The Scope of the Computer

The Cinema and the Computer

Govenor Stanford's bet

The story goes – and although it has been repeated in almost every history of photography, there is no documentary evidence to support it – Govenor Leland Stanford of California needed someone to settle a $5,000 bet. The question was: does a horse ever have all four feet off the ground?

Whether or not the bet existed, the Govenor certainly turned, in May, 1872, to Edweard Muybridge, the Director of Photographic Surveys for the US Government, to find the answer to the question that had troubled artists for over two thousand years. Muybridge set a battery of trip-wire operated cameras at intervals along a track at the Govenor's ranch. It took the exposure of half a million wet plates before he succeeded in taking true moving pictures in 1879. A year later his Zoopraxiscope projected onto a screen animated photographs of animals, birds and athletes. The cinema was born.

Muybridge was, in fact, born Edward Muggeridge in Kingston-upon-Thames in 1830. Discovering that he had been born on the site of a palace of the Saxon kings who held court at Kingston, he changed his christian name to that carried by two of these kings and altered his surname at the same time.

A century after the cinema began its life as a scientific tool, the computer is offering new creative opportunities to film makers. Appropriately, one of the most interesting pieces of computer animation created recently has been a simulation of one of Muybridge's trotting horse sequences.

Although computer movies have only recently gained widespread attention, their history goes back further than might be expected. Between 1939 and 1944, John Whitney and his younger brother, James, produced experimental 8mm and 16mm films in California. Their experiments included the use of pantographs to move simple cut-outs into complex images, and pendulum machines to draw the sound track directly onto the film. Looking for ways to eliminate the laborious frame by frame method of conventional animation, the Whitneys in 1954 bought a war surplus gun-director unit, an elementary form of analog computer.

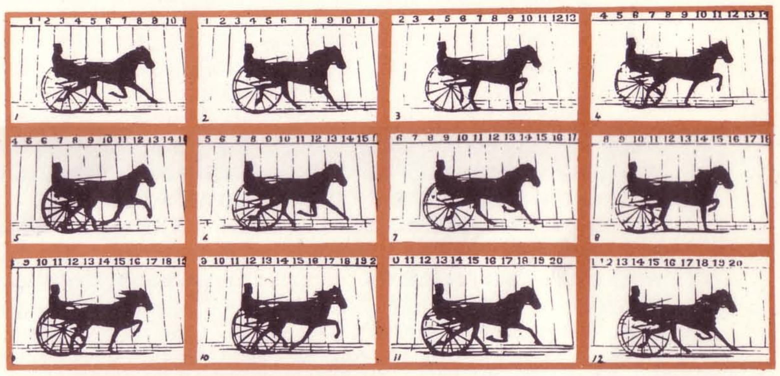
Very advanced for its day (as long ago as 1961!) was 'Catalog' in which Whitney used this equipment to synchronise animation to an Ornette Coleman sound track. In this film, simple images such as numbers and words are transformed into swirling geometric structures.

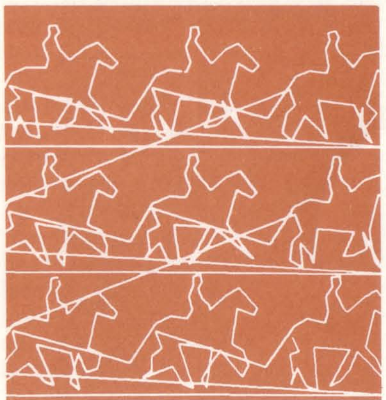
The Whitneys' work has demonstrated the great flexibility that can be obtained from an analog system or from an analog/digital hybrid. Most developments, however, have been produced on digital equipment. Any form of graphic output, paper from a plotting table, for instance, can be put on film, but the most successful systems on both sides of the Atlantic have taken advantage of the fact that the film used for microfilm records is identical to 16 mm movie film. The only problem is that microfilm recorders tend to be expensive.

Every man his own Walt Disney

Computer animation clearly offers several major advantages, the biggest of which is that it makes possible substantial savings on the cost of hand animation. Considering that a conventional 'hand drawn' movie running at 24 frames/second requires up to 1,440 different views for a one minute sequence, it is easy to see that typical costs can range from £100 to £1000 a minute. By contrast, the cost of computer-made movies can range from under £10 a minute to between £100 and £200.

Having produced a computer movie, revised versions can then be produced with little effort or expense. Orientation of timing or of particular sequences can be readily altered while special effects such as dissolves, zooms and pans, are easily achieved. The computer also allows someone who is unskilled in the visual arts to make an educational film almost single handed. Moreover it offers the ability to create films which





Top:

The origins of the cinema. A sequence photographed in the 1870's by Muybridge.

Bottom:

A Muybridge Horse sequence screened on the BBC TV programme, 'Tomorrow's World'. Produced at Edinburgh University by Stan Hayward and programmer John Oldfield.

would be impossible, or at best extremely laborious, to produce by hand animation. For example, films in true perspective or even stereoscopic films to be viewed with 3D crossed-polaroid spectacles.

As with a conventional movie, the first step in producing a computer film is to draw up a storyboard, showing a sequence of sketches with notes on motion, time duration and camera activities such as zooms and wipes. The programmer must then convert these drawings into explicit computer instructions. These statements are then processed and the output, thousands of (X, Y) coordinates and control codes, is stored on tape. The tape is then fed to a microfilm recorder where it generates the required pictures on a special cathode ray tube. The film magazine of the microfilm recorder is advanced after each frame is completed. It is possible, of course, to film straight off a standard graphic display unit, although the curved screen tends to produce a distracting pincushion effect.

The set of commands forming the picture language does more than simply keep track of (X, Y) coordinates, it also provides a host of services to save the programmer from the drudgery of housekeeping details. The first programming step consists of a picture description of an image. To save specifying every line and point, primitive picture macros are usually available. TRANS, for instance, would set up the circuit symbol for a transistor. Additional parameters select such options as size and orientation.

About twenty animation languages are currently in use, mostly developed in the USA and Canada, and largely using FORTRAN as a host language. One British language is GROATS, an ALGOL package developed by Bob Hopgood at the Atlas Labs at Chilton, Berkshire. HICAMPER, developed by Sherwood Anderson at the University of Syracuse and at the Johns Hopkins University, is a specialised language for rendering two-point perspective or isometric views. A human draughtsman can take a day to produce one isometric view of a building, and while the finished drawing may look realistic, it is still only an approximation. The computer can rapidly produce a whole series of perspectives from a shifting viewpoint with the added bonus that they are totally accurate. HICAMPER is ideal for analysing the field of vision from a particular viewpoint – for example, from the cantilevered balcony of a planned building or from an aircraft cockpit approaching an airfield which has yet to be built.

In compiling a picture language, one of the features to be considered is the ability to suppress 'hidden lines.' When you take a pencil and draw an Oxo cube, you know from experience the need to eliminate the lines hidden on the far side of the cube. Otherwise you end up with what looks like a cube made of wire. The programming logic demanded by the computer to determine which lines or areas are to be ignored is very expensive both in terms of core storage and processing time. From time to time, ingenious hidden line algorithms are published in the computer journals, but most of these are limited to certain types of figure. Alternatively, they occasionally fail to resolve difficult cases. An acceptable compromise is to put up with the generation of a few illegal lines and paint them out later by hand.

Hail, CAESAR !

Many computer movie-makers believe that the real future of the art must lie in interactive systems in which the user draws or traces a figure directly with a light pen or onto a two-way plotting table.

The most well-known interactive system is CAESAR, a commercial configuration built by Computer Image Corporation, of Denver, Colorado. Here the animator starts by drawing a few illustrations for a new cartoon character. This artwork is then viewed by TV cameras which convert the pictures to signals that can be processed by the computer. Usually a few drawings, and never any more than ten, are sufficient to define the character for all time. The computer can now treat all the moving elements of the character separately: arms, legs and mouth. By translations and rotation about an axis perpendicular to the artwork it can produce a fully articulated character at standard TV frame rates. In producing a sequence, CAESAR parallels the conventional film maker's methods. Normally, an animator works between 'extremes': a master animator draws important frames (the extremes) and his assistants fill in all the remaining drawings (the inbetweens). With CAESAR, the operator follows the storyboard and positions the character on the viewing screen by controlling the computer console. This 'extreme' is then recorded. Then a new position is set up and recorded and the computer is instructed to perform all the inbetweening.

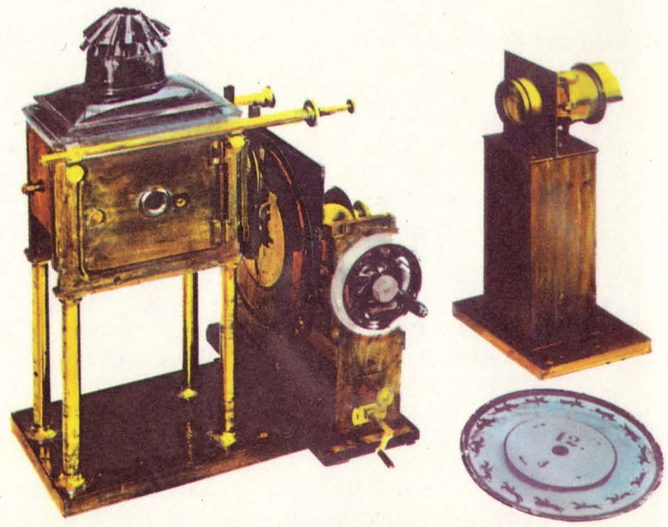
A typical sequence of a man walking up to a stick, kicking it, falling back and breaking up into his component parts was

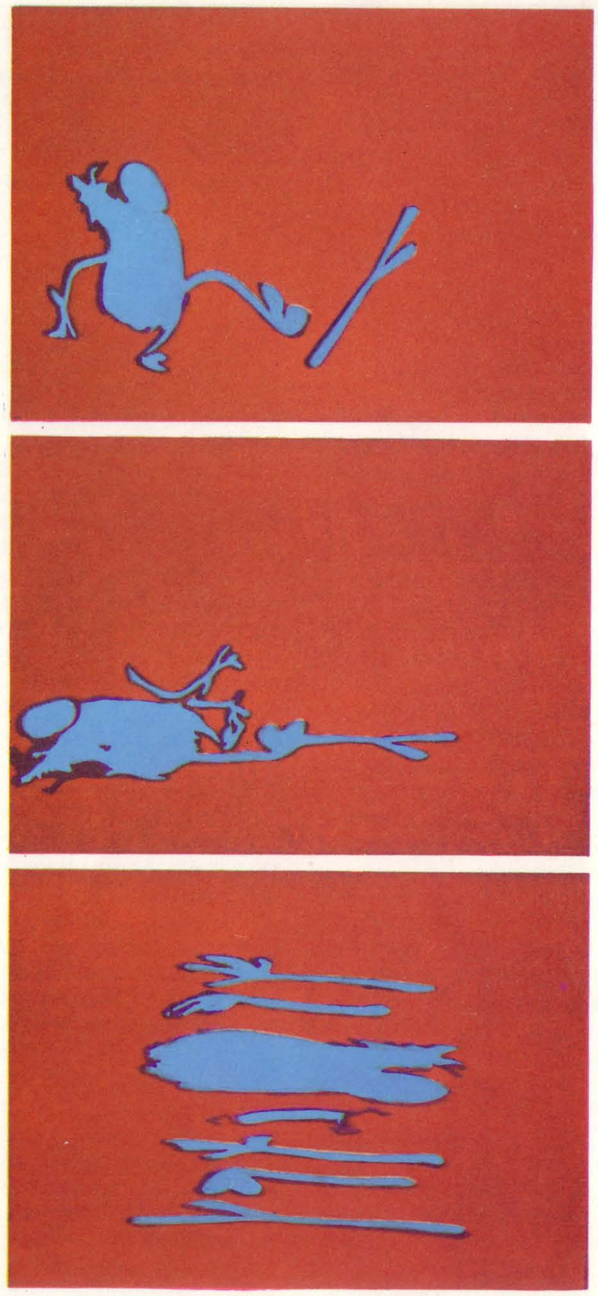
Top:

Muybridge's Zoopraxiscope, the ancestor of the movie projector, is preserved in Kingston-upon-Thames Museum.

Bottom:

CAESAR is an inter-active system devised by Computer Image Corporation, Denver, Colorado. These photographs were taken from the system's TV tube when the operator instructed the cartoon man to kick the stick. The man falls back then breaks into his component parts.





planned, timed, programmed into the computer and recorded onto video tape in about five minutes. The makers of CAESAR claim that with standard equipment a conventional animator might take as much as two weeks to animate and photograph the same sequence. On the other hand, computer animation cannot match the sophistication afforded by traditional methods – it will be some time before we are likely to see a computer character who can emote as dramatically as Donald Duck.

After the first few computer film makers had got over the urge to produce arty films using Moiré fringes and the like, the most extensive use of computer animation occurred in the educational area. The technique, for instance, played an important role in the NASA space programme as a simulation tool. Television programmes produced by the Open University make regular use of computer animation, particularly in the field of mathematics. Today's students, brought up with television, have learning habits undeniably biassed toward visual media.

Producer Ed Goldwyn of the Open University, in deciding over two years ago to use computers, did two very important things. First he opened the door to the highly specialised field of making technical films regularly and relatively cheaply. And, more important, he created a training ground for a team of programmers to apply themselves to film problems. The team, headed by Bob Hopgood at Atlas, is regarded as possibly the best of its type in the world.

Turning a sphere inside out

Perhaps the weirdest of all studies is topology – the branch of mathematics dealing with properties of position that are unaffected by changes in size or shape. Topological properties, in effect, are geometric properties that stay the same in spite of stretching or bending. Topology is full of apparent paradoxes and impossibilities: even experienced mathematicians find many of the concepts difficult to grasp. However, in teaching topology, films can play a valuable role. They can illustrate moving curves and surfaces which could never be adequately described by a lecturer at the blackboard.

At the Education Development Center, in Newton, Massachusetts, Dr Nelson Max has produced several films concerning 'regular homotopies' – continuous deformations of curves and surfaces. For many years mathematicians had suspected that it was impossible to turn a sphere inside out by a regular homotophy in 3-dimensional space, i.e. by a deformation with self intersections but without tears or creases. Stephen Smale in 1959 caused much surprise when he proved that it was in fact possible. But his proof was abstract and did not contain an explicit solution. Such a solution appeared seven years later in a 'Scientific American' article by Anthony Phillips, but considerable effort and imagination are required to form a mental picture of the technique. Nelson Max's 30-minute film gives a convincing demonstration simulated by a computer and is one of a series of films he has produced aimed at bringing an appreciation of topology to a wider audience. He points out that the inside-out-sphere film could have been attempted with clay models, but unlike the computer-produced film, this would not have permitted the effect of transparency which allows the viewer to see the full continuity of the surface.

Edwin Abbott in his remarkable book, 'Flatland', describes the difficulties of living in a world limited to two spatial dimensions – the world that Popeye would inhabit if he could move about inside his newspaper strip cartoon. The dwellers of this world simply can't understand a third spatial dimension. So they are baffled by the distortions of the 2-dimensional projections into their world of simple 3-dimensional objects out of our world.

By the same token man finds himself in a world of three spatial dimensions and is unable to visualise a fourth spatial dimension perpendicular to the three that we live in. We can't even be sure that the events we witness aren't the 3-dimension projection of some high-dimensional event.

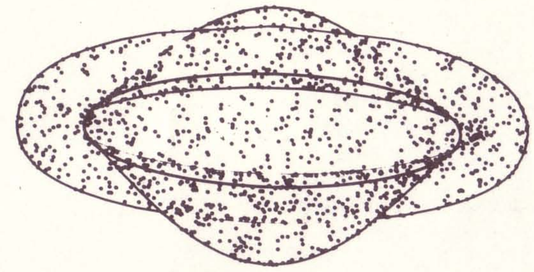
Human visualisations, however, don't worry the computer. It is quite as happy dealing with objects in 4-dimensional space as it is in 3-dimensional space. Just give it a fourth coordinate and it can locate a point in 4-dimensional space. Actually, the mathematics and projective geometry of 3-dimensional space can be generalised to any number of dimensions so that an n-dimensional hyperobject can be mathematically projected into an (n — 1) dimensional space.

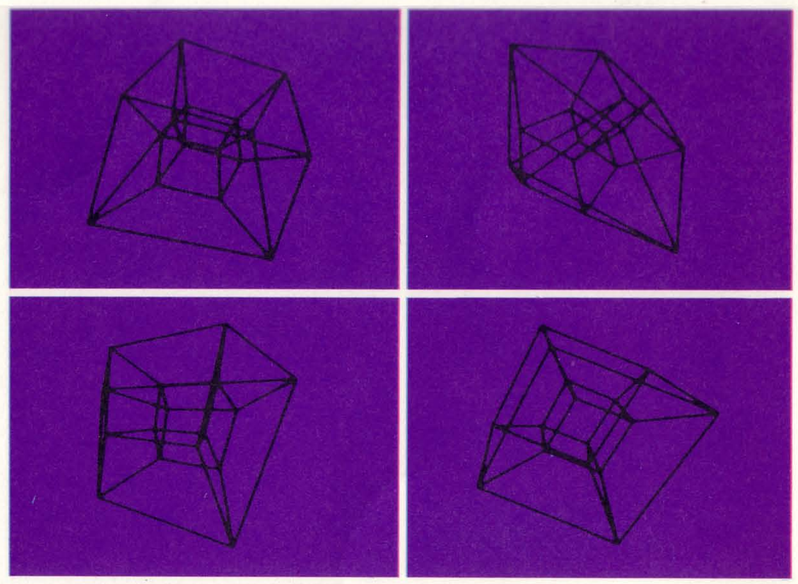
Michael Noll of Bell Telephone Laboratories produced in 1967 a now-famous 3D movie of the perspective projections into 3-dimensional space of a 4-dimensional hyperobject. At first it was hoped that the movie would give some 'feeling' or intuitive insight for the visualisation of a

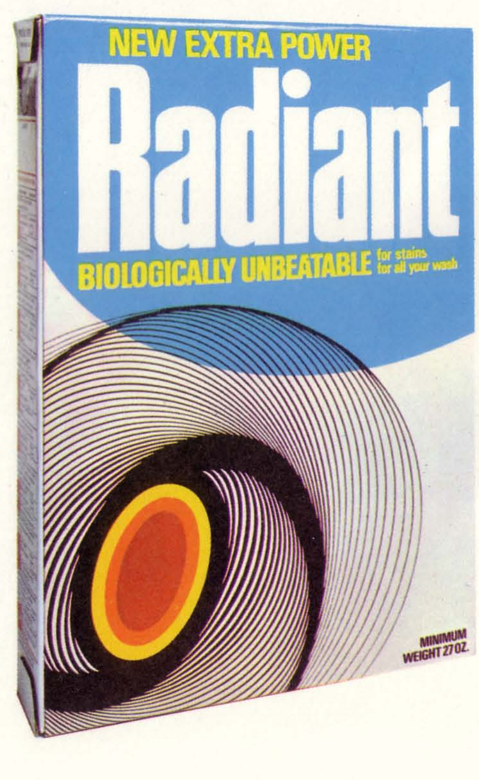
Top:
Topologists have long been interested in the possibility of turning a sphere inside out without tearing it. Nelson Max's film of the technique helps mathematics students to visualise a proof that would otherwise be highly abstract.

Bottom:
Working for the J. Walter Thompson agency before the launch of Radiant washing powder, Wyatt Cattaneo Productions commissioned Tony Pritchett to program this sequence for an experimental TV commercial featuring the Radiant symbol.

Centre
Stereo pairs from Michael Noll's film showing the 3-dimensional perspective projection of a 4-dimensional hypercube. Place a paper on edge between the pairs and position your head so that each eye sees only one image. These images should then merge into 3-D.







fourth dimension. Unfortunately, the film failed to do this, although most people are awed by its fascinating beauty. The technique had, though, already proved useful in extending knowledge of 3-dimensional perspective projections of higher dimensions. The techniques have now been applied to real-time graphic displays so that users can rotate, translate and manipulate hyperobjects and hyperdata, and immediately see the results.

Noll has also applied his stereo techniques to other purposes including choreography documentation using 3D stick figures, and a 3D depiction of the hearing process in the inner ear. In 'Simulated basilar membrane motion' the film shows by greatly exaggerated motion the calculated deflections of the membrane when various types of sound hit the eardrum.

Film stars

Some critics – and not always disgruntled animators – have complained that many of the educational films produced by computers could have been made quicker and at less cost with human labour. While computer film making is still suffering from its growing pains there may be an element of truth in these comments. But some scientific films would simply be impossible to produce by hand anyway. Professor R.W. Hockney of Reading University simulated the evolution of a galaxy of 50,000 stars, using the facilities of the NASA Langley Research Center, Virginia. At each time-step of the calculation, a revised (X,Y) position was obtained for each star plotted on the microfilm recorder. The film, of about two thousand frames, was made in five computer runs, each using five hours on the CDC 6600. Some fifty magnetic tapes were produced.

Readers who are wondering if they can use their line printer to produce useable graphic output for film making, should reflect that if all of the star coordinates had been printed on a line printer, there would have been 200 million numbers, about 20 million lines, or two thousand years of printer time.

Several computer animators, impressed by the news that a recent soup commercial lasting sixty seconds cost $160,000, have seen a luxury market for their wares. But it's not plain sailing. One American producer reports that he took his computer showreel around the advertising agencies to be told, "It's a pity you can't do this stuff in colour". When, after much effort, he produced a series of colour sequences, he was rewarded with the comment", "Too bad you can't appreciate the graphics because of all this distracting colour".

More successful have been Computer Image Corporation, of Denver, whose stablemate to CAESAR is a system called SCANIMATE which can handle very simple character animations but which is mostly used to deal with print, symbols and abstract areas of moving colours and shapes. TV networking in the USA makes it more common for local businesses to advertise, so SCANIMATE makes it possible at low cost to produce a commercial, for example, in which the contrast of a plateful of spaghetti leap and dance on the screen to suddenly arrange themselves into the name of a drive-in restaurant.

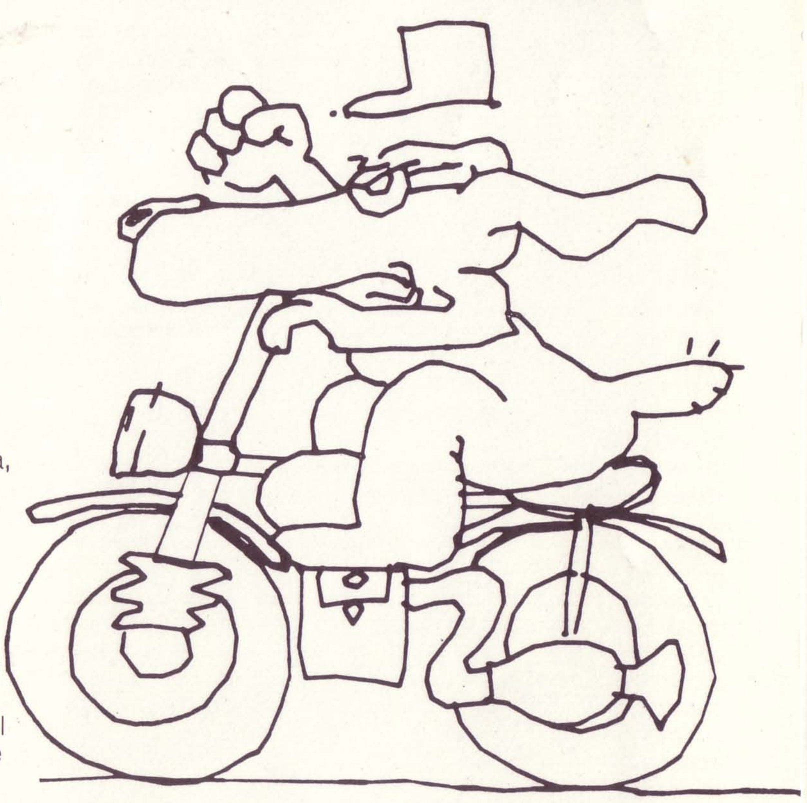
SCANIMATE uses as its starting point ordinary artwork. This is viewed by a TV camera and converted into signals that can be processed by an analog computer. As with CAESAR, an inbetweening process is usually employed, between two or more extremes. The original artwork image can be put through an almost infinite variety of motions: exploding, zooming to a point or vanish, plasticising, growing, shrinking, pulling through itself, revolving twisting, squeezing, undulating and more. A particular advantage is that this interactive system allows the results to be seen and corrected within minutes. The principal criticism of all non-interactive systems is that it takes ages to produce a correct piece of film, particularly if your installation works in batch-time with a long turn-round time.

A home-grown interactive system even more ambitious – and far less expensive – than SCANIMATE is CADMAC, still under development at the Nuclear Power Labs at Imperial College, South Kensington. This uses a reversible plotting table as the primary input/output medium linked to a PDP-8/E computer with 4K core storage and back-up magnetic tape units. Other delights not all yet plugged in will include black and white and colour video tubes, a digitally controlled video rostrum camera, colour and sound synthesisers, and frame by frame video playback with an alter option.

One of the users of CADMAC is Stan Hayward, a well-known writer and designer of conventional animated films, who has been at the forefront of the British computer movie scene since he won a Honeywell competition for new uses for the computer in 1969 – the prize being £1000 worth of computer time and a terminal in his flat. Hayward has founded a new

Top:
SCANIMATE, a system developed by Computer Image Corporation, uses ordinary artwork as input and puts this through a variety of operations: exploding, zooming, growing, shrinking, twisting, and so on. These are the opening frames of a TV commercial produced on the system for the Pontiac Division of General Motors.

Bottom:
A still from an experimental film produced at the Chilton Atlas Laboratory.



company, The Computer Studio, to promote new markets for computer animation. Among his ideas are moving blueprints to show the workings of engines, animated instruction manuals for car repairs, and visual aids in music that show an instrument playing itself.

His experimental animated identi-kit, produced at Scotland Yard's request, produces a perspective view instead of the conventional head-on view. By calling up various options, the figure can be made to grow long hair, wear spectacles or don a hat. Eventually it will be able to make use of CADMAC's colour video to synthesise skin colours in accurate tones, while given a voiceprint of the 'criminal', the figure's lips could even move in synchronisation with the voice.

Hayward's company also makes other computer services available to the film industry – in such areas as accounting, scheduling, stock control and critical path analysis. In conventional animation, a special camera known as the rostrum camera is used to photograph the successive drawings. For such effects as zooming, tilting, panning or tracking, the movements of the camera must follow coordinates painstakingly computed by a cameraman. The Computer Studio uses its own timesharing terminal to compute listings of these rostrum coordinates for other animation studios.

Is it Art? or just a craft?

The conventional cinema became an art very quickly – largely because it was easy for the non-technical to learn how to operate a camera. But considering that computer-generated graphics have been around now for twenty years, computer movies have been slow in making their mark and establishing their own standards. A possible reason is suggested by Professor Huggins of the Electrical Engineering Department at Johns Hopkins University: "Why has it taken twenty years to provide generally useful visual displays for human communication with the computer? The answer to this question is, I believe, not unrelated to the fact that most speakers at computer graphics conferences exhibit poor graphic aids and slides. I can only conclude that practitioners of computer science, unlike those of other disciplines, seem able to function entirely at the symbolic level with no need to communicate at the iconic or enactive levels of human experience. Their world is apparently a syntactical structure of symbol strings."

Professor Huggins will forgive us if we interrupt him to highlight 'iconic' as this year's computer jargon word – meaning 'of the nature of an image.'

"Over the past two years, have led a seminar in Iconic Communications at the Johns Hopkins University. I have required each of the participants to produce a computer animated film showing some abstract idea purely by the use of animated pictures without relying on traditional words and symbols. The participants have revealed marked differences in their abilities to accomplish this assignment. Those who were highly skilled in computer programming appeared to be the least able to express an idea iconically, and in most instances they gave up and created instead either a pretty graphical design or wrote a programming language that presumably might be of use to someone else for this assigned purpose."

John Halas, who is writing a book on computer animation and is accepted as one of the world's greatest animators, has expressed the warning that if the film makers leave too much to the scientists, the visual possibilities of computer animation may be lost.

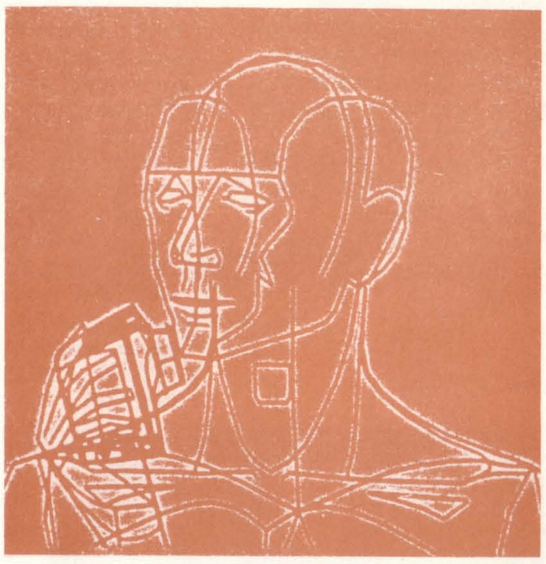
There is, however, greater optimism on this side of the Atlantic, perhaps one by-product of a broader-based educational system. Certainly, if the gloomy reports from America are any indication, artists and scientists seem more able and willing to talk to each other in Britain. One centre where the two cultures meet is the Atlas Lab at Chilton – described by John Chittock of the 'Financial Times' as "an odd mecca where clean-shaven physicists and hirsute artists find themselves in perfect harmony." At the Royal College of Art, Colin Emmett, who uses the computer to create typographical transformations (for instance 'MAN..ANT') pops across the road to use the computers at Imperial College.

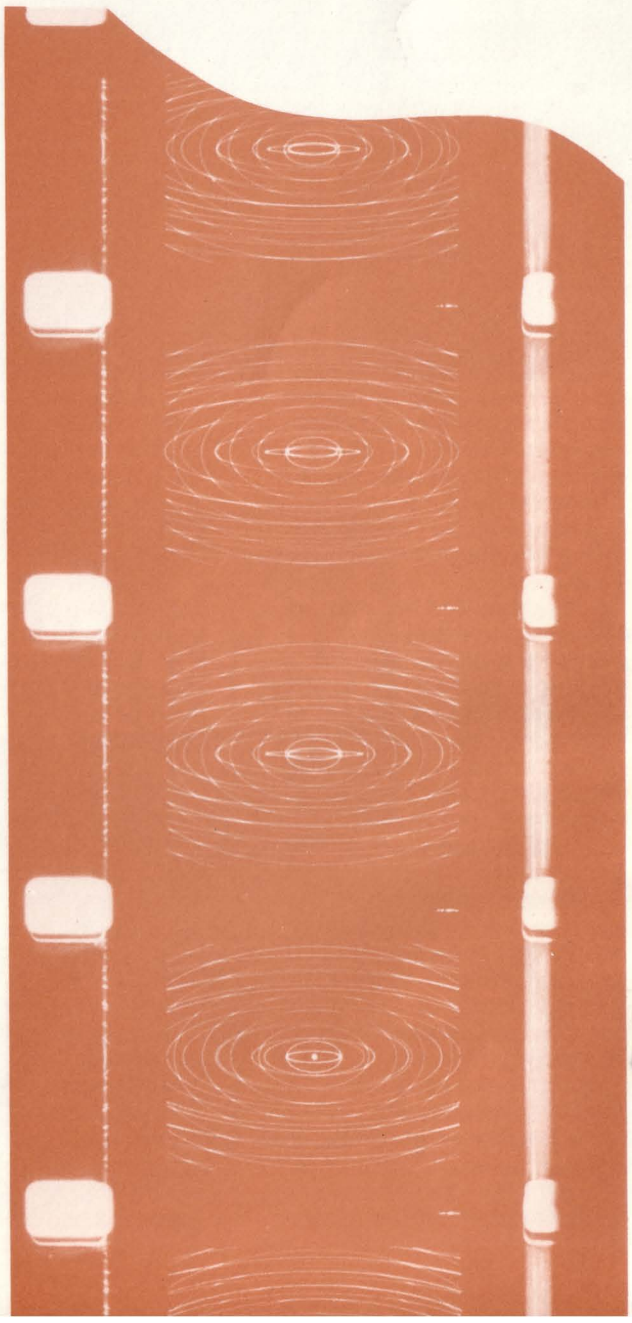
Most noticeably, the traditional makers of films have been slow to grasp the opportunities offered by the computer. But with the technologists offering an increasing number of new lamps for old – lasers, videocassettes, stereoscopy, multi-screening, holography, cable vision, and colour and sound synthesisers – life must be getting confusing in Wardour Street and Hollywood.

There is a real need for a clearing house for film technology although the problem may not be too little ready hardware, but too much. Professor L.Mezei of the University of Toronto feels that it has recently become apparent to many people that most of the attention has been placed on the technical problems, and not nearly enough effort has been

Top:
An American 30-second TV commercial in which a 3-dimensional man uses and explains the features of a Norelco cordless shaver.

Bottom:
A remarkable study in light and shade. Frames from a recent film made at the University of Utah by Edwin Catmull.





expended on the development of useful application packages for the many potential areas where graphics could make a significant contribution.

"Many practical applications with widespread potential are actually relatively simple. In the near future the bandwagon effect may well occur with respect to computer graphics, as it has occurred with other areas, if the potential benefits are suddenly realised by a large number of users."

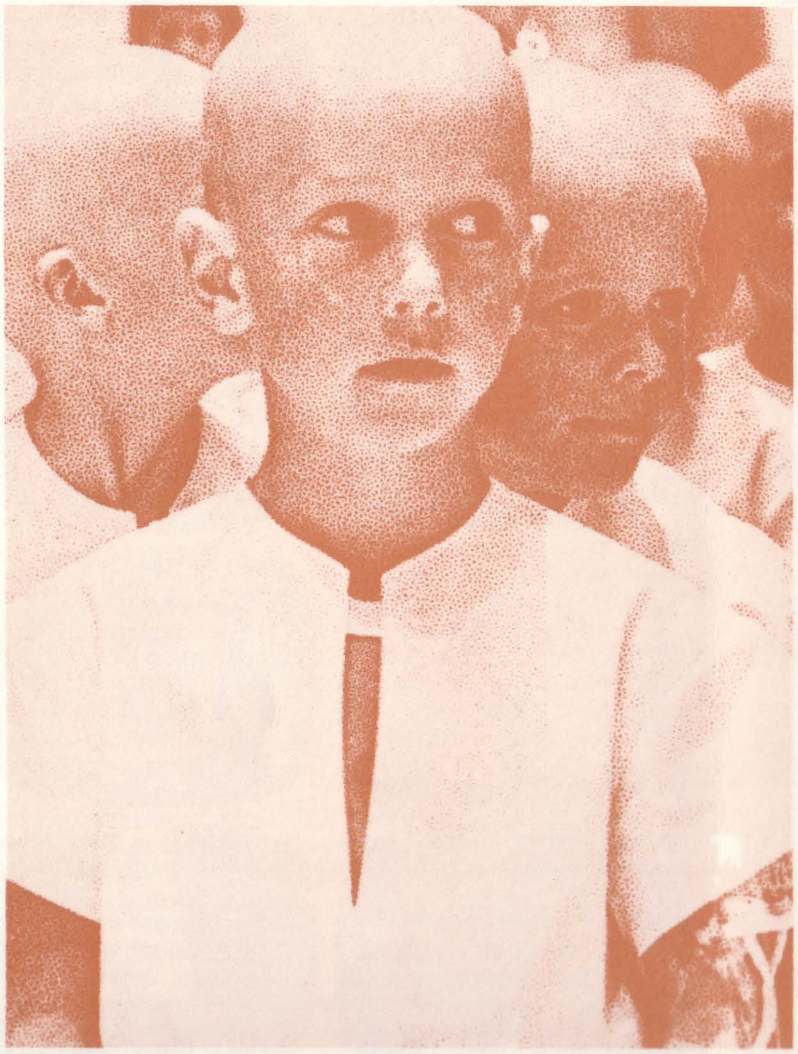
Stan Hayward has gone on record in November, 1971, by saying in a British film-making journal: "I predict that one year from now the basis for a computer animation industry will be firmly established."

At a computer seminar last summer, however, one transatlantic professor was more cynical. He told about the girl who went to the doctor and complained:
"I have this problem. I've been married three times and I'm still a virgin".

"Tell me about it",

"Well, the first time I got married my fiancée was on his way to Viet Nam. He left right after the ceremony and was killed in action. So I married and was still a virgin. The second time we were on our way to the honeymoon and we had a car accident which killed my new husband. My third husband is very much alive but he is a computer graphics expert. He would rather sit at the side of the bed and talk about how wonderful it is going to be."

For the ordinary cinema-goer, the computer in such films as '2001' and 'Fahrenheit 451' has joined the famous monsters of movieland. Warner Brothers' 'THX 1138' takes place in a computer-controlled subterranean world. SEN 5241, played by Donald Pleasance, is arrested for altering the computer circuit which determines the destiny of his colleagues THX 1138 and LUH 3417.



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