'COMPUTERS AMAZE,

DO THEY DESIGN ?'

THE NATIONAL COLLEGE OF ART AND DESIGN

"COMPUTERS AMAZE, DO THEY DESIGN"

A THESIS SUBMITTED TO :

THE FACULTY OF HISTORY OF ART AND DESIGN AND COMPLEMENTARY STUDIES

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INTRODUCTION

The word computer appears in practically every aspect of our daily lives to-day. Computers have reached an astonishing level of technological sophistication in the last 20 years. The power that could previously only be provided by the big computers is now readily available on small desk-top computers at a fraction of the price. The last few years has seen Computer Aided Design systems being applied to Industrial Design.

The aims of this thesis are :

1. To examine what Computer Aided Design systems have to offer

2. To describe the applications to Industrial Design

3. To determine if they assist in the design process

4. To outline other applications outside of Industrial Design

5. To determine if Computer Aided Design applications to Industrial Design result in a real time saving in a design project

6. To examine the monetary aspect: To determine whether or not capital investment cost's in Computer Aided Design systems can be justified through increased profits.

In this thesis I adopt the position of mediator , having in one hand a Computer Aided Design system , in the other the design process and I propose to analyse and identify the real applications of the system to the design process.

CHAPTER ONE

'WHERE IT ALL BEGAN'

Introduction: This chapter will examine the origin and early history of Computer Aided Design.

The development of Computer Aided Design began as early as 1960. There were three early principal types of systems available. The first was a 'Sketch Pad' system developed by Ivan E. Sutherland, a computer software writer and University lecturer. His system was designed to be used on the TX-2 computer network at M.I.T.'s Lincoln computer laboratory. This was 9163. His system allowed the user, mostly engineers at first, to generate designs by sitting at the computer terminal and monipulating their drawing displayed on the screen by using a 'Light Pen' and the keyboard. Sutherland demonstrated this 'Sketch Pad' system at the 1963 Joint Computer Conference in London and it generated interest among many engineers toward the potential of Computer Aided Design. (Ryan, David L. 1977 p. 6)

The second principal system during the time of Sutherland's early work, at M.I.T. in Boston, IBM were simultaneously in the process of developing a Computer Aided Design system. The DAC-1 (Design Augmented by Computer) which was developed by IBM for General Motors car design and development section. It was made public at the 1964 Joint Computer Conference. Although some smaller systems had been incorporated into the car and aerospace industries as early as 1960, IBM's design became the model and

forerunner of many interactive Computer Aided Design systems installed by large companies from 1964 onwards. (Ryan, David L. 1977 p.8)

The third important early system was developed around the same time by ITEK laboratories for camera lens design work.

Since then Computer Aided Design systems have been increasingly employed in several areas of Mechanical, Civil, Electrical, Chemical and Industrial Engineering as well as Architectural and Industrial Design.

At this early stage of development Computer Aided Design in Architecture lagged considerably behind its application in engineering. Architects in general seemed adamant to dispel any ideas of its application to building design. Lack of information on the potential of Computer technology in relation to their work contributed to this. Another reason for this may have been based on economics. The engineering - Automotive and Aerospace industries were much larger funded by large multinational organizations and because of this they had large amounts of money available to invest in this expensive equipment. The Architectural and Industrial Design companies were much smaller and were unable to do so. 'In the automotive and aerospace industries the budget allocated to the design of a product is generally quite large, often several times the cost of the product, unlike in Architecture or Industrial Design where the cost must generally be kept to a smaller percentage of the overall cost of the design'. For this reason it was hard

for the design firms to justify the capital cost of such equipment. The early Computer Aided Design systems cost anything between several hundred thousand or millions of pounds, leaving them well beyond the budget of most Architectural and Industrial design firms. (Ryan, David L., 1977 p.10-12)

In the United States discussion on the potential of Computer Aided Architectural Design began to be published about 1964-65. Christopher Alexander, in 1964 published an influential book called "Notes On The Synthese of Form" which generated considerable enthusiasm in computer based systems in Architectural Design but in the same year a conference held at Boston Architectural centre on "Architects and the Computer" attracted only 600 Architects. This again showed further their lack of awareness among Architects in computer based systems. (Mitchell, William J., 1974 p. 30)

Some experimental aided design and graphic systems were developed during the late 1960's by Souder and Clark Co., but realistically their efforts proved fruitless as regards systems being bought or used by Architects or Designers. The first practical applications were in the areas of structural and mechanical calculations, cost estimation and economic analysis but they did not involve any of the available design systems purely because of the prohibitive cost involved. (Mitchell, William J., 1974 p. 36)

Because technology continued to develop during the 1960's the computer became more powerful, cheaper and smaller. The power

that could previously only be provided by the big computers was becoming available on smaller desk top computers at a fraction of the price. This instilled a renewed interest among Architects and Industrial designer who realised the potential of computers in design. As a result these smaller computer based systems were making their way into design practices' during the early 1970's.

Basic research into Computer Aided Design was financed by some governments but most of the research cost was absorbed by the large companies themselves because they were developing their own systems. Universities also carried out research work in conjunction with several companies. The Civil Engineering Department at Pennsylivannia State University is an example of this. They pioneered and developed many important architectural, engineerging and design applications - building description, space planning and graphic images on computer were some of them.[2]

The development of Computer Aided Design systems has continued relentlessly to this day. Computer Aided Design has attained an astounding level of sophisticated and minuterization. The basic Computer Aided Design systems's are well within the price range of smaller companies. We have now entered the era of simply choosing a system that suits a particular company and budget best.

CHAPTER TWO

'COMPUTER AIDED DESIGN IN INDUSTRIAL DESIGN'

Introduction: This chapter analyses the applications of Computer Aided Design to Industrial Design. It discusses the design process and the computer applications within each area. The aim of this chapter is to outline the design requirements in a typical product design project and to access the computer systems ability to assist them. This chapter also discusses two projects in which a Computer Aided Design system was used throughout the design process and describes the results.

Industrial design is concerned primarily with the development work associated with products to be manufactured. Design is a business. Industrial designers are similar to architects because they both approach their work in a similar way and they must both achieve a level of creativity and style in their work to succeeded in a problem resolving and design orientated field. For a company owner time efficiency and time management are key elements in running a successful business.

The Architectural industry is an example of an area that has seen dramatic changes taking place in the past 20 years. The industry as a whole has been subject to new working conditions, new materials and new equipment to facilitate the work. These changes stem from, a cost cutting drive, an obvious deterioration in natural resources world-wide and the abundance

of new man made materials combined with the desire to create a better and more efficient building technique. Electrically powered tools and hydraulically controlled machines are rapidly replacing manual labour. They are appreciately shortening the time required to complete a job. From history it is obvious that architectural and industrial design lagged considerably behind engineering in the application of new technologies but this is not the situation today. Autofeed, automation, auto-replay are words associated with modern working and living environments in a technological aware society.

The computer age has produced new applications in science and engineering. Developing computer systems has itself developed a new area of employment world wide.

Since industrial design is a business and Computer Aided Design systems are available to the designer certain questions must be addressed to determine if a Computer Aided Design system has real practical applications in the design process:

- What do Computer Aided Design systems offer?
- Where are the applications in industrial design?
- Do they assist in the whole design process or certain areas more effectively than others?
- Do they result in real time saving?
- Can the capital cost involved in purchasing a Computer Aided Design System be justified for Industrial Design?

•Do the systems have any real applications to industrial design or are the manufacturers monopolizing on the awareness of designers to adopt new technologies to design?

'WHAT DO THE THE MANUFACTURERS OFFER'

The up to date systems described by manufacturing companies today show an astonishing level of technological sophistication in Computer Aided Design systems. The quantity of printed material -folders containing coloured reproductions of concept designs, finished renderings and technical drawings all drawn on computer by enthusiastic manufacturers is astounding. The following extract is a good description of the latest systems available and describes the companies interpretation of computer versatility in design.

> Industrial designers and stylists have found conventional CAD/CAM systems to be far too restrictive. ALIAS, is the first computer system to provide all the creative tools that you need, combined with a fast intuitive method of operation that complements your design skills. With ALIAS you can create and manipulate models without artificial restrictions enabling you to form and modify your concepts quickly and with ease.
>
> Furthermore, advanced visualisation techniques.....models may be rendered with

> lifelike colours and textiles and viewed from any angle in realistic environments. Environments phenomena such as fine mist, mountains and water. ALIAS provides all the tools that you need to quickly turn your creative vision into reality and can reduce your development cost and improve profitability by dramatically shortening product to market lead time. (ECS Design Manual, August 1989, P. 1-3)

This extract is best described as a generalization of the description of most other manufacturers systems and what they offer. The only significant difference being, the ALIAS system described costs approximately £300,000 most of the other systems are cheaper.

Professor John Frazer, Director of Computer Aided Design at the University of Ulster states:

> I do not recognise any existing Computer Aided Design system as a useful design aid - and nor apparently does any practising designer.
>
> There are excellent computer draughting systems for drawing, there are excellent computer modelling systems for modelling something you have already drawn, there are excellent computer simulation systems for

> simulating what you have already modelled, excellent structural packages for calculating what you have already simulated and so on. But there is a singular lack of any software which fundamentally assists the design process....there are a number of packages around which claim that they aid design process when they are in fact obstructing it. (Frazer, John, CIRCA 1990, p.28)

Although this may appear an alarming statement it does describe Professor John Frazers opinions on Computer Aided Design systems with reference to the 'Design Process'. It is the application of computer based systems to the process of design that he feels is counter productive. In order to elaborate on specific computer applications the design process must first of all be defined.

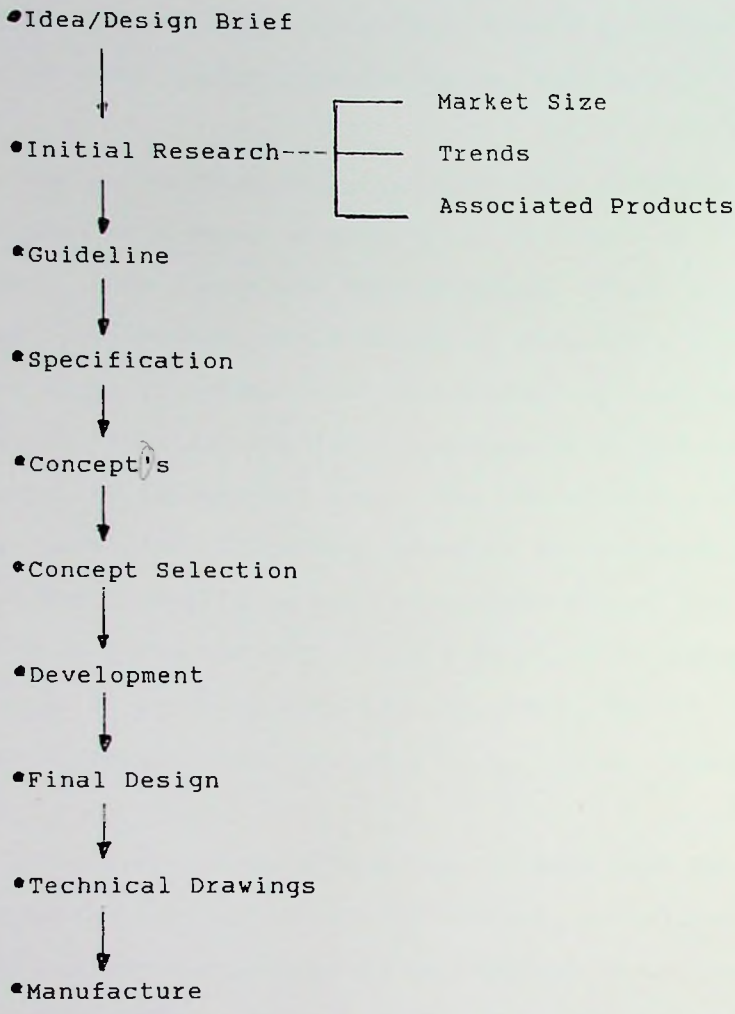
'THE DESIGN PROCESS'

The design process can be described as all the work undertaken by a designer from the time he or she receives the project brief until the time the final working drawings are completed. It can be argued that the design process follows a set sequence i.e. sketching to concept drawing to development drawings etc, a patterned sequence which is carried from one project to the next. But because the designer is exposed to such a range of problem solving and the term 'Design' encompasses such a vast

area it is non constructive to say that the design process can be carried out by doing x, y, z, in order and that order is compatible each time, for every project. Sketching drawing and development work are an integral part of any design work but the order in which they are executed cannot be pre-determined conclusively as a general design process. This point is clearly seen in a project that has been allocated three week working time for example. Sometimes the project will be finished in two weeks because the solution was discovered early. Sometimes the project will over-run the allocated time. In either situation a patterned sequence did not work or at least it did not work within the framework of the 'design process' for the project that over--ran the allocated time.

A broad outline for a designing project is shown in diagram 1 Industrial Design is concerned primarily with the design of products to be manufactured. An industrial designer may take sole responsibility for the whole of the design but designers often work in conjunction with engineers for large projects to integrate complex engineering requirements into a single design solution. (Tovey, Michael, Jan 1989 p.26)

Diagram 1



The majority of the workload for an industrial designer is between the initial sketches and the final working drawings. This area can be broken into stages and the present computer applications available to them can be evaluated.

DESIGN SKETCH

Introduction: This section examines sketching in a design project. It looks at conventional sketching and outlines the Computer Aided Design applications to this area.

Sketching and drawing is an integral part of industrial design. It is used as a means of developing the ideas of a designer from his mind into a physical form on paper. These sketches are generally completed very quickly, encapsulating all the thoughts of the designer. Sometimes only a shape or form is drawn, a series of lines and shading. Sometimes a single word or phrase is enough to capture the idea. The aim of this exercise is to get as many ideas a possible drawn in the shortest possible time. The diversity or even ridiculousness of ideas seldom matters as again the purpose is generation of ideas. It can be viewed as an escapism from reality often extending beyond the bounds of practicality but this is of little consequence.

What is of consequence though, is the fact that this pen to paper mental exploration works extremely effectively as past of the design process. There is no computer system available which allows the designer this freedom. The hand eye coordination when sketching on paper is lost when the computer is used. This is because you are drawing on one surface and the image is produced somewhere else i.e. you sketch on the tablet and the image is shown on the monitor. It is almost like drawing with invisible ink. The lack of fluidity and spontaneity detract from the very essence of generating ideas quickly. It dampens the creative impulse.

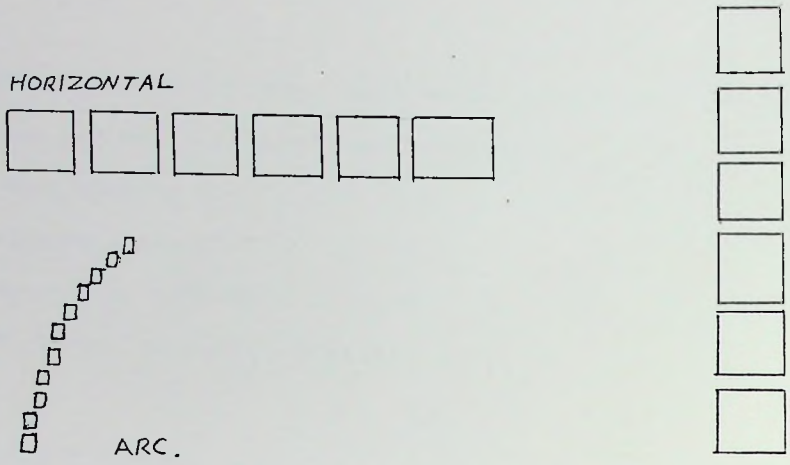
I have not yet met a designer who uses or prefers to use a computer to sketch on. Because this area of the design process is fundamentally important. The significance of the lack of a single suitable system or the likelihood of there even being a suitable computer aid in this area is important to note.

This should not be seen as a criticism of a Computer Aided Design system unless the manufacturers state that their system is suitable for sketching ideas - then it becomes an issue. At present no manufacturer claims to offer this facility, but none of them state that their system is not suitable for this application. It is the users misconception therefore if he or she purchases a Computer Aided Design system to discover that they cannot produce sketches as quickly and creatively on computer as they can on paper.

The title 'Computer Aided Design' is both accurate but misleading however. It is accurate in the sense that it reads 'Aided Design' which is true. The word 'Aided' however is often treated or interpreted as a conjunction, a word merely to join 'Computer' and 'Design' but this is not true. 'Aided' in this sense is a real word with a real meaning. It is a computer to assist with design. Even the word's 'Aided' and 'Design' together are misleading. It suggests that the system is an aid to the design process, whereas in fact it is only an aid to some areas of the design process. As outlined at the beginning of this chapter, the computer is of no use in sketching ideas, in fact it henders creative impulse.

The psychological impact of viewing an image on a computer screen is another important consideration. The computer generated image is perceived as a more finite illustration than that of a sketch on paper. The reason for this is two fold, firstly the computer is perceived as a 'serious machine' mostly because of a fundamental lack of knowledge on how it operates and this seriousness filters to the way we perceive the images on the monitor. An everyday example of this would be the difference between a typed page and a hand written page. The typed page is perceived as a more 'serious' text. Secondly, the computer image is composed from a geometric configuration of dot's. A line between two points consists of a series of dot's, each touching together. This principle is not seen when a horizontal or vertical line is drawn because of the configuration of the screen but it is evident when an arc or a diagonal line is drawn. This is shown in diagram 2 . Because of this an illusion of geometric configuration is created, a configuration which is alien to the sketches drawn on paper. It creates an ambience of geometry and scientific array within a simple line. This further detracts from the fluidity of a basic sketch or doodle.

It is in this form of geometric configuration that all computer generate images are shown and it is not true to say that a finished rendering appears like a scientific array of dots. The finished quality that can be achieved in rendering on computer is very good.



Diag 2 THE GEOMETRIC CONFIGURATION OF A LINE AND ARC DRAWN ON COMPUTER

'86

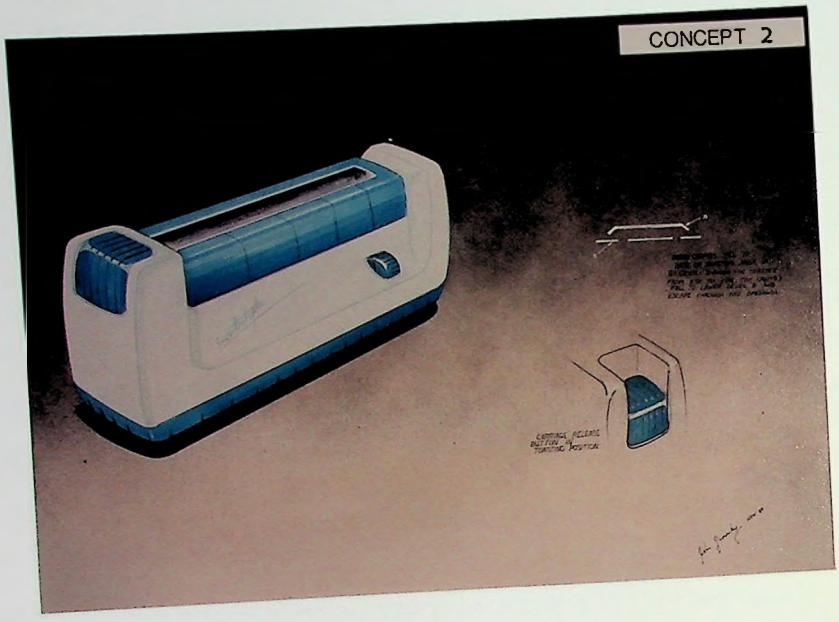
CONCLUSION - Computer applications to sketching:

- •cannot match conventional sketches
- •not used by designers
- •dampens creativity
- •portrays a contrived image
- •creates geometric patterning.

THE CONCEPT DRAWING

Introduction: This section explains the function of the concept drawing and examines the computer applications to concept presentation.

The concept drawing is an important part of industrial design and the design process. It is a detailed drawing to show how the product will look as a possible design solution. It is important because it is one of the first drawings shown to the client in a design project and must show not only innovation but it must also have a high standard of presentation to satisfy the client, who is paying for it. Many of the ideas from the sketches are unified into a single design proposal or concept. The concept shows in great detail the form and function of the design. The significant difference between the concept drawing and the sketch is that the concept drawing can be finished to a much higher degree of accuracy and detail since many of the engineering, manufacturing and ergonomic criteria will have been sorted out during the sketch stage. Several concepts will have to be presented to the client in a single design project. Diag 3.



Diag 3 A CONCEPT DRAWING.

19b

Computer applications in this area work very well. Because many ideas have been generated through sketching, they can now be drawn onto the computer for rendering, presentation and development work. This rendering and development work on computer allows the designer to work in a natural and familiar way while refining the concepts. Three dimensional views can be generated in true perspective as well as a view from any angle using the computer. The system allows the designer to zoom in on a specific detail or rotate any view while still maintaining true perspective. The work can be continuously improved and refined without having to re-draw the overall shape again, which is the situation with development work on paper. Surfaces can be deformed, smoothed out or given textures until they meet the exact requirements of the designer. (Newton. Sidney, Logan. Brain, October 1988 p. 198)

In this application of concept presentation and development the 'serious perception' as discussed earlier in this chapter enhances the concept appearance. Because the concept drawing is a serious attempt to show a real object in its true form, shape and texture the computer environment strengthens its credibility.

When the designer is satisfies that the concept is complete the image can be rotated again to show a view that best describes its overall appearance. A series of views may also be shown. These views can be photographed from the screen and displayed as large prints, they can be printed using a colour laser copier or shown to the client on the monitor. Diag 4.

Diag 4 A FINISHED RENDERING DRAWN ON COMPUTER

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The problem with rendering on paper is that once a colour, shadow or highlight is drawn, it is permanent. If the colour chosen is too dark for example it is impossible to remove that area. Many concept rendering have to be redrawn and coloured again as a result of mistakes like this. A coloured area or highlight drawn on computer can be removed or altered quickly. This allows the designer to be more adventurous in approach and technique, knowing that at any stage mistakes can be rectified.

In this application the Computer Aided Design system proves itself extremely effective. The process of rendering concepts, cutting out and laying down by conventional methods on paper takes a considerable amount of time and the end result is not always a reproduction of what the designer wanted. The level of quality is not always predictable. The Computer Aided Design system however allows the designer the scope to re-arrange the presentation until it is exactly as he or she wants, quickly and efficiently, therefore creating a greater overall consistency and better quality visuals.

CONCLUSION - applications to concept design and development:

- good three dimensional plotting
- easy to modify form
- high quality visuals
- ability to view the concept from any angle
- ability to select and change colour and surface texture
- computer enhances the credibility of the concept design.

'SOLID MODELLING'

Introduction: Solid models constructed in a soft material are used to describe the real three dimensional qualities of a product in a design project. This chapter examines the use of computer and high speed milling machine in the production of solid models.

When a detailed concept is drawn on computers it allows the designer the option to have this model produced in solid three dimensional form. The Computer Aided Design data-base can be linked to a multi-axial C.N.C. milling machine which on command will sculpt any shape drawn on the computer from a soft material - usually styrene. The C.N.C. milling machine can produce a simple shape like a cube in less than one minute. With this facility the designer can have a three dimensional solid model quickly at his disposal to evaluate scale and appearance of a design proposal. Solid modelling has always been a part of the design process in industrial design but prior to the computer - C.N.C. milling machine facility solid modelling was always a separate task. The concepts were drawn first and when they had been completed the foam models were constructed. The C.N.C. machine offers accurate tollerancing and therefore a dimensionally accurate fo m model can be produced. This allows the designer freedom to work on other areas of the design or different concepts as the milling machine independently produces the model. Because of the simplicity of the system it allows solid models to become part of the design process at a much

earlier stage and eliminates the necessity for the designer to make the block models manually,

The automotive industry is where this system is found usually though. The milling machine with multiaxial head is expensive. It was a purpose built machine originally for machining complex tools for injection moulding and in this application it makes a large cash return. Although the design process makes a cash return the solid modelling is only a part of that process and it is difficult to justify using this sophisticated machine with mainly engineering tendency's for sculpting simple forms. It's best application to industrial design would be as an integral part of model making and component manufacture with the flexibility into the application of solid modelling. In this way its main application would not be the construction of three dimensional soft models but it would always be available for that purpose. (Cross, J.D. October 1988 p.215)

CONCLUSIONS - This Computer Aided Design system linked to the Multi-axial C.N.C. milling machine allows:

- solid models to become part of the design process simply and efficiently
- However the application of this equipment to solid modelling alone is hard to justify
- as part of a range of facilities available on the milling machine in a design workshop makes most sense.

TECHNICAL DRAWING

Introduction: This section examines the role of technical drawing in industrial design and describes the Computer Aided Design applications in this area.

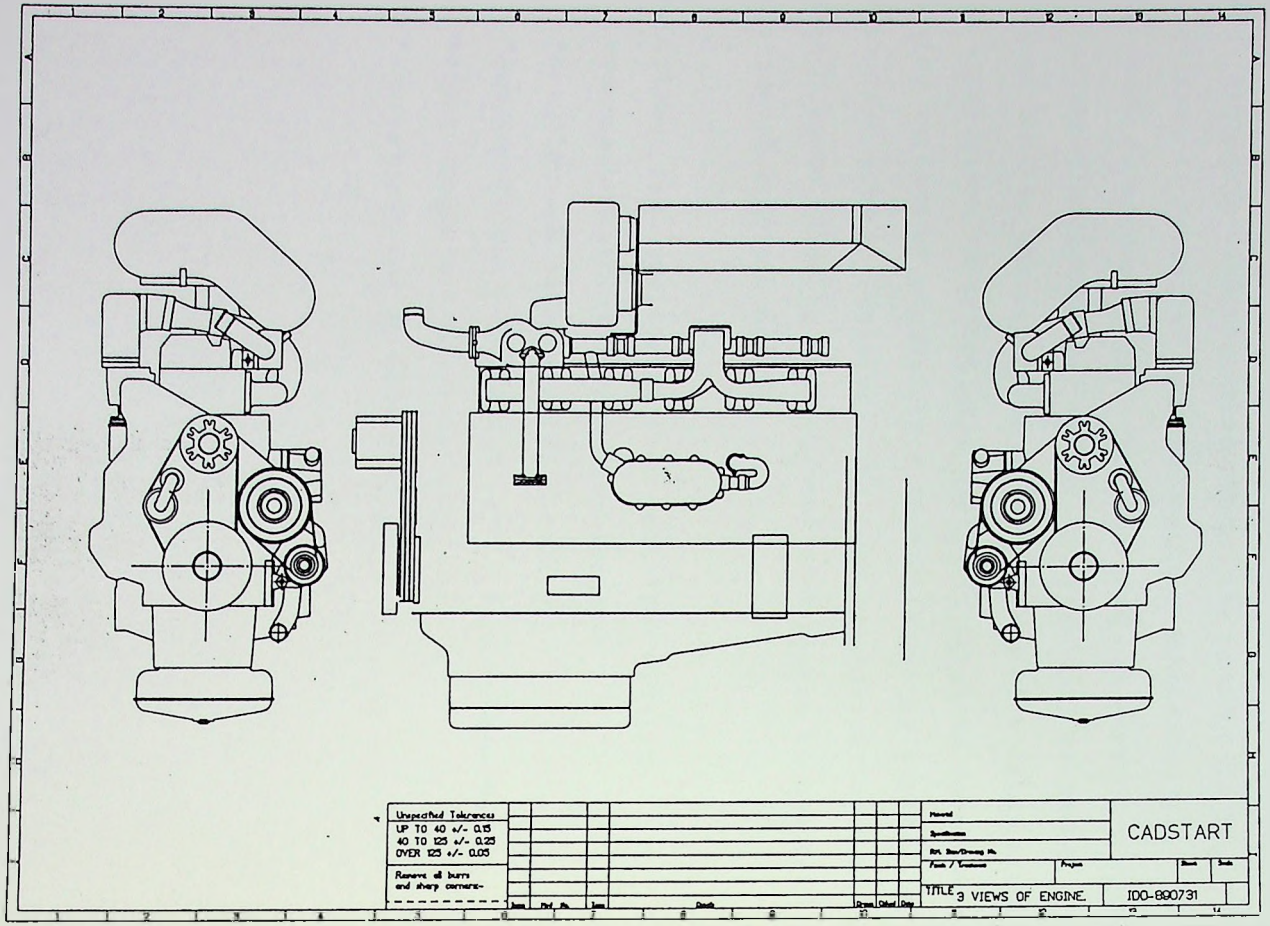
Technical drawing in industrial design is the means by which a design solution is shown in a two dimensional engineering format for manufacture and production. New materials and manufacturing process's combined with the designers ability to venture beyond simple shape in industrial design has resulted in the technical drawing becoming more complex and detailed in the past 10-15 years.

Using a conventional drawing board with machine-head to create a general assembly and complete part drawing's for a product like a modern jug kettle will take approximately one week to complete. Most of the moulding details will have been worked out before starting a technical drawing. but finer details such as clipping, ribbing and accurate draft angles may be figured out during the technical drawing process. Unlike any other area of the design process the technical drawing allows no room for error. Drawings must be re-checked carefully before they are released to the manufacturers for tooling and machining of components. A mistake in the technical drawing for the jug kettle could result in a flawed tool, a mistake that cannot afford to happen when machining costs exceed £120,000 in this application.

To produce the same drawings on a Computer Aided Design system takes approximately 15 percent less time. This means a saving of almost one day. Although the time saving element is very significant the real benefits of Computer Aided Design is the accuracy attainable within the system. This application like all other Computer Aided Design applications only offers itself as an aid to the process and while the system itself is fallible, the designer must understand fully the technical drawing task and only apply the computer to simplify the process. With the technical drawing package the designer can create the entire drawing from its components. These components can be assembled together on the computer screen to investigate clipping mechanisms, screw holes, parting lines etc, and to analyse the drawing as an assembled product. From this image the designer can see where possible assembly problems may have been overlooked in the individual component design.
shows a Technical Drawing done on computer.

The ability to change and modify any detail simply on the system is a great advantage, It allows changes to be made without erasing correctly positioned lines which is what happens when doing technical drawing on paper or film. Lines erased from film in conventional technical drawing never disappear completely and traces of these lines can often appear in the finishes drawing. (CAD User, October 1989 p. 20)

The time efficiency is achieved by automating the time consuming tasks in technical drawing i.e. Hatching, Dimensioning, Tolerancing and Centre Lines. A section can be hatched



Diag 5 A TECHNICAL DRAWING FROM THE CAD SYSTEM

completely by simply outlining the area and activity the 'hatch' made. Similarly with the other areas, the section to be dimensioned is described and the computer dimensions and tolerances it automatically. The designer can work on a number of drawings simultaneously, by storing partially complete drawings on disc and returning to them again at a later stage. This application is potentially useful if there is more than one designer working on a project or if a designer is working in conjunction with an engineer. The disc containing the technical drawing can be taken by the engineer or designer to complete their specific detailing.

CONCLUSION - real applications to technical drawing:

- accurate drafting - true line lengths
- hatching and dimmensioning facility
- components can be combined into a single drawing
- draft angles can be re-set
- corrections can be made easily.

'FEASIBILITY OF CAD TO INDUSTRIAL DESIGN'

This section- (1) Outlines the real time saving in the design process with Computer Aided Design

(2) The overall time saving in a typical design project

(3) The cost of Computer Aided Design systems

(4) Can the cost be justified through time saving.

The following list shows a general breakdown on time taken in a typical design project.

AREA	TIME
Research	5%
Design and development	35%
Office and contract administration	15%
Working drawings	18%
Product supervision	15%
Presentation	5%

(Mitchell, William J. 1977 p.56)

Through this chapter the Computer Aided Design applications to industrial design were examined. The design areas and applications are listed and the success of Computer Aided Design in that area evaluated.

(1) Sketching: There were no real applications in this area. The computer generated sketches were not suitable to express the ideas of the designer in a creative way.

(2) Concepts and Rendering: The Computer Aided Design system worked well in this area of the design project. It offers good visualization and presentation applications. Work can easily be modified and a range of colours and surface textures can be applied to the concept rendering.

(3) Development: This Computer Aided Design application allows the designer to improve and refine the design easily. Three dimensional views could be generated in true perspective. Surfaces could be smoothed out, deformed or given textures to suit the designers requirements.

This area of sketching, concepts and rending and development work, is allocated approximately 35% of the total working time in a design project. Although the computer does not assist sketching it shortens the concept and development stages by approximately ten percent. A computer aided design system is also extremely versatile in it s applications to technical drawing. Here we see the time taken in technical drawing reduced by 15%. This shortens the technical drawing stage in relation to the whole of the design process by approximately 3%. The research and office - contract administration areas are principally report orientated and most modern design offices will have good word proccessing facilities without needing to rely on this facility in the Computer Aided Design system.

Therefore the total time saved in the industrial design process in a Computer Aided Design system is approximately 13%. In money terms this percentage savings can be deducted from the cost of a design project to calculate the money saved by using Computer Aided Design system. The jug kettle , discussed early in this chapter is a typical example of a project in a design consultancy. The design work required in a project like this would usually take approximately three months to complete for one designer and cost the client approximately £14, 500. The 13% saving in design time would increase the consultancy profit for the project by approximately £2,000.

A design consultancy with three full designers could complete up to 12 similar projects a year. This would increase annual profits by approximately £24,000.

This figure does not include maintance or running costs and would be reduce if these were deducted. A consultancy owner could expect to pay approximately £150,000 for a system capable of handling all the features described in this chapter. This is the first question to be addressed by the consultancy owner. At face value it would appear that the Computer Aided Design system would pay for itself in six years provided it was used on all design projects full-time. There are however other associated costs including training updating software and depreciation once the system is purchased. Because of this it will take approximately 10 years before the system will have paid for itself. (CAD User November 1989)

There are MANY APPLICATIONS for Computer Aided Design systems in Industrial design. The system shortens the design process by 13% and will, over a period of approximately 10 years offset the initial capital costs involved in purchasing it. Therefore it is a viable business proposition for any consultancy owner. The main applications of Computer Aided Design system at present tend to move towards the engineering side of design, but it is only a question of time until industrial designers incorporate the system fully into the design process. Looking ahead it is hard to imagine an Industrial design consultancy without Computer Aided Design system five years from now.

CHAPTER THREE

' A COMPANY METHODOLOGY'

COMPUTER AIDED DESIGN: A COMPANY METHODOLOGY
INTRODUCTION: This chapter looks at two products, a professional video camera and an arena spotlight designed by Philips through extensive use of Computer Aided Design.

In 1973 the American designer, Syd Mead was at work in Philips to help improve techniques in visual standards. Visuals played an important role in the design process within Philips. A 'working group' was set up in 1973 to explore the possibilities of new techniques of Computer Aided Design. Philips were determined to develop a system which could be applied to the 'phase of product realization' applications for Computer Aided Design at this time were mainly in the areas of engineering and 'technical design'.
(Heskett, John , 1989 p 31)

In 1986 CID purchased a Computer Aided Design system which they customized for their applications. They saw three main advantages in Computer Aided Design:

- (1)'Replace physical models by computer models'
- (2)'Ability to provide more specific means of evaluation'
- (3)'Exact definition of form resulting in better communication skills'

CID then set up a Computer Aided Design studio and worked with outside systems experts to provide training for their designers on Computer Aided Design applications. By 1988, fifteen product and graphic designers were trained on the system.
(Heskett, John, 1989 p 57)

> In 1985 the product group, IPG, of Philips held a workshop for portable camera design.....This was a preliminary step in the design of new video cameras.....The workshop was intended to gain as much material as possible about the work of cameramen in news gathering and location work.....This would give the design, developement and marketing departments at Philips a much clearer understanding of what the market required.
> (Heskett, John, 1989 p 130)

As a result of that workshop the new camera the LDK.90 system was produced in 1987 and Computer Aided Design was applied extensively throughout the development work. The camera was awarded a Gute industrieform page for outstanding design. Fig 6

Flotor Levendig, a designer in CID used the Computer Aided Design in the design of the studio version, the LDK 900. Fig 7 The main advantages to the system he found were:

> It was possible to make a clear and realistic presentation of what a product would look like and to show possible modifications.....The applications of Computer Aided Design techniques also demonstrates the possibilities of rapidly capitalizing on the advantages of getting it right the first time. (Heskett, John 1989 p. 133-134)

Lighting is an integrated part of any modern stopis stadium. 'The needs of a flexible lighting system, in which case must be taken to avoid disturbing players and spectators with glare that can hamper performance or cause discomfort'. For this reason Philips decided to design a new sports light to 'replace the earlier model developed in 1987. The design brief required the new design to portray a high-tech, modern and professional look. The light was developed through extensive use of Computer Aided Design similar to the video camera. A range of views were generated on computer to show detail's and work out manufacturing process: Fig 8

Fig 6 C A D USED DURING DESIGN WORK FOR THE L D K 90 VIDEO CAMERA BY PHILIPS

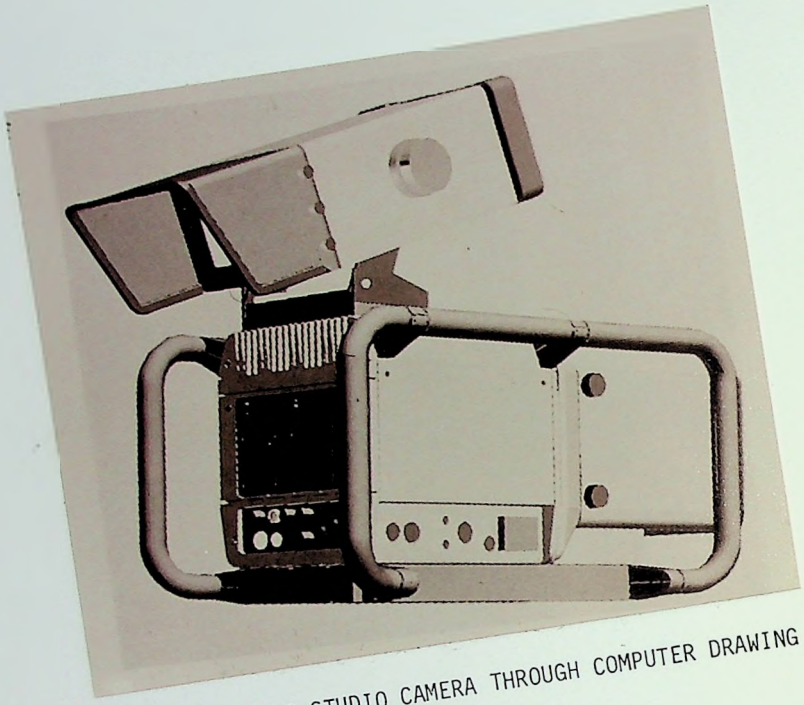


Fig 7 L D K 900 STUDIO CAMERA THROUGH COMPUTER DRAWING

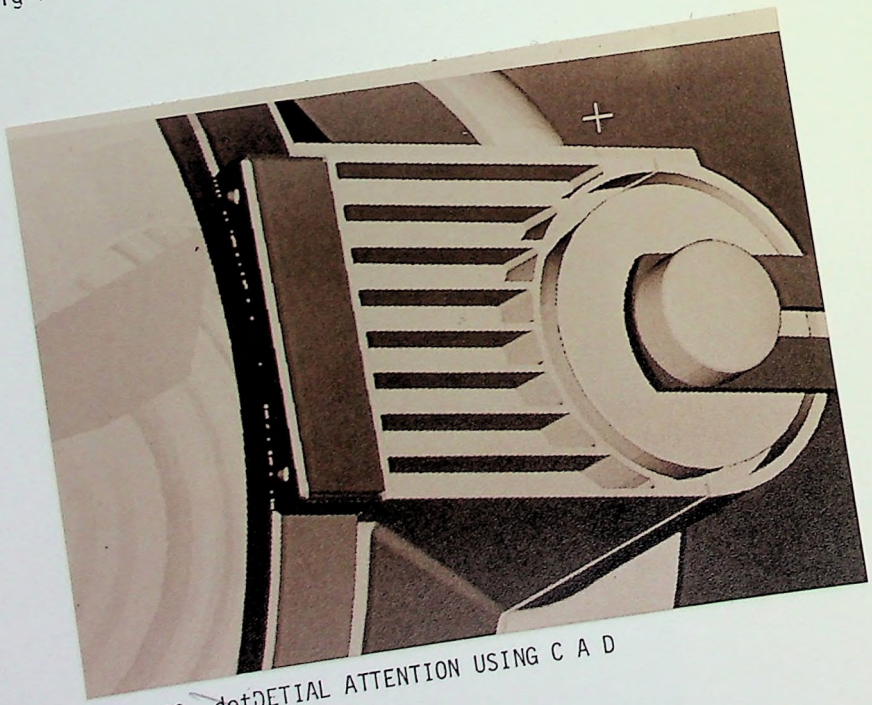


Fig IO detDETIAL ATTENTION USING C A D

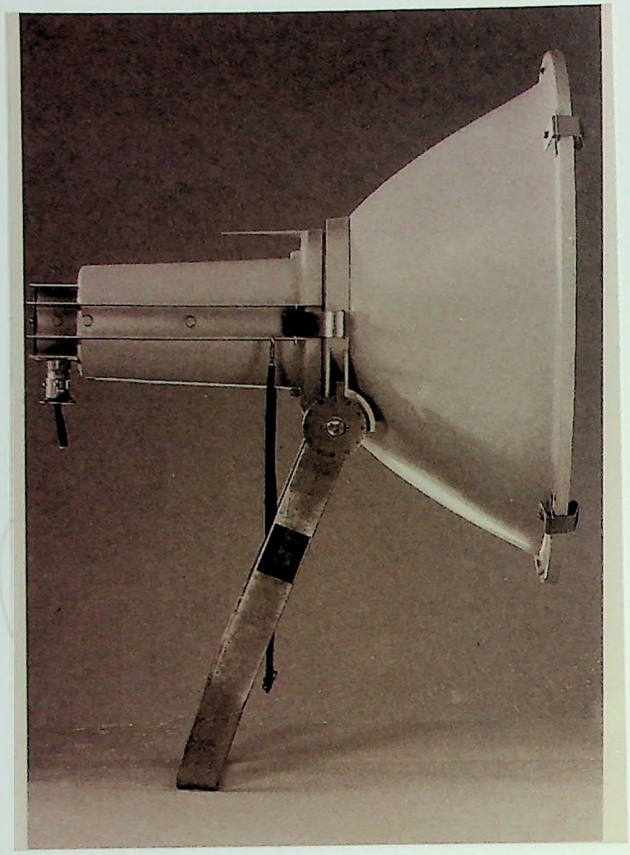


Fig 9 THE ORIGINAL SPOTLIGHT

Fig =IO THE NEW SPOTLIGHT

CHAPTER FOUR

APPLICATIONS OF CAD TO OTHER DESIGN FIELDS

Introduction: This chapter deals with applications of Computer Aided Design systems in fields directly outside the realm's of product design, but each with an inherent design requirement. It examines the computer applications in -

(1) Flight Simulation
(2) Aerospace industry
(3) Automotive industry
(4) Modular design in architecture and interiors
(5) Design engineering (mechanical)
(6) Lighting
(7) Ergonomic testing

Through comparison it is possible to parallel computer applications in these areas with product design and access the most successful application - the common element being a computer.

1- FLIGHT SIMULATION

Introduction: This section examines the computer applications in flight simulations. It outlines the problems encountered in Flight training and the scope of computer generated imagery.

The aviation industry uses Computer Aided Design in many areas of its design and testing work today. Their most exciting application is in flight simulation. Pilots today learn to fly in much the same way as they have done for the past 50 years. This is with their hands at the controls of a real aircraft and accompanied by an instructor sitting beside them. Once they can land and take off safely which takes only 10-20 hours, the remainder of their training is completed solo. Learning to fly has caused many problems in the performance of the small aeroplanes is constantly increasing. As there aircraft become increasingly faster their manouverability at high speeds is critical and the reaction time of pilots must be incredibly fast.

For example in Fighter aircraft training, the average speed is approximately 330 metres per second. This is over one mile every five second. If the ground slopes upwards at five degrees, a slope that is very difficult to detect from above 300 metres, an aircraft flying at an altitude just above this will collide directly with the ground in 20 seconds. If the aircraft is being flown at an altitude of 50 metres, which is often the case in flight training or rescue missions this cuts the collision time to two seconds. (Flight International, May 1986 p.46)

The first effort to solve this problem came at the end of World War Two. The first flight simulator was developed. It allowed pilots to practice many flying tasks while sitting safely on the ground, even practice responses to unlikely

events that could lead to disaster. This early development in flight simulation required a detailed model of an environment, roads, trees, mountains etc to be made in three dimensional form. The first models though were mainly of aircraft carriers or landing strips. A model of this type would have measured approximately 30 metres by 60 metres scaled to measure approximately ten square miles. The controls of the aircraft were connected to a high speed motor that moved a video camera into the position that the flight deck area of the aircraft was directed. There were no Computer Aided Design applications at this stage but work was soon to begin on their introduction.

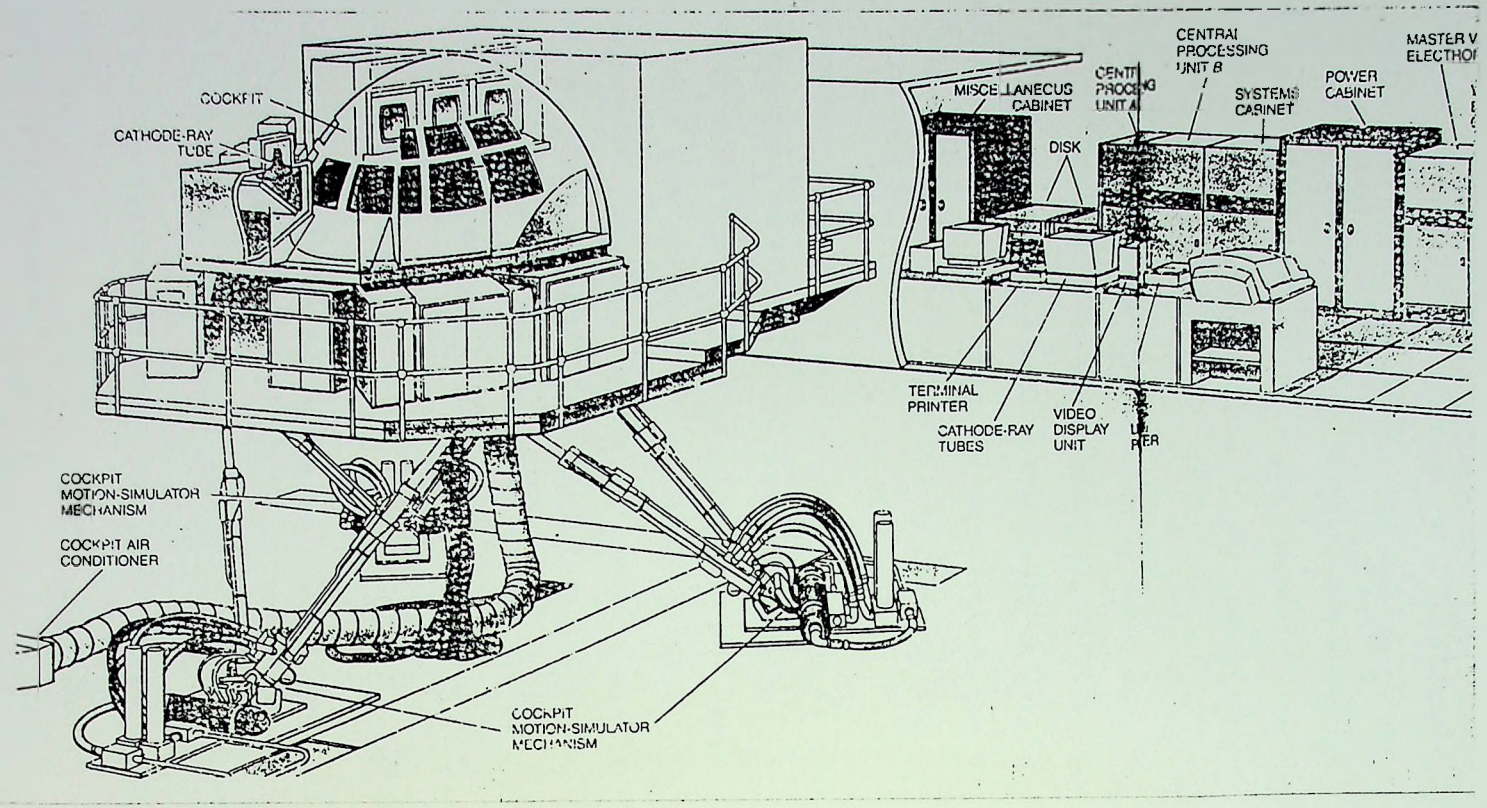
The problem to be overcome with this board system, was that the speed of the aircraft had also to be simulated and this meant that the entire ground area of the model would be covered in less than one minute. As a result, pilots frequently using the simulator became familiar with the terrain and therefore could memorise oncoming contours. This eliminated the element of surprise, one of the reasons why the simulator was designed initially. Because the board models were normally scaled at approximately 300 to 1, this meant that a pilot coming in to land would be approximately three metres from the ground, but the camera lens would have to be one to two centemetres from the model to simulate the real distance. At this close distance the lens would not have a sufficient depth of field to simulate the sharp images a pilot would normally see. The models were also expensive to construct, difficult and time consuming to change and in an attack simulation, buildings or ships could not be destroyed. (Flight International, May 1986 p.48-50)

The late 1970's saw the first real application of Computer Aided Design and Computer imagery. Computer generated imagery on the Computer Aided Design system is currently being applied to most large airline companies and flight training schools World-wide. The computer is used initially to draw a landscape similar to that of the board model. These images are stored in the computer memory. The images describe the landscape in detail, surface texture, size and quantity of a given environment. When the graphic imagery is drawn all the information is programmed and stored in the memory from where any sequence of images corresponding to the pilots view from any angle or distance. The enormous memory capacity needed to contain this vast amount of information is constantly being developed. Fig 11 shows the layout of a 747 jet flight simulator. (Flight International, May 1986 p.51)

To simulate the motion of the aircraft the flight deck structure is mounted on a platform which can be moved up, down, left and right as well as tilted with the aid of synchronized hyrdraullic ram's. This feature enables the system to simulate the aircraft banking left and right, climbing as well as atmospheric turbulance.

The principle advantage of the computer generated imagery is that it offers unlimited size of terrain. Where the board models offered only approximately ten square miles the computer can offer thousands of miles every type of terrain, from deserts to mountains and cities and can also simulate landings and take-off's from any runway. When memory capacity is developed further even greater detail like textures on leaves

LAYOUT FOR A FLIGHT SIMULATOR. Fig 10



and trees, patterns on sand, waves in oceans will be included. The infinite detail will create an astonishing realism on the computer screen. These applications of Computer Aided Design in flight simulation shows how versatile the computer is in this area and its positive application in flight simulation.

The rate of learning is also greatly improved by using the simulator. Research has shown that individual flying tasks are mastered much faster and attain a much higher level of skill when practised separately. A take-off can be practised ten times in one hour. (Flight International, May 1986, p. 52)

Flight simulators can be easily justified by the saving of fuel costs. It costs approximately £4,000 to fuel a 747 jet aircraft in training while a one hour trip in the 747 flight simulator costs less than one twentieth of this. It costs nothing to crash on the simulator however and so the risk of accident is removed. The Computer Aided flight simulator is constantly being developed and refined. The present system offer an extremely versatise bridge between simulator and real time flying.

CONCLUSION - application of Computer Aided Design in flight simulation work extremely well in:

- practical terms - mastering flying skills
- economic terms - simulators can be justified by savings in fuel costs
- risk element is eliminated

2- AERO-SPACE INDUSTRY

Introduction: This section describes the applications of Computer Aided Design to aircraft design and manufacture.

Prior to the introduction of Computer Aided Design in aircraft design and manufacture, engineers world-wide had to crawl over huge drawing boards in specially constructed warehouses in order to define every detail of an aircraft. They also relied on massive wind tunnels to evaluate aerodynamic characteristics of a new form or detail. By incorporating a Computer Aided Design system into their work the industry has been able to eliminate many cycles of wind tunnel testing and more importantly the construction of expensive test models. With Computer Aided Design and computerized data systems the production time for a large commercial airliner has been cut by at least three years. (Flight International, September p.32)

During the time that 'Concord' was being designed the computerized data systems found their first serious design application. British and French designers and engineers exchanged countless visits between Filton and Toulouse to compare and compile large quantities of note and drawings. Despite language difficulties they produced the worlds first supersonic jet airliner. Notes and detailed technical drawings would be so well integrated with the Computer Aided Design system that the language barrier had no negative effects on production time. Because, most of the work was done on computer all information was stored on disc and this allowed the designers and engineers to travel freely between both

countries with all the information or partially completed sections without the restrictions of massive ink drawings. The applications of extremely accurate and detailed technical and wire frame drawings available on the Computer Aided Design system was in this situation explored to its maximum. The Computer Aided system was used to plot the complex aircraft components and body contours and analyse stress, strain, and airflow over the body surface. As engineering equations and technical drawings must comply to international standards, this engineering language was compatible in both computer systems. The old drawing board method can no longer meet the requirements for aircraft design. The Computer Aided Design system describes masses of technical information in its simplest form. Fig 12 shows the manual process of plotting an aircraft wing. Fig 13 shows a typical wireframe drawing of an aircraft nose cone and body contour. (Flight International, September 1984 p/ 32-36)

CONCLUSION - Computer applications for aircraft design is extremely efficient in:

- detailing of body contours through wire frame drawings
- analysis of stress, strain and airflow
- complex technical drawings.

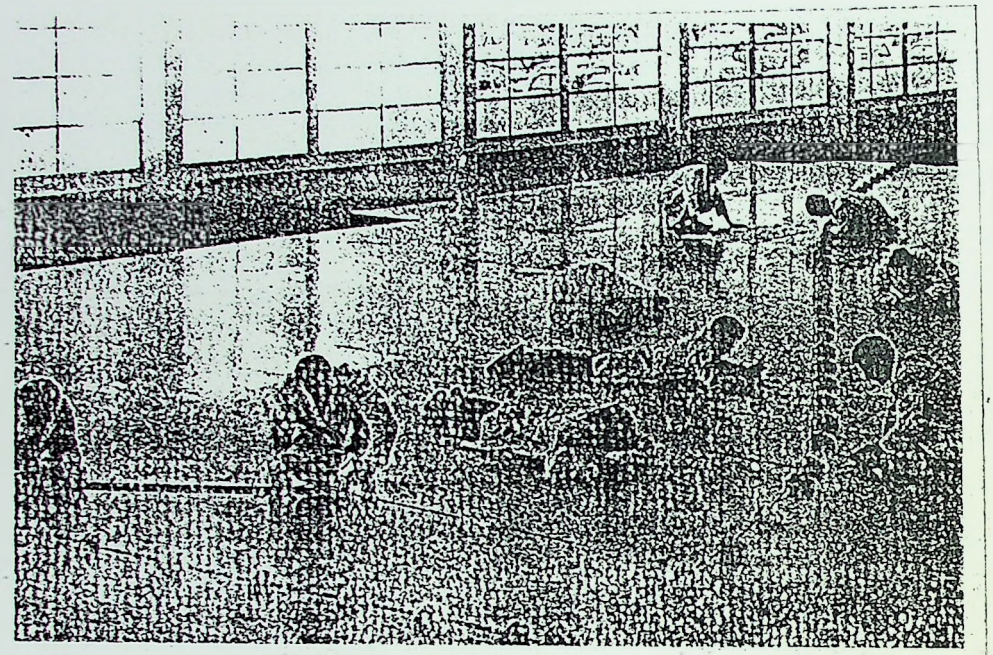


Fig 12 . MANUAL PROCESS OF MARKING OUT THE WING OF AN AIRCRAFT.

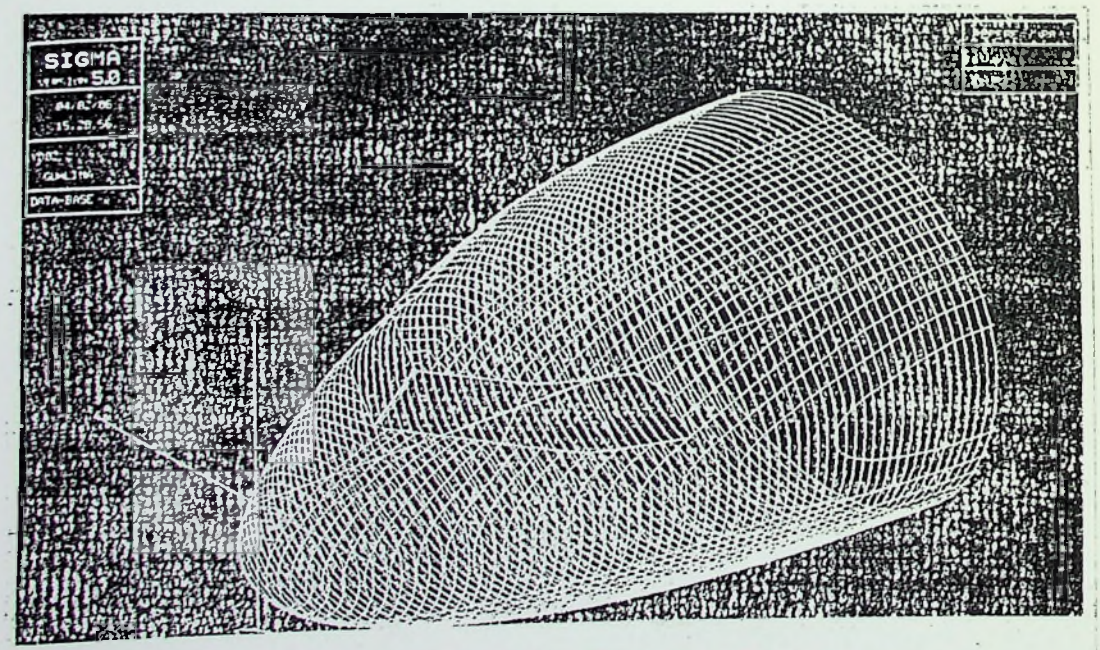


Fig 13 . A TYPICAL WIRE FRAME DRAWING PRODUCED ON CAD FOR THE COCK PIT SECTION OF AN AIRCRAFT.

3 AUTOMOTIVE INDUSTRY

Computer Aided Design applications were introduced to the automotive industry in 1970. Before the introduction full size illustrations had to be drawn on a wall or large drawing board to describe body contours. Standard dimen ions were shown with black photographic tape which was applied as an underlay for the drawing. The process was freehand and involved a considerable element of trial and error. In 1970 the first Computer Aided Design system 'CAR SCAN' was introduced. It relayed measurements from the wall mounted drawings to the computer so the designer could manipulate these drawings on computer. It eliminated the need for the photographic tape.

(TOVEY, MICHAEL , January 89 p.31)

From this initial introduction the automotive industry developed its own Computer Aided Design systems to meet individual requirements. The main application for Computer Aided Design systems in the automotive industry to-day are :

- Concept Generation
- Design development
- Modular kit design
- Drafting
- ELECTRICAL SYSTEMS
- Parts DIGITIZING
- ANALYSIS
- CNC Data
- 3 D assembly trials
- Standard parts
- testing

Although no single system is capable of handling all these features, what is available to the car companys is a number of modular systems, capable of communicating with each other through appropriate interfacing. This means that wire frame drawings from one system, for example can be transferred onto a surface geometry system to examine body contours. (Fig 14)

(TOVEY, MICHAEL , January 89 p 31-32)

The indusrty also use the multi-axial CNC milling machine, described in chapter 2 for solid modelling and development work. Because of th sweeping curves in most of to-days cars,the process of technical drawing in the industry is difficult. It is hard to define each curve accurately. The foam model produced on the milling machine is used to assist in this area. The contours of the model are scanned using a laser and the images relayed to the computer to build up the outline for the technical drawing.

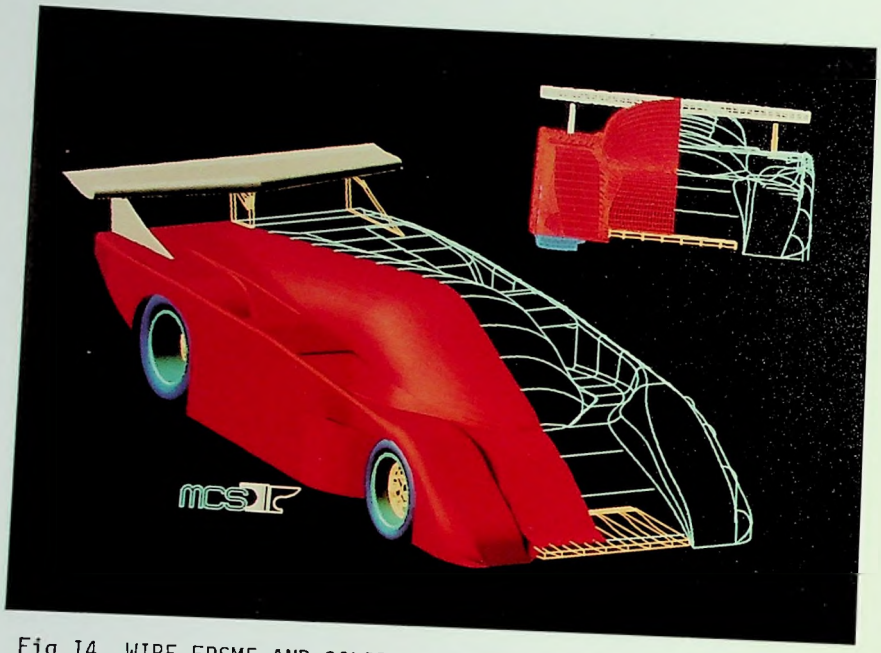


Fig I4 WIRE FRSME AND SOLID MODELLING IN THE AUTOMOTIVE IINDUSTRY

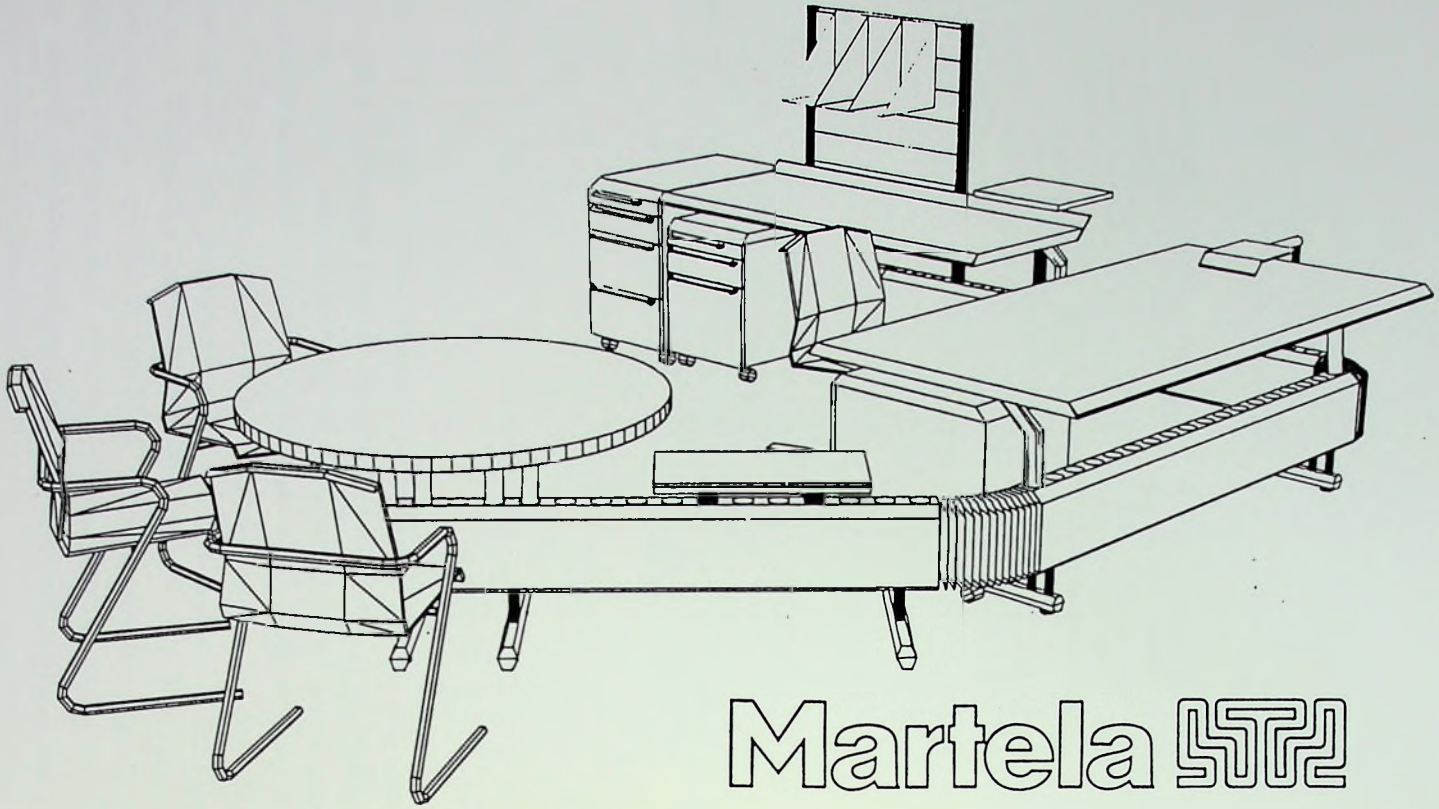
4 ` Modular DESIGN IN INTERIORS AND LIGHTING '

Introduction: This section describes the work on a customized Design system currently being developed by a London lighting company. It also examines the applications of Computer Aided Design in modular interior fittings.

A Computer Aided system is currently being developed by ` MARLIN' a West London lighting company to help clients choose a lighting arrangement that will suit their requirements. As part of the project they catalogued each characteristic or every fitting and light they had available. Sizes, output, colour rendation, heat dissipation and cost were all included. Their computer system can plan a lighting layout in detail and produce a computer generated image of its effects. The room dimentions, reflective characteristics of the floor, walls, ceiling and number of windows are all typed into the computer which calculates the resulting illumination level, for any lighting arrangement. This system works extremely well as any number of combinations or lights can be examined easily and it eliminates the necessity of going through catalogues to find a suitable lighting arrangement with a client.

(BLUEPRINT, February. 87 p 36)

Similar applications are available to assist the display of modular interior fittings. All the available shelving, tables and chairs etc. are drawn using a Computer Aided Design system, again the specific requirements of the client are used as a guide line and from there a selection can be made from the total list of fittings. The modular fittings can be arranged in any order on the computer and shown to the client. (Fig 15.)



q Fig I5 MODUL R INTERIOR FITTINGS DRAWN ON C A D

5 ERGONOMIC TESTING

INTRODUCTION: This section examined the computer applications in two ergonomic projects.

Fig 16. shows an image generated on a Computer Aided Design system in an ergonomic project. This example shows a figure on a tractor looking backwards to check a trailer, while at the same time remaining seated in the driving position. Through this computer image it is possible to access posture, reach, field of view, and instrumentation from a typical situation in the driving seat of a tractor. This experiment was carried out on a Computer Aided Design system called `SAMMIE' which is mainly used for ergonomic evaluation.

Fig 17. Shows a view from the operating area of a lightweight fork-lift. The image also includes in the distance the objects that are going to be retrieved. The geometrically based drawings discussed in chapter 2 are ideal for this application as all ergonomic data is compiled in geometric form and term's.

(DESIGN STUDIES, July 1986)

As we have seen in this chapter Computer Aided Design Systems are used for many applications in design related fields outside of Industrial Design. They have been succesfully integrated into the automotive and aerospace industries but their applications are limited to development work and the final stages of the design process. The system lacks any real application to sketching and concept generation. This chapter also outlined the Computer Aided Design applications to Engineering and Ergonomic testing. In this application the whole of the system is applied to the work, therefore the company owner would be utilising the system as a whole. The overall conclusion in this thesis will outline the best applications to Industrial Design in relation to the questions raised in Chapter Two.

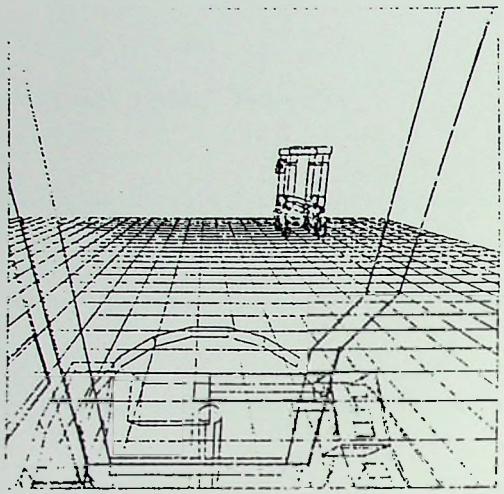


Fig I6

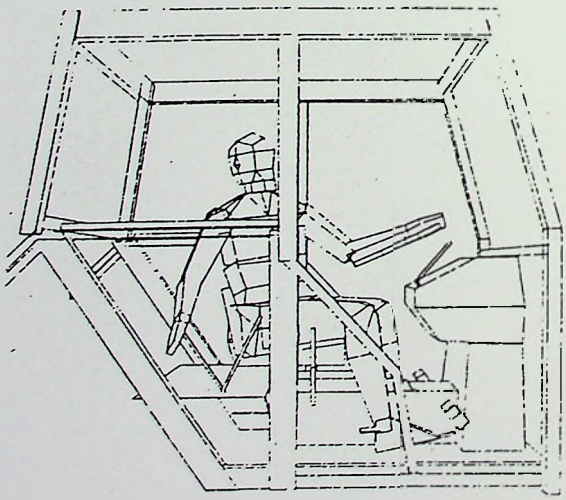


Fig 17 C A D DRAWINGS IN ERGONOMICS PROJECT

CONCLUSION

- The system does not support sketching
- It is inherently unsuitable for generating ideas quickly
- Successful in concept presentation and development work
- Provides the accuracy and speed required in technical drawings
- Supports integration of technicial drawing and manufacture
- Reduces the time taken in a design project by 13 per cent
- Offers itself as an aid to the design process

BIBLIOGRAPHY

1. Design Now:Industry or Art Prestel (Presetel-Verley, Munich 1989)

2. Computer Graphics, Vince, John (Frances Pinter, London 1973)

3. Industrial Design in Engineering, Flurscheim, Charles L. Design Council London (Springer-Verlay, New York 1980)

4. Computer Aided Architectural Graphics, Ryan, Daniel L. (Marcel Dekler, Inc New York)

5. Computer Aided Architectural Design, Mitchell, William J. (Petrocelli/Canton, NY 1977)

6. Computers and their applications, Goldstein, Larry J. (Prentice-Hall, New Jersey)

7. Bit by Bit, Augarten, Stan (Allen and Union, London 1985)

8. Computer Images:Sate of the Art, Deken, Joseph (Thames and Hudson, London 1983)

9. Using Computers to Create Art, Wilson, Stephen (Prentice-Hall, New Jersey 1986)

10. Computers for Imagemaking, Clark, D.R. (Pergamanon Press, Oxford-NY 1981)

11. A Practical Introduction to Computer Graphics Angell, Ivan O. (University Press, 1974)

12. How people look at pictures:A psychology of visual perception Buswell, B.T. (University of Chicago Press, Vhicago 1981)

13. Art and Illusion, Gambrich, E.H. (Princeton University Press, Princeton 1969)

14. History of Programming Languages, Wexelbliat, Richard L. (Academic Press, New York 1981)

15. The Principles of Engineerging Design, (Butterworth Co., London 1982)

16. Visual Thinking, Arnheim, R. (University of California Press, Berkley, LA, London 1976)

17. Philips: A study ofg the Corporate Management of Design Heskett, John (Treford Publications Ltd, London 1989)

PERIODICALS AND MAGAZINES

1. The Primary Generator in the Design Process Darke, J. Design Studies Vol. 1 No. 1 1979 p. 36-44

2. Inside CAD, Leslie, Mark Design Journal March 1987 p. 67-71

3. Caustration and its effects: The Blackguard in CAD Clothing Newton, S. and Logan, Brian S Design Studies Vol. 9 No. 4 1988 p. 36-44

4. Design discippline and the significance of visuospatial thinking Miller, W. Design Studies January 1989 p. 12-23

5. Drawing for Designing , LLoyd-Jones. P Leornardo Vol. 17 No. 4 1984 p. 269-276

6. The Electronic Craftsman, CIRCA, CIRCA January 1990 p. 28-32

7. Drawing and CAD in Industrial Design Tovey, Michael Design Studies January 1989 p. 24-38

8. The Chip National Geographic Octouber 1982 p. 421-457

9. The computerized design studio is comming of the drawing board Adweek September 27, 1982 p.38-54.