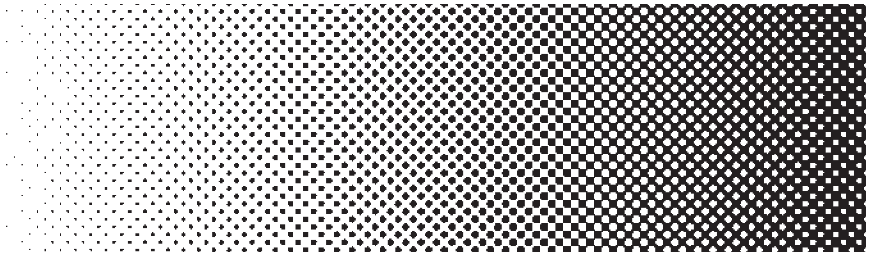


Figure 4-2. Dots have been removed from the highlights and shadows in this AM Hybrid screen.

Choosing the Appropriate Screening Technique

The placement and structure of dots resulting from any halftoning technique will result in a similar image, especially if the image is viewed from a distance. Changing the halftoning process will result in only minor differences in image quality and tonal range.

Printers who desire to increase the fidelity of printed reproductions may be tempted to implement FM or hybrid screening technologies. Such implementation may produce sharper and richer halftone reproductions. However, these improvements must not be taken at the expense of a smooth and economical workflow. Whenever a halftoning process disrupts workflow—for example, by requiring a specialized raster image processor (RIP) or output device—or adversely affects the pricing of a job, printers would be wise to be prudent in their adoption of new technologies.

Depending on the specific application, each of the three screening technologies explored in this article fills a niche based on the process, substrate, and ink used to reproduce the original photograph. When choosing a screening technique, it is important to

FEATURE ARTICLE

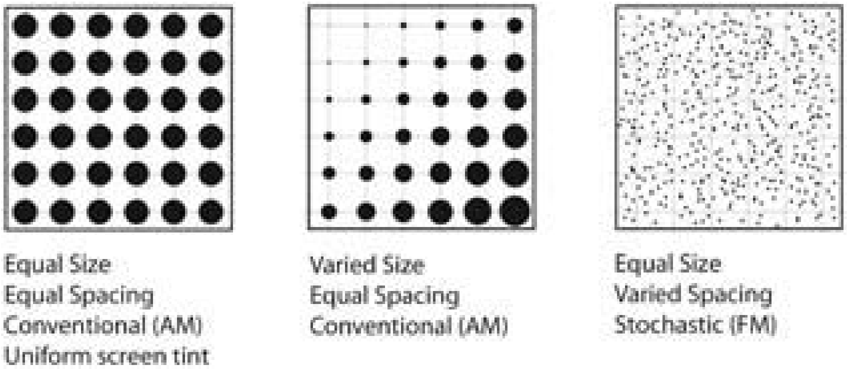


Figure 5. All dot structures control light absorption and reflection.

consider the basics of photographic reproduction rather than get caught up in new technology for new technology's sake.

Back to the Basics

Regardless of screening technique, it is important to remember that all reproductions should faithfully reproduce the intent of the original in light of the circumstances in which the printed image will be viewed. In particular, halftones must accurately control light and provide an appropriate resolution depending on viewing distance.

Controlling Light

All halftoning processes create dots that control the light reflected back from the substrate. Considering again that a press either prints ink or leaves the substrate blank, a dot of black ink absorbs the light that strikes it, while unprinted paper reflects the light. Regardless of the arrangement of the dots, the image perceived by the viewer is controlled by the absorption and reflection of light. The different dot structures in Figure 5 illustrate that the combination of black dots and white paper display the illusion of gray when viewed at a distance great enough so the human eye can no longer resolve the individual dots.

Viewing Distance

Halftone dots should not be discernable by a reader at the viewing distance appropriate for a given type of printed job. Although the perception of individual dots is affected by the viewer's visual acuity, it is also dependent upon the distance between the printed page and the viewer. A photograph in a magazine is generally viewed at a distance between 12 and 20 inches. So, small dots are appropriate. On the other hand, very large dots may be employed on a roadside billboard since viewing distance could be hundreds of feet.

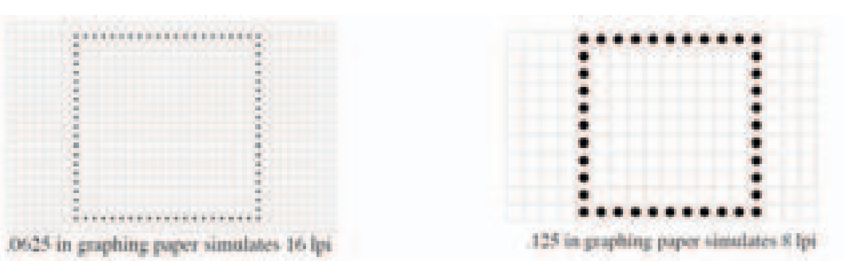


Figure 6. When a viewer can no longer distinguish 16 LPI dots, 8 LPI dots can still be discerned.

Resolution

The smaller the halftone dots, the less likely they are to be discerned by the viewer. To make dots smaller, increase the number of lines per inch (LPI) so that more lines of dots are displayed. In Figure 6, four times the number of dots are required to display the square at 16 LPI in comparison to the square at 8 LPI. If the viewing distance is increased so that the 16 LPI dots begin to merge into perceived lines creating a square, the 8 LPI dots will still be distinguishable. The choice of the appropriate LPI for a given job is complex and must consider the image resolution of the original scan or digital photograph, the capabilities of the imagesetter or platesetter, and the chosen printing process, press, ink, and substrate.

Combining the Basics

Figure 7 illustrates a single image reproduced using three different halftone screens. Sample A was originally screened at 20 LPI. Sample B was reproduced using the LPI chosen for this Journal (133-150 LPI). Finally, Sample C was originally screened at 40 LPI. (The resolution of Samples A and C may no longer be as stated due to scaling by this Journal.) Several people viewed the original version of Figure 7 at varying distances. At normal reading distance (between 12 and 20 inches), none of the viewers could discern the halftone dots in Sample B. However, they could all distinguish the individual dots in Samples A and C. If five-seven feet separated the viewer and Figure 7, depending upon the visual acuity of the individual, Samples B and C appeared the same. Thus, at a distance of five to seven feet, 40 LPI dots seem to disappear. When the viewers moved back to a distance of 10 to 13 feet, Samples A, B, and C all appeared the same because, at that distance, 20 LPI dots seem to disappear. Therefore, the greater the viewing distance, the lower the LPI can be without affecting the visual quality of the reproduction.

Conclusion

For more than 150 years, printers have been faithfully reproducing CT originals using halftoning techniques. For about 120 years, printers could

Figure 7. The different LPI dots in this composite image disappear at varying viewing distances.

only use the AM halftoning technique invented by Henry Talbot. In recent years, the advent of powerful RIPs and high-resolution output devices has increased the variety of halftoning techniques available to the printer. In particular, FM and Hybrid techniques can be used to increase the aesthetic qualities and fidelity of printed reproductions. Each of these new techniques provides benefits and drawbacks as highlighted in this article. Printers and students of printing need to test these techniques to ensure that their benefits outweigh their costs.

References

Agfa Corp. (2003). *White paper: XM (cross modulated) screening technology; increasing print quality in a computer-to-plate (CtP) workflow.* www.agfa-press.com/techpapers/commercial

Balas, D., Lanzerotti, B. (2004). *Bridg's technical supplement: A guide to halftone screening*. Wheaton, Illinois. www.bridgs.org

Blondal, D. (2003). *The lithographic impact of microdot halftone screening*. Taga Proceedings in Montreal, Canada.

Kipphan, H. (2001). *Handbook of print media*. Springer-Verlag, Berlin, Heidelberg, New York.

Antique car photograph included with permission from the photographer, Allen Vaughn, Jr.

All other figures created by the author.

Garth R. Oliver *taught Graphic Communications at the high school level in Hawaii and South Carolina for five years. He taught in the Graphic Communications department at Clemson University for four years and is currently a Lecturer in the Information and Logistics Technology Department at the University of Houston.*

Dr. Jerry Waite *has been involved in the printing and publishing business since he was a high school freshman. He taught graphic arts at the high school and community college levels in Southern California for 19 years. Dr. Waite currently teaches most of the undergraduate credit courses in graphic communications technology at the University of Houston. Dr. Waite is also a Past-President of the International Graphic Arts Education Association, is Treasurer of the Accrediting Council for Collegiate Graphic Communications, and is the editor of the Visual Communications Journal.*

This is a refereed article.