Computer graphics for television

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The skillful and creative use of the new graphics technologies has added an electrifying dimension to programs and commercials. Visual capabilities that would have seemed beyond science fiction in the 1950s are available today at prices even the smallest station or production house can afford.

However, the phrase *computer graphics* is a confusing one, for the pace of technology has resulted in such a variety of computer graphics devices, that now there are many forms of such graphics: some posterize or animate still images; others turn graphic figures into moving abstract patterns; still others create pictures that look like paintings or even like photographs. Some operate in real time—images are put into motion at full speed before the operator's eyes—others require slow assembly of pictorial information for later playback. Some systems operate directly in NTSC video standards, others require a TV or film camera, or other kind of converter.

The graphics computer

The kind of computer most facilities have these days to handle logging and bookkeeping is a digital computer. It stores and manipulates discrete signals or pulses, known as *bits,* that are combined to form codes which represent letters of the alphabet or numbers. Some computer graphics systems for television, especially the newest ones, use this type of computer.

But there is another kind of computer also used for graphics purposes, and it probably hasn't been heard of since the 1950s, at least in a form called a computer. It is the analog computer.

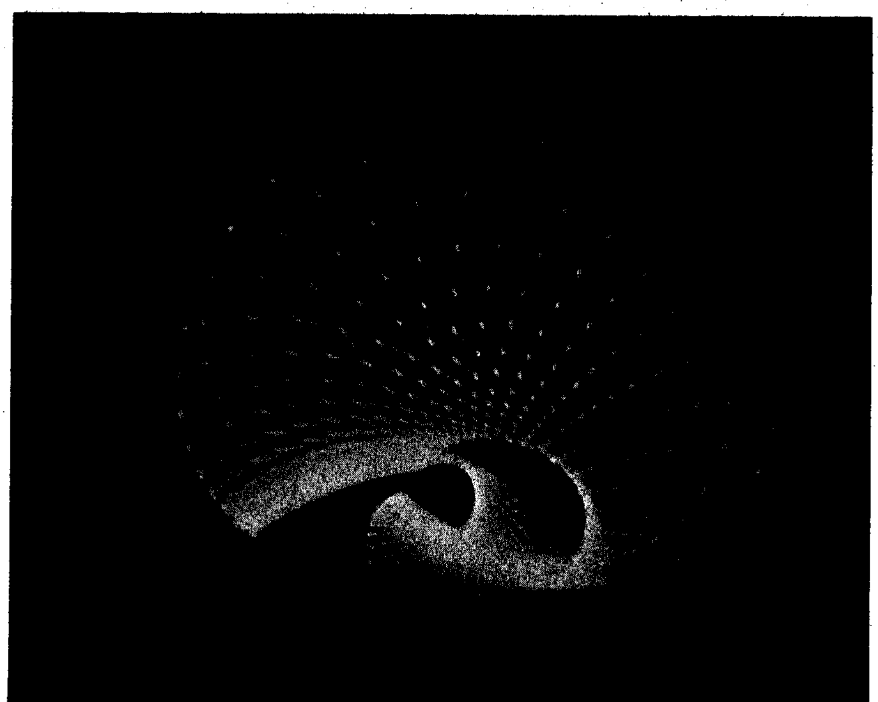
Analog computer graphics were first used by creative artists to create complex Lissajous figures, still and moving. Artist Ben Laposky, designed the first analog system solely for artistic purposes in the 1940s. His creations, known as Oscillons, are b&w and color still images. Mary Ellen Bute used an oscilloscope and analog circuits in the early 1950s to make motion pictures. And in the late 1950s, a filmmaker, John Whitney used more sophisticated military surplus analog gun computers to build an image creation system using optical/mechanical scanning.

But the analog computer did not really find its way into TV graphics until the late 1960s when the Computer Image Corporation introduced the Scanimate process, which has since been popular for advertising graphics, station IDs, and used extensively by the TV show *Sesame Street.*

Rather than using analog circuits to create abstract designs—although Scanimate is capable of doing that—Computer Image saw the device as a tool for adding motion to otherwise lifeless corporate logos and other static figures.

Although analog graphics systems are capable of producing beautiful geometric designs and fantasy imagery, they are also useful for image manipulation of a more conservative type. This author has created film footage on a Scanimate (using a kinescope recording camera filming the high-resolution CRT display) depicting the moon circling the earth and a rider on a horse moving across the screen.

Each of these scenes only required a single litho original to be created. In the moon sequence, the litho consisted of a drawing of the moon and a drawing of the earth. In the rider sequence, the litho



***Oscillon No. 507,* Ben F. Laposky.** Analog computer graphics were first used by creative artists to create complex Lissajous figures. (Photograph courtesy of Ben Laposky) original showed a horse and a rider (each separately located on the cel). The Scanimate computer positioned, sized and moved the images accordingly to create the scenes described. Though simple visual sequences, conventional film animation techniques would have required dozens of original litho images or cels to be drawn.

The Computer Image Corporation has even developed a special system just for cartoon-style animation. With this system known as CESAR, one can create standard animated cartoons using far less original art than required by standard optical animation.

The Computer Image Corporation is not the only company that has produced analog graphics computers. Several years ago Steve Rutt and Bill Etra designed and built several models of the Rutt/Etra video synthesizer. They were similar to Scanimate in some ways, although slightly different in capabilities and operational architecture. Graphics produced by this system have been used in major feature films and national TV spots.

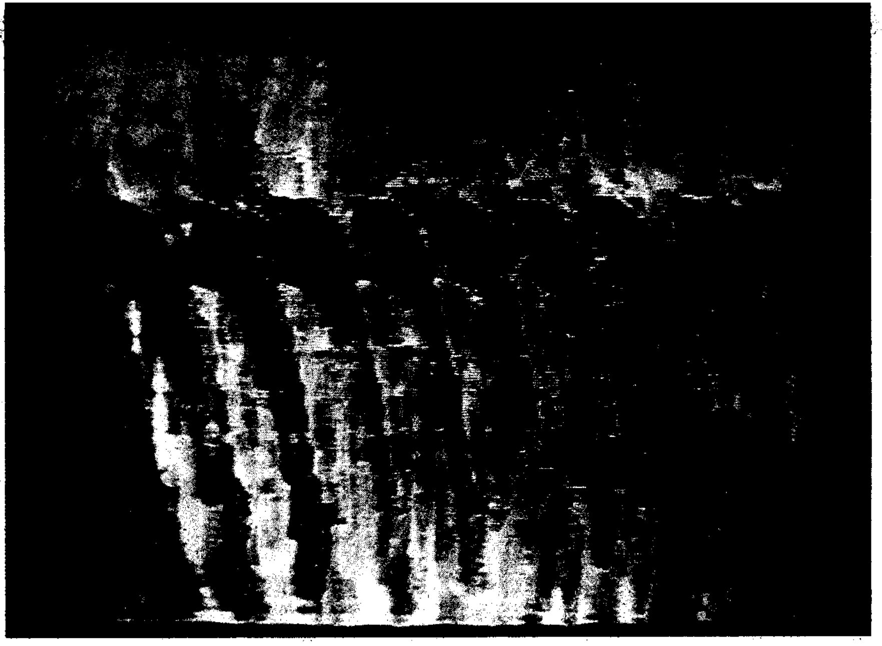
Probably the most famous artist-designed analog graphics system is the Paik/Abe video synthesizer designed by Korean Artist Nam June Paik (known as *the father of video art*) and Japanese Engineer Shuya Abe. The best-known installation of a Paik/Abe system is at Boston's WGBH-TV, although a smaller Paik/Abe system also exists at the California Institute of the Arts and perhaps elsewhere. Although used exclusively for fine arts, (not commercial art), the Paik/Abe system at WGBH has been used by a number of now-prominent artists, some of whose tapes command good prices by collectors. And Boston viewers have enthusiastically received the abstract visual accompaniments to the Boston Symphony concerts created on the Paik/Abe by Ron Hays.

Although there are many kinds of analog graphics systems, they all have three basic characteristics related to their creative use that the TV producer or ad agency art director should keep in mind when contemplating the use of analog imagery:

1. Analog systems are hardware oriented. The operator of an analog system directly manipulates, in real time, the controls of the image system. And the hardware determines the kind of image manipulations that can be done. Each system has its own *visual vocabulary.* To use analog graphics to its best advantage, the creative artist should know the workings of the system to be used. There are several agency art directors who have gone to a computer graphics house with a preconceived notion of the images wanted, only to find that the analog system being used could not produce that image. It is important to understand the system first, then come up with a visual concept that is within the system's vocabulary.

Unlike most other art media, analog imagery is determined more by the machine than by the operator. Six operators of the same computer are apt to produce images more alike than they are different (in style if not in content). To get beyond the *look* of the machine, analog computer images must be combined with a completely different medium.

2. Motion is the analog system's best virtue. Although some artists have made use of still imagery produced by a graphics computer, the real success of systems such as the Scanimate computer and the Stephen Beck, Rutt/Etra and Paik/Abe *synthesizers* can be attributed to their capability to produce movement that is unbelievably fluid and graceful. And this motion is created in real time, so the artist can experiment with scenes and time sequences to match musical passages or to fit the metre of other action.



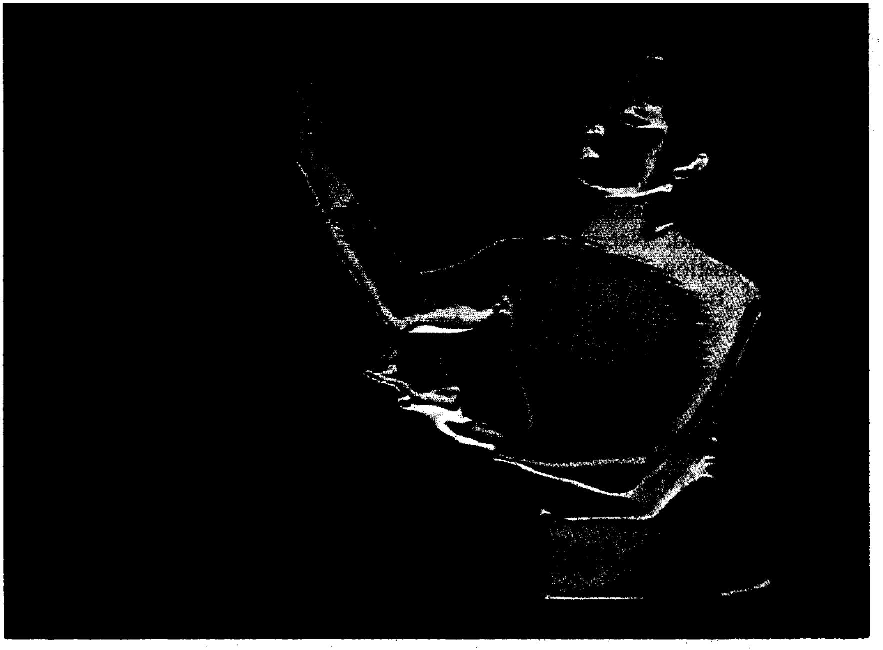
***Lightfall*, Eric Somers.** Electronic abstraction created by the author using an analog system put together at Creighton University. Brushstroke effect is similar to electronic painting possible with some digital systems, except that with the digital system representation art is also possible. Colorizer used was made by Colorado Video. (Photograph courtesy of the author)

3. Abstraction is a major part of the analog vocabulary. Although there are many uses for analog computer graphics as a simple and low cost substitute for conventional cel animated in creating cartoon-type animation, a major attraction of analog computer imagery has been the fantastic look of the final product. Whether used to modify an image from a camera, or to generate a kaleidoscopic design, the output of the analog system usually looks futuristic and modern. And it seems to be a medium that appeals to a generation brought up on TV viewing. But it attracts the most attention in self-conscious applications where the images look electronic and bizarre.

A digital world

In spite of the capabilities and beauty of graphics sequences generated by analog computers, it is becoming a digital world. This does not mean that the specialized capabilities of the analog computer must be discarded; hybrid systems are being built that provide some of the advantages of both analog and digital equipment.

Some new analog systems are



Dancer, Eric Somers. Example of TV camera image colorized by an analog system. Gray scale levels are replaced by new colors and tones to produce graphics art effect. Colorizer used was made by Colorado Video. (Photograph courtesy of the author)

designed to be controlled by a digital computer, so lengthy visual effects can be programmed and stored in the digital computer's memory for execution at the appointed time. Also, a digital computer can be used to create images that are further manipulated by an analog system. Finally, digital-to-analog converters can be used, which along with the appropriate software (programs), allow a digital computer to emulate an analog computer.

The popular image of digital computer graphics is that it is something brand new—something on the leading edge of technology. Actually, computer graphics are nearly as old as the digital computer itself. A cathode ray tube display designed for graphics was used with the early Whirlwind I computer at MIT in 1950. And graphs, engineering drawings and even works of art have been created by computers using pen plotters, CRTs, even printers (a la the computer portrait printers so popular in shopping centers). Although the largest use of graphics has been for scientific purposes, many books have been written about computer art, and there are even whole magazines that deal with nothing else.

Probably the greatest boon to computer art occurred in the 1960s when interactive computer systems came into widespread use. These are systems that the operator can program from a keyboard terminal in conversation with the computer. This allows the user to feed in data or a command and immediately see the results, a big improvement (from a graphics standpoint) over punching hundreds of computer cards, then turning them into a central operator who runs them and returns the printout.

Even as computer art became popular and major exhibitions were being mounted by distinguished art galleries the output of a digital computer was still not seen much on television. This was due to the fact that the computers being used were exceedingly expensive, and the graphics images had to be created by programmers with extensive training. TV stations and production houses did not have the personnel or money. Some methods of programming took weeks to program the frames for a 30-second TV spot. This was not an appreciable savings over hand-drawn cel animation, and the images were not as good. Also, there was no provision to preview the animated sequence in real time. Early digital computer animation required each image to be drawn by the computer slowly and recorded on film, a single frame at a time.

Digital computer graphics seems new because it has only been during the past five years that such imagery is possible at low cost. The development of microprocessors and other LSI (large-scale integrated circuits) devices has drastically cut the cost of hardware, and graphics programs are being written that allow an artist with little technical training to create images, still or animated, on a TV screen.

There are several amazing but true capabilities of computer images:

- Digital computer graphics can be produced on a CRT that are virtually indistinguishable from TV camera images. That is, the computer can create *real* images of real-life things that have shadings of light and color, shadows and highlights caused by apparent light sources, etc.
- Digital computers can construct animated sequences that almost mimic Disney-style hand-drawn animation, yet unlike similar animations produced with analog systems, there are no original cels to be photographed by a camera.
- Digital computers capable of producing color graphics suitable for direct broadcast (without any rescanning from a CRT display) can be purchased for less than $4000.

Image production

Although there are considerable hardware and software differences between the various digital graphics computers, the principles of image production and manipulation are the same.

A certain portion of computer memory, a portion often called a frame buffer, is mapped for display. That is, each location in memory corresponds to one pixel in the final display. If one thinks of the final video image as being made up of a series of *dots* drawn by the computer, each dot is one pixel.

The device that changes the code in memory into a video display is called the *display controller.* It samples the frame buffer 30 times per second and creates a video image by using the code stored in each memory location to create a pixel of the appropriate brightness and (possibly) color. On simple systems the information for each pixel is contained in a single digital bit. This means that in such a system each pixel can only have two states, *on* or *off* (corresponding to the binary 1 or 0). No brightness or color variations are possible.

In a more sophisticated system each pixel might be represented by eight bits or even by a 16-bit digital word. The 16-bit pixel could have 2^{16} possible states or 512 possible combinations of brightness and color.

It is clear that the more bits used to represent each pixel, the greater the memory space requirement will be for the display buffer. If the number of pixels used to create an image is also high (in order to achieve better resolution) then the amount of memory consumed by the display buffer can become very large. It is obvious that the more complex and real looking the final image, the larger the computer it will take to produce that image.

And if an image is to move in real time, then the element of computing time enters. Note that the display controller samples the frame buffer 30 times per second (if the video is US standards). If animation is desired in which certain images are to be changed for each frame, then the computer must compute all or some of the contents of the frame buffer 30 times per second. Needless to say, each computation takes a certain amount of time (no matter how small) and if a high resolution display is used, the computer simply won't be able to make the changes fast enough. At the present level of technology, therefore, extremely detailed animation is not done in real time with most digital computers.

Visual capabilities that would have seemed beyond science fiction in the 1950's are available today

With digital computer graphics there is always a trade-off between image quality and memory space/execution time.

How does a digital code of the picture get into the frame buffer?

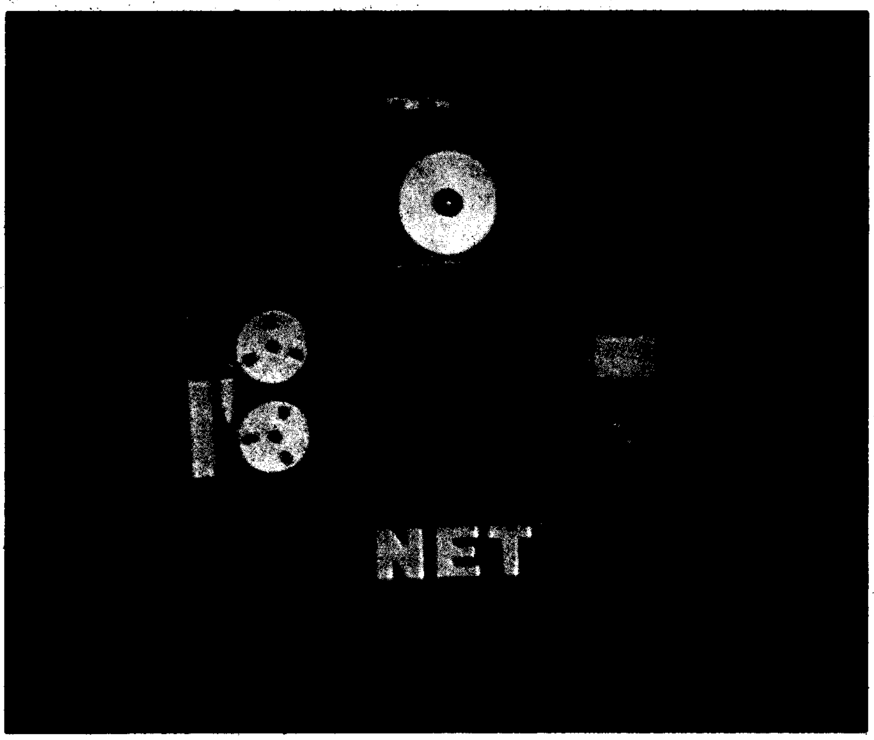
One way was simply to *tell* the computer what you wanted to draw. Digital computers only manipulate a single digital word (usually 8, 12, 16, 32 or 64 bits in size) at a time using a special code. This was an extremely slow and tedious process, but in the earliest days of computer graphics was the only way to produce pictures.

Programmers very soon, however, began writing graphics *languages* (either incorporated into general purpose high-level computer *languages* or existing separately) so that pictures could be drawn using a more compact programming code.

Various kinds of **hardware** have been developed that, when used with the appropriate software, allow easy and rapid specification of pictures in a computer memory, without having to write elaborate descriptions:

• The **graphics tablet** looks like a little writing board lined in squares. A stylus or other pointer is used by the artist. When he places the stylus against the drawing tablet at a certain point and activates a small trigger, circuits in the tablet sense where the stylus is on the drawing tablet and the computer draws a point on the screen. As the artist moves the stylus, a complete image is drawn on the screen. Provisions are made for the artist to specify the color and brightness of each line, provided the computer is capable of storing such information about each pixel in its memory. Since this form of entering picture information is so similar to ordinary drawing it is becoming popular with artists especially now that programs exist that allow the artist to use the computer without having studied programming.

• The **light pen** is a stylus, that is placed directly on a screen in order to define a location. It is usually less accurate than the drawing



State-of-the-art analog computer images by Computer Image Corporation using Scanimate. (Photograph courtesy of Computer Image Corporation) tablet, but is often used as a pointer when selecting commands from a printed menu or when pointing to graphics figures you want the computer to manipulate (for example, enlarge, rotate, change color, etc.)

- The **digitizer** accepts images from a TV camera and translates the output into a digital *image* in the frame buffer. This is what is used by computer portrait systems and also what allows for digital special effects using ordinary TV images (as are possible with some of the newest production switchers).

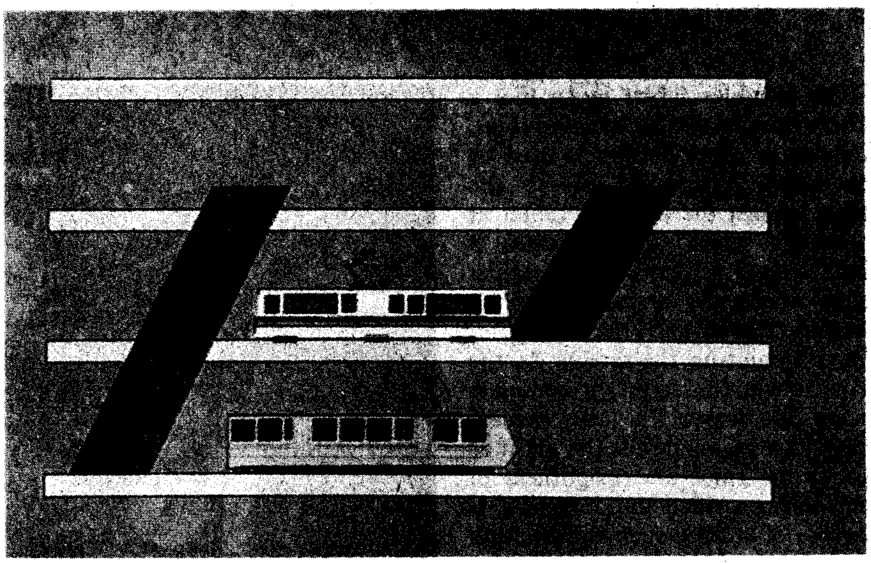
Computers can be programmed to manipulate the contents of the frame buffer memory (or any other memory location that may be used to store pictures waiting to be displayed, or control information, etc.) These manipulations can result in color changes, rotations of all or portions of a picture, enlarged, reduced, squeezed, expanded or replicated images.

Storage is the digital computer's strongest virtue. If a digital computer can do nothing else, it can store a graphics image for future reference. As a result, graphics information of a detailed nature can be displayed and images can be created that don't look especially *mathematical.* Each image may take some time to create, but the storage feature allows the computer to *recall* the same image time and time again for use in a different way.

Digital graphics require planning. Although some have analog controls to provide some real-time manipulations, digital systems are best used when the desired images are planned and put into a program that the computer can execute on demand. This differs from the free-form trial-and-error method that can be used with an analog system.

Digital systems are software oriented. If the analog graphics artist must be an expert on control circuits and waveforms to make best use of his tool, the digital graphics artist must understand the operation of the program used to produce and manipulate digital graphics.

The actual internal workings of a digital computer are so far removed from the operations of an applications program that even a professional programmer using a high-level language doesn't need to know much about the circuits he is using. He just needs to know the language and its features.



***Painting,* Fred Yung.** Example of electronic painting created on the Ampex Video Art System (AVA) by Fred Yung. (Photograph courtesy of Ampex Corporation)

Real systems

There is not enough space to discuss every digital graphics system available, but included are a few that have contrasting features to get an idea of the range of products made.

In introducing digital graphics, a system capable of producing real-looking images, near photographic in quality, and systems capable of Disney-style animation have been discussed.

These systems are so complex that the equipment is not sold to individual production houses, but rather computer experts who have assembled the necessary hardware and software offer use of their facility and staff on a fee basis.

The most real-looking images this author has ever seen produced by a computer without camera input are those created by the Synthevision process developed by MAGI (Mathematical Applications Group, Incorporated). The images are created for a variety of applications from advertising to architectural modeling of new buildings and military simulations. The animated sequences are not created in real time, and must be recorded on film from an extremely high-resolution display. Initial programming is quite costly and time-consuming, though making later changes in movement of already defined images can be relatively inexpensive. Synthevision images are created with a 3-D perspective, so even cartoon animations using the process tend to look more like puppet animation than traditional cel cartoons.

A process designed to simulate the look of cartoon character animation is VideoCel offered by Computer Creations of Indiana. The process was developed by two aerospace engineers, Thomas Klimek and Richard Brown, who had formerly been involved with computer graphics applications in the missile industry. Their intent in designing VideoCel was to create a computer animation process in which the artist has the most direct possible involvement. This is in contrast to computer graphics houses that expect an agency to submit a storyboard for total execution by the computer firm.

Key drawings for the animation are drawn by the artist using a digitizing tablet. The computer then calculates the movements in between the drawings needed to make the action complete (using information put into the computer by the operator) and creates the sequences. Animation of the 30-second TV spot takes about a week—

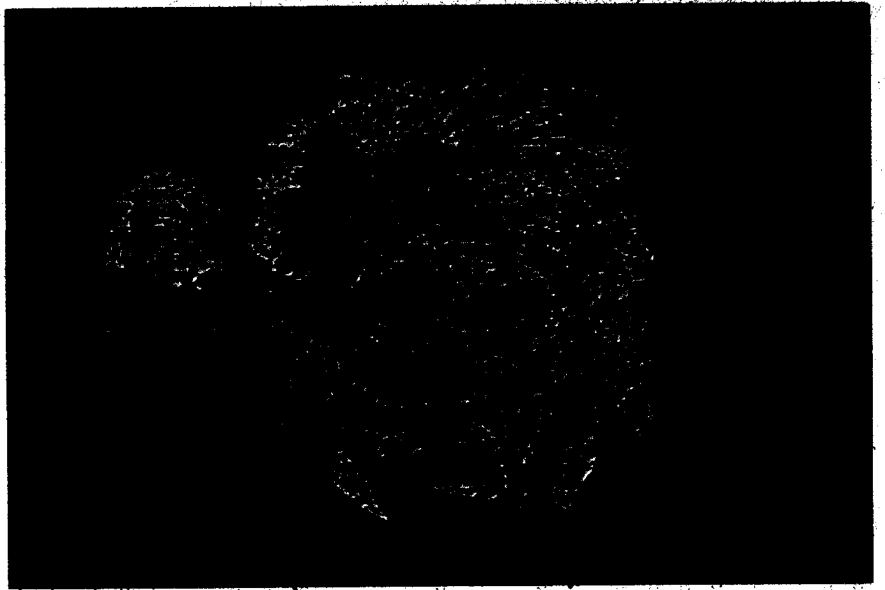
much less than the standard five to six weeks for conventional animation—but the cost is about the same as cel animation. Sequences can be recorded on videotape or film. Like Synthevision, VideoCel uses a high-resolution display.

Of perhaps greater interest to most production houses and TV stations is equipment that can be owned in-house for daily use. Three systems (there are many more in existence), will be considered. Each is designed for a very different sort of graphics task. The systems are the **Ampex Video Art Systems,** the **Telestrator** and the **Apple Computer.**

Most readers have probably seen the output of the **Ampex Video Art** system in the Superbowl XII computer drawings by artist Leroy Neiman. Indeed, the entire system is designed solely to produce still drawings of the highest quality using techniques familiar to traditional artists. The system dedicates an 8-bit word to each display pixel giving the artist 256 color/brightness combinations per drawing. Each combination can be defined by the artist from a virtually limitless total number.

The artist works at a drawing tablet with a stylus that can be used as a brush. Different brush sizes and shapes can be selected from the menu—even new brush styles can be created—so that each stroke of the stylus can seem to be a stroke with a wide or thin paintbrush. To save time, the artist can command the computer to fill any bounded area with a certain color. A font mode allows the artist to add alpha-numeric information. There is even a history mode that provides for the storage and retrieval of every color choice and pen motion used to create a drawing. Also, portions of a drawing can be changed in size or repositioned without the artist having to redraw the form.

Every attempt has been made by Ampex to devise a system capable of producing paintings rivaling those produced by conventional brush and ink means. The system is designed for interactive use by artists in broadcast stations and production houses and avoids any of the traditional *electronic* look.



Albert, **Saul Bernstein.** Electronic painting done on an Apple Computer. (Photograph courtesy of Apple Computer)

In addition to the creation of hand-drawn images, the system can accept graphics input from a TV camera and digitizer. This allows basic artwork to be quickly digitized and then changed or embellished by manipulating the creative functions of the computing system. The system does not offer direct real-time animation, but drawings can be created and stored on a videodisc for playback in real time.

The Telestrator by Interand most resembles the operational features of an analog system. It is a dedicated computer illustration system designed to be used by facilities with a minimum of effort.

If the Ampex Video Art system is designed to be an electronic canvas, then the Telestrator is designed to be an electronic answer to the weather reporter's magic marker or the sports analyst's chalk.

The system makes use of a special transparent tablet placed over a TV monitor. As the stylus is moved over parts of the tablet, the system senses the values and determines the stylus location. The system is capable of drawing continuous lines of various widths, and dotted and dashed lines. There is also capability for storing preselected symbols for manipulation in real-time by reference to the position of the stylus on the tablet. Thus, a weather forecaster can use a predefined series of symbols to indicate storms, highs, lows, etc., without having to draw each one every time it is to be put on the screen. The symbols on the screen can be moved and/or change size in real-time.

If the Ampex system is aimed at the needs of the experienced artist, the Telestrator is aimed at the needs of the non-artist. Symbols can be created off camera before air time and then be made to write themselves on, or even to erase themselves, to give the impression that the weatherperson (or sportscaster, newsperson etc.) is drawing the symbols in real-time. Of course, the symbols can actually be drawn in real-time, but the automatic drawing feature can help steady possible on-camera jitters of the non-professional artist.

Since the Telestrator is not designed for fine arts applications, most of the shading features of the Ampex system are missing. However, the system is lower priced than the Ampex one and is built into a small lecturn-type console. It is also heavily advertised to the educational broadcast market as a more convenient, flexible and sharper answer to the blackboard. An interesting sidelight is that Interand has available a separate Memory/Scan Converter package. This unit accepts analog input and can even be used as a storage oscilloscope. By using the proper analog circuit, one could create analog still video art of the type described in the first part of this article (art similar to the Oscillons of Ben Laposky) and

Telestrator. A color Telestrator is used to manipulate the various characteristics of a symbol for the number 5. (Photograph courtesy of Interand Corporation)

store and broadcast these forms using the Interand Memory/Scan Converter instead of using a re-scan camera photographing the analog display.

The final system is the **Apple Computer,** a personal computer with quite a bit of graphics capability. At the outset it must be pointed out that the *video output of the Apple Computer as it comes from the manufacturer is not NTSC broadcastable color video.* However, a converter board designed to make the Apple graphics broadcastable has been announced by Video Associates Labs of Texas. This $1000 option is a must for TV broadcast applications. Since the cost of the Apple is extremely low in the first place (about $1200 to $6000 depending on options and peripheral equipment) even adding the Video Associates board still keeps the Apple graphics system well below that of most competitors.

The Apple features both high-resolution graphics, and low-resolution graphics. The low-resolution graphics can support 16 brightness/color combinations. The high-resolution graphics can support only six color/brightness combinations (black, white, violet, green, red and blue) and not all colors are available to each pixel.

But of greatest interest to video professional is the availability of a graphics tablet to give the Apple some of the features of the Ampex Video Art system. Of course, the Apple is not as sophisticated as the Ampex system. The resolution is lower (192 x 280 pixels in comparison to Ampex's 562 x 512 or optional 768 x 512) and the variety of color/brightness combinations is much lower. The software package that comes with the Apple graphics tablet does not give the artist as much flexibility as does the Ampex system, yet quite striking posterized paintings can be achieved as, for example, the picture of Albert Einstein created by Saul Bernstein.

No facility or producer should expect the Apple to take the place of more sophisticated graphics systems, yet small stations and production houses might find the Apple a useful tool for making charts and titles. Some artists use the Apple to create sketches that can be stored on disc for showing to a client before executing the final art in more conventional non-electronic media. All in all, the Apple is probably the most flexible of the systems described in this article. But the flexibility and low purchase price are offset by creative limitations that should not be taken lightly.

No article on digital graphics would be complete without mentioning some of the special effects possible with digitally controlled video switchers. Some of these can store images and change their size, relocate them, replicate them, etc. Sometimes their digital electronics have been interfaced to analog controls so that the effects can be managed in real time with knobs and levers, rather than with typed commands.

Digital effects systems designed to work in conjunction with switchers include the MCI/Quantel DPE 5000, the Vital SqueeZoom and the Grass Valley/NEC DVE systems. The zoom and rotation effects produced by these units could also be used effectively to animate still images produced by the Ampex Video Art system or an Apple computer.

Purists may argue that the new digital effects are mere "gimmicks," and certainly gimmickry has often been used in television to replace artistry. But many serious creative artists and producers are exploring digital and analog graphics in order to seek new ways of communicating in pictures. In some cases the purpose is to realize cost savings; in others, the intent is to make visual communication more expressive. Sometimes it is possible to realize both goals at once. □