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THE MACHINERIES OF JOY

Introduction:

In October of 1983, I traveled fromSan DiegotoLos AngelesandSan Francisco, researchinga proposed article for OMNI Magazine. What I saw astonished me.... andinfluenced me heavily when I went on to write the novel-length Blood Music andEon. Here was not the beginning of the computer graphics revolution, which hadoccurred decades earlier, but the beginning of the flowering of that revolution. I could hardly restrain my enthusiasm. I suspect the last few pages ofthis piece will date badly as time goes by, but they show my frame of mind. And the frames of mind of dozens of other authors, as well; the information age hastaken science fiction by storm.

OMNI never used this piece, although they paid me for it. Nor did they use the hundredsof pictures I gathered, a selection from which would have accompanied it. Many people gave generously of their time, yet never saw their names or ideasin print. I hope this publication pays them back in some small measure.

The circumstances described below have, of course, changed considerably. Digital Productions has changed hands and management; Robert Abel and Associates is no longeran independent company. The revolution has become even more stimulating andpromising. Its effects are everywhere.

This article was completed in early 1984.

THE MACHINERIES OF JOY

"Dinosaurs!"The artist spreads his arms as if to embrace them. "I need the exactspecifications--gridwork layouts of bones, muscles, scale patterns." The artist'soffice is covered with drawings of spaceships and alien beings, strange landscapesand mechanical diagrams. "If I have those, I can put them into the computer. We can program eachmuscle, make the skin ripple over the muscles. Tell the computer how they took a step, how they fought..."

And once again, dinosaurs will walk and fight. The artist is living a childhood daydream: he has the power to bring dead creatures to life. Even more remarkable, he has the power-- with the aid of dozens of technicians, programmersand fellow artists--to film objects that have never existed in any materialform and make them interact with live actors.

But dinosaurs are a future project. The matter immediately at hand is a space battle. At night, within a stark white-walled enclave, the artist, director and techniciansit before a video monitor, examining the progressive stages of a nonexistentspaceship's destruction. Highly detailed ships-- complete with crew--are dueling to the finish. One spaceship is destined not to survive; its

hullis disassembled in the first of six boxes on the monitor. The early stages ofan expanding blast are overlaid in subsequent boxes.

The artist describes an explosion in space. "I'd like the whole screen to flash whitefor one frame. Next we see an opaque fireball--fuzzy at the edges--surrounding the debris." He demonstrates an expanding sphere with hand gestures. "Then we ramp it down to transparency as the fireball grows." (To "ramp" is to smoothly increase or decrease any function.) "When the shockwave passes, all the little stuff--gases and tiny fragments- -fly past and then we seethe big scraps, a little slower, not as much energy." His grin is gleeful now. The director nods in agreement; this is, indeed, an explosion in space, not yourusual smoke-and-fireworks exhibit.

The stages of the explosion are being fed into powerful computers, isolated beyondglass walls at the opposite end of the studio in a pristine white-floored

environment. Artist, director and technician are playing god games in an unreal universe.

Ultimately, it is all numbers, points charted in a space of three dimensions withina computer. Each number represents part of the position of a pixel, or pictureelement, millions of which go together to form a shape. It is the computer'sduty to keep track of the numbers, and the shapes they represent. Perspective, color, shadow, motion, must all be processed with scrupulous accuracyor the apparent reality will collapse.

The numbers are then converted to signals which can be displayed on a monitor. The pixels assemble, and a spaceship is destroyed, frame by frame. When the

resultis printed onto film, it will be indistinguishable from very high-grade specialeffects accomplished with painstaking model work.

It will look as real as anything else in the finished motion picture. The artist, director and technician are, of course, fictitious, and the scenario is atechnological fantasy, not to be realized for years, perhaps decades to come--

And if you believe that, you haven't been keeping track of recent advances in theincredible field of computer graphics.

It is happening now.

The artist is veteran production designer Ron Cobb, (ALIEN, CONAN THE BARBARIAN); the director is Nick Castle (TAG, SKATETOWNU.S.A.) and the motion pictureis THE LAST STARFIGHTER, a joint Universal-Lorimar production. Under the auspicesof Los Angeles-based Digital Productions, headed by John Whitney Jr., allof the special effects for THE LAST STARFIGHTER are being done by digital scenesimulation--computer graphics designed to match reality. Using two powerfulCray super-computers and a phalanx of other machines, Digital Productions is taking a gamble--some say a big gamble--by committing itself wholeheartedlyto the future.

The future of computer graphics will be extraordinary. Most of the experts in thefield--the best can still be numbered on two hands--agree that we are on the vergeof a revolution perhaps more basic and disruptive than Gutenberg's movable type. Communications and education will be fundamentally reshaped. The entertainmentindustry will experience changes far more drastic than the transitionfrom silent movies to talkies, and talkies to TV.

The power that presently resides in the hands of a knowledgablefew, will soon beavailable to all.

But first, back to the numbers.

The world of the computer is a very simple one. Everything is broken down into bits, a bit being the information required to answer any question with yes or no; in binary, yes equals 1, and no equals 0. Binary numbers consist of chains ofones and zeros. (In binary, 01 equals one, but 10equals two.) More elaborate codeshave been created to relate letters and symbols to certain numbers--thus allowingcomputers to display both numbers and text. Other codes relate the positionsof glowing dots on a video screen using coordinates much like those on amap. A picture can be "digitized"--broken down into these numbered positions--and put into a computer, which can then manipulate the picture in a widevariety of ways.

A picture can also be formed within the computer by charting key elements on a graph, feeding the computer coordinates and instructing it to draw lines or curvesbetween the points. Mathematical equations which determine fixed geometricfigures or curves can simplify the process; the computer can be instructedto draw a circle of a certain diameter around a point, or an ellipse; totrace out a square and expand it into a cube, and so on.

In fact, a "space" is determined within the computer, having three or more dimensions, and any object can be described within that space, given sufficientlydetailed coordinates. If the object is simple, like a cone, a "lathe" program can rotate a triangle around an axis to form a cone, or a circle canbe turned around any diameter to create a sphere, much as a shape is spun froma block of wood on a lathe. More complex, irregular shapes take more complicatedinstructions, and much more time. Once the object is constructed in asimple line drawing, or "wireframe," additional programs can add a light sourceto give it highlight and cast a shadow. Colors and textures can be

"mapped" on its surface. A point of view can be established, and what is not seenfrom that point of view--the back of the object--can be clipped, making it

appearopaque and solid.

The process seems simple enough, but in reality the work involved in creating real-seemingobjects on today's machines is extensive. The most complicated methodsof creating objects in a computer--such as a technique called "ray tracing"-- can take weeks of computer time. Simpler techniques can reduce the timeto fractions of a second, but with a corresponding loss of color, shadow anddetail.

Once the object's numbers have been fed into the computer, the computer knows whatthe object looks like from all sides, at any distance, in relation to any otherobject or perspective within the machine's memory. A nonexistent spaceship canbe made to zoom past a simulated planet, approach a much larger "mother ship" and dock inside a highly detailed landing bay, all in perfect perspective.

The computer can then display the objects in two dimensions on a video screen, orsend signals to a printer to transfer images to film. Since the object has actuallybeen mapped in more than two dimensions, the computer can be instructed toproject two points of view, creating a parallax similar to that between our twoeyes. The slightly separated images can be combined stereoscopically for a realisticfeeling of depth.

If the film image needs to be "squeezed" anamorphically onto 35mm stock for laterprojection on a wide screen, the computer can do that, as well. Any requiredlens can be simulated within the machine. In the 1950s, artists and programmersbegan to pioneer the techniques still being elaborated upon today.

John Whitney Sr. was among the earliest, starting in the late 1940s. He later receivedthe first IBM grant to study computer graphics in detail, and was installedin a ground-floor corner window of the IBM building inNew York, displayingimages for passers-by.

Bill Fetter began exploring the possibilities of wireframe animation at Boeing inthe late l950s, and assembled the first computer generated commercial in the late1960s.

In the early seventies, Ken Knowlton and Michael Noll came on the scene--Knowlton working for Bell Labs, and Noll arranging for the first gallery showingof computer art. Noll's specialty was simulating "clay paintings"--made withplasticine-- using computer images. Many viewers couldn't tell which were picturesof real clay paintings, and which were simulated.

In the last ten years, the progress has been astonishing; around the world, computersare helping to create images for scientific research, education, fine artand entertainment.

Sometimes the divisions between these categories are erased; the enchanting beautyof a moving computer image can turn a prosaic enterprise--such as stress analysisof pipe joins--into art. The most extensive use of computer animation hasbeen in advertising. Already familiar to TV viewers are the plethora of "neon"-look commercials for banks, airlines and automobile manufacturers.

Generically, computer animation relying on line graphics is known as "vector" animation. Using various animation techniques--inside and outside the computer--the lines of these "wireframe" drawings can be made to glow like neon tubes. This look has become so widespread that within the industry it is becominga cliche, to be avoided if possible. Filling in a wireframe object with

color, shadow and texture is called "raster graphics" or "raster" animation.

This requires a more powerful computer, such as the Evans and Sutherland, or the Digital Equipment Corporation VAX machines commonly found in commercial studios.

Some interesting effects can be obtained by fudging (not a technical term). The surfaceof an object to be vector- animated can be covered with "cross-thatching," using more lines instead of full raster graphics. This is knownas "psuedo-raster" animation and can be charming, even though it falls in amiddle range likely to be used less often as equipment and programming improve.

Crude raster graphics can be judged by "aliasing"--the appearance of the "jaggies" along an object's edges. Each pixel stands out against a contrasting color, and when the object moves, the pixels can appear to march along the edge. These can be eliminated by coloring alternating edge pixels in shades that mediatebetween the contrasting colors. The border is softened slightly, and the graphicsare said to be "anti-aliased."

The most powerful computers available to animators-- the Cray series (the Cray

1, an expanded version called the Cray XMP, and a much smaller, even faster Cray 2)usually reside in defense establishments and major research laboratories.

Digital Productions is the only private effects studio that owns Crays. The Cray corporationis reluctant to release the locations of all its machines, but it is wellknown that the Sandia Labs and Lawrence Livermore National Laboratory have anumber on hand.

By time-sharing--having the computers process their work when not otherwise busy--researchers in several such establishments have done important work

programmingcomputers to "understand" and draw transparent objects, lenses and realisticlandscapes.

Two of the most prolific of these researchers are James F. Blinn at the Jet Propulsion Laboratory inPasadena, and Nelson Max atLawrenceLivermoreNational Laboratories.Blinn's group at JPL animated the striking computer simulations of theVoyager probes' journeys to the outer planets, widely shown on network and publictelevision in 1980-81. Nelson Max has worked largely on graphic representationof biological processes. Using his graphics programs, he has been ableto predict how molecules will interact before lab tests have been made. Max hasalso investigated the effects of mutagens on DNA, and modeled the structure ofvery tiny viruses.

After months or years of painstaking labor, computer artists display their wares atannual SIGGRAPH conventions. (SIGGRAPH stands for Special Interest Group, Graphics, a division of the Association of Computing Machinery, or ACM.)Private individuals, employees of giant research establishments and commercial film studiosgather to compare notes and keep up on the latest developments.

C.P. Snow's "Two Cultures" are inevitably wedded in computer graphics.

Not since Leonardo da Vinci have so many technical disciplines been required of workingartists. Not only must they have basic drawing and drafting skills, but theymust know at least the rudiments of programming. They must understand how lightreflects, refracts and diffuses--and be able to translate their knowledge intoterms the computer can digest. The artist can no longer stand aloof from scienceand math. New techniques can take him to the frontiers of theory. Recent workin the texturing of surfaces has used fractals, mathematical entities capableof generating very complex patterns. Perhaps the most familiar example

ofcomputer animation with fractal-generated landscapes is the "Genesis" sequencefrom STAR TREK II: THE WRATH OF KHAN, made for Paramount Pictures by Sprockets, the computer division of Lucasfilm's Industrial Light and Magic.

One of the focal points for computer animators was the Walt Disney production of TRON.Information International, Inc., (known as triple-I), Mathematical Applications Group, Inc. (MAGI) Robert Abel and Associates and Digital Effects allcontributed their expertise; yet TRON contained only ten to fifteen minutes offull computer animation. The rest was accomplished with conventional special effectsand animation techniques.

A great many of the people who worked on TRON have now moved on to positions in companiesaround the country. A few, such as Richard Taylor, are still involved withfeature-length motion pictures.Tayloris reportedly hard at work on a film calledDREAMER forParamount. In advertising, two of the biggest film companies havemade a major commitment to computer graphics. Robert Abel in Hollywood--long renowned for the beautiful combinations of live action and back-litanimation in his Levi's and Seven-Up commercials--assembled a computer graphicsdivision while assigned to do special effects for STAR TREK: THE MOTION PICTURE.Unlike Digital Productions, however, Abel keptall his other special effectstechniques, considering computer graphics as another tool, not an end in itself. "A lot of the stuff we do is combination," Abel explains, "where we combineminiatures and live action with computer images." Pure computer animation, at present, is more expensive than many other techniques, and in Abel's view, flexibility and variety are necessary to the production of commercialadvertising films.

Bo Gehring, in charge of Bo Gehring Associates inVenice,California, originally cameto the west coast to do computer animation tests for Steven Spielberg's

CLOSE ENCOUNTERS OF THE THIRD KIND. The tests proved unsatisfactory but Gehring stayedon to found his own company--again, with a complete spectrum of techniquesat his disposal. Unlike Abel, who began as a documentary filmmaker, Gehring's roots are in computer graphics, but he agrees with Abel that commitmentto one technique is risky. As for getting involved in feature films:

"Ninety million dollars is spent each day on advertising in theUnited States," Gehring says. "Feature films can't begin to match that level of financing. I'm securewhere I am."

Both Gehring and Abel believe that computer graphics is still in its infancy, andwill probably have a major effect on all forms of visual communication. For themoment, however, neither is willing to make the leap of faith required for anoperation such as that being conducted at Digital Productions. And truthfully, Gehring admits that his financial backing is not equal to Digital Productions', which is supported by Ramtek, a major computer company."I am a bitenvious of what John Whitney Jr. and Gary Demos have come into at Digital--all that [computing] power. But I'm happy with my situation, and just can'tsee taking that kind of risk right now."

Gehring also expresses an interest in digital sound synthesis. "I'm one of those peoplewho has to pull off the road when something really intriguing comes on thecar radio. I firmly believe that sound is at least the equal of sight in bandwidth--complexity of information--and synthetic sound is a fascinating area that'sbarely been explored." Another of the Big Three companies, R. Greenberg inNew York, is rapidly building its computer graphics division.

Computers have revolutionized the film industry in many more ways than computer graphics. Virtually all commercial studios, whether producing advertising or featurefilms, use computers to control complex camera movements or integrate differentelements of photography. At Robert Abel, slit-scan photography is a stapleitem. The process was originally developed by Con Pedersen and Douglas Trumbullwhile working for Stanley Kubrick on 2001: A SPACE ODYSSEY. Pedersen nowworks at Abel, where he supervises other aspects of special effects production, including computer graphics. (Trumbull, interestingly, seems to eschewfull computer animation. In his recent film BRAINSTORM, even sequences whichappeared to be computer-generated were done using other techniques.)

In slit-scan, a camera is mounted at the end of a long track, at the opposite endof which a piece of flat artwork is masked to reveal only a narrow horizontalslit. As the camera moves forward very slowly, a computer coordinates themotion of the slit up or down on the artwork. The result is a drawn-out imageof the artwork, stretched in perspective by the camera's approach.

Computers are also responsible for the many forms of motion-control used to photographspace battles at Lucasfilm and elsewhere. Signals from a camera mount arefed into a computer, which memorizes the camera positions and can then controlthe camera for repeated passes. Different models, mattes and other specialeffects elements can be added with great precision.

Computers are even involved in stop-motion puppet animation at Industrial Light andMagic. The "Go-Motion" computerized system was used in DRAGONSLAYER to memorizethe motions of an armatured miniature dragon as it was manually "walked through" its sequences.

All these elaborations--from slit-scan to Go-Motion puppet animation--are likely tobecome passe, before the end of the century. Whatever the risks, Digital

Productions isobviously where the field is moving. But computers have one major hurdleto leap before they dominate. Character animation--whether it be the fluidmotions of a Disney cel-animated deer, or a human being--is still very difficultfor computers. Computers are happiest when dealing with shapes defined bysimple mathematics--planes in perspective, spheres, cones, polygons and polyhedrons. Humans (not to mention Bambi or dragons) are not composed of these objects, at least not at first glance. Living characters are lumpy, bumpy and in constantmotion--all parts of them. Muscles shift beneath skin and skeletal angleschange. Facial expression is a nightmare of complexity, with hundreds of musclesproviding a bewildering variety of shapes--all of them familiar to the viewer, and therefore difficult to fake convincingly.

For the artist, years of study are required to convincingly replicate human and animalshapes. The human mind is enormously more complicated than any modern computer, with millions of "algorithms" all smoothly blending in unconscious processes. How can a computer hope to match the work of a skilledcartoon animator, much less the reality of a human being?

Tim Heidmann, at R&B EFX inGlendale, believes character animation is the stumblingblock of computer graphics. "When you think of all the expertise requiredto get a Disney- type character on film--including the distortion of reality, stretching characters to add life, exaggerating expressions--the

problemseems insurmountable." Heidmann does computer graphics for R&B EFX using amuch smaller Hewlett-Packard business computer. The HP manipulates wireframe imageswhich are then photographed and enhanced by hand in R&B's own small

animationstudio. The entire system cost under $25,000, "What computersdo best," he explains, "is what human animators do with the most difficulty--changing perspective, drawing geometric shapes. And what humans do bestis most difficult for computers--especially a small system like ours: coloring, shading, characters." R&B combines the two with ingenuity instead of massivenumber- crunching.

Digital Productions is hard at work using both ingenuity and brute computing powerto overcome the difficulties of animating characters in a computer. Most ofthis work is under tight wraps of security, but it appears they are building uphuman and human-like figures by creating "intelligent shapes" which will mimicmuscles on fixed skeletal frames. These "intelligent shapes" will be programmedto interact with other shapes--other muscles--around a skeleton, withinthe constraints of skin.

Motion studies of animals and humans are programmed into their machines to give themparameters within which to work. Ron Cobb explains: "A computer doesn't knowwhere to stop. If you have a character's arm swinging, the arm in the machineisn't real. It doesn't have an elbow or a shoulder to stop it. It just keepsswinging in a circle until you tell it what the limits are. Then it has thelimits in memory, but you have to be very specific, very careful."

The computer cannot intuit anything. It is literal. Everything must be described indetail. Consequently, the computing capacity and time required to control thesefigures will be enormous--at first. But the cost of the early stages in laborand money can be compared to research and development costs in any industry. The initial outlay is always greater than the cost of later work.

One small hint of the coming revolution is provided by the locations of two majorcompanies relying on computer graphics. Cranston-Csuri, founded by pioneer

computerartist Charles A. Csuri, is located inColumbus,Ohio. Computer Creations takes pride in being based inSouth Bend,Indiana--far from the advertisingcapitols ofNew YorkandLos Angeles. Electronics can deliver messagesand products around the world; in the future, location will be less and lessimportant.

Size will also become less important. With computers, a commercial studio can beginoperations with only a handful of creative people. Pacific Data Images, in Sunnyvale,California, has only four employees, yet has already landed major advertisingand promotional contracts. With initial costs of less than a million dollars, entrepreneurs like PDI's Carl Rosendahl are already taking advantage of thebuilt-in flexibility of the computer. Costs are dropping, and software is improving, albeit more slowly than hardware. Within ten years, the big advertisingcompanies will be surrounded by smaller, tougher firms with equal capabilities. The bottom line will then be not money, but creativity. There is nolack of creativity. The computer images and motion pictures produced by artistsaround the world are dizzying in variety and quantity.California's David Em is well known for his architectural fantasies and abstractions. Paul Allen Newell has animated M.C. Escher-inspired tesselated designs that transform withenchanting smoothness and precision.

Nancy Burson ofNew York(profiled in OMNI, "The Arts," June 1983) uses computersto digitally combine photographic images of people and animals. She wasresponsible for the portrait of Big Brother commissioned for CBS's tribute toOrwell's 1984. By digitizing and melding the portraits of the twentieth century'sworst tyrants, she came up with a hauntingly familiar, somehow benevolentand yet very unsettling hybrid. Much more charming is her mix of

womanand cat.

Em, Burson and Newell highlight the successes and problems of presenting computergraphics on the printed page. Em's and Burson's images are static, suitablefor magazine reproduction, but the charm of Newell's work lies in motion.

Even more difficult to convey is the wonder of a live computer art performance, whereperformer and audience are one. Ed Tannenbaum of Raster Master in San Francisco has installed a performance art center in his city's public-access sciencecenter, Exploratorium. A video camera photographs people in a room as theymove about and then feeds their images to a computer. The result is

projectedin real-time (that is, live) on a large screen, allowing infinite varietiesof human-machine artwork. Children can dance and paint with their bodies, becoming their own kaleidoscopes.

Educators inevitably become more involved with computer graphics as classroom computersproliferate. Simple graphics programs can teach even very young childrenhow to work (and play) with computers. Today's youngsters will find computersand computer art a part of their lives. This is where the revolution trulybecomes powerful.

In one or two decades, at the present rate of progress, computers cheap enough forhome use will be capable of graphics even more sophisticated than those beingproduced by today's major studios. Graphics buffs will be creating, tradingand selling programs to generate different kinds of images--including imagesof realistic characters.

Eventually, perhaps by the end of this century, a kind of visual typewriter will

bepossible. Any scene the programmer/artist/writer can imagine, will be brought tolife using computer animation. As software and hardware advance and become cheaper, and as information and image networks expand, virtually anybody can becomea Cecil B. De Mille. The major requirements will be time and talent--not money.

The greatest handicap to cinema at the moment is the dominance of accounting overcreativity. Faced with budgets of tens of millions of dollars, studio executivesare justifiably concerned that their products should appeal to large numbersof people. The result is often pabulum. Primary creativity is endlessly ignoredor second-guessed.

Commercial television networks are even more handicapped; to satisfy advertisers, incredible numbers of people must tune in to their programs. Few artistsor writers have ever made anything worthwhile by pandering to the lowest commondenominator, yet this is the current state of most of network television.

The printed word allows more freedom. A pencil and a piece of paper are all that isrequired for expression in print. The production of a book is measured in tensof thousands of dollars for an average press run, not millions.

Publishing--for the moment--still allows a great many writers to create personal works. A writer can establish a reputation with only a few hundred or a few thousandsteady readers.

Yet only ten to twenty percent of Americans regularly read books. Newspapers and magazinesfare better--but less than half of all Americans receive any of their informationfrom the printed word. What we have is a colossal failure of a communicationsmedium--print--to reach the masses.

For many people, print is difficult to assimilate. It has many uses and

advantages, but often it cannot convey information as quickly and efficiently as othermedia.

The dilemma is clear. Print offers diversity and individual expression--as well asthe active participation of the reader, in imagining and fleshing out what thewords convey--but cannot reach as many people as television or motion pictures.

Television and motion pictures appeal to the masses, but more often than not spoon-feedpabulum to a barely conscious viewer.

By combining both print and vision, computers will break the money monopoly and allowmany more people to work with "pictorial narratives," a catch-all phrase forthe multitude of art forms which will inevitably develop.

Robert Abel sees a future society with individuals becoming more and more isolated, physically, as the electronics revolution allows them to work at home. With increasingly sophisticated entertainment forms, there will be less need to leavehome for recreation. With more leisure time, the public will demand more entertainment. And with more artists able to produce complicated pictorial narratives, the demand could well be met with an explosion of creativity--if the audienceisn't already conditioned to textureless drivel. If it isn't too late evennow...

Take a deep breath.

We're going to enter a possible future, and it will take some effort to get used toit.

You're on a street. A woman approaches you. She appears to be wearing a jungle. You stare in amazement as she passes; to a distance of about six inches, all

aroundher, you can see gnarled trees, vines and creepers, exotic birds, even a leopardlying in wait.

She walks along a wall and the building suddenly smiles at her--the entire wall onemassive pair of lips in three dimensions. "Good morning, Miss Andrews," it says. "How may we serve you today? Shopping for apparel, or just out for a stroll?" AdWalls are formal and slightly stodgy by design. Virtually everyone is known, on sight, by ad companies who use computers to target not just groups of consumersbut individuals.

The woman pays no attention and continues on. The smile disintegrates into a flightof wildly colored butterflies as you approach.

"Distinguished sir," the AdWall says. Butterflies flitter around you. "I don't haveyour name in memory at this moment. How may Freepic serve you today?"

You mumble something about wanting to find a computer store.

"Chips'n'discs, the city's oldest computer store, lies but two blocks away."A mapappears in front of your face, then transforms into a speeded-up visual tour. You see yourself walking two blocks south, turning left, and entering the store. The image ends with a large-scale projection of the storefront. Symbols conveyinghours of business, product lines available, and even clerk's faces are overlaidon each side of the map.

You make your way through parti-robed citizens and find the store. Inside, you marvelat the systems available. There are computers for computing, and for just aboutanything else imaginable. You can rent information networks, even gain accessto a world-wide library system for a low monthly fee. ("Less than one percentof the average household income!" a display enthuses. There are two billionsubscribers.)

Your domicile can be turned into any environment you wish, complete with sounds andsmells. You can even create your own environment, using the Apple 89 Worldmaker.

"Occupation?" the clerk asks. The clerk grins and fades to transparency, then opacifiesagain, as required by law in the first few minutes of service. You realizeyou are being served by a very realistic hologram.

"Writer," you say.

"Oh, then you need a minezeye." It takes you a few minutes to realize the clerk means"Mind's Eye." The unit is quite small, the size of a cigarette case, and comescomplete with plugs to hook directly into the cerebral cortex.

"The Mind's Eye is a Hair Trigger unit, taking instruction in basic Brainwave, spokenlanguage or even Touchcode, rather like typing. If you wish, it has a translatorwhich can turn a videotext into a visual experience. Plug the Mind's Eye into a Page Turner and you can interactively turn your favorite classic into amotion picture, just a you visualize it; you coordinate the action through the cerebralcortex plugs. Some training required," the clerk informs you cheerfully. Videotext combines visual and aural information with high-density symbols--symbols which both inform and trigger intellectual and emotional cues inthe adept viewer. Some videotexts compress a hundred flashing signals within afew seconds' time. The symbols are distant relatives of Egyptian heiroglyphs--and modern road signs. Some are based on the logos of famous businesses. Some are as stylish as Japanese calligraphy.

Realtime units will soon be available. If you think it takes too long to imagine ascene, Realtime can supplement your brainwaves. If a jungle is required, Realtime has seventy different jungles in memory, and soon will have cable connectionswith real jungles, which can be digitized and reshaped at will.

All computers in Chips'n'discs are, of course, Child Easy. In fact, the 1-Thru-5 unitis designed to be used by an infant. It comes complete with Sensual Crib andaccess to the Sesame Net.

If you're a fiction writer, you can peddle your creation on the Lie Wire (stet!). If you're a philosopher, your works can find their audience (for a fee, ofcourse) on the Mindbender cable. Historians frequently sell to the Pasttime Cable.

On any of these networks, you can start out on the Low Rung and gradually, throughjury selection or User Acceptance (the ratings, that is) move up step by stepto the very height of success. A single work might reach as many people as,

say, the Britannica Visual.

Peripherals include MovieLife, a chip which can be dropped into your home computerto turn any 20th century film into a living experience for you and your family. If you'd prefer to see Humphrey Bogart star in THE MAN WHO WOULD BE KING, instead of Michael Caine, that can be arranged. If you'd like to see an enhancedcolor version of the original KING KONG, with synthesized stereo sound, MovieLife will oblige. Live actors are still in great demand. They frequently licensetheir images for computer generation, making a substantial second income--but virtually everyone acknowledges that a real actor is better than a simulation. Some actors have ruined promising careers by selling rights to less reputableretailers, who place their personas in all sorts of compromising products.

But be warned--if you get too involved in all this, and happen to Drop

Out--leave the real world and zip along the underground nets, where all sorts of unsavorystimulations are available--the Bug Police are tapping the wires every day. There are many legitimate adult services, such as FantaFem and Woman of Your Dreams, but many more balance precariously on the borders of the law, or fallcompletely offsides."Bookstores?" The clerk responds to your question with somesurprise. "We've heard of a few shops catering to the collector's market--and of course, there's always the Winston Smith Society. It meets once a monthto trade crumbling paperbacks."

You look around the shop, at the profusion of systems that serve more to supplementor replace creativity than enhance it. "Don't you have anythingfor someonewho just wants to tell his own story, with his own images?" you ask, frowning.

"Sir," the clerk says indignantly, "that's where this all begins. Not everyone isas privileged as you must be, however."

You are reminded of electronic music instruments, decades in the past. Some becameso elaborate that you barely had to touch a key to produce a tune. Distasteful to the concert pianist, perhaps, but a great deal of fun for the dabbler.

"Come with me," the clerk says, taking you in his ghostly hand. "Let me show you somebasic models. For the person who wants to create, rather than simply consume."

You are led into a simply and tastefully furnished room. A boy and girl, no olderthan ten, are sitting before an extensive keyboard. Colors and vague shapesflicker in a cleared area beyond the machine. "Did we get all thenumbers rightthis time?" the girl asks. "We want it to be as accurate as possible."

"They're right," the boy assures her.

"Let's see it, then."

The boy pushes a display key.

In the cleared area, a tyrannosaurus rex appears in horrible, fascinating

detail, tail swishing back and forth, walking on its six clawed toes. It opens

itsmouth and emits a curious, bird-like squawk. "Oh, they didn't sound like

that," the girl says, shaking her head vigorously.

"How do you know?" the boy asks.

"Let's make it roar."

With a few nimble keyboard touches, they make the beast change its tune and

roar.

"Don't you just love dinosaurs?" the girl asks, clapping her hands.

Your fingers twitch. Where was this kind of machine when you were a child? You

stepforward and politely ask, "Here. May I play with that? "I've always fancied

seamonsters, myself..."

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