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Computer Aided Industrial Design

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COMPUTER AIDED INDUSTRIAL DESIGN
—Microcomputer based CAD
—Design Development using a CAD system

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CHAPTER I

INTRODUCTION

The intention of this paper has three parts, the first chapter describes the basic principles of Computer Aided Design including the methods and tools that are common to computer applications for design tasks. The second chapter is a study of the microcomputer, Computer Aided Design system. The third chapter is a model design study using an educational Computer Aided Design system on the microcomputer, and how to develop ideas during each design stage.

Our technological community is entering a new era of enhanced creativity made possible by the development of Computer Aided Design (CAD). This augmentation of the human intellect is a product man—computer synergism: a partnership between the man and the computer, a combination of the best qualities of each to form a greater capability. The progress expected in this field during the next decade has been likened, in magnitude, to the progress already achieved by the use of the computer. Industrial design is a process of planning and decision making used to produce information to ensure correct manufacturing.

This definition applies to any design process and the use of a CAD system and thus embraces the importance of a computer system to have an improved visual communication. The visual display is very

important because industrial design is based upon expressing a well thought out form. Information flow and the decision making process at each stage of design, the designer searches for many possibilities so they can decide on a final design. The designer's testing and adoption of new ideas and techniques helps in each stage of the design. Computer aided design is often associated with computer aided manufacturing (CAM). CAM starts with machines that use computer data. The information is feed into the computer by a person and the machine uses this information to complete a specified task. CAM is used during the manufacturing of a product, but CAM is not part of initial design process itself. The same applies to computer aided testing (CAT), and computer aided work planning (CAP), and computer aided maintenance. Knowledge about available manufacturing, testing, and maintenance capabilities certainly influence the design. Recently the term computer aided engineering (CAE) has been used as a collective term for computer aids to design, while restricting CAD to computer aided drafting.

In the field of Industrial Design the use of CAD systems is used for the reduction of time and cost during the manufacturing of a product. The system that the designer uses today is not made so that the designer can easily produce a rendering and drafting. In large industries the Industrial Designer has does not have access to the full range of the computer processes. If the Industrial Designer was to have access to the CAE, CAP and CAT systems the designer could

produce a product that was close to error free. If the CAD, CAP, CAT and CAE systems were placed together, with the designers having access to each system, the designer would not be very successful because the applications of each program does not allow the user to be creative with their design. This type of database would allow the designer to concentrate on the form of the product without having to place a great amount of time on understanding all of the processes needed to produce a product, until the product was finalized, and at this point the designer could send the final idea through a series of tests and manufacturing processes, which would tell them where the flaws of the design were occurring.

1. Definition of Computer Aided Design.

It seems to be a popular idea today that CAD means a menu of analysis programs that can be called on by the designer. Generally these programs have very crisp acronyms. However, the avant-garde researchers in this area know that the true descriptor is computer—augmented design, and that this implies the synergistic interplay of man and computer.

Further, many analysis types that generally associate themselves with CAD are rarely involved with the interconnection of computers and every day engineering hardware. This area of computer-directed systems has so many fundamentals in common with CAD, and is often approached by designers with the same professional qualifications.

It seems wrong not to treat these topics as specialties based on a common set of fundamentals. The compulsory nature of this thought is obvious when one approaches the design of physical systems with integral logic components: that is, the components of the device perform their physical function as well as some logic function.

Whereas a microscope enables us to examine the structure of a subminiature world and a telescope reveals the structure of universe at large, a computer display enable us to examine the structure of man-made mathematical world simulated entirely within an electronic mechanism.

Computer graphics might best be defined as the communication of graphic (non-alphanumeric) data to or from the machine.

The CAD of CAD/CAM is basically the designing, drafting and analyzing visual information, displayed on the computer screen which has been composed of mathematical data.

With these three definitions of CAD we can easily see two important facts about CAD systems. First of all, we should understand the CAD, by data-base structure. A hidden base of programming lies behind the visual magic of CAD. The power of design without setting pencils to paper and analyzing and testing objects before they exist in the tangible world is created by vast painstakingly put together computer programs, often consisting of millions of recorded instructions.

The second factor is communication with graphics. Unlike business computer systems that crunch away numbers dealing with payrolls and inventory, the CAD system opens a window into the visual data.

Through this window, the computer can be ordered to display a wealth of information as drawings, diagrams, and even three dimensional images as real as if they were made of wood or metal not equation and numbers. Because man is a visual animal and his mind grasps the contents of a visual display infinitely faster than it can process an array of numbers or words, communication with graphics will be dominant in the future.

In addition to these two factors, interactive communication should be positioned in understanding CAD systems. When the necessary programming has been done, the designer can analyze and test the design right in front of his eyes. This interactive graphic communication requires two way communication between the user and computer, which needs more space in memory and more speed of operation. Instantaneous feedback is primarily necessary to provide effective participation between the user and computer. Interactive graphics systems are able to display not only the g raphical representation of the object being modeled, but also the result of analytical routines as well. This important feature allows designers to participate in an interactive design loop. In this way, he can maintain a conversation or dialogue with the computer, inserting human creativity into the decision-making process, and in turn constitutes the fundamental characteristic of an effective CAD systems.

Extremely fast and accurate, CAD systems store, retrieve, manipulate and display graphic information such as design of specific products. The basis of all this remarkable activity lies in the unseen, painstakingly

assembled computer programs. In the most basic application of CAD, these programs allow automated drafting, analysis of model and communication with computer graphic displayed on screen. CAD not only speeds up the slow and laborious work of drafting, but also enables the designer to study various aspects of an object, or assemblage, by rotating it, separating it into segments, or enlarging and shrinking details. Therefore, to understand the CAD system and the graphic information developed interactively by computer and user, in terms of a data-base structure, we should know the structure of computer systems and the structure of the programs which have been developed for graphic industry.

2. History of CAD.

Knowledge about the history of CAD will provide a better understanding of the present state of the art, and may even enhance the creativity of those planning to work in this field. There are several reason for this:

(1) As was the case when general system theory was developed in terms of both material and information flow certain analysis techniques were bypassed for hundreds of years. We did not have the ability to process information, but we did have the ability during and after the Industrial Revolution to process material flows. An appreciation of history will give insight into work of a fundamental nature that has already been completed.

(2) Understanding the diversity of the fields that give a background for computer augmented design is necessary so that workers who tend to contribute in a relatively narrow area have some insight into the colleagues that they may interact with.

Although CAD systems on the industrial design level, depend upon the developments of computer technology, and developments of CAD in the industry in general, they have influence on designing.

Table. 1 shows some of the milestones in the history of computer aided design. An infinite number of applications can benefit from developments in computer technology, in the CAD, and computer graphics. The technology has moved so rapidly that it has outfaced our ability to apply it immediately. To view as vast an area as we can, it is necessary to ponder the history of CAD before describing the areas where computer graphics has already demonstrated it's enormous potential.

Early in the 1950s, the Servomechanisms Laboratory at the Massachusetts Institute of Technology (M.I.T.) developed the first automatically controlled milling machine using the Whirlwind computer. This has led to do evolution of the Automatically Programmed Tool (APT). We note that computer-aided manufacturing is not a descendant of CAD, but has a distinct origin of its own. The step from APT to design programs including computer graphics functions, was outlined by Coons. In 1963 the development of a new system, based on the designer using a graphic display terminal was introduced.

Table. 1

HISTORY OF CAD

1736 Euler First paper on topology.
1850 Maxwell Field Concepts.
1920 Kron Network analysis.
1950 Energetic approach to systems analysis.
1950 MIT, Solution to differential equation on a cathod ray oscilloscope at Lincoln Lab.
1951 MIT Whirlwind I / First automatically controlled milling machine using the computer (CAM).
1953 Sage Air traffic control system was used to detect and displays the location of aircraft over USA continent.
1957 Backus Fortran Largge scale graphic plotting.
1960 Quantitative "System approach"
1962 Culler & Fried "Culler & Fried system."
1963 Sutherland Schetch-Pad system was developed at MIT as an impetus for interactive computer graphics.
1964 Practical time sharing.
1965 General Motors, DAC-1 (Design Augmented by Computer).
1965 Miller Integrated Civil Engineering System "Design language"
1966 Bitzer Plasma display / First practical interactive CRT's.
1967 Freeman Algorithms for the solution of hidden-line problems.
1969 Storage tube terminals.

1960's / Most large companies became participated in search of this field such as IBM, General Motors, Lockeed, McDonnel Douglas, GE and so on.

1970 Holographic Input/Output device.
1972 Design optimization by real time adaptive control.
1972 Univ.of Rochester / PADL-1 & 2 (production automation project) two geometric modeling systems.
1973 Lockheed demonstrated computer graphics.
1975 Eastman Computer-aided drafting.

1970's / The research began to bear fruit for various industries. Most soft and hard-ware were developed.

1980's / More popular to people by lower price and trend changing to microcomputer. CIM (Computer Integrated Manufacturing) for full computer process with data-bank.

This system was developed at MIT by a computer programer by the name of Sutherland. The software that he developed used the principles of rubber band lines, circles of influence, magnification, rotation and subframming of objects displayed upon the screen. In 1964 the General Motors Research Laboratories announced the development of a new system called the DAC-1 (Design Augmented by the Computer) system. The system was built by IBM according to GM's specifications in which the main concern was on producing hard-copies of drawing with the use of the interactive graphics techniques. The next graphic system that was developed came from the Bell Telephone Laboratories. The system was developed for geometrically arranging printed-circuit components and placement of connective wiring for schematic designs. This CAD system was an early implementation of the distributing CAD processing power along a local interactive workstations and a central host computer. IBM Components Division designed a hybrid integrated-circuit modules in 1966. Freeman suggested, in 1967, an algorithm for the solution of hidden line problems. A system called Gold was developed in 1972 at RCA for integrated circuit mask layout. Gold was implemented on a custom-made refresh display, it was driven by a small computer with a single disk, and was capable of interacting with a large time-sharing computer. The first half of the '70s was a time of much enthusiasm along the early CAD scientists and systems developers. Much theoretical work was done, laying down the fundamentals of CAD as we know it today. The Integrated Civil Engineering Systems (ICES) were developed followed

by a number of systems which implemented many principal ideas regarding a CAD methods base. The theory of finite elements and associated programs started a booming development. At the same time, considerable research activity was going on in the area of hidden line/surface removal. The University of Rochester's Production Automation Project in 1972, developed two geometric modelling systems called PADL-1 and PADL-2. In 1973, Lockheed demonstrated that computer graphics was a cost effective design process. In 1975, Chasen from Lockheed Aircraft Corporation described, in a publication, the benefits of computer graphics in CAD systems, and Eastman conceived a data base for this system. Hewlett Packard developed a microprocessor-base raster scan display terminal. In the late '70s the government became aware that the use of CAD and CAM systems were very economical and begin to provide funding for the integration of CAD technology towards the small sized industries. In the first part of the '80s these computer graphic systems became a standard tool for the large to mid sized industries.[1)]

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1)J. Encarnacao and E.G. Schlechtendahl. Computer Aided Design. (Berlin: Springer-Verlag Berlin Heidelberg, 1983). pp. 9-10.

John J. Allan III. Foundations of the Many Manifestations of Computer Augmented Design. In J. Vlietstra & R.F. Wielinga (Ed.), Computer Aided Design. (Amsterdam: North-Holland Publishing Company, 1973). pp. 31-36.

3. Design Concept of CAD.

A. Design and Computer.

The term CAD meaning, using the computer for designing, therefore CAD does not include computer technology and the system itself. The point is not the potential of the computer but more so the designer using it. The computer becomes a tool to create designs with. An important part of CAD is the way it can help in creating designs and how the operator uses it. CAD is the design system itself.

> "The CAD is a technique in which man and machine are blended into a problem-solving team, intimately coupling the best characteristic of each, so that this team works better than either alone." [2)]

It should be emphasized that using the computer to aid in design is different than using the computer to aid in analysis. In aiding design it suggests to the designer what might be the most appropriate thing to undertake.

The better way of approaching a definition for the CAD is to discuss the element in the definition of CAD. Design task must be done within time and economical constraints. A designer makes his decisions based on his best available information which is, in part, a function of how well he can communicate with his environment.

[2)] Ibid., P. 29.

His information interchange, with his environment can be facilitated with the proper computer interface, thus allowing the designer an opportunity to make a greater number of effective decision per unit time. More decisions per unit time means that some otherwise ignored or grossly estimated component interactions of the systems which the designer is designing may now be evaluated more quantitatively.

The statement above implies that (1) we must pay attention to time and economic restraints, (2) a designer's knowledge is a function of his ability to communicate with his environment, (3) a computer can facilitate this information interchange, (4) because design is decision -making we would like to make more effective decisions per unit time (5) that the sum total of individual efforts of man and machine are transcended when man-computer synergism takes place, (6) we are always striving to employ the best characteristics of each, and (7) given that some design system can work with many human designers, we are then capable of working with an integrated, multi-disciplinary team.

B. Philosophy of Designing with CAD.

In the past fifteen years the computer has changed the way that the design and design analysis processes are preformed. Theories are use to established clarity and insight. However, there is a gap with any theory to the actual practice of the theory. The theory needs to

have an approach so that the user can more fully understands the bases of his problem. The computer has made it easy for the designer to create work that is closer to error free and enabled the designer to optimize his time spent doing a procedure. Man has made great discoveries in the past 100 years, but in the more recent past man has started to make quantum leaps in the area of computers aiding man's mind. Further use of the computer will allow the designer to relieve himself from the tasks that has slowed his learning capacity down and allow him to improve in every field. The computer will also allow the designer to access a great deal more of the information that is available to him and stimulate each individual designer to a greater awareness of his environment. The computer will then supply the storage capacity for leverage, and it will also supply a method for communicating at a "high level".

C. Applications of CAD

Dividing applications of CAD into a few categories is impossible because there is no field that has not been affected by increasing demands of CAD.

The categories listed on next pages are the selected areas of infinite number of applications in order to grasp the idea of present—standing point of CAD system in general.

(1) CAD / CAM

CAM, the other side of CAD/CAM, refers to something that has come to be commonplace in manufacturing plants; computer control of production machines. They range from machine tools running on punched tape instruction to robots that can be programmed to perform any of variety of industrial tasks. The potential is greatly magnified when CAD and CAM are joined together.

Furthermore, if CAD/CAM implies full computerization which can be described with the acronym CIM (Computer Integrated Manufacturing), that system involves not only just connecting CAD terminal to computer controlled machines but also thoroughly computerizing a plant or company's manufacturing operation including control of the flow of parts and materials and the movement of products through the various stages of manufacture.

(2) Simulation (training & modeling)

One of the first significant applications of real-time digitally generated image is in the training of pilots as well as astronauts. Display of environmental terrain as seen from the cockpit of the aircraft are used.

The simulations must be sufficient to provide all the visual events necessary for pilot training and they must be generated fast enough to simulated motion.

Another application of simulated images are the modeling of the products for the analysis and test which can save enormous amount

of time and money, and also give safety increasing importance. These images of models can be a product itself or the user of the product such as Cyberman or Sammie which have been used at automobile companies.

Considering the immense amount of data necessary for a single image, one can easily realize how much data should be required for the real-time image generation.

(3) Architecture & Engineering

Interactive computer graphics is responsible for dramatic change in structural engineering analysis and design such as building structure, exterior and interior in architecture, electronic circuit design, engineering vehicle dynamics in aerospace, and the production of pressure vessels and mechanical parts.

The method used in these fields utilizes a set of simple shaped, interconnected elements to represent a complex object from which these models are derived structural equations that specify the contribution of each element to the total system response. When the contributions of individual components are combined, the behavior of complex projects can be predicted.

The extremely voluminous and complex geometrical and topological information required to describe three dimensional problems can now be generated via interactive graphics in microcomputers.

(4) Data Analysis & Communication

While words can be used to answer some questions, a visual image

may provide a clearer and faster explanations to communicate and analysis data that has been done.

One of the most practical areas where the computer graphics are used for data analysis is the map making from images that are sent from space. The technique called Remote-sensing provides us the new images, which are far beyond the visible aspects of our surrounding, are generated by measuring reflections of electromagnetic energy, including infrared, ultraviolets, X-ray, and microwave.

In map use, Remote-sensing technique has been particularly useful in detecting and analyzing something emphasized by special theme applying various band width for specific purposes such as water pollution, oil search, climate forecasting or density of population. Furthermore, these kinds of images can be reproduced by use of false—color presentation scheme, highlighting patterns to pin point the specific subject.

(5) Medicine & Chemistry

Computer graphic systems are being increasingly used to present bio-medical information for medical research, diagnosis and treatment planning. A computers system's ability to combine information from two-dimensional images, such as X-ray photographs fluoroscopes, or topographies scans, into full three-dimensional representation, can provide the medical profession with a new vision of the human body.

In the chemistry fields, drug design is moving from the lab to the terminal screen. A computer generated image of the DNA molecule

is used to make the model of molecular structure and this model can be viewed from any different angle.

Being at the core of life, DNA is of special interest to drugs researchers, who study how new drug interact with it. They design drugs and check out their properties without leaving the consoles.

(6) Crafting Image

Computer have revolutionized the method by which images are made. Computers especially equipped with graphic devices are sensitive to the movements of the computer artist. These computers function as the artist's apprentice, quickly taking care of all repetitive, complicated and tedious details.

The image drawn by computer can be used not only for the work of artists and designers but also in TV graphics which allow for the easy creation of logos, simple charts, graphs, illustrations, and series of advertisement.

As the technique has been rapidly developed, the three-dimentional images which are described show perspective and shading with infinite numbers of colors which are almost same as the realistic objects that the artists and the designers are going to describe, even in sculptures, photographs, or architectural drawings.

(7) Cartoon Animation

The traditional method of creating motion in an animated sequence requires the animator to draw a large amount of pencil drawings with

gradual or exaggerated variation from one figure to the next. The entire animation process is extremely labor intensive and rising labor cost are substantly increasing the production expense.

Several computer-aided approaches have been developed to solve these problems and reduce the costs such as the method called key—frame in-betweening, where the key-frames are drawn or traced into the computer and the computer performs the interpolation. These kinds of images generated by computer are interactively colored and automatically merged or assembled after pencil sketches have been digitized.

Recent developments now allow the simulation of multi-plane cameras and special effects. If these techniques are used properly, the quality of animation can be enhanced significantly in the future.

4. Industrial Design and CAD

A. Industrial Design in CAD Systems.

In CAD, it is more important how a designer can design effectively rather than what one can do with a computer system. A computer system in design is a tool. The point of using a computer system is to design methods to help one to utilize the system effectively. The concept of design has been changed from the time when the manufacturing was done by hand, with uncertain concepts of design, to today,

with the complicated information for creating the better design, we will be required to employ a new system.

An information processing tool, which has been developed, is computer hardware and its operating technique. The improvement of the operation speed and memory capacity of a computer, development of input and output devices, increasing the application of the computer and in turn making it possible to collect and exchange large amounts of data in varied fields of information. The technique of computer graphics, with which the input and output of a figure became possible, visualizing the complicated information and form with figure, and the removal of factors of trial and error, makes the problem clearly apparent. Therefore the designer and the computer have an intimate new relationship. The experience, knowledge, general principles, and logical considerations of the majority of people, should be saved as general information and using this information a designer can concentrate on exploring creative designs.

CAD, which is how to arrange steps and techniques to achieve the object concretely, is a reasonably composed program that has been completed for a specific computer system for creating design work. The use of computer techniques, such as tools and applications, for the computer design system and techniques used in the design process make a CAD system a very usefull tool in the industrial design field.

B. Designer and CAD Interaction

Even though a computer is a useful tool for the designer, it can make a designer a robot if they pursue effectiveness of the system without using their creativity. Utilization of CAD systems makes the designer concentrate on informal factors.

The efficiency of CAD ultimately depends on a designer, but in many ways it is governed by computer techniques such as the memory capacity and operation of the computer.

The advantages through CAD systems are as below ;

(1) The existing design information which was saved as a database of experience, knowledge and research can be utilized easily. Therefore one can manage design techniques effectively.

(2) The cost and time for simulation can be saved by using the computer. One can decide on the final idea carefully and accurately in the design phase by making the analysis and synthesis of the object simple.

(3) The labor and cost of producing the drafting and perspectives can be saved.

If a designer uses a CAD system during the design stage, they can concentrate on the creative problem, but if the design process is standardized, the creativity of the designer can be restricted. A designer should be careful not to be restricted on the creativity of the progressing design program because this weakens the final designs

created. When a designer tries to find the best design of a product, at the beginning of the formulation process, the designer can at that time give, to the product, only what the designer can offer, and that is their creativity and originality. A smart designer creates a form to fulfill the desires of the people.

The designer should have the capability to understand, describe, and formulate ideas for the situational problems, because these functions can not be completed by a computer.

During the design process of a product a computer will take on the quantity job, such as data and information storage and this will be broadened with the development of a computer technique at which point the designer will take on the responsibility of a products outlook.

With the development of a computer technique, the human qualities and creativity of a designer is then emphasized greater.

CHAPTER II

MICROCOMPUTER BASED CAD

1. CAD Education at College

The short term needs of college educators consist of training experienced designers to be proficient in the use of state-of-the-art CAD system. Such training is generally rote in nature, with the objective of making the trainee productive as quickly as possible. Such training has been easily accomplished in the past for artwork or drawing type applications. But new directions in complete CAD workstations will require a deeper understanding of the concept.

Industrial design is made up of a lot of fields. For example: the movement of the Space Shuttle from the needle, and designers learning about form ,color, texture, material, production processes, human factors, technical reference, and to help them in the decision making process. Companies have a different job applications, each company having a special CAD program and workstation. The industrial design student needs the microcomputer at this time because this type of computer will fit the needs of the students to learn computer applications. Many years of studying, to gain the knowledge in specific and more practical studies, are needed to be able to utilize the available CAD design systems using company based applications.

CAD represent a continually evolving integration of computer and computer graphics into the complete design-production process. The objective of university programs, is the education of students who can contribute to this integration process in a meaningful way.

Student will needs to thoroughly understand CAD/CAM from all points of view:

(1) as knowledgeable user of state of the art computer aided tool;
(2) as innovative creators of the hardware and software components which make up the computer aided tools;
(3) as systems integrators who can evaluate the impact of these tools on the total design production process. [2)]

In the university, the training and teaching effort involves the development and evaluation of special hardware and software for a personal computer to be used as low cost introductory operator training system.

Although CAD systems and software are developing everyday, all types of software are helping to improve the basic skills of the college student and small businesses in CAD systems applications.

The microcomputer represents one method for reducing training costs while still maintaining a flexible approach to training. The micro-

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[3)] Tosiyasu L.Kunii, (Eds.) Computer Graphics: Theory and Applications. (New York: Springer-Verlag, 1983), p. 203.

computer is well suited for introductory training, such learn as learning which buttons to push.

Such systems are designed to be less complex than productions systems, and are therefore less intimidating. One can also program instructions modules directly into the system to monitor exercises and provide help as needed. For example, an exercises may consist of showing the trainee a partially completed problem, and than asking for the next step.

Although the microcomputer suffers from limitations such as execution speed, display resolution, and memory size, it has enough capability to be a suitable training device.

2. Background of Microcomputer.

A. Mainframes to Microcomputers

CAD, or designing with the aid of a computer, has evolved to the point where each one of us will be exposed to its capabilities. Today, designing with the aid of a computer is not reserved for a chosen few. By purchasing a CAD package for a few hundred dollars to a few thousand dollars anyone can begin to design.

Almost 40 years ago a group of individuals at the University of Pennsylvania developed a computer called the ENIAC (electronic numerical integrators and calculator). The ENIAC is first generation computer, based on vacuum tubes, and was the first fully electric digital computer.

Table. 2

HISTORY OF MICROCOMPUTERS

1948 Bell Laboratories invent the transistor.
1959 Texas Instruments unveils the first integrated circuit.
1964 John G.Kemeny & Thomas E.Kurtz develop the BASIC programming language.
Digital Equipment Corp. advertises the PDP-8 minicomputer.
1971 Intel Corp. 4-bit 4004 microprocessor on a single chip.
1972 Intel Corp. introduce the 8008, their first 8-bit microprocessor
Nolan Bushnell founds Atari and ships the Pong video game.
1974 Gary Kildall develops the CP/M operating system.
1975 IBM 5100, the first briefcase-size computer (BASIC, 16K bytes,and a tape cartridge storage system)
1976 Texas Instruments announces its TMS9000, the first 16-bit microprocessor.
Apple Computer Inc. formed.
Shugart, 5 1/4-inch mini-floppy disk drive.
1977 The 1st West Coast Computer Fairs in San Francisco (Apple II and Commodore PET are introduce there).
1978 Epson America Inc. MX-80 dot-matrix printer; its high performance and low price.
1979 CompuServe, a telecommunications utility, founded
1979 Texas Instruments unveils TI-99/4, which include a color monitor
1980.2 Sinclair Research announces its ZX80 computer.
.3 Microsoft Corp., the Z80 SoftCard for the Apple II (availability of CP/M business Software)
.5 Apple Computer Inc. announces the Apple III.
.6 Shugart begins selling 5 1/4-inch Winchester Hard-disk drive.
.7 Commodore Vic-20, Radio Shark TRS-80.
.7 Zork, is first distributed by Personal Software Co.later by Inficom, its creators.
1981.4 Adam Osborne, potable Osborne I (Z80, 5inch Display, 64k RAM, 2-disk drive, keyboard, 2-serial port.)
.5 Xerox Corp. 8010 its use of icons,the "desktop metaphor", the mouse pointing device begin to influence microcomputer market.
.7 Hayes Inc. Smartmodem 300, which becames the industry standard.
.8 IBM introduces the PC (8088, 64K RAM, 40K ROM, 1-disk drive), which legitimized the microcomputer industry to the rest of the world and established preeminence of the Intel 8086-family processor and the Microsoft MS-DOS operating system.
.11 Epson America Inc. HX-20, the first laptop computer weight 3 lb. and runs a CMOS.
1982.5 Grid systems, Compass, futuristic briefcase-size potable computer with an electro-luminescent display.
.6 Motorola Inc., Hitachi Ltd. release preliminary specifications for 256K-bit chip.
.6 Intel Corp. announces the 80186 and 80286 processor
1983.1 Time magazine selects the Computers as its "Man" of the year.
.1 Apple Computer Inc. Lisa Computer
.2 IBM announces the IBM PC XT. It adds a 10mb hard disk, 3 extra slots.
.4 Microsoft Corp. announces multi-tool word "Word".
.7 Hewlett-Packard Company announces the HP-150, "Touchscreen"
.9 Shugart Corp. announces 1-gigabyte write 1-optical-disk.
.10 Borland International Inc. Turbo Pascal for CP/M and 8086 based computer.
1984.1 Apple Computer Inc. Introduces the Macintosh.
.5 Apple Computer Inc. unveil Apple IIc
.6 Motorola Inc. Adds the 68020 32-bit processor to its 68000.
.8 IBM announces the IBM PC AT (80286, 256k-bytes RAM, one 1.2-mega bite floppy-disk drive, Hard-disk) and its PC Network local-area network.

First generation computers took up large amounts of power, and were for the most part inefficient. For example, the ENIAC weight over 30 tons, filled a space 30x50 feet, and used enough electricity to operate three 150-kilowatt radio stations. Another first generation computer, which has developed at MIT in the early 1950s, filled a room about the same size as the ENIAC, had 4K of memory, and had less computation power than an ATARI home computer (64K, $100). The cost of first generation computers in the early 1950s were in the millions. The cost of computers has dropped tremendously in the past 35 years.

Second generation computers used transistors instead of vacuum tube. Transistors were introduced in the mid-1950s, and significantly reduced the amount of space and power required for the computer. A few years after transistors were invented, circuit boards; several components, such as resistors, diodes, and capacitors could be assembled on a single circuit board. Because of this new technology, computers became more compact and computing speed increased.

During the mid-1960s more compact circuits were designed and thousands of electronic components were formed on a single chip of silicon called an integrated circuit (IC). The advent of this integrated circuit technology is known as the third generation of computers. Because of the compactness of this new technology, signals had less distance to travel, which allowed computers to perform millions of operations per second.

Fourth generation computers are microcomputers. A microcomputers is basically on a chip. The size and cost of microcomputers have made mass production of personal computers a reality.

Personal computers are designed for both the nonprofessional and the professional who does not have specialized knowledge of computers. Changes in the marketing strategies of computers and software vendors recently made off-the-shelf personal computers with CAD commercially available. For the purpose of clarity and to limit confusion, the term personal computer will only be used when it refer to a specific system. The term microcomputer will be used to talk about small computer systems.

B. Microcomputer

Despite differences in appearance, all microcomputers are made up of the four basic modules (Fig. 1). The input device, the central processing unit (CPU), memory, and an output device. Data is processed in the CPU and stored in memory in binary digits (0 and 1).

(1) Central Processing Unit (CPU).

The CPU is the brain of the computer system, it was that part of the system that processed data or information. A CPU contains various electronic circuitry that is used for arithmetic and logical operations and for controlling the overall operation of the system. CPU the brain is not

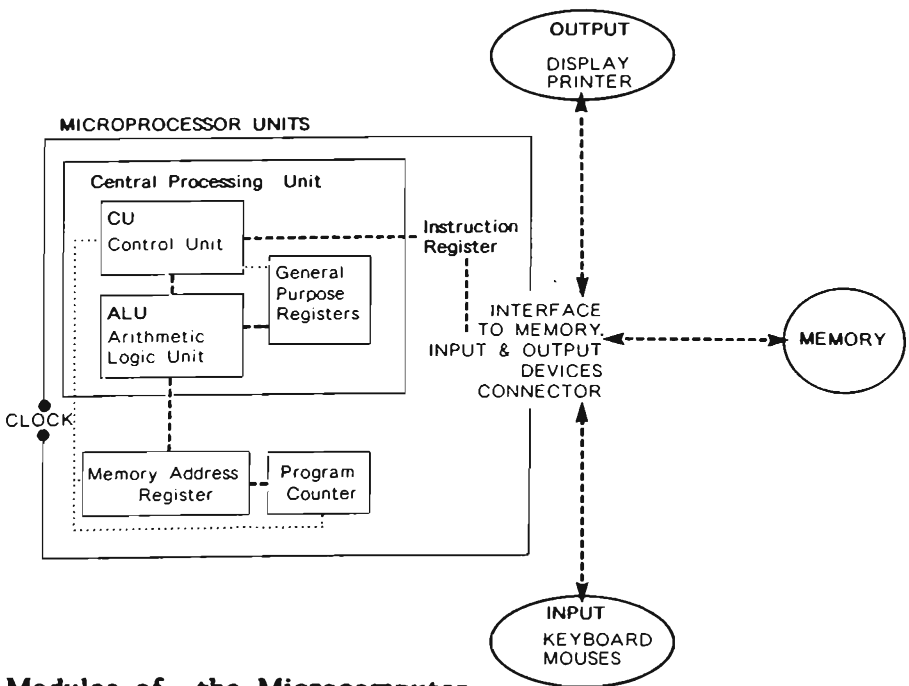

Fig. 1 Basic Modules of the Microcomputer.

just the electronics that make up the CPU. It is also instructions that tell the CPU how to, and when to, operate. A CPU's instructions are sometimes referred to as a microprogram or firmware. The instructions are usually stored on read-only memory (ROM) chips.

By function, the CPU can be broken up into two major parts. These two parts are called the 'Control Unit (CU)' and the 'Arithmetic Logic Unit (ALU)'. The control unit contains control circuitry used to direct and coordinate the activities of the entire computer system. The control unit can also be described as the decision maker. Specifically, the control unit does the following:

(1) Locates and retrieves instructions from memory.

(2) Interprets the instructions and generates signals that start a specific action.

(3) Direct and controls data from the CPU and other devices.

The CPU does its thinking with the arithmetic logic unit before it makes a decision. Even though the CU controls the operations of the ALU, the ALU does the arithmetic computation and comparisons. Think of an ALU as a number-crunching device that checks to see if answers are right.

Both the CU and the ALU contain 'Registers'. A register is a device used to store temporary information for the CU and the ALU. Most CPUs contain five major types. The control unit contains an instruction register (IR), a program counter (PC), and an address register (AR). The arithmetic logic unit contains a buffer register (BR) and the accumulator (ACC). Most registers currently in use store small amounts of information--usually

one computer word. Most CPUs also have other types of registers called general purpose registers (GPRs).

Today's microcomputers contain processors in their CPUs which are located on microchips of silicon. The computer, which started by filling a large room, is now located on single chip. Hence the name microprocessors, or microprocessing units (MPU). An MPU is the control and processing portion of a microcomputer, and in some cases it can be considered a small computer in itself. In fact, if you add memory, an interface unit, and a microprogram, it could be called a microcomputer. Today, the majority of microcomputers use 16-bit microprocessors. This generally means that the number of bits that can reach the MPU is 16 bits wide. It is called a data path.

In a advantage of 16-bit MPUs is in their capability to handle more information within a specific time period; they are therefore faster processors. However, what makes one MPU "better" than another MPU is not just the word size (8bit or 16bit) but performance, speed, compactness, ability to enable graphics and/or sound, and available software. Some 16-bit MPUs used on personal computers include the 8086 and 8016 by Intel. Another microprocessor is the 8088, which has an 8-bit external path but a 16-bit internal data path.

It appears that within a few years 32-bit MPUs will be available for personal computers. When these MPUs become available, it will be like having the number crunching capability of the old IBM 370 mainframe.

Clocks are usually located in the MPU but are controlled by an exter-

nal. Generally, clocks determine how long it takes for the computer to execute individual instructions. The 16bit microprocessors run between 5MHz to 12MHz. The frequency and stability of the MPU is dependent upon the clock's operation; if the clock were off, almost every logical device within the MPU could be affected.

(2) Memory; RAM and ROM

There are primarily two types of memories used in computer systems today: random access memory (RAM), and read-only memory (ROM). RAM memory is the type of memory the CPU uses to store or retrieve information randomly.

RAMs use MOS (metal-oxide-semiconductor) technology in their construction. RAM memory is volatile, meaning that if power is lost, all data stored in memory is lost. To avoid this loss of data, MOS memories are refreshed (RECHARGED) periodically. MOS memories contain storage cells (capacitors) that use the presence or absence of an electric charge to represent the value of a bit. Each RAM chip contains the logic required to perform a refresh on itself and doesn't require involvement by a CPU. Because MOS memory require a refresh cycle, it is called dynamic. Another type of RAM is called static MOS. In static MOS or static RAM the storage cells used are different than those used on dynamic RAM. A bistable circuit called a flip-flop is used in a static RAM instead of the capacitor used on a dynamic RAM. Static RAMs do not need to be refreshed.

Another type of memory used to store microprograms is called read-only-memory (ROM). As the name suggests, this type of memory can only

read from. ROMs are nonvolatile, which means information is not lost when the power is turned off. ROMs are usually used to store the MPU microprogram, generally called 'firm-ware'. Another variation of ROM is called EPROM (erasable programmable ROM). An EPROM allows a user to erase its contents with the use of ultraviolet light.

(3) Input and Output Devices

An input device is a tool for the user to communicate with the CPU. Specifically, it provides the means for the user to input programs, commands, and data to the CPU. The most frequently used device on a personal computer is a keyboard.

An output device provides the user with the means to receive information from the CPU so it can be used. The most frequently used output devices on a personal computer are the video display screen, followed closely by the dot-matrix printer.

(4) External Auxiliary Storage

RAM is volatile. When information is stored in volatile memory and the power is turned off, the information is lost. An external auxiliary storage device is required so that the information can be stored and used again.

The types of auxiliary storage devices vary. Some of the most popular auxiliary storage devices used today are the following:

(a) Floppy disks

(b) Hard disks

The floppy disk is one of the most widely-used auxiliary storage device for minicomputer and microcomputer systems. Floppy disks (also called diskettes) are similar to 45 rpm records, but instead of using grooves likes a record, a disk is made of Mylar, coated with a magnetic emulsion similar to that used on tape cassettes. Each disk is sealed in a cardboard envelope to protect the disk from dust and handling. The envelope has a small slot that allows the read/write heads on the disk drive to access it.

On a typical 5¼-inch floppy disk, there are 35 to 40 tracks and up to 110 sectors per track. Each track can be randomly accessed by moving the read/write head over the disk. A system using double-side/double-density disks can store about 360K bytes of useful information.

A hard disk is available for many personal computers. A hard disk device is similar in concept to a floppy disk device. Disks range from 5 to 12 inchs in size for small computer systems. Because hard disks are manufactured with greater precision, the density or compactness of the storage capacity is greater. Quicker access time is another benefit of harddisk. The amount of time it takes to read or write data to hard disk can be up to 50 times faster than floppy disks. When hard disks were first developed, they were nonremovable. That is, they were a part of the disk drive assembly it self and couldn't be taken out.

Today, removable disks are also available. Removable disks allow a user to replace one disk pack with another. Easy installed hard card disks are available. CAD software need large capacity storage systems and hard disks are highly recommended for this application.

3. CAD Graphic Devices Applications

Operators, designers, engineers, and graphic artists use CAD/CAM systems. The CAD system combines the computer's ability to process, store, retrieve, and display computer graphics with the user's input.

The range of CAD applications is large and is growing every year, but most application areas can be grouped into three major categories; design, analysis, and manufacturing. Some specific applications include mechanical design, drafting, printed circuit design, architectural design, integrated circuit design, and technical publications. CAD is not limited to these: however, these are the major areas where CAD/CAM is widely used.

The traditional way in which engineering drawing are created, revised, copied, and distributed has undergone few basic changes since they became an essential part of communicating technical information. Most of the change have been improvements in materials, tools, reproduction methods, and technique. These have resulted in substantial economics and improved efficiency, but now the field of engineering graphics is gradually entering a new era made possibly by electronic and electro-mechanical technology.

A. Interactive Graphics.

An interactive graphics system consists of a group of devices working in conjunction with a computer. It usually consists of the following;

(1) A minicomputer. Reduction of computer size and cost are largely

responsible for the progress being made with interactive graphics.

(2) Up to four design stations, each with an electronic tablet, keyboard, and a cathode-ray tube display (CRT).

(3) A memory bank capable of being programmed with basic information, capable of recording and storing input, and capable of providing cathode-ray, tube display of any of this information on request the design station.

(4) A variety of output devices such as plotters, computer output microfilmers, tape or disk memory, and units to make tape for operating tape-controlled machines.

Interactive graphics represent a drastic departure from traditional engineering graphics. It permits the engineer, designer, drafter to perform all design functionswithout the traditional drafting tools and media. In addition, it uses the ability of the computer to perform calculationsand make automatic checks. In spite of an interactive graphics system's ability to perform a large number of functions, it is not a replacement for the drafter. Rather it is a tool which enable drafters to practice their profession more efficiently.

Experience has shown that most drafters adapt well to interactive graphics with some traditional training. More and more companies are taking a hard look at interactive graphics. Their interest is based on the potential for increased productivity at lower cost for engineering drawing. In addition, there are fringe benefits in the areas of drawing storage, reproduction and distribution, generation of parts lists and price lists, inventory control and

other production related functions and calculating and compiling engineering information.

It is likely that no two interactive graphics installations are exactly alike, but all have two basic parts hardware and software. The hardware consists of a computer and related pieces of equipment. In some situation the entire system may be purchased from one supplier. In others, the do-it—yourself approach is the most desirable, with the various piece of hardware coming from different suppliers. The choice of approach largely depends on the needs of each individual application.

Software is the key to any interactive graphics system. It consists of the computer programs and stored information that make a system work. Software gives each interactive graphics system its own unique ability to perform specific functions in creating engineering drawings or compiling engineering data. Suppliers of complete hardware systems usually also develop software that can perform specific function or can be modified as required. On the other hand, there are suppliers whose specialty is software packages that can be used as-is, with do-it-yourself combinations of hardware as required by a specific combination of hardware. Software packages for drafting applications have been slow in development, but this is changing as the demand grows. In some cases the cost of software may be higher than the cost of hardware.

Interactive graphics is not something to be taken lightly. The costs involved and complexity of the many related considerations need to be fully investigated, understood, and evaluated.

The ultimate aim of interactive graphics is to achieve greater drawing output at lower cost. This doesn't happen automatically. It starts with a through analysis of the tradition graphics procedures in use, including their relationship to other function such as manufacturing, quality control, inventory and stock control, and purchasing. This is especially important because it is not likely that all aspects of the traditional graphics system can be replaced by interactive graphics at one time. At the very least, the two systems will probably have to work together until the interactive system is completely functional. It is also possible that an interactive system may only be a practical replacement for part of a traditional graphics system.

Interactive graphics are most easily implemented in disciplines which can be standardized to a substantial degree. For this reason, interactive graphics are more widely used for electrical, electronic, and printed circuit diagrams than for mechanical drawings.

The rest of this chapter will deal with the various components required to make up a CAD system.

B. CAD Display Terminal.

The modern graphics display is extremely complicated in construction. It consists of three components: a digital memory, or frame buffer, in which the displayed image is stored as a matrix of intensity values: a display monitor, i.e., a home TV set without the tuning receiving electronics: and a simple interface, called display controller, that passes the contents of the frame buffer to the monitor. The image must be passed repeatedly to the

monitor, 30 or more times a second, in order to maintain a steady picture on the screen.

Typical program structures (Fig. 2) for computer displays have the form shown here. Information about objects is stored in the data base. Information about the appearance of the objects is stored in the display file. The actual appearance of the objects is specified by programs in the display-file generator. These programs perform geometric operations and expand the definition of objects.

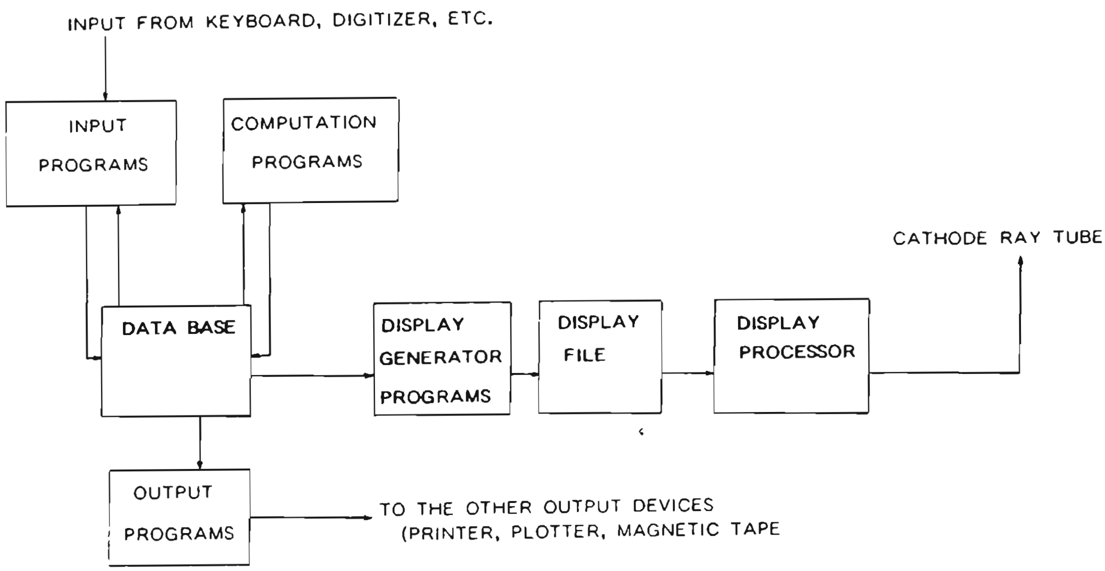

Fig. 2 Typical Program Structure.

In addition to understanding data based structure of computer graphics there is another important element, we should grasp the idea of the computer display system. In general, two types of computer display equipment are

available: calligraphic or vector displays, and raster video displays. Both types depend on the glow emitted by a phosphorescent screen when bombarded with a stream of electrons.

The vector displays are cathode ray tubes (CRT) and are unique in their ability to draw from one arbitrary (X1, Y1) location on the screen to another (X2, Y2) location. If the beam is turned on when it is deflected to various parts of the screen, it leaves a visible trace that has been encoded as a sequential and directional record of point coordination (Fig. 3). Therefore, the resolution of the image depends on a short test line segment.

The raster video displays consist of two basic components, frame buffer and digital to analogue converter (Fig. 4). The pattern converted by DAC is scanned horizontally by electron-beam of cathode ray and draws graphic images proceeding downward one line after another. The resolution of this display, thus, is determined by the size of pixels.

C. Graphics Input Devices.

An input device provides the means for user to enter programs, commands, and data into a computer graphics database. An input device in a CAD system can be used to control the cursor on the display to converting existing drawing into computer usable form.

An input device can be thought of as a tool for capturing data and

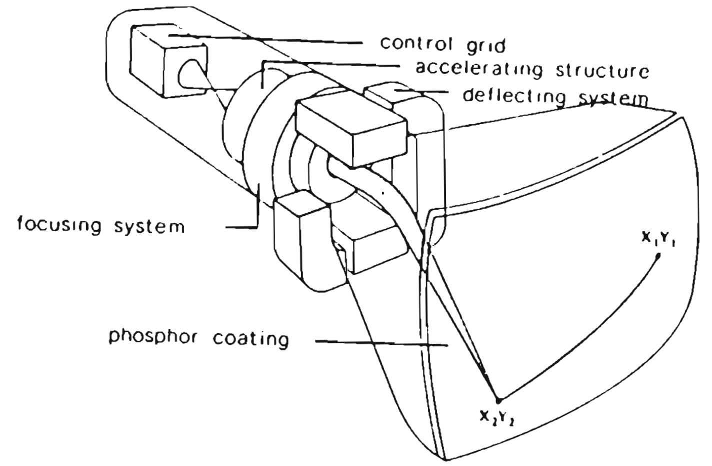

Fig. 3 Vector Calligraphic Display.

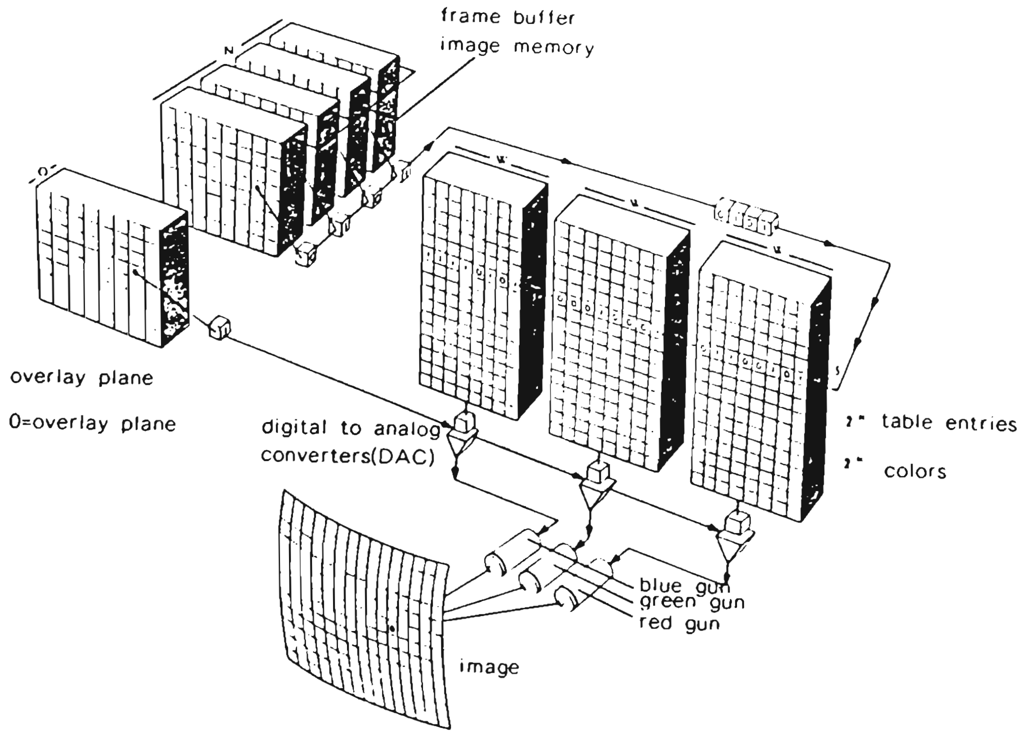

Fig. 4 Color Mapped Frame Buffer.

then sending it to the graphics database for processing. There are different types of input devices, and each one can interact with the CAD system in different ways.

(1) Digitizer Tablet

A Digitizer tablet is a drawing tablet upon which user draw using an electronic pen. Graphic work has been traditionally done using pen and paper; because of this, many people prefer a digitizer tablet as a CAD input device. The digitizer tablet consists of two separate components, the digitizer tablet and the positioning pen or puck. A digitizer tablet is a large flat surface over which you move a digitizer pen. The operator would draw on the tablet using the electronic pen the same way anyone draw with a pencil on a piece of paper. Graphics tablets come in many sizes ranging from 6x6 inches up to 60x40 inches. A digitizer is a good CAD input device. Another input device that is used is called an electronic puck and stylus.

The digitizer tablet is probably one of the most versatile input devices that allows a user to maintain control over the interactive graphic system.

There are three general uses for digitizer: graphic input, cursor tracking, and menu input. Graphic input is the obvious use. A source document such as map, drawing, IC mask, X-ray film, or piece of hardcopy is secured to the tablet. Areas of interest are digitized (pointed to or traced), and the X-Y coordinates are appropriately processed by a computer. The operator can move a cursor and track their movement on a graphic display. The operator is interacting with a display by moving a hand-held device on a

digitizer. Moving the device left and right moves the cursor same direction on the display. Using a digitizer as a menu input pad really has nothing to do with graphics. The digitizer acts like an infinitely redefinable array of programmable function keys.

Mouses, joysticks, trackballs, light pens, Koala pad, and other devices are often used for cursor tracking or menu selecting on the screen, but many studies have proven that although a digitizer may be more expensive than another device it outweighs its price in productivity increase.

(2) The Mouse

The mouse is a hand-held input device. There are basically two different types of "mice". One type contains rollers on its base to allow it to be moved over any flat surface. When this type of mouse is rolled, its direction is determined by the number of revolution of the rotors under the mouse. Another type of mouse uses optical sensing mechanisms to determine the location of the mouse in relation to the cursor on the display monitor. This type of mouse requires a special mouse pad, which works in conjunction with the mouse to track the cursor across the screen.

The mouse is used with very little motion by pushing it across the mouse pad. The mouse can be picked up and placed back on the pad without any change in the screen cursor position. The mouse contains two or three separate buttons used to select an item of the screen, input commands, or a variety of other uses that depend upon the application program being used. The mouse is simple and comfortable to use. Many personal computer

and CAD system manufacturers are now using a mouse as an optional input device.

(3) Keyboards and Function keys.

A CAD keyboard is similar to a typewriter keyboard. It normally consists of alphanumeric and function keys. The keyboard is used to enter commands to the system, such as dimensions or measurements, during a design process. Keyboards are mostly used for text entry, and they are not always useful for graphics input. In early CAD system, the keyboard was the only input device that could be used to input numeric coordinates of various points and select objects. Some keyboards also include special function keys to allow you to interact with the system without having to rely on a digitizer or other input devices.

(4) Light Pen / Touch Pen

The light pen is another direct working on the screen and is fairly interactive work. It is two different ways in which light-pens are handled, depending on the type of output device used. It may take the picture element directly from display file (as done with random writing refresh vector displays, which have a timing correspondence between reading the elements from the display file and writing them on the screen), or it may take the position picked on the screen (as done with refresh raster displays) and find the picture elements by scanning the display file and checking for correspondence. Hence, no searching is required; the identification of the graphical

element pointed at with the light-pen is immediate. Storage type devices do not have this capability; it requires the direct identification to be simulated by the input of a pair of coordinates the display surface with a subsequent search for the nearest graphical element.

D. CAD Output Devices.

There are two major classes of the output devices: devices for hardcopy production (plotter, printer), and interactive graphic devices. No matter what type of application a user might be doing on a CAD system, an output device of some kind is required to get a copy of the drawing or design. Because lasting results are always necessary in almost every application of interactive computer graphics, there are three basic types of results a user may want on a CAD. They are a plot, a hard copy, or a photoplotted copy. Let's first discuss plotters, which generate plots.

(1) Pen PLotters

Pen plotters are usually used to produce a finished drawing. They can use ballpoint, liquid-ink, or mylar-tip pens. A pen plotter, uses a combination of pen movements in the X and Y direction to produce straight-line drawings. Two independent motors move the pen and paper in the horizontal and vertical directions. Combined action of the two motors controlled by a built- in processors enables a plotter to draw lines in almost any direction. Colors can be plotted on drawings by changing the pens. Most plotters

can use several types of pens with different line widths. This allows a user to draw on different types of surface, which have different absorption characteristics.

In the traditional method of designing, a designer would normally be sitting at a drafting table and inking in the drawing. With plotters, the same capability is built into the CAD system. Once a drawing is designed, the plotter plots the drawing for the designer. There are three different types of pen plotters. They called flat-bed plotters, drum plotters, and belt-bed plotters.

(2) Laser Printer

Laser printer/plotters write the picture line by line similarly to the electrostatic plotters. They are very fast, and best suited for combining alphanumeric and graphic output. Laser plotters are expensive machines, and not typical for CAD applications.

(3) Ink Jet Printer

Inkjet printer have been developed particularly for graphic output of colored areas rather than colored lines. They are not yet very popular in CAD environments. The production of colored picture with these machines is oriented more toward the presentation of results to management or customers, rather than toward communication on a technical level. The price of these devices are decreasing.

Other printer/plotters operate on a mechanical basis and produce pictures

comparable to those of the inkjet plotters. Needles or flexible hammers hit against ribbons of different colors while being moved along a line to be printed.

4. CAD concept on Microcomputers

A. Hardware Supported by CAD Programs.

The ability to generate graphics on a computer to provide graphs, charts, engineering drawings, solid modeling, and pictures, is here today. Before the appearance of microprocessors, intelligent graphics terminals were too expensive and large sized. Graphics processing was originally accomplished on a centralized processing unit. With the advent of microprocessors, computer graphics are now within the reach of an average worker. Today, graphics software and individual microprocessors (for example, the INTEL 8088, used on many personal computers as a graphics processor) are educational aids or small office computers within a stand alone systems without any reliance on a host computer.

A display terminal is a window into the world of design. Combined with other hardware and software components, its called a 'Work Station'. The very term work station implies an area where someone work. It is at the work station that we interact with the system to create, modify, or display design works.

CAD programs make unusually heavy demands on micro-computer. Probably the most critical hardware decision is which video adapter card and display terminal (monitor) to use. The standard IBM color system suffers from barely acceptable resolution in single-color mode and unsatisfactory resolution in four-color mode, the reasonable low-cost option

is the Hercules Monochrome graphics system. The 720 by 348 Hercules resolution is serviceable, but user will have a difficult time with a complex design work because user misses the use of colors for parts separation. The following chart (Table. 3-1) is about CAD program support video adapter system and resolution.

The Microcomputer's cursor keypad is not a good substitute for a digitizing device. The best (and most costly) option is a digitizing tablet using either a pen-like stylus or a puck with one to 16 buttons. Preexisting drawings can be traced better by using a puck, but many users find the stylus more like a drawing instrument. Tablets further allow the operator to place tablets on the pad if the CAD program supports them. Tablets are available in many sizes; larger tablets are better for tracing in old work, and 9 or 12-inch square tablets work well for most applications. Some CAD systems support mice as a alternative to a tablet. A mouse is satisfactory for drawing input, but because it is a relative device, tablet menus cannot be used. Some CADs also support joysticks, but most find joysticks much less satisfactory than tablets or mice.

Most CAD systems support a long list of plotters (Table. 3-2). Some CADs also can draw to a dot matrix or laser printer, but output created with these devices is usually too small and inaccurate for finished drawings. The main determinant in plotter selection is the maximum plot size the device can draw. Most serious CAD environments require "E" size plots (36" by 48"), although "D" or smaller plotters have their uses too. Here again, speed counts: plotter throughput can be a major

Table. 3-1

HARDWARE SUPPORTED BY CAD PROGRAMS

	AutoCAD	In*a*Vision	ProDesign II	3Design/3	MegaCADD	VersaCAD	Dr. Halo II	CADKEY
VIDEO DISPLAY OPTIONS								
IBM CGA	●	●	●	●	●	●	●	●
IBM EGA	●	●	●	●	●	●	●	●
IBM Professional	●							
IBM 3270			●				●	
AT & T 6300	●		●				●	●
Cambridge M-1024	●							
Conographic M-40	●		●		●	●	●	●
Hercules Graphics	●	●	●	●	●	●	●	●
Persyst BoB			●					
Scion PC640	●							
Sigma Designs400	●				●		●	●
Tecmal GM	●		●		●	●	●	●
Vectrix	●							
Amdek MAI				●	●		●	
Number Nine	●				●		●	●
PLOTTER OPTIONS								
Amdek Amplot II	●			●	●			
CalComp 965	●		●					
CalComp 104x	●				●	●		
Epson HI-80			●					
Hewlett-Packard 7470, 7475	●	●	●	●	●	●	●	●
7550, 7580	●		●		●	●		●
Houston Inst. DMP-29	●		●		●			●
DMP-41, 42	●		●	●	●			●
Enter Computer's Sweet-P	●		●					
Roland DG	●		●		●			●
Ioline LP3700	●		●		●	●		

Table. 3-2

HARDWARE SUPPORTED BY CAD PROGRAMS

	AutoCAD	In*a*Vision	ProDesign II	3Design/3	MegaCADD	VersaCAD	Dr. Halo II	CADKEY
PRINTER OPTIONS								
Epson FX-80/100	●	●	●	●	●	●	●	●
HP Laserjet 2686A	●	●	●				●	
Okidata 92/93	●	●	●	●			●	
Quadjet (color)				●			●	
Textronix (color)							●	
Epson Compatible				●	●		●	
DIGITIZER OPTIONS								
CalComp 2x00 tablet	●					●		
GTCO Digipad 5,7	●		●	●			●	●
Hitachi Tiger II	●		●	●	●	●	●	
Houston Inst.								
PC PAD	●		●		●		●	
HI-PAD	●		●	●	●	●	●	●
Kurta Series	●		●		●	●		●
Numonics 2200	●					●		●
Summagraphics								
Bit Pad One	●		●		●	●	●	●
MM tablet	●		●		●	●	●	
Mouse Systems Mouse	●	●	●	●	●	●	●	●
MicroSoft Mouse	●	●	●	●	●	●	●	●
USI OptoMouse	●							
Logimouse	●	●				●	●	

factor in a commercial system, especially if the operator works with complex plots. A printer buffer can further save time by storing plotting commands while you work. The lesson to learn before choosing hardware for a CAD system is that equipment that seems inexpensive now may end up costing more over the long haul in terms of throughput and efficiency. [4)]

B. CAD Programs for the Microcomputer

CAD software is made up of complicated sets of drawings and editing capabilities. The greater the number of features, the greater the power of the program. CAD programs are made up of straight lines, arcs and circles, points rectangles, ellipses, polygons and multi-width lines. Free-form sketching solid modeling, zoom, pan, grids,"snap" and scaling are some of the features that improve the ability of the program. Some CAD programs can make both two dimensional and three dimensional images which increase the range and quality of images that can be produced on a microcomputer. The chart (Table 4) indicates which drawing, editing, and other features. CAD programs can store images on-disks to allow the user to create a library of information that can then be inserted into other drawings.

[4)]Glenn Hart "CAD: The Big Picture for Micros" PC Magagine, March 11, 1986, pp. 117-179.

Table 4-1

CAD Software Capabilities.

	AutoCAD	In*a*Vision	ProDesign II	3Design/3	MegaCADD	VersaCAD	Dr. Halo II Graphics only	Paint Brush Graphics only
DRAWING COMMANDS								
Line	●	●	●	●	●	●	●	●
Auto line closing	●	●		●	●			
Continuation	●	●		●	●		●	●
Wide line	●	●	●			●	●	●
Parallel lines						●		
Point/Node	●					●	*	*
Cilcle	●	●	●	●	●	●	●	●
Arc	●	●	●	●	●	●	*	*
Ellipse		●	●		●	●	●	●
Multipoint curve			●		●		●	●
Rectangle		●	●			●	●	●
Squire		●			●		●	●
Polygons		●		●	●	●	*	*
Polylines	●			●	●		*	*
Solid areas	●	●		*	*		●	●
Arrows			●	●		●	*	*
Text	●	●	●	●	●	●	●	●
Centering	●		●	●	●	●	●	●
Auto-aligned	●		●	●	●	●	*	*
Font changes	●	●	●	●	●		●	●
Rotation	●	●	●	●	●	●		
Bold-face		●					●	●
3Dimensional Drawings								
Torus/N-side shape/Extend				●	●	●	*	*
Curved surface					●	●	*	*
Solid modeling				●	●		*	*
V-point changings	●			●	●	●	*	*
Object tree				●			*	*
Hidden line Removing	●			●	●	●	*	*
DRAWING ASSISTANCE								
Snap/ Variable sizing	●	●	●	●	●	●	●	●
Aspect	●	●			●	●		
Isometric	●		●	●	●		*	*
Grid/ Variable sizing	●	●	●		●	●	●	●
Axis/ Variable sizing	●	●	●	●	●		*	*
Orthogonal mode	●	●	●			●	*	*
Object snap	●	●	●		●	●	*	*
EDITING COMMANDS								
Selection/ Individual objects	●	●	●	●	●	●	*	*
Group objects	●	●	●	●	●	●	*	*
Window	●	●	●			●	*	*
Last object	●					●	*	*
By entity type				●	●	●	*	*
Erase	●	●	●	●	●	●	●	●
Unerase	●	●	●		●	●		
Move	●		●	●	●	●	●	●
Copy	●	●	●	●	●	●	●	●
Mirror image	●	●		●	●	●	●	●
Rotation		●	●	●	●	●	●	●

Table 4-2

CAD Software Capabilities.

	AutoCAD	Int*a*Vision	ProDesign II	3Design/3	MegaCADD	VersaCAD	Dr. Halo II Graphics only	Paint Brush Graphics only
EDITING COMMANDS								
Endpoint join	●			●	●	●	●	●
Resizing		●				●		
Layer change	●	●			●		*	*
Area fill		●	●				●	●
Break/ trim	●			●	●		*	*
Line/Circle	●					●	*	*
Fillet	●					●	*	*
Chamfer	●						*	*
Arrays	●			●		●	*	*
Rectangular	●			●		●	*	*
Circular	●					●	*	*
File editor								
INQUIRY COMMANDS								
List Characteristics	●			●	●	●	*	*
Calculate distances	●		●	●	●	●	*	*
Calculate areas	●					●	*	*
Calculate moments						●	*	*
Graphis Commands	*	*	*	*		*		
Painting					●		●	●
Text font					●		●	●
Line/ Cilcle/ Squre					●		●	●
Spray					●		●	●
Shirink					●		●	●
Copy					●		●	●
Grid					●		●	●
Pattern editing					●		●	●
Zoom					●		●	●
PLOTTING CONTROLS								
Variable sizing	●		●	●	●	●	*	●
Pen speed control	●		●		●		*	
Plot rotation	●	●	●					●
Automatic scaling	●			●	●			●
Exact scling	●		●	●	●	●		●
Spooling		●						
Plotter optimization	●							
Hiddenline remove plotting	●			●	●	●		
ATTRIBUTES								
Visible/ Invisible	●				●		*	*
Editable	●					Opt.		
Output Comma delimited	●							
Output fixed position	●							
Output special format	●							
DISPLAY CONTROLS								
Menu display	●	●		●	●	●	●	●
Command display	●	●	●	●	●	●	●	●

Table 4-3

CAD Software Capabilities

DISPLAY CONTROLS	AutoCAD	In*a*Vision	ProDesign II	3Design/3	MegaCADD	VersaCAD	Dr. Halo II Graphics only	Paint Brush Graphics only
Zoom	●	●	●	●	●	●	●	●
Window	●	●	●	●	●	●	●	●
Specify magnification fact.	●	●	●	●	●	●	●	●
Nesting/return	●	●			●	●	●	●
Pan	●	●			●	●		
Visible coordinates	●	●	●		●	●	*	*
Visible dimensions		●	●				*	*
Change limits	●						*	*
Change unit base	●		●	●	●	●	*	*
Named views	●			●	●	●	*	*
Solid fill control	●				●		●	●
Object dragging	●	●	●		●			
Isometric drawing	●					●		
Perspective drawing				●	●	●	*	*
Cursor icons		●					●	
LAYERS / Max. number	inf	16	inf.	*	*	250	*	
Named layers	●							
DIMENSIONING					Link		*	*
Linear	●		●	●	●			
Angular	●			●	●			
Diameter	●			●	●			
Radius	●			●	●			
Extension lines	●			●	●			
Tolerances	●			●	●	●		
Leaders	●				●	●		
Center Marks	●			●	●	●		
Horizontal	●			●	●	●		
Vertical	●			●	●	●		
Aligned	●			●	●	●		
Rotated	●			●	●	●		
BLOCKS							*	*
Define from active file	●	●	●	●	●	●		
Save on-disk	●	●	●	●	●	●		
Size scaling on insertion	●	●	●	●	●	●		
Rotation on insertion	●	●	●	●	●	●		
HATCHING/Number of pattern	41					●		
User defined pattern	●			●	●	●		
HELP /On screen	●		●	●	●	●		
MISCELLANEOUS COMMANDS								
COMMAND SCRIPTS	●							
SLIDE SHOW	●				●		●	●
FREEHAND SKETCHING	●	●			●		●	●
3DIMENSIONAL	●			●	●	●	*	*
LINK PROGRAM	●			●	●	●		
TABLET MENUS	●		●					

Many of the CAD programs provide some kind of cataloging of the stored parts, making retrieval faster.

Some specific application packages (software) used on CAD/CAM systems are:

a. Mechanical design and drafting.

b. Solid shade and rendering.

c. Numerical control for manufacturing.

d. Architecture design and drafting.

e. Interior design and perspective drawing.

f. Circuit design.

e. Industrial Design.

Some CAD software add high level links to languages like FORTRAN, Pascal and C, and with the AutoCAD software the program has these language features built into the program.

Software utilizes the abilities of the computer hardware and allows the operator to increase their working capabilities.

The charts which indicate, width a dot for yes, what each package offers, are based only on the intrinsic features of the program and not the work-arounds.

(1) AutoCAD

Autodesk Inc.'s AutoCAD dominates the microcomputer CAD market through its use of third-party programs books and its sophisticated programing. The AutoCAD program is typically sold with three extension

options called ADE-1, ADE-2, and ADE-3. Each program builds on the previous level, increasing the capabilities of the program, all of which have been written in C language. The AutoCAD can operate CAD/CAM/ CAE hardware. AutoCAD drawings can be interchanged between most large CAD systems (CADAM, Intergraph, Computervision, CALMA and APPLICON BRAVO) as well as IGES. The data from the AutoCAD program can be extracted from the drawings generated for use with programs like Lotus 1-2-3 and Symphony from Lotus and dBASE II and III. AutoCAD is available in German, French, Italian, Swedish, English, Spanish and Japanese. The installation of this system is very straight forward because of its supporting instructions. The program provides a wide range of video adapters, digitizing devices, plotters and printers. The AutoCAD program is available on IBM-PC compatible computers and can support over 120 different peripheral devices. The use of on screen menu which occupies a strip along the right side of the screen makes moving around less of a chore because each screen has a command to return to the previous menu or to the root menu. AutoCAD can be considered both menu and command driven which directly shortcuts the menu system. The operator can also customize their own menu of objects or texts and designate an area of the screen, through a block menu, for their own menu lists. Layers improve the AutoCAD system because of the convenient of grouping related entries on separated layers, especially since each layer can be displayed in a different color on the screen. Auto dimensioning of objects can calculate distances, the lengths of peri-

meters and the areas of closed polygons, exact screen coordinates, and angles. The text commands for the AutoCAD can be sized; justified right, left or center; rotated at any angle; and aligned between two points (in which case AutoCAD sizes the text to fit perfectly). Version 2.17 of AutoCAD is available for a variety of microcomputers based on the 8086 family of microcomputers. AutoCAD offers a combination of features that obviously work for a tremendous number of users. It is an excellent package that can be recommended to a wide variety of CAD disciplines. [5)]

(2) Prodesign II

Prodesign II is one of the lowest priced computer aided drafting software available. The Prodesign II supports a wide range of peripherals. The program's memory requirements are extensive for an entry-level package; it requires a 512K-byte system with about 475K free. The operator specifies the parameters for most commands by positioning the cursor and entering points with the numeric keypad or, optionally, with a mouse or digitizing pad. The user can also specify points by entering exact X and Y coordinates or a relative distance and angle. Prodesign has more than 26 commands, and you use 10 Alt-key sequences, 18 punctuation characters, and the 10 function keys to issue commands as well.

[5)] Ibid., pp. 126-132.

Autodesk, "AutoCAD: User Guide. Version. 2.17." 1985.

ProDesign II's drawing aids includes three types of grids: full intersecting horizontal and vertical lines, axes along the edges of the drawing, or dots.

ProDesign II has these features as follows:

a. Provides an on-screen zoom command to change drawings.

b. Has full on screen rotate capabilities.

c. Allows full editing of drawings on the screen.

d. Allows lines of varying thickness to be used.

e. Draws curves, circles, ovals, and arcs easily.

f. Has exceptional text display features.

g. Allows figures and symbols to be created, stored, and retrieved at any location, size, angle.

h. Provides advance CAD features such as Chamfers, Auto Dimensioning, Fillets.

i. Provides for user-created files to be input and displayed on the screen. This allows data from other programs to be used. [6)]

(3) 3Design/3

3Design/3 is a CAD system that is useful as a teaching aid, but the memory requirements and inter-changing of disks make this system difficult for an entry level package; it requires 256k memory and a graphic

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6) American Small Business Co., "Prodesign II: User Guide", 1985.

board. The options for peripherals is limited. The operator specifies the parameters for most commands by positioning the cursor and entering the points through a numeric keypad or, optionally, with a mouse or digitizing pad. The exact X and Y coordinates can be seen upon the screen making it easy for the operator to make exact 3-dimensional parts. The 3Design/3 system is made up of four different parts, the first is the 3-dimensional edit program, the second is the 3-dimensional modify program, the third is the drafting program and the fourth is the 3-dimensional solid shading program. 3Design/3 uses the full keypad for operating the system. The 3Design/3 program drawing aids include intersecting horizontal, vertical and diagonal lines. [7)]

3Design/3 has these features as follows:

a. Provides an editing program for line or polygon removal.

b. Has on screen rotation capabilities.

c. Allows figures and symbols to be created, stored and retrieved at any location, size and angle.

d. Draws circles and arcs easily.

e. Has text display features

f. Provides hidden line removal.

g. Uses a tree based system for organization and movement of objects.

h. Has a modify program.

[7)] Tritek Vision Company, "Three Dimensional Design and Drafting", 1985

i. Provides solid shading program.

j. Provides perspective viewing.

k. Can be linked to AutoCAD and CADplan.

(4) MegaCADD

MegaCADD is made up of three different programs. Design Board Professional offers 3-dimensional designing. Design Board Illustrator is a graphic software tool for creating slide shows, animated sequences and colorful presentation graphics (only IBM CGA mode). Design Board Link, which integrates MegaCADD's 3-dimensional software with popular 2-dimensional drafting packages, including AutoCAD, VersaCAD and CAD-vance/CADplan. MegaCADD's list of compatible computers and peripherals is continually expanding. The MegaCADD system uses a 512k memory and supports monochrome and color graphics card with resolutions between 320x200 to 1024x768. The MegaCADD program is easy to learn because the use of a mouse or digitizing pad to enter points is faster than using a keypad.[8)]

The features for the MegaCADD are as follows:

a. Provides the operator with icon-menu driven and on-screen menus and prompt programs to make commands easy to remember.

b. Has flexible editing allows quick enhancement and clean-up of CADD pictures through icons of draw, move, paint, scale, rotate and erase.

c. The created image can be edited at the pixel-level.

d. Can create free-hand sketching.

e. Adds color, shapes, patterns and textures to created objects.

f. Offers a variety of fonts that can be integrated with graphics on the Design Board Professional program.

g. Has a variety of line types, including dotted and dashed patterns.

h. Operator can store user-defined symbols, such as text, patterns, logos, etc.

i. Operates wide variety of output devices such as color dot-matrix printers, laser jet printers, inkjet printers and Polaroid Palette.

j. Animation ability to allow walk-through, fly-by, walk-around views, etc.

k. Provides slide show imaging and can grab images in low resolution IBM emulation mode from AutoCAD, VersaCAD or CADvance/CADplan along with it's own images from MegaCADD's Design Board Professional.

l. Offers 3-dimensional design Modeling with database of independent 2-dimensional surfaces items.

m. Programed for multiple views for revision.

n. Has Automatic hidden line removal.

o. Can create perspective, axonometric, 2-dimensional orthographic and exploded views.

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8) MegaCADD Inc., "Design Board: Professional, Illustrator, Link.: User Guide. 1986.

CHAPTER III

DESIGN DEVELOPMENT USING A CAD SYSTEM

As we have discussed before, various kinds of CAD programs have been developed for the students who study in the field of industrial design or own a small enterprise, and these programs are useful for understanding the CAD system and improvement of design work effectiveness.

In college programs, which have short training terms and a difficult data base to use, the education of CAD is limited to teaching the concept of CAD and basic usage of it.

Because most CAD programs were made for reducing working hours and increasing productivity the problem of developing a creative form, which is a finalized object of industrial design has not yet been solved.

The creative problem solving of design is up to the designer, but a designer using a computer system can examine more diverse forms, suggest reasonable form and minimize error which happen during the design process. As a model case, the design development phase of my "Automated Ticketing Terminal" was completed using an educational CAD software program and microcomputer system.

1. Project background

The "Automated Ticketing Terminal" project was given to the students of Rochester Institute of Technology from NCR Corporation as a design problem to help the students gain experience, for the application of their studies to the working world that they would be entering.

NCR traditionally produced cash registers and computer related components for office automated systems. NCR had many of the components that were required for this new machine available like the printer, card reader and CRT screens. The new product was developed through the use of their existing products but set-up for a new consumer. A new design does not come from the sky, but like most designs they evolve from a previous design and some innovative ideas.

The "Automated Ticketing Terminal" is a new product which makes it possible to purchase and reserve traveling tickets by using credit cards.

This products requirements were the fast and easy use of this machine by simplifying the components and the processes for both the buyer and the service personnel.

This project has been done once with traditional processes such as research and analysis - idea sketching - rendering - drafting - modeling and from this problem solving analysis the necessary and unnecessary options were discovered.

On the basis of my experience in the design process, the planning of the CAD system usage was finalized.

The new reasonable form can be created from the existing components by considering the data of dimensions, working options, new functional additions and the limits of the design process.

2. Design Process and CAD System Architecture

The architecture of a particular CAD system will certainly depend on:

(1) the task to be solved by the system;

(2) the computer resources available for its implementation (both hardware and software);

(3) the experience of the CAD system user;
With the consideration of upper options, the range of working process and usage of program of each phase were decided from the function of the design development stage.

(4) with each problem of different designers a new architectural system needs to be considered.
Two points need to be considered: what kind of program package is the most efficient and what type of capacity is needed for the subject being worked upon.

The program package should be studied to produce a CAD system. The familiarity with basic commands, programs and special program characteristic functions will decide the effectiveness of the system architecture.

The NCR project in which I have established each design stage

in the program package and the work being produced and the relationship between hardware and software is shown below.(table. 6)

3. Design Development.

At the first step, which is the research and analysis phase, possible data files (Picture #3-9) were created by classifying Human factors, Environmental factors, Component functions, Special requirements, Technical reform, Component dimension, etc. The files are the design limitation files, human figure files and component files (Picture #10-18). These files were created by minimizing the limitations which can interfere with the creativity of the design. These files that were created could then be shared with the other designers who are also involved in the same or related projects.

At the form development phase, by modifying data files (Picture #19-21) through the use of the system, the designer makes a tree of each part that the designer will need. The main components will be compiled into the data files and entered by the tree based file with sub-sets which will connect to other sub-sets or files and hold all the necessary components to make a main component a complete form. The system tree can be very useful for relationships between components and quick drawings of a newly developed form. Because the main object can move, rotate, scale, translate, and have object selection, perspective,

Table. 5. Design Phase and CAD System.

	Step 1. Prepare Strategy	**Step 2. Design Consideration Strategy**	**Step 3. Form Development Strategy**	**Step 4. Evaluate**	**Step 5. Detail Design & Drafting**
WORK	Design Information Input. Engineering Science. Material and Production process. Ergonomics. Technical Information. Information related to Specific need.	Problem Identification. Problem Difinition. Solution Concept. Design Limitation. Check point. Design Concept. CAD System Oganization.	Preliminary Design Transformation. Simulation Modify file. Perspective.	Evaluate Chart, pre-presention. Check to Synthesis Hardcopy.	3D-Drawing Detail drawing. Dimensioning.
APPLICATION MODE	Research Organize Data.	Analysis Data file. System file.	Designing Systemtree.	Compare idea. Screen	Drafting.
CAD program	Program package. System Concept. Program Operation. Program Study.	System file File Modify. File Coordinate. Hardware Checking. System Tree	Transformation. Ware frame. Solid Modeling. Hiddline Remove.	Basic, Slide Checklist.	Drafting.
	Basic, C., Fortan Halo.	3design/3 PaintBrush.	3Design/3 Paintfile	Autocadd.	

and solid shading, it is important to understand of the tree base file. If a main object is rotated the sub objects of the tree of the main object will rotate along with the main object. The tree of any given object can be split from its main object and move freely from its main object.

By starting to combine the components, the experience of understanding of the form increases, and this makes the examination easier to study whereas this is not as easy to do with the traditional way of sketching.

The outside look of the form can be easily seen by removing the hidden lines from the produced wire frame drawing, and examined further with perspective and solid shade modeling (Picture #22-34).

The human factors can be examined with the product by calling up the figure from the file to help simulate human interaction (Picture #35-44).

Finished ideas through these phases are analyzed and studied but these ideas need to be compared through making a photo or a hard copy. Although these images can be produced for a reference they can not be produced into presentation quality drawings without a considerable amount of work. I have created a system method of producing presentation work (Picture #45-55) that makes each idea of a given design easy to analyze and revise. I have produced ten different ideas that have been placed into an evaluation chart (Picture#56-58) that deals with each component function, variability, visibility, creativity.

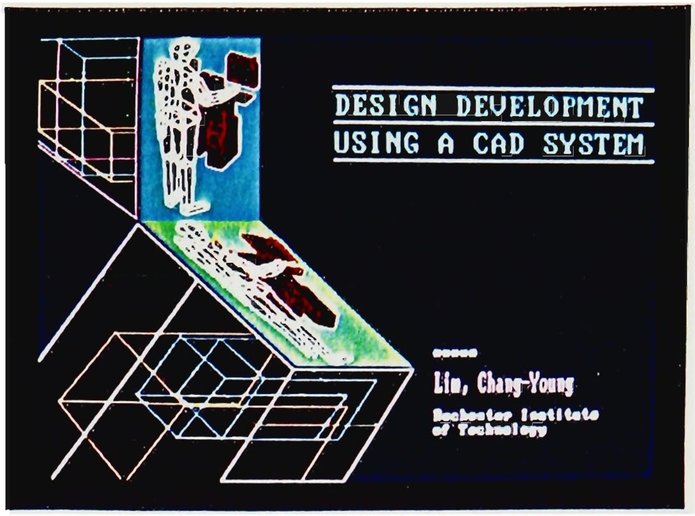
Each design has been given points based on one point as a low

score and many points as a high score. Two designs have been chosen because of their high score based upon this chart. After these two ideas were chosen the development of the forms were continued and the one with the best possibility of being acceptable for a future design (Picture #59-60).

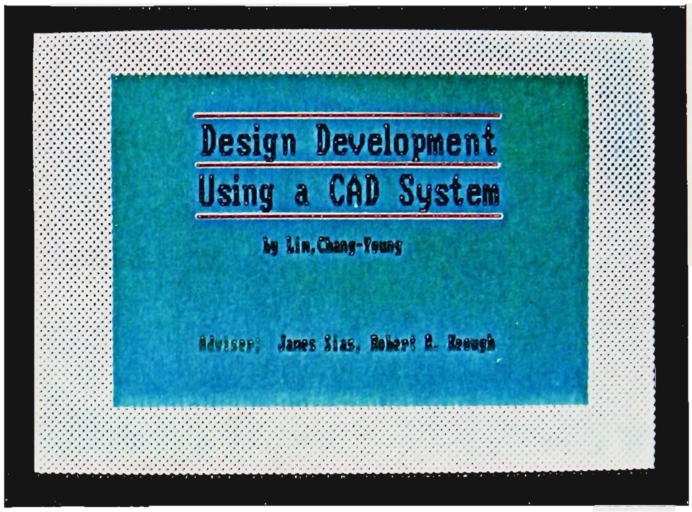
Actual design steps begins by choosing an adequate design. The data from the chosen design is linked to the computer aided drafting program to move on to the next phase.

At the computer aided drafting phase (Picture #61-66), instead of two dimensional drafting, three dimensional drafting is possible. The three dimensional drafting adds accuracy and reality to the finished data. The finished data from the drafting stage can then be connected to the preparation of production and which can make direct communications between the engineer and the designer easier and more efficient.

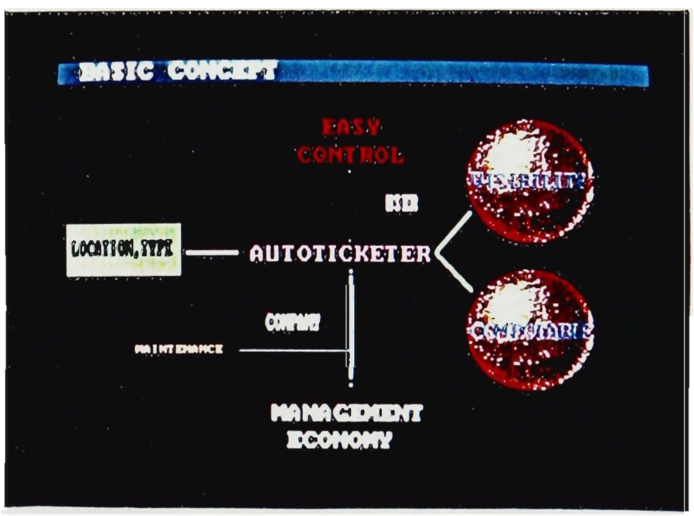
#1. Title 1. Thesis Show

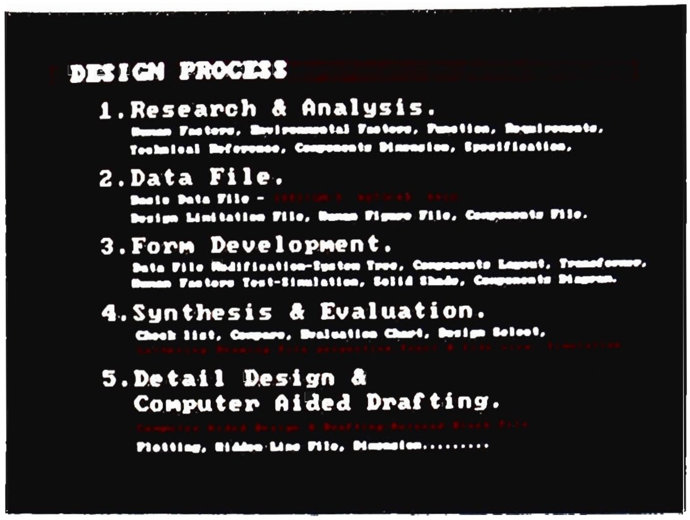


#2. Title 2.

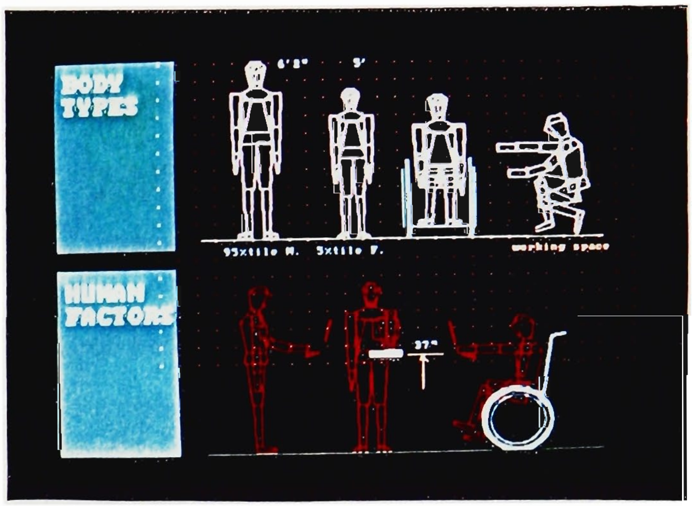


#3. Design Concept

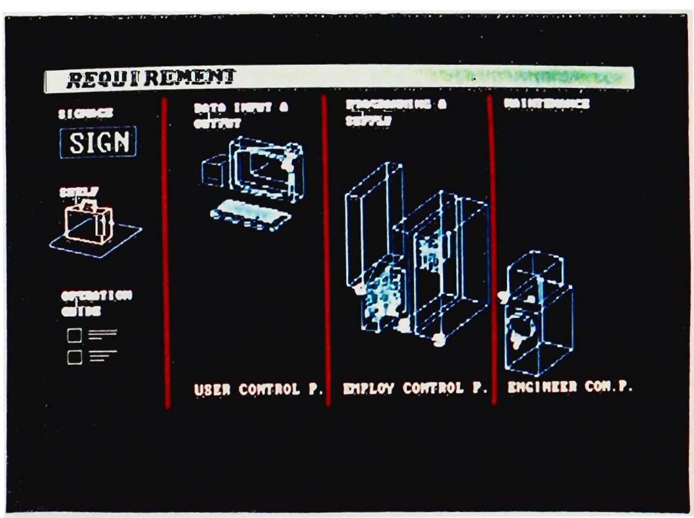




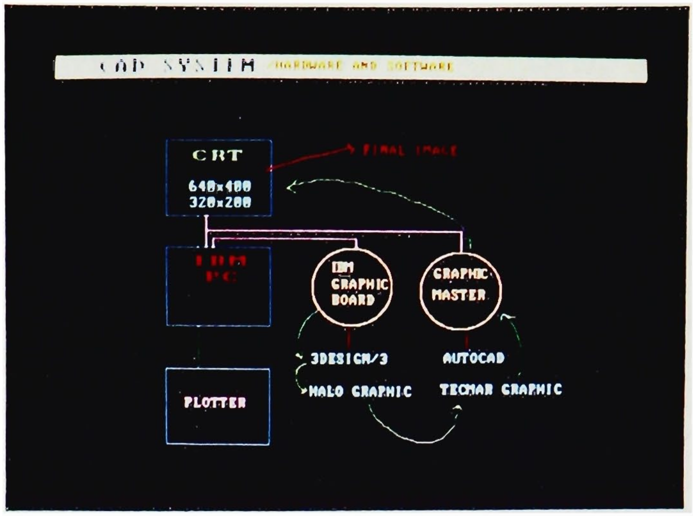
#4. Design Process



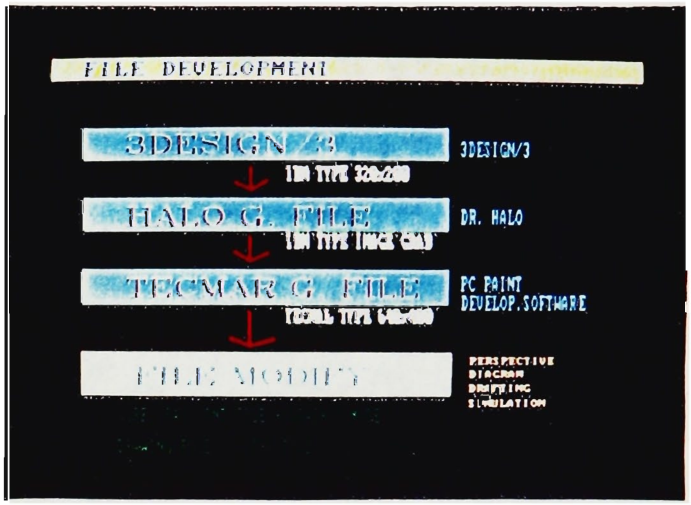
#5. Human Factors



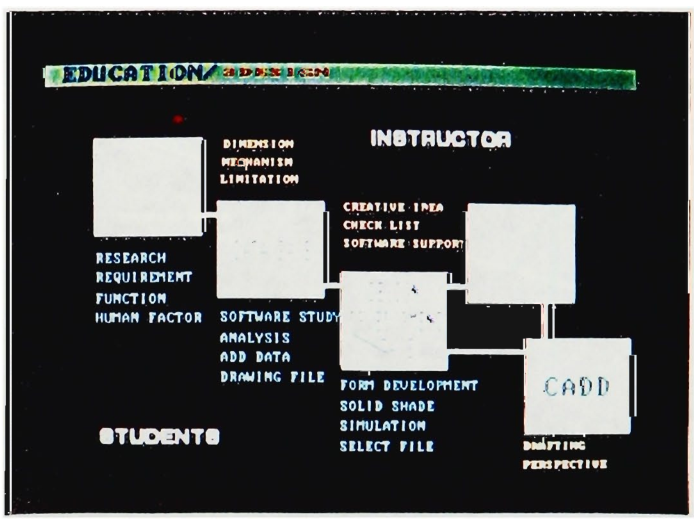
#6. Design Requirement.



#7. CAD System

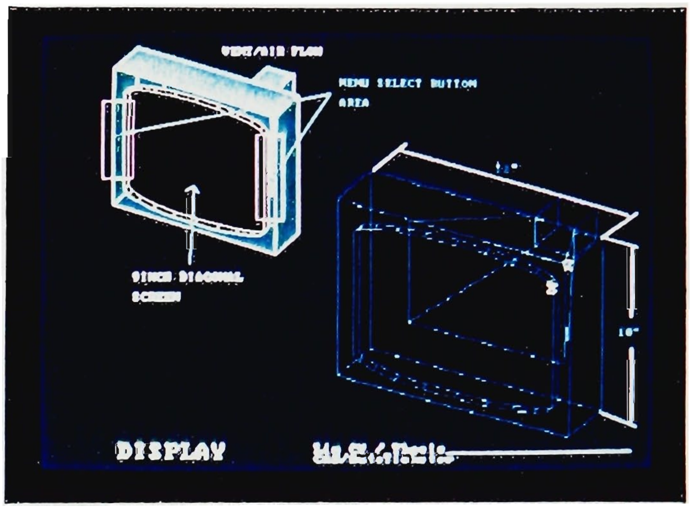


#8. File Development

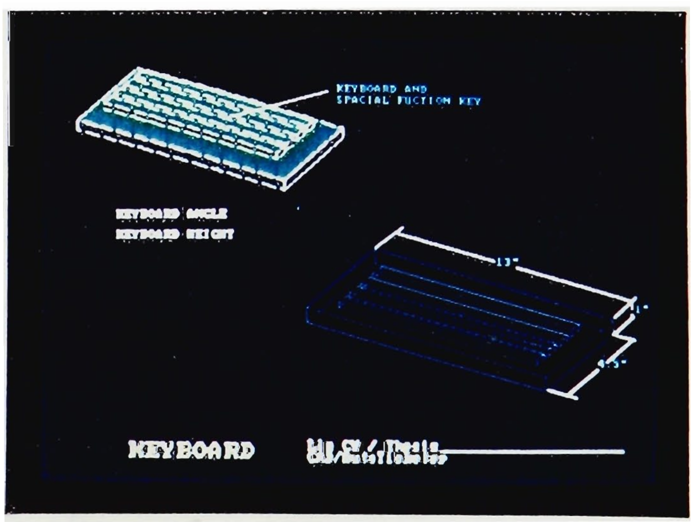


#9. Educational Proposal.

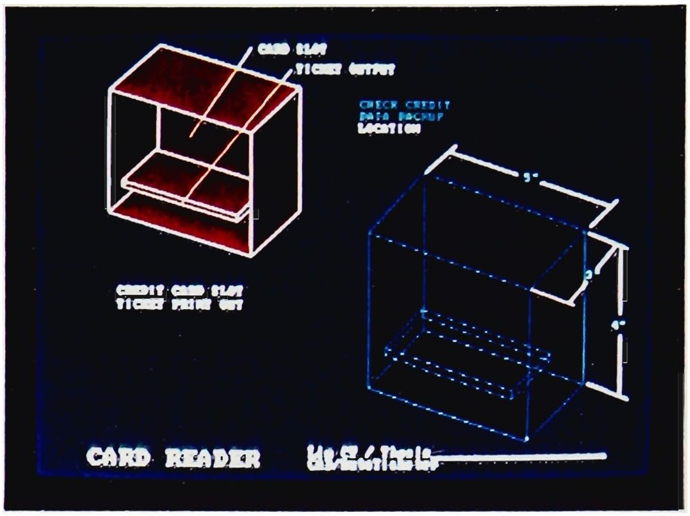
#10. Title 3.



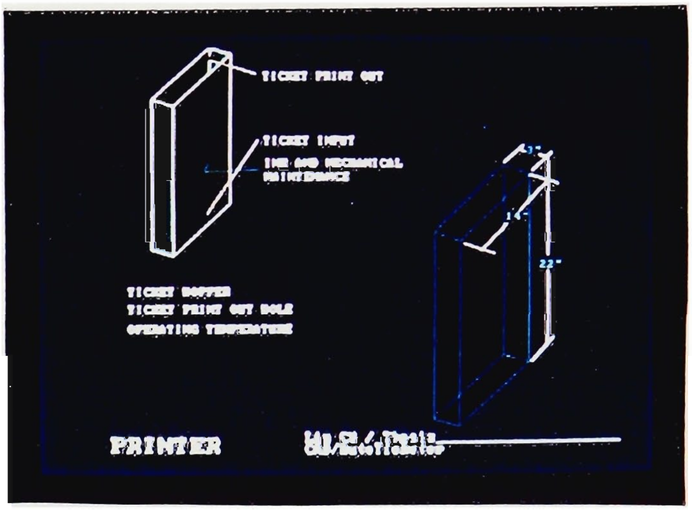
#11. Data/ Display



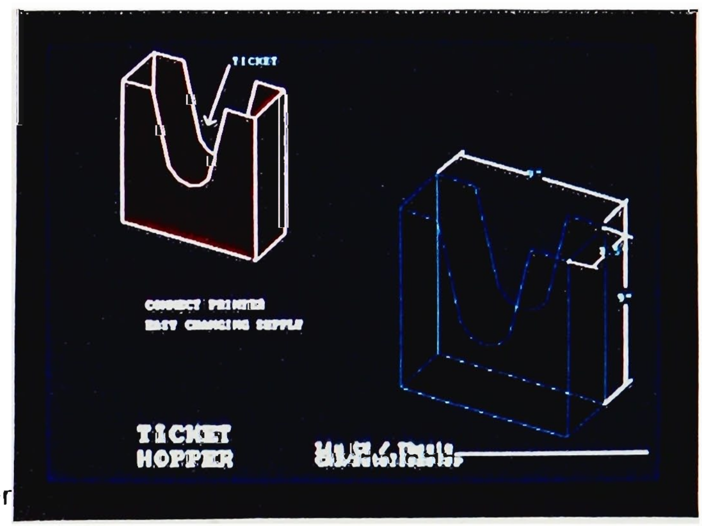
#12. Data/ Keyboard



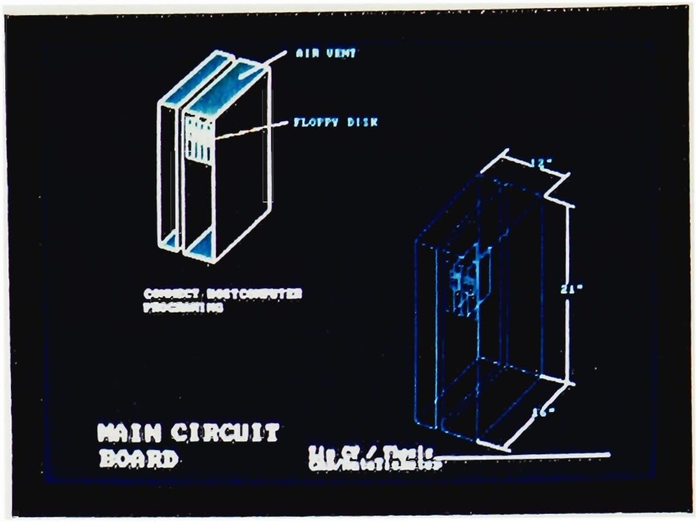
#13. Data/ CardReader



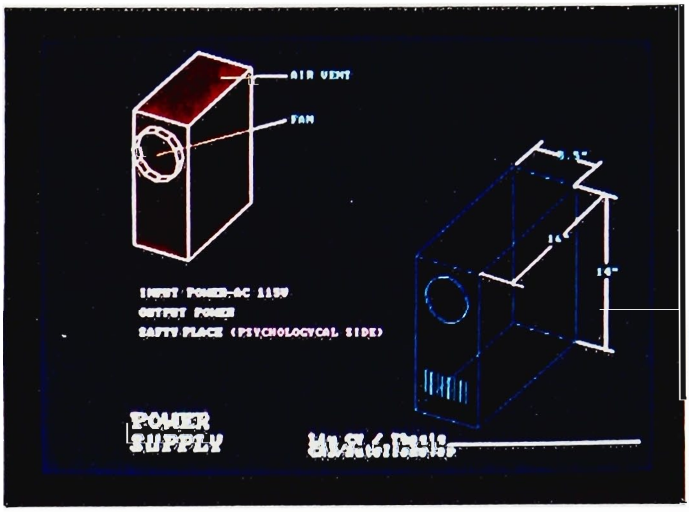
#14. Data/ Printer



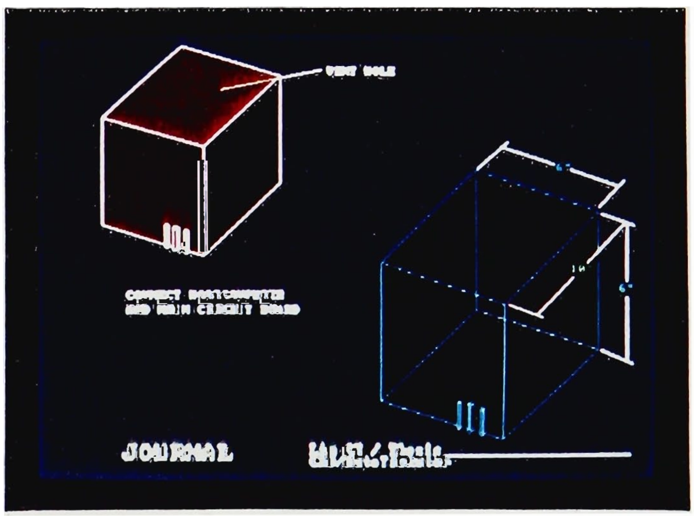
#15. Data/ Ticket Hopper



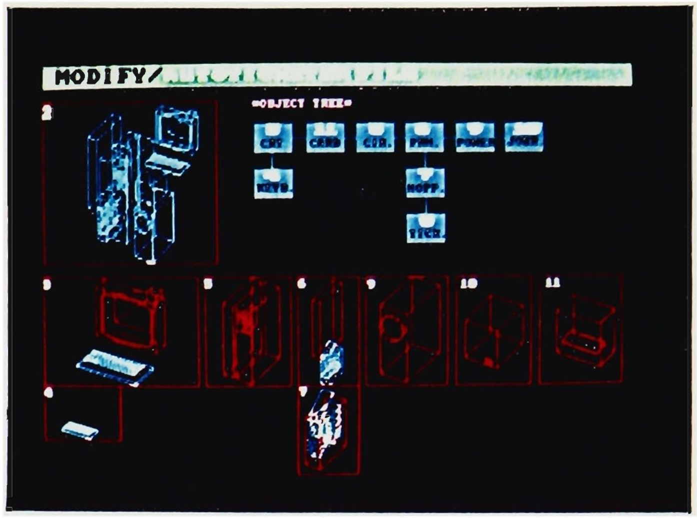
#16. Data/ Circuitboard



#17. Data/ Power Supply

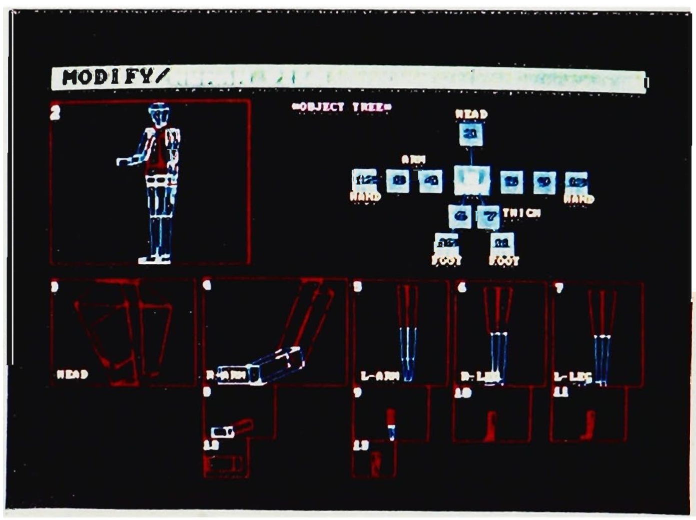


#18. Data/ Journal

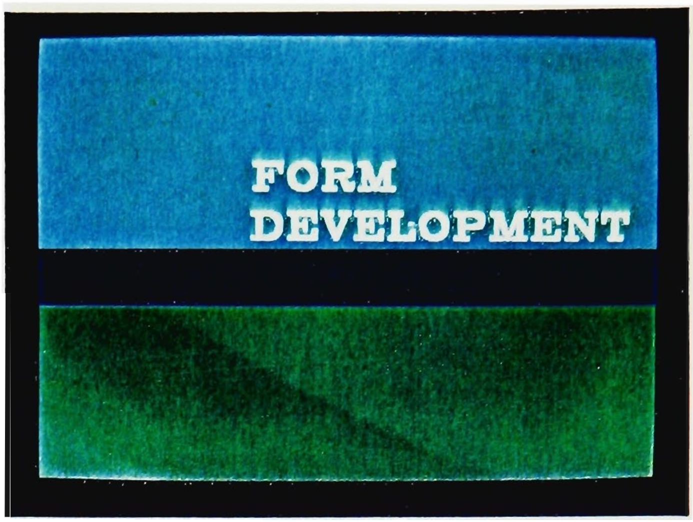


#19. Modifying System
Tree/ Data File

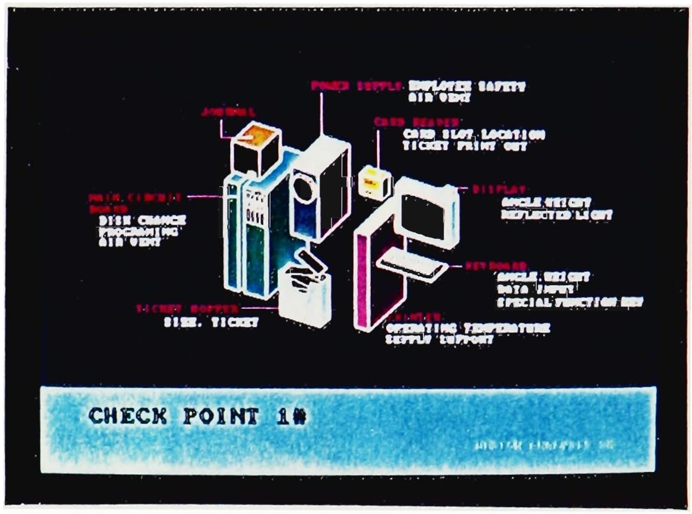
#20. Using Color Sample
Display Color



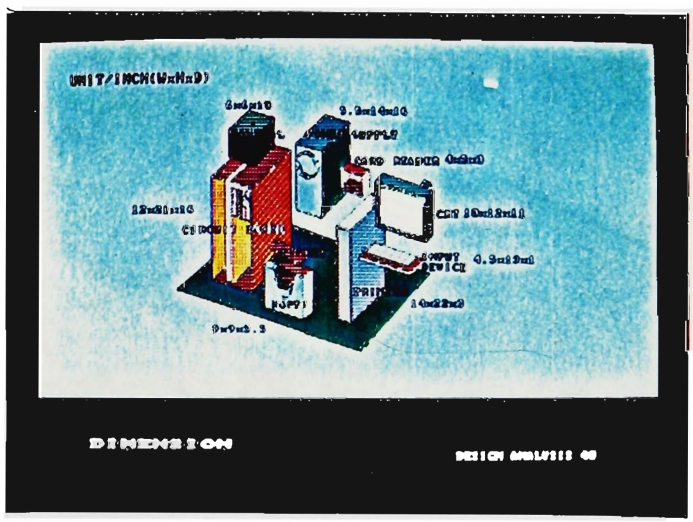
#21. Modifying System
Tree/ Human File



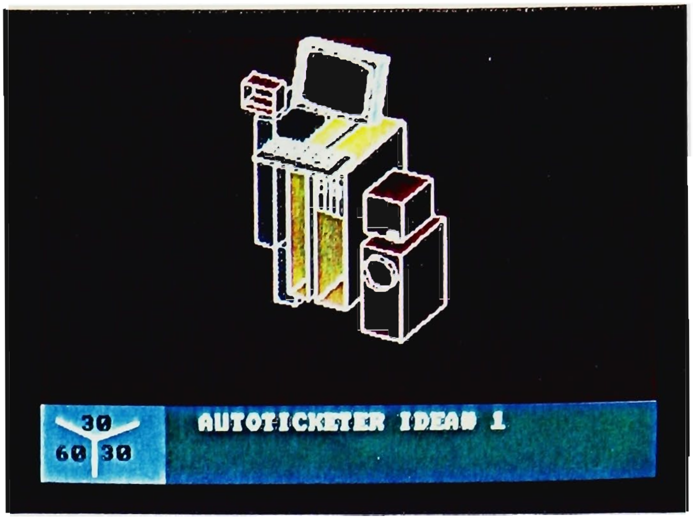
#22. Title 4



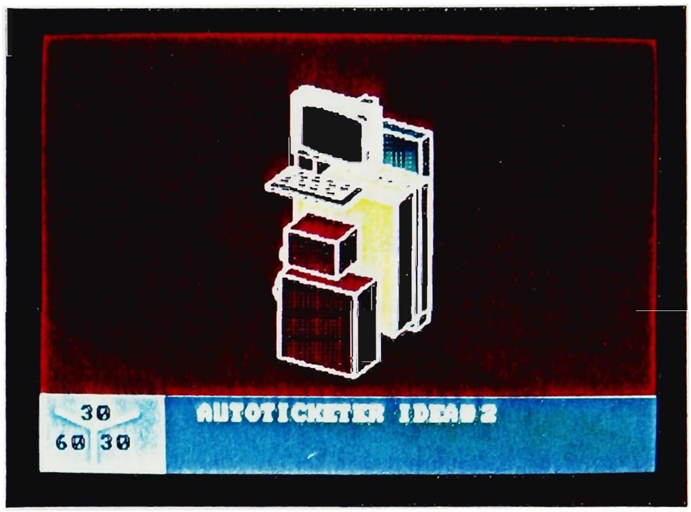
#23. Design Check Point
Design Limitation



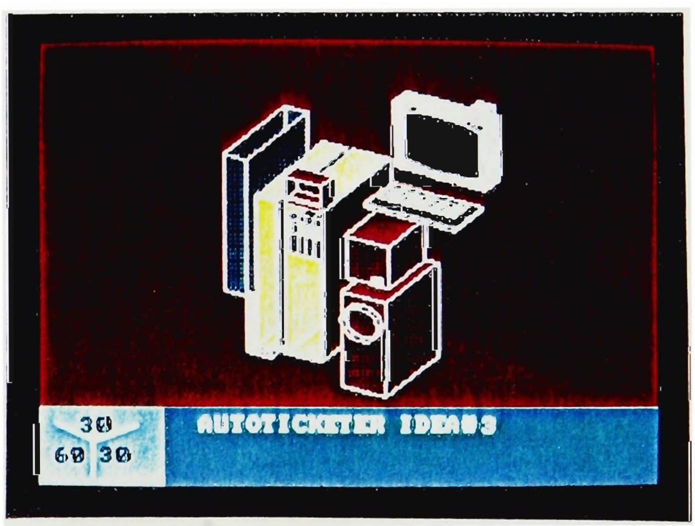
#24. Design Check Point
Dimension



#25. Idea# 1.



#26. Idea# 2.



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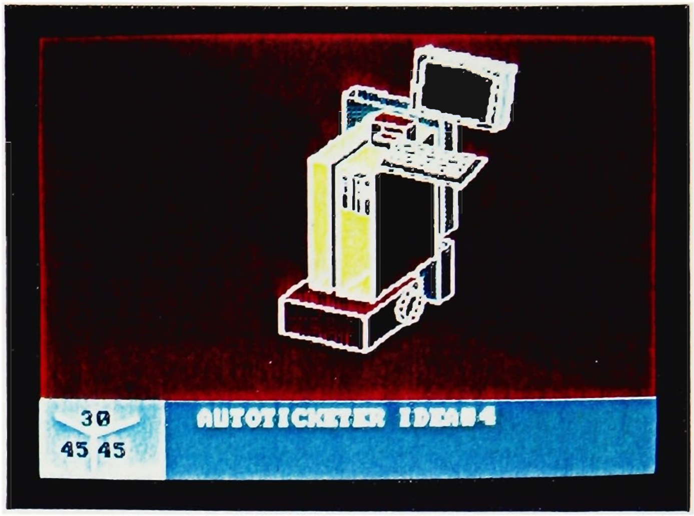

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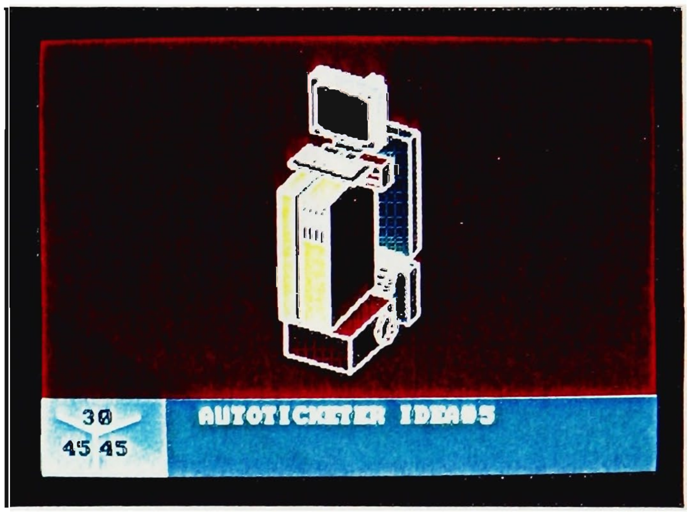

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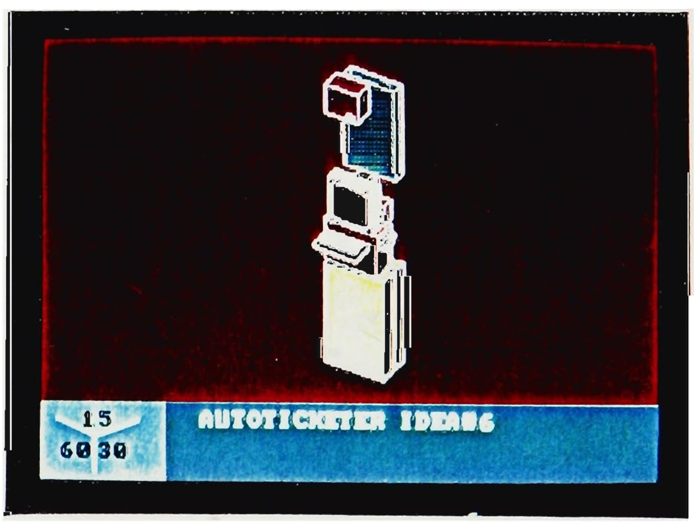

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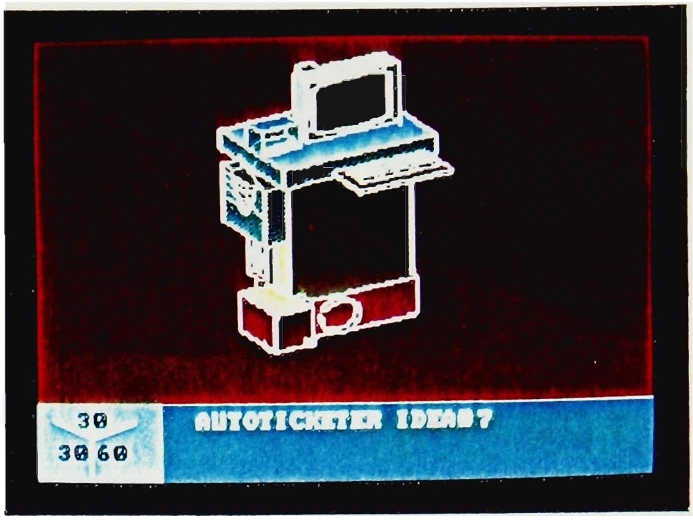

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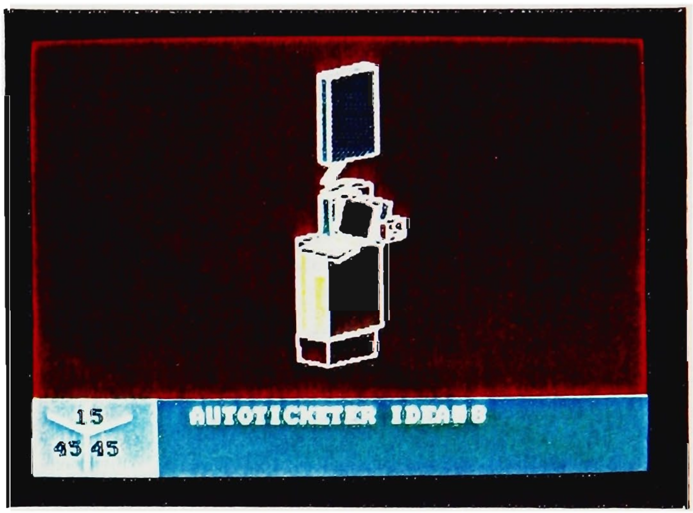

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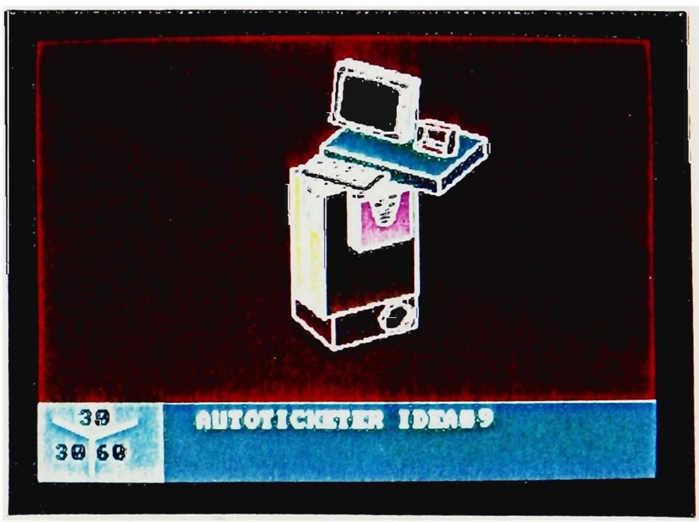

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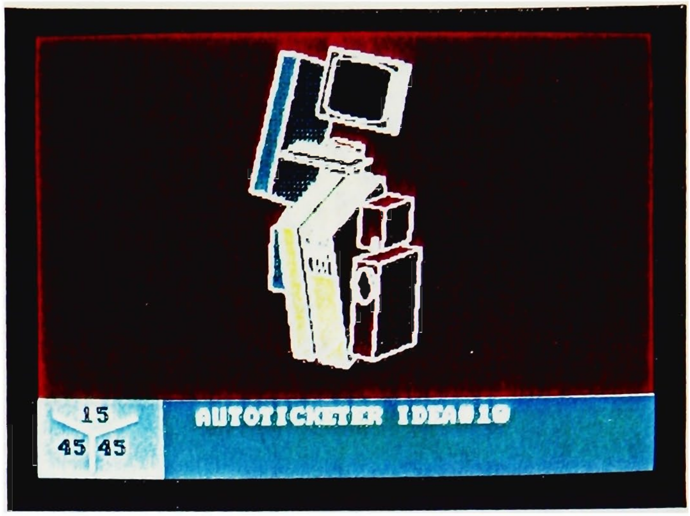

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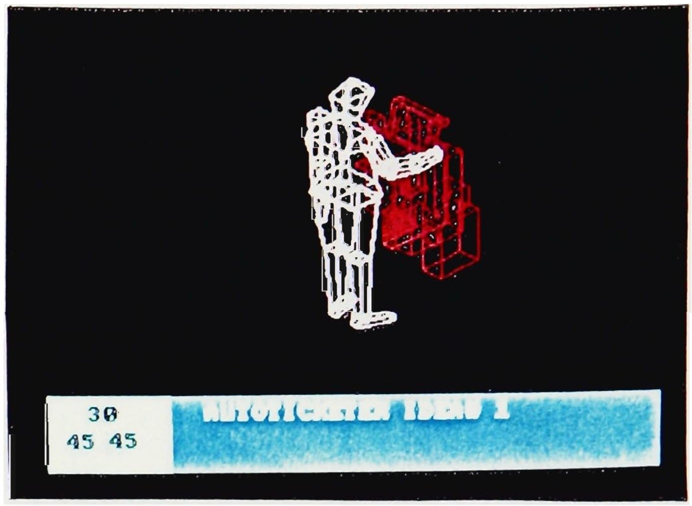

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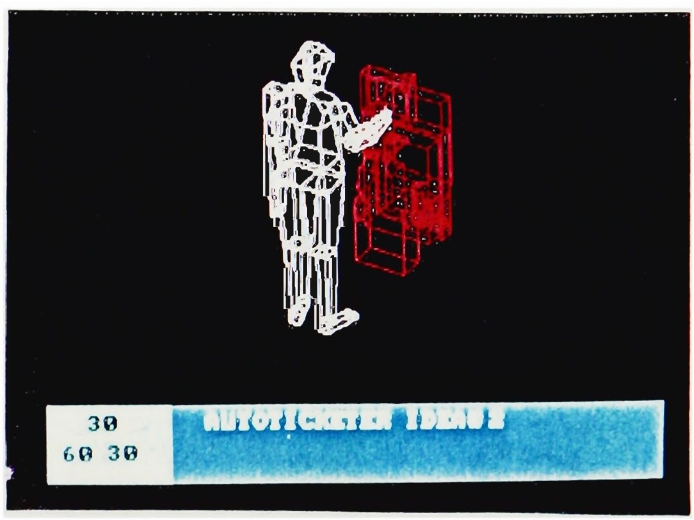

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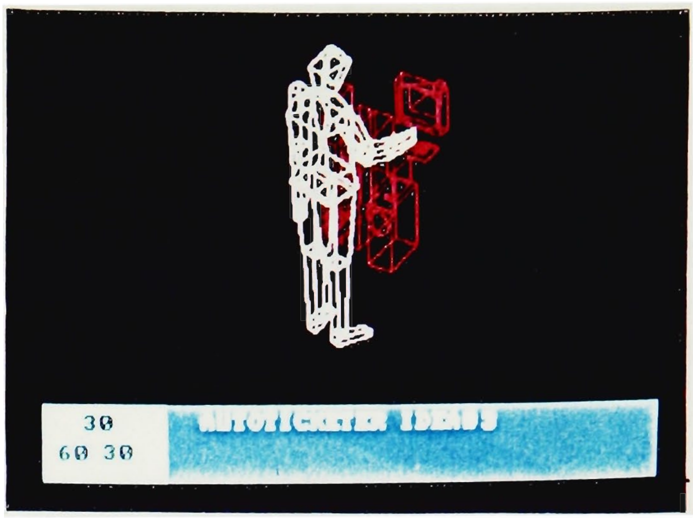

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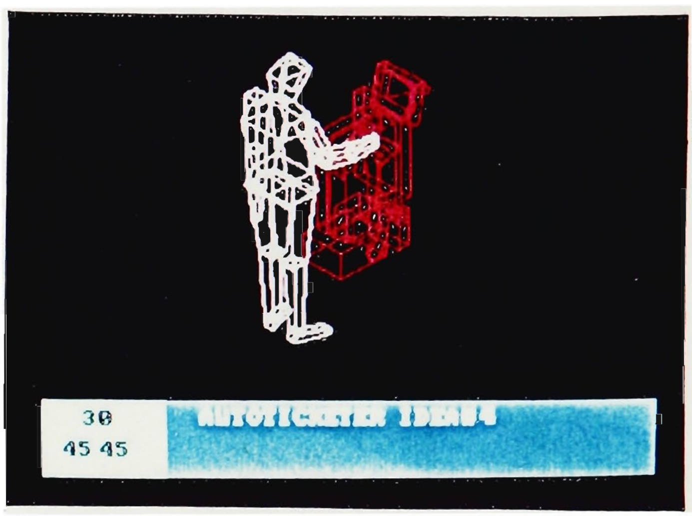

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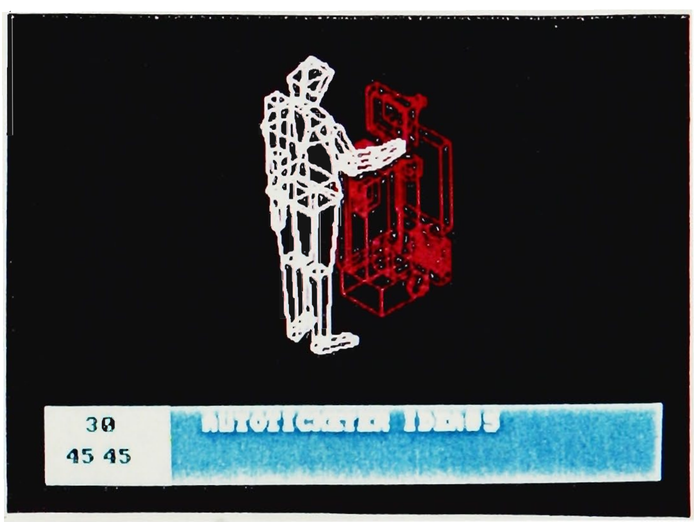

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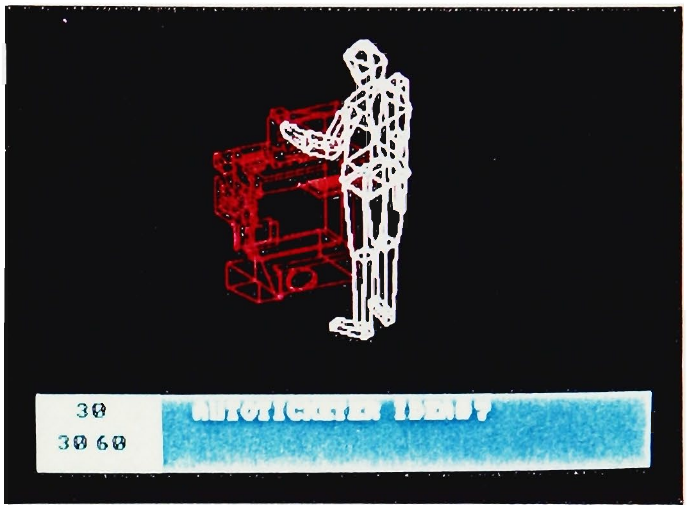
#40. Idea# 6. Simulation



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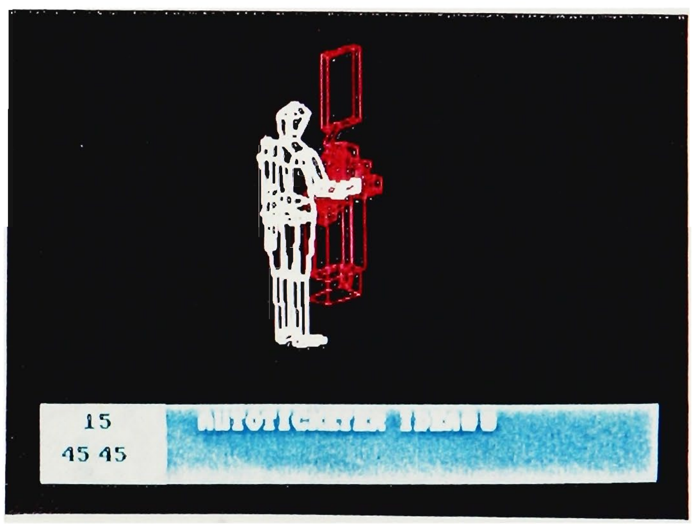

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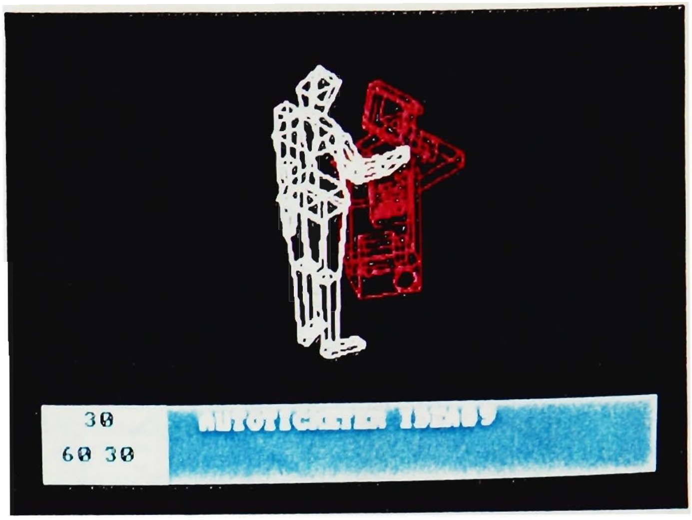

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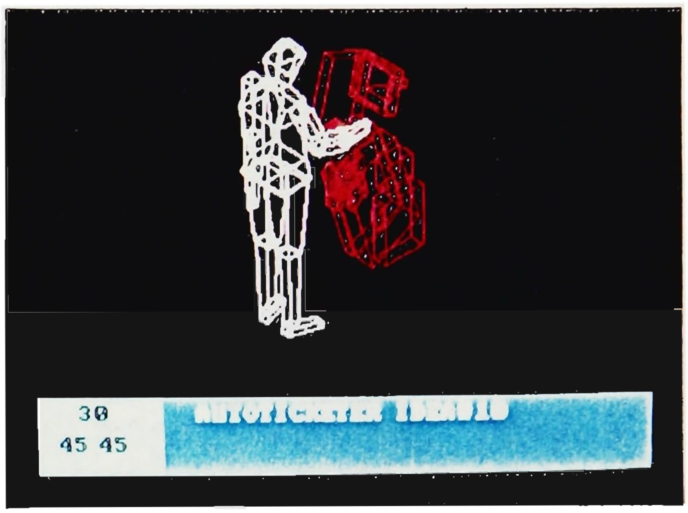

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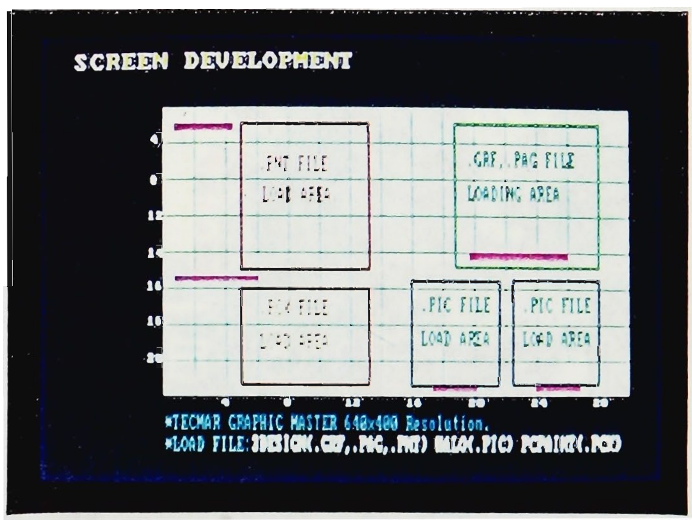

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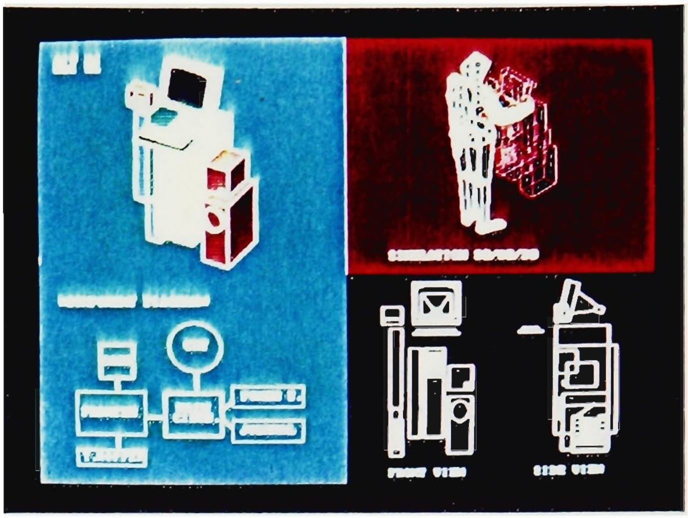

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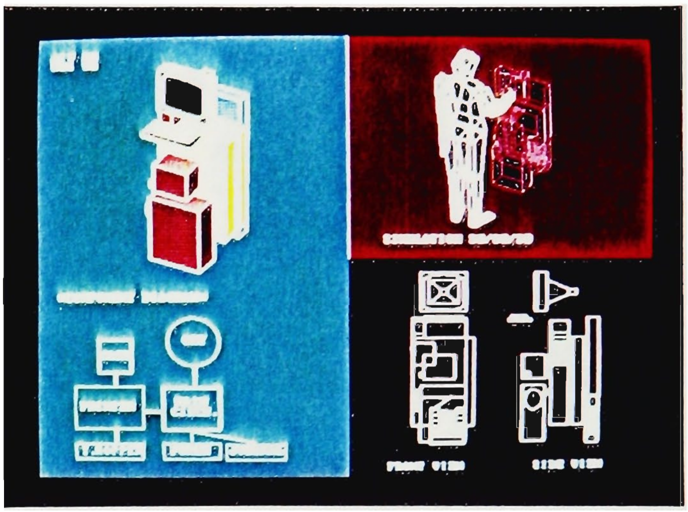

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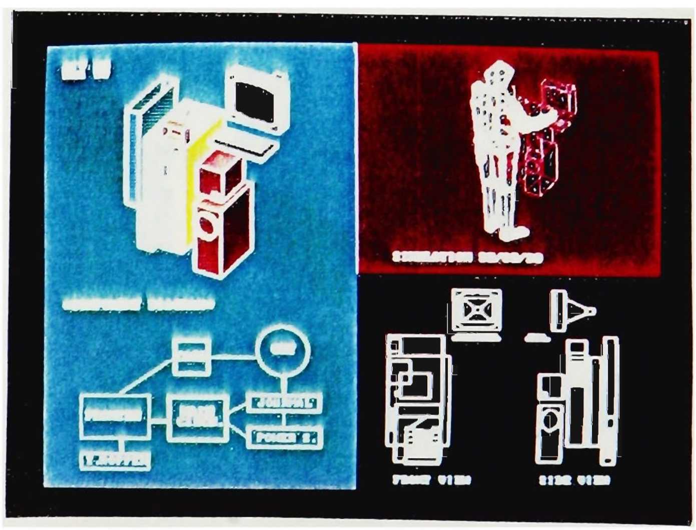

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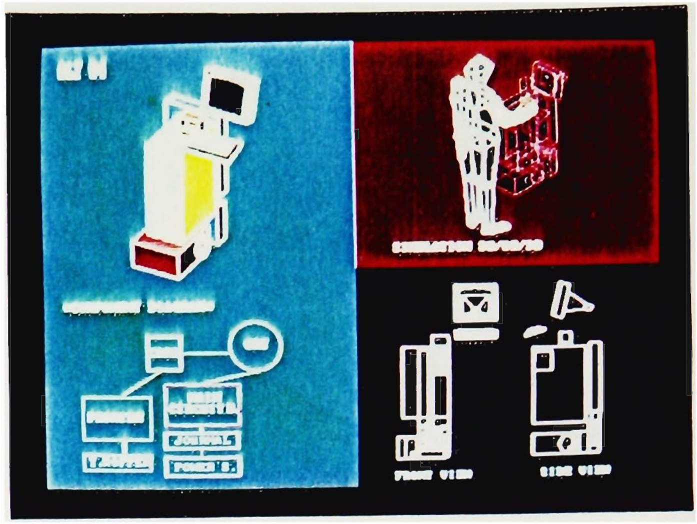

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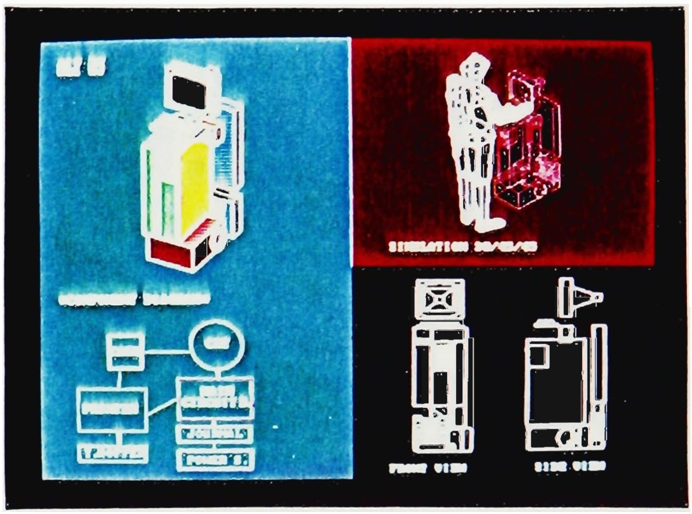

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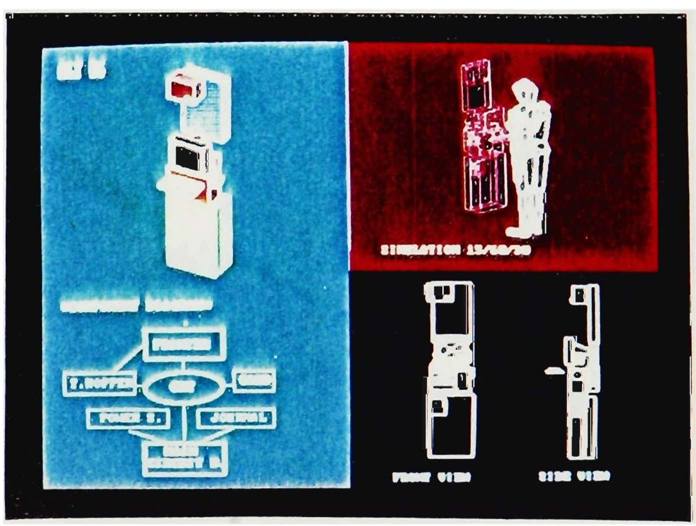

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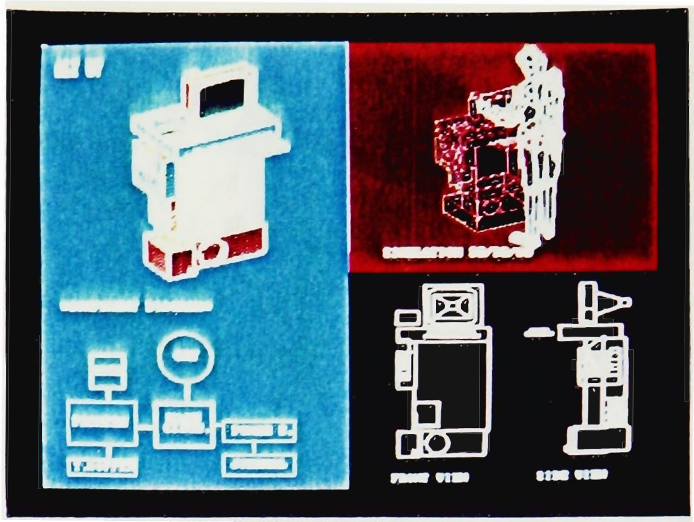

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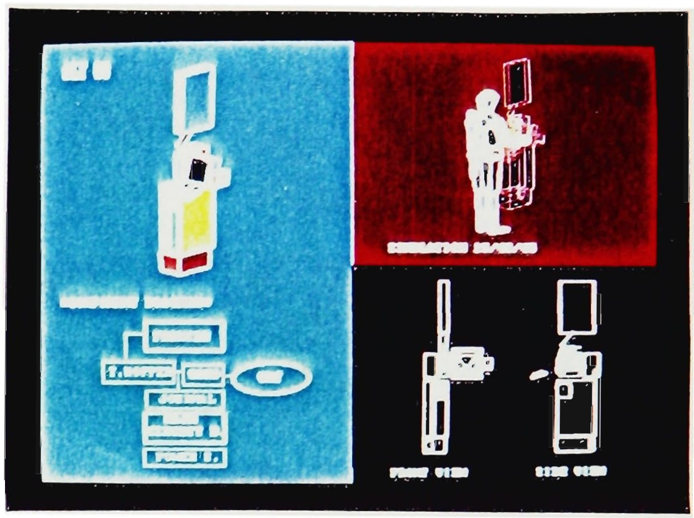

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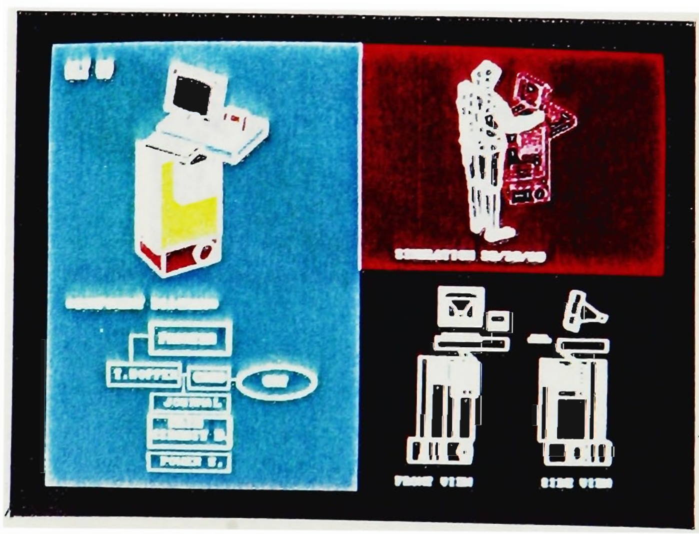

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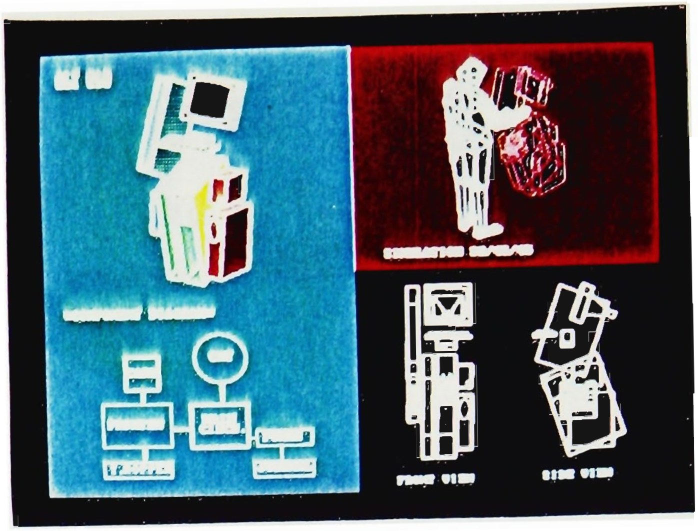

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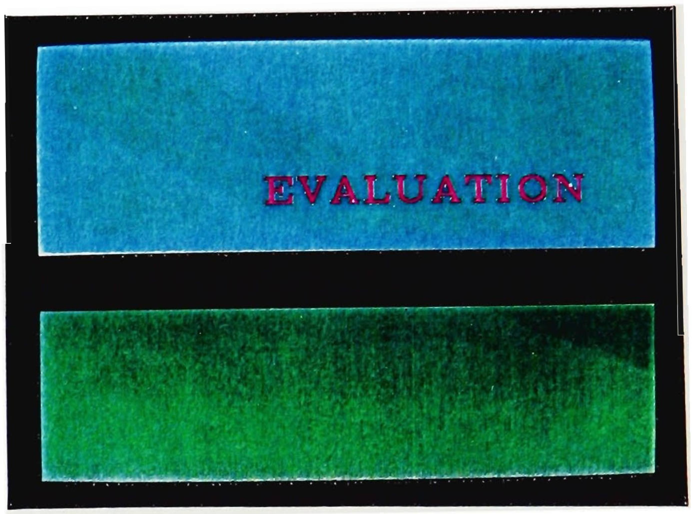

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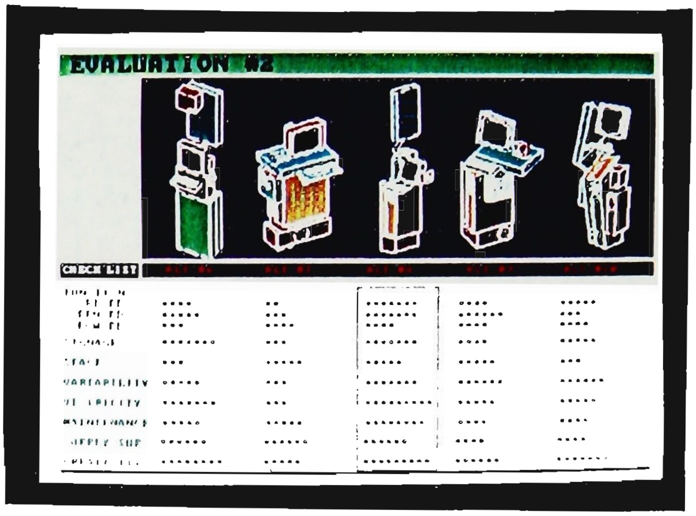

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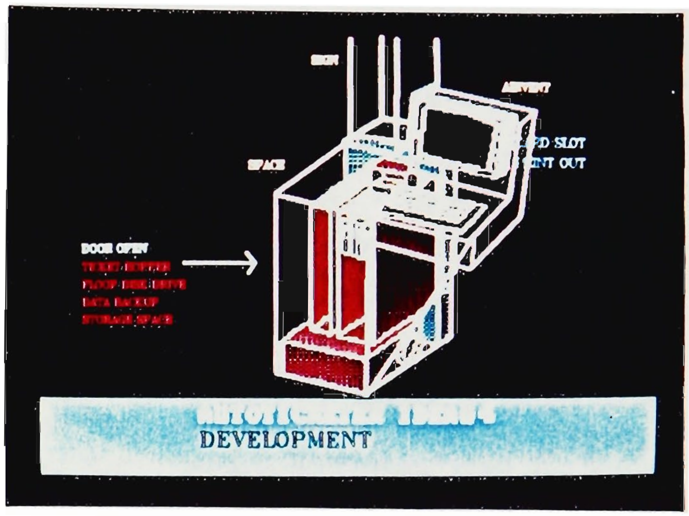

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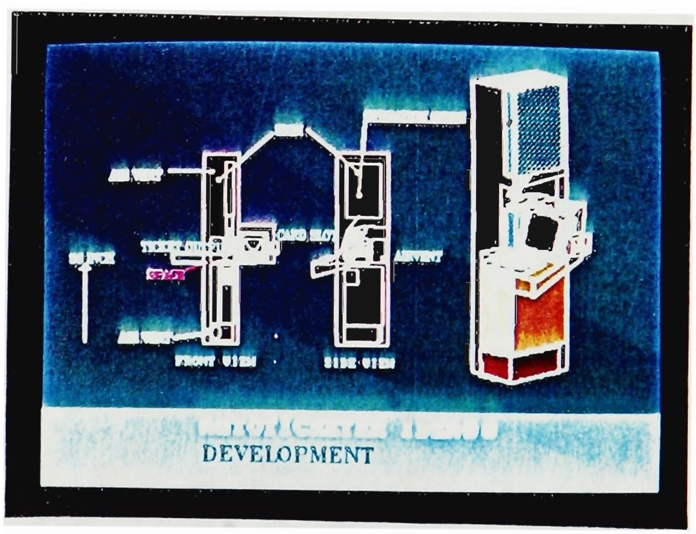
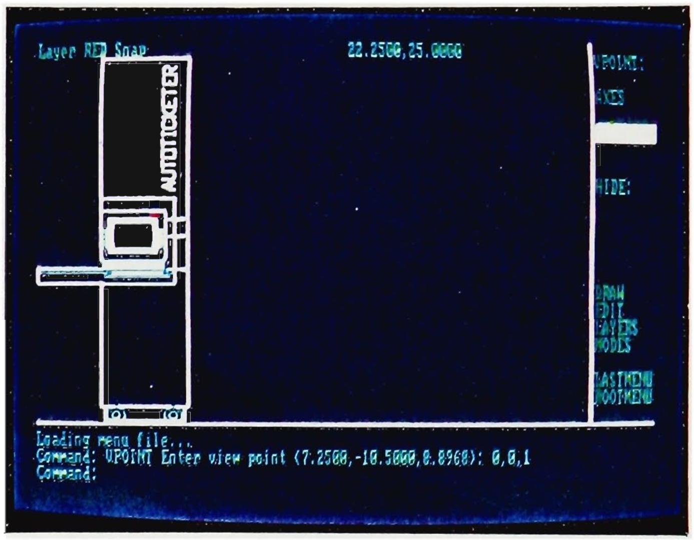


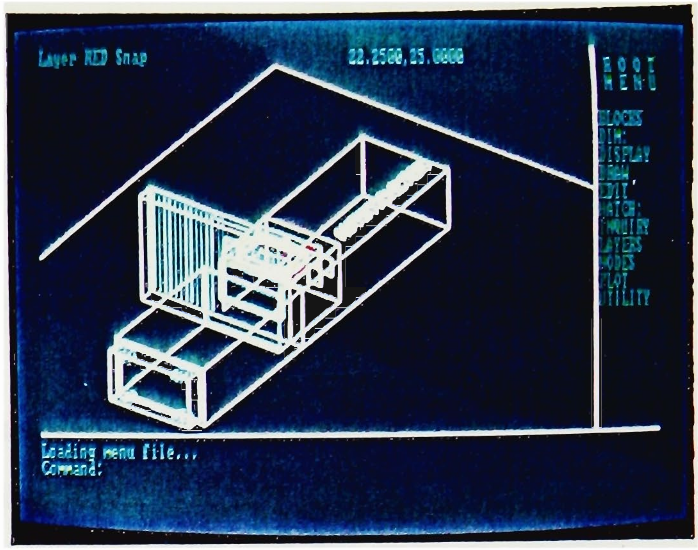
#60. Design Development

#61. Title 7.



#62. AutoCAD Drafting

#63. AutoCAD Drafting



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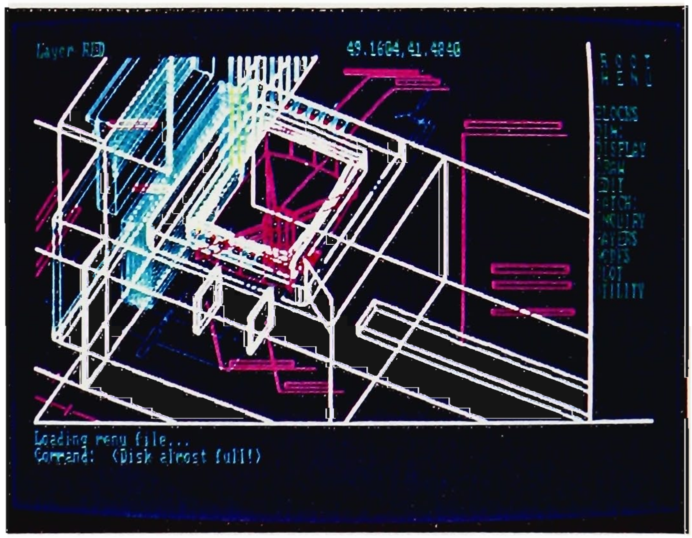
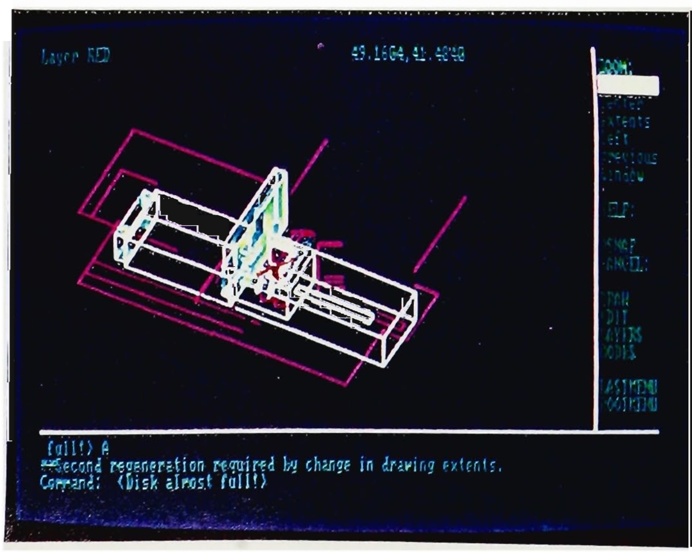
Isometric



#65. AutoCAD Drafting
Detail Drawing



#66. AutoCAD Drafting
Dimensioning

CHAPTER IV

CONCLUSION

The manager of a company will have an advantage by introducing a CAD system because designing and manufacturing process time and cost can be reduced. The engineering field was the first to receive a CAD workstation. This workstation made it possible to check problems of the manufacturing drawings and evaluate the design through wire frame models or solid modeling.

For the Industrial Designer it has not been established as a highly improved method of working. The evaluation of new technology is based on the possibility of the new technology having an effect on the future and it is not directly related with actual usefulness of the technology. The increase of function and memory capability of computers, and the fast development of CAD programs has helped in improving the usefulness of a CAD program package in the design field. A design project connects many kinds of fields and it has to consider a variety of problems. This case of connecting many fields and a variety of problems has been almost impossible together the resources, but the use of a CAD system can solve this problem.

The introduction of CAD systems in design should make the designer concentrate on the informal work and which helps to place emphasis

on creative work. The computer can also help in making communicating to other departments, at each stage from the development of idea to the final production. The industrial design CAD systems which demand not only improvements of workable designs and reduction of cost and time but also helping the designer in the evaluation of the CAD design would be helpful. This is not easy because computers do not have the ability to be creative on its own.

An industrial designer organized CAD system architecture and the efficient use of the computer, could help the designer work towards a more creative design. The designer would make a creative form which could then be sent to the model making area and sent through a computer without having to be interpreted by a model maker. The designer could check for expected problem areas, and the design could then be made to the designers orders.

The education of student who will use a CAD system has some problems. It education of a student with a simple CAD program package, they learn to only operate the one system and this makes the designer nothing more than a simple one system operator. The professional CAD system education can neglect the development of creativeness because of the learning curve needed to understand the system.

In this paper I defined the difference between CAD and Industrial design, and discussed the useful functions of an input and output devices of microcomputers which are very helpful in the education field. Because

a professional workstation needs a lot of money, and learning time is long, this system is not as effective for the student. Some educational CAD package programs have similar concepts as the large CAD program packages. The student learns the basic concept of the CAD system and they then have a chance of using the CAD system for organization of their ideas.

The project of "NCR Automated Ticketing Terminal" was completed using a CAD program package which is widely used in the field of industrial design. I discovered a greater capability for the design development through the use of several CAD systems. The disadvantage of educational CAD program packages were compensated by connecting a graphics program package and with this I increased the efficiency of the program and this made the effective presentation possible. I could then easily develop a form in which each idea could easily be checked for the requirements of the design, and this made it possible for the same quality drawing to be produced to help in making a fair evaluation. Sometimes we make a mistake of the choosing a design because it was completed with excellent drawing skills and not upon the merits of the design idea.

I think, the results of this project gives the reader the capability to organize a CAD system for the designing of a project and to have the concept and basic capability to construct and use a high level workstation.

The development of a design needs to start with the form of the project, but keeping in mind the function of the product. With the

development of the NCR automated ticketing terminal I started with the basic components and tried to come up an appearance form, and then fit the components into that form.

This method does not work with every design project and each project has to be considered on a case to case basis, and the computer architecture based accordingly.

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