

Experiments in digital graphic design

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Graphic design, layout, and the use of typography are among topics discussed in this essay about the collaboration between an art director at IBM and researchers at the Visible Language Workshop of the MIT Media Laboratory to produce printed journal cover designs. We highlight how a traditional graphic designer and computer programmers worked together to produce visual results on a computer display.

In 1986, IBM and the MIT Media Laboratory Visible Language Workshop (VLW) began working together on a number of experiments to explore various ideas for using digital tools to supplement the mechanical process of graphic design. The principal participants were the authors of this essay. At that time, the commercial use of “desktop publishing” was five years away, and an art director from a traditional art background who was interested in digital tools and applications was somewhat unique.

At the time this essay was being written, Muriel Cooper was the Director of the Visible Language Workshop. Upon her unexpected death in 1994, I finished this essay documenting the highlights of our work for this special issue of the *IBM Systems Journal*.

As an art director, I was intrigued by the notion of being able to create beautiful new forms of color artwork on computers. As a researcher, Cooper was intrigued with the potential of designing with typography and creating page layouts digitally. Before we met, I had not seen designed fonts, such as Helvetica, displayed on a computer screen. The process I was familiar with was to place a *type order* with a typeset-

ting vendor and have the vendor return *repro galleys* that would be pasted on a *mechanical*. The type order would specify what fonts to use, the repro (reproduction) galleys contained the printed fonts, and the mechanical was the desired formatted page. In 1986 there was no way to use the computer to visualize the layout of an actual page of text with color artwork included. Any digital text layout systems I had seen did not really mimic a printed page. My only recollection is that green monospaced fonts on green displays were all that could normally be seen. I had, however, experimented with researchers at IBM to create specialty full-color graphics.¹

The scope of the experiments with Cooper at VLW included the documentation of the day-to-day work of an art director (the data were placed into an “expert systems” database, or knowledge base), the documentation of the graphic design process and the tools used in this process, and the creation of experimental software to simulate the graphic knowledge and aesthetic issues of an intelligent illustration tool and to perform electronic page layout for cover designs. Some of these experiments were grouped under a project called EICON (Expert Illustration Configuration)²—research that was funded and sponsored by IBM.

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Several IBM publications benefited from these experiments. Cover designs for both *Perspectives in Computing*³ (no longer published) and the *IBM Systems Journal* are discussed in this essay, although other corporate technical publications of IBM, such as the *IBM Journal of Research and Development*, have cover designs produced as a result of this work.

The experiments began with the idea of documenting traditional graphic design processes and tools and then creating digital alternatives. Drafting pens, type galleys, color markers, paints, pastels, etc., were the day-to-day tools of illustrators or designers, some of which I used. Also documented were my thought processes in dealing with commissioned art, or in creating art myself.⁴ The Visible Language Workshop laboratory where the experiments were done was created for advanced graphics research. Since the experimenters wanted to create a particular look for a cover layout or a cover art graphic, custom code was written by various VLW students when the functionality needed for a particular graphic look was not available in the research toolset at the VLW.

A new way of working was explored. The model of collaboration was for me to sit next to a programmer and create a design that would then be visualized on a computer screen. The collaborations were in real time, thus immediate results could be seen as we worked. Although I was familiar with giving direction to illustrators who in a week or two would return artwork on paper, this new interactive way of working was visually quite exciting when “instant” results were seen.

Art and graphic design

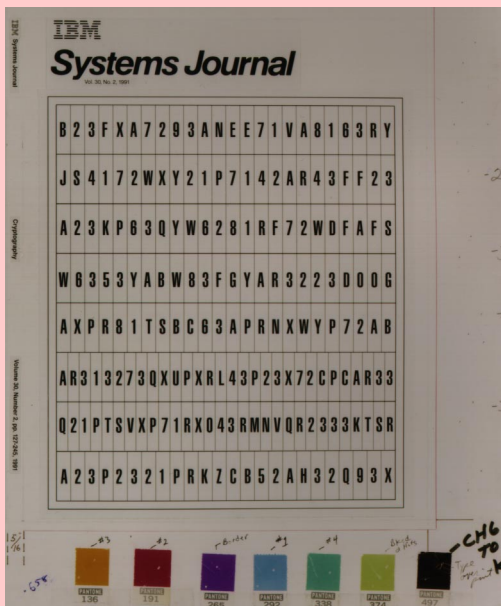
It is true with all artistic endeavors that the discipline of the craft, such as the control of the brush, must be learned before beauty and individual creative solutions flow. There are also aesthetic principles that can be applied, such as the use of positive and negative space, the dominance of form or color, realism or abstraction, and size relationships. A wonderful example of the documentation of learning a craft is a book from the 1600s, titled *The Mustard Seed Garden Manual of Painting*,⁵ which explores Chinese brush painting. One of the thoughts that flows through the book is the achievement of excellence in painting with the heart and the hand working together. With mastery of the brush, the artist can paint an individual view of a flower or a butterfly—capturing the essence of things.

Mastery of tools and principles of aesthetics is necessary for creating visual solutions for graphic designers and art directors in the publishing world. Generally speaking, graphic designs for publishing use a mixture of typography and artwork or photography that will ultimately be reproduced in multiple copies by commercial offset lithography. Knowledge of the printing process is necessary so that a desired mechanical can be created.

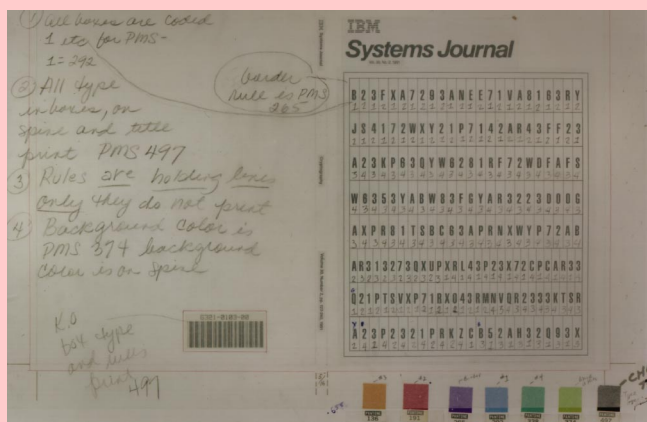
The mechanical is the precise guide, as specified by a publication designer. Usually it is a piece of smooth-finish illustration board that has rules (drawn lines) indicating size and crop, and it might include typography, a drawing, or a photograph. Anything pasted on the mechanical has to be of reproduction quality. If items are provided separately from the mechanical, such as artwork, a low-quality copy of the item is placed in the exact size on the mechanical with a “for position only” notation. Anything placed on the mechanical has to be totally clean and error free, as film and ultimately printing plates are created from the mechanical. In publication design there is a separate mechanical for each page.

For some instance where color printing is desired, black lines are provided on the mechanical with a production instruction to introduce color. Figure 1A shows an example of a black-line reproduction-quality mechanical. This is called *match color* printing and the colors are specified by noting PMS⁶ numbers. PMS colors are a recognized color standard in commercial printing, and the bottom of Figure 1A has swatches of the PMS colors requested for this design. Figure 1B shows additional instructions that are given (usually on a tissue overlay) for printing. Figure 1C shows how this design actually printed. In other instances, actual color art such as a photograph or painting is provided, and the artwork is produced by *four-color process* printing. Four-color process printing involves camera work to create separations that are four screened negatives. Each negative will be used to make a separate printing plate (one for cyan, one for magenta, one for yellow, and one for black). When printing is done, the four plates print sequentially in registration and the color art reappears. It should be noted that match color printing can also be done by configuring four-color process screens. For example, PMS 2708 (blue) could be specified as 34 percent cyan and 8.5 percent magenta for process printing. (The percentages given are screen values.) Both of these kinds of printing use photochemical processing.

Figure 1 (A) A traditional line mechanical with reproduction quality typography and PMS color swatches, (B) printing instructions on tissue overlay, (C) final printed cover



(A)



(B)



(C)

Table 1 Layout of images on the grid¹⁰

Visual Appearance	Explanation	Rule
Size	The layout of images is related to their size, i.e., all large images will not be placed together on the grid, so that the balance between them can be achieved in terms of size.	IF the size of the image is large, THEN do not place another large image next to it.
Contrast	Contrast of images in style, color, and value is the primary decision factor when placing images next to each other.	IF the color of the image is dominant in a color, THEN do not place another image with similar color composition adjacent to it. IF there is a small dark image on one corner of the layout, THEN balance the image by placing a large gray image in the opposite corner.

Traditionally, mechanicals were created using paper, ink, and repro galleys. Color art was provided as a separate item. Today, many designers use desktop publishing techniques to create mechanicals. Using desktop publishing, the typography, the artwork, and the printing instructions may all be included on an electronic computer disk that is provided to a prepress vendor. Also today, the emerging technology of digital-to-plate (DTP) allows the direct creation of the printing plate by eliminating the film-making step in the traditional photochemical process. At this time we are expanding our use of electronic text preparation and artwork to produce the IBM journals, but that work is not included in this essay.

When we speak in terms of the mastery of electronic tools for graphic design applications, the creative act of generating complex, high-resolution images for print in an electronic environment can be primitive and awkward for an artist or designer in comparison to the more traditional methods. By high resolution we mean a visual result of sufficient quality⁷ so that the tools used have not rendered the typography illegible, or so that the details of the art are not blurred. By more traditional methods, we simply mean the use of brushes, press type, and drafting pens that had become “tools of the trade” for graphic designers. Serious attempts at artwork in two or three dimensions can require not only very expensive equipment,

but a dedicated programmer or operator sitting beside the artist.⁸ True interactive visualization of final artwork or page layout coupled with planning and sketching is a profoundly desirable goal. These thoughts guided our experiments.

Use of a grid system

IBM publication layouts (specifically, those under the guidance of Musgrave⁹) are designed using a *grid* system. A grid system in publications means there are standard layouts used from issue to issue. Generally, use of a grid would include standard positioning of type, consistency in the number of columns used for typography in an article, the style of artwork used, the positioning of folios (page numbers) and footlines, as well as how many colors are used for printing. For example, the title of the publication would always be in the same place and in the same typeface from issue to issue.

There is a “rhythm” and “flow” that occurs when the viewer leafs through a grid-designed publication, which is due to repetition of style of typography and artwork. Grids contribute to repeated recognition, similar to the use of logotypes in corporate identification programs. Grids are advantageous because they do not require that individual pages be redesigned from issue to issue, which can be a time-saver when

Table 2 Selection of images¹⁰

Selection and Relation	Explanation	Rule
Selection	This rule can be implemented by keeping a log of all articles in a particular issue and their related images. Rules in the knowledge base that describe the content of pictures <i>and</i> articles will correlate the two and find the best candidate.	IF there is no image selected from an article, THEN select an image from the article based on the content and relation of images to the others selected.
	The content of the image should be a good representation of the internal content of the article.	IF the content of the image is a good representation of the article, THEN select the image, ELSE try another image from the article.
	The overall color should be “pleasing” to the viewer, i.e., an image with an overall “disturbing” color scheme will not be used on the cover—to avoid a disturbing feeling from the publication.	IF the color scheme of the image is acceptable, THEN select the image, ELSE try another image from the same article.
Color relation	The images selected should be mutually agreeable in color and produce appropriate contrast, i.e., images having a common color for their background will probably not work together.	IF overall color dominance is not similar and has the desired degree of contrast, THEN keep the selected images, ELSE reject the image that has least popularity OR change the color of the image.
	Change color	IF the image is photo of people, THEN only color of the surroundings may be changed. IF the image is an abstract illustration, THEN the color may be changed by specific rules entered by the expert.
Content relation	The content of the pictures should be of different kind, i.e., all images of only people, or computer images will project a monotonous look, but a mixture of above will make an interesting mix to provide a balance of content.	IF the number of images selected is less than or equal to the categories of content, THEN IF more than one selected image falls into the same category, THEN change the selection of the image from the same category of content to the one that has different content.
Style relation	A mixture of different style of images, i.e., photographic, sketches, paintings, line drawings, lithographs, etc., is desirable to get a mixture of styles.	IF the images are of a similar style and there exist more styles to choose from, THEN select an image from the style not already selected.
Image dominance relation	The images should have a variety to achieve a balance of visual style—the overall flow and curves, transparency of colors, and use of lines in a similar style should not be conflicting or repeated in the images.	IF images selected have a similar use of color, THEN select another image in the same context with a different color. IF images selected have similar lines of dominance, THEN select the image with a variety of dominance.

Table 3 Sizing and cropping¹⁰

Sizing and Cropping	Explanation	Rule
Sizing	The images with strong theme, details, etc., will be large, and those with relatively uninteresting detail will be made smaller.	IF the image has a strong theme, THEN make the image large, ELSE IF it is comparatively uninteresting, THEN make it small. IF the image has minute detail, THEN make the image large.
Cropping	The image will be cropped based on the content, its emphasis, and the grid proportions.	IF the image proportions are vertical, THEN size the area of interest and crop the image to 1:2 proportion. IF the proportion of the image is square, THEN crop the image to 1:1 proportion.

deadlines are important. Also, they can be economical because there can be standard pricing when services such as typesetting are purchased from vendor sources.

Once the grids are designed, creative time is spent on cover designs and individual pieces of artwork inside the publications. Mastering the use of grids is like mastering the use of the brush in Chinese painting—once the tool is mastered, the mind is free for creativity in areas that change from issue to issue.

Cover design layout

For our first example to be discussed, the approach for designing the cover of *Perspectives in Computing*³ was to use a grid to contain multiple pieces of artwork and ruled boxes separating those pieces. Along with the grid, rules for cover designs were created and placed into a knowledge base.^{4,10,11} The knowledge base consisted of design rules that the art director used for designing the covers. The rules applied to the selection, sizing and cropping, and the layout of the artwork. Software to implement the rules and apply the grids was developed by programmers in the VLW using the LISP programming environment with foreign-function interface to C graphics routines.¹² Each production rule in the knowledge base describes an inference that can be made about a specific situation. Table 1 shows examples of this. In Table 1, the rules discuss the laying out of selected images, taking into

consideration the visual quality of the image and the overall balance in the layout. The appearance of the image is more important than the content when laying out all the images together. The rules in Table 1 depend on the various ways that the images interact with one another in their visual quality.

This interaction of images is further discussed in Reference 10, and an example of a rule about repetition is: It is desirable to avoid repetition of a layout (but the integrity of the grid is maintained) so that each entity maintains identity in spite of having common origins in rules. This can be an integral part of the knowledge base, such that the expert system, having knowledge about the past solutions, can determine which layouts are repeats and avoid them.

Selection of images

To design a cover for *Perspectives in Computing*, all artwork that would be published with an individual article was looked at to determine if a single piece would be suggestive of the content of that article. The cover would consist of many images, where each article would have one image representing that article. The artwork was also looked at for its attractiveness. At the beginning stages of the cover design, more than one piece of artwork per article might be chosen for consideration. The final look of a cover for *Perspectives in Computing* was a mosaic of multiple pieces of artwork, and how the pieces “worked together” from a

Figure 2 Appearance of the computer screen with automatic layout options displayed

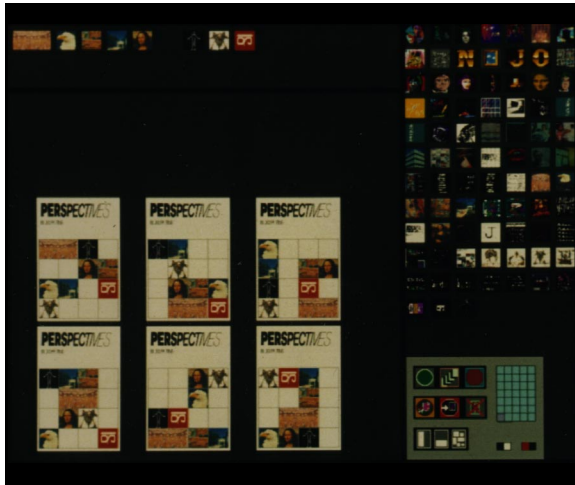


Figure 3 Automatic layout options that were considered bad designs



content as well as color point of view was important. Table 2 illustrates some of the rules for selection of images. The resulting cover reflects the editorial content of the issue with each article having equal importance represented by one image.

Sizing and cropping

Perspectives in Computing was illustrated by fine-arts style illustrators. Authors of papers did not request very many technical illustrations, so fine-arts style illustrations were commissioned to depict the article contents. For example, the style choices might be watercolor paintings, woodcut prints, oil paintings, or pen and ink drawings. The resulting artwork was sized and cropped for placement on the cover depending on the content or color of the artwork, and the grid proportion of the cover.

Design rules were used to determine the cropping and sizing. Table 3 contains some of the rules.

The design of the overall cover began with preparing the “mock-up” cover for an issue. Since the title of the publication was expected to become a logotype (a distinct graphic symbol), the graphic was scanned and placed into the working VLW environment. Also included in the mock-up was the proportioning of the cover (8 1/2" × 11"), and the ruled boxes (which changed in number and size depending on the issue artwork). All of the artwork that were candidates for

inclusion on the cover were then scanned and placed into an image library. The use of low-resolution images for this image library resulted in a more efficient and faster manipulation of the digitized data.

With all of the preliminary artwork selection and grid work completed, the interactive design of the cover began. Figure 2 illustrates what was viewed on the computer display—artwork was displayed as single miniatures on the righthand side; underneath them were icons (symbols) representing the grid proportions of the art area of the cover, and also icons for various functions that could be performed on the artwork. This screen view was both attractive to the user and functionally easy to follow—the result of work performed as part of other research projects¹³ at the VLW. For example, icons were used instead of words to describe functions such as “create a layout,” and colors were displayed as actual colors.

Individual pieces of artwork were selected with a mouse click from the image library and displayed (in an enlarged view) on the left side of the screen. Each piece of artwork could be cropped. For example, the original photo of an eagle that was scanned was actually the entire eagle, but the image was electronically cropped to feature just the head of the eagle. Color could also be added to the artwork, such as a red background added to a symbol. When needed, a paint program¹⁴ was used to alter any artwork that required adding color or altering the image.

At this point in our experiment, a discovery was made that the “documented rules” were giving options that resulted in artwork all jammed together based on color compatibility, but did not account for areas without art (negative space) in a manner that was visually pleasing (see Figure 3). The program was then reworked.¹⁵

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All of the layout options were shown interactively in real time, which may, interestingly enough, have contributed to the feeling of confusion. Also, a display screen large enough to show the image library, the command icon panel, the artwork to be used, and the layout options was needed, thus a 19-inch color display screen with 256 (8-bit) color capability was chosen.

IBM SYSTEMS JOURNAL, VOL 35, NOS 3&4, 1996

Figure 6 Sketches of ideas for the *IBM Systems Journal*, Volume 26, Number 2, cover art

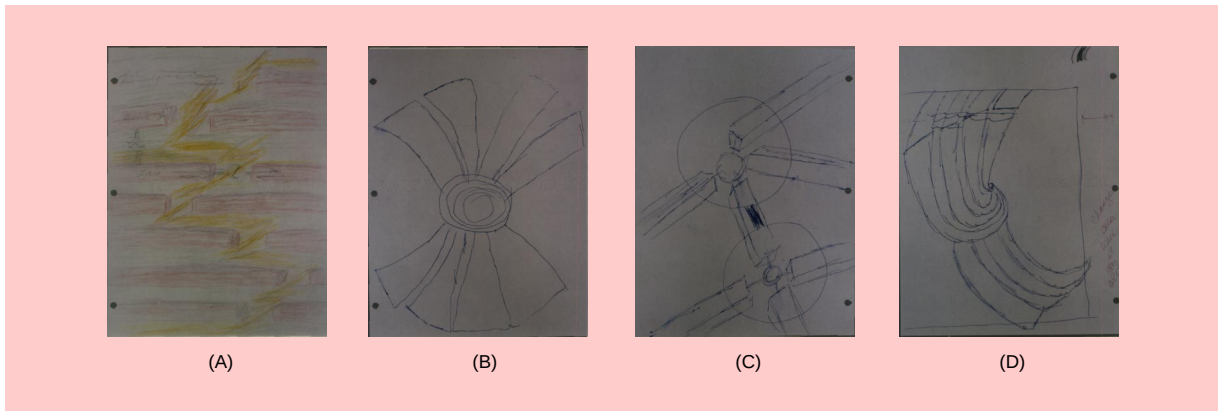


Figure 7 The cover of the printed *IBM Systems Journal*, Volume 26, Number 2

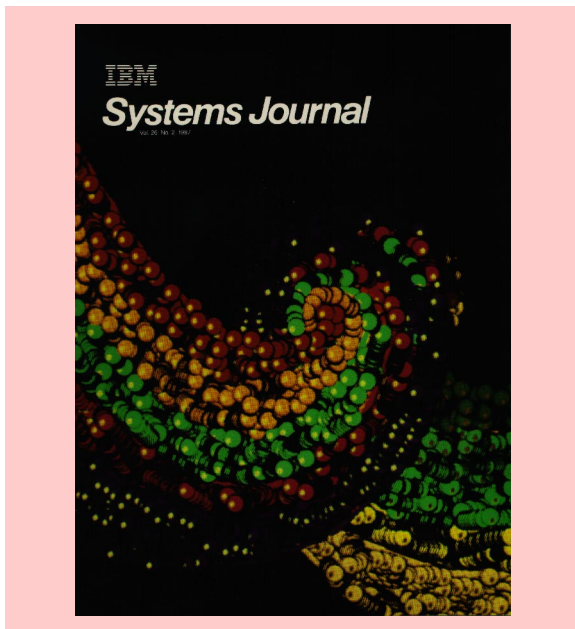


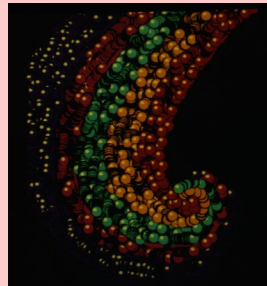
Figure 8 The sphere with its highlight, used as an electronic brush



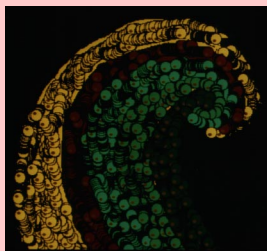
yet possible, to have the ability to view the automatic options and, at the same time, have the ability to bypass the system after an option was given that was “almost” acceptable. For example, the designer might want to move a single piece of artwork around after an option was created by the automatic layout.

The conclusion drawn from designing a cover this way was that this new electronic environment would save both time and effort on the part of the art director, would offer many more options than were previously considered, but would still leave the human creative decision-making process intact.

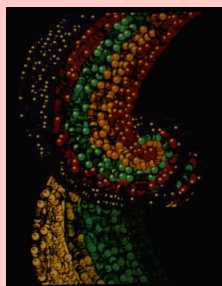
Figure 9 (A) The first shape created; (B) a mirror image of the first shape with color change; (C) the first shape merged with its mirror image, along with another color change



(A)



(B)



(C)

Cover art

Although the rules for designing the cover for *Perspectives in Computing* worked well for that publication, another publication, the *IBM Systems Journal*, had a different focus and audience, and thus a different design.

New cover designs. Cover designs for the *IBM Systems Journal* include publication information, such as the publication title and volume number, and a single piece of artwork that relates to the content of the issue (sometimes to a theme of an issue, or perhaps to an individual paper). Technical diagrams or charts that give precise data are not usually used on the covers, although the cover might contain an aesthetically altered version of a flowchart that suggested an idea. Our experiments created cover designs and posters. Computer paint programs, computer animation programs, and a mixture of these two that included typography were developed, along with a new set of rules.

Documenting the sketch process. After a cover topic for the *IBM Systems Journal* is chosen, hand sketches are usually made. Once the sketches are completed, some of the ideas are used to create the finished artwork. Figure 6 shows some sketches that were done by the art director as ideas for Volume 26, Number 2, of the *IBM Systems Journal* cover design. The cover was intended to symbolize gateways that transform protocols between networks. Figure 6A created the impression that this is a complicated procedure, but it is not, so “looser,” less complex sketches were done (Figure 6B, 6C, and 6D). Figure 6D had the most potential, since there was an appearance of something flowing to a central source, and the flowing image could be made to look like it changed or was transformed when it came out again from the center. In documenting this sketching process, we discovered it was very desirable to be able to look at two-dimensional drawings such as these, and then have them end up later in the process quite easily as “razzle-dazzle” three-dimensional works of art. A computer paint program¹⁴ was then used to create the final cover art, discussed next.

Computer paint programs. For the creation of the *IBM Systems Journal*, Volume 26, Number 2, final cover (see Figure 7), we chose an electronic *brush* because the “paint” used with the brush did not have to be traditional paint such as oil or acrylic—it could be something totally unexpected. What the brush uses for paint can be an object that will electronically

exhibit some of the traditional characteristics of paint, such as smearing, or smoothly filling an area with color.

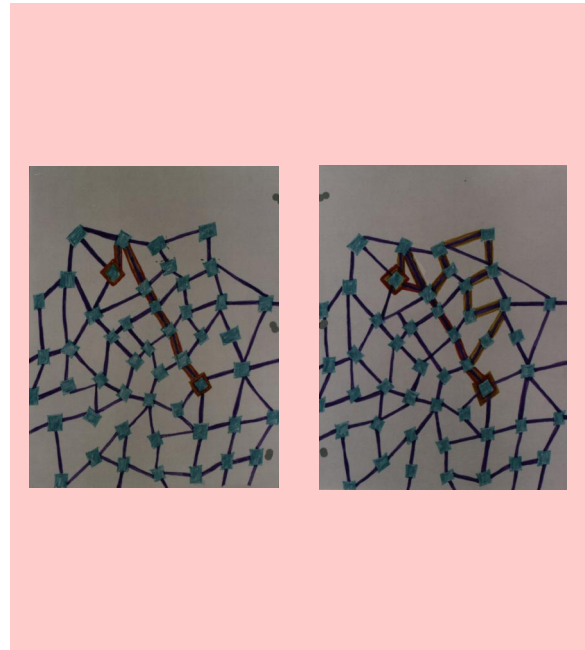
The paint in this instance was a sphere with a highlight (see Figure 8).¹⁴ When the sphere was moved electronically by the brush, it behaved similarly to paint. When moved fast, it began to lose its shape and fill in areas (like paint smears). When moved slowly it retained its shape (like dabbing paint, where the dab will retain the shape of the brush). The colors for the artwork were chosen from a color palette displayed on the screen. Figure 9A shows the first step that was created for this cover design. Using an icon menu command, the artwork could be flopped (mirror image), and the colors could be changed (see Figure 9B). This is similar to what might happen if a graphic designer sent a piece of artwork to a photographic laboratory and requested special processing. Figure 9C shows the original artwork merged with its mirror image along with two different color choices. This again might traditionally have been done by a photographic laboratory using special processing. The final artwork used to print this cover was a 35-mm slide that did not include the typography. The slide was made by photographing the display screen. The resolution of the screen was not of sufficient quality to adequately reproduce the type for inclusion in the photograph.

Working on this cover allowed the creative process to be explored as well as the use of a new tool that allowed real-time (and interactive) integration of processes that traditionally take days. In this instance the options were offered in a manner that did not seem confusing. Because the result was one piece of artwork, the real-time advantage contributed to keeping the creative momentum flowing.

Computer animation programs. The use of computer animation programs allows the designer to look at artwork from various angles. For the cover of the *IBM Systems Journal*, Volume 27, Number 1, an animation program¹⁶ was used.

For this *Systems Journal* cover, sketches were done by the art director (see Figure 10). The cover was intended to symbolize a very involved network that could very easily track and repair problems that it automatically diagnosed. Two-dimensional sketches were done, but a three-dimensional piece of final artwork was desired. After the sketches were completed, a paint program was used to create two separate views of a network, and then an animation program was

Figure 10 Sketches for the *IBM Systems Journal*, Volume 27, Number 1, cover art

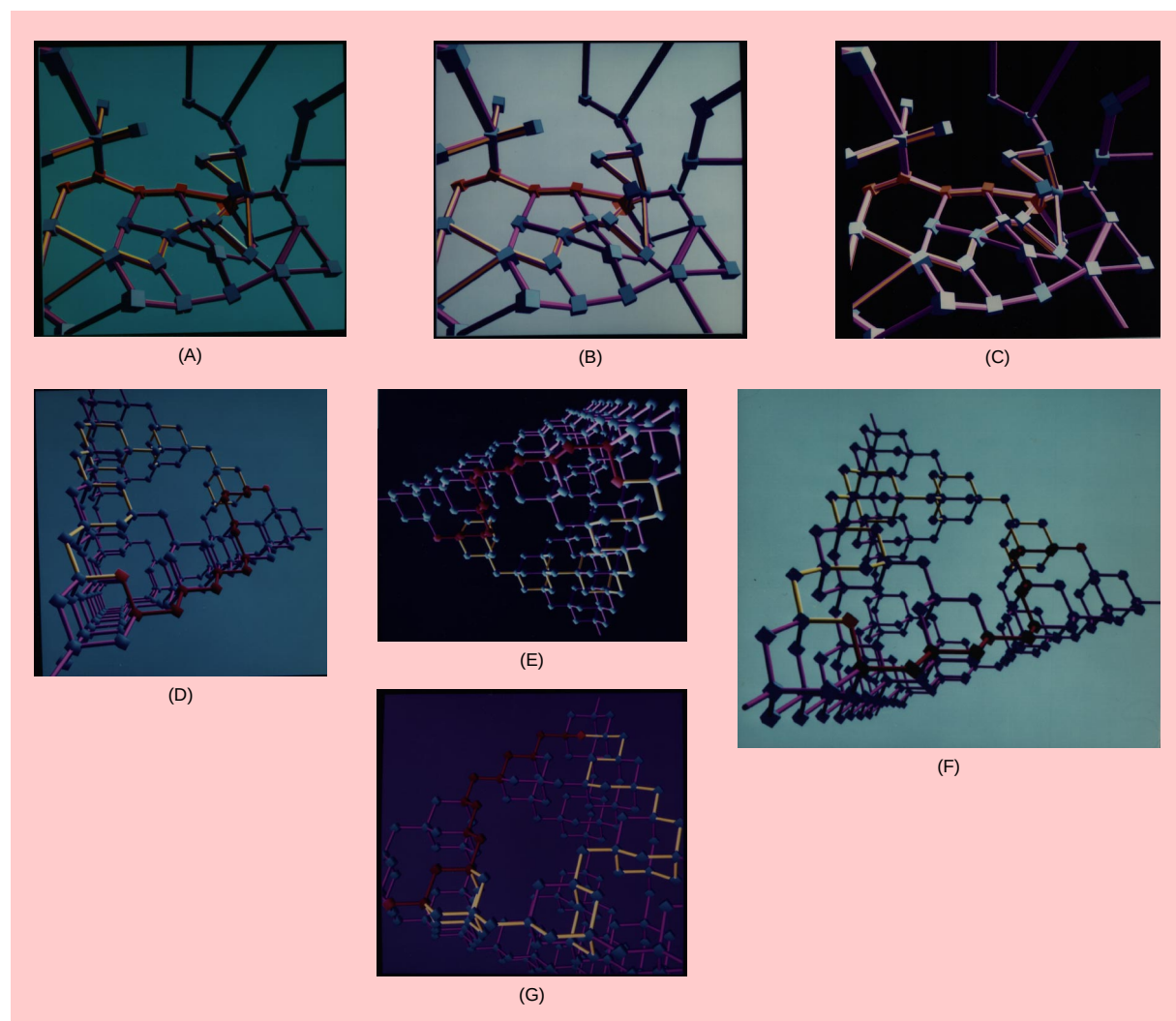


used to render the artwork in three dimensions, rotate it, and shade it using a light source from various angles. Also, because the artwork would be photographed from the display screen, antialiasing,¹⁷ or line smoothing, software was introduced so that a high-quality piece of reproducible artwork could be obtained. Figure 11 (A through G) is part of this series.

Both the paint program and the animation program had the capability to allow different color choices to be selected. The degree of color shading to the color choice depended on the previously calculated angle of the light source that could not be altered once the angle was chosen. Figure 11A was the chosen option for the cover of the *IBM Systems Journal*, Volume 27, Number 1 (see Figure 12 for the printed cover). Figure 11G was the selected option used to illustrate an article in *Perspectives in Computing*, Volume 8, Number 1.

With the use of the animation program, many more options than the original sketch could be explored. The network image could be viewed from a large number of different angles. This would have taken a

Figure 11 A series of options created as potential cover art for the *IBM Systems Journal*, Volume 27, Number 1



tremendous amount of time if all of these views had been prepared in more traditional ways, such as oil painting or air brushing. By “stopping the action” and using a “still” in the animation progression, a dynamic approach to looking at options was possible. The only drawback was that sometimes the shading appeared quite natural when the animation program was running; but when the “still” was taken and the viewer no longer had the action of the progression, the still no longer had the desired color choices. Again, the option to bypass automatic programs seemed desirable, since the color was only selected by auto-

mation dependent on the shading calculated from the angle of a specific light source.

Typography

The integration of typography into the design process is very necessary when ideas are being communicated for print applications. Typography can be static, such as columns of type that communicate in words, or evocative when its position or nature becomes expressive. Expressive typography is generally used in logos, posters, or cover designs.

An idea that explored expressive typography was a cover needed for the *IBM Systems Journal* that featured OS/2* and PS/2*, new products of IBM at that time. At first an abstract visualization of some of the technical concepts behind the OS/2 operating system or the PS/2 hardware was explored for the cover, but the decision was made to reinforce the words instead.

The text was prepared using outline fonts¹⁸ provided to the VLW, and the typeface Meridien Medium was selected as the font style. A paint program and a translucent color drawing program¹⁹ were also used to create an impression of technical as well as artistic design. The text OS/2 PS/2²⁰ was electronically superimposed on the background, and translucent painting was done electronically on top of it. By using the paint program, a portion of the art was highlighted and enlarged until the individual pixels were visible. Figure 13 shows what was created before we decided to use translucent digital painting. Figure 14 shows the actual cover for the *IBM Systems Journal*, Volume 27, Number 2, that was printed with the translucency. In the final version, the color rectangles around the artwork were introduced in the printing process.

Using these electronic tools, we were able to interactively explore options that would be prohibitively slow using traditional means.

The hardware and software environment

Two different system configurations were used at the Visual Language Workshop for these experiments. The hardware consisted of 68020 (15.7 megahertz) processors that included floating point processors. In one instance the processor was attached to a 1024 × 768 pixel frame buffer (or graphic display), and in another it was attached to a 1280 × 1024 pixel frame buffer with microcoded firmware. The firmware of the microcoded display processor had functions for Phong and Gouraud²⁰ shading of three-dimensional polygons including lighting and surface models. The 1024 × 768 pixel frame buffer had a color palette of 256 displayable colors (8-bit) out of a total palette of 16.3 million colors. The 1280 × 1024 pixel frame buffer had a color palette of 1.2 million displayable colors (24-bit) out of a total palette of 16.3 million colors. All work was stored locally, with 8 megabytes of local storage. The machines were linked in a local area network through Ethernet with 110 megabytes of local disk storage and a server with 1 gigabyte of disk storage. The UNIX** Operating System was used. The programming languages used were C, or a combination of C and common LISP.²¹

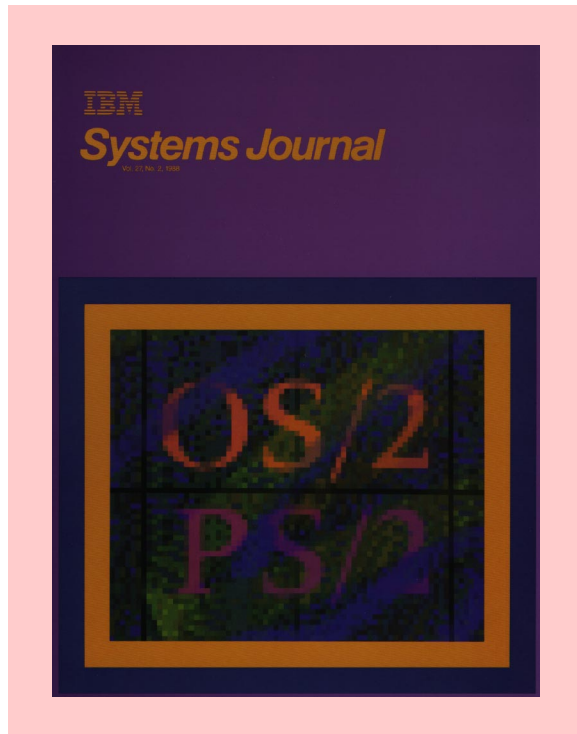
Figure 12 The cover of the printed *IBM Systems Journal*, Volume 27, Number 1



Figure 13 Artwork option created for the *IBM Systems Journal*, Volume 27, Number 2, cover art



Figure 14 The printed cover for the *IBM Systems Journal*, Volume 27, Number 2



Conclusion

The electronic environment, such as that described in this essay, offers a great many new options to graphic designers and art directors. Although some of these options may simulate traditional photographic or painting techniques, they can be offered in an almost instantaneous manner that is not possible by traditional means. As was also described, the ability to offer many options in an interactive session is highly desirable. It can be a cost saver, and it can expand the horizons of creative problem solving.

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Cited references and notes

1. J. F. Musgrave, "Experiments in Computer-Aided Graphic Expression," *IBM Systems Journal* 17, No. 3, 241–259 (1978).
2. The original contract for the EICON Project was funded by IBM Corporation, Thornwood, New York, from July 1, 1986, to June 30, 1988.
3. *Perspectives in Computing* was published by IBM Corporation from October 1980 until spring 1988.
4. Joan Musgrave, art director of IBM Corporate Technical Publications, participated in a case study on the layout of IBM's corporate technical publications, funded by HELL GmbH, at the Visible Language Workshop, Media Laboratory, MIT. She also conducted a design workshop on the covers for *Perspectives in Computing* at the VLW. There are written transcriptions, tape recordings, and videotape recordings of the sessions.
5. Chieh Tzu Yuan Chaun (1679–1701), *The Mustard Seed Garden Manual of Painting*. A facsimile of the 1887–1888 Shanghai edition with the text translated from the Chinese and edited by Mai-Mai Sze, Bollingen Foundation, was published by Princeton University Press, Princeton, NJ in 1978.
6. Pantone Matching System (PMS), Pantone, Inc., Moonachie, NJ.
7. Sufficient quality would mean a display that was at least 1024×768 pixels, or a printer that was at least 600 ppi.
8. Cynthia Goodman discusses this in her introduction to *Digital Visions, Computers and Art*, Harry N. Abrams, Inc., New York (1987).
9. One of the assignments of the art director of IBM Corporate Technical Publications was to redesign these publications to improve readability and enhance their visual attractiveness. The redesign work was done with a specific deadline. Originally, color printing for both publications was done only on their covers, and the *IBM Systems Journal* was much smaller in size. In the redesign, new grids were established, different type fonts were chosen, color was introduced to the inside of the publications, and the size of the *IBM Systems Journal* was changed. The *IBM Systems Journal* was redesigned in 1983, and the *IBM Journal of Research and Development* was redesigned in 1984. Joan Musgrave received awards from the Society for Technical Communications for both of these redesigns. She also received an IBM Corporate Division Award for the design of the *IBM Systems Journal*.
10. This work is documented in A. G. Badshah, *GRID—Graphic Intelligence in Design: An Expert Layout System*, M.S. thesis, MIT, Cambridge, MA (1987).
11. R. Greenlee, *From Sketch to Layout: Using Abstract Descriptions and Visual Properties to Generate Page Layouts*, M.S. thesis, MIT, Cambridge, MA (1988).
12. Hewlett-Packard Common LISP.
13. Funded by HELL GmbH and Hewlett-Packard Co.
14. Bob Sabiston: MIT class of 1989. Paint programs (in C): "Paintbox" (1986) and "NewPaint" (1988), MIT.
15. Russell Greenlee, student in master of science visual studies program, MIT, 1988, reworked the program.
16. "Animate" in C by Bob Sabiston, 1987–1988, MIT.

17. Antialiasing is the apparent smoothing-out of the “jagged” appearance of curved or angled lines or edges as they are displayed on a raster display screen, by any of several methods. One approach is to blur the edge by adding pixels of shades averaged between the object and the background colors.
18. Digital font data provided by Bitstream, Inc., Cambridge, MA.
19. “Scribble” was a translucent drawing program written by Russell Greenlee, student in master of science visual studies program, MIT, 1988.
20. J. D. Foley and A. Van Dam, *Fundamentals of Interactive Computer Graphics*, Addison-Wesley Publishing Co., Reading, MA (1982), pp. 498, 577–579, 582–583, and 619.
21. Hewlett-Packard UNIX version 6.0, and Hewlett-Packard Common LISP. Hewlett-Packard Series 9000, Model 350 SRX “Bobcat” Workstations. Equipment grants to MIT Media Laboratory by Hewlett-Packard Co.

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Muriel R. Cooper Professor Cooper was a professional designer, educator, and researcher whose commitment to computers and graphic design led to the founding of the Visible Language Workshop in 1975, of which she was director. She had a broad-based background in all forms of visual communication. Her work has been internationally acknowledged in innumerable exhibits and publications. Prof. Cooper’s design work in print includes over 500 books, over 100 of which have been awarded recognition in various competitions. The second AIGA Design Leadership Award was awarded to MIT for the design excellence of the MIT Press, Design Services, and the VLW, all of which she founded and directed. She coordinated the overall plan for VLW research and education that investigates the intersection of graphic design research and artificial intelligence. Her own research concerns were the qualitative graphic filtering of information in a dynamic electronic environment, the relationship of traditional design knowledge of electronic media and the evolution of a new graphics design language for the new multimedia electronic medium. Muriel Cooper died in 1994.

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