NC 0020093 X
M0056899NC

National College Of Art And Design

Faculty of Design

Department of Industrial Design

Computer Animation in Film and Design

by

Thomas O'Neill

Submitted to the Faculty of History of Art and Design
and Complementary Studies in Candidacy
for the degree of Bachelor of Design

1992

Acknowledgements

I would like to thank my supervisor, Mr Paul Caffery, for all his help and advice. Special thanks are also due to Mr David Moran of Pixamation (Dublin), Mr Des McMahon of Gilroy McMahon (Architects, Dublin), The Queen's University of Belfast and The University of Limerick.

Contents

List of Illustrations

List of Illustrations (Contd.)

Page

Introduction

It is the intent of this thesis to show how animation has developed from a basic cel process as used in cartoons such as those used by Walt Disney, to modern computer animated processes as used in the film Terminator 2 (1991). This will illustrate how the limits of the animation process have been pushed back from a labour intensive, time consuming process, into one that can achieve photorealistic results with a fraction of the work.

The film industry has acted as a surrogate mother for developing animation technology used by Industrial designers. Chrysler cars and Sony products will be used as examples of how their design techniques have changed.

This thesis will then discuss how the design process is being limited by the interface between the designer and the computers being produced to serve their needs. It will then show how these interfaces are likely to be transformed in the next five years.

Finally the invention of 'Virtual Reality', a technology that is as yet largely experimental, will be investigated and its implications for the design process will be explored.

Animation is the process of conveying moving images to a viewer. The process has been around since as early as 1877 when Emile Reynaud began projecting moving drawings onto a screen by a series of mirrors and lanterns. Animated cartoons date from 1906, but it was Walt Disney who first realised the potential of animation as a means of expression and communication. Disney said : 'Animation can explain whatever the mind of man can conceive' (28, p. 13). This statement succinctly shows the potential of animation as a design medium. Today though cartoon animation only forms a fraction of the animation work being carried out. The film and design industry are now the main employers of its techniques.

The boundaries between verisimilitude and that which is termed reality are constantly being blurred, due to the evolution in the methods and means of conveying images. This though is not a new concept to be faced for the first time in the twentieth century. The Greeks believed that everything was an illusion with the exception of mathematics. Plato, in The Republic, used his cave theatre as a way of discussing his theories regarding the nature of reality.

> **Imagine mankind as dwelling in an underground cave .... imagine a low wall has been built, as puppet showmen have screens in front of their people over which they work their puppets .... see, then, bearers carrying along this wall all sorts of articles which they hold projecting above the wall, statues of men and other living things, made of stone or wood and all kinds of stuff.** (22, p. 304).

Plato asserted that the things we see in this world are shadows projected by 'ideal' objects and beings, of which they are merely temporary instances. We therefore see an illusion based on reality, a Virtual Reality. Virtual Reality, many now believe, will be the biggest revolution in the way we think and communicate since the introduction of moveable type which enabled printing presses to turn out books to the masses.

Chapter I :

The Origins Of Animation

Introduction

The animation industry has developed dramatically in recent years. Historically, animation was produced by hand painting individual cells which were then filmed. The film industry however soon demanded more sophisticated model/puppet animation which demanded new techniques such as stop motion or motion control. These techniques in turn required new technical advances to compose the individual films into one thus giving the effect of a single shot. The advent of computers has helped to reduce animation's more labour intensive costly processes.

In The Beginning

Traditionally animation sequences of high quality were performed almost exclusively by studios such as Disney, who set the standards with classics such as <u>Snow White and the Seven Dwarfs</u> (1937) and <u>Fantasia</u> (1940). These feature length cartoons used time honoured techniques, which were laborious and time consuming, to handle and develop the tens of thousands of drawings which were required to produce these. The basic procedures involved in cartoon animation are :

1. Idea
2. Storyboard
3. Plan Action
4. Record Sound
5. Layout
6. Animate
7. Test

8 Background
9 Trace
10 Paint
11 Check
12 Photograph
13 Edit
14 Dub
15 Negative Cut
16 Print

These procedures involve a lot of drudge work. The character or scene was first drawn in one position, known as a cel, then the scene was redrawn with a slight movement, making the second cel. Each frame or cel must then be checked by 'flipping' to determine the accuracy of movement and timing, in a photographed pencil test, before the final painted cel is filmed. A partially painted cel taken from an Emerald City Production (based in Dun Laoghaire Dublin) is shown in Illustration 1.

Flat hand drawn 2D animation such as these only form a tiny fraction of the animation sequences being seen on our big screen today. Special effects sequences such as those used in 2001 A Space Odyssey (1969) and Star Wars (1977) are completely dependent on animation, using techniques very closely approximating to those of cel animation.

George Lucas' Star Wars created a film effects revolution when it was released in 1977, spawning the state of the art in film animation techniques. Lucas set up a new special effects studio in the San

Mrs Otis : Emerald City (1989)

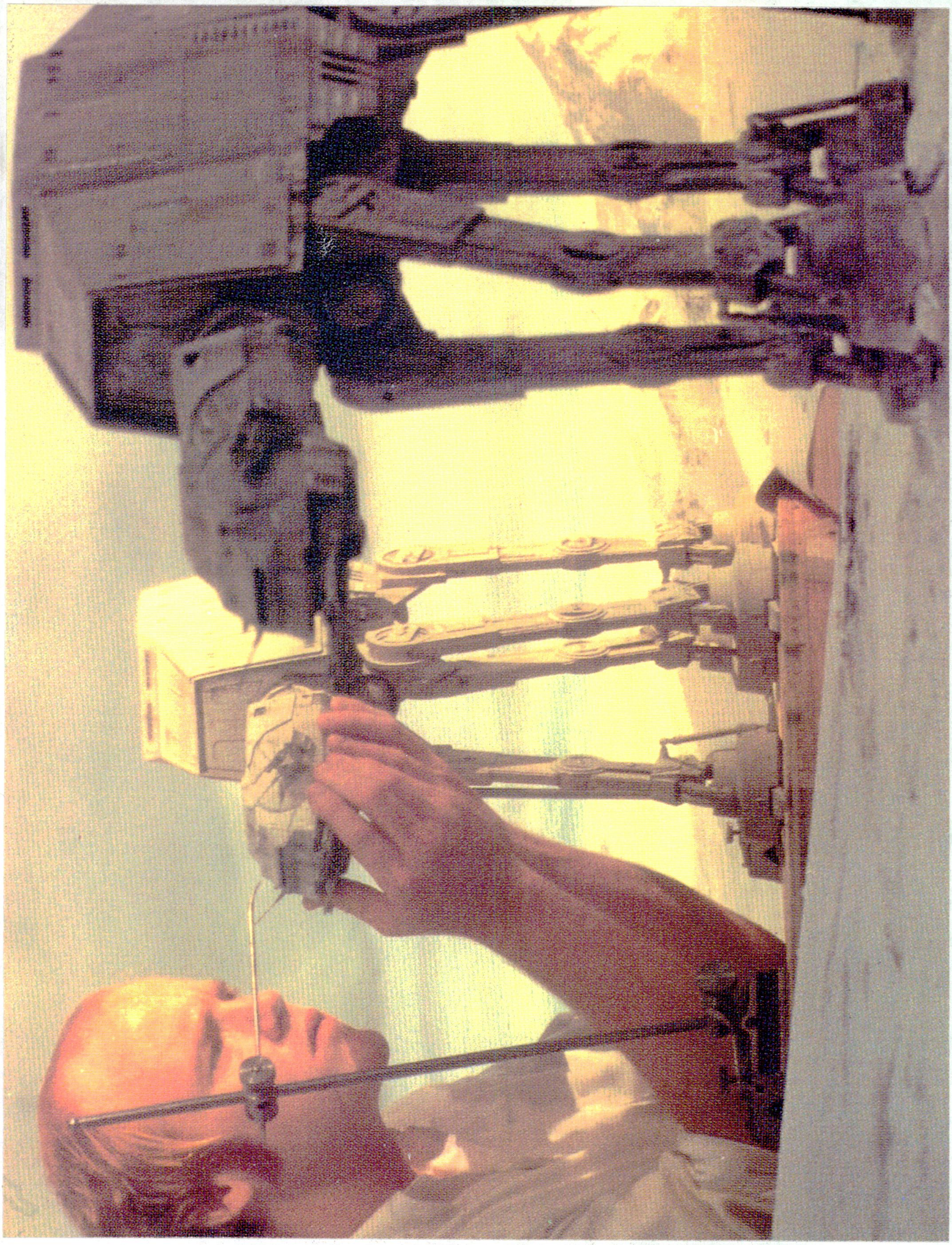
Illustration 1

Fernando Valley to bring his visions to life, and named it Industrial Light and Magic (I.L.M.). The I.L.M. team used many specialist techniques to bring scenes to life, some of them being closely linked to cel animation.

Stop/Go Motion

One such technique is Stop Motion Photography which takes advantage of the fact that movies are actually a succession of still images that, when projected quickly enough, allow us to perceive the images as one continuous motion. Stop Motion is then a variation of cel animation, except in 3D, and usually employs miniatures or puppets which are photographed one frame at a time. In between frames, the objects are manipulated through portions of a movement, such as walking or running. This manipulation required the use of pointers to determine the amount of adjusting required between photographs, this can be seen in Illustration 2 which shows Snow Walkers being animated for <u>The Empire Strikes Back</u> (1980). Many problems arise with this process. The scenery and other props must not be disturbed in the adjusting process and if any mistakes occur in this, or the movement of the models everything has to be reset and done again.

Another process, similar to Stop Motion, that was developed by the I.L.M. crew is Go Motion. This process uses puppets which perform continuous movements with the aid of computer controlled motors. When these puppets are filmed the camera can expose the movement as it occurrs and thereby film the blur that had been missing in traditional Stop Motion cinematography. As a result the scene is much more realistic. This technique was first used to critical acclaim in the film <u>Dragonslayer</u> (1981).



Snow Walker scene from The Empire Strikes Back (1980)

Illustration 2

Motion Control

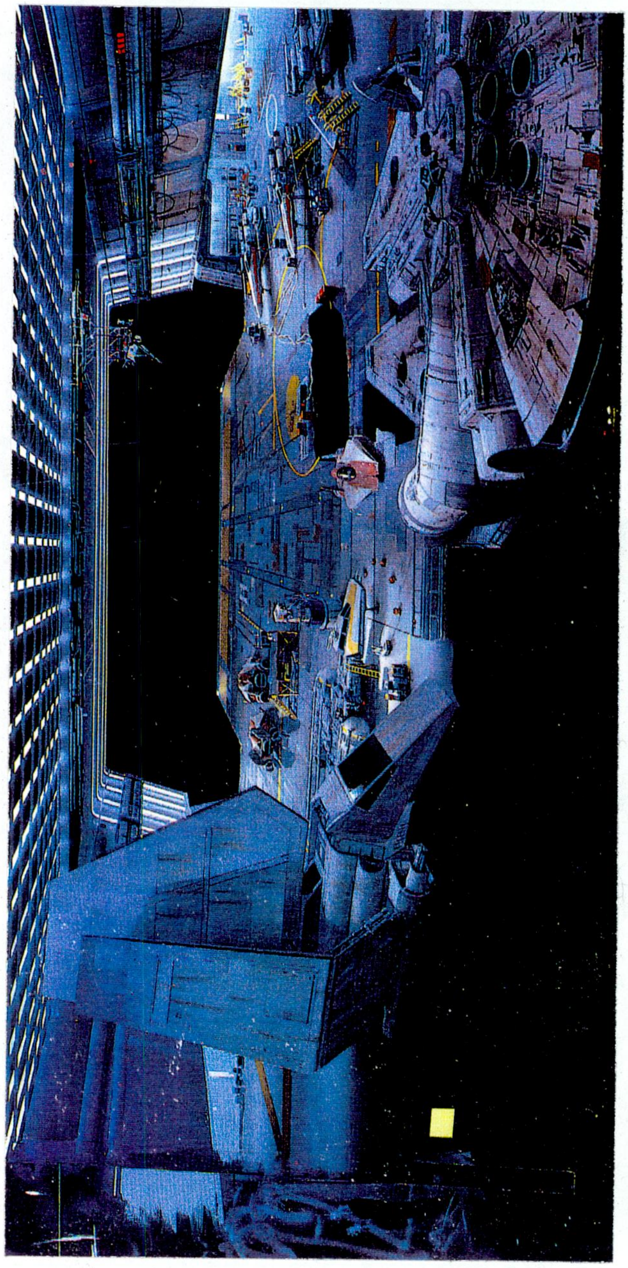
Yet another technique that was used to great applaud by I.L.M. was Motion Control. This is the technique by which things, such as space ships are made to appear to race towards us, through a starry sky. This effect is achieved by moving a camera down a long track, sometimes up to 60 feet long, towards a relatively stationary model. This will permit a mere speck of a model to race towards us and pass by mere centimetres from the camera. The cameras for these shots are mounted on a crane on tracks, all of its functions, including focus, being controlled by a pre-recorded computer program.

Matte Painting

These effects shots already mentioned often require dramatic backgrounds which do not exist in real life, or backgrounds that need to be enhanced. This is often achieved by a technique which has been around since as early as 1905. The processes involved are highly skilled, but basically involves painting a scene onto a blank piece of glass. This is depicted in Illustration 3 which shows a scene taken from Return of the Jedi (1983). The blank spaces on the glass are then overlaid with live action to produce the final composite shot shown in Illustration 4.

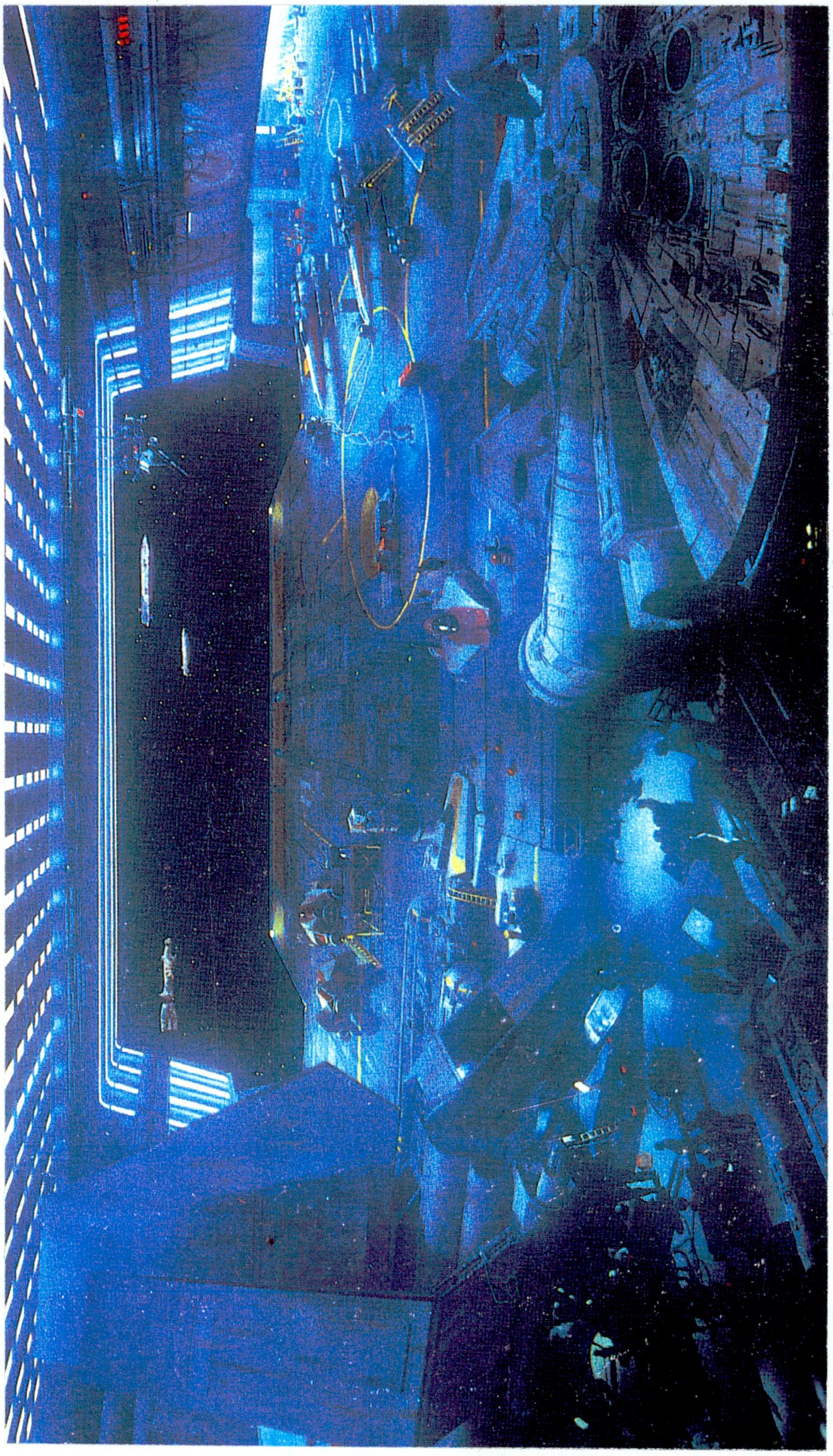
Rotoscope Camera

How then are such effects as laser flashes and lightning created on these films? This task falls to a camera known as the Rotoscope which operates in a format very similar to that of cel animation. The camera usually operates as a projector, projecting the film's image onto a flat work area. The artist works on a clear plastic sheet known as a cel, which is specially located in place. The artist then traces the required



Matte Painting from Return of The Jedi (1983)

Illustration 3



Composite Shot from Return of The Jedi (1983)

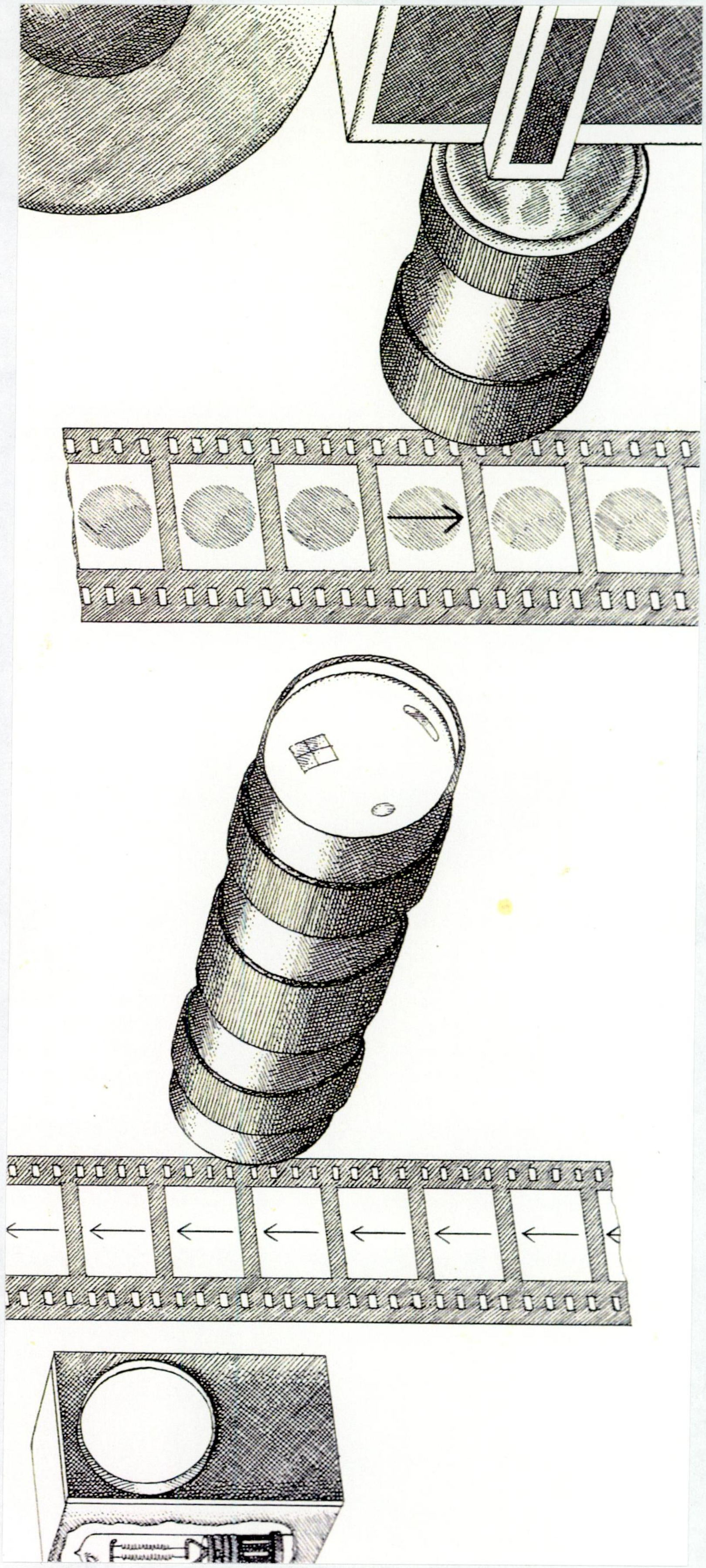
Illustration 4

part of the image onto the cel, which is later animated. After each frame is traced the film in the camera will be advanced to the next frame which will show the image in a slightly different position and the image is traced onto a new cel. The process is then repeated until a stack of cels are produced corresponding to the particular scene. These cels are then overlaid by the Optical Department onto the live film.

Optical Compositing

All the animation techniques which have been described, and there are many more, are carried out in isolation. They must however be transferred onto the final reel of film to be shown in the cinema. The process used to achieve this is known as Optical Compositing and makes use of a machine known as the optical printer. An optical printer, as shown schematically in Illustration 5, is basically a camera mounted at one end of a solid support, with one or more projectors pointed towards it. Film passes through the projector and the camera re-photographs it. In this way several different layers of film can be composited onto a single film, creating the illusion that they were all filmed in a single take.

One of the inescapable conclusions that can be drawn after examining the animation processes just outlined, is that there is a great deal of expensive, time consuming and tedious work involved. These are some of the main contributing factors that have led to the increasing usage of computers to speed up this process and make it cheaper. Originally computer animations suffered from 'jagged' motion and lack of naturalism in movement, but this is now becoming a thing of the past with the advent of new, more powerful technology, providing higher resolution and more fluid movements. These systems are now



Optical Printer

Illustration 5

beginning to replace the more expensive end of animation, like inking, inbetweening of frames and stop motion scenes in film.

Perceived Problems In Computer Animation

Objections to computer animation originate from the fear that the computer will eliminate the role of the craftsman by taking control, like Hal in the film 2001 (1969). Another fear is the absence of skilled handwork which would require less talent than the more traditional forms of animation. However, nothing can replace a strong imagination or good design appreciation. Similar objections were raised when photography was first discovered and used as an art form. This point is illustrated by Alvey Ray Smith of Lucasfilm :

> **The camera was an incredible development in its day, but now nobody gives a second thought to picking up a camera. And it's going to be the same with computer graphics, I suspect. First there will be a love affair and then everyone will settle down to making artistic use of the new language of images that are provided.** (25, p. 198).

The underlying view by people opposed to the computer is that it is a law unto itself rather than a progression of inventions and technical advances by humans who are responsible for their use and abuse. Since computers, so far, do not have the ability to fully think for themselves they cannot, as yet, threaten the artistic process or be the actual designer. No good design comes easy, no matter what equipment is developed. Computers are not yet capable of using trial and error procedures like humans. Like a ruler, the computer is a tool which acts as an aid, and extends the capabilities of the hand and brain, allowing complex actions to be undertaken.

Summary
The arrival of computers has made a big impact on the animation scene by reducing costs, laborious work and improving special effects. However, the computer has created a fear that the skills required for the more traditional animation procedures will be lost and that the computer will assume control.

Chapter II

Computer Animation And The Film Industry

Introduction

When computers were establishing themselves within the film industry they had a combination of problems; their lack of processing power, low resolution and film makers reluctance to use them. The breakthrough happened when the computers became advanced enough to cater for scenes which the film makers required and only the computer could produce.

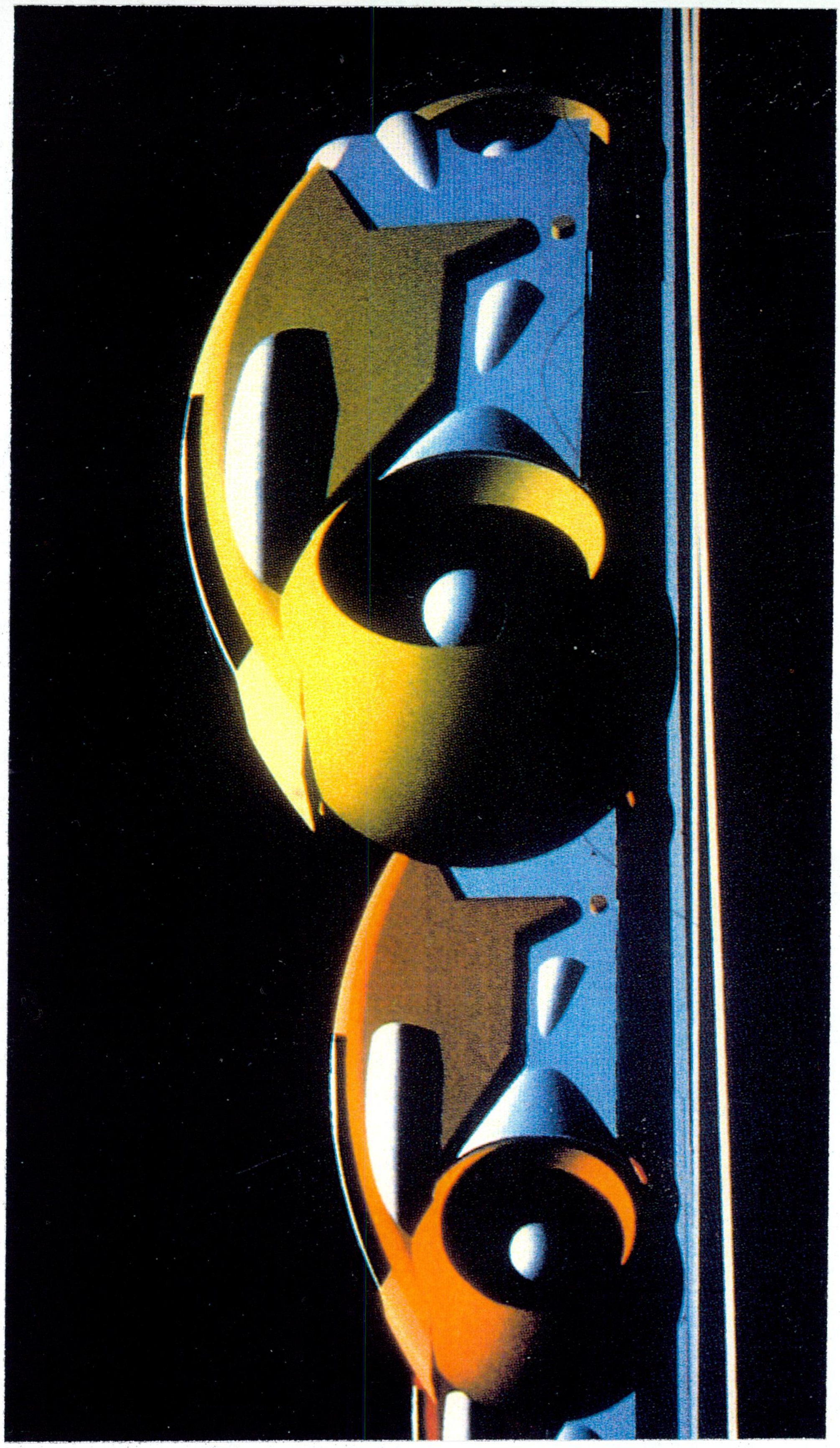
The Early Days

Back in 1974 Dr. Ivan Sutherland went to Hollywood after forming a consortium; the Picture Design Group. The group was formed from computer buffs and two experimental film makers. Sutherland was a computer graphics pioneer and had devised the first interactive digital graphics program. His aim was to persuade the Hollywood industry to take on board his vision of a 3D animation system. In 1974 though, this was the material from which science fiction movies were made and the computer hardware was just not powerful enough or advanced enough for the job required. Attitudes towards computer animation tended to be relegated to the realms of fantasy, until early in 1989 when the tide quickly, but positively changed and a record number of films using various digital effects sequences were produced.

Today animation processes are becoming increasingly dominated by the use of the computer. The first film to employ computer generated images for any length of time was Star Trek : The Wrath of Kan (1982), the genesis sequence, which lasted only a few minutes, was completely animated with the use of computers. Initially computer animation sequences were limited to bit parts as in Star Wars (1977); most of the special effects being performed by models using motion control. The only exception to this was Tron (1982) which used fifteen minutes of computer generated effects which were produced by MAGI SynthaVision, it was however still heavily dependent on matte painting and live action. A scene from Tron is depicted in Illustration 6, but it is easy to see that the forms generated are very basic and geometric.

Since then a series of major films have incorporated various sequences which are heavily, if not totally, dependent on computers to produce them. Films such as Star Wars (1977), Tron (1982), The Abyss (1989), Willow (1987), RoboCop 2 (1990), Total Recall (1990), Arachnophobia (1990), Ghost (1990), Flight of the Intruder (1991) and the biggest of them all Terminator 2 (1991). Computers are not only taking over in the feature film end of animation, but also in the 2 Dimensional world of feature length cartoons, with computers being used to generate 3D backgrounds which are overlaid with 2D hand animation as in Disney's latest release, Beauty and the Beast (1991).

Unfortunately Tron was not a box office success, this was probably more attributable to the acting and the story than to the special effects.



Sequence from Tron (1982)

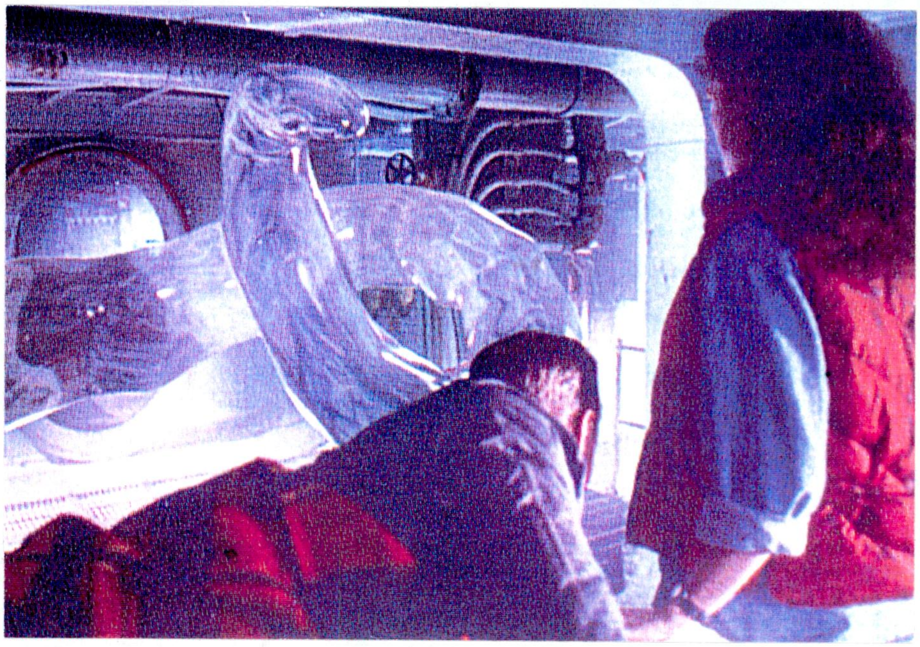
Illustration 6

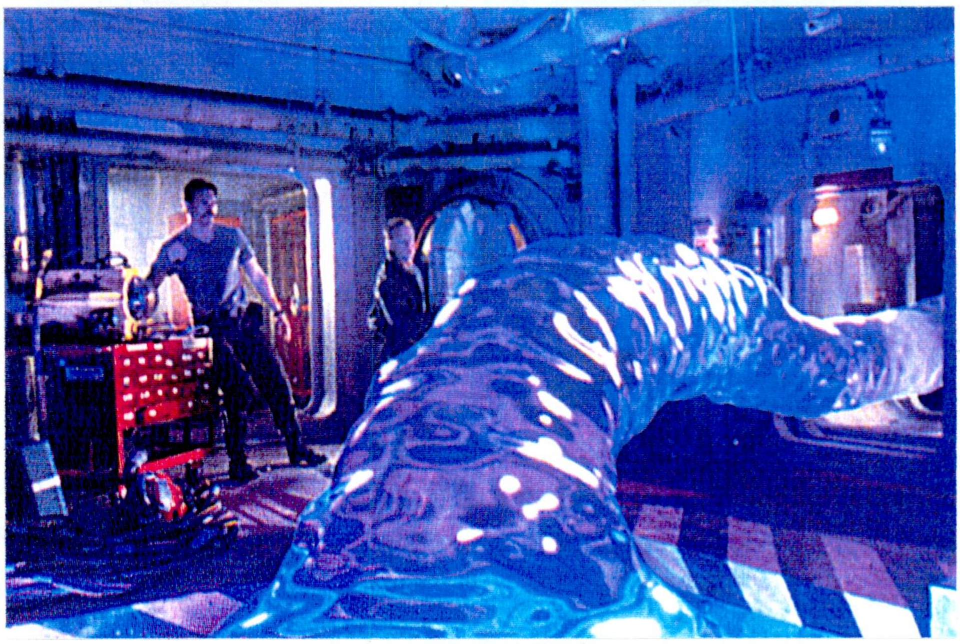
Due to its failure at the box office, producers became very reluctant to use computer animation again.

Breakthrough

Film makers who were trying to produce ever more dramatic scenes for films soon realised that it was impossible to achieve results of the proper quality using traditional animation techniques. These difficult scenes largely resulted from the need to produce animated, believable humanoid forms, i.e. a synthetic actor. Synthetic actors that act like humans are basically impossible to produce with hard models, as they are of an organic form and require fluid movements. The only answer to this problem is the use of computer animation. The pioneering film that brought a synthetic actor to the big screen was The Abyss (1989) directed by James Cameron. The Abyss featured a watery computer generated pseudopod that mimiced the expressions of a human face. The sequence, which lasted two minutes, is shown in Illustrations 7 and 8 and proved just what could be done with computer animation by showing that synthetic actors could be incorporated into films. It only took until the summer of 1990 before the next synthetic actor hit the big screen, in the form of an animated face on a computer screen. It belonged to a junkie cyborg in RoboCop 2. In the same summer the blockbuster film Total Recall employed yet more animated human characters, this time in the form of skeletons walking and running behind a giant X-ray screen of the future.

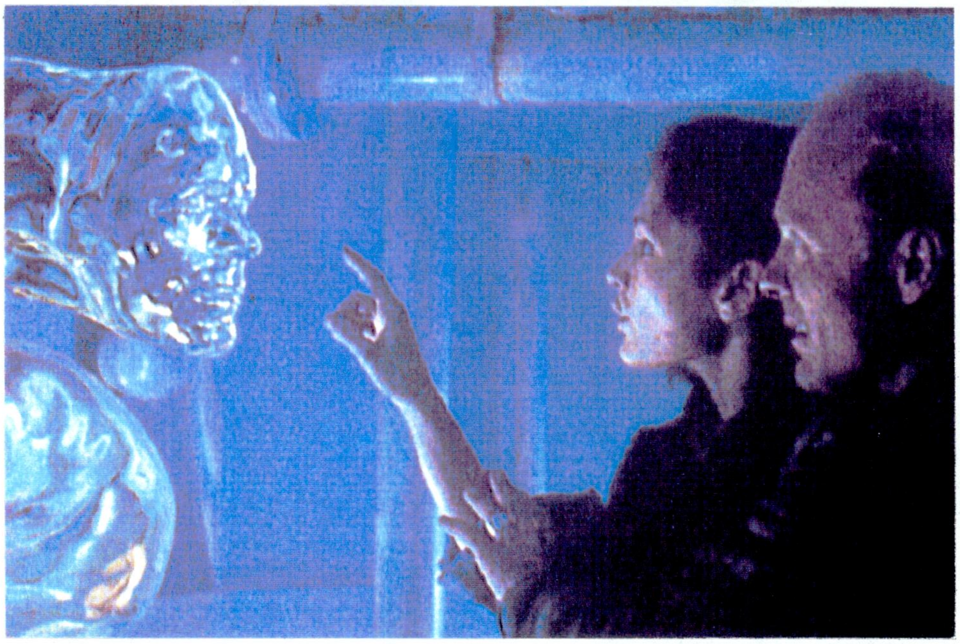
The images for the screen were created by Metrolight and they had to be computer animated as it was impossible to generate an image that





The Abyss Pseudopod Sequence (1989)

Illustration 7



The Abyss Pseudopod Sequence (1989)

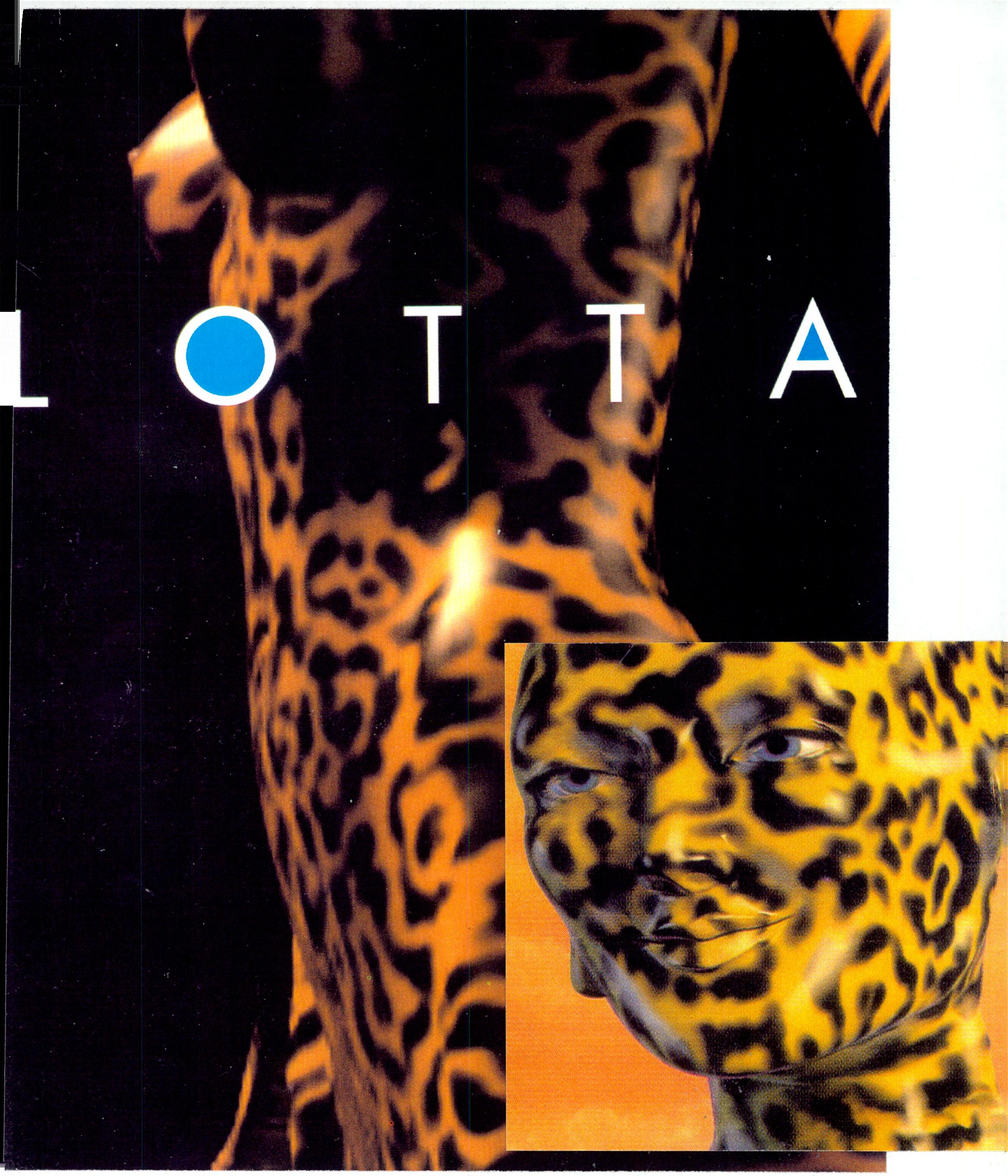
Illustration 8

looked like an X-ray yet moved like a real person. Skeletons could have been employed using stop and go motion, but the variable transparency look of an X-ray would have been impossible to achieve. Even though Total Recall represented yet another step in the use of animated characters on screen the models created were of skeletons having hard edges, and did not have to perform facial expressions as do normal characters. Even in The Abyss the head was not meant to look like flesh but a watery pseudopod and in RoboCop 2 the character only had an animated face, not a full head. The problem with animating characters says Charlie Gibson of Rhythm and Hues, a Hollywood based animation studio, is that the closer an animated character gets to reality the more unrealistic it looks.

> **When you get something looking 88 or 90 percent realistic, the little nuances that you want to see from a human aren't present, and it begins to take on an extremely creepy appearance.** (21, p. 62).

Overcoming The Problems

The problem with any human animation, but more especially facial animation, is that people are experts on the way a human should move and what it looks like. The recognition of facial expressions is one of the first skills we develop as a child. As a result the public has very high expectations, but animated characters have now been created which can live up to these standards. Two such characters have been shown at the Annual Siggraph Conference in 1989. The conference provides a platform for exhibiting all the latest developments in the computer graphics industry. One character, Lotta Desire, in a scene from



Stills from The Little Death (1989)

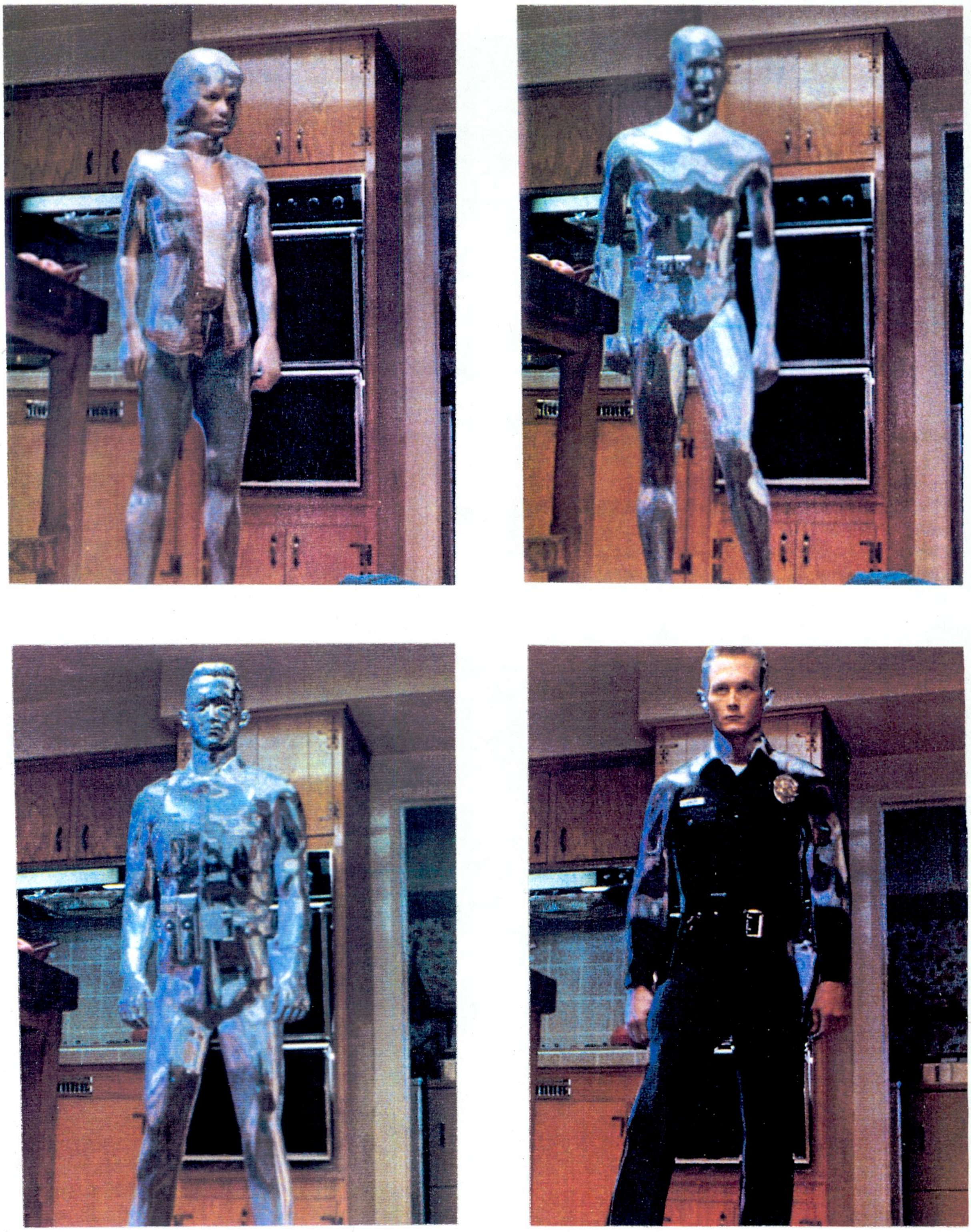
Illustration 9

The Little Death (1989) displayed her natural shape, as can be seen in Illustration 9, and demonstrated her smooth breathing motion. The other Dozo, in Don't Touch Me (1989), showed that it was possible to make a character sing and perform complex dancing motions.

Bearing in mind the critical standards of human perception, James Cameron took a huge gamble when he decided to produce his sequel to Terminator (1984). The history of Terminator 2 (1991) began two years earlier on another Cameron film The Abyss. The shimmering gravity defying pseudopod, previously shown in Illustrations 7 and 8, which could mimic human faces, proved to Cameron that computer graphic technology had reached the critical break-even point in terms of cost, time and effort. This scene convinced him so much of the technology's potential that he felt capable of writing the script of Terminator 2 around the idea of a computer generated robot; the T1000.

An Effects Revolution

The T1000 was conjured up out of bits and bytes by the Industrial Light and Magic (I.L.M.) team, the special effects facility spun off from George Lucas' Star Wars. Denis Aurren, the effects supervisor for Terminator 2 who worked on The Abyss, said that before this an effects scene could be dropped from the film if it didn't work, but the computer animated scenes in Terminator 2 were integral to it. The scenes were first storyboarded and then computer graphics were generated as required, which is opposite to the way these images are normally produced. The daunting task facing the I.L.M. team was to



Metamorphosis of T1000 : Terminator 2 (1991)

Illustration 10

Still from Terminator 2 (1991)

Illustration 11

create a chrome character. The T1000 was supposedly made from a 'poly alloy', allowing it to transform from one shape to another, as shown in Illustration 10, where it transforms from a woman into a policeman. It can also walk through fire, self heal bullet holes, pass fluidly through bars; the latter is presented in Illustration 11 and ultimately be spectacularly destroyed in a vat of molten steel.

It is apparent that technology has now improved with regard to the production of animated characters. Many specialist software programs were also written throughout the film to boost existing programs or totally new ones such as 'Make Sticky', to achieve scenes that had never been attempted before, such as that of passing through the bars in Illustration 11. The computer technology though was not just confined to animation sequences, it was also used in several scenes such as removing wires in a scene where a motorbike is suspended from a crane and to reverse a scene which was filmed from the wrong side. It is evident that a pixel has the capabilities to do almost anything and it drastically reduces the amount of drudge work involved in animation.

The task of building a computer generated man from head to toe began with the process of painting a grid on Robert Patrick (who plays the T1000 when in policeman disguise) and shooting him with synced cameras from the front and side for days so that they could study his mannerisms. Four models of the robot were created, each mainfesting increasingly greater detail. The first model looked like a 'blobby man' made out of mercury, as seen in Illustration 12, while the fourth was a nearly exact metallic replica of the actor, down to the wrinkles in his

'Blobby Man' from Terminator 2 (1991)

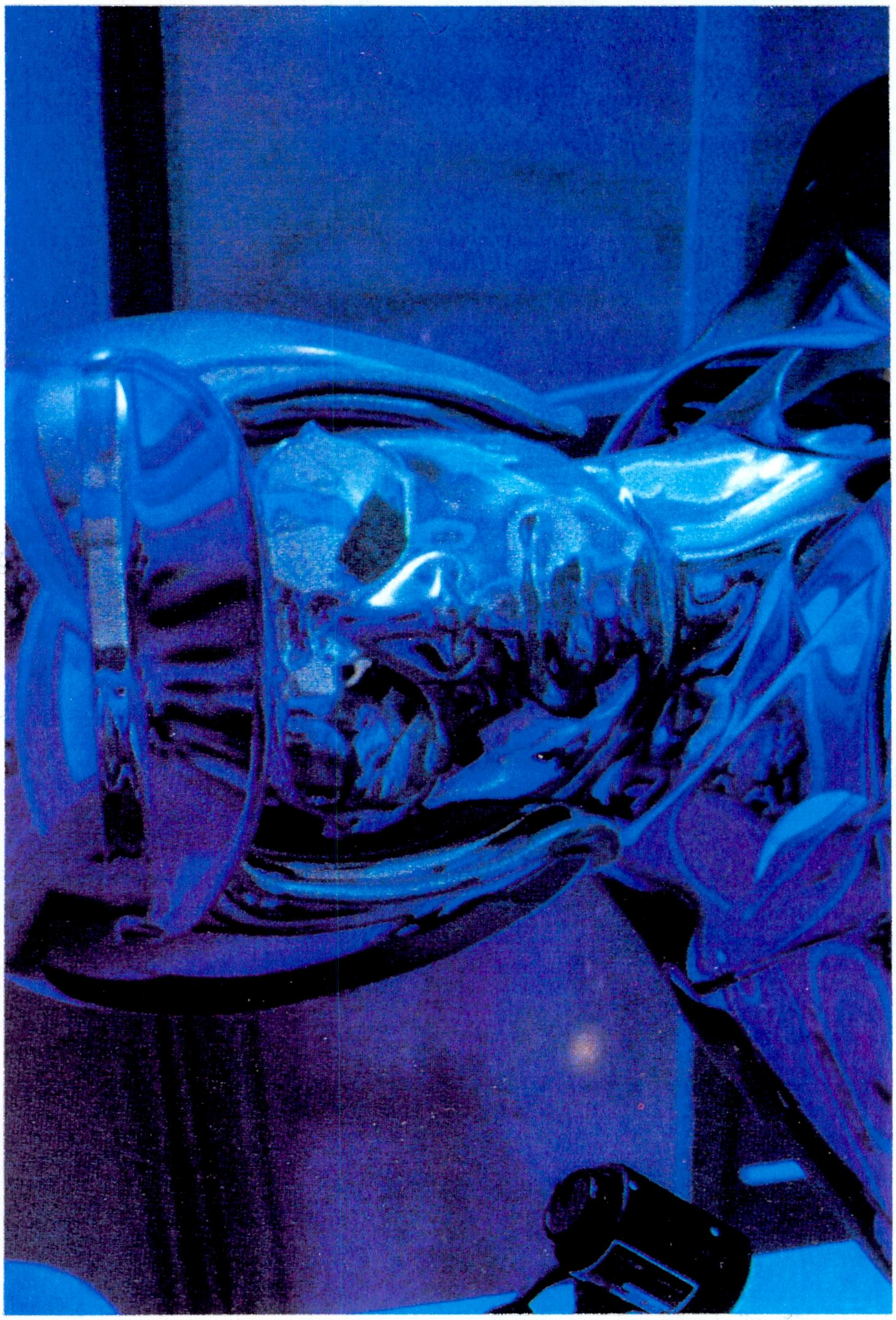
Illustration 12

Fire Sequence from Terminator 2 (1991)

Illustration 13

T1000 Metamorphosing from a floor : Terminator 2 (1991)

Illustration 14



Still from speaking scene : Terminator 2 (1991)

Illustration 15

police uniform, as shown previously in Illustration 10. These models were to be used with an amazing effectiveness in a scene that displays the T1000 invincibility; it walks calmly out of a blazing wrecked truck, the surroundings reflected perfectly on it's body, as depicted in Illustration 13, and gradually transforms into the actor Robert Patrick as it walks away. Illustration 13 also shows a computer operator working on this scene.

A series of scenes occur throughout the film where the T1000 evolves into various forms. One of the most dramatic of these scenes is shown in Illustration 14, where the T1000 masquerades as part of a checkerboard floor and then transforms itself into a copy of an unsuspecting man. The robot also performs a first in the film industry and speaks. The scene occurs when the robot liquefies, flows into a helicopter and speaks while in metallic guise; the latter is depicted in Illustration 15. The robot tells the terrified pilot to, 'Get out'. The scene was accomplished by scanning Robert Patrick's head with lasers while he pronounced 'Get out', one phoneme at a time. A technique was then developed whereby only the bottom part of the T1000's face was animated as his sunglasses kept creating a jittery movement. The data from the scan was then transformed into patches and interpolated through key frames to perform the mouth movement.

The most complex scene of all though happens when the T1000 falls into a vat of melted steel and changes through all the forms it has taken throughout the movie. A close up of this scene is realised in Illustration 16; Steve Williams, the chief computer animator, can also be seen

Vat scene from Terminator 2 (1991)

Illustration 16

working on this sequence. The concept was that the T1000 was short circuiting so heads and hands were popping out from anywhere. Steve Williams said : 'Andrew Schmidt and I used every trick in the book for that, including the kitchen sink '. (26, p. 61).

Many of these animation scenes throughout the film were heavily dependent on a technique called morphing. The technique was first developed by I.L.M. for the movie Willow (1987) to transform animals from one species to another. The basic process of which involved a two dimensional image wrapping technique.

The box office success of Terminator 2 provided the turning point for computer animation opening the floodgates on a film effects revolution, and doing for computer animation what Star Wars did for motion control technology in model animation. It has often been said that if Disney's Tron had been a box office success back in 1982, animation technology would have been fully embraced back then. The reality of the matter is that the technology at the time was just not up to peoples expectations. The technology also suffered from a considerable amount of user resistance; directors preferring to work with something they could touch and feel such as motion control models as opposed to computer animation. However it is now getting to a stage where animation sequences can be storyboarded on computer screens allowing the director to use a mouse and to move camera angles and backgrounds, to produce the desired composition. The animation firm will then go and produce the sequence knowing exactly what is required.

In present circumstances using hand drawn storyboards, this scenario is not possible and the animation firm will produce the scene from whatever angle is easiest for them to work, resulting in scenes that are usually much less dramatic than was originally intended.

The argument though that was most commonly placed against usage of computer animation is the costs involved. According to Variety magazine Terminator 2 (1991). (26, p. 62) cost more than $100 million to produce, making it the most expensive film ever made. This cost though cannot be totally blamed on the digital effects, the undisclosed fee for the computer animation being a relatively small amount, when sequel rights and actor fees are taken into account.

Summary

Although computers initially had only 'bit' parts in film they now should be regarded as being capable of achieving just about anything asked of them. Unwanted parts of a film can be digitised out, scenes can be reversed and unbelieveable shapes can be conjured up and made to perform any task. Animation has at last come of age.

Chapter III

Computers For Design

Introduction

Computers are rapidly expanding their applications from film animation into other areas of design. Industrial design requires a system which can cater for both its engineering and artistic aspects. Computers can now provide this and have advanced to the stage where they can even produce finished models for testing and tooling from.

From Fantasy To Reality

The film industry is not totally isolated but is very closely linked to all the other areas of the design professions. The design process used in film follows through the same principles of concept ideation, refinement and final execution to achieve a particular end result.

The film industry however has one major advantage over all the other design professions, it is a multi-million dollar business that it is willing to take the risk of investing large sums in developing specialist equipment to create particular scenes in a movie. This point has already been exemplified in looking at the development of Terminator 2 (1991)

The design industry can only gain by this development of ever more sophisticated means to generate images for communicating with. This spin off effect from the film industry is clearly illustrated by Colin Cantwell, president of Crystal Chip Inc. Cantwell formerly worked in motion picture special effects for films such as Star Wars (1977) and

2001 (1969). He has now developed a computer package for displaying architectural designs in the environment in which they would be built. This allows the client a more realistic feel of what the designs would look like. An example of his architectural rendering can be seen in Illustration 17.

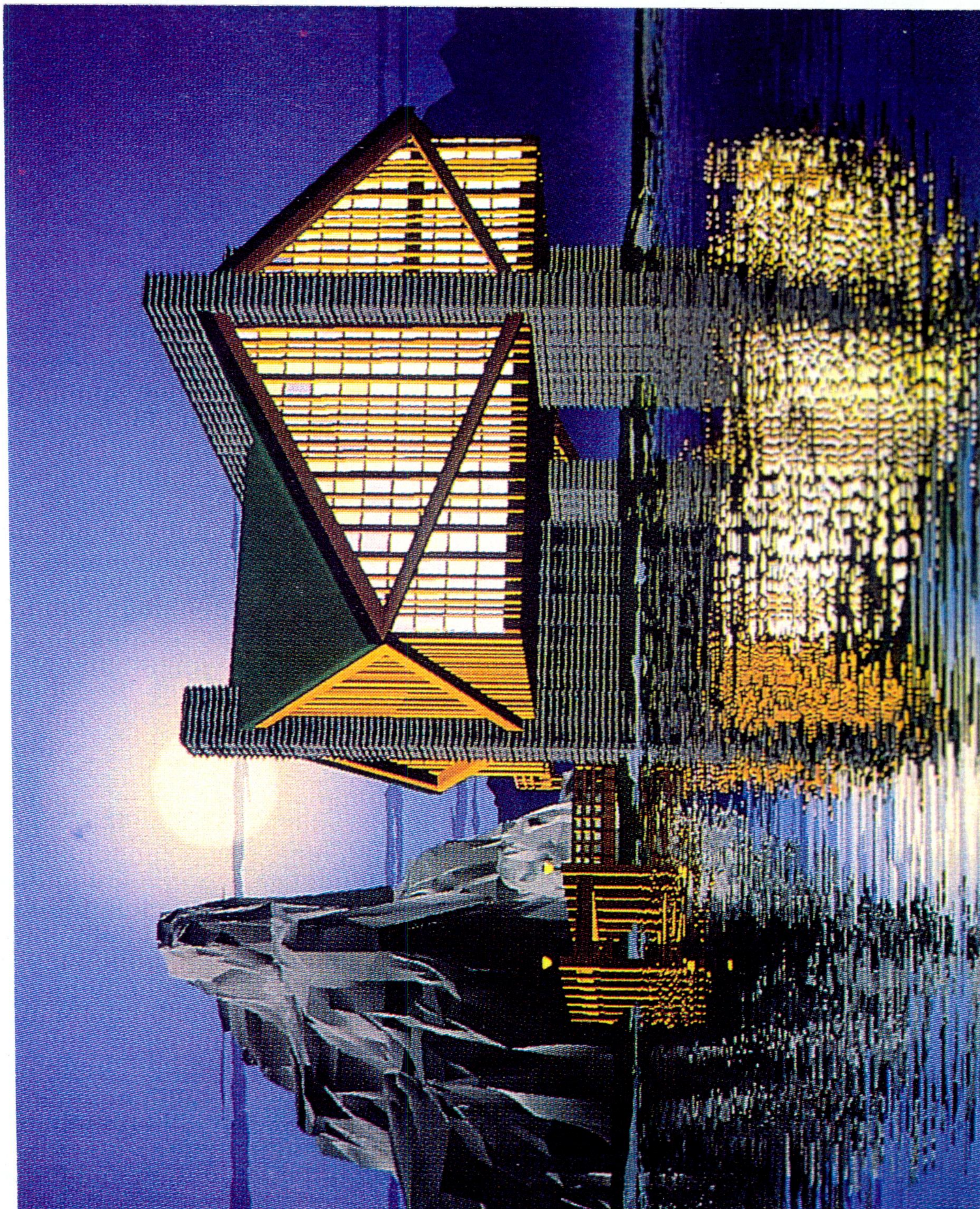
Commenting on his early education in the film industry Cantwell goes on to say:

> **Some of the approaches of 3D computer graphics could have come directly from Hollywood's special effects stages, where beautifully crafted minatures are carefully lit by a few subtly colored light sources to immitate the natural full sized world. These subtle lighting techniques are directly applicable to architectural design.** (19, p. 114).

The link between film animation and design is easy to see, but the process has more often been applied to industrial design than to architecture, due to the fact that most of the objects animated in film are more often products than buildings.

Problems In Developing Industrial Design Systems

The industrial design profession has often been given the role of being the guardians of style. The profession ~~though~~ suffers from a schizophrenic nature, being part artistic and part engineering. It is this schizophrenia however that has made it difficult for software vendors to develop just the right tools for the job required. On the one hand they need the rapid 3D modelling and rendering capabilities, usually associated with animation systems and on the other they need the mathematical precision of a C.A.D. system to produce engineering drawings and calculations. Most systems that claim to be aimed specifically at industrial designers tend to be derived from one side or



Architectural Rendering

Illustration 17

the other of this divide tending to be step children of mechanical C.A.D. and animation systems.

Industrial Design At Chrysler

One company though that has successfully integrated computers into their industrial design department is Chrysler, who also own Dodge cars. Chrysler is one of the largest car manufacturers in America and was one of the first to adopt the Conceptual Design and Rendering System (C.D.R.S.) developed by Evans and Sunderland (Salt Lake City). In Chryslers pre C.D.R.S. days the design process would begin with rough hand sketches that showed what a new vehicle might look like. These vehicles would be drawn to specifications that would determine what requirements the vehicle would have to fulfil; whether two door or four door, or what headroom was required. A concept would then be picked by management and detailed up to a final rendering. The rendering would then be interpreted onto a drawing that would be dimensioned using tape. The tape is thin electrical tape that is pasted over a drawing to represent the basic silhouette of the vehicle. Sculptors then measure the tape as they develop the fullsize clay model.

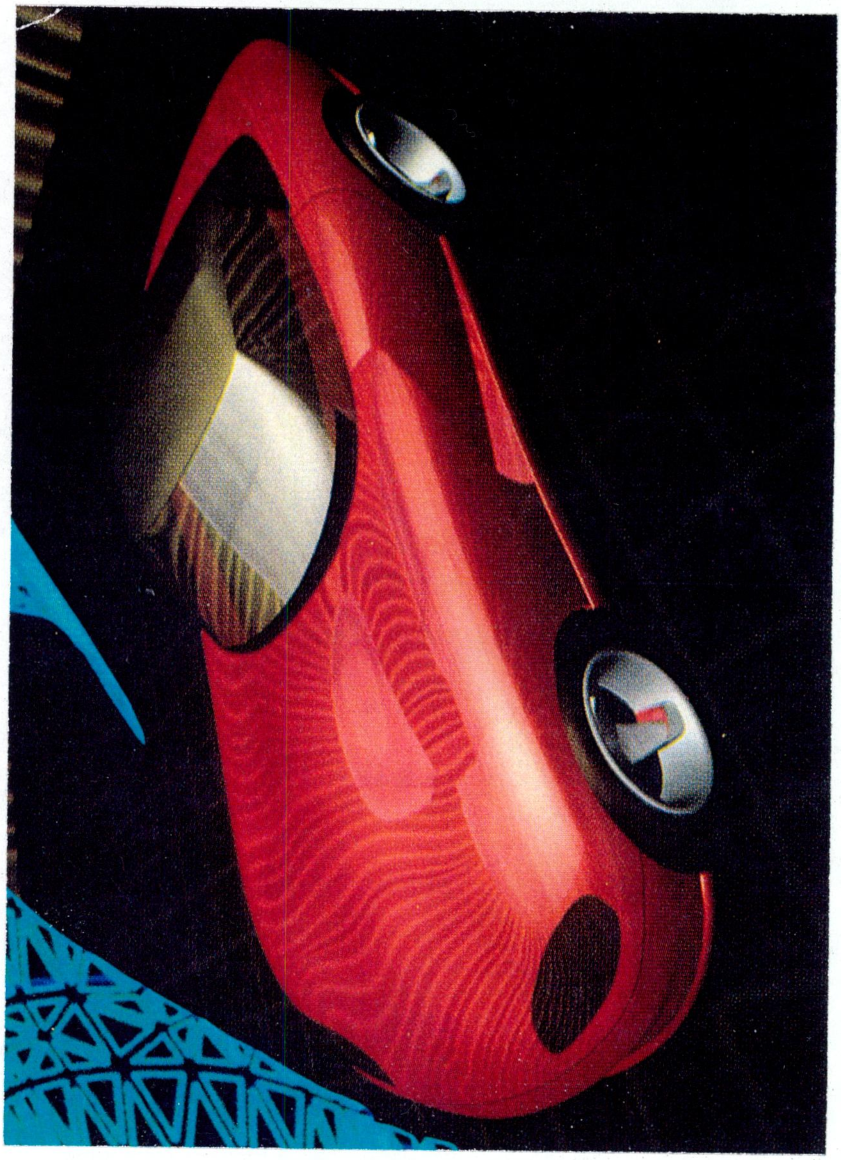
If one portion of the clay model is 'off' in its dimensions however, the model would have to be modified. As a model usually weighs 4000 pounds, and includes a steel and plywood substructure, any modification could take up to six weeks to complete. Only when the model was fully built would it be analysed using co-ordinate measuring machines.

The dimensions would then be given to the engineers and manufactures who would do cost and feasibility studies. If the engineers could not manufacture the design for a particular reason the clay model would have to be sent back to be modified. The clay model would often have to be modified as often as ten times. This tedious sequential design process is now being automated with the use of the C.D.R.S. system. Under the new process computer graphics allow the designer to evaluate new designs for size and proportions on the computer screen before committing it to a labour intensive and costly model.

In addition the C.D.R.S. system promotes concurrent engineering because the same geometry used for imaging (mathematical surfaces, for example) can be passed onto engineering and manufacturing so they can use their computer systems to evaluate the feasability of the design.

These mathematical surfaces are created by designers who start out by using a light pen or mouse to sketch out the basic lines of a new model on their computer screen. Mathematical surfaces can then be developed from these curves and rendered as shaded images, which can be dynamically rotated in 3D computer space. This allows the model to be examined in a manner similar to that of walking around a clay model.

The C.D.R.S. system was used by Chrysler to develop its latest sports car, the Dodge Viper, which can be seen in its computer development stage in Illustration 18. The Viper is an evolution of the original muscle car design, drawing its inspiration from the famous A.C. Cobra, designed by Carol Shelby in 1962 and shown in Illustration 19 in full racing trim. Although the Viper may not embody the new spirit of the green age with its fuel gulping V10 engine, few could argue that it is a anything but beautiful when its organic form is seen in real life, as

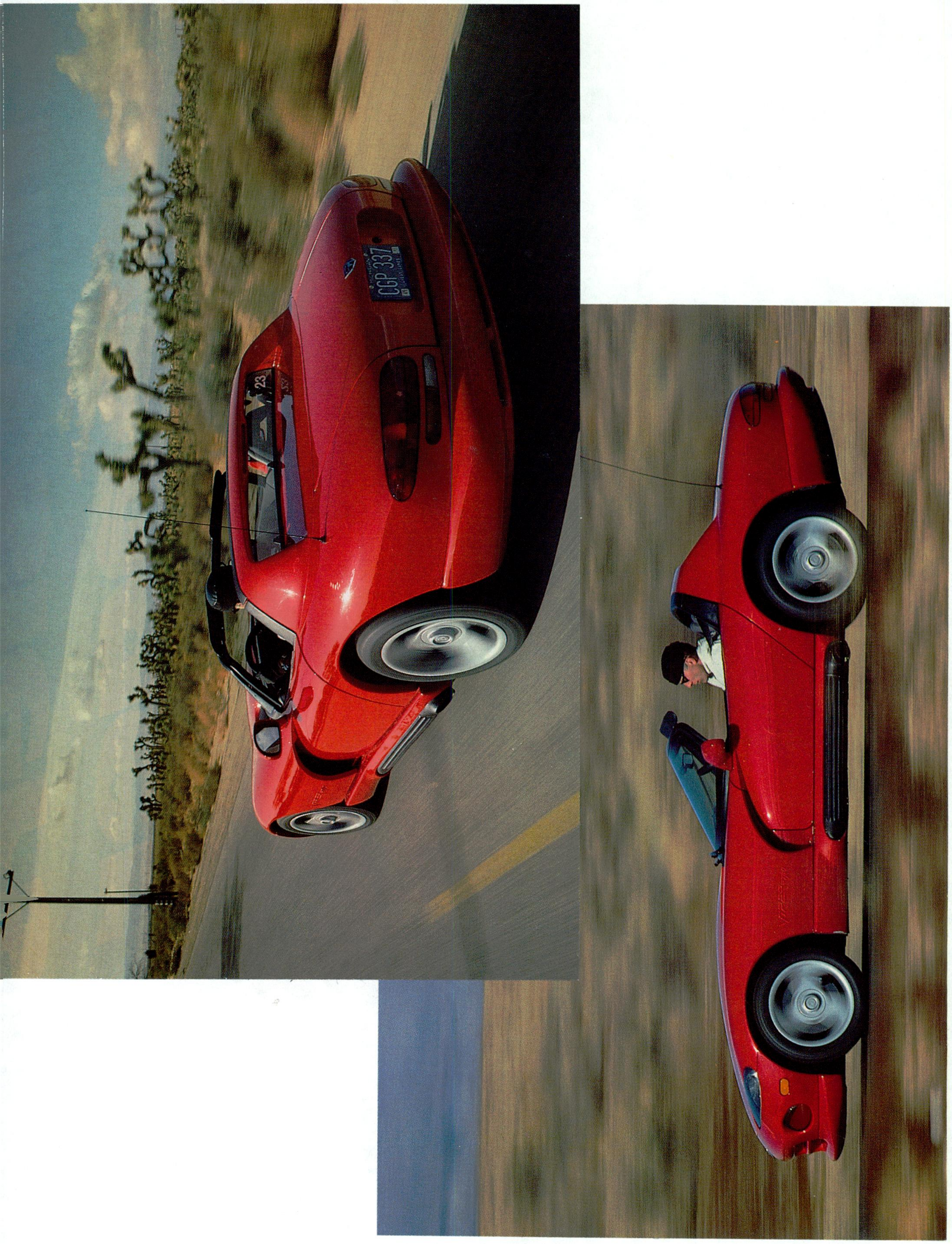


Computer Model of Dodge Viper

Illustration 18

1966 A.C. Cobra

Illustration 19



1991 Dodge Viper

Illustration 20

viewed in Illustration 20. The Viper is a living testament to the quality of design that can be achieved in this new age of Industrial Design.

Hands Versus Computer Rendering

Although the C.D.R.S. system, developed by Evans and Sunderland, represents a huge leap forward in reducing the tedious tasks involved in the industrial design process it is by no means the perfect solution. Many designers still prefer to stick to traditional Pantone (marker) renderings as they feel that computer renderings are just too clinical and do not represent enough of the designers intentions or save enough time to justify the cost. It is like comparing a painting to a photograph; the photograph is accurate, but the painting is more interesting and communicates more.

At the 1991 Siggraph Conference two people were promoting computer renderings with more feeling and termed them 'dirty' pictures. Xaos Michael Tolson said :

> **In my opinion, computer graphics are far too perfect, we need more dirty images, confused images, images that are smudged at the edges. We have to be less fettered by the medium.** (23b, p. 54).

This view was echoed by Harold Buchman who works for Rhythm and Hues animation : 'God forbid there should be motion jerkiness, low resolution, that the shading be a bit off '. (23b, p. 54).

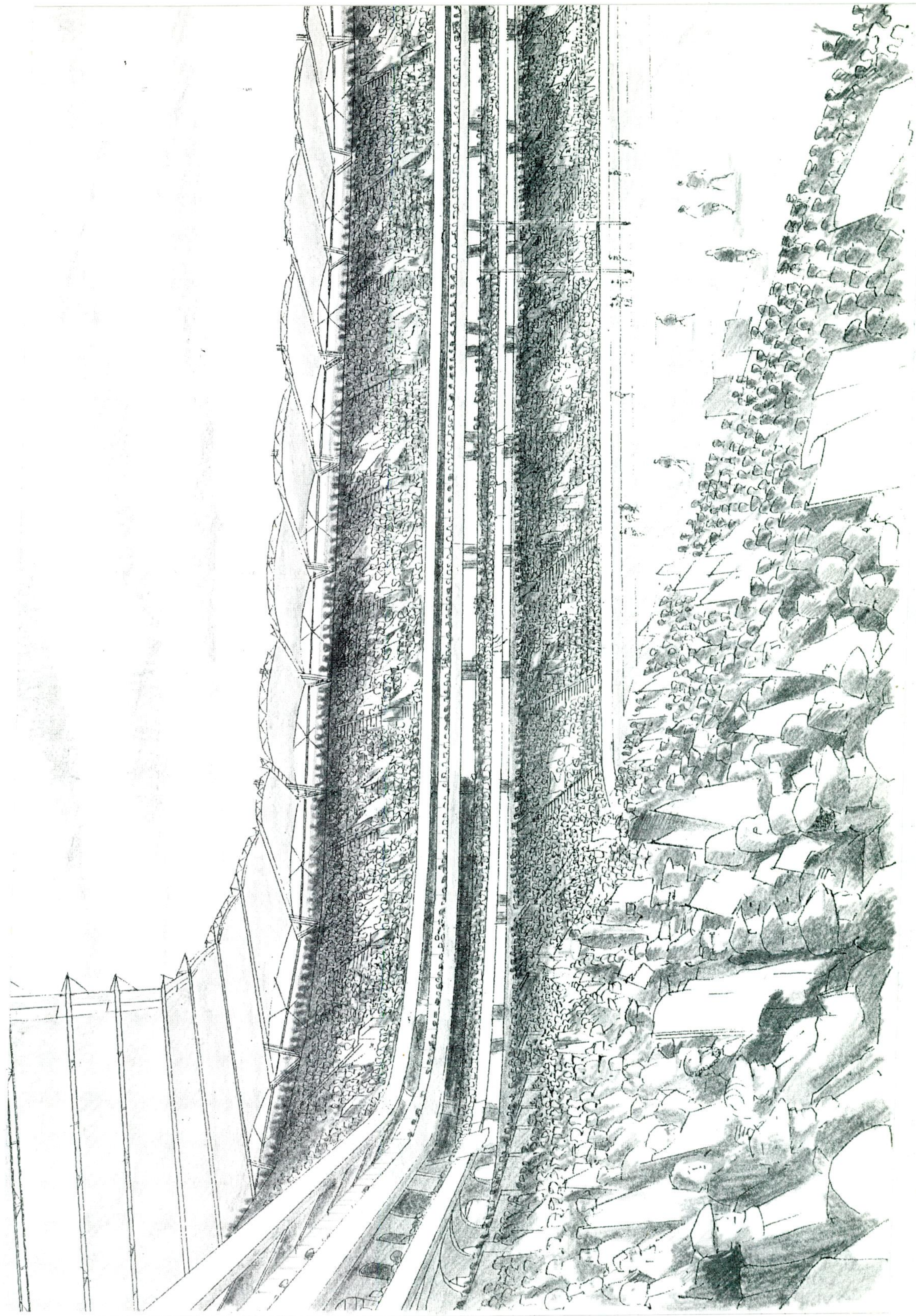
The problem extends from the fact that most systems are derived from machines built for scientific visualisation or business graphics. For too long people have been obsessed with trying to create photorealism; though this was to provide a benchmark by which to judge just how good they have become. The idea being that you get your grounding in reality and then abstract from what you have learned.

Not all designers though feel that current systems are not up to the job. John Stribiak, president of 'John Stribiak and Associates', claims that the person running the machine is the only limitation to it's performance, citing that it is possible to do ergonomic studies, product renderings and environmental analysis on computers.

One of the main reasons for this backlash against computers is that people are inherently afraid of change. What we are running into is a scenario like that in the early days of the Industrial Revolution, where the thousands of shoddy goods that were produced using sham materials were blamed on the invention and usage of machinery that facilitated mass production. The same applies today as during the Industrial Revolution, that bad design can only be blamed on the designers not on the machines that design or produce them. This machinery is after all only a tool, like a ruler, for the designer to use, not a replacement for them.

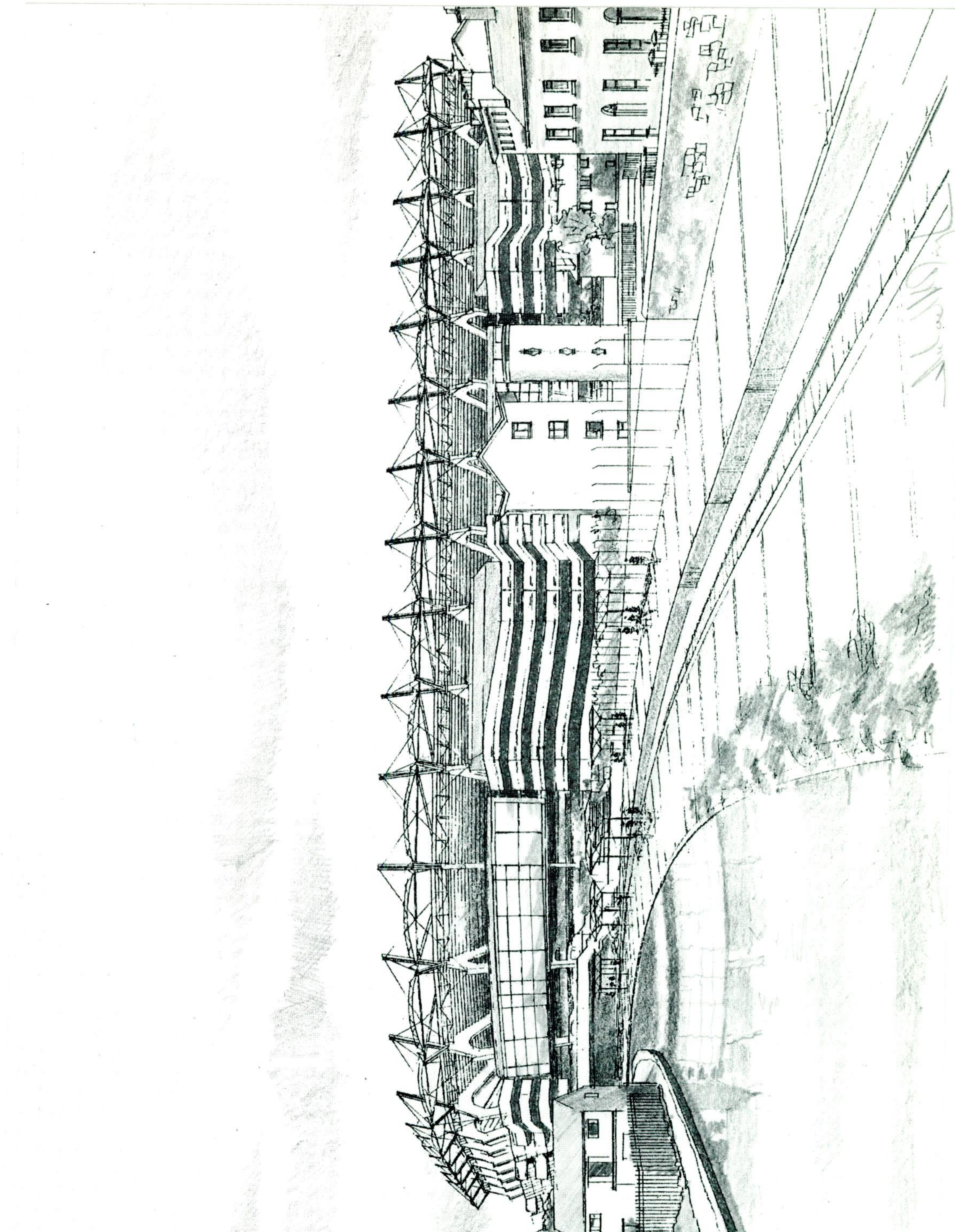
The Advantage Of C.A.D.

We do not need to travel as far as America however, or even continental Europe, to see the transformations that computers are having on the design world. The redesign of Croke Park was won by a Ballsbridge design team. The firm of twenty five people is run by Des McMahon who says that his decision to invest £200,000 into computer hardware was one of the main reasons that helped him win the contract. In a recent Sunday Independent interview Mr McMahon said :



Future Interior of Croke Park

Illustration 21



Future view of Croke Park from the canal

Illustration 22

> **A small Irish firm like ours would not have got this contract a few years ago. To manually draw and redraw eighty thousand seats would have required an army of draughtsmen, thirty people working throughout the night.** (7, p. 14).

Hand drawn views of the stadium are shown in Illusrtations 21 and 22, and it clearly shows the size of the task that would have been involved if every seat had to be drawn by the conventional methods of draughtsmen. This ability to reduce the drudge work left the staff more time to work on models and to watch for flaws, thus securing themselves the contract.

Rapid Prototyping

The need however to spend a large amount of time working on models, as seen in the case of Mr McMahon, may also now be eliminated with new technology that is already on the market. Rapid Prototyping (R.P.) is an inexpensive method for creating real life 3D computer models that can be touched and handled by the user. In the last year and a half these systems have become faster, more accurate, less expensive and are already being hailed by the design world as a strategic new tool.

Rapid prototyping first appeared on the market as recently as 1987, but already the technology has advanced to such a point that their potential seems unlimited.Rapid Prototyping systems can be roughly divided into two groups. One group consists of those photopolymer-solidification systems that create parts by using ultraviolet light to solidify liquid resin. The other group uses heat to bond materials such as waxes, thermoplastics or composites in layers. Both systems though build parts using a layer-building process. This involves layers

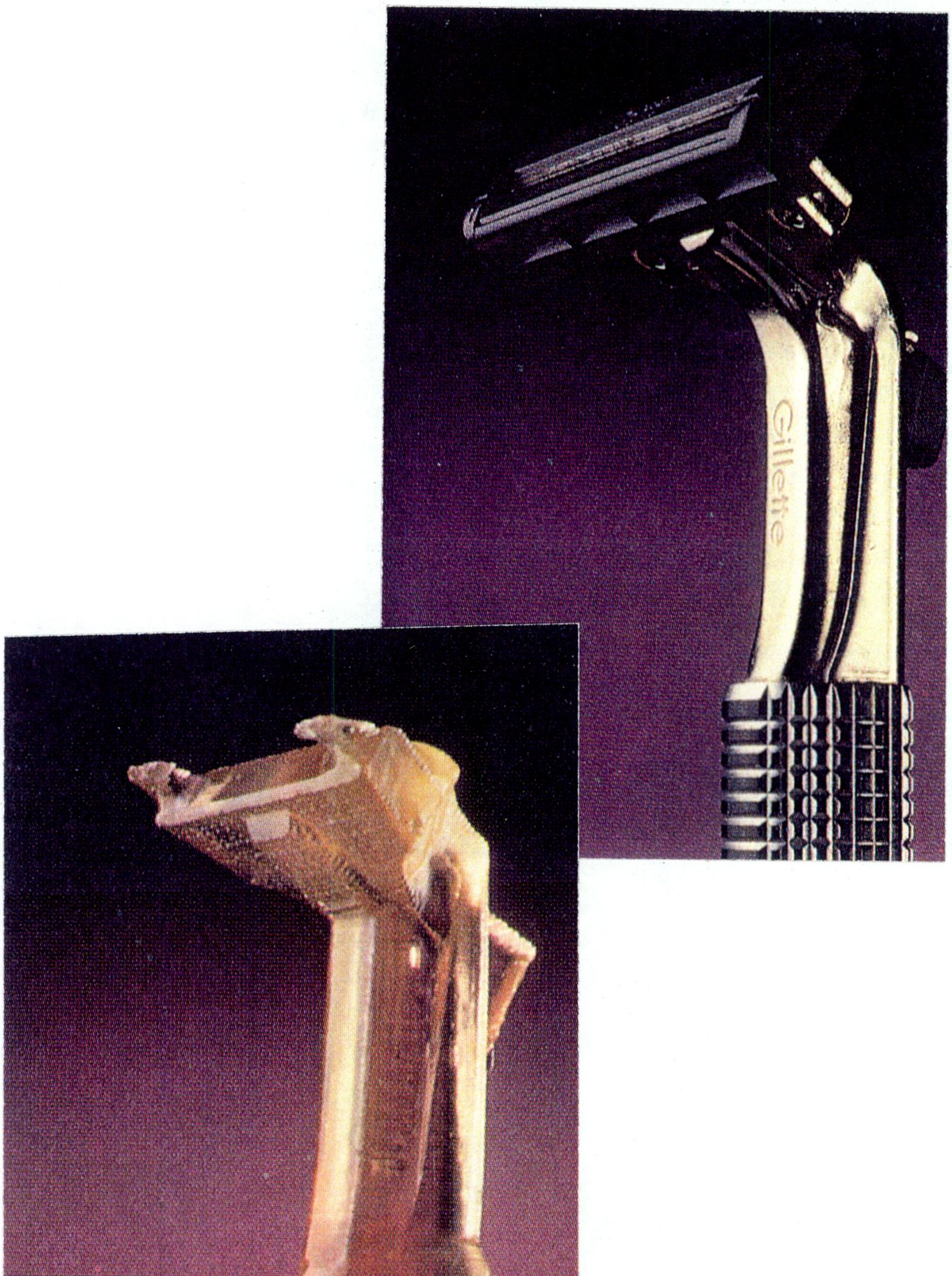
Exhaust Manifold

Illustration 23

of material, as thin as 0.05mm being intricately fabricated one on top of the other. The layer information comes from horizontal cross sections of a 3D C.A.D. model, the layering process being repeated from top to bottom until the part is complete. The technique permits the construction of literally any shape that can be modelled on a C.A.D. system, even shapes that cannot be formed using conventional fabrication tools and techniques. This is exemplified in Illustration 23 . It shows an exhaust manifold that was produced on a rapid prototying device, it would have been impossible to machine from a single piece and as a result would have to be built from several pieces resulting in a very expensive model.

One of the main advantages for R.P. users is the production of a physical model early in the design process which allows it to be shared with marketing, purchasing and manufacturing people at the initial stages, thereby allowing the business and engineering side to be run simultaneously. This technique was used by Gillette when producing its new razor; the Gillette Contour Plus, shown in Illustration 24 in its prototype and final form. The use of the rapid prototyping machine meant that Gillette could bring its design from conception to production much faster and cheaper than would otherwise have been possible.

Probably the most important application of R.P. models is their spreading use as master patterns. The R.P. part serves as the pattern around which material is formed to create a master tool. This process will improve a firm's edge over their competitors by shortening the time involved in the development cycle, thus ensuring that their product will reach the market first.



Prototype and Final Form of Gillette Razor

Illustration 24

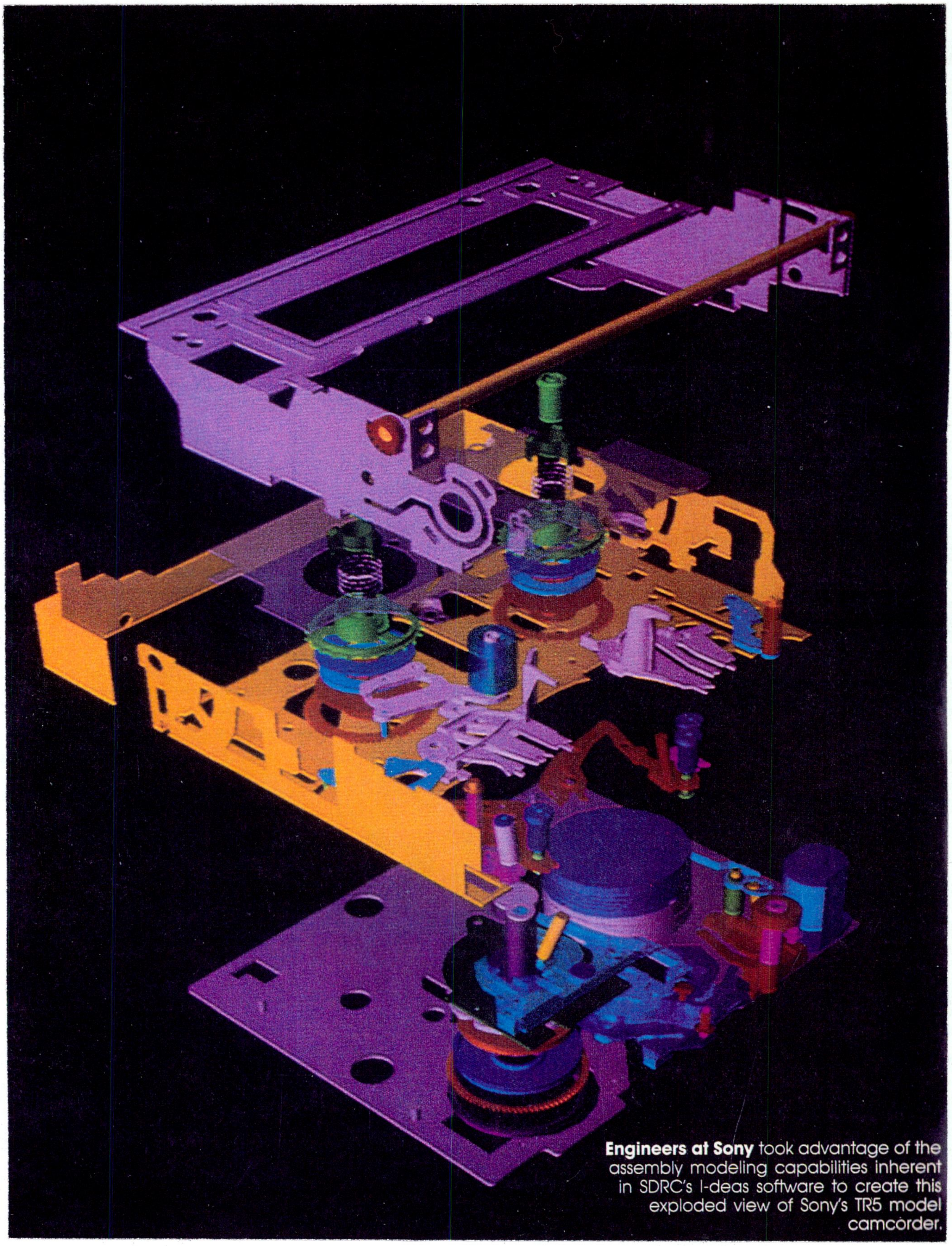
Functional Testing

Another new way that manufacturers are starting to make use of R.P. models is in the area of fit and functional testing of new designs. The old resins that were used to make these models were too weak to allow them to be clipped together and would crack if dropped. The new resins, though can be milled, drilled or even tapped with screwthreads, providing a more ideal material for prototyping. It will soon be possible to produce these prototypes from the material that it is to be manufactured in and also to use more than one colour; this will facilitate the more accurate testing of designs.

Unfortunately in 1992 the usage of most of these systems is confined to large companies, but the drive is now on to develop a desktop system. The movement has been accelerated by the enormous predicted demand from people such as architects, sculptors, medical practictioners and small design firms. However the market depends on the belief that users are working on 3D systems already, the reality however is that most work is being carried out in 2D. The introduction of a tool such as a R.P. desktop system however might persuade more users to convert to regular usage of 3D packages.

Assembly Design

If however desktop rapid prototypes do not provide the incentive to adopt 3D solid modeling its uses for designing assemblies may be more inticing. There are two main advantages for using these 3D assembly systems. The first is that it can be used to check for interference, tolerance and other properties in the same way a prototype assembly can be checked. The other is that they can provide the information necessary for programming tool paths and determining mass properties.



Exploded view of Sony's TR 5 model camcorder

Illustration 25

One of the most advanced of these packages is produced by Structural Dynamics Research Corp (S.D.R.C.) of Milford, Ohio. This package was used by engineers at Sony Products to design the assembly of its TR5 model camcorder. An exploded view of the TR5 assembly, produced on the S.D.R.C. system, is displayed in Illusration 25. The system allowed the designers at Sony to check whether or not it was actually possible to put the various pieces together. It is often not enough just to know that parts of an assembly can fit together, but you have to be able to move them to where they fit together; for example, various pieces may have to be assembled within the confines of a certain housing. The S.D.R.C. system allowed Sony designers to manipulate the pieces of the TR5 to ensure that this was possible. It also allowed them to check for tolerance stacking in the assembly. Tolerancing is the process of giving maximum and minimum sizes on a dimension for manufacturing. This means that when you have hundreds of pieces that are plus or minus a value they may not actually fit together. S.D.R.C.'s ability to check for tolerance stacking allowed the Sony engineers to determine which set of tolerances would allow the assembly to fit together.

These systems also offer one other major feature, the ability to allow a change to ripple automatically through all the other parts in the assembly. At present a change in a single part of the design in an assembly involves the tedious process of changing all the other components so that the new one can work; with the S.D.R.C. system this task is eliminated.

It is obvious that this system allowed Sony's engineers to produce its TR5 camcorder more efficiently and accurately than would otherwise have been possible.

The Hardware Market

Many design consultancies have not as yet made full use of all this new technology. However in the future they will be forced into using this equipment if they are to maintain their competitive edge. The growth in the performance capabilities of personal computers (P.C.) has resulted in the growth of applications and new users, and as a result has allowed manufacturers revenues to rise while prices fall. This in turn has spurned software and hardwaredevelopers to produce more for less; you can buy a system for the same price as it was a few years ago but it has a dramatically increased performance. The animation market is already flourishing and some researchers have forecast it to be worth as much as $50 billion dollars worldwide by 1994.

Summary

It has been demonstrated that computer animation is here to stay in the world of design. The use of animation systems and rapid prototying has provided the ability to reduce hundreds of labour intensive tasks. This means that design consultancies can reduce the time and cost in creating a product. Clients have now begun to expect this cost reduction and shortening of development times which cannot be achieved by any means other than through the use of computers. The computer therefore has become an essential tool of the designer.

Chapter IV

Merging Man And Machine

Introduction

The continuing development of the interface between the computer and the designer is one of the main reasons for their increased usage in Industrial Design. These new interfaces allow the designer to utilise tools with which they are already experienced. The future of the continuing intergration of computers into the design process is however dependent on them being made to fit designers and not visa-versa.

Interface Systems Today

At present, systems used for generating computer images usually consist of a paintbox, a lightpen and a high definition screen, coupled with a keyboard and mouse for occasional commands. One operator employing this equipment is David Moran, an industrial designer, who runs the company Pixamation, a consultancy based in Dublin. At the moment most of Moran's work is for sequences in television advertisments, but he hopes to concentrate more on industrial design work in the future. He was trained in the traditional techniques of the industrial design process, but painlessly made the move to using computers instead of his markers, pencils and is shown working in Illustration 26 with a wireless lightpen on his Quantel paintbox. The monitor is a broadcast Sony which enables him to achieve very high resolution drawings.

Industrial Designer using Quantel Paintbox

Illustration 26

Use of a Lightpen to manipulate screen image

Illustration 27

Instructions are conveyed to the computer by moving the lightpen over the paintbox; this can be seen in Illustration 27 where the pen is used to distort the shape of the letter 'Q'. The computer also allows the image to be fully animated and sound added to provide the ultimate sell to the client. It is apparent that an interface such as this is much more natural to the designer than using a keyboard.

A more advanced version of this system is now produced by Metrolight and is shown in Illustration 28. The Metrolight system, depicted uses a Zenith flatscreen monitor bonded to a custom built transparent tablet thus allowing the operator to look down at a page type screen, which is more natural than looking up at a monitor. This is combined with a wireless stylus to draw with and a mouse to pick functions, meaning that the system is the closest thing at present to conventional sketchpad setups.

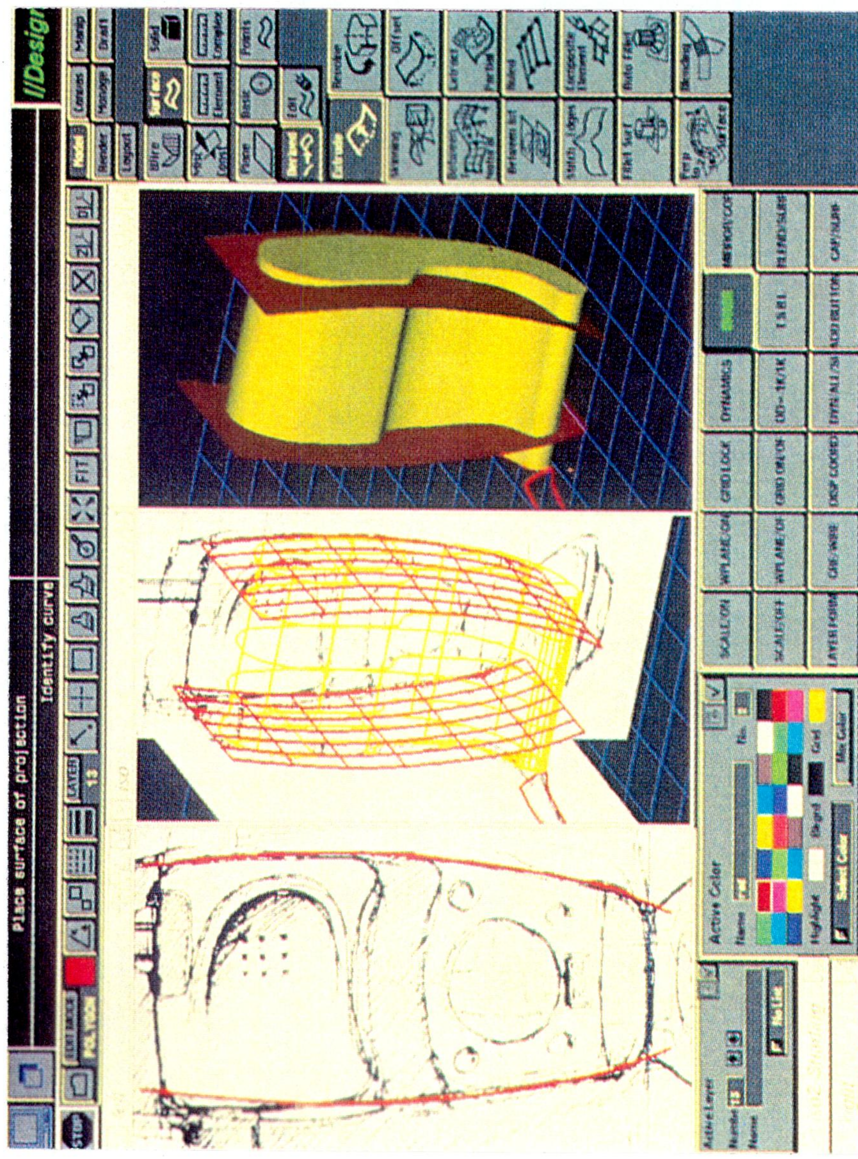
The most interactive system though is probably that produced by Intergraph. This system allows the user to scan-in hand drawn sketches and then build them into complex 3D models. Illustration 29 shows this development sequence on the intergraph system using a walkie-talkie sketch.

Problems With Present Interface Systems

None of the systems discussed offer any real substitute for free hand sketching in concept generation as hand sketches still provide the ideal stimuli to the mind's eye. The systems outlined previously are really only suitable for the more advanced stages of the design process and still require an experienced operator to use them properly. All the indications so far seem to suggest that at present

Zenith Flatscreen Monitor

Illustration 28



Model Development on Intergraph System

Illustration 29

industrial designers will actually have to alter the way they work in response to the new technology. This has already happened in the past when designers were forced to adapt to new mediums, such as markers, when they used to work in pencil. It is likely then that such a process will happen again.industrial designers will actually have to alter the way they work in response to the new technology. This has already happened in the past when designers were forced to adapt to new mediums, such as markers, when they used to work in pencil. It is likely then that such a process will happen again.

Future Systems

In the future designers may not have to undertake any retraining at all. Hardware vendors claim that their systems will soon become more intelligent, intuitive and mathematically invisible, and that there will be a tighter intergration between 3D models and 2D drawings. Daniel Langlois, president of Soft Image, predicts that systems will soon allow a designer to create a 2D sketch on paper, which can be scanned into a computer whose software will be able to extract a 3D model from the false perspective that has been drawn. This will allow the designer to have access to the 3D model as quickly as possible; and that is after all the ultimate goal of every Industrial Design system.

Computer interfaces therefore are now on the verge of breaking free from the old window, icon, point and click which was previously used. They are no longer capable of manipulating all the information which can now be processed by computer. Human interface design now probably represents the single most important discipline in information technology. It is the point of contact of the user with the system and if this fails the mightiest of computers becomes useless. It is due to this fact that Japanese researchers are now concentrating so heavily on interface development.

Interface Development

Japan is the world leader in the research and development of human interface design. It was originally forced to make its systems more graphically oriented than anyone else, because of the written form of its language. As a result their interfaces have, from the outset, tended to be more sophisticated than their competitors.

The Japanese are currently working on their most ambitious project so far, in Sony's Corporate Research Laboratory. They are creating a program called System G. System G is a real time video animation and texture wrap system which is connected to a keyboard. It has been used to fully animate a 3D mask which sings with a one-frame delay when the keyboard is played. The facial distortions are so good that in short sequences they can fool the viewer into believing that a real person is being displayed on screen. This is clearly evident in the stills from the sequence shown in Illustrations 30 and 31.

Artificial Intelligence

The next step was to incorporate this mask into an interactive system with the intelligence to react to human facial expressions, spoken commands and body language. This task was undertaken by the worlds largest telecommunications company, Nippon Telegraph and Telephone (N.T.T.), however their main priority was not to focus on

Animated Mask from Sony's System G

Illustration 30

Animated Mask from Sony's System G

Illustration 31

a design medium. Nippon Telegraph and Telephone wanted to upgrade the endpoint interface of its telephone network, which currently uses a twelve button touch tone pad. The objective was to allow those calling for directory assistance, for example, to carry on spontaneous, natural conversation with a true to life Max Headroom. The system also allows faces to be scanned in from real life offering the enticing potential for adding a 'cosmetic' menu to the two way video conferencing systems of the future. Voice recognition will also be incorporated into the programming and will be supplemented with lip reading pattern recognition to improve accuracy in telemonitoring interaction. This system developed by N.T.T., coupled with Sony's System G is seen by the Japanese as the next evolutionary form of the icons used in todays computer interfaces. Design systems, in the next few years, will increasingly make use of these new interfaces, making the designers job less tedious and provide a constant reduction in the time required to bring a design from conception to production. This will hopefully reduce the costs of products, and possibly lessen the boredom of designers who have to spend many weeks working on a single product.

Summary

As humans naturally interact with other humans, by means of speech and facial expressions, the development of interfaces that simulate these actions would provide a much more natural means of communicating with the computer. Designers would therefore be facilitated with easy to use and natural devices which would bring about a revolution within their occupation.

Chapter V

Virtually A Reality

Introduction

The future of the design process may be a return to a form of the hand craft industry where a single designer was responsible for a product from conception to production. Virtual Reality is the means by which the design process may be revolutionised.

Cyberspace

As futuristic as synthesized human interface systems may seem, an even more radical one which will incorporate some of the technology just described is already lurking around the corner and in some cases has even been implemented. Virtual Reality (V.R.) is the system that has everyone talking. The words alone conjure up a myriad of ideas, hopes and scientific possibilities. So what is Virtual Reality? In its simplest definition it is a synthetic representation of reality. It is more interactive than joysticks, mice, light pens and computer screens. Devices facilitating VR are more akin to those used on advanced flight simulators. The participant in a virtually real experience has multi-sensory input as well as considerable interactive control over the experience. This means, for instance, that a participant can not only watch his synthetic hands clap together, but he can hear them clap through attached earphones.

How is this interaction with the computer brought about? Illustration 32 depicts how this full interaction can be achieved with a user. The user in this case is wearing a Visette headset, produced by

W. Industries Virtual Reality Equipment

Illustration 32

W. Industries, which provides full 3D vision and multidirectional sound. Objects can be controlled in the virtual world via the joystick held in the right hand. They can also wear a data glove (not shown) which is a glove with a built in array of sensors designed to monitor wrist, hand and figure movements and positions, and then transmit the data to the computer in real time. Finally the user can sit at a console or walk on a floor, as in Illustration 32, that senses your position and relays it to the computer.

What this all means is that via multisensory feedback equipment, the participant's mind/body can be cajoled, teased and seduced into a temporary suspension of disbelief by sythesised sensory data, creating a type of 'electronic L.S.D.'.

Design Medium Of Tomorrow

The implications of all this is the ultimate in user interfaces, where the artist, designer, animator or indeed anybody can directly interact with a computer without using a keyboard. In other words, if the operator wants to move something on the screen, they can, with the use of VR equipment, reach directly in with their hands and rearrange the shape of objects, text or whatever else may be displayed.

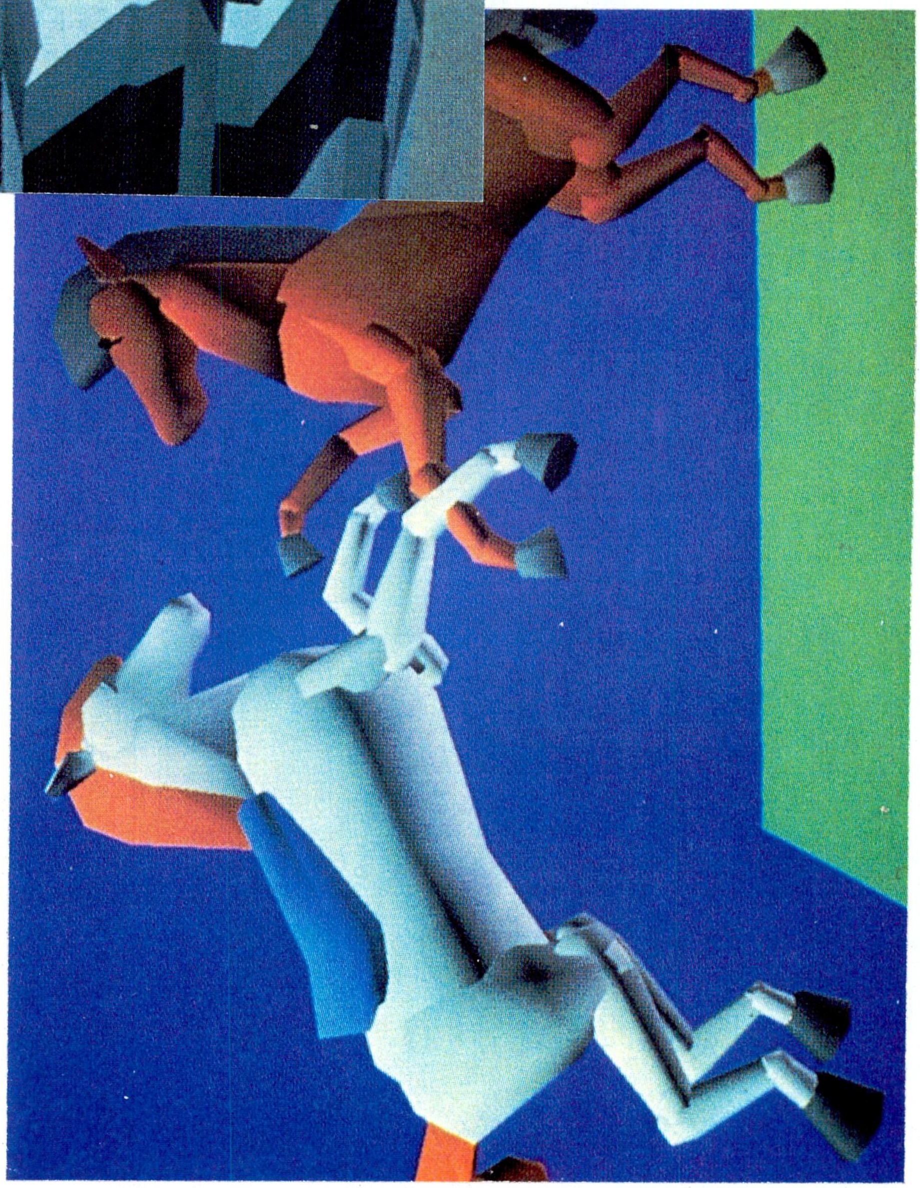
Application Today

Virtual Reality though is not just some far off fantasy, but is already being used today. Although many of the applications of visuality systems to date have been in the games industry, where it can provide the ultimate thrill, it has been taken on by large corporate firms with the aim of turning technology into marketable products. Many applications have been suggested ranging from virtual surgery for medical training, to compact disc based travel magazines that transport viewers to exotic places. Most of these ideas are fantasy for the moment but companies such as N.A.S.A. and Boeing are well on their way to making full use of the technology. Boeing's researchers have developed a rudimentary graphical representation of a human mechanic performing maintenance on a digitally modelled plane. In the future Boeing hopes to use a V.R. implementation of the system to determine the ease of physical access to maintenance points while an aeroplane is still in the early stages of its digital design.

Another example of V.R. use today is a Matsushita kitchen showroom in Tokyo. The customer wears a virtuality headset to allow them to design their choice of kitchen. They start with a virtual empty room and can place various appliances in different locations to get a feel for the finished layout; hence the system is being used as an effective sales tool. The end result is improved communication, and that is after all what virtual reality is all about.

Rendering Speed

Behind all this commotion V.R. is still a new technology and advances are only slowly being made. The system, as it exists today, has many inherent problems, the main one being that existing computers cannot generate images fast enough when the user moves their head. Even with simple cartoon-like worlds, as shown in Illustration 33 objects tend to have a noticeably jerky movement. When the person hooked to the system makes a move, there can be a disconcerting delay in the virtual representation of the users action. As a result of this, there is a constant trade off between lag and the quality and complexity of the picture being shown to the viewer.

The World of Virtual Reality

Illustration 33

Electro-mechanics

Cyberfeel presents another major problem for the development of V.R. This is the electro-mechanical side of V.R. where even the simplest of physical feedback systems, essential to interactive control, are inherently difficult to replicate due to their physical complexity. If one imagines the problems faced at N.A.S.A. Research trying to create a V.R. glove that can provide believable pressure simulation as it grips a virtual wrench. Additionally the virtual wrench slips while attempting to fasten a virtual nut to a bolt. Such features give a flavour of the magnitude of the problems which may be encountered. Another problem with the interface equipment is : do people really want to encumber themselves with uncomfortable devices? A possible solution has been suggested; instead of a headset, the viewing screen could be placed on a contact lens and so placed directly on the users eye, thereby allowing complete freedom of movement.

Side Effects

There are those who laud the side effects of V.R. technology as its downfall. Will it adversely affect vision due to fixed focusing, or might it affect real world orientation in unanticipated ways? Indeed research was carried out more than 25 years ago by a scientist called John Lilly with a device called an Altered State Induction Device (A.S.I.D.) to find out the effects of altered consciousness. Lilly's subjects were suspended in a relaxed position sitting on a hanging chair. They wore headphones and were blindfolded, the subject was then rocked in a random motion. The typical user suffered from vertigo often going into a hypnotic state that left them highly vulnerable. Lilly eventually abandoned his work as some test subjects suffered from potentially horrific experiences.

Even researchers today, such as those at the Human Interface Technology Laboratory have run into some problems. William Bricken, a chief scientist there jokes : 'I've had a little trouble bumping into doors, I don't take them seriously now'. (5, p. 54).

The problem with V.R. at the moment is that not enough is known about the psychology of the human body to be capable of fully interacting with it. It may be somewhat ironic that we have to learn more about our own world before we can go on safe and successful voyages into the new worlds of 'virtuality'.

A Return To The Hand Crafts

The implications that Virtual Reality holds for the design process could be totally revolutionary. Virtual Reality allows a synthetic hands-on approach to design, where the designer can literally mould an object with their hands. This process can then be likened to that of the hand crafts where a crafts person would work with their hands, manipulating the material they were using. The use of V.R. would mean that the whole design process would turn the clock back a full circle, to that of traditional hand craft industries. Therefore the methods for creating a design and turning it into a finished product would not be identical, but there would be similarities in the basic process of a hands-on approach.

It is quite possible that a V.R. system will eventually be linked directly with an intuitive engineering package that will determine the manufacturing requirements of a particular design. A single designer could then be responsible for a design from conception to the final mould for mass production. This would mean the reunification of the

design process that was subdivided when Josiah Wedgwood introduced specialisation for the production of his porcelain.

A design approach such as this also has echoes of Ruskin's Seven Lamps of Architecture, (1849). The first lamp in his book was the lamp of sacrifice, the second was the lamp of truth. Truth to Ruskin was making by hand, and making by hand was to him making with joy. It was in this sense that Ruskin believed in the superiority of the Middle Ages over the Renaissance.

It is possible then that we could see a return to the values of middle age society, which individuals such as Ruskin and William Morris so vehemently campaigned for. Morris though had never been able to overcome the problem of creating art for the masses, as he recognised that : 'All art costs time, trouble and thought'.(17, p. 24).

A design medium, such as Virtual Reality could possibly eliminate this problem. It could bring, for the first time, a 'synthetic' hand craft to the masses and once more restore the 'Joy of the maker'. (17, p. 24).

Summary

When Virtual Reality is eventually perfected as a design medium it could prove to be the biggest revolution in the design process from the time when moveable type face was invented for printing books.

Conclusion

In the next few years it is highly probable that all areas of the design process will undergo a radical transformation. The designer however is in no danger, as yet, of being eliminated. As design is often cited as being the highest level of thinking, since it involves the creation of new ideas and concepts instead of the regurgitation of existing ones, it is highly unlikely that an artificial medium can be created that will match the creative genius of a human brain. The machines of the future will however act as the next generation of tools to be employed by designers to facilitate their job of communicating with others.

The production of Terminator 2 (1991) clearly indicates how the animation process has developed into a sophisticated form. This technology is presently being incorporated into the design process. Close links exist between industrial design and animation. They both involve the same basic process of problem solving to achieve their end results; the finished reel in cinema and the production model in industrial design. In animation the starting point is the problem of how to achieve a desired effect on the screen. In industrial design a design brief from a client outlining a problem is the springboard from which a solution has to be created. Both then follow a process by which the desired form is agreed and the appropriate techniques of communication are employed to convey this to the customer. In each case the final customer is the general public, but they both have to pass through the intermediate stage of the director in film and the client in industrial design.

It is highly probable then that the technology used to create Terminator 2 (1991) will be given its next starring role in a boardroom conference, at the side of a designer who is showing their latest concepts to a client.

The interface between the user and these computer systems is however the area that is likely to see the most radical changes over the next decade. Interface design can be regarded as a way of tracing the development of computers. The transformation from one generation to the next has been a process of removing barriers between the user and the computer. The first generation of computers in the 1940s, were operated by playboards, the next generation were the punchcards of the 1950s. The 1960s saw the introduction of keyboards and this was followed by menu type commands, using point and click devices in the 1980s. Today we are using devices such as paintboxes and lightpens, but it is interfaces such as those being developed by Sony Products and Nippon Telegraph and Telephone that provide an insight into what user interfaces will possibly look like over the next five years. The adoption of interfaces such as these will however be an even more dramatic jump than that from punchcards to keyboards. Computers that can operate through the use of voice inputs and body gestures will reduce the skills and time required to interact with it. As a result it will encourage increased usage by designers.

This is the immediate future, though what lies beyond that is potentially much more radical and exciting. Virtual Reality is the technology that holds the key to the way forward in the development of computer interfaces. It may be regarded by many as nothing more than a pipe dream, but Virtual Reality is now at the forefront of research of many companies, one of the most notable of which is Autodesk. John Walker runs Autodesk, and it is he who took the gamble that designers would pay several hundred dollars for a less powerful version of the multithousand dollar C.A.D. software. Large architectural and construction firms were employing such software on mainframe computers, for use on their personal computers. Autodesk created AutoC.A.D. and it became one of the personal computer software best-sellers of all time. This success is direct evidence that designers will pay for intelligence amplifying design tools, even relatively crude ones, if it gives their own expertise the right kind of boost. Walker now believes that the same people who made his company worth close to a billion dollars (AutoC.A.D. users to whom envisioning 3D objects is serious business) are ready to move their points of view through the window of the computer screen and into the virtual worlds they are trying to design.

If Walker's predictions are correct and Virtual Reality takes off as a design medium in the next century, then maybe the dreams of William Morris and his contemporaries will be realised; namely the design process returning to a handcraft basis. As to whether a 'synthetic' hand craft will provide more satisfied designers however, only time will tell. It should at least though reduce the costs involved in bringing art to the public, as the time and effort required to produce a design will be greatly reduced. In this sense Morris' dreams may be realised as more people would be able to afford and therefore appreciate works of design.

The effects that these new technologies will have on designers and their designs are difficult to predict. One can only guess that they will follow, to a certain degree, the patterns of technological revolutions over the centuries. The last time the human thought process was dramatically affected was when the western world learned to read 500 years ago; this was due to the invention of moveable print. Less than a century after this invention the literate community in Europe had grown from a privleged minority to a substantial portion of the population. As a result peoples lives were changed dramatically, not because of the printing press itself, but rather because of what that invention made it possible for them to know. Books were just the vehicles by which a multitude of ideas escaped to the public and as a result transformed the society in which they were living. The effects of moveable type expanded far beyond the boundaries of what inventors ever dreamed of. In the same way it is impossible to foresee what the wider implications of these new design mediums will be.

It is likely though that this new technology will meet a lot of resistance and be blamed for bad design. Society though has already gone through this scenario during the Industrial Revolution, and it will hopefully not make the same mistake twice. The success, or the downfall of this new technology will therefore depend on what we choose to do with it and how we react to it.

Bibliography

1 APPLETON, Elaine, "Tools Path Simulation", Computer Graphics World, vol. 13, no. 9, September 1990, pp. 85-91.

2 BAKER, Robin, "Clay for Today", Design, no. 494, May 1990, pp. 38-40.

3 BULGIN, Russell, "Wind Scream Viper", Car Magazine, February 1992, pp. 70-77.

4 COOK, Rick, "Designing Assemblies", Computer Graphics World, vol. 13, no. 11, November 1990, pp. 42-50.

5 DAVIS, Dwight, "Reality Check", Computer Graphics World, vol. 14, no. 6, June 1991, pp. 49-54.

6 EMMETT, Arielle, "Guardians of Style", Computer Graphics World, vol. 14, no. 6, June 1991, pp. 31-40.

7 FITZGERALD, Kyran, "Dark Horse Des to Score", Sunday Independent, February 16 1992, p.14.

8 GOODMAN, Cynthia, Digital Visions : Computers and Art, New York, Harry N Abrams Inc, 1987.

9 GRANTZ, John, "A Fluid Market", Computer Graphics World, vol. 14, no. 3, March 1991, pp.29-32.

10 GROSS, Daniel, "Merging Man and Machine", Computer Graphics World, vol. 14, no. 5, May 1991, pp.47-50.

11 HALES, John, The Contemporary Animator, London, Butterworth-Heinemann Ltd., 1990.

12 LEOPOLDSEDER, Hannes, Der Prix Ars Electronica : International Compendium of the Computer Arts, Frankfurt, Vertias-Verlang, 1990.

13 LOVELESS, Richard, The Computer Revolution and the Arts,Tampa, University of South Florida Press, 1989.

14 MORAN, David, Interview on Computer Animation, Pixamation, 21 Upper Mount St. Dublin, January 8 1992 and February 10 1992.

15 MacNICHOL, Gregory, "What's wrong with Reality?", Computer Graphics World, vol. 13, no. 11, November 1990, pp. 102-108.

16 McMAHON, Des, Interview on use of Computer Aided Design, Ballsbridge Dublin, February 17 1992.

17 PEUSNER, Nickolaus, Pioneers of Modern Design from William Morris to Walter Gropius, London, William Clowes Ltd., 1984.

18 PHILLIPS, Richard, SIGGRAPH '88 Panels Proceedings, Los Alamos, Los Alamos National Laboratory, 1988.

19 PHILLIPS-MAHONEY, Diana, "What it Takes to Get Real",Computer Graphics World, vol. 14, no. 7, July 1991, pp. 113-117.

20 PORTER, Stephen, "Winds of Change", Computer Graphics World, vol. 14, no. 2, February 1991, pp. 34-40.

21 PORTER, Stephen, "Made for the Stage", Computer Graphics World, vol. 13, no. 8, August 1990, pp. 61-69.

22 RHEINGOLD, Howard, Virtual Reality, London, Secker and Warburg, 1991.

23a ROBERTSON, Barbara, "Beauty and the Beast", Computer Graphics World, vol. 14, no. 12, December 1991, pp. 45-50.

23b ROBERTSON, Barbara, "The Electronic Theatre", Computer Graphics World, vol. 14, no. 7, July 1991, pp. 46-54.

24 SHOOR, Rita, "Hollywood Stlye", Computer Graphics World, vol. 14, no. 3, March 1991, pp. 34-39.

25 SMITH, Thomas, Industrial Light and Magic : The Art of Special Effects, London, Columbus Books, 1986.

26 SØRENSEN, Peter, "Terminator 2 : A Films Effects Revolution", Computer Graphics World, vol. 14, no. 10, October 1991, pp. 56-62.

27a SØRENSEN, Peter, "From the Computer Screen to the Silver Screen", Computer Graphics World, vol. 13, no. 10, October 1990, pp. 57-64.

27b SØRENSEN, Peter, "User Friendly Animation", Computer Graphics World, vol. 13, no. 3, March 1990, pp. 129-133.

28 THOMAS, Frank, The Illusion of Life, New York, Harry N Abrams Inc., 1962.

29 WOHLERS, Terry, "Advances in Prototyping", Computer Graphics World, vol. 14, no. 12, December 1991, pp. 53-60.

30 WOHLERS, Terry, "Practical Prototypes", Computer Graphics World, vol. 13, no. 3, March 1990, pp. 102-108.