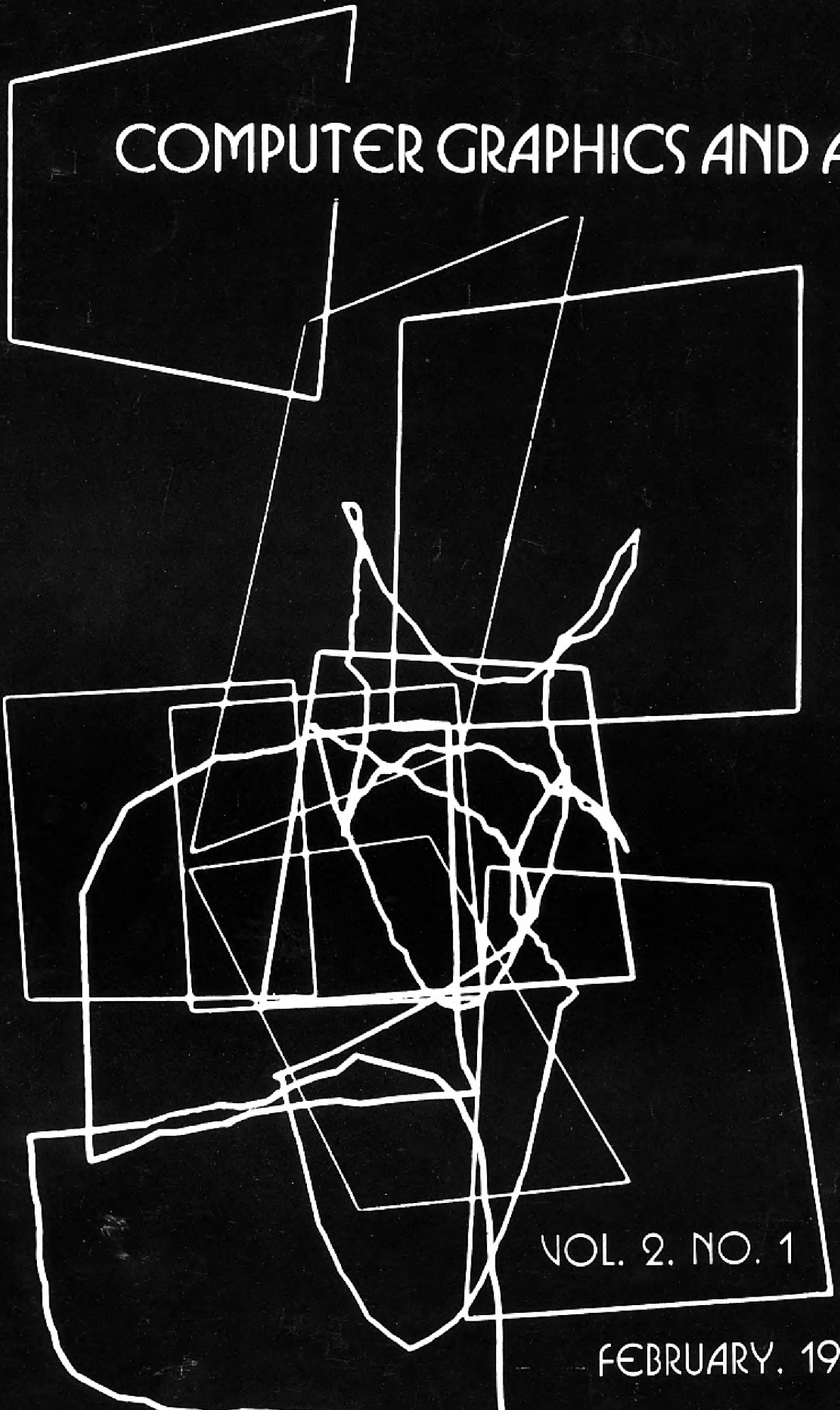


# COMPUTER GRAPHICS AND ART



VOL. 2. NO. 1

FEBRUARY, 1977

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 Berkeley Enterprises, Inc. -  
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COMPUTER GRAPHICS & ART is published  
 quarterly, 4 issues per year. Printed  
 in the U.S.A.

#### ANNUAL SUBSCRIPTION RATES

Personal, U.S. & Canada, \$10 per year  
 Personal, Foreign, \$13 per year  
 Library, Departmental, \$15 per year  
 SUBSCRIPTIONS ARE ON A PREPAID BASIS.  
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THE MAGAZINE OF INTERDISCIPLINARY COMPUTER GRAPHICS FOR  
 PROFESSIONAL GRAPHICS PEOPLE AND COMPUTER ARTISTS.

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 Paris, France
- 3 - EDITORIAL - "A Call for Graphics Curricula"  
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 graphics courses to a Graphics Center at Chico.)
- 4 - ANNOUNCEMENT - COMPUTER GRAPHICS AND ART  
 (Renewal notice -- CG&A begins Volume 2.)
- 5 - DIAMOND THEORY  
 by Steven W. Collinane, Jamestown, New York  
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 thematics for use in the varied computer arts  
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- 8 - GRAPHIC TECHNOLOGY AND THE DISPLAY OF SPATIAL DATA  
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 definitions, storage, hardware and software  
 problems, trends are reviewed in depth.)
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 (The history of digital plotters is discussed,  
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 University, Chico, California  
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 this large industry. Examples of present, new  
 knitted and woven automated systems are illus-  
 trated. Analysis of input, output, storage  
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 tion of new heat transfer, laser scanning sys-  
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 studied.)
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- 35 - ANNOUNCEMENT - COMPUTERS AND PEOPLE
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 Paris, France

NOTES ON THE COVERS: Illustrations are produced by mani-  
 pulation on a CRT screen (IBM 2250) from a pattern of two  
 equal squares, programme, "MOLNART 1." They are from a  
 June, 1976 Exhibition by the artist at the Polytechnic of  
 Central London.

# EDITORIAL

## A CALL FOR GRAPHICS CURRICULA

### Background

No doubt early man invented many personal sounds and symbols to express ideas about relationships, experiences, and the world. Each man expressed life in unique and idiosyncratic forms, unintelligible to others. Man lived in a "partially" understood world. Each person re-invented the wheel of symbol formation and communication ...until people became wise enough to agree to use mutually agreed upon symbols for specific meanings. This agreement to form a foundation of communication between people became the cornerstone for new growth in understanding and achievement. This foundation became the source of new forms of symbol communication that included mathematics, science, art, music, and other natural languages. This agreement of communication between people gave rise to synthetic, computer languages and systems.

### Objectives of CG&A

This magazine was formed to provide useful, stimulating information for professional graphics people. It was also formed to allow people to publish their innovative ideas, and thus establish their territorial credits for specific techniques and materials. With publication of these materials, the originator receives professional credit, allowing wide dissemination of information to others. In accord with these concepts, the articles in CG&A are seeking fuller technical development of presentation, thus conveying more useful information.

### The Need for a Graphics Curricula Center

There is a need for a GRAPHICS CURRICULA CENTER. At present many institutions offer varied courses in computer graphics. These courses are aimed at specific groups of students, and they focus upon stated objectives, with unique approaches and techniques, utilizing varied languages, hardware and software systems. These courses are the result of extensive time and effort on the part of the originators.

Too often, at national and international conferences, there are obvious "re-inventions of the wheel" by unknowing persons, who have poured their efforts into areas already highly (and satisfactorily) developed by other professionals. How much more can be achieved in computer graphics if professional graphics people work together to form a communications foundation, exchanging syllabi, references, etc.

Funding for this GRAPHICS CURRICULA CENTER is currently being sought. The Department of Computer Science at California State University, Chico, is willing

to be the site of that information center.

### Functions of the Center

A REGISTRY OF COMPUTER GRAPHICS COURSES will be established (alphabetically by state and institution). It will include:

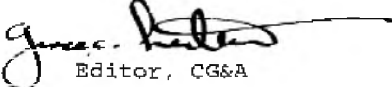
- Title of the Course
- Name and Address of the Originator
- Catalog Description of the Course
- References, Teaching Materials Used
- Class Level, Number of Students
- Institution

In addition, the interdisciplinary graphics references now available will be put on a text editing system, and updated periodically, using professional volunteers. (See the February, 1976 issue of CG&A.)

### A Call for Participation

This is an invitation to participate in this GRAPHICS CURRICULA CENTER. Your ideas are cordially invited. With this useful information center for graphics people, communications between people will be enhanced, and the state of the art will proceed quickly beyond the present, afforded by the foundation of knowledge of professional people. Publication of syllabi will occur periodically in CG&A and in Computers and People, an international monthly magazine, now in its 26th year of publication.

With your help, this information center can become a reality. Together we can revitalize research, teaching, learning, and the wide and wonderful world of computer graphics.

  
Editor, CG&A

NOTICE: The exhibition, "The Varied Computer Arts" is still in the funding, formation stage. A roster of invited participants has been made. Dimensional works are particularly sought, along with new computer art in varied art forms. Please write the editor if interested. Our anticipated opening is in August, as part of ICCH/3 in Canada - then touring the U.S.

For more details, see the August, 1976 CG&A and the August, 1976 Computers and People Annual Art Issue.

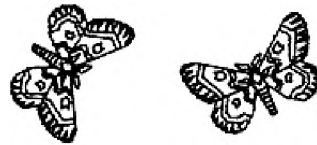
ANNOUNCEMENT: The May, 1977 issue is now in process. Please send your materials by March 13 for the May issue. Contributions for the August issue are due by July 1. Particularly sought are more technical ideas, with illustrations. Send an abstract if desired, for discussion.

# IT'S RENEWAL TIME - CG&A GOES INTO VOLUME TWO

## COMPUTER GRAPHICS AND ART



*COMPUTER GRAPHICS and ART* is a new international quarterly of interdisciplinary graphics for graphics people and computer artists. This new periodical is aimed at students, teachers, people from undergraduate and graduate institutions, researchers, and individuals working professionally in graphics. Its topical coverage is broad, embracing a variety of fields. It is useful, informative, entertaining, and current.



Send your manuscripts, papers, art, and ideas to:

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### Here Are Some Samples:

#### Learning Through Graphics

by Dr. Al Bork, University of California, Irvine, California  
A ten-year forecast for computers, education, and graphics by a leading authority.

#### Art of the Technical World

by Dr. Herbert Franka, Munich, Germany  
Computer art as the bridge between the two realms of art and leisure.

#### Expanding the Graphics Compatibility System to Three Dimensions

by Richard F. Puk, Purdue University, Lafayette, Indiana  
Design considerations for a user-oriented 3-D graphics system.

#### A Personal Philosophy of Ideas, New Hardware, and the Results

by Duane Palyka, University of Utah, Salt Lake City, Utah  
The frame-buffer from Evans and Sutherland allows the artist to treat the computer as a paint and brush medium.

#### How to Build Fuzzy Visual Symbols

by Alex Makarovitch, Honeywell Bull, Paris, France  
A new approach to computer art and graphics by a computer scientist.

#### The State of the Art of Computer Art

by Grace C. Hertlein, Editor  
Comparisons of early computer art and today's newer art. What is art? What is art in computer art?

#### Inexpensive Graphics from a Storage Cathode Ray Tube

by Charles J. Fritchie and Robert H. Morriss, Tulane University, New Orleans, Louisiana  
Illustrations and photographic techniques used to achieve graphics from a storage tube CRT.

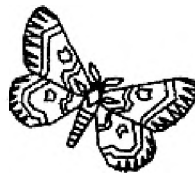
#### An Investigation of Criteria for Evaluating Computer Art

by Thomas E. Linehan, Ohio State University, Columbus, Ohio  
The new aesthetic of computer art requires a departure from the previous, formalist-traditionalist doctrines for evaluating art.



### List of Coverage for Up-Coming Issues

Applied Arts and Graphics  
Architectural Graphics  
Cartography Systems  
Computer-Aided Design  
Computer Assisted and Managed Instruction  
    Utilizing Computer Graphics  
Computer Graphics in Physics, Chemistry,  
    Mathematics, etc.  
Computer Programs for New Applications  
Display Systems and Graphics  
Fine Art and Media Explorations  
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Hardware Systems and Graphics  
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Syllabi for Computer Graphic Courses



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- I am particularly interested in coverage of the following subjects: \_\_\_\_\_
- I would like to receive materials on other Berkeley Enterprises, Inc. publications:  *COMPUTERS and PEOPLE*  *The COMPUTER DIRECTORY and BUYER'S GUIDE*  *People and the PURSUIT of Truth*  *The Notebook on COMMON SENSE and WISDOM*  *WHO'S WHO in COMPUTERS and DATA PROCESSING*  Books
- I am interested in:  black and white computer art reprints at low cost (a bonus for subscribing to CG&A)  77 page FORTRAN IV art manual  45 page interdisciplinary graphics bibliography by G. Hertlein
- Additional Comments (attach another paper if needed): \_\_\_\_\_

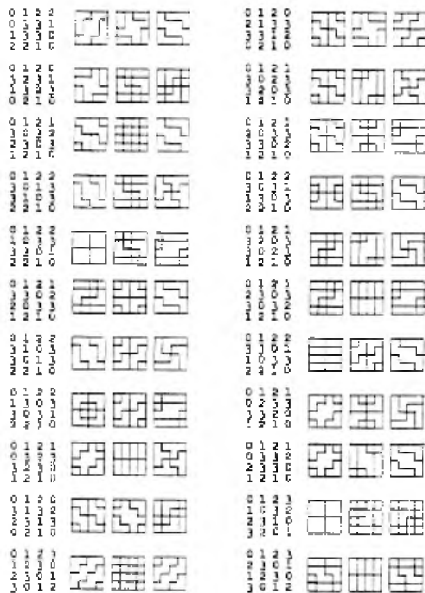
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# DIAMOND THEORY

by Steven H. Cullinane  
134 Huxley Street  
Jamestown, New York 14701

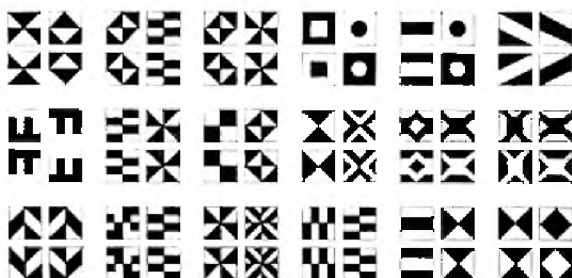
The following illustrations and notes are from the paper, "Diamond Theory," a method of achieving innumerable designs from mathematics. The artist may then choose from the designs to make use of them in paintings and sculpture.

The paper is a technical mathematical work, very heavily illustrated, copyrighted by the author, and available from him for \$2.00.

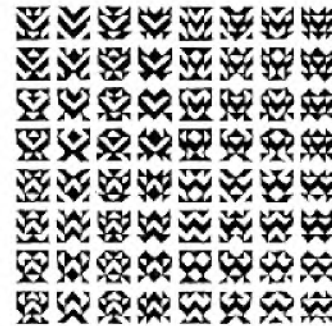


ABOVE: List of foursquares and their block maps. The illustrations shown above are but a few of those generated by the author's system.

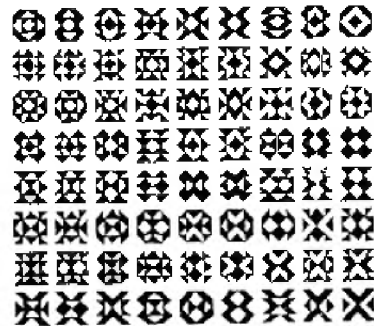
BELOW: "Alternate Designs for Faces of Cubes in a Movable Sculpture" by Steve Cullinane. [These and the designs used in "Design for a Movable Sculpture" are examples of "good sets" of geometric figures.]



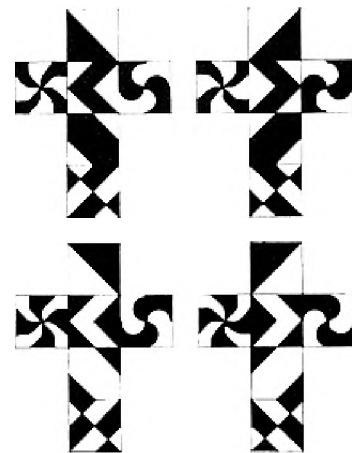
BELOW: Sketch for a painting of the normal diamonds with orbits that are arrows.



BELOW: Sketch for a painting of the normal diamonds with orbits symmetric under H and under V.



BELOW: "Design for a Movable Sculpture." The sculpture consists of 16 cubes -- four copies of the four cubes below -- arranged in a 4x4 plaid matrix, so that permutations of rows, columns, and quadrants, along with rotations of the cubes show different sets of faces, yielding a variety of regular geometric matrices.



sculpture © 1976 Steven H. Cullinane

**DEFINITIONS:** The set  $F$  from which the  $n^2$  entries of an  $n \times n$  matrix  $M$  are drawn we will call the set of elements of  $M$ . For conciseness, by a permutation  $p$  of the elements of  $M$  we will mean, according to context, either a permutation on  $F$  or the transformation of  $M$  to a matrix  $M_p$  that it induces. For example, taking  $F = \{0, 1, 2, 3\}$  and  $M$  as shown,  $p(01)$  induces the following transformation:



Note that the entries of  $M$  occur within a lattice of squares. We will continue to view matrices in this way, whether or not the lattice is shown explicitly.

We now substitute for the elements of  $M$  the four triangular half-squares (which we will call simply triangles) in this order: (ILLUSTRATIONS AT RIGHT.)

The diamond-like matrix  $D$  at right is the result of this substitution.

Copyright © 1976 by Steven H. Cullinane.

**FACT --**  $D$  has the following properties:



(1) Any matrix (i.e., geometric figure) obtained from  $D$  by a permutation of elements is either symmetric or self-complementary (black and white interchanging) under some rigid motion of the square.



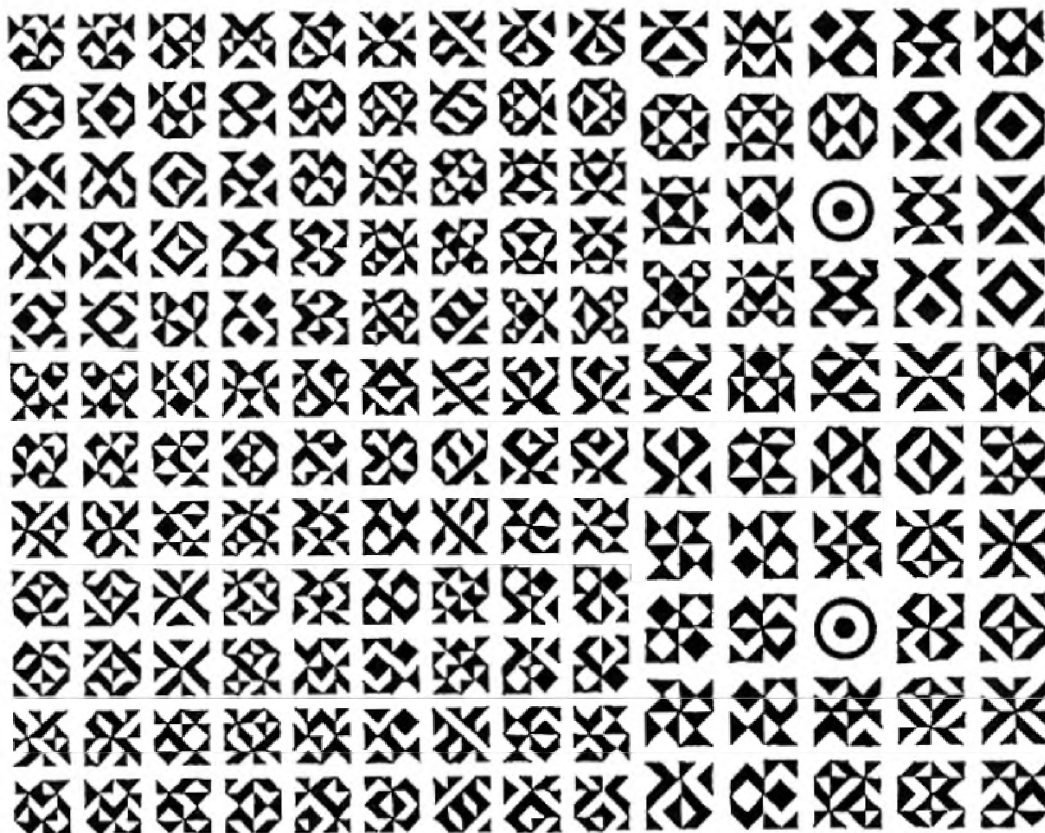
(2) Any matrix obtained from  $D$  by a row-column permutation (one of rows and of columns) is also symmetric or self-complementary.




(3) The same is true for permutations of quadrants (the sub-squares obtained by bisecting a square along each median).

(4) The same is true for any combination of the three sorts of permutations mentioned above.

**NOTE:** For complete details of this system, see the paper, "Diamond Theory," available from the author.

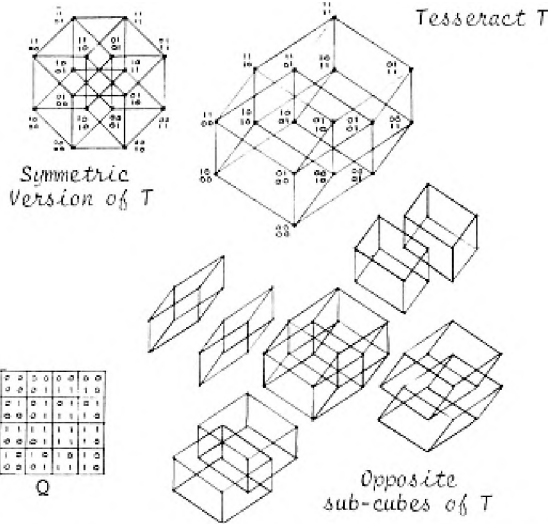


At right, the half-squares: 

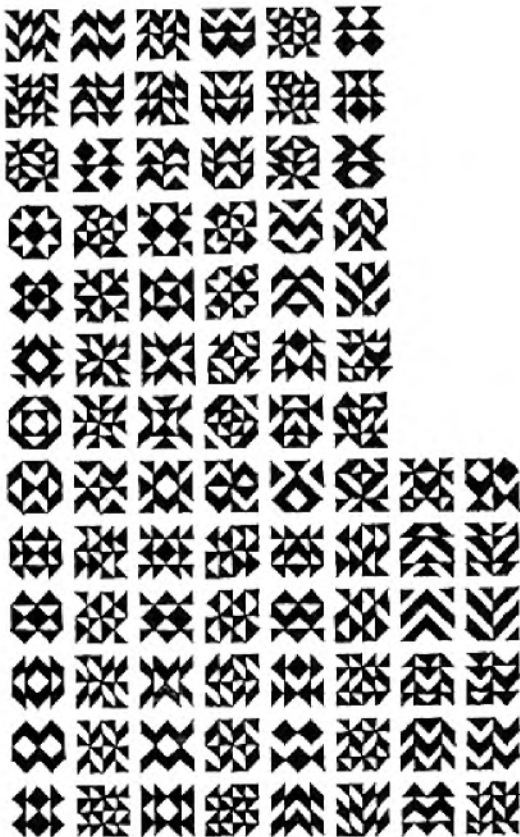
**ABOVE:** "Canon" by Steve Cullinane shows the subtle interrelationships and symmetries existing among the 156 distinct (in the sense that none can be obtained from another by a rotation in the same plane) figures formed by using the four triangular half-squares as elements of  $4 \times 4$  Latin squares. At right is an illustration of the half-squares.

A Latin square is an  $n \times n$  array of  $n$  types of elements with each element appearing exactly once in each horizontal row and exactly once in each vertical column. The "eyes are there to fill out the spaces that would otherwise be empty."

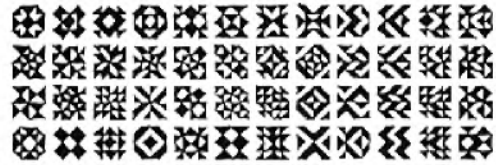
Note: In analyzing the structure of a 4x4 matrix, the tesseract (i.e., hypercube) T at the right below is sometimes useful. Note that T is the diagram showing partial ordering, by inclusion, of the subsets of a four-element set. If the matrix Q at the right is considered as drawn on a torus, then entries of Q are adjacent if and only if the corresponding vertices of T are. The entries in a row, column, or 2x2 submatrix of Q correspond to the vertices in a parallelogram in the drawing of T.



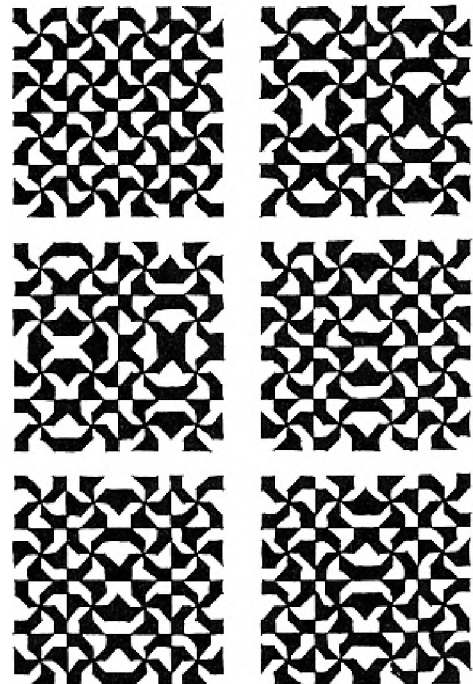
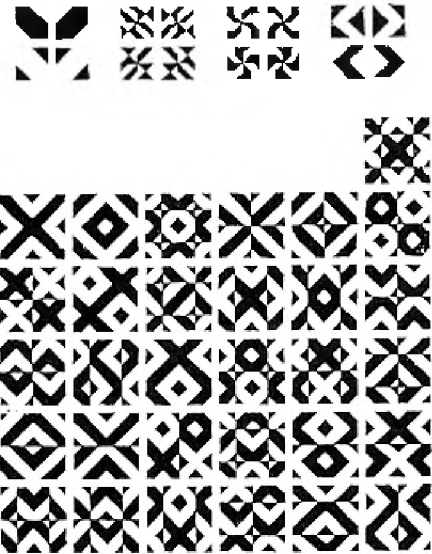
BELOW: Additional illustrations of the half-square diamond manipulations and resultant designs.



BELOW: Sketch for a painting of the diamonds derived from "star" foursquares -- those that yield wholly symmetric diamonds, among others.



BELOW: "Some Geometric Matrices other Than Diamonds." Examples are quadratic matrices, modulo complementation and symmetries of the square, formed from the following good sets of figures:



# GRAPHIC TECHNOLOGY AND THE DISPLAY OF SPATIAL DATA

Prof. Eric Teicholz  
Laboratory for Computer Graphics and Spatial Analysis  
Graduate School of Design  
Harvard University  
Cambridge, Massachusetts 02138

"There are still many problems that need to be solved before automated cartography reaches its potential...It has been estimated that it will take ten years or longer for most potential U. S. users to acquire and have integrated general mapping systems."

## ABSTRACT:

This paper will explore three aspects of computer graphic technology. The first part deals with a special type of graphic data - spatial data. The section will include a definition of spatial data, how it is used for a variety of automated mapping applications,<sup>1</sup> and various technical issues that relate to its capture (encoding), storage, processing and its soft (CRT) and hard display. Part II will discuss graphic hardware technology as it relates to issues of spatial data and Part III will describe some hardware and software problems that are not yet solved and trends that are taking place in the development of the technology and applications and systems software to support mapping applications.

## PART I: THE ANALYSIS AND DISPLAY OF SPATIAL DATA

A spatial datum, called a geographical entity, is a special piece of statistical information: one that has a location identifier. The statistical description is a list of attributes of the entity being described and the values associated with the attributes. The location description of the entity is the representation of its location at some point on the earth's surface.

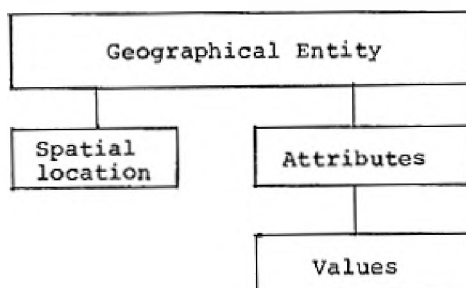


Figure 1: Geography Entity

## Data Referencing

Geographic entities can be referenced using a variety of geocoding (geographic encoding) systems. All systems (except for the regular grid) are based on a system of cartesian coordinates. Of the nongridded systems, there are both planar and terrestrial classifications.

Planar systems treat the earth's surface as being flat. This usually proves quite satisfactory for small-scaled measurements but does not work well for large distances. To get around this problem, many different "localized" planar systems have been developed which only leaves the problem of integration. Fortunately, there are standards for this in the United States. The U.S. Coast and Geodetic Survey (USGS) has worked out, for each state, a referencing system called the State Plane Coordinate System which divides the U.S. into approximately 120 zones.<sup>2</sup> Boundaries between systems usually occur along minor civil divisions and conversion formulas from one State Plane System to another are well worked out.

Terrestrial (Geodetic) systems use three-dimensional coordinate systems usually based on latitude and longitude measurements. Most geodetic systems use an ellipse as the 3-D model of the earth. Based on location and the desired application, various agencies will use different major and minor axes of the ellipse to give a better and more accurate spatial representation. In general, terrestrial referencing systems are used whenever accurate computation of spatial distances and areas is required.<sup>3</sup> Computer programs exist for converting from one system to another.

NOTE: This paper was originally presented at the WESCON Conference, Los Angeles, California in September, 1976. Eric Teicholz is an Associate Director, Laboratory for Computer Graphics and Spatial Analysis, Harvard.

Grid referencing systems, as can be imagined, are quite straightforward and provide a facile means of operating on the data - especially for overlay operations. Unfortunately, grids are not without their problems - especially in the areas of encoding, accuracy, storage and their "intractability". Encoding of either regular or irregular grids is technically straightforward. The encoding problem relates only to the amount of data that must be collected (usually for every matrix cell) even if the data are sparse. The accuracy of a grid is clearly not as great as planar and terrestrial systems. If a fine mesh is selected, the encoding problem usually becomes too tedious to be practical. The storage requirements of grids are also great. You will therefore find, for example, that most raster scanning input systems will vectorize the bit maps before passing on the data for subsequent storage or processing. The intractability of a grid relates to the inflexibility of changing from one grid mesh scale to another and the difficulty in changing scale once a unit cell has been selected.

### Spatial Data Operations

No matter what referencing system is used for the encoding of a geographic entity, the data must still be stored and manipulated before being displayed on a CRT or hardcopy is generated. For one thing, "header" information must often be entered along with the coordinates themselves. Headers will often contain data about the coordinates (such as the type of cartographic or topographic feature represented), the number of points that make up a line, the accuracy of the data, "neighborhood" relationships (used in topological data structures), chaining information and other pertinent data that depends on a particular application.

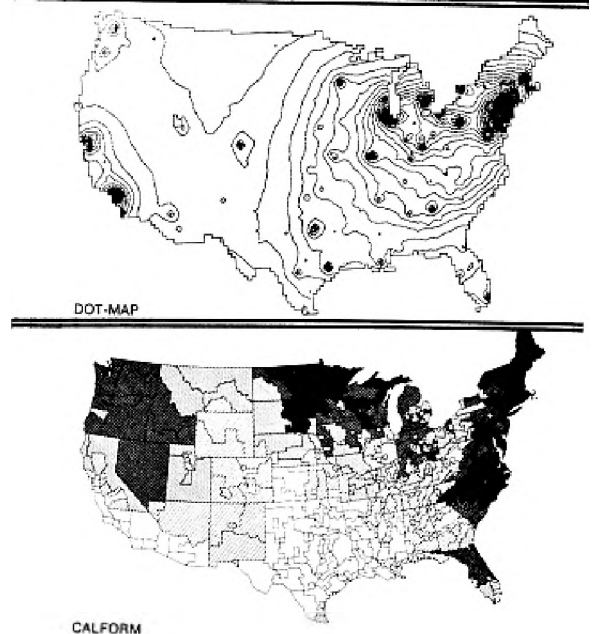
Error checking is another operation that must occur after encoding and before display takes place. Typical errors that occur with spatial data include nonclosure of polygons, T-sections that overlap, lines that don't join and "parallel" lines not being completely parallel. Error correction is an extremely tedious task associated with automated map making. The most successful solutions involve using the computer to find and correct the errors whenever feasible. Subsequent error correction is best accomplished using an interactive graphic (usually mini-based) processor and CRT to find the errors and then, using a "menu" containing such commands as "join", "add", "subtract", and "delete", correct all the possible errors that can be manually detected.

AT RIGHT: Illustrations from the Lab-Log.

Automatic error correction is intrinsically delimited by the encoding and internal data structure. At one extreme is a bit map or vector file that enables a processor to perform only hardware (parity) error verification. Perhaps another extreme is represented by the Census Bureau's DIME (Dual Independent Map Encoding) file topological data structure which uses a redundant set of encoding features to enable several accuracy and completeness checks to be performed by computer.

There will also be data compression and data packing operations that should take place because of storage benefits. These include the compression of data into binary words and line data filtering or generalization to simplify the data.

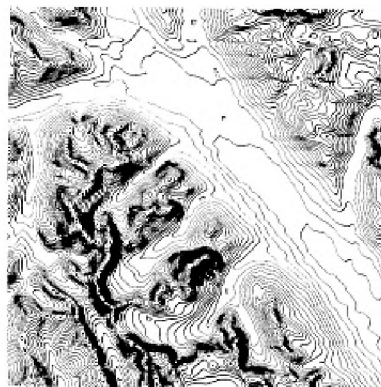
The scaling of cartographic data consists of the selection of an appropriate data scale, simplification and/or displacement. Simplification of geographic entities relates to the determination of how features that cannot be presented in full detail should be generalized when displayed at a smaller scale. This is often done by smoothing if a linear symbol is being presented. Displacement relates to the operation performed when two or more symbols overlap with each other. Rules for displacement are often sophisticated and require a great deal of processing. Once again, the best working environment seems to be an interactive CRT work station where the map maker will manually manipulate features. Transformational manipulations are relatively straightforward and relate to x-y or x-y-z data translations. In general, mapping transformations will include angular, area, distance and direction alterations.



## The Mapping Process and Classifications

BELOW: Illustration from International Technology Marketing, Newton, Mass.

The next question to address relates to map classifications and their characteristics. Mapping, whether manual or automated, can be considered a five-stage process. Maps are a reduction of some quantitative or qualitative attribute that has a geographical location (a geographical entity) so scale determination becomes important. One must decide for what purpose the map is being used so that communication of information becomes important. Maps are also a generalization of reality so one must therefore select what information is to be generalized. One must also select the graphic characteristics ("cosmetics") of a map such as legibility functions, symbolism, and notation. Finally, there is the physical construction or display of the map by either automatic or manual means.



Yoeli<sup>4</sup> distinguishes between "basic" and "derived" maps where basic maps represent a one to one mapping of original data surveys, and derived maps are produced as a result of compilation, simplification and generalization of basic maps.

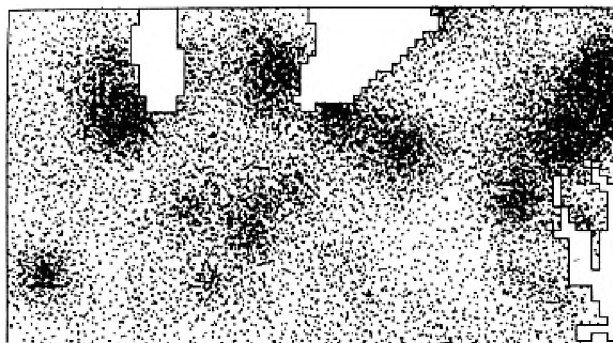
the particular feature represented such as a contour, a utility pole, or a transformer location. A planimetric map, often produced by civil engineers and surveyors, is a type of topo map but without the addition of measurable relief features such as contours to show mountains, valleys and plains. Thematic maps emphasize a feature or attribute rather than an x-y location.

A second classification of maps relates to topographic and thematic map types. A topographic map is usually constructed from a Digital Terrain Model (DTM) and presents the horizontal and vertical positions of

A matrix chart of map types versus attributes is shown below and indicates, on a relative scale of one (least or simplest) to ten (largest or most complex), requirements for each of the classes of maps.

	Thematic		Geographic Information System	Topographic		
	Social	Environmental (Land Use)		Planimetric	Utility/Engineering	Topo
Resolution	3	6	5	9	8	9
Data Base						
- Complexity	6	6	7	2	3	5
- Bulk	4	7	9	8	8	10
Size of Current Market	7	8	2	10	8	10
Growth Potential	6	7	10	7	8	2
Users - Real No. of	7	5	1	8	4	10
Producers	9	6	1	7	3	1
State of Automation	9	7	1	4	8	3
Digitizing Complexity	6	5	9	4	7	2
Amount of Data Manipulation (Application Level)	8	6	8	3	4	3
Am't of Graphic Manipulation	5	4	3	7	7	7

Figure 2: Mapping Classification/Attribute Matrix<sup>5</sup>



DOT-MAP

No matter what the map classification, a display program must map points, lines or areas. Dot maps use point symbolism to represent any real or conceptual quantity. A program will assign a unit value to some point symbolism and locate this symbol on a map. Dot maps involve design issues such as the magnitude, size and placement of the dots. The figure on the right is from the Laboratory's interactive DOT.MAP<sup>6</sup> program which displays, within the area of each matrix cell defining the study area, a number of randomly-distributed dots proportional to the cell's attribute value. Smoothing and interpolation of the input data may be performed as well as arithmetic manipulations of the data matrix (scaling by factors and powers, simple growth projections).

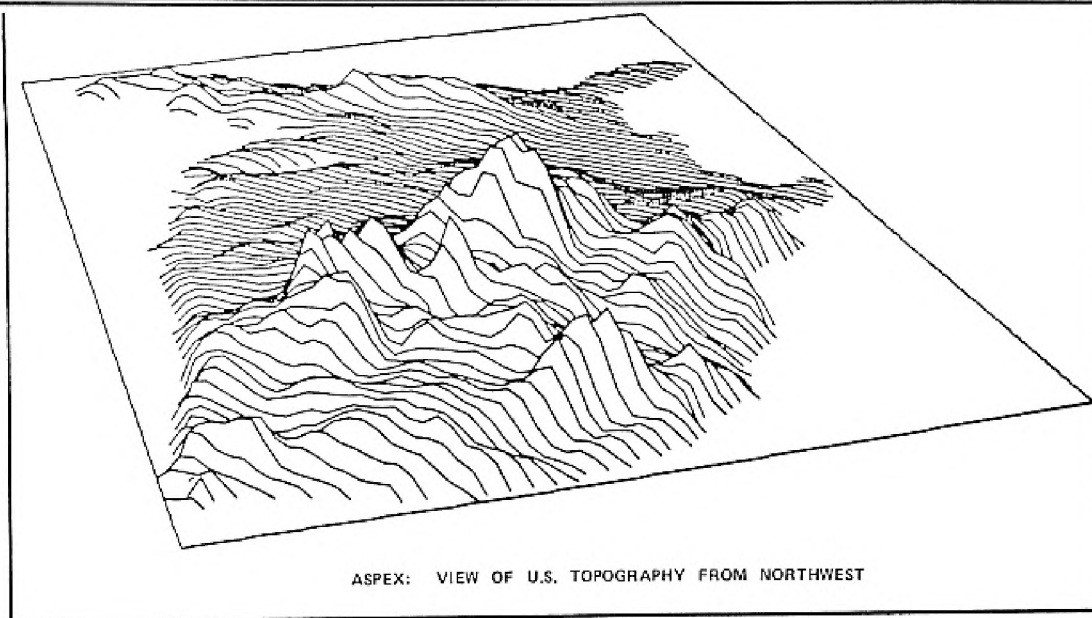
Linear data is displayed using line symbology - usually with flow maps that show linear movement by either symbolizing direction and frequency by means of lines (usually with arrow-heads) or by those that portray varying amounts of flow by varying the width of the line.



ABOVE: River Gorge and Environs: SOLARE Terrain Model represented with Dot-Map.

Figure 3

The mapping of qualitative and quantitative area and volume data will use colors and/or textured patterns to represent spatial attribute values. Statistical surfaces have data attached to geographic locations. Representations of this data can be done in two or three dimensions. Examples from the Laboratory's interactive ASPEX<sup>7</sup> 3-D surface mapping and INPOM<sup>8</sup> 2-D thematic mapping programs appear below.



ASPEX: VIEW OF U.S. TOPOGRAPHY FROM NORTHWEST

Figure 4a: ASPEX Output

# CONTERMINOUS UNITED STATES

OUTLINES DERIVED FROM U.S. COUNTY DIME FILE

DETAIL LEVEL = 7

STATES RANKED IN ALPHABETIC ORDER

STANDARD SHADING  
THIS MAP SHOWS THE 10 LEVELS  
OF STANDARD SHADING STORED BY INPOM.  
SYMBOL SHADING USING THE CHARACTER X  
HAVE UP LEVELS 1 THROUGH 5. CROSS-  
HATCH SHADING USING LINES AT 45 DEGREES  
AND 135 DEGREES HAVE UP LEVELS 6-10.

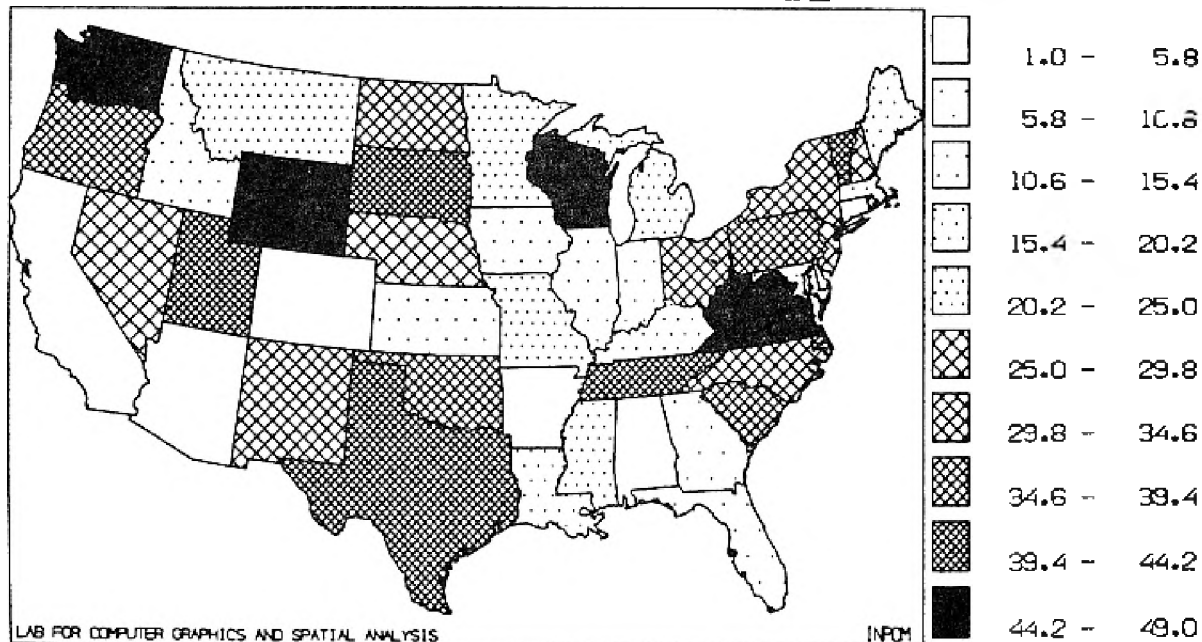


Figure 4b: INPOM Output

## PART II: GRAPHIC TECHNOLOGY

The technology of computer graphics encompasses three separate functions: capture, processing and display of graphic data. Capture relates to automatic or manual encoding of base maps and attributes. Processing relates to computer graphic operations such as overlaying of images, scaling, clipping and windowing, two- and three-dimensional transformations and other features normally associated with interactive graphics<sup>9</sup> such as "dragging" (positioning a picture part relative to a light pen stylus coordinates), "rubber banding" (attaching constraints to the beginning and end points of a line), "pointing" (at a CRT display to interact with a data base) and "inking" (free hand drawing on the display). Display relates to the hard and soft output of previously received digital data. A variety of line and film plotters and CRT displays have been designed for this purpose.

### Data Encoding

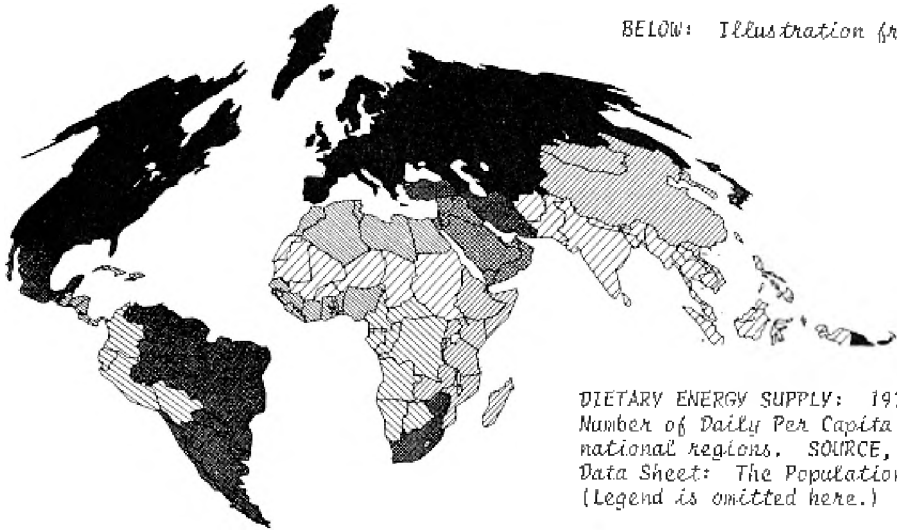
Input for encoding spatial data is accomplished with either manual or automatic table-type devices or film scanners. Manual or automatic curve-following devices usually consist of

a "tracking" head and a measuring system interfaced to an electronic control and recording device. Digitizers may either be off-line or on-line with the important advantage of on-line digitizing being the facilitation of editing operations.

Manual digitizers record coordinate information on a point-by-point basis whereas dynamic digitizers (automatic curve followers, film scanners) record coordinate information in a continuous stream. Manual machines can normally digitize from 200-5,000 points per hour depending upon the input drawing size and density and the number of attributes per base map polygon. In automatic digitizing, the tracking of a line is accomplished as a result of computer and/or optical/electronic sensor hardware. The recording head will automatically follow a line or scan an entire drawing in a raster or grid pattern.

In some cases, extremely large geographic data bases of both statistical and locational information (geographic entities) already exist. The most well known of these include a variety of census files<sup>10</sup> distributed by the U.S. Department of Commerce and the World Data Bank I and II (forthcoming) distributed by the CIA.<sup>11</sup>

BELOW: Illustration from the Lab-Log, 1977.



DIETARY ENERGY SUPPLY: 1974  
Number of Daily Per Capita Calories, by 24 international regions. SOURCE, 1975 World Population Data Sheet: The Population Reference Bureau, Inc. (Legend is omitted here.)

### Data Processing and CRT's

Graphic processing functions have traditionally been performed on the host CPU - at a high cost in overhead. With the advent of mini- and microprocessors, however, many of the scaling and format conversions have been taken over by specialized display processors developed by manufacturers of CRT's or the hardcopy display device. Display processors will often perform many operations on the display file such as formatting, scaling, and refreshing and include, in the case of CRT's, other operations such as permitting programmable interrupts.

Most sophisticated display processors are found in conjunction with CRT's. The chief advantage of the CRT in mapping is its speed (often in the 80,000 vector per second range). Principle disadvantages relate to size and resolution (about a 19 inch maximum) which limit the amount of data that can be discerned. There are two classes of graphic display systems in common use today: video (raster) and digital. The digital storage tube display is the least expensive graphic CRT (starting at \$3,000) and has a relatively unsophisticated display processor with the CPU doing most of the work. Images are "painted" on the display surface in any random sequence given by the computer by having the computer drive the electronic beam from place to place to trace out individual lines of a picture.

Video displays use television techniques such as raster scan. They generate pictures in a sequence from left to right, top to bottom. The picture must be refreshed from 30 to 60 times a second or the traditional "flicker" problem will result. With raster displays, data must be structured beforehand but, unlike storage tube CRT's, they offer the capability of using a light pen or other light-

sensing device to selectively erase and interact with the display file. Because storage tubes are not refreshed, the image can be painted at any speed and are therefore often used as terminals to time sharing systems.

### Data Display

Data display consists of hard and soft (CRT) graphic output. Drafting systems consist of a drafting surface which can be of any size, a positioning system (usually a servo or stepping motor) and a drafting tool assembly consisting of such mechanical devices as pens (liquid ink, ball point, felt-tip), pencils, scribing materials, cutting knives, or photo-optical devices such as light or electron beams.

Drafting systems can be either raster or line. Raster systems draw on phosphor surfaces such as a CRT or on light sensitive material such as film. The fineness of the grid mesh determines the accuracy of the plotter and some of the laser film systems<sup>12</sup> can generate several million dots on a 4" x 5" sheet of film (250 dots/inch). With all systems, operational characteristics such as speed, accuracy and drafting surface determine the economics of the type of map that can be produced. In general, most cartographic installations will use an interactive system for capture and editing (and sometimes manipulation) and a high resolution COM device for output of topographic maps or a utility plotter for thematic maps. High resolution color output is usually achieved photographically whereas low resolution color displays can be produced with the new Hertz Color Jet Plotter.<sup>13</sup>

### Turnkey Systems

One of the more exciting developments in the analysis and display of

spatial data is the use of mini-based turnkey systems for mapping applications. These configurations, costing in the \$50,000-\$150,000 range, consist of a graphic input station (digitizer, tablet, function keys, joystick or keyboard), output station (flatbed, drum, light beam, microfilm or electrostatic plotter), an interactive CRT work station for data base management and cartographic editing, and a large secondary mass memory (disk, tape or drum) for storing the large data bases needed for map making. There will usually be a communications interface to a remote processor to perform the management and file manipulation functions. The graphic data structures used in turnkey systems are usually quite simplistic because the systems are designed to be used for a variety of applications. This means that most cartographic application software must be built on top of the existing operating systems which is sometimes quite difficult. Figures 5 and 6 below<sup>14</sup> show the current size of the turnkey systems market (1974 figures) by vendor and the sales of turnkey systems by industry respectively.

	\$ millions
Applicon	\$10.0
Auto-Trol	1.0
Bendix	2.0
Calma	4.5
Computervision	13.0
DEC/Redac	2.0
Dimensional Systems	0.3
Gerber	1.0
Hampshire	0.5
Information Displays <sup>15</sup>	0.0
Macrodata	1.5
M&S	0.2
Tektronix <sup>15</sup>	0.0
United Computing	0.5
Total	\$36.5

Figure 5: Current Size of Turnkey System Market (1974 Figures)

	\$ millions	
	1975	1978
Electronics	\$58	\$150
Drafting	12.5	60
Mapping/cartography	7	20
Architecture/engr	2.5	3
Govt/univ research	3.5	7
Totals	\$83.5	\$240

Figure 6: Sales of Turnkey Systems by Industry



Figure 7: ComputerVision's AUTOSCAN Scanner.

### PART III: PROBLEMS AND TRENDS

There are still many problems that need be solved before automated cartography reaches its potential. The profession is still in its early stages of growth although there is a tremendous amount of activity in the area caused by changes in technology, the availability of data bases, the lack of skilled cartographers, the pressures of converting to a metric system (in the U.S.) and other factors. It has been estimated<sup>16</sup> that it will take ten years or longer for most potential U.S. users to acquire and have integrated general mapping systems.

Some of the problems relate to data bases. Potential users including county, state and federal agencies want geographic data bases for information system applications. This requires sophisticated data structures and a careful structuring of the data into a large management system that can provide for a variety of applications. The state-of-the-art of data base management systems has simply not reached a point of making this cost effective in all but the narrowest of mapping application areas.

Other problems relate to a lack of acceptance of information system standards (especially within government agencies) and to a general lack of data standardization. It is clear that standardization must take place on a variety of levels including definitions, units of measurement, formats, classification systems and coding systems employed. Until this happens, all of the individual efforts taking place will remain separate with integration an extremely difficult task. Compatibility of data and programs is just not taking place which results in a singular lack of knowledge transfer.

The standardization should also be extended to graphic languages. At present, major interactive mapping efforts are resulting in the development of general and special purpose languages for the capture, manipulation and display of spatial data which results in, once again, a lack of coordination. At a recent ACM Symposium on Graphic Languages,<sup>17</sup> Suski listed several problems with existing languages:

1. Existing languages are sometimes aimed at only a small group of users within a specific applications area.
2. Existing language documentation is inadequate or not widely disseminated.
3. The existing language and/or its implementation is defective in some way.
4. The appropriate language is not available on the user's own computing system.

5. People like to use languages they have invented for themselves. This latter group often justifies development of special application languages by pointing out even minor deficiencies in already existing systems.

Yet another technical problem relates to data entry and data compression. Scanners for cartographic applications still have many hardware and software problems. In general, the source manuscript is not good enough for scanning and must be re-drawn before data input can begin. In other cases, only legal descriptions exist for the data base. This is particularly true of surveyors' descriptions of plots for planimetric mapping applications.

In the area of remote sensing, often used to create data for digital terrain models, there is the problem of pattern recognition to discriminate between and classify data. At present, the human eye has a clear advantage over any automated system. The computer, to accomplish the same recognition, normally will detect spatial patterns by template matching after image restoration (the image is usually degraded - especially from satellite photos), and image enhancement (smoothing and sharpening of picture) has taken place. These usually consist of a highly sophisticated set of complex operations that are expensive to perform and achieve only satisfactory results at best.

Although problem areas should not be minimized, several developments and trends are taking place that are noteworthy. One such trend is towards the development of integrated mapping systems on turnkey interactive mini-computer based hardware. It is clear that spatial data encoding, editing and map design is best achieved in an interactive environment. This trend is supported by a number of newly emerging systems on the market and the rapid growth of the industry in general. In addition, most cartographic operations can be handled sequentially thereby eliminating large core requirements. When large data bases are used, a communications interface to a remote computer can be added with the host CPU used to store and manipulate the data files and perform some of the analytic operations on the files.

At the input stage, there is a great deal of R & D effort in digital picture processing that is applicable towards automated cartography. Companies such as Kern Instruments, Inc., Bendix and K & E are currently interfacing mini-computers and microprocessors to stereo plotters in order to digitally capture data from aerial photographs. Combined with editing operations performed on the processor,

a relatively clean digital terrain file will be created by the operator of the traditional stereo plotter. K & E has interfaced a microprocessor to a theodolite so that COGO-type operations can be performed in the field.

One also sees a trend towards the increased development of geographic information systems based on topographic, rather than hierarchical, data structures. The ability to automatically perform some error checks and to selectively retrieve and manipulate data that is applicable to a wide range of subsystems (utilities, fires, crimes, zoning, etc.) is important and is an area in which a great deal of time and money is being expended. An incentive to the development of urban information systems is the fact that comprehensive parcel mapping systems are necessary for tax revenue purposes. An impetus to regional information systems is that current legislation<sup>18</sup> is pending before Congress that will require regions to develop comprehensive land use planning programs.

In technology, we are seeing computer output microfilm (COM) and electron beam recorders (EBR) being increasingly used, especially when high production and high accuracy requirements can warrant the expense. Mass storage is rapidly falling in price which aids the cartographic data base problem. Laser encoded film disks and low-cost laser disk drives have been developed which specify a density 1,000 times greater than current magnetic tape or disk surfaces.

In graphics, there is a trend towards raster scan devices which can readily support grey tones and color, are inherently cheaper than storage tube displays and that have R & D costs, associated with the development of these devices, paid for by firms wanting to compete in the mass consumer market of stored home-TV.

In general, the promise of automated cartography is realizable with today's technology. The political, economic, and technical activities in this area support this assumption. There is no longer a question of spatial data availability. Rather the question has shifted to reliability, accuracy and accessibility of the data. Interactive graphics seems to be the best analytic and managerial tool we have to respond to these needs.

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#### References

- 1 This paper will deal with technical issues related to maps rather than charts and graphs.
- 2 For a more complete discussion, see Tomlinson, R.F., editor, Environment Information Systems, Ch. 13, Vol. 1 of Geographical Data Handling, International Geographical Union on Geographical Data Sensing and Processing for the UNESCO/IGU Second Symposium on Geographical Information Systems, Ottawa, August 1972.
- 3 See Stepler and Schmidt, Cartographic Automatic Mapping (CAM) User's Guide Program Documentation, Central Intelligence Agency, Office of Geographic and Cartographic Research, December 1974, 119 pp. (NTIS/DF-74/001a, PB-238 358/6WC).
- 4 Yoeli, Pinhas, Display and Analysis of Spatial Data, Ed. by John C. Davis and Michael J. McCullagh, NATO Advanced Study Institute, John Wiley and Sons, 1975, 378 pp.
- 5 Modified from a chart appearing in: Teicholz and Dorfman, Computer Cartography: World Wide Technology and Markets, International Technology Marketing, Newton, Mass., May 1976, 426 pp.
- 6 Programmed by Geoffrey Dutton, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University.
- 7 Programmed by Jim Little and Jim Dougenik, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University.
- 8 Programmed by Jeffrey Clemm, Laboratory for Computer Graphics and Spatial Analysis, Graduate School of Design, Harvard University.
- 9 See Newman, W.M. and Sproull, R.F. Principles of Interactive Computer Graphics, McGraw-Hill, New York, 1973.
- 10 For additional information, write the Census Use Study, U.S. Department of Commerce, Bureau of the Census, Washington, D.C. (USA).
- 11 The WDB-1 is a country outline data base developed by the U.S. Central Intelligence Agency and distributed by NTIS, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22151 (USA).
- 12 Such as the Dresser DIE LGP-2000 Lasergraphic Plotter and the Gerber 1434 Laser-Controlled Photoplotting System, Hartford, Conn. (USA).

REFERENCES (Concluded)

- 13 For additional information, write Prof. Hellmuth Hertz, Lund Institute of Technology, Department of Electrical Measurements, P.O. Box 725, S-220 07, Lund 7, Sweden.
- 14 Modified from charts appearing in: Teicholz, Eric, Interactive Graphics Comes of Age, Datamation, December 1975, pp. 50-53.
- 15 The Tektronix 4081 and IDI's IDADS System 150 started delivery in 1975 and are therefore not reflected on the chart.
- 16 Teicholz and Dorfman, op. cit., p. 2-1.
- 17 Suski, Gregory J., Automatic Generation of Computer Graphics Languages, Proceedings ACM Symposium on Graphic Languages 26-27 April 1976, Miami Beach, Computer Graphics, Vol. 10, No. 1, Spring 1976, pp. 113-122.

- 18 See Dueker, Kenneth J. and Drake, Joseph S., The Land Use Policy and Planning Assistance Act of 1972: Information Systems Implications, Institute of Urban and Regional Research, University of Iowa, Iowa City, October 1972, 31 pp.

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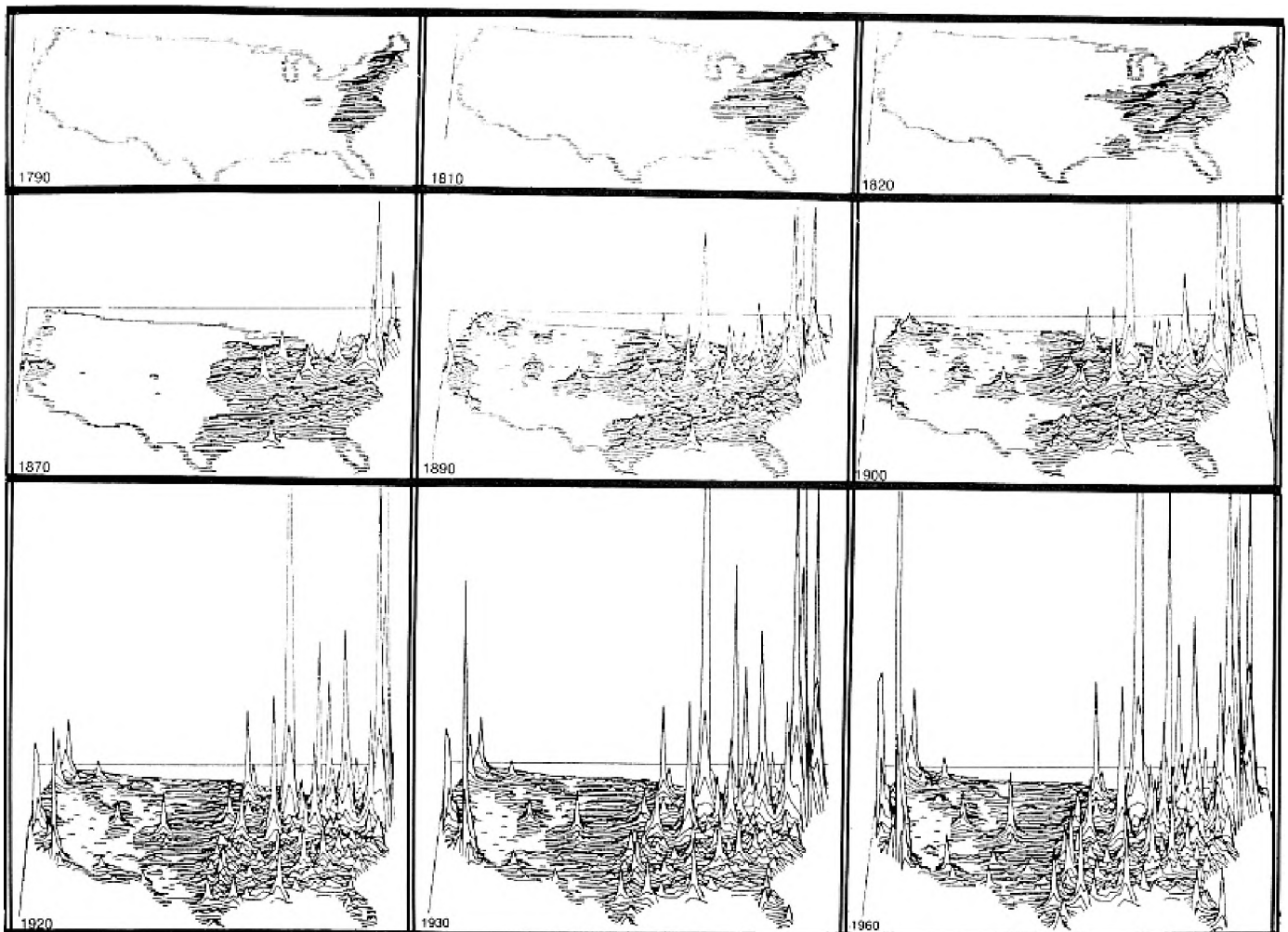
NOTE: The new Lab-Log, January, 1977, is available from:

LABORATORY FOR COMPUTER GRAPHICS  
AND SPATIAL ANALYSIS  
Graduate School of Design  
520 Gund Hall  
Quincy Street  
Cambridge, Mass. 02138

The new Lab-Log is \$1.00, prepaid, and contains a definitive catalog of the programs, data bases and publications of the laboratory.

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BELOW: Selected Maps of U. S. Population Density from "Manifested Destiny," from the report by Geoffrey Dutton, Laboratory for Computer Graphics and Spatial Analysis, Harvard University, 1975, 30 pages. [See page 17 in the Lab-Log for details of this report.]



# DIGITAL PLOTTERS- A LOOK AT THE FUTURE\*

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## INTRODUCTION

Digital plotters have been a part of the data processing world since the late 1950's when California Computer Corporation (CalComp) in Anaheim devised a plotter that used incremental stepping motors instead of the analog servo motors. This radical new concept also included a sprocked drum that passed long rolls (or fan fold) paper back and forth under a moving pen mounted on a fixed arm. Since the late sixties, plotters have become, similar to just about every other aspect of the automatic data processing industry, faster, cheaper, more flexible and of a higher resolution and accuracy.

In point of fact, a user is often paying for technological advancements such as plotter speed that are entirely unnecessary. For example, several plotters claim drawing speeds in excess of 40 inches/second (IPS). There is no inking system on the market that can keep up with this speed. Liquid ink, for example, flows no faster than 10 inches/second. When pressurized liquid ink systems are used, maximum speeds can still not surpass about 25 IPS - and even these are obtainable only on long, relatively straight, line segments.

This paper will briefly look at several aspects of plotter technology. First will be a short description of the types of plotters currently available; second will be the components that make up a digital plotting system; third will be trends in digital plotter technology; and fourth will be a list of companies currently manufacturing digital plotters.

\*The author wishes to acknowledge that some source information for this article came from the following two publications:

1. Teicholz et al, The Computer Graphics Industry: A Study for Users and Practitioners, International Technology Marketing, Newton, MA., July, 1974.
2. Stover, Richard, Projections for Digital Plotters, Computer Decisions, July, 1976, pp. 54-55.



POLYVRT

## I. TYPES OF PLOTTERS

### A. Pen Plotters

Pen plotters, as mentioned, appeared in the late 1950's and were an extension of analog X-Y technology. Major efforts in drum plotter technology have been to improve accuracy and to increase velocity and acceleration. Today, drums are available with widths of up to 48 inches. Flat-bed plotters use a vacuum of electrostatic paper hold down and a pen carrying carriage that moves in both X and Y directions. The carriage movement is achieved by cables, straps, lead screws, rack and pinions and the newly developed "SAWYER" principle which uses linear motors. Using the rack and pinion technique, the motion in one direction can be almost unlimited and some aircraft and shipbuilding industries have plotters up to 75 feet long. Cutting tools can be substituted for the pens for "rubylith" cutting.

### B. Light Beam or Photoplotters

The light beam plotter is essentially a flat bed plotter fitted with a light or photo exposure head. The head contains a light source, shutter and density controls (or flashing technique), an optical system and an aperture wheel or disk with a number of different apertures of shapes that can be projected onto the film. Standard shapes (for printed circuit work for the most part) are implemented by flash exposure with the film stationary at the proper position. The appropriate apertures are selected by a control number identification using a rotary aperture wheel. The number of apertures available range from 8 to 96.

### C. Computer Output Microfilm

COM appeared in the early sixties but is only beginning to be used extensively for graphic output. The reasons for this have been the relatively high cost of the basic equipment and the associated photo processing and hard copy preparation equipment needed. As can be expected, COM is incredibly fast and minimizes the requirements for processing time. Line quality, acceptable to military drawing standards, is achievable with some COM equipment. This ability does not come inexpensively (a high quality COM system costs well in excess of \$200,000) which means that COM is applicable to those installations having an extremely large output volume.

## D. Electrostatic Plotters

Electrostatic plotters use a linear array of closely spaced writing nibs (about 100 per inch) embedded in a stationary writing head. The nibs selectively create minute electrostatic dots on the paper as it passes over the writing head. The paper is then exposed to a toner to produce a permanent, visible image of the text. Electrostatic plotters are characterized by the nib spacing or density; the paper speed in IPS; and printing speed in lines per minute; and the plot width. Nib densities range from 72 to 200 nibs per inch, plot widths from 8 to 22 inches, and paper speeds from .75 to 2.2 IPS. The printers have very high output speeds, relatively low costs, can produce plots or alpha numerics with equal speed and are completely quiet.

## II. COMPONENTS

From the above descriptions, we can infer that digital plotters can be divided into three distinct components: Drafting surface; positioning system; and drafting tool assembly. Paper, mylar or photographic plates may be placed on the drafting surface, which can be either a drum or a table. Drafting tools can be mechanical for drawing on paper, plastic or scribing materials; or photo optical for drafting on photo sensitive material with light beams, laser beams, electron beams, etc. The positioning device steers the tool along a predetermined path directed by the computer.

Characteristics of digital plotters can be considered in terms of working area, drafting surface, drafting velocity and acceleration and accuracy. Working areas range from millimeters (COM) to almost unlimited size (rack and pinion flatbed plotters). Drafting surfaces are either drum or flat bed. There are not very accurate position devices for drums (.01 inch) and overall accuracy is usually not specified. Flat beds are more accurate (and more expensive) than drum plotters.

Lines are produced in either a raster or a vector mode. In raster type devices, density of detail is not important and velocity is therefore specified as the time in which a certain area can be covered. Drafting speeds for a 1 meter by 1 meter drawing range from a few minutes to 1 hour. Velocity of vector machines are specified as the maximum velocity at which the drafting head can be driven along one axis. These speeds range from 5 IPS to 40 IPS. Acceleration is the time it takes to reach the required velocity from a static position. Because of the different characteristics of inks, maximum drafting velocities are specified for each of the tools used. In addition, to retain maximum accuracy in dynamic positioning, the machines must slow down when drawing complicated lines and achieve maximum velocity only when straight lines are drawn.

Resolution is measured as the smallest achievable distance between two plotted points. The drafting tool assembly can simply not be positioned in smaller steps. Repeatability is defined as the ability to position the assembly at any point within a specified tolerance. Positional accuracy is the ability to position within a specified tolerance of the input coordinates of a point. Dynamic accuracy is the maximum deviation from a line that is actually drawn to its numerical definition.

It is extremely difficult to compare all of these factors between machines, and bench mark tests are needed for particular applications.

## III. TRENDS

The technical characteristics of pen plotters have improved much faster than the technology involved with inking systems. Besides inking characteristics, quality is also lost with higher speeds. For reasonably complex plots, there will probably be no savings in plotting at speeds in excess of 15 IPS. If one is going to obtain higher speeds, other technologies must be used, such as writing on film with a high speed light source or by electrostatic techniques. We can therefore look forward to laser driven optical and electromechanical devices drawing on heat or photo sensitive materials at extremely high speeds. As usual, these devices will be expensive for many more years and will be cost beneficial in high production or time shared environments only.

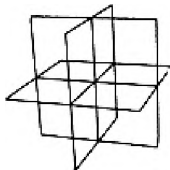
Another trend is the getting away from stepping motors that produce "saw tooth" effects and using absolute feedback motion systems rather than non-feedback incremental systems. This will affect even drum plotters as well. The technology will take place because of the tremendous advances in large scale integration (LSI) micro-circuit technology.

Microprocessor technology is also making an impact on digital plotters. This is particularly true for the plotter interface. For example, microprocessors can accept compressed data enabling the plotter to be used as a terminal over a voice grade telephone line. In this manner, the data can be accepted simultaneously while the plotter is drawing at normal speed. The microprocessor also foretells an age of universal interfaces enabling the plotter to be interfaced to any computer. The most common method is to use a standard alpha-numeric port, the RS 232 Serial Asynchronous, interface.

Finally, a microprocessor can be used to overcome some of the problems of incremental plotting by being able to identify, over transmission lines, transmission errors and, using a buffer storage, getting the computer to resend the data rather than plotting bad data.

Finally, microprocessors allow for programmable controllers permitting such operations as scaling, rotation and character addition. They can also optimize plotter operation by controlling acceleration and deceleration. The Tektronix 4662 interactive digital plotter even comes equipped with a built in joystick control which enables the user to move the pen to a desired position on the plot and then transmit the X-Y data points to the CPU.

In general, digital plotting will be increasingly accomplished in a stand alone environment or as a time sharing terminal over telephone lines. Off-line magnetic tape drivers will be replaced by mini or microprocessors and more and more of the standard analytical operations such as rotation and scaling will be taken away from the host CPU and given to a local processor.



#### IV. PLOTTER MANUFACTURERS

Applicon Inc.  
154 Middlesex Turnpike  
Burlington, MA 01803

Artronix  
1314 Hanley Industrial Ct.  
St. Louis, MO 63144

Arvin Systems, Inc.  
1771 Springfield Street  
Dayton, OH 45403

Auto-trol Corporation  
5650 North Pecos St.  
Denver, CO 80221

Broomall Industries, Inc.  
682 Parkway  
Broomall, PA 19008

California Computer Products  
2411 W. La Palma  
Anaheim, CA 92801

Calma Company  
707 Kiefer Road  
Sunnyvale, CA 94086

Curran Computer Corp.  
946 Main Street  
Hackensack, NJ 07060

The Cybernetics Corp.  
175 Jackson Plaza  
Ann Arbor, MI 48106

Digicom Inc.  
Paramount Bldg.  
Chelmsford, MA 01863

Electronic Associates, Inc.  
West Long Branch, NJ 07764

Paul-Coradi Inc.  
643 W. Onondaga St.  
Syracuse, NY 13204

Geo Space Corporation  
5803 Glenmont Drive  
Houston, TX 77036

Gerber Scientific  
P. O. Box 305  
Hartford, CT 06101

Gould, Inc.  
3631 Perkins Avenue  
Cleveland, OH 44114

Houston Instrument  
One Houston Square  
Austin, TX 78753

IBM Corporation  
1133 Westchester Avenue  
White Plains, NY 10604

Litton Datalog  
1770 Walt Whitman Rd.  
Melville, NY 11746

Optronics International, Inc.  
7 Stuart Road  
Chelmsford, MA 10824

Time Share Peripherals  
Route 6  
Bethel, CT 06801

Varian Data Machines  
611 Hansen Way  
Palo Alto, CA 04303

Versatec Corporation  
2805 Bowers Avenue  
Santa Clara, CA 95051

Wang Laboratories, Inc.  
836 North Street  
Tewksbury, MA 01876

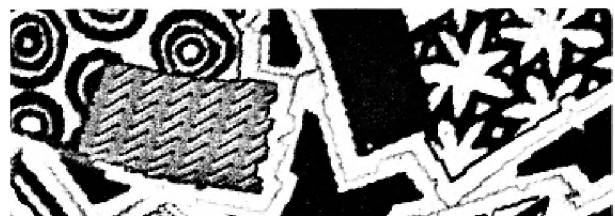
Xerox Corporation  
701 S. Aviation Blvd.  
El Segundo, CA 90245

Xynetics Electroglas, Inc.  
2901 Coronado Drive  
Santa Clara, CA 95051

Zeta Research, Inc.  
1043 Stuart Street  
Lafayette, CA 94549

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BELOW: COMPUTAKNIT textile--see page 21.



# The Potential of Computer Art in the Textile Industry

by Grace C. Hertlein, Associate Professor  
Department of Computer Science  
California State University, Chico  
Chico, California 95929

*The idea of using computers in textiles is not new. Innumerable artists have experimented with the idea of using computer art for varied textile purposes. However the full range of computer designs in the textile industry has not been implemented. The use of computers in knitted and woven textile production systems is well developed. Screen-printing and new methods of printing on fabric are still in early stages of exploration...The full implications of computer art and computer-controlled textile systems is perhaps another "industrial revolution," in which newer designs, new computer-assisted textiles could enhance private and industrial environments.*

## BACKGROUND

Computer systems are changing and revolutionizing the textile industry. Included in this industry is the design and manufacture of woven and knitted materials, rugs, wallpapers, and printed cloth.

The uses of computers in the textile industry may be divided into two broad areas:

1. Computer systems are utilized for the input, manufacturing process, and output of finished textile materials.

2. Libraries of computer art have the potential to generate a vast, highly varied system of patterned designs to be used in these textile products.

The potential of computer applications in the textile industry is readily apparent. The idea of using computers to control a series of knitting and weaving machines is a highly feasible application of computers. Both systems are precisely numerical, and the requirements for execution of knitted and woven materials can be input, stored, retrieved and output readily by a central processing unit, with the latter controlling the output product.

Since knitted and woven production methods are numerical in nature, and printed methods are less numerical, knitted and woven systems have been developed in greater depth than printed systems. The latter systems are the new areas to be explored in future textile applications.

The idea of using computers to generate thematic families of patterned designs for use in textiles is perhaps an "obvious" application of computer art. In surveying the majority of works produced with the aid of the computer, even the best works are manipulations of design modules that result in attractive, highly decorative patterns that lend themselves readily to contemporary textiles. However, the use of the computer as a designing colleague to develop very new and highly varied patterns for textile applications has not been fully developed.

This brief article reviews present uses of the computer in the textile industry and reflects on the potential applications and changes that may be anticipated in the very near future.

## AUTOMATED WOVEN/KNITTED SYSTEMS

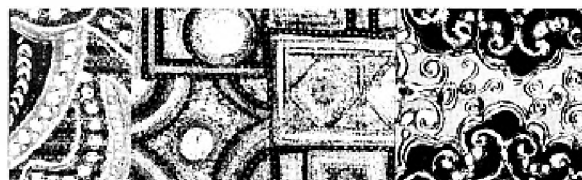
The idea of using a programmed system to produce textiles was demonstrated by the use of the Jacquard loom early in the nineteenth century. (1) This manual pre-programmed system of punched cards allowed a single weaver to produce identical yardage of complex tapestry material.

Since the warp and weft are expressed in measurable strings of numbers, the weaving process is readily adapted to automated computing processes.

Automated weaving has been pioneered by artist-mathematician, Janice Lourie (2) who brought a background in the varied arts to contemporary weaving. She has written at length about adaptation of art systems to weaving (3) and her ideas of the potential of computer art in textiles are described in her definitive text, Textile Graphics/Computer Aided, published in 1973. Particularly interesting are notes of the work accomplished by the point (graph) paper designer who adapts manual patterns for use by the computer.

Generation of designs to be used in the computer is still an incomplete area, partially explored. The use of a computer program to generate weave structures is described by W. G. Wolfgang of the Philadelphia College of Textiles and Science (4) in the November, 1976 Computer Graphics and Art.

BELOW: Detail of textile collage from the COMPUTAKNIT System.



The generation of varied design forms is an important topic and will be discussed later in this article.

The COMPUTAKNIT System

Figure 1 (below) reveals the Flow Process Chart for the COMPUTAKNIT System. Input into the system is via direct tracing of the artist's design on a digitizer. The coordinates of each color block for each pattern are thus input as data. As the artist traces the patterns, they may be edited and changed on a cathode ray tube. Each portion or subset of the design is recorded on magnetic tape in the computer system. The data is converted for automated weaving on one or more knitting machines. A library of desired patterns is maintained on magnetic tape, and a number of automated knitting machines can be simultaneously controlled by the process computer. Different patterns may be produced on several machines at the same time, and designs may be changed rapidly without stopping the machines. (5)

In studying the literature and material on automated weaving/knitting systems, it appears the the output or products made with these systems are not as artistically inventive as the hardware developed for textiles. The products of the Wildt Mellor Bromley COMPUTAKNIT System are more attractive and innovative, often using a collage-like approach to design. There is an apparent weakness in reviewing the output of these systems, as though the manufacturers were so caught up in hardware and software development, that the designs for execution on these systems have not been sufficiently considered. It resembles the "GIGO" idea--garbage in, garbage out. Good design input into a complex automated system gives excellent output. Additionally, new systems require new design content and approaches.

Some technical, descriptive material from this system is given below. These ideas and descriptions, along with the chart below are from reprints (5) by the manufacturer, Wildt Mellor Bromley, Aylestone Road, Leicester LE2 8TE, England.

TECHNICAL DATA

Diameter: 30 inches  
 Feeders: 48  
 Gauges: 18, 20, 22 n.p.i.  
 Electronic Pattern Control

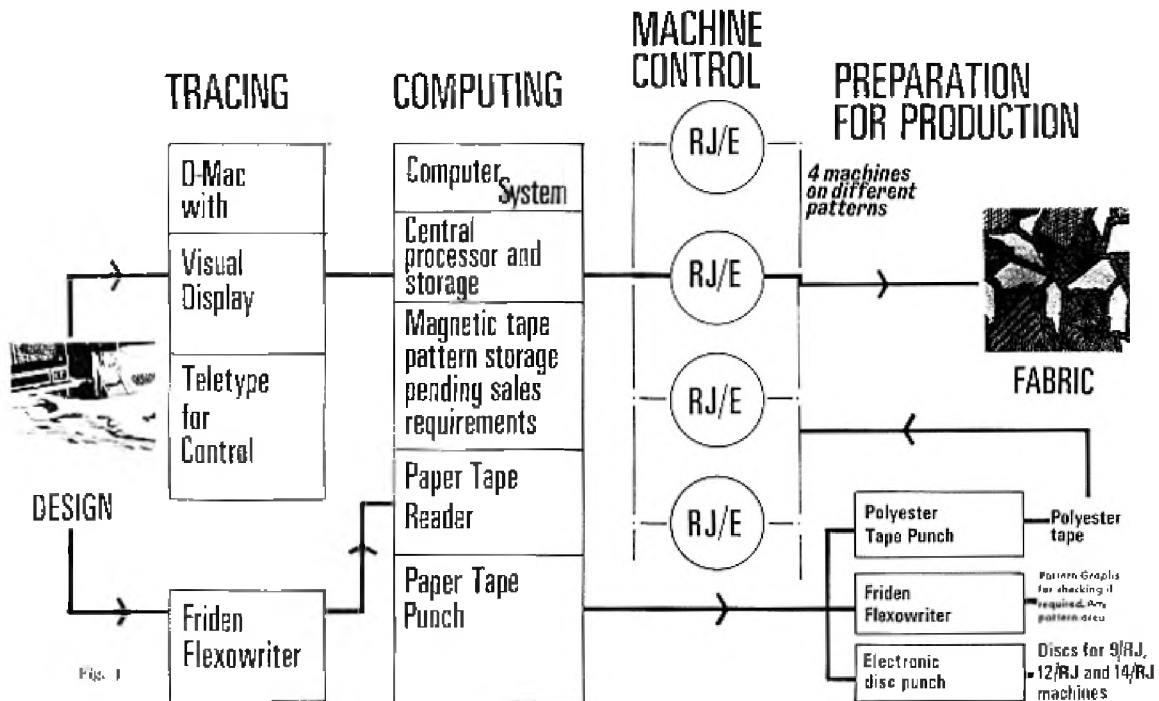
Double Jersey Jacquard Fabrics:

In 2, 3 or 4 colors with or without Birds-Eye back;  
 Jacquard designs in ripple stitch;  
 Double-sided lace effects;  
 Jacquard tuck stitch patterns;  
 Interlock fabrics, double pique;  
 Ponti-de Roma;  
 Birds-Eye patterns;  
 Jacquard patterned cloque or relief stitch.

The use of a Friden Flexowriter has two functions within this system: (1) To manually convert pattern graphs into paper tape, and (2) To read paper tape from the process computer to produce a pattern graph or visualization of the data. This affords flexibility of input/output of design patterns. Polyester tape is also used in the COMPUTAKNIT System.

In this and the other automated systems discussed here, there is the capability of direct designing and input of design data, sampling fabrics minutes after designing, and editing patterns quickly. Production of accepted patterns can be accomplished the same day, and different simultaneous machines can produce output.

BELOW: Figure 1. The Flow Process Chart of COMPUTAKNIT



## The Mayer Electronic System

Another automated knitting system is that of Mayer & Cie., Tailfingen, West Germany. This system is described in *Wirkerei-und Strickeri-Technik*, No. 4, 1972, in the publication series, References from the Technical Press. (6)

For the reader not acquainted with the ideas behind computer-aided knitting and weaving systems, the execution of automated textiles requires a system of contactless switching, controlling and regulating operations. This means that the control pulses necessary for the knitting and weaving process are given automatically by the computer. An enormous number of pulses are transmitted to the production machines by the controlling process computer, controlling the complex pattern data and directions to achieve the textiles. The output unit automatically sorts the patterns according to color and transmits corresponding information chains to the knitting machines. A sample would be: 00110011000..., and 1 equals no-knit, 0 equals knit. It is obvious that a natural and inevitable application of computers is in knitting and weaving systems.

Below are two diagrams, Figure 2, Schematic Diagram of the Arrangement of a Computer, and Figure 3, Schematic Diagram of the Arrangement of an Electronic Knitting Machine Control System. Diagrams are from the above source, by Ernst-Dieter Plath.

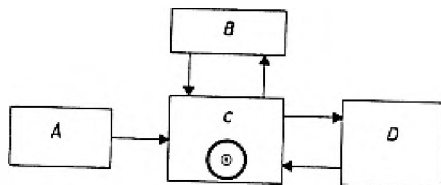
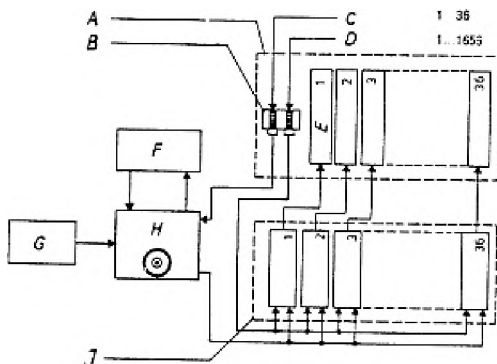


Figure 2. Schematic Diagram for the Arrangement of a Computer.

A = input unit; B = programme unit; C = central processing unit with internal memory; D = output unit

Figure 3, below: Schematic Diagram of the Arrangement of an Electronic Knitting System.

knitting machine control system  
A = Knitting machine OVJA 36 E; B = Signal transmitter, synchronously driven by the OVJA 36 E; C 1... 36 = Feeder instructions 1... 36; D 1... 1655 = Needle instructions 1... 1655; E = Patterning mechanism; F = Programme unit; G = Input unit; H = Central unit with store; I = Intermediata store; J = Output unit.



## The ElectroKnit 48 System

An American computer-controlled knitting system is by Rockwell International of Reading, Pennsylvania, called the ElectroKnit 48. In this system, pattern input may take any of the following forms:

- Black and white or colored patterns on gridded paper;
- A gridded color representation of the design on a special mylar paper for automatic scanning;
- Ungridded colored artist's designs;
- Knitted, woven or printed fabric samples;
- Photographs of patterns.

The material from Rockwell International is newer, in that the other references are from 1972. Therefore, the other examples given may have (5 years later) variable input as above. To achieve superior, highly varied forms of design, it is necessary to develop varied input and storage forms, as discussed below.

In addition to the above, standard IBM 80 column cards may be used and paper or mylar tape.

The use of a scanning system in the ElectroKnit 48 permits patterns up to 144 wales wide to be read and scanned as a single pattern. Wider patterns are sectioned and entered sequentially. Editing and pattern manipulation is accomplished by means of a computer printout. Errors are corrected by means of a display screen, keyboard input and cursor control.

Important in this system is pattern manipulation and change: backgrounding, scaling, mirroring, transforming, and rotation. In addition two or more designs may be combined to form new patterns.

This marks an advance in development of design, a concept important in achieving textiles of art quality. However, in spite of the flexible input and manipulative capacities of this system, it is noticeable that their illustrations of knitted output are not of the art quality of the COMPUTAKNIT System. This confirms the need for design development excellence, as an integral, interdependent part of the textile process. The designers who make the patterns are a key part, not subordinate, in this automated textile process.

In summary, from this brief description of knitted and weaving systems, one can observe that the hardware is well developed, and that software, input/output techniques are becoming more flexible and more user-oriented. What we have is an "automated" Jacquard loom. We can safely predict greater, wider development and dissemination of automated knitting and weaving systems, perhaps replacing the non-automated systems. The ease of design input, editing, and the speed of sampling and production make knitted and woven industrial development inevitable. The textile industrial revolution is here.

## NEED FOR VARIED INPUT, STORAGE METHODS

In discussing automated systems with textile manufacturers in June of 1976, the one reaction was to augment present input/storage systems to allow for greater ranges of designs that may be attained by each input method. The specific input methods determine the type and kind of designs entered into the system. The more sources available, the greater the range of forms.

The ideal input sources are:

- Cards
- Cursor
- Digitizer
- Joystick
- Mouse
- Rand Tablet
- Light Pen
- Sketches, Gridded and Ungridded
- Paper Tape, Mylar Tape
- Magnetic Tape
- Cassette
- Photographs

Storage should be equally flexible:

- Floppy Disk
- Large Disk Track Storage
- Mylar Tape, Paper Tape
- Magnetic Tape
- Cassettes

Backup storage is necessary, and this is obvious.

## TEXTILE DESIGNS, NON-AUTOMATED SYSTEMS

In June, 1976, the author exhibited computer-designed, manually silkscreened textiles as part of NCC '76. Meetings with textile manufacturers took place during a three-week period. Much was learned about the textile industry, its present trend towards automated systems, with a trend to go beyond present manual or non-automated printing systems to automated modes.

There will always be a need for non-automated printing systems, due to the desire of individuals for one of a kind, or highly artistic productions of a limited nature, as opposed to the mass-production, automated textiles. Editions of non-automated textiles can be predicted to replace present systems.

Of particular interest in conversations with textile firms was the minor role of the textile artists. The latter generally operate on a free-lance basis, and are paid for accepted patterns only, not for their total labor. Some firms employ artist-stylists, who work full-time, and are cognizant of the style trends and requirements of their firms. There are a growing number of independent textile designers, however. Occasionally, a firm will hire a very well known artist to execute a line of designs, but firms admit that this is generally not very profitable.

During the month of June, the author

had the opportunity to study room after room, samples of the newest in textiles in major New York City firms. An attempt was made to analyze the specific requirements for varied design forms to be used in the textile industry. The manual practices of these firms had not prepared them to verbalize what they used, what they needed. They knew what they liked when they saw it, but could not describe any details or parameters. These firms considered computer art to be suitable high-fashion industrial designs for banks, company offices, hotels and motels. They did not regard computer art as suited to fabrics for private homes and questioned their use for garment design. The author firmly believes these firms are in error, and that computer art forms may reflect such a variety of design patterns, that such art is highly suited to all textiles, whether screen-printed, thermal printed, knitted and woven automatically, etc.

Only one firm appeared to have some beginning insights into the potential of computer art, Eric Mayer Associates, of New York City. This firm acts as a consultant to the textile industry, but does not manufacture textile materials.

In summary, computer art may be advantageously used in garment textile design, and also for private and industrial textiles. There is a great need for new forms to enrich and enhance the garb, the dwellings, and the environment of man. Applied computer art can make that enriching contribution to art in everyday living.

## COMPUTER-DESIGNED MODULES FOR TEXTILES

Computer art is a modular art, in which design forms are input, and then creatively changed and manipulated to achieve ever-new perceptual derivations from the input design. It is pattern design, and thus is ideal for textiles, rugs, wallpaper, etc. The ideas for using art in everyday living are from the Bauhaus. (7) In the early 1900's the Bauhaus artists and craftsmen designed textiles, ceramics, furniture, wallpaper, architecture--useful, beautiful art products for people. Although their work and ideas influenced the art schools and art departments internationally, the idea of useful or applied art has not been fully realized in many countries. This is where the role of computer art can enhance and revolutionize the environment of people. The textile industry is one of many major factors in creating that environment.

A society needs a range of patterns, both old and new, as a reflection of art expressions of many kinds of people. It is the author's opinion that a well-developed art library of computer art forms arranged in categories or families of design, together with a library of subroutines to vary these inematic forms can provide the textile industry with patterns not obtainable manually, with variety and beauty that transcends forms attained by manual processes. In addition, these new design forms are in accord with a technological era and methods

of technological production systems.

In May, 1974, the author discussed these new families of forms and how they may be limitlessly varied in "Computer Art: Steps Towards a Measurable Analysis." (8) The detailed tables in the article are referenced here (but not listed because of length). However, a brief listing of categories is given:

- Polygon Manipulations
- Continuous Line Designs
- Curvilinear Derivations
- Structural Components
- Contemporary Fine Art Derivations
- Computer Art Derivations
- Art History Derivations
- Alpha-Numeric Forms
- Natural Derivations
- Mathematical Derivations
- Scientific Derivations

Each of the above categories is broken down into subset forms. Each design may be varied greatly to achieve ever new forms. Related design forms may be combined and varied to achieve new patterns. The more abstract the form, the greater the number of design manipulations possible.

These forms may then be manipulated to achieve new designs:

- Increments and/or Decrements
- Offsets (with or without change of scalar value)
- Rotations
- Radiations
- Mirrors
- Randomizations
- Serial Imagery (Block and Rotational)
- Three Dimensional Views
- Transformations

The design form that is manipulated is known as the component graphic. However, at times a richer result is attained by taking a module and manipulating it -- then using that changed module as the augmented module (enriched design) and manipulating this more complex form in a pattern. An example is randomization of a form. Then taking that same form, mirroring it on the X, Y, and X/Y and randomizing the four forms.

From the listing of family forms above, and the subroutines to change these patterns, one can see that the whole world affords subject matter suitable for computer art designs that may then be input into applied art forms, including computer designed and automated textiles. The range of forms that may be explored exceeds manual possibilities. This is in accord with the major trend in computer art, to use the computer increasingly as a design colleague, and then to take this new design pattern back into fine and applied art. (9)

Examination of the products of computer controlled knitted and weaving systems reveals a need for new families of design forms, in order to make full use

of the computer's potential in every area of design and production. One is reminded here of McLuhan's idea that the content of the new medium too often is the old medium. An example is manual tracing of traditional (manual) art as input into a computer textile system. True, manual art sketches, photographs, etc. are viable material for textiles. Yet how much more in keeping with the new vision of automation are the images created with the assistance of the computer.

In addition, the role of the designer should be an interdependent one, not subordinate, in unity with the processes used. Using computer-assisted art, this synthesis of design/production becomes possible.

#### PRINTED TEXTILES

Man has been printing textiles for thousands of years using varied techniques that have included printing, stencil forms, batiks, screening processes, etc. Silk-screening, first an industrial process, was adapted for fine art purposes and now designs adapted for art are taken back into commercial systems, returning full circle.

There is a need to explore new printing methods, to achieve faster systems, and to automate printed textile processes. This is not as measurable as the knitted and woven processes. However, conferences with textile manufacturers indicate that the next revolution in textiles will be in automated printing systems, and that these systems will outnumber knitted and woven systems.

We will now examine other printed production systems that depart from present and/or traditional known methods.

#### HEAT TRANSFER SYSTEMS

One of the newest systems for textiles (six years old now) is heat transfer. David Durand, President of the Freeman Transfer Printing Company of Providence, Rhode Island, has been dedicating himself for the past six years to offset heat transfer.

Non-heat transfer printing methods on textiles are expensive (and messy). It is faster to print via heat transfer paper vs. the wet methods of printing textiles. (10) 85-line screens were refined to make use of 150-line screens. Sublimation inks were also modified and changed. Fabric finishing techniques were also explored and modified. Many of David Durand's employees are graduates of the Rhode Island School of Design.

After selecting a design, transparencies are selected on a Crossfield scanner using DuPont CRONAR Scanner Film, which is processed in a Crossfield processor charged with CRONATONE, a continuous tone chemistry. Color changes are programmed into the scanner, then continuous tone separations are screened onto CRONAR Halftone Litho film for dot etching. Contact negatives on CRONAR Ortho S, along with CHL positives, are processed in a CRONALITH 24L processor with a Liquid Custom Replenisher chemistry. This system, manufactured by E. I. DuPont

and Nemours, is available in a bulletin:

DU PONT ADVANCE INFORMATION BULLETIN  
(AIB #20). Write:

E. I. Du Pont de Nemours & Co., Inc.  
Photo Products Department  
Chestnut Run Location  
Wilmington, DE 19898  
Attention: F. W. Pickett

A glossary of terms used in heat transfer printing is available in the reference cited (11) by J. M. Centa. The system makes use of sublimable dyes, dyes that can be vaporized (from a solid directly to a gaseous state) by application of heat to fabric. This application of heat to dyes occurs in a temperature range that is non-injurious to the fabric.

Fabric manufacturers are already making use of heat transfer systems. In 1975, 2860 million linear yards of textiles were printed in the United States. By 1980, according to J. M. Centa, 3650 million linear yards of textiles will be printed, with the proportion of heat transfer systems to grow in volume. (11)

We can expect automation of heat transfer systems in the very near future, going beyond the wet inking systems now commonly used in textile system production.

#### EXAMPLES OF NEW SYSTEMS

Chemco Photoproducts Co., Glencove, New York manufactures a film, Chemco Textile Film (Code 650) that is used throughout the textile industry to prepare negatives and positives for printing fabrics. In one of their publications, the "Chemco Copyboard," (12) the firm describes the use of transfer printing by the Bernard Screen Printing Corporation of New Hyde Park, New York. The firm prints 25 million yards of fabric a year.

The former screen and squeegee systems have been replaced by new printing systems: automatic flat bed, rotary screen and roller.

In Bernard Kushner's firm, the colors for a fabric are chosen by the customer, and the exact colors selected with a spectrophotometer connected to a computer. It then provides the exact formula to mix the dyes for the desired color. The computer determines the cost of the dye, fastness of colors, and how light will affect the fabric. The computer determines the latter according to the conditions the fabric will experience, since artificial light and sunlight affect colors differently. Most of Bernard Kushner's fabrics are printed with six or seven colors, although some fabrics use up to twelve colors.

Color separations require making a negative for each color. The Kushner firm makes use of large multiple film positive prints as large as the width of the cloth to be printed. (This technique can well be adapted to the knitted and woven systems

described earlier, as well as for rugs and wallpaper.

The same Chemco bulletin describes a new powermatic film used with laser scanning manufactured by the HCM Corporation Hell DC 300L Laser Color Scanner. This scanner is used to make color separations used in textiles, and separations for other purposes. Laser screening exceeds contact-screen scanning systems by two to four times as the latter system. The film used is half the cost of film used with other systems. The film utilized in the HCM Laser System is Powermatic rapid access film. In addition film processing time for separations is reduced from seven minutes to 90 seconds.

Research into present industrial systems for printing should reveal further new and feasible systems for printing of fabrics, wallpapers, rugs, etc. One of those systems is a jet printing method. This system is so new that the author was unable to obtain literature on the subject, although discussion with professional graphics people confirmed its use at the present time.

#### THE IMAGE REVOLUTION

Computer graphics is one facet of the image revolution. The generation of images and manipulation of images by computer is changing and altering disciplines and processes. Along with computer graphics, varied photographic processes are becoming far more sophisticated, including the use of lasers to accomplish more tasks. Printing systems, as the heat transfer methods are revolutionizing the procedures for printing textiles and affording new types of final products. The systems of printing papers, magazines, advertisements, package designs are moving towards computer preparation of copy, and actual automation of products.

The revolution of image-making via computers, lasers, photography is being coupled to revolutions in printing systems.

This is where the revolution in textiles will emerge next. The full implications of computer art and computer-controlled textile systems is perhaps the next "industrial revolution," in which computer designs, computer-assisted, produced textiles could enhance private and industrial environments.

#### REFERENCES

- (1) Dorf, Richard C. Introduction to Computers and Computer Science. San Francisco: Boyd and Fraser, 1972, 19.
- (2) Lourie, Janice R. "The Textile Designer of the Future," Handweaver and Craftsman, Winter, 1966, 8-9.
- (3) \_\_\_\_\_, Textile Graphics/Computer Aided. New York: Fairchild Publications, 1973.

(Please turn to page 34 for conclusion.)

# THE PROGRAMMING

# CHOREOGRAPHER

by Analivia Cordeiro  
905 West End Avenue, #123  
New York City, N. Y. 10025

*The author, formerly from Sao Paulo, Brazil, is now living in New York City for a year. She describes her experiments in choreography and television at the University of Campinas, Brazil.*

Until a short time ago, few people could have imagined that the computer would play any role in the field of the arts. However, its use in the current art scene is an undisputed fact, characterized by a dynamism, manifested through many experiments in the fields of the visual arts, music and dance. For the public, the principal difference in the use of the computer in each of these areas is in the output, which could be an actual work of art or a series of instructions, the interpretations which will permit the production of the work of art.

The use of the computer in the field of dancing is of the second category. The output consists of information for the performance of the dancer, as well as for the technical team producing the show.

The objective of this article is to show how the computer can be used in choreographical programming for television, a field to which the author has been dedicating herself, in a pioneering fashion, in Brazil for the last few years.

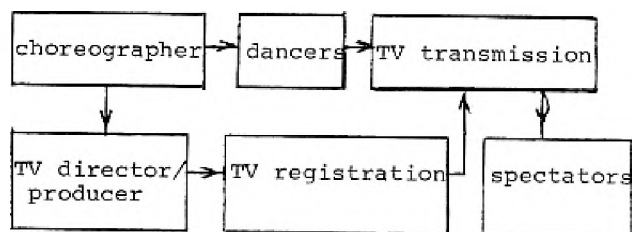
This process, instead of using the dancers as choreographic instruments, allows the choreographer to utilize the computer in the creative act, giving greater potential for new aesthetic results.

## THE FAILINGS OF TRADITIONAL CHOREOGRAPHY

As I observed, the choreographer's function, when working in television, is to direct the movements of the dancers and establish an understanding with the television producer and director. They determine how the pre-arranged movements of the dancers will be registered by the television cameras, which transmit the dance. The message received by the spectator is a function of the movements of the dancers, captured by the cameras.

It could be said that the camera is the eye of a dynamic spectator.

The relationship between the dance-TV-spectator can be represented as follows:



ABOVE: "M3X3" - Camera in overview, from dance experiments by Analivia Cordeiro, from the film, "Computer Dance/TV Dance," 1974.



ABOVE: "M3X3" - Camera in lateral view, from experiments in dance at the Computer Center, State University of Campinas, Campinas, Brazil.

Through practical experience I have observed three basic defects in this process. The choreographer's influence on the television is not direct. His (or her) behavior is determined by the television director and producer, who interpret and subjectively translate the "intentions" of the choreographer. This is a factor of interference of the choreographer's message. On the other hand, the television register -- in this case, the cameras -- act on the dancers without their being conscious of it, because the relationship, dancer -- camera, doesn't exist.

If we consider that the choreographer gives the dancer's a degree of freedom of expression, we will, in this case, have yet another factor of interference of the choreographer's message.

The choreographer communicates with the dancers through metaphors, to induce the dancer to make a movement or a series of movements he utilizes verbal or corporal expression. This relationship is unsatisfactory to the choreographer because "words cannot express the exact degree of the individual neglect or ability in the moving factor," (4) and also for the dancer, who through the imitation of the choreographer's movement, limits his individual expression.

#### THE COMPUTER

The use of the computer in choreography for television could be of interest in the following areas of human activity:

- To those concerned with the analysis of operational systems. These would observe the decomposition of the language of the dance and of television into their components, the algorithm which relates them, generating the choreography, the communication of the output of the computer to the interpreters.

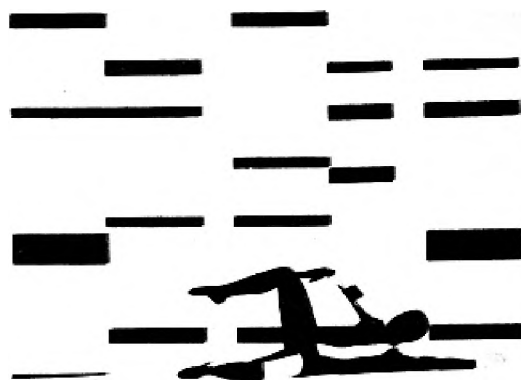
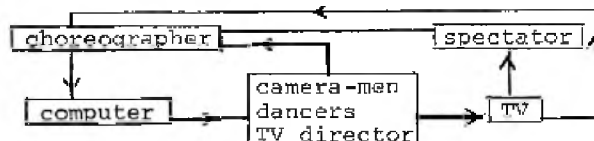
- To dancers and choreographers seek-new forms of notation and reading/interpreting human movement.
- To television teams, who would be working in a new context, unique dance, that is a mobile and rhythmic photographic subject.
- To everyone interested in the application of computers in new fields.

#### THE STAGES OF THE CREATIVE PROCESS - ARTIST-INTERPRETER-SPECTATOR

The objectives of this process can be divided into the following stages:

- To choose from among the components of the language of dance and television, those relevant for the transmission of the message wanted by the choreographer.
- To relate these components in an algorithm which will give the elements indispensable to the transmission of the choreographer's message.
- To communicate these elements to the participants in such a way as to allow the transmission of the artistic message to the spectator.

The aesthetic object will be produced through the actions of the interpreters. This process of production is called computer-assisted art (2) or computer-aided art. The creative process is integrated by the choreographer, the computer, the interpreters (dancers, camera, TV director/producer) and spectators. Its integration can be expressed by the following flow chart:



ABOVE: "0° - 45°" - Experiments in dance and television, Campinas, Brazil.



ABOVE: "M3X3" - Camera in lateral view, television dance, Análvia Cordeiro.

To instruct the computer, the choreographer uses the syntax of the language of dance and television and elements of scenography. "But in dance, analysis of movement is often personal and rarely detailed and scientifically based. We know that the performance of a computer depends entirely on the material fed into it, and so for dance the elements of movement must be clearly defined and the right selection made to describe what is wanted," said Ann Hutchinson (3), in a "A Reply" to the A. Michael Noll article, 1966, "Choreography and Computers," Dance Magazine, January, 1967.

#### THE COMPONENTS OF DANCE AND TELEVISION

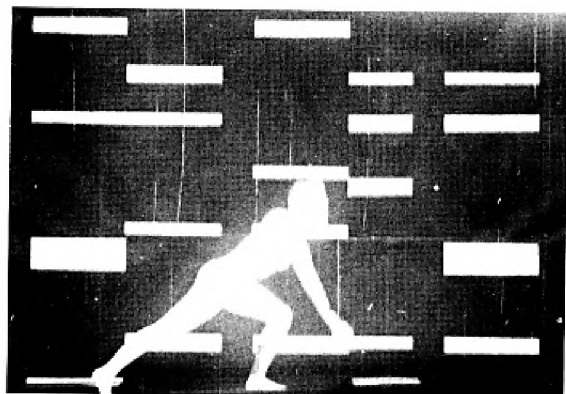
The components of the dance are:

- DISPLACEMENT IN SPACE -- The path of the dancer in space.
- POSITIONS OF THE BODY -- "The trajectory of the movement can delay materially in the change of an object or in a new body's member position." (4)
- MUSCULAR STRENGTH -- The energy expended by the dancer in a given movement.
- FLUENCY OF THE SEQUENCE OF POSITIONS IN THE TEMPORAL DIMENSION -- The relationship between time, the sequence of positions and the muscular effort of the dancer.

The components of television are:

- CAMERA ANGLE -- The angle of observation of the object.
- PLANES OF FOCUS -- The distance between the observer and object.
- VISUAL EFFECTS -- Visual alterations in the register of the camera.
- CHANGE OF CAMERA -- Passing from the image seen by another.

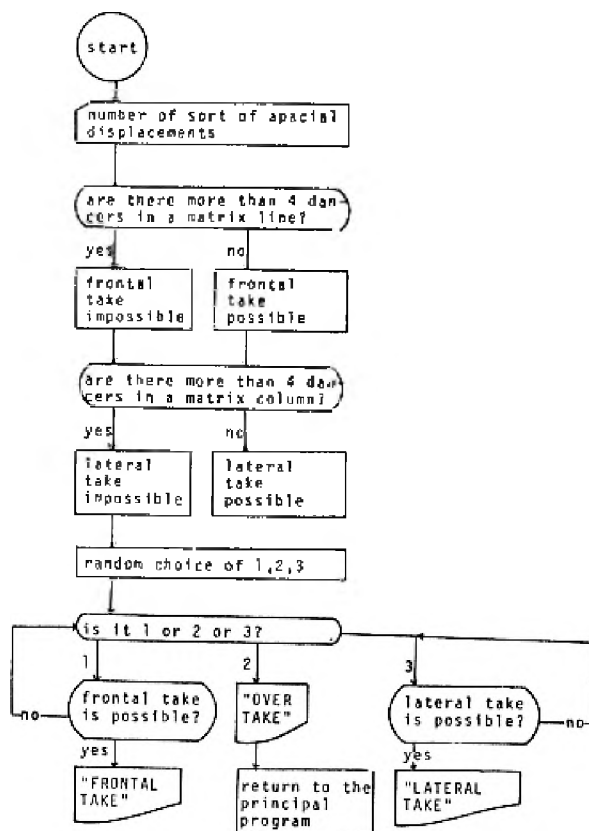
BELOW: An example of visual effects, in which the dancer moves as a white form with horizontal white lines.



#### THE ALGORITHM

By selecting components and establishing formal relationships between them, the choreographer structures an interactive dance-TV system. In this way he creates the algorithm which will generate the choreography he imagined. (In the dance-TV system the elements of scenery are explicit.)

An example of the subroutine "camera takes," processed after the subroutine "movement of the dancers" in the M<sub>3</sub>x3 choreography:



"The basis for the incorporation of chance may reside in this: stylistic regularities, as captured in programs, are not sufficient for the clear-cut description of a work of art, and in consequence offer certain degrees of freedom, each style permitting a multitude of realizations. In conventional artistic production, these empty places are filled intuitively." (2)

INTERPRETATION AND EXECUTION

The next stage consists of the translation of the algorithm into computer language. After processing the computer furnishes the elements for the interpretation of each of the participants.

The dancer receives instructions like:

time	4s	5s
displacement in space		
camera	over	frontal
postures		

The camera-man and TV director receives:

time		
camera angle	over	frontal
planes of focus	medium	close
visual effect	total high-contrast	

The scenographer receives the costume and scene description.

In acting, the interpreters must execute the elements given. The choreographer considers these indispensable for the transmission of his message by television. Those considered dispensable are left open, for the interpreter to create his own character. For example, the information given to the dancer consists of time, position of the body (in accordance with the camera view-point), displacement in space, while muscular effort and fluency of the sequence of positions remain undetermined. The energy used is the component, which to my mind gives greatest expression of individuality. "It gives us the capacity to produce new positions, encounters and percussions, new contacts and possibilities of tactile experiences both within the body itself and in relation to its surroundings." (4)

During the practice the interpreters can criticize the elements which are impracticable, and suggest new ways of expressing these elements, which would assist in the full realization of both the dancers and the choreographer's aims. This justifies this creative process: the programming and its actual verification will compose a dynamic element in the relationship planning/practical application.

In his interpretation, the dancer executes the positions within the determined time.



ABOVE: The author, Analivia Cordeiro, film-maker, dancer, and choreographer. Miss Cordeiro graduated in Architecture, and began using the computer in dance in 1973.

Also the transition from position to position is performed according to the given instructions for spatial displacement. The dancer is free to describe the trajectory connecting the positions. However, the choreographer is aware of all possibilities available to the dancer. For example, a dancer following a rapid rhythm has four possibilities of dynamics of movement:

number	time	muscular effort	trajectory
1	fast	light	straight
2	fast	strong	straight
3	fast	light	indirect
4	fast	strong	indirect

In their interpretation, the camera-man and the TV director read the instructions:

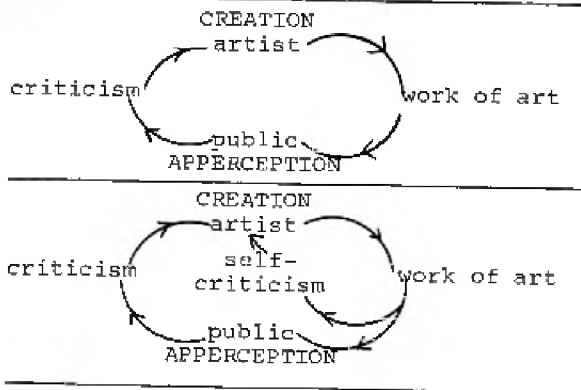
camera front - medium plane - vertical line effect - 4 seconds and in this case, choose an image with a medium plane and this type of effect, within the given time.



At the moment all the participants execute their parts simultaneously, the programmed result is transmitted.

#### THE PUBLIC, CRITICISM AND FEEDBACK

Only a few spectators have the opportunity to express their opinions. At the present, this is done through personal contact with the choreographer. As he and the other interpreters are also spectators, self-criticism is the most common form of criticism.



"The social communication in art. The feedback process of art incorporates in the production phase a corresponding circular process where the artist, by letting his work set upon him, successively perfects it, in terms of trial and error." (2)

#### THE ADVANTAGES OF THIS CHOREOGRAPHIC PROCESS

I would like to point out the most relevant characteristics of this process:

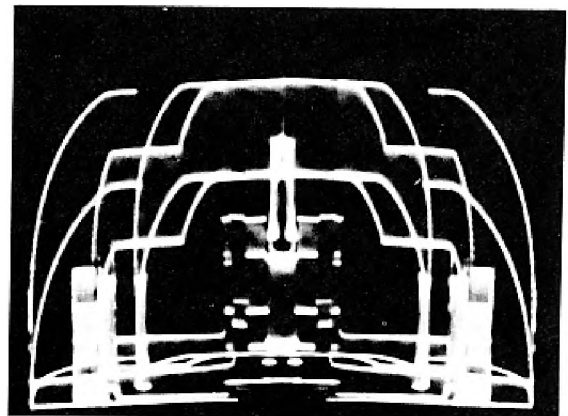
- Through the computer output, the choreographer does not communicate metaphorically with the dancers, that is with words or with his own movements.
- The choreographer objectively transmits the possibilities of movement of the body in the space and time given, supplying written and graphically syntactical components of the movement.
- The objective is to program the visual aspects of the movement. In television transmission, the camera is the eye of the spectator.
- The relationship interpretation/programming presupposes both pre-determined and undetermined elements. We are not concerned with making an animated film using real dancers.
- The interpreters have a precise awareness of their own interpretations.

that is to say, at each moment the camera knows how to focus on the dancers, and the dancer knows how he or she will be seen by the cameras.

- This process does not claim to be the only solution for the problems of production of dancing on television. Its significance is in the way it makes explicit the relationships which occur in any television-dance production. Because of this it can be used in different types of dance production.
- Every choreographer has his or her own personal style. One of the manifestations of this diversity is the degree of freedom given the dancer. This method can be used by other choreographers in different ways. For example, the choreographer may opt for not specifying body-positions.
- In operational terms, a fruitful suggestion would be the use of this process by a creative team composed of the choreographer, musician, producer and director of television, scenographer, computer applications analyst - that is to say, the specialists in the fields involved: dance, television, and computing.

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ABOVE: Theater graphics by Otto Beckmann.

# RE:VIEWING

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## LOGIN:

When Edison added motion to the picture, he lit the light for the twentieth century to move into a dimension that Freud never dreamed of. The rattle of the projector and the click of the cash-register beat out the rhythm of a nation hypnotized by its' image. The noise rose like a raga over the land to become the quiet hum of today's electric media, and the people now raise their ears to listen. But like Narcissus, when they reach out to grasp their likeness, it dissolves into the ripples of a new age -- an age which has lost all contact with the object.

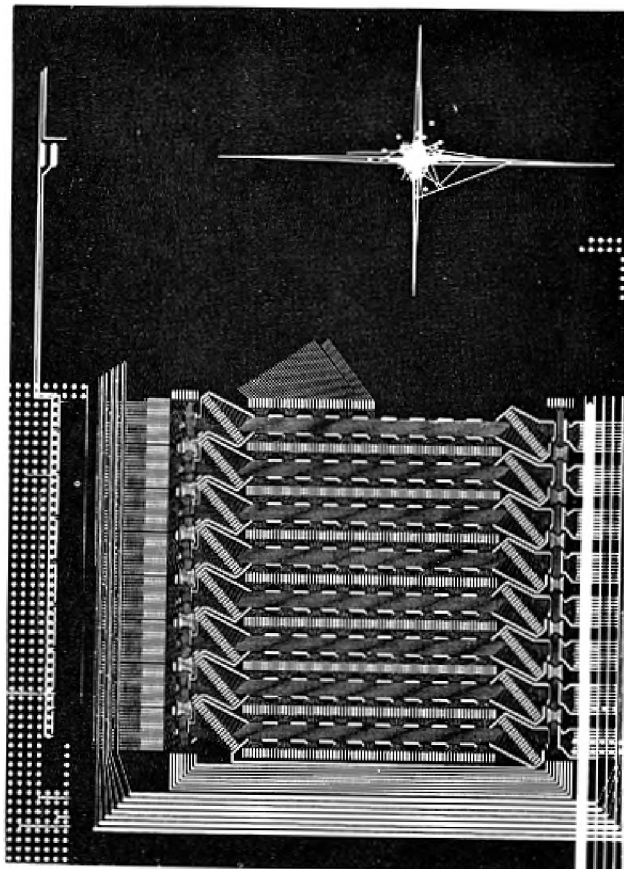
The medium of computer imagery will play an important role in the image-generating machinery of the future. It utilizes a visual language (called mathematics) and when a visual language joins with electric speeds of operation, the consequent power will change the shape of man's vision.

RE:VIEWING will appear in each issue. We will examine books, films and occasionally, computer graphic video tapes. We will often speak of computer graphics within the larger context of electronic media, since its ultimate significance will be realized within this larger context.

## A NEW INTEGRATION OF MEDIA

As we move into the last quarter of the twentieth century, tremendous forces of consolidation are at work integrating each of the new media into each other, creating a powerfully expanded synthetic hybrid. Like a collapsing white dwarf the new media technology continually crushes in upon itself -- creating condensed collections of super-powerful systems -- which in turn attract more electric systems into their net. The result is a self-contained culture increasingly incapable of any communication with those outside of the net -- all alone in the dark.

Let's sketch some examples of this intertwining of media forms. Over 45% of network television originates on motion picture film (despite cries of the "death" of the movies), thus merging these two quite separate media so totally that they are now indistinguishable in the cultural mind and vocabulary. The sleeping giant of cable-TV is able to provide homes across the land with a wide bandwidth wire for interconnection. Systems in California use cable as babysitter and for talking back and forth among subscribers.



ABOVE: Detail (or portion) of "Night Scene" by Lillian Schwartz, internationally renowned filmmaker. The artist works with computers, lasers, and microphotography, combining electronic music with the computer-generated forms in her films. In addition, these computer forms are often taken into serigraphy via photography into editions of graphics, combining varied media.

Image feedback: Future competition between Ma Bell's fibre-optic telephone network and cable feedback systems will leave today's network giants panting in the dust of one-way (lack of) communication.

## NEW GENERATION

A new generation of video equipment is here, and it is digitized. Cameras which "remember" the correct 3-gun alignment position will calibrate themselves at the push of a button, saving hours of technician set-up time. Their basic digitized electronic structure should allow facile interfacing with the graphics power of the new cheap computer systems, providing video as a standard input/output device, inexpensively.

Within the last year, the consumer market has opened to the public a new phenomenon of "computer stores", retail outlets in local shopping centers to provide low-cost computer graphics capability to any home.

The video disk allows a storage capacity of 55,000 slide images on a single disk the size of a phonograph record, each one instantly retrievable. Interfacing this device with a digital main frame should allow effects like freeze-frame and animation graphics.

In addition, there are satellite communications, holographic TV (a stereo TV system was demonstrated at the October SMPTE conference), and the optical computer, a device which is still on the horizon and so fundamentally visual in its operation as to eventually transcend the power of all the above systems.

#### THE SURREALISM OF THE 70'S

When Isaac Newton devised calculus, he divided up Renaissance reality into little pieces -- tiny quanta with no connection, faces lost in the crowd. At that moment in time, the "Golden Mean" gave way to multiple vanishing points, and a new universe appeared on the horizon. The Romantic poets saw the universe in a drop of water. Today these microcosms and macrocosms are subjects for investigation by science.

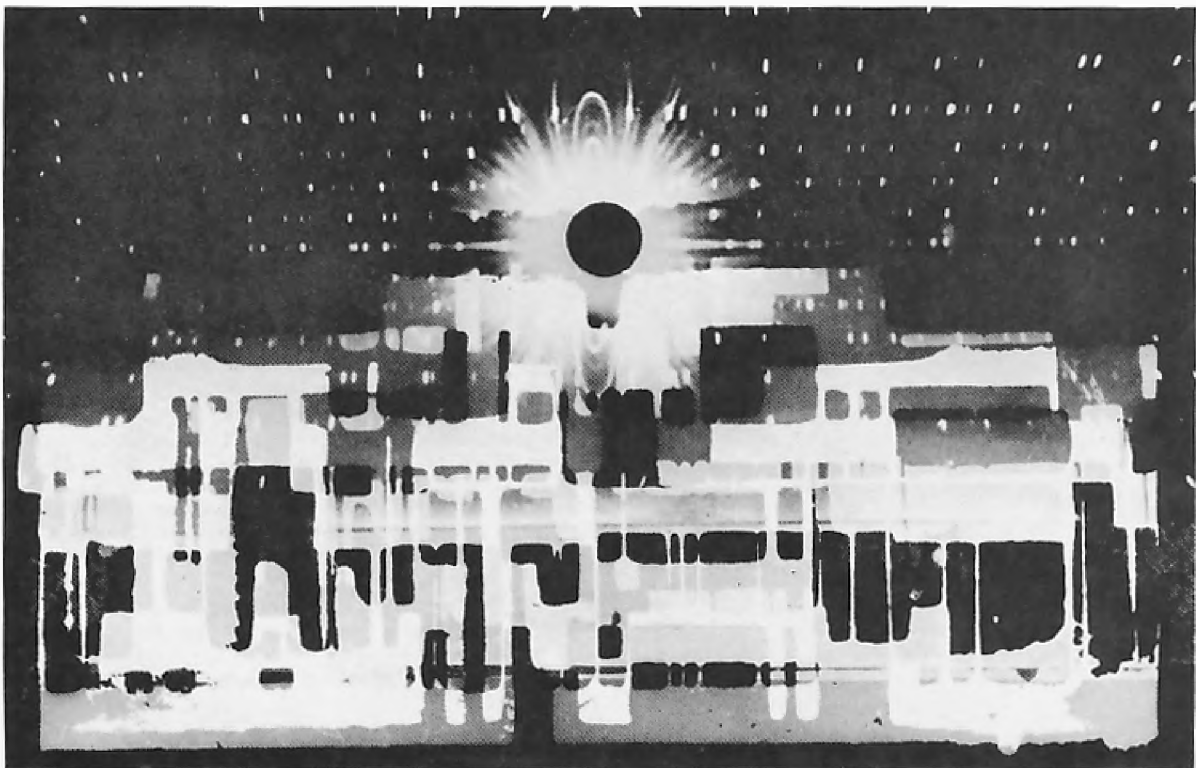
Computer graphics allows a student to ride a road at speeds approaching light, or to build architecture that exists only in the designer's mind. A scant fifteen years ago a class in Mechanics had only a chalkboard and the instructor's enthusiastic hand-waving to demonstrate time-changing phenomena. Computer graphics is becoming today's most valuable tool in visualizing abstract structures which were previously seen only in men's minds. Computer graphics is the Surrealism of the 1970's.

#### THE FUTURE AND CHANGES

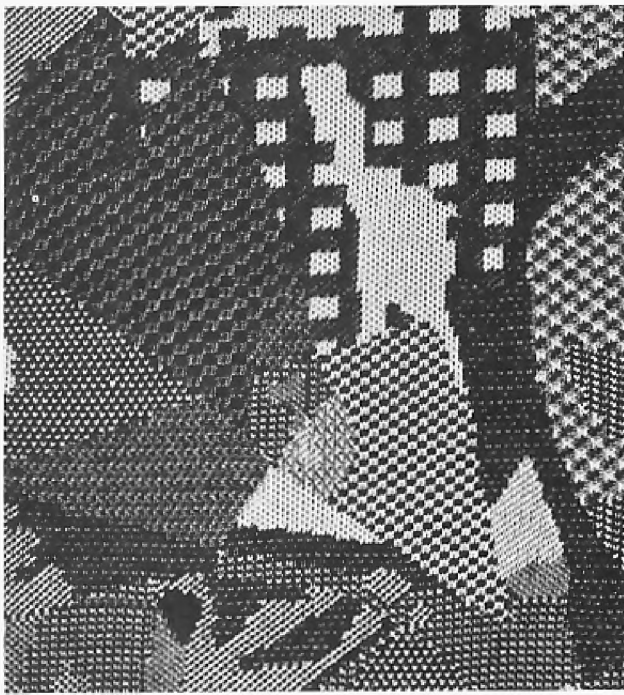
We don't yet understand the changes to be wrought in the "wired-in nation", but they'll be profound. Whether the next century finds us huddled alone in darkened living rooms, hypnotic captives of the image-makers, or celebrating a new-found togetherness with our fellow man, the changes to come will be articulated first by society's artists. Like a military advance guard probing unknown territory before the main body of troops, the avant-garde artist senses where we are going by reflecting and intensifying where we are at present. Thus his art becomes for us a mirror, allowing us to see more clearly and prepare for the dawn beyond tomorrow.

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BELOW: The "Ars Intermedia" computer art group was founded in 1966 in Vienna, Austria by Otto Beckmann. The group consists of artists, computer engineers, and computer scientists. They work together on varied artistic and scientific problems, making use of a hybrid computer system that outputs their work in unique forms, as below, using their "Creative Architectural Design CAD3" program.



ABOVE: Scenery Design by Professor Otto Beckmann, founder of the Ars Intermedia Group. Oskar Beckmann, his son, and a member of the group, designed and built a hybrid computer for their art research and output.



ABOVE: From COMPUTAKNIT, detail (portion) of a fabric, three color flat jacquard, incorporating no fewer than 45 design mixtures.



ABOVE: "Organic form" by G. Hertlein, design for textiles, from microfilm. One of a series of experiments for textiles.



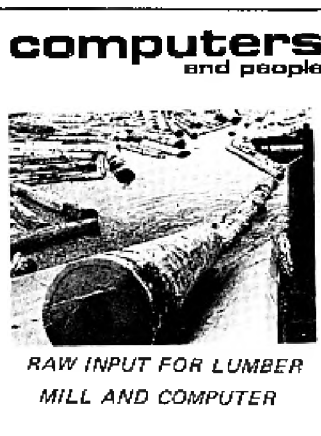
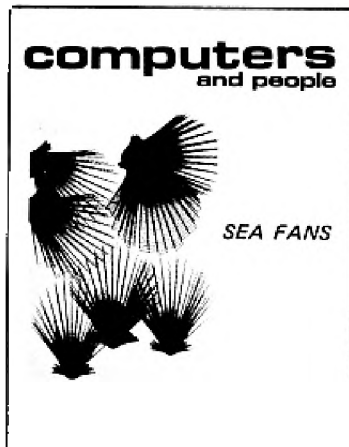
ABOVE: "Seashells" by G. Hertlein, design for textile, from microfilm.

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