May-June 1978
vol 4, no 3

creative computing

the #1 magazine of computer applications and software

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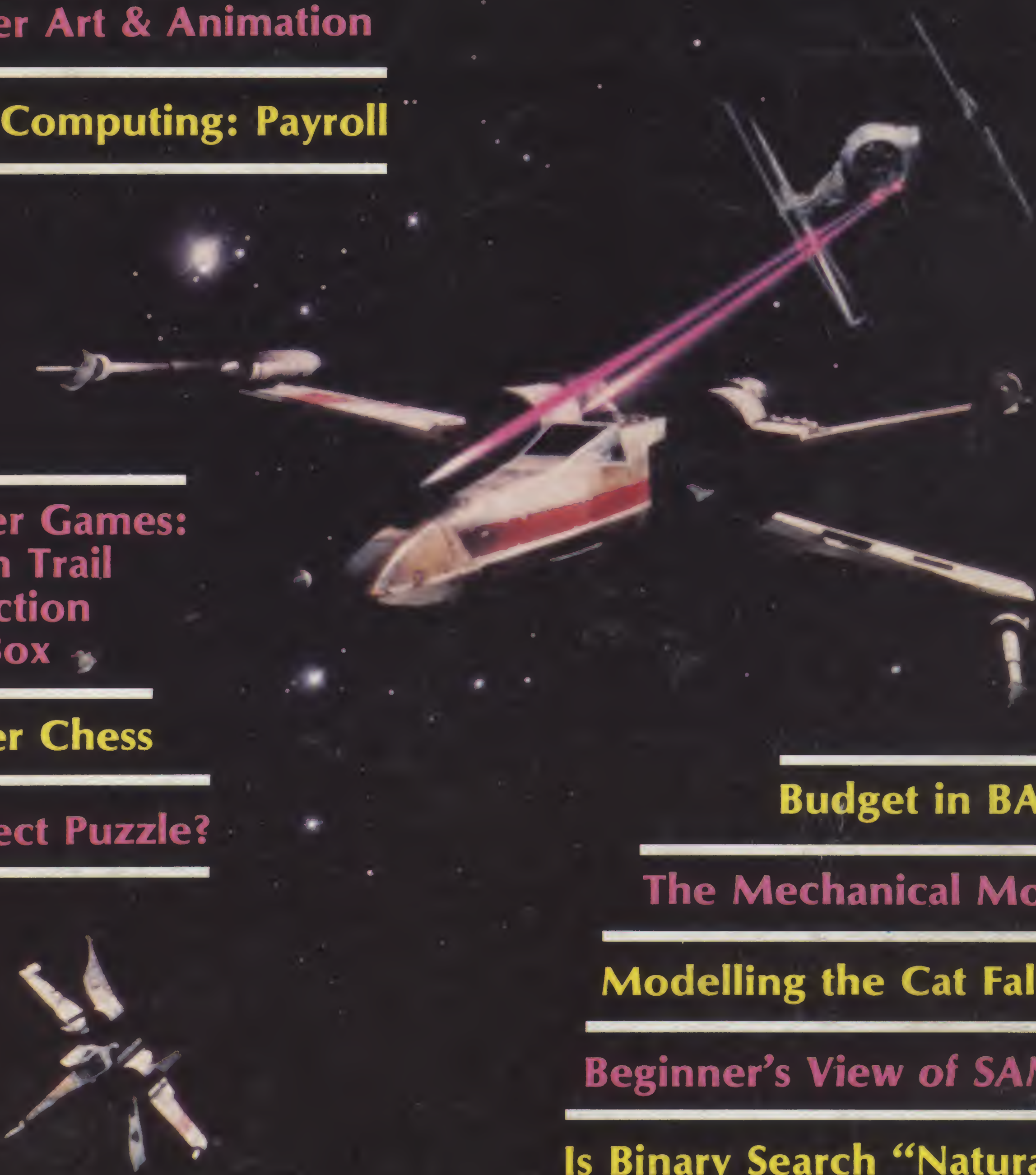

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The Mechanical Mouse

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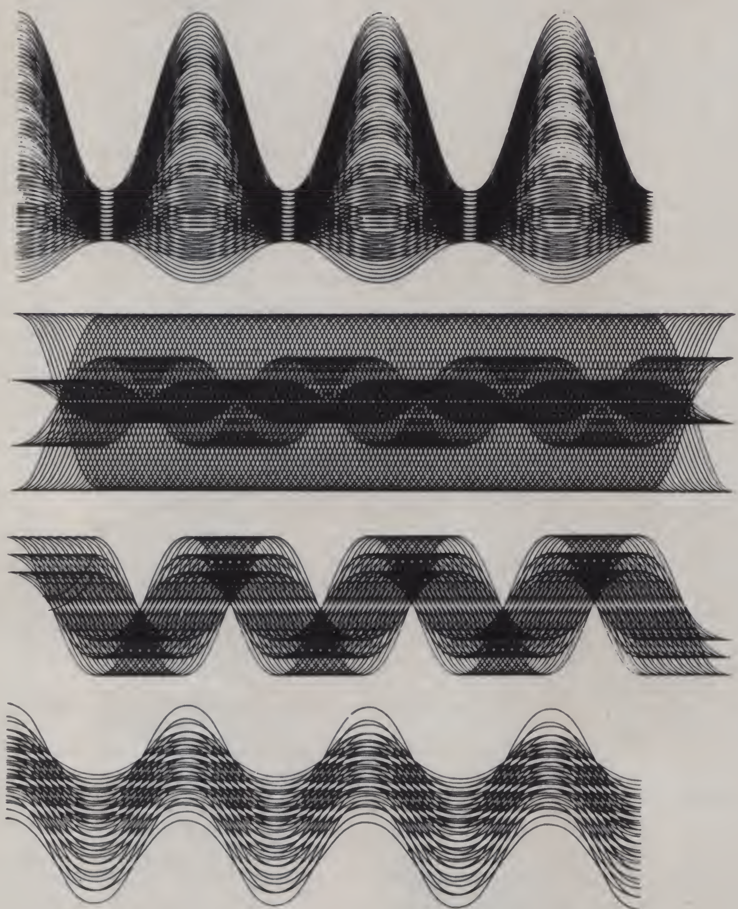
Is Binary Search "Natural"?

With dazzling speed, the computer has reexplored a succession of blind alleys in the visual arts. But the future looks different. "Whatever the technical route, we are on the verge of realizing an entirely new artistic mode."

Idols of Computer Art

ROBERT E. MUELLER



These pure sine waves of differing amplitudes by Bruno Sonderegger are Lissajous Variations in which step voltages and frequency changes are used. Since the sinusoid is a "natural" function, this design falls into the Idol of Nature category.

The computer is dangerously close to being our modern version of the kaleidoscope. The twists and turns of programs give unexpected variations of form that seem to be strikingly beautiful. But is it art? What is beauty? Many people in the computer field do not seem to realize that there is a long history of aesthetic investigation into this problem. I am an artist (with woodcuts in many museums including the Museum of Modern Art in New York City), and also an aesthetician who bridges science and art (I have an engineering degree from MIT and a degree in philosophy from NYU). I have given computer graphics a lot of thought since its inception—see my book The Science of Art: The Cybernetics of Creative Communication, *chapter 8, The Computer Apprentics (Day, 1967.) This article entitled IDOLS OF COMPUTER ART, reprinted with permission, was published originally in* Art In America *(May-June 1972.) I thought it might be of interest to the readers of* Creative Computing. *It summarizes the pitfalls and limitations of computer graphics as fine art, for the benefit of people who either take themselves too seriously, or who would like to try and take themselves more seriously as artists.*

— Robert E. Mueller

It is not surprising that a device as powerful as the computer should influence art—the latest in the long line of technological developments to do so. While I believe it will ultimately cause a minor revolution in all of the arts, the results to date are exceedingly poor and uninspiring. But all new media take some time to be assimilated—not to mention the economics of making them available for something so nonutilitarian as the arts.

Since Pythagoras, music has of course been far more tractable than visual art to mathematical, and thus eventually computer, manipulation. Johann Joseph Fux set the stage for classical music in 1715 with his *Gradus ad Parnassum*, the basic treatise to codify counterpoint in music. A similar mathematical impulse prompted Helmholtz to write his *Sensations of Tone* in 1863, and also

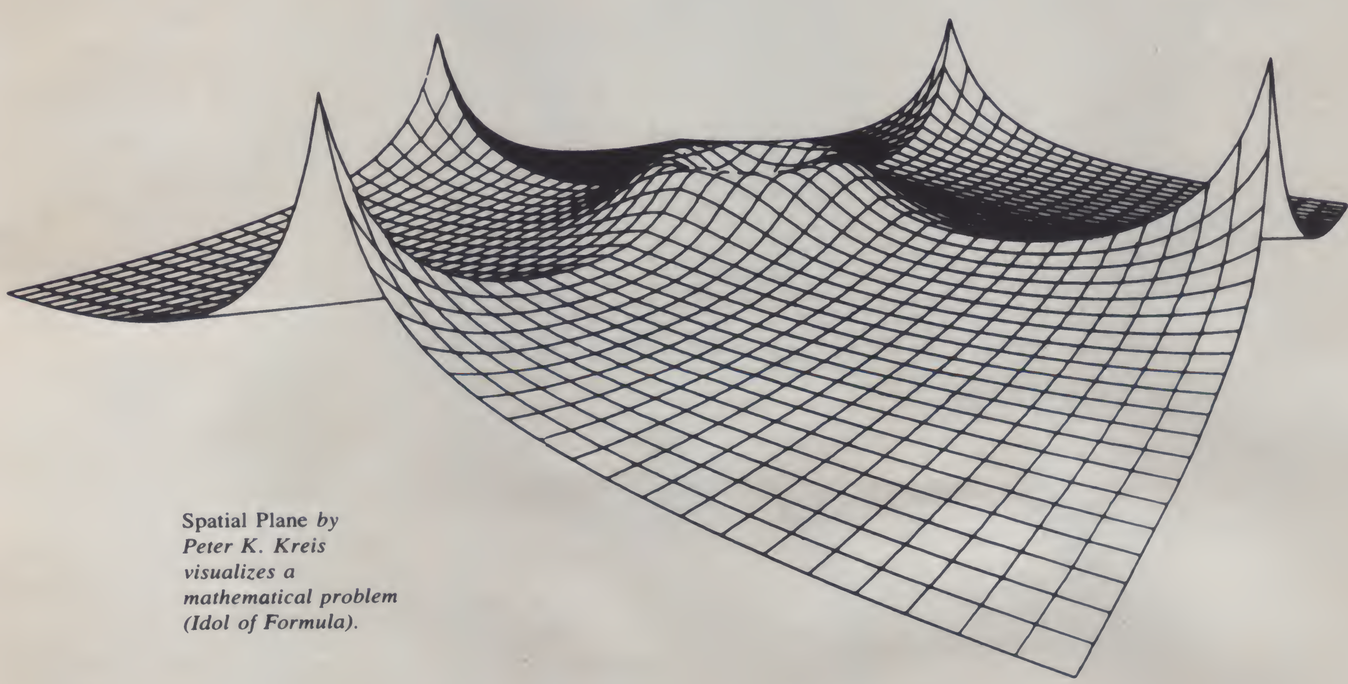
Paul Hindemith his *Craft of Musical Composition* in 1936, both updatings in disguise of Pythagoras' drive toward ordering musical notes. Schönberg took a different tack when he introduced the arbitrary, acoustically independent technique of the twelve-tone row; it represents the triumph of the urge toward mathematical abstraction over empirical necessity, the same urge Euclid demonstrated when he lifted geometry out of the practical world and put it on the plane of pure thought.

The computer permits this very old desire to organize tones or create new ones to be accomplished with great ease, and at a level of organization far beyond our capacity for perceptual discrimination. Milton Babbitt has pushed the impulse to mathematize musical quantities and qualities to its limit, subjecting harmonic, timbric, rhythmic and dynamic variations to the dominance of a single mathematical logic—a feat possible only with a computer. And specialized computer languages are in existence to increase the spectrum of possible tones, all generated directly on magnetic tape with little technical knowledge of the computer required to use them.

One would expect that mathematical ideas would similarly influence the manipulation of light and color. Although color organs are very ancient (Aristotle refers to the relationship between color and music in his *On Sense),* no artist has managed to apply mathematical virtuosity to visual phenomena for expressive purposes. Indeed—with a few notable exceptions—artists have remained somewhat aloof from the technological know-how our age has contributed toward color theory and production. But with the recently invented devices for creating or handling color (e.g., color phosphor cathode-ray tubes, electroluminescent screens, or holographs) this might change. And given the computer to control them, new opportunities for inventive manipulation will no doubt open up, limited only by the availability of such media and their comprehension by interested artists.

While these technological breakthroughs are being ironed out and made available, the computer specialist has been engaged in a private, often playful investigation of the computer's potential for making graphic curiosities. These productions are related to the fantastic curves invented by nineteenth-century mathematicians, and before that to constructed geometrical shapes the Greeks derived from conic surfaces. Of course the computer specialist doesn't realize it, but his computer graphics are exactly like those unpredictable and originally meaningless curves that just happened when geometric elements were fiddled with indiscriminately. Mathematicians assigned them highly romantic names: Devil's curves, Rose curves, Witches of Agnesi, Syntratrixes, Curves of Pursuit, Loxodromes, Caustics. This activity preceded the invention of analytic geometry, and was perhaps instrumental in its birth. Computer graphics may be a similar paradigm of some future computer mathematics.

Judging by the results, three major classes of computer graphics are being produced. The first, which I call "Lissajous Variations," has its counterpart in the traceries of pendulums and their mechanical or elec-



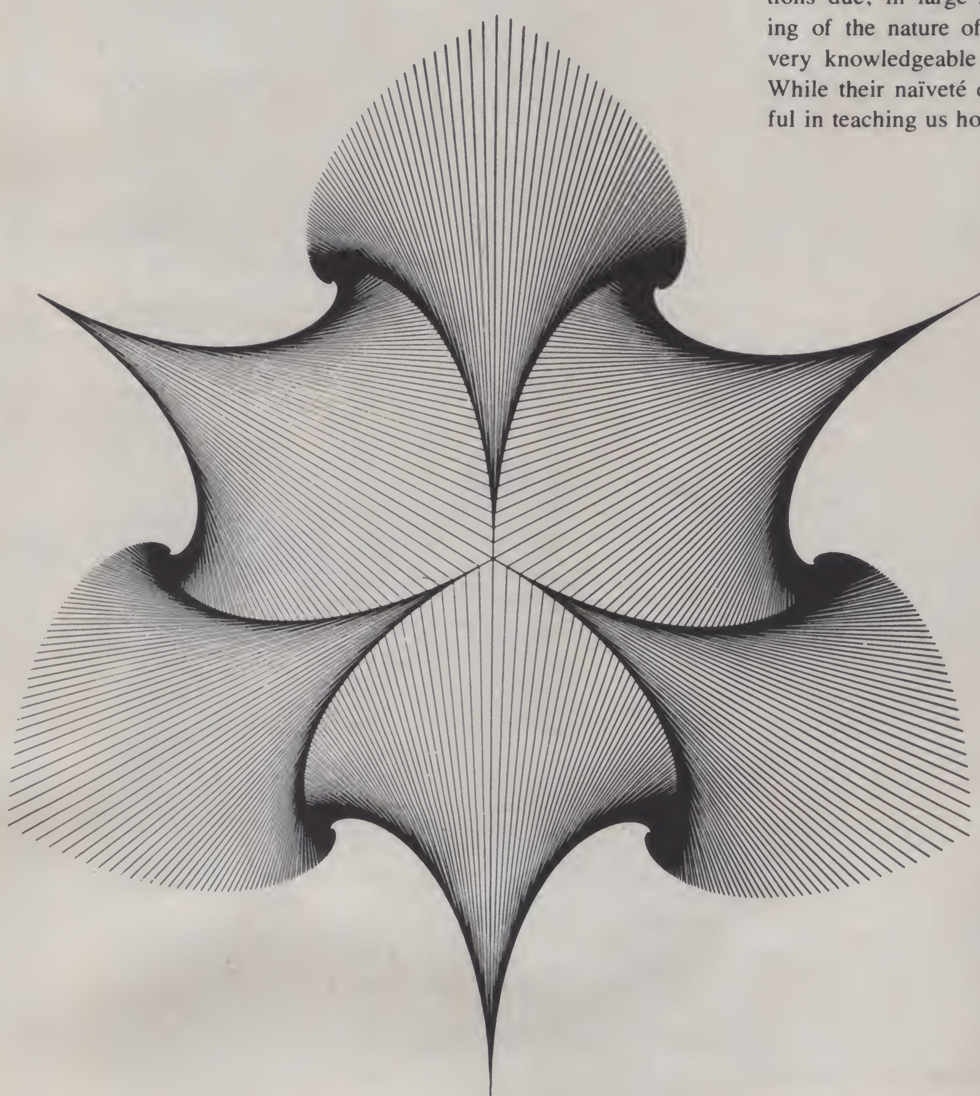
Spatial Plane *by Peter K. Kreis visualizes a mathematical problem (Idol of Formula).*

tronic equivalents. They were first investigated in 1815 by Nathaniel Bowditch (and were sometimes called Bowditch Curves), but studied in detail by the French mathematician Lissajous whose name they now bear. Lissajous figures are generated when two or more vibrating systems act on one another. These systems can be mechanical, like a pendulum supported by two or more legs; or they can be electronic, as when signals interact and are viewed on an oscilloscope. When the vibrating systems are generated by a computer and made visible by a pen plotter or cathode-ray-tube peripheral device, the resulting Lissajous Variations can produce complex and highly interesting forms.

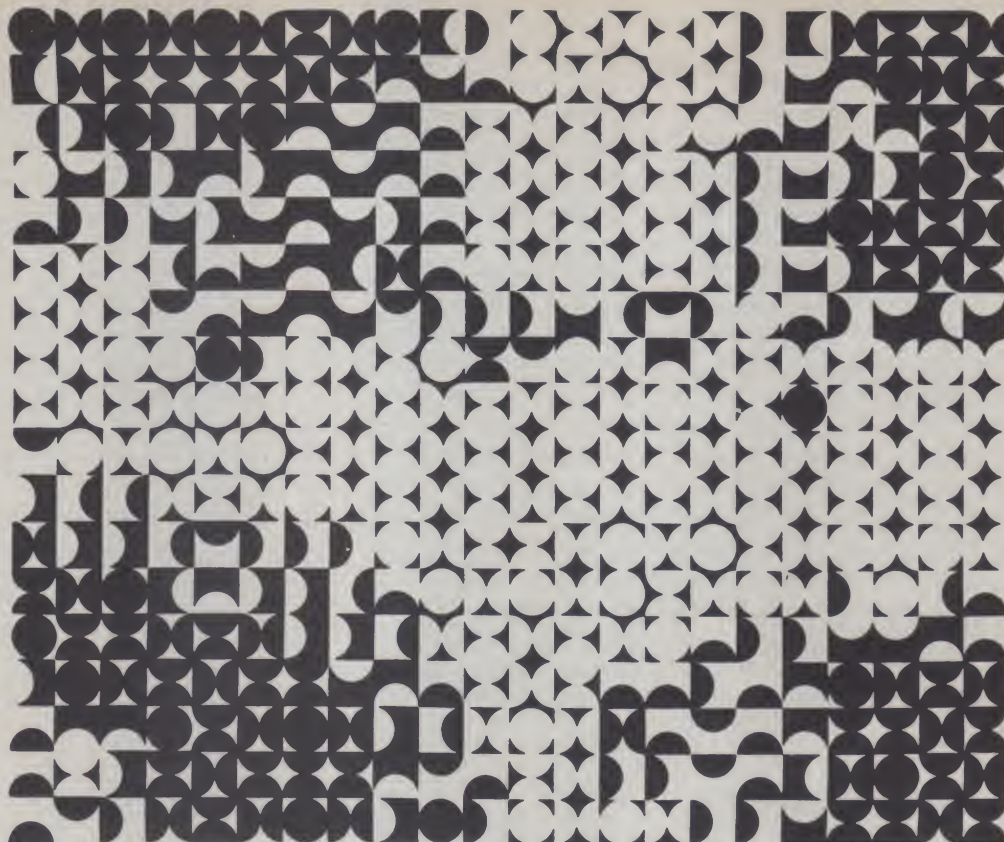
The second class of computer art, "Transformations," takes some recognizable picture or curve or function, and subjects it to a consistent alteration. It is related to the distortions of fun-house mirrors, and also to the technique for reducing photographs to halftones for the purpose of printing. But instead of converting the picture to a series of dots, this technique breaks down the original into many different elements, sometimes lines, spirals, wavy variations or perhaps arbitrary shapes or symbols.

The third and most interesting class of computer graphics, which I call "Controlled Serendipity," has the most artistic potential. This technique uses a given visual shape or form, either one derived from a photograph or picture or from a mathematical curve—or even from a new form made directly by the programmer—and subjects it to various random manipulations. The resulting pattern is observed and alterations are made on the original shape in order to see what happens the second time around. This is a feedback process in which randomly discovered elements can be emphasized or attenuated at will by the operator. It imitates a mode many artists use—the incorporation of accident—except that the randomness is introduced on purpose, in most cases through random-number generators. In science this introduction of randomness is sometimes called "dither," and B. F. Skinner has called Impressionism "realism with dither."

But computer art to date suffers from basic limitations due, in large measure, to a lack of understanding of the nature of art. Computer specialists are not very knowledgeable about the history of abstract art. While their naïveté could be refreshing and even helpful in teaching us how to exploit a totally new medium,



Crest *by Kerry Strand is a Lissajous Variation using non-sinusoidal functions (Idol of the Kaleidoscope).*



Zdeněk Sýkora based this Controlled Serendipity graphic on a computer program which distributed the design elements over a grid, producing playful variations on simple shapes (Idol of Game).

it has prevented them from achieving anything but the most superficial designs. They do not realize that Duchamp and Gabo, for instance, experimented with similar mechanically and photographically originated graphic ideas in the early decades of the century.

The errors into which specialists fall when attempting to apply the computer to art, one may call the Idols of Computer Art, in the same sense that Francis Bacon's Idols of Science stood for the traps of scientific theorizing. I feel that, to date, computer artists have been preoccupied with six intimately related false notions, which may be called "Idols of Nature," "Idols of the Formula," "Idols of the Kaleidoscope," "Idols of the Game," "Idols of Disguise" and "Idols of the Eye." Since these Idols apply to fundamental ways in which perceptual material is organized, it is reasonable to suggest that they also apply to music and any other art form subjected to computer manipulation.

All three categories of computer art can be used to generate what I call the "Idol of Nature," or that tendency to use natural order as a basis of patterned form. Things in nature such as crystals or flowers, the human body, landscapes, and so on, can become a meaningful part of a work of art. But when nature is simply reflected—increasingly possible as computerized techniques advance—its value as art becomes problematical. The results may be impressive, but they lack the necessary human insight and intervention, remaining "art-like" rather than becoming art. For example, natural forces are being released or channeled when Lissajous patterns are formed. These patterns represent not art so much as a methodological realization of forms implicit in nature, even though that nature is, of course, quite removed from a flower or sunset or crystal.

A subclass of this Idol is the "Idol of the Formula," in which a predetermined mathematical equation is used to *generate* some structure. Mathematics becomes a "new nature" generated by man. The generated forms may not be obvious from the original formula, but since they are implicit in the "givens" of mathematics or programming, they wait to be released by some technique for the eye to see. Most mathematical constructions fall into this class, and although conic sections or topological soap-bubble forms are interesting and perhaps highly suggestive, they offer nothing other than a rather empty inspirational force. Though we can say that mathematics is not art, some mathematicians think of themselves as artists of pure form. It seems clear, however, that their elegant and near-"esthetic" forms fail as art, because they are secondary visual ideas, the *product* of an intellectual set of restraints, rather than the *cause* of a felt insight realized in and through visual form.

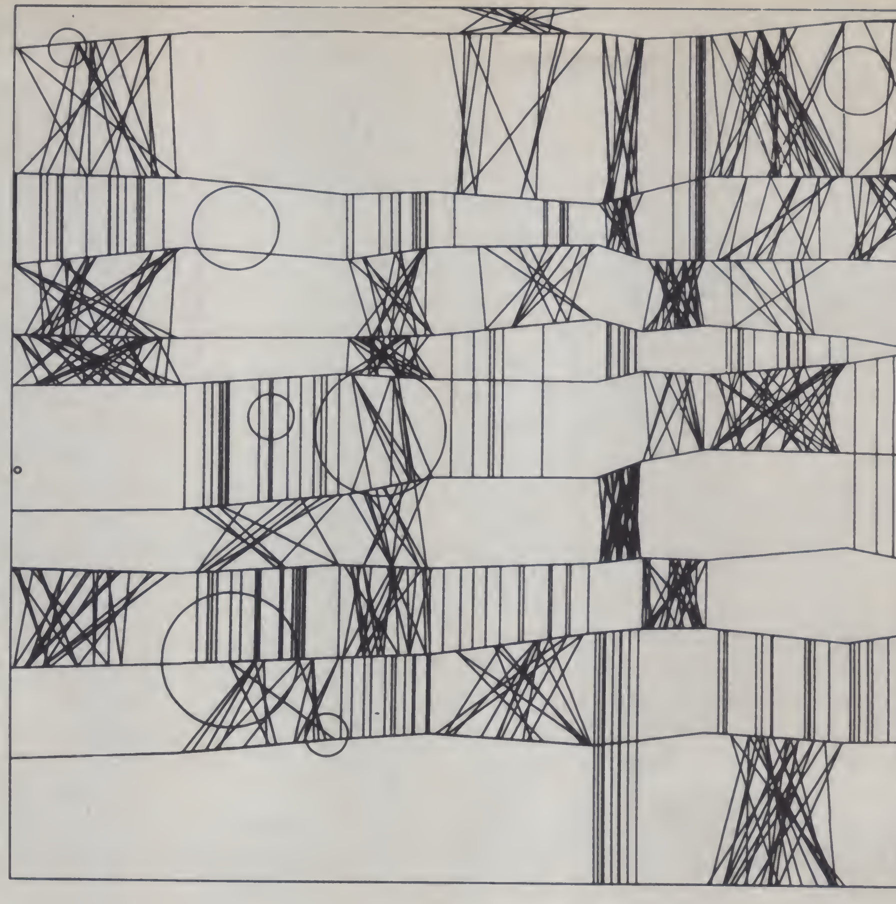
The "Idol of the Kaleidoscope" is mainly the product of the "Lissajous Variations" category. The mirroring of elements always transfers a feeling of great order, as do all effects of symmetry and periodicity. It leads to pleasant design, but not, I think, to art. Art should surprise us and demonstrate unexpected qualities, and the surprise or shock is due not so much to its novelty as our inability to understand its irrationality. Art we "understand" seems highly ordered or organized because we have exhausted it of its disarray, and by doing so have changed our perceptual devices for detecting degrees of disorganization in our experience.

Ordering through symmetry and periodicity is the obverse of the desire to randomize—an equally fallacious end in itself. The "Controlled Serendipity" category uses a quota of chaos in the interests of complexity and the unpredictable, producing what we might call the "Idol of the Game." Making chaos or order a matter of principle is recognized by physicists in the concept of entropy—the measure of the tendency for matter to run down or become increasingly disordered. Entropy measures of pure order or pure randomness represent a predictable termination of expression, and they are both null-points of artistic communication. But it is the *failure* to attain pure order or pure chaos that makes such attempts meaningful, recalling Claude Shannon's Theory of Information that all significant human form must lie somewhere between them. Fortunately between these extremes there is, as Rudolph Arnheim points out in his *Entropy and Art*, an incredibly rich variety of structures. Their continual evolution enables us to order our mental-perceptual mechanisms into conventions through which reality—and art—is interpreted. This is partly what Suzanne Langer means when she says that art attains values appropriate to our intuitive judgment about its worth.

In "The Idol of Disguise" some form or design is dressed up in an attempt to give it a new perceptual status, as represented by the "Transformations" category. The prevalence of this type of alteration makes it a very deceptive trap for computer artists. We enjoy looking at the old transformed into the new, with some remnants of the old still present to tell us where we are. Perhaps this impulse prompted Picasso to include relatively realistic nude bodies along with the African masklike faces of *Les Demoiselles d'Avignon*. Total newness is incomprehensible—even if it were possible. The "Idol of Disguise" represents the repackaging urge manifest in art as eclecticism—one way to sell the novel to a conventional world.

Charles Osuri and James Shaffer's Sine-Curve Man *demonstrates how a photographic image is transformed into a series of sine waves (Idol of Disguise).*

Friede Nake has translated a picture by Paul Klee to create a "new" work (Idol of Disguise).



The "Idol of the Eye" plays on that organ's perceptual capacities for novel effects, often to the point of saturation and sensory overload; many "Lissajous Variations" fail because of this. This "Idol" is illustrated by optical illusions, the visual "enigmas," which are the Op artists' "nature." We now begin to enter those gray areas where our perceptual apparatus causes subtle and important inflections. Music, for example, depends upon the nonlinear qualities of the ear to generate the hierarchies of harmonic importance. And of course the eye's physiological limits play an important role in our reaction to color harmonies. But we do not yet know exactly how optical illusions can be exploited most fully, although artists like Vasarely or Bridget Riley have begun to show us meaningful artistic applications.

Is it possible to imagine more viable computer art? The greatest single limitation on computer graphics seems to be the peripheral devices, the input and output equipment by which people can enter their visual ideas into the computer and receive them back. Another problem is that the artists' visual field of interest is far more complex than technicians realize. Consider line, for instance: the most superficial study of artists' drawings reveals nuances of stroke, pressure and texture inaccessible to the monolithic ball-point stylus or the cathode-ray beam, moved step by step across a sleek, homogeneous visual plane.

At this point in the development of computers, the visual ideas with which they deal are so simplified that they bore the sophisticated artistic mind to death. What is needed is an electronic medium offering as much control and variety as, say, watercolors. This is not inherently impossible, though most computer designers respond to such an opinion with a look of total incredulity—especially in the area of peripherals. The answer may lie in a television system linked into a computer, with some direct manual control provided for the artist. Such a system must allow human manipulation of as small or as large an area as the artist desires, and could theoretically be as subtle and precise as any classic artistic medium. Hands become the crux of human involvement with visual media, because without their virtuosity minds are stranded.

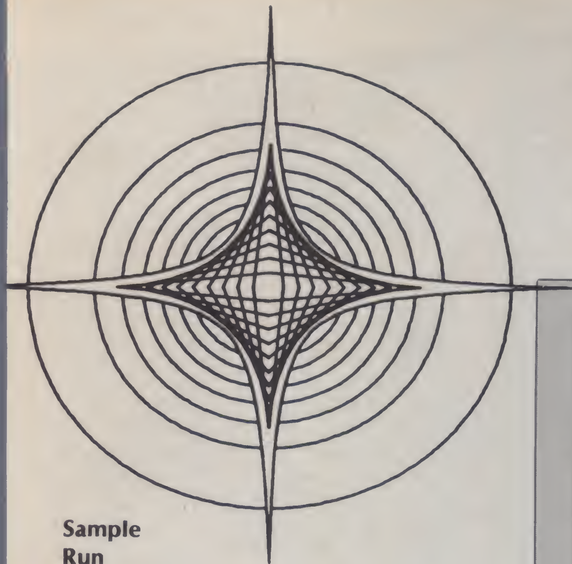
Although no existing electronic medium gives an artist direct manual contact with the computer's visual memory or computational powers, video control clearly lends itself to computer adaptation. The most interesting idea so far was conceived by Lee Harrison III. His device can be seen any evening on television, manipulating the titles and formats of commercials. Harrison's device splits into sections any given input image placed on a pickup screen. The operator can manipulate these sections one by one, varying their relative positions, distorting their shapes, sizes, colors, and so on; and images can be brought together or overlapped in full color for photographing or video taping. The images are controlled by analogue-computer circuits, but an artist must twiddle knobs to make his alterations, and learn a complex system of switching more restrictive than liberating.

A more direct if less professional approach is that of many young artists who go right to the seat of video artistic control—attacking a color television receiver in its circuitry, working with video tape systems, learning how to fiddle with resistors and capacitors in order to make interesting images in real time, photographed or recorded on video tapes. This type of floundering around *in* a new medium can lead to new insights which will clearly have a direct influence upon computer art.

An idea conceived while I was investigating the problems of computer art and video manipulation may provide a crude start in gaining more precise control over computerized images. Marrying Harrison's perfection with the video tinkerer's urge for freedom, it exists only as a patent application at present. Technically very simple, my device requires neither analogue nor digital computers, though of course they would expand its potential. With this system a person could draw by hand directly into video, in full color, using regular brushes or pens (but without pigments of any sort). This provides an extremely delicate control, right down to a single hairline of video input at any given point. And since this input is immediately converted into electronic signals, it can release a repertoire of arbitrary shapes, designs or other visual effects that emanate from or surround every point of contact with the brush or stylus. Through a keyboard control, these other shapes can be "played" point-by-point by the operator's left hand while he draws individual points with his right. This in effect multiplies a person's hands, permitting him to draw circles, entire lines, bands of colors, or many different geometric or other forms anywhere on the screen simply with one touch of the brush to the surface of the input "draw" screen.

Whatever the technical route, we are on the verge of realizing an entirely new artistic mode. An electronic-video-computer visual medium is as different from painting as film is from theater. As more interesting ways of rendering visual form are developed, and as the specialists begin to understand the limitations of their device. I am sure we will begin to see much stronger results. The most powerful impact will be, I feel, on mathematical form and problems of pattern recognition, an area on which computer specialists are already at work. They will probably discover that computer graphic productions are not so much art as they are new insights into the forms that must be explored in order to make the computer a more useful tool for dissecting generalized shapes. Afterward, perhaps, with some luck and know-how, the artist can begin to use the computer in his own way. But computer graphics will never become computer art until the technical processes become second nature to their artist-manipulators. ■

Shift No. 2, 1969, *by Auro Lecci, is a design in which restraints are transformed to create an expanding septagon around a point (Idol of the Eye).*



Sample Run

Computer Art: Stargate

Joe Jacobson

I create computer art using either a CRT output or a mechanical plotter. The first step is to find an idea or theme. Then I figure out a computer routine that will generate this design. The last step is to write the program and run it. Some programs embody generalized geometric routines and will draw a range of different pictures in response to a variation in the parameters entered through the keyboard. Other programs are designed solely to draw a particular picture that is envisioned at the beginning.

The picture shown, "Stargate", was drawn with the latter type of program. The geometric ideas came from several sources. Kelly Freas, the well-known science fiction artist, had shown me a geometric design he created for a logo. Christian Kuebler, a fellow experimenter in computer art, had suggested an interesting geometric algorithm several years ago. And I had an idea I wanted to use sometime. It occurred to me to make a synthesis of these design elements in one picture, and "Stargate" is the result.

This picture was generated on a Tektronix 4051 terminal, which can be used as a stand-alone microcomputer. It uses BASIC and has a package of graphics routines, and provides the user with 8K of RAM. The picture is displayed on the terminal storage CRT screen, and the system includes a hardcopy machine.

I've collected about a hundred such "plotter art" pictures, done over several years by myself and a few friends. ■

Joseph P. Jacobson, 18-C Franklin Drive, Maple Shade, NJ 08052

```
100 REM "STAR GATE"
110 PAGE
120 REM
130 A=3.3176
140 B=0.3214
150 C=10
160 WINDOW -10,10,-10,10
170 VIEWPORT 15,115,0,100
180 MOVE 0,C
190 FOR X=0 TO C STEP 0.1
200 Y=A/(X+B)-B
210 DRAW X,Y
220 NEXT X
230 FOR Q=0 TO 30 STEP 5
240 I=8-SQR(Q)
250 MOVE 0,I
260 J=1
270 FOR T=0 TO PI/2 STEP PI/(25*I)
280 X=I*COS(T)
290 Y=A/(X+B)-B
300 Z=I*SIN(T)
310 IF Z<Y THEN 370
320 IF J>1 THEN 360
330 MOVE X,Z
340 J=J+1
350 GO TO 370
360 DRAW X,Z
370 NEXT T
380 NEXT Q
390 MOVE -C,0
400 FOR X=-C TO 0 STEP 0.1
410 Y=-A/(X-B)-B
420 DRAW X,Y
430 NEXT X
440 FOR Q=0 TO 30 STEP 5
450 I=8-SQR(Q)
460 MOVE -I,0
470 J=1
480 FOR T=PI/2 TO PI STEP PI/(25*I)
490 X=I*COS(T)
500 Y=-A/(X-B)-B
510 Z=I*SIN(T)
520 IF Z<Y THEN 580
530 IF J>1 THEN 570
540 MOVE X,Z
550 J=J+1
560 GO TO 580
570 DRAW X,Z
580 NEXT T
590 NEXT Q
600 MOVE -C,0
610 FOR X=-C TO 0 STEP 0.1
620 Y=A/(X-B)+B
630 DRAW X,Y
640 NEXT X
650 FOR Q=0 TO 30 STEP 5
660 I=8-SQR(Q)
670 MOVE -I,0
680 J=1
690 FOR T=PI TO 1.5*PI STEP PI/(25*I)
700 X=I*COS(T)
710 Y=A/(X-B)+B
720 Z=I*SIN(T)
730 IF Z>Y THEN 790
740 IF J>1 THEN 780
750 MOVE X,Z
760 J=J+1
770 GO TO 790
780 DRAW X,Z
790 NEXT T
800 NEXT Q
810 MOVE 0,-C
820 FOR X=0 TO C STEP 0.1
830 Y=-A/(X+B)+B
840 DRAW X,Y
850 NEXT X
860 FOR Q=0 TO 30 STEP 5
870 I=8-SQR(Q)
880 MOVE 0,-I
890 J=1
900 FOR T=1.5*PI TO 2*PI STEP PI/(25*I)
910 X=I*COS(T)
920 Y=-A/(X+B)+B
930 Z=I*SIN(T)
940 IF Z>Y THEN 1000
950 IF J>1 THEN 990
960 MOVE X,Z
970 J=J+1
980 GO TO 1000
990 DRAW X,Z
1000 NEXT T
1010 NEXT Q
1020 WINDOW -10.10,-10,10
1030 VIEWPORT 40,90,25.75
1040 N=10
1050 D=1
1060 M=1
1070 T=0
1080 R=M*D
1090 X=R*COS(T)
1100 Y=R*SIN(T)
1110 MOVE X,Y
1120 IF T>1.5*PI THEN 1200
1130 M=N+1-M
1140 T=T+PI/2
1150 R=M*D
1160 X=R*COS(T)
1170 Y=R*SIN(T)
1180 DRAW X,Y
1190 GO TO 1120
1200 M=M+1
1210 IF M>N THEN 1230
1220 GO TO 1070
1230 END
```

Author at Tektronix 4051, used as a stand-alone microcomputer to generate Stargate.