ABSTRACT OF THESIS

The Current Utilization Of Graphic Data Processing In Industry And Education With Implications For Industrial Arts

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Since the initial development of the computer shortly after World War II many new innovations in the computer and its peripheral devices have increased its application to many areas. The most recent of these peripheral devices is the cathode ray tube system which allows for the manipulation of graphic data. It was the purpose of this study to investigate the current and projected effects of graphic data processing upon industrial arts. The study was concerned with the various types of cathode ray tube units, a survey of their industrial and educational applications and an analyzation of the acquired data as to the implications for industrial arts.

The data were secured from manufacturers of the cathode ray tube systems and selected industrial and educational applications. The selection of the education sample was based on two previous studies concerned with the use of computers in education. The Higher Education Media Study was conducted by the Association for Higher Education and the Department of Audio-Visual Instruction of National Education

Association in cooperation with the Bureau of Higher Education of the United States Office of Education. The second study, Computers in Engineering Education, was conducted by the Information Systems Committee of the Society for Engineering Education and was completed in November of 1965. Industrial applications were selected on the basis of engineering need and research and development programs as identified through Thomas's Register, Poor's Digest, and the College Placement Annual. All identified firms were surveyed.

Since many of the applications were experimental in nature, some of the sections particularly in the educational questionnaire were not completed. The data acquired, however, indicated the computing systems used, application areas of the cathode ray tube system, personnel requirements, current and projected drafting needs, and developments in computer assisted instruction. Though a great number of present applications were not identified, the projected future uses are unlimited. Implications and recommendations as to the content, methodology, and curriculum of industrial arts were formulated.

Accepted by Robert C. Nash, Chairman

Clyde Hackler

C. Nelson Grote

THE CURRENT UTILIZATION OF GRAPHIC DATA PROCESSING IN INDUSTRY AND EDUCATION WITH IMPLICATIONS FOR INDUSTRIAL ARTS

A Thesis

Presented to

the Faculty of the School of Education

Morehead State University

In Partial Fulfillment

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Master of Arts in Education

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by

Chester Steven Rzonca

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Accepted by the faculty of the School of Education, Morehead State University, in partial fulfillment of the requirements for the Master of Arts in Education Degree.

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CHAPTER I

THE PROBLEM, DEFINITION OF TERMS, AND A REVIEW OF RELATED LITERATURE

Thoroughout civilization mankind has developed machines to ease the pains of labor. Until recently, these machines were confined to tasks of a mechanical nature. Shortly after World War II, however, the invention of the computer brought about an extension of man's mental abilities.

The computer was designed to analyze as well as retain facts. It supersedes man in that analyzation is performed quickly and retention is permanent. Its great speed allows it to access volumes of information in mere micro-seconds. These abilities, however, must be started and guided by man. The great disadvantage of the system lies in the slow process of man-machine communication.

Many refinements have been made in computing systems. In construction, for example, the third generation has been reached. From the early vacuum tubes, progress has led to transistors and micro-transistors. Physical size has been reduced and computer speed increased. The main difficulty, however, still lies in the field of cybernetics. Communication with computers can be thought of as having two distinct parts. One is the transposing of information so that it can be used and stored within the computer. The other is the entry and retrieval of information within the computing system.

Internal operation is based on the binary code. Any fact or process is stored according to some number of the base two. It would be rather cumbersome and inconvenient if a binary number had to be written each time a particular process had to be performed. In view of this, symbolic languages, which are a short cut form of English with numerical significance, were developed. They are convenient to the operator and easily utilized in the computer.

At the time these languages were being developed, physical means for entering and extracting information were also being devised. The original means of communication is the familiar punched card used at the typical college registration. This method has been supplemented by punched paper tape, magnetic tape, magnetic discs, magnetic drums, magnetic ink, and finally the latest development of graphic representation, the cathode ray tube.

In graphic representation, a cathode ray tube, similar to the common TV screen, provides a visual means of checking or entering data into the computer. In addition, data may be inspected at any interval while it is being processed and the final result is displayed in graphic form. This method transposes raw data into usable data in a very short period of time. It is with this method of graphic representation that the writer is concerned.

I. PROBLEM

Statement of the problem. It was the purpose of this study to investigate the current and projected effect of graphic data processing upon the program of industrial arts education. The study consisted of three basic parts. First it was concerned with the analysis of the various types of graphic data processing units, their related components, and a determination of their most efficient use in computing systems. Secondly, by means of an instrument, a survey was made of present industrial and educational applications of this media. Thirdly, these data were then analyzed and evaluated for future implications and necessary changes in industrial arts education were recommended.

Importance of the study. At the time of this writing there is little published related literature concerning the application of graphic data processing in the field of education. There is reason to believe, however, that subject matter in the industrial arts curriculum will be directly or indirectly affected by this media of computer communication. Since colleges and universities prepare industrial arts teachers, they are obligated to provide an accurate representation of industry and are responsible for the development of new and better curricula which can be used in the teaching of industrial arts at all levels. The current applications of graphic data processing represent the "cutting edge" of technology. In view of the potential of this means of computer communication to both industry and education, there appeared a necessity for research in order that education be kept abreast of the times.

II. DEFINITIONS OF TERMS USED

Alphanumeric representation. This is a presentation of data in the form of letters, numbers, or established symbols.

Bit. The smallest magnetized unit of storage.

Byte. The smallest number of bits that can be read or stored by a single instruction.

Cathode ray tube (CRT). This is a phosphor coated vacuum tube with the ability of glowing briefly when hit by an electron beam.

Cybernetics. A scientific study of those methods of control and communication common to computers.

Graphic representation. This is a presentation of data in the form of lines, bars, charts, graphs, vectors, or established symbols.

Graphic data processing. This is a method of computer communication which allows direct and rapid access to stored data which can be generated, scanned visually, selected, processed, modified, and redisplayed in alphameric and graphic representation.

Hardware. The mechanical, magnetic, electrical and electronic devices of which a computer and peripheral equipment is built.

Industrial arts education. This term is defined as a program of teacher education conducted by colleges and/or universities in which industrial arts teachers are prepared for certification at the secondary level. Subject matter in such a program is either directly or indirectly related with graphic representation.

Off-line. Referring to peripheral devices which may be used with or without the computer.

On-line. Referring to peripheral devices which are used as an integral part of the computing system.

Parity. The condition of equality which exists among the bytes of computer storage.

Software. A collective term used to describe the programs necessary for computer operation.

Time-sharing. The ability of the computer to do many tasks almost simultaneously. This allows for various departments of a firm to use a single computer or for various firms to use the same computer.

Utilization. This term is defined as an efficient use aimed toward a productive application.

III. STATEMENT OF HYPOTHESES

Graphic data processing will significantly influence the field of industrial arts at both the collegiate and secondary levels.

1. It will have an immediate impact on the selection of content in industrial arts classes, especially in the field of technical drawing.
2. It will bring about a significant change in the methodology concerned with the teaching of industrial arts.

3. It will effect curriculum planning in the field of industrial arts.

IV. REVIEW OF THE LITERATURE ON THE ADVANTAGES OF GRAPHIC DATA PROCESSING

In the past several years, many articles have been written about graphic data processing. These articles contain information on a particular application or a single development. A selected review of some of these short articles is necessary to show the importance of this method of computer communication.

Although computers have been used for many years in areas where graphic information is important, man has not had an effective means of communicating with the computer in a graphic mode. Now through the use of the cathode ray tube, equipment has been developed which allows computers to receive, file, and create graphic data. This equipment enables man to extend his creative abilities and perform existing jobs more effectively.[1]

Graphic data processing makes it possible to exchange graphic information at electronic speeds. Designed to help engineers, designers, and businessmen, the new system allows the user to communicate with a computer in almost the same way he talks with his colleagues.

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[1]Harold Wolpe, Graphic Displays Through Computers, A published report presented to the International Communications Congress held in Philadelphia, December 7-11, 1962 (Poughkeepsie, New York: IBM Corporation, November 1962), p. 1.

The instantaneous handling of graphic data reduces the time between the conception and execution of an idea.[2]

> The mode of communication is "conversational" putting the primary user in direct contact with the computer. The designer or draftsman can enter information into the system and direct the computer to perform routine operations. He can also exercise his judgement and communicate his decisions to the computer while he is working on his problem, thereby eliminating the need to anticipate and program decision-making routines.[3]

The graphic data processing system can speedily and efficiently perform the following duties formerly left to designers and draftsmen.

1. Recording information in the form of drawings.
2. Filing.
3. Retrieving.
4. Revising existing drawings.[4]

VI. RELATED LITERATURE ON THE COMPONENT EQUIPMENT OF GRAPHICAL DATA PROCESSING

In order to gain a true perspective of graphic data processing and related equipment, we should first be aware of the requirements to be met by such a system. The objectives of the General Motors Corporation, a leader in this field follow.

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[2]Irving Abzug, "Graphic Data Processing," Datamation, January, 1965, p. 35.

[3]Verlin L. Hoberecht, Application of Data Processing to Revision of Engineering Drawings, A published report presented to the Design Engineering Conference, May, 1965, (New York: The American Society of Mechanical Engineers, March 1965), p. 1.

[4]Ibid., p. 1.

The first requirement was that the process would produce a hard copy drawing for engineering use. The second requirement was that the process would simulate man-to-man communication where one man is observing details or discussing them with a second man who is either drawing or pointing to a particular part of a drawing. The third objective was the simulation of the comparison function. The system should allow for the overlay of two drawings so that their similarities and differences could be observed. The fourth objective was to achieve communication of non-graphic information.[5]

In order to fulfill these objectives efficiently, the system would have to:

1. Introduce data rapidly and accurately to the computer.
2. Operate on this data.
3. Observe the results of these operations and have the ability to modify them while still in the on-line environment.
4. File the original data and final results for future reference.[6]

The first equipment developed was a graphic console which included a display tube, control buttons, lights, a card reader, an alphanumeric keyboard and a position indication pencil.[7]

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[5]Edwin L. Jacks, "A Laboratory For The Study Of Graphical Man-Machine Communication," The GM DAC-I System, A report presented at the 1964 Joint Computer Conference (Warren, Michigan: Research Laboratories, General Motors Corporation, 1964), p. 344-45.

[6]M. Phyllis Cole, Philip H. Dorn and Richard Lewis, "Operational Software in a Disk Oriented System," GM DAC-I System, A report presented at the 1964 Joint Computer Conference (Warren, Michigan: Research Laboratories, General Motors Corporation, 1964), p. 351.

[7]Barrett Hargreaves and others, "Image Processing Hardware for a Man-Machine Graphical Communication System," GM DAC-I System, A report presented at the 1964 Joint Computer Conference (Kingston, New York: Data Systems Division, IBM Corporation, 1964), p. 363.

A typical display unit is the IBM 2250 which has the ability of visually displaying tables, graphs, charts, and alphanumeric numbers and figures. Data are presented on a twelve by twelve inch square area on the face of a twenty one inch cathode ray tube. The display area contains over 1,000,000 display points that can be addressed by x and y coordinates. Within this same area, 74 lines of 52 characters each can be displayed.[8] This console is supported by an alphanumeric keyboard which is a typewriter-like device used by the operator to compose messages consisting of letters, numbers, and symbols.[9]

Another feature is the program function keyboard which provides for manipulation of the computer program by means of changeable descriptive overlays. Each overlay is coded by a subroutine to control the computer. One overlay might be used to enlarge, decrease, or delete a screen image while another might be keyed to various electronic symbols.[10] Closely related to the program function keyboard is the light pen which may also be used for communication by pointing a pen-like device at a portion of the cathode ray tube. This portion of the image may then be controlled to enlarge, decrease, or delete itself from the image area.[11] Still another means is the operator

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[8]International Business Machines Corporation, IBM System/ 360 Systems Summary (Poughkeepsie, New York: Customer Manuals, IBM Corporation, 1964), p. 17.

[9]International Business Machines Corporation, IBM System/ 360 Component Description, IBM 2250 Display Unit Model I (Kingston, New York: Product Publications, IBM Corporation, n.d.), p. 6.

[10]Ibid., p. 30.

[11]Ibid., p. 12.

control panel. This allows the operator to become an intergrated part of the computer system. By means of switches and indicators, the operator is able to maintain basic control of the program.[12]

These features can be further increased by other additives. Absolute vector graphics, for instance, provides the ability to draw vectors from any point on the 1,024 by 1,024 grid to any other point. The vector can be drawn at any angle and of any length.[13] The buffer storage unit provides a means of regeneration by which an image can be maintained on the face of the cathode ray tube while the computer can be freed for other work.[14]

The character generator is used to reduce the time needed for the display of a character. Instead of using the computer to create a character by addressing individual points, the character generator is used to transfer a one byte representation. Sixty-three characters including the alphabet, numbers, and special symbols are available. These characters come in a standard size and one which is one and a half times the standard size.[15]

Recorders and scanners are sometimes used to implement the use of the 2250. Through the use of thirty-five millimeter film, information may be processed in and out of the computer in natural form. In the IBM 2280 Film Recorder, an output device, the same cathode ray beam used to develop a screen image is used to expose the desired information on 35 millimeter silver emulsion film. The time required

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[12] Ibid., p. 10. [13] Ibid., p. 13.

[14] Ibid., p. 10. [15] Ibid., p. 10.

for development is less than one minute. The 2281 is similar to the 2280, but is an input device. The cathode ray beam is passed through two photomultiplier tubes. The intensity is measured and then transferred to the computer.[16]

A combination of the 2280 and the 2281 is the IBM 2282 which has the abilities of both units. Since certain components are common to both units, only one mode of operation is possible at a time.[17]

In the development of recorders and scanners, program system objectives dictated that line widths .05 per cent of image size must be maintained. Thus the system was designed to provide an accurate method for converting graphic data to digital form.[18] Used in conjunction with recorders and scanners is a device called a plotter. It produces engineering drawings from English-like statements or as a form of computer output.[19] When used with the telegraph communi-

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[16]International Business Machines Corporation, IBM System 360 System Component Description, IBM 2280 Film Recorder IBM 2281 Film Scanner, IBM 2282 Film Recorder/Scanner (Kingston, New York: Products Publications, IBM Corporation, n.d.), p. 5.

[17]International Business Machines Corporation, The IBM 2282 Film/Recorder/Scanner Unit (A circular by the IBM Corporation, New York: IBM Corporation, n.d.).

[18]Fred N. Krull and James E. Foote, "A Line Scanning System Controlled from an On Line Console," GM DAC-I System, A report presented to the 1964 Joint Computer Conference (Warren, Michigan: Research Laboratories, General Motors Corporation, 1964), p. 377.

[19]International Business Machines Application Program, 1620 Drafting Program Application System (White Plains, New York: Technical Publications, International Business Machines Corporation, n.d.), p. 1.

cations system, it is possible to transfer data for a completed drawing across the nation or to another country.

All of this component equipment was developed to facilitate the use of the graphic console. It is estimated that most computers can execute from 10,000 to 1,000,000 instructions per second. A human programmer can write and correct about 100 instructions per day. The ratio of speeds is about 30,000,000 to 1.[20] Through graphic data processing, the need of many programmed instructions is eliminated. Without the formerly mentioned software, the programmer would still have to convert his output information from his own internal format to a format required by the hardware. He would not be in a position to make easy, efficient and flexible use of the hardware.[21]

VII. REVIEW OF THE RELATED LITERATURE ON THE APPLICATIONS OF GRAPHICAL DATA PROCESSING

The following applications have been taken from an IBM publication describing the 2250 graphic display unit.[22] In the

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[20]H. C. Brearly, "Computers, Computing, and Careers," Report Number 171 (Urbana, Illinois: Department of Computer Science, University of Illinois, March, 1965), p. 9.

[21]Thomas R. Allen and James E. Foote, "Input/Output Software Capabilities for Man-Machine Communication and Image Processing System," GM DAC-I System, A report presented at the 1964 Joint Computer Conference (Warren, Michigan: Research Laboratories, GMC, 1964), p. 387.

[22]International Business Machines Corporation, Use of the IBM 2250 Display Unit (White Plains, New York: Technical Publications, IBM Corporation, n.d.), p. 1-2.

field of engineering, we are interested in design efficiency in addition to a suitable drawing. The engineer can make a rough sketch on the face of the console using the light pen. The lines are then automatically made smooth. Now the engineer can enter essential specifications which the design must contain. The computer then figures items such as weight, indurance, cost or power. These values are then displayed with the sketch. If the engineer is not satisfied, he can indicate the items in need of further change and resubmit them to the computer. This process of operator control and computer processing can continue until a suitable design is reached.

The graphic data processing system in engineering allows all design logic and parts specifications to be stored within the computing system, thus allowing for quick accessability. It eliminates routine human tasks and provides for a better design by on the spot testing.

Another use of visual communication is in the field of inquiry and management control. An example is the use of the various motor vehicle departments in reviewing license and motor vehicle registration. An application can quickly be checked and corrected. Often large supply houses receive phone calls which demand a reply in a few minutes. Stock can quickly be inventoried and a response given.

In scientific computation, intermediate as well as final results can be presented in the form of bars, charts, curves, points, or symbols. The time in the transfer of messages between computer and operator has been cut to a minimum. In the analysis of the space probe, the process time has been cut from three weeks to two days.

> With time sequenced aerial photography and image-processing techniques, the trajectories of any or all vehicles over a large stretch of highway can be determined. From such trajectories, head way, spacing, volume, density, and velocity data can be derived. The effects of traffic flow on ramps, merger lanes, driver-information signs, and congestion causing events can be calculated. Ultimately, such knowledge will produce operational methods for maintaining high capacities on highway transportation facilities in high-density situations.[23]

At present there is little evidence in the literature reflecting the application of graphic data processing in education, but the effects of industry will soon relate to industrial subjects. According to Talkington, the need for these industrial subjects will not lessen, although the areas of emphasis will change. He states that a greater demand for creativity and knowledge acquisition through the computer will accompany the basic principles of drafting. The tedious drawing of repetitive parts will be unnecessary. Through the guidance function of industrial arts, an introduction to visual computer communication should be presented in order for youth to become part of the new technical culture. The need for education to stay with the times has been increased.[24]

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[23]IBM Data Systems Division, Application of Data Image Processing Techniques To Traffic Acquisition (Kingston, New York: Data Systems Division, IBM Development Laboratory 1964), p. 4.

[24]Joe E. Talkington, "Computer Graphics in the Schools," The Journal of Industrial Arts Education, May-June, 1966, p. 20.

CHAPTER II

THE DESIGN OF THE STUDY

Limitations of the study. Difficulty in the identification of firms using the cathode ray tube system (CRT) and the hesitance of these firms to elaborate upon their usage served as the main limitations of this study. This difficulty can be attributed to the presently rather confined use of this recent development. The relatively short period of time that the CRT has been used for computer communication, its importance as an on-line media, and its expense are all factors contributing to the lack of industrial applications.

Although General Motors and the Massachusetts Institute of Technology experimented with the CRT as early as 1963, public results of research in this area were not known until the Fall Joint Computer Conference of 1964. Present developments of industry, then, have occurred over the past two years. Many of these developments are still in the theoretical and experimental stages.

However, in general application, as a real-time control device, the CRT system is the most efficient means of computer communication. The areas of application include management, design, test monitoring, scientific computation and others which are included in the body of this study.

The solving of unique problems for a particular application demands costs in both time and money. Having solved these problems, the concerned firms are not willing to make the results of their research publicly known where the released information can be easily utilized by competitors. Again the cost of the CRT system, including the computer, prohibits experimentation by many smaller or conservative companies. Cost is also the major prohibitive factor against the use of the CRT in computer-assisted educational programs.

The manufacturers of the CRT system, having an ethical responsibility as vendors, are also hesitant to relinquish the names of firms presently using their system. Typical of the manufacturers is the IBM Corporation which controls a majority of the computer market. As a matter of company policy, it refuses to give out information concerning present customers. General information from the manufacturers did lead to the identification of some specific industrial applications and to the areas of development contained within the aerospace, air-craft, automotive, and design industries.

Another limitation of the study was the lack of suitable library facilities. Most of the periodical literature concerned with the CRT is located in Engineering Journals. Since Morehead State University is not primarily devoted to the education of engineers, the library facilities are limited in engineering publications. Most of the review of periodical literature was performed in the libraries of the University of Kentucky and University of Connecticut. Still, some of the articles listed in the Applied Science and Technology Index could not be found.

<u>Assumptions of the study</u>. Industrial firms using the CRT were identified through the review of the literature and from

information provided by manufacturers. Though these sources did not identify all firms using the CRT system, it is assumed that a comprehensive sampling suitable for the purposes of this study was provided. The method of contacting and sampling these firms will be discussed later in this chapter.

The data collected from these firms is an indication of CRT usage. As previously discussed, the great importance of the CRT system has limited the amount of information available. In some cases, the information presented by the firms may not be an accurate representation of their developments or the degree of their usage. It may be assumed that actual use is ahead of the information released to the public.

Though the present utilization of the CRT system is confined, it is felt that future advancements in computer technology will increase the influence of the system. With the advent of time-sharing, telegraph and data transmission lines, and the dissemination of present CRT knowledge, the realization of common CRT usage will become possible.

Computer design advancements, only recently available, allow for a more efficient use of both large and small computers by the CRT system. Through time-sharing, several computer activities may be carried on almost simultaneously. The same computer, therefore, can be used in a CRT system and at the same time for more common computational chores. New, smaller and thus less expensive computers will also serve to lower the overall cost of the CRT system.

This study, then, is based upon the assumption that future uses of the CRT system will cause it to be a prominent means of computer communication. These uses will be new and different allowing for the computerization of areas previously thought of as infeasible. The current uses are offered as concrete examples which will be expanded for general acceptance in industry and education.

Initial Data Acquisition. Periodical literature concerning the capabilities, uses, and manufacturers of CRT systems was reviewed as the initial step in data acquisition. Approximately 160 articles were reviewed. From these articles, eighteen manufacturers of CRT systems were identified and contacted to obtain data including the cost, capabilities, application areas, and users of their systems. Fifteen of the manufacturers responded to this letter of inquiry.

Identification of Industrial Firms. Only three specific firms were identified as users of the CRT system from information provided by the manufacturers. Their suggestion and the review of related literature contained present application to the aerospace, aircraft, automotive, and design industries. The armed services and government agencies were also suggested.

Both sources also indicated that industries concerned with CRT development would have to be large, have a vast amount of money reserved for experimentation, have a definite need for the engineering disciplines, and they would have to be competitive within their area of specialization. Through the use of Thomas's Register, Poor's Digest and the College Placement Annual firms were selected on the basis of engineering need and interest in research from the industries suggested by the manufacturers. The armed forces, government agencies and firms specializing in computer services were also classified as having a need of the CRT system. Size and competition were not used as criteria for selection since they were considered relative values. Although the manufacturers can possibly be considered users of their own equipment, they were not included in the sampling procedure for it was felt that there inclusion would bias the selection of industrial firms.

A form letter was then sent to these firms to determine if they were using the CRT, the extent of their usage, their areas of application, their cost and the capabilities of their system. From this initial data, categories or areas of application were determined leading to the classification of the responding firms.

Acquisition of Questionnaire Data From Selected Industrial Firms. In order to justify the implications of industrial CRT system usage and the incurred educational responsibility, a questionnaire was developed to secure the following data deemed necessary for the study:

1. Size and type of firm
2. Hardware equipment used
3. The number and type of personnel concerned
4. Problems and advantages of the CRT system
5. Educational responsibility
6. Effect on the field of design and/or drafting

Since only 20 firms responded to the original form letter as using the CRT system, all were included as participants of the questionnaire.

Acquisition of Data From Selected Educational Institutions. In order to gain an insight into educational applications, five institutions were initially contacted as to their uses of the computer. These institutions were identified through the related literature as being instrumental in the development of computer assisted instruction. Their uses will be discussed separately from the uses of those institutions contacted in the survey.

To survey educational uses centering on computer-assisted instruction and future educational implications a questionnaire was developed to secure the following data deemed necessary for the study:

1. Size of institution
2. Size of computer-assisted education program as to the number of students and the amount of their usage
3. Hardware used
4. Number of staff concerned
5. Problems and advantages of the CRT system
6. Subject areas feasible through CRT systems
7. Rating of computer-assisted instruction

The selection of educational samples was based on two previous studies concerned with the use of computers in education. The first was the Higher Education Media Study, completed in August of 1966, was a project of the Association for Higher Education and the department of Audio-Visual Instruction of the National Education Association in cooperation with the Bureau of Higher Education of the United States Office of Education. The second study, Computers in Engineering Education, was conducted by the Information Systems Committee of the American Society for Engineering Education and was completed in November of 1965. The studies contacted a total of 1,577 institution of high learning to gather data on various computer applications. Since the CRT is dependent upon the computer it was felt that the comprehensive sampling of these organizations would provide an excellent basis to gather data concerning the applications of graphic data processing.

The Higher Education Media Study identified fifty-four applications in computer-assisted instruction, 21 in information storage and retrieval, and an additional 106 unclassified applications. Since the computer-assisted instruction and information storage and retrieval applications are logical areas of CRT utilization a q-sort was used to provide a 50 per cent sampling of these areas. In addition a 10 per cent random sampling was performed of the unclassified group. Computers in Engineering Education identified an additional fifty-two institutions. Since the field of engineering was instrumental to the development of the CRT, a q-sort was used to sample 50 per cent of these later institutions. This procedure brought the total sample of educational institutions included in the survey to seventy-two.

Supplementary Data Acquired Through Personal Interview. Though the questionnaires were comprehensive in respect to the acquisition of the desired data, it was felt that additional information would be necessary particularly in the determination of encountered problems and future implications.

Several educational institutions and industrial firms were selected to provide this additional information and evaluate the questionnaire form. These participants were selected on the basis of their geographic proximity and leadership in either industrial applications or computer-assisted education.

Evaluation of Acquired Data. The data secured were evaluated as to their implications for Industrial Arts Education. These implications were classified into three general categories:

1. The effect upon the various subject fields commonly taught in Industrial Arts as a representation of industry.

2. The methodology used in the teaching of Industrial Arts in relation to computer-assisted education and the necessary physical facilities.

3. The curriculum revision necessary in Industrial Arts Education brought about by the developments in the cathode ray tube systems.

Supplementary information about the manufacturers, industrial firms, and samples of the questionnaire are included in the appendix.

CHAPTER III

THE NATURE AND CHARACTERISTICS OF THE CATHODE RAY TUBE SYSTEM

The cathode ray tube system (CRT) provides for an instantaneous display of stored data which may be altered or updated at the convenience of the operator. The data displayed may be regenerated indefinitely through buffering units thus allowing the computer to perform other routine tasks while the CRT is being used.

It is the purpose of this chapter to present information pertaining to the early developments of the CRT system, its areas of application and the peripheral equipment necessary for its implementation.

I. EARLY DEVELOPMENTS

The CRT system is an outgrowth of research conducted to find a simple and efficient means of communication between man and the computer especially with respect to graphic data. The original efforts were initiated to make a more efficient use of the scarce supply of engineering ability. Though the computer had long been used to solve engineering equations, the element of man-machine communication was a consistent problem. It was also felt that a graphic solution, which could be viewed during its computation, would be much more beneficial to the user than the familiar print-out sheet. Limited success in the use of the CRT system began in

1963. These early systems left much to be desired, but, did offer ease of communication and graphic presentation.

The joint efforts of the International Business Machines Corporation (IBM) and the General Motors Corporation (GM) led to the development and production of the necessary hardware equipment. General Motors supplied the requirements for the desired equipment along with the experience it had incurred in the use of computers in automotive design. The IBM Corporation supplied the technical knowledge necessary for peripheral equipment development. Their early system included the CRT, light pen, alphanumeric and program function keyboards, and 35 mm. recording and scanning devices. Though little published information is available concerning the present state of development at General Motors, recent correspondence with the corporation indicates that much of the work is of an experimental nature. The indication of this correspondence, however, is hardly compatible with the efforts extended by the corporation. During an IBM presentation concerning the CRT system at Morehead State University it was learned that General Motors has spent five hundred thousand dollars a month on graphic data processing since 1963. This brings the present total to twenty-two million dollars spent on program development which is housed in a highly restricted laboratory. It would seem that the present state-of-the-art at General Motors is beyond publicly released information.

Since its early developments, the IBM Corporation has significantly improved and expanded its offerings. They currently offer four models of the CRT designed specifically for alphanumeric or graphic representation. Their system is complemented by a full line of peripheral equipment and off-the-shelf software packages.

At the same time, the Rand Corporation, a private research organization, was developing their "Tablet" for graphical communication. A horizontal grid was developed which allowed the user to write or draw in a natural manner. The grid eliminated the need for any computer controlled scanning system to locate or track the stylus.[1] The CRT is used to display the drawing as it exists in digitized form. Development has been carried to where it represents a practical and economical tool.

While these developments brought about a sophistication in hardware, the Massachusetts Institute of Technology was making equal strides in software. Ivan Southerland's Sketch Pad allowed for a two dimensional representation of a three dimensional object. His programming advancements allowed for a CRT generated isometric drawing when the top, front, and side views were drawn on the face of the CRT tube.

During the interview at Massachusetts Institute of Technology, the investigator also learned of the developments of Dr. George Coons whose work with software will allow for rotation, enlargement and reduction of three dimensional objects. When fully developed, this

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[1]M. R. Davis and T. O. Ellis, The Rand Tablet: A Man-Machine Graphical Communication Device, (Santa Monica, California: The Rand Corporation), p. 21 et passim.

software can be offered as an integral component of the CRT system. Much of the work in graphics at Massachusetts Institute of Technology is performed at their Lincoln Laboratories. This research branch is to a great degree subsidized by the Federal Government. The results of their projects are seldom used within the institute but are offered to interested private corporations.

II. AREAS OF APPLICATION

As a design and information storage/retrieval tool, the CRT system has found application in the aerospace, aircraft, automotive and engineering industries. Its graphic mode allows for the tracking of plane flights and the calculations involved in flight patterns and landing paths. The same type of system is also being used to track and analyze the paths of space vehicles at blast-off and re-entry phases.

In the engineering field, the CRT and its peripheral equipment can be used to easily and quickly enter data into the computer. The data may then be processed, stopping at any time for necessary alterations. The engineer can communicate with the computer effectively having had little or no previous training in CRT usage. To illustrate this point, the United Aircraft Corporation gives the engineer a short explanation after which he is allowed to experiment on his own for approximately three hours. This brief procedure renders the engineer a competent user of the CRT system. The time period of IBM seminars in the use of CRT consoles is of similar duration.

Applications in the automotive field according to General Motors confined largely to design. Previous drawings may be stored on a 35 mm. aperature card from which they may easily be generated to the CRT screen for alterations. Another application, presently being used by the Chrysler Corporation, is in the area of information inquiry. They are using the CRT to verify their warranty program. A less costly area of application lies in the presentation and retrieval of alphanumeric data suitable for business needs. Inventories, budgets, sales records and personnel files can conveniently be kept through the CRT system.

Some needs require both graphic and alphanumeric data. An example of this is the presentation of annotated graphs suitable for management conferences. During an interview with the Westinghouse Corporation, Mr. James Stevens described a system which provided graphic information concerning the status of sales, inventory, and production of the various appliances distributed by the corporation. Additional information concerning applications will be provided in Chapter IV.

In summary, the CRT system can replace or be used in conjunction with current peripheral devices to perform any computer task. The capabilities of the CRT system, however, exceed those of all peripheral devices yet developed. Again, the ease and speed by which the operator can communicate with the computer and the graphic display produced are the main advantages.

III. THE CATHODE RAY TUBE

The cathode ray tube (CRT) has previously had wide application as the viewing screen in television sets and oscilliscopes. By definition the CRT is simply a vacuum tube with the ability to glow when its phosphor coated surface is hit by an electron beam. This simple definition does not, of course, include the limitations and qualities which must be taken into consideration when the CRT is to be used as a computer communication media.

Foremost of these considerations is the method of controlling beam movement within the tube. Either electrostatic or magnetic deflection may be used. In magnetic deflection, beam movement is controlled by a change in current applied to coils placed outside the tube while in electrostatic deflection beam movement is controlled by the difference of voltage applied to two parallel plates within the tube.

Both methods have their advantages and disadvantages. The beam movement in a magnetic tube is less costly, but slower, than the faster more expensive beam movement of the electrostatic tube. Wider beams are possible through the electrostatic system which demands high voltage. The narrow beam of the magnetic system operates on high which is easily satisfied through transistorized circuits. Settling time is less with the electrostatic system than with the magnetic.

The method of beam movement must be selected according to the CRT system requirements and cost.[2]

The phosphor used in the CRT should be bright, flicker free and require as little regeneration as possible. The phosphors generally used produce a short, bright beam which must be regenerated thirty times a second. They have a long life and may easily be detected on the face of the tube. Phosphors requiring less generation have a shorter usable life and lack the brightness necessary for displays.

The size of the CRT varies from fourteen to twenty-one inches. Actual usable surface is reduced by tube neck diameter and angles of deflection and the desired work area shapes. Accuracy in this usable work area is determined by line resolution, jitter, and settling time. Line resolution of 100 lines to the inch is common allowing for almost 1½ million points which are addressable on a twelve inch square work area. Jitter is the lack the beam to hold at only one of these addressable points. Settling time is the amount required for the beam to hold one spot size after movement. Settling time is less than one thousandth of a second and jitter is confined to one spot size.[3]

Cost is directly related to these qualities. A large CRT with high line resolution, low settling time, and little jitter is

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[2]Carl Machover, "Modular Graphic CRT Displays Available From Information Displays, Inc.", (New York: Information Displays, Inc., 1966), p. 2. (offset).

[3]*Ibid.*, p. 4, et passim.

naturally more expensive than a smaller less accurate tube. The cathode ray tubes available from the Information Display Corporation range from six to sixteen thousand dollars. The cost of the tube, however, is just a small part of the amount needed for the entire system.

IV. DEVICES NECESSARY TO DRIVE THE DISPLAY

The computer, composed of the memory, control and arithmetic sections is basic to the CRT system. Data must be transferred from the computer to the CRT through data transfer channels, the interface control, and data registers to the beam deflection unit. These devices are essential for the transfer of digitized data from within the computer to the displayed data on the face of the CRT.

The interface control and data transfer channel compose the switching device which activates the extraction of data and stipulates the method by which data will be transferred. It must be noted that the computer and CRT system are not in constant direct contact. While data is displayed for operator observation and modification, the computer can be used for other data processing routines. The interface also has the function of checking the parity and validity of the data being received. Data bits used by the computer may be of either even or odd parity. In an even parity machine, the bits must always add up to an even number while in an odd parity machine the bits must always add up to an odd number. The validity check merely assures that the data and instructions being received are compatible with the stipulated software program.

From the interface, we proceed to the data register. The function of this device is to separate the instructions from the data to be processed. The instructions are referred to the control center while the data to be presented are referred to the beam deflector. The instructions are processed by the control center and used to control beam movement and other display variables. The data bits are then received by the deflection unit and converted to analog signals. These signals with proper instructions from the control center are applied to the deflection yoke of the CRT. The beam, blanked or unblanked, can now be moved to the proper screen position to produce the desired display. The blanked beam is covered so that it can move across the CRT screen without producing an image. The unblanked beam activates the phosphor to produce a display.

V. INPUT DEVICES USED TO ALTER THE DISPLAY

The most common peripheral device used with the CRT is the alphanumeric keyboard. With it, the user can call out, alter, or define data on the face of the screen. Its physical appearance is similar to that of a typewriter keyboard. Numbers, letters and symbols, including those common to cybernetics, are available through this keyboard whose capacity is either 64 or 128 characters. Upper and lower cases of the alphabet are available depending upon the manufacturer. The alphanumeric keyboard can be used to compose messages, text, or instructions essential to the operation of the computer. The typed matter is instantly displayed on the face of the screen where it may be edited. Corrections can then be made or the data can be transferred for storage within the computer. Cursors are available to show the point being addressed on the screen. Typical typewriter spacing is used in the composition of messages or letters.

In preparing a computer program, the alphanumeric keyboard can be used in place of the traditional card punches and verifiers. The information can be visually edited thus eliminating the time formerly used for verification. The transfer of data now takes place at electronic speeds instead of the mechanical limitation imposed by the card read unit. In more sophisticated systems, the alphanumeric keyboard is used to define geometric shapes. A preprogrammed subroutine is activated through the keyboard which allows for the acceptance of data. Once the subroutine has been activated, the geometric object can be defined through an established programming language. For example, CIR 2/3, 3 would be the mnemonic operation code for a circle whose radius is 3 inches and whose center lies at the cartesian coordinates of $x = 2$ and $y = 3$. This procedure can be adapted to lines and used to form geometric planes or solids. Other pertinent data such as finish, cost, or machining instructions may be included at this time. Other uses of the alphanumeric keyboard include the review of personnel files, the insertion of engineering equations, the selection of graphs and computer assisted instruction.

Another means of entering data to the CRT system or modifying it, is the light pen. The light pen is a photocell used to draw on or otherwise communicate with the CRT. The lines drawn on the face of the CRT may be visually inspected and then entered into the computer as stored digitized information. This information may be recalled and altered for any future use. The light pen may also be used to identify parts of an established display by circling the desired portion or by initiating a preprogrammed code. For instance, we may wish to enlarge or rotate a particular portion of a given display. The operator would activate the light pen by means of a foot pedal or console switch and circle the desired portion. The program function keyboard, to be described later, would then be used to enlarge or rotate the desired portion of the display allowing the original image to fade away. To change values in a displayed electrical circuit, a light sensitive area would be included in the original display. This light sensitive area would then be activated by the light pen allowing for the initiation of a subroutine. Alternate values could then be substituted by means of the alphanumeric keyboard.

The last input device of the CRT system to be discussed is the program function keyboard. This device is used to call data from storage, manipulate it or subject it to some available subroutine. The typical program function keyboard consists of 32 keys coded to a particular subroutine. We may, for example, wish to call a drawing to the viewing screen which has been stored by a numbered code. By pressing the proper precoded button, the computer is readied to query storage. The number of the desired print is typed in by using the alphanumeric keyboard and the print is then displayed on the screen.

The investigator has personally worked with this type of drawing during an interview with Mr. Samuel M. Masta, manager of the IBM Advanced Scientific Center. The print was a trestle bridge, often displayed and discussed by the IBM Corporation. By pressing the designated buttons, the capabilities of enlarging, rotating, reducing, and perspective creation were demonstrated. The bridge originally came into view as an isometric drawing. It was then rotated right, left, forward, backward, and made larger or smaller. By depressing the foot pedal, the light pen was brought to focus on a particular portion of the bridge. All of the former operations were then performed on this section, while the remaining bridge structure faded away. The most impressive part of the demonstration was the ability of the program function keyboard to create a perspective. It too, could be altered by any of the previous operations.

VI. DEVICES USED TO IMPROVE THE EFFICIENCY OF THE CRT SYSTEM

Buffering and generating units are included within the system to increase its efficiency. Both save the valuable storage space and the time needed to transfer data between the CRT system and the computer. Though the units vary from one manufacturer to another, their general function remains the same.

Buffering units are used to regenerate the display on the face of the CRT. In the discussion of phosphors, it was noted that the display must be regenerated thirty times a second to be visible to the eye without any indication of flicker. Once the display has been initiated, the buffering unit maintains the image without involving computer storage. Transfer time between the CRT and the buffering unit is much less than that between the CRT and computer. In the newest CRT systems, storage devices are included which absorb much of the buffering function.

To further save time and computer storage, most manufacturers provide generators to display characters, vectors, and geometric shapes. The vector generators allow for both absolute and indefinite vectors. Absolute vectors can be drawn anywhere on the face of the tube by specifying the end points of the vector. The need for all points between the end points is eliminated. Thus the storage for an entire line is concerned only with the addresses of the line's extremities. The indefinite vector is similar except that a point and the direction which the vector must take is specified. Data transmission takes place from the generator to the CRT eliminating the use of computer storage. Circle generators and those for other geometric shapes are similar in function.

The character generator is used to present numbers, letters, and special symbols as designated by the alphanumeric keyboard. These characters as stored on punched cards, magnetic tape and within the computer occupy only one column or bit of storage. For graphic displays, the series of points or lines making up the needed letter would have to be stored as individual bits. The character generator eliminates the need of these points. It stores the letter as the extremities of the end point of the lines which make up the letter. When the letter is called for, the extremities are sent to the deflection yoke of the CRT where the unblanked beam is positioned to form the letter.

VII. INPUT/OUTPUT DEVICES DEVELOPED AS AN OUTGROWTH OF THE CRT SYSTEM

Outgrowths such as the recorder, scanner, slide projector, microfiche and motion picture equipment rely directly on the CRT. While the CRT is independent of these devices, its use in conjunction with them greatly expands the area where it finds application.

The devices most widely used to support the CRT are recorders and scanners. They provide an alternate means of communicating with the CRT and computer through the familiar 35 mm. microfilm aperture card. The scanner reads drawings, geometric figures, or other alphanumeric and graphical data from the aperture card and transforms this data into digitized information to be used within the CRT and computing systems. Thus, any 35 mm. microfilm aperture card may be read and displayed upon the face of the CRT for modification. When modifications have been completed, the digitized data is sent to the recorder where it is reverted to the graphic microfilm form. These devices are termed off-line for they operate independently of the computing and CRT systems except during initial data transfer.

Conventional techniques can then be used to duplicate the microfilm or produce hard copy. Information can be conveniently stored on the aperture card and still be in a form where it can easily introduced to the computing system. The hard copy can be used when it is necessary to remove information from the viewing area. Microfiche is also used where miniaturization is desired. It cannot as yet be read directly into the computer through present scanning devices.

The latest developments lie in CRT photography. Motion pictures or slides can be taken of the information presented on the CRT. In the Federal Laboratories system, multicolor maps and other formats can be photographed and developed in less than two minutes. These photographs are converted to slides or movies and can be projected to any convenient size. Developments such as these are currently being used by the Army in their War Room Display System at Fort Wayne, Indiana.

The Tasker Instrument Corporation has developed a commercial overlay similar to the original Rand Tablet. It consists of a fine wire grid which is placed over the face of the CRT. In their normal position, the wires are not in contact with each other. However, when they are depressed by the use of a stylus, the corresponding x and y coordinates are stored as digitized data within the computer.

VIII. EXISTING INPUT/OUTPUT DEVICES USED IN CONJUNCTION WITH THE CRT SYSTEM

The greatest implication of the CRT lies in its use with tape driven numerically controlled machines. These machines have proven their advantages and are quickly growing in number. Programming the punched paper tape, however, has proved to be somewhat of a problem. Computers have been used for the calculation necessary for the tape development. Now, with CRT drafting techniques much of information needed to program the punched tape is already in digitized form within the computer. In a personal interview with Mr. Lee Presscott of the United Aircraft Corporation, the idea of a completely automated production system was emphasized as the end product of their research. Their program is aimed at the development of CRT drawings which will be converted, through the use of the computer, to usable punched paper tapes suitable for numerical control machining. The United Aircraft Corporation is only one of the firms presently working in this area. Once the system is perfected it will further the use of both the CRT system and numerical control machining.

When the hard copy desired is too large for the hard copy printers, the CRT system may be used with automated plotters and drafting machines. The plotters are the less accurate of the two but can be used to draw from eighty to six hundred inches per minute. The drawing machines are somewhat slower, running between two hundred to three hundred inches per minute, but have a tolerance of ±. 001. The plotters and drawing machines have been used by many firms. Having preceeded both the CRT system and microfilm equipment, they will continue to provide the necessary hard copy, particularly when large prints are necessary. Typically, the plotters can be used for prints up to 5 feet by 100 feet.

The CRT system can, of itself or through the computer, accept data from most peripheral devices such as card readers, magnetic tape readers, paper tape readers and disc and drum storage units. It may be used to supplement these devices or in lieu of them.

IX. SOFTWARE AND CRT CAPABILITIES

Software is a major controlling factor which limits or expands the effectiveness of the CRT system. The software may be divided into programs which control the operation of the various peripheral devices and those programs used for actual data manipulation. It is well to note that all of the peripheral devices discussed would be useless without well developed software.

The standard programming which allows for data transfer between devices and the initial data display is almost always provided by the manufacturer. These standard programs are compatible with any application of the CRT system after initial development. Programming used for data manipulation, however, must be adapted or modified to most new applications. An example of this is the display of graphs for management conferences. Though the initial concept necessary for the programming of graphs is similar in any application, the type of graph, its size, graduations and the like would have to be adapted to new situations. In most cases some modification of existing programs is necessary for their adaptation of new areas. The problems of programming are not particular to CRT systems but are evident of computer use in all applications. For unique applications an entirely new software package would have to be developed.

In order to more fully utilize the developed software and the capabilities of the CRT System in general, many graphic consoles may be linked to a single computer. Six or more consoles are common in multiple use and one exception, the Philco-Ford system to be used in the Philadelphia schools, will link thirty consoles to a single computer. The extent of peripheral devices used in multiple console operation is determined according to the application. Since the hardware devices of the CRT system have reached a sophisticated level, the future of its application lies in software development.

X. SUMMARY

The CRT system has quickly developed into an effective computer communication media since its introduction in 1963. Characterized by ease of operation, graphic presentation, and on line control it is adaptable to any situation where use of the computer is necessary. The use of associated peripheral devices greatly expand current and projected applications of the system. As current uses become wide spread, other applications will become readily apparent.

Since the present level of sophistication in the hardware devices is adequate, an emphasis will be placed on software development. Objectives of the United Aircraft and McDonnel Corporation lead the investigator to believe that a completely automated production system will be developed. Computer aid, from the initial drawing to the machined component will be possible within the next five years.

As the use of the system becomes wide spread, increased production and improved techniques will serve to lower current purchase and rental costs. As costs are lowered, the system will again be made available to a wider number of users allowing the CRT to become a common means of data exchange between man and the computer. Over all development of both hardware and software will allow the CRT system to take its rightful place in the computer age.

CHAPTER IV

THE CURRENT UTILIZATION OF THE CATHODE RAY TUBE SYSTEM IN SELECTED SAMPLES OF INDUSTRY

A form letter, inquiring as to possible use of the CRT system, was sent to sixty-four industries whose selection was described under the heading of Initial Data Acquisition in Chapter Two. The first mailing brought twenty-nine responses, or a 45 per cent reply. A second form letter was sent to the thirty-five firms who had not replied. Five additional responses were received, bringing the total response to 53 per cent.

Of the thirty-four firms responding to the form letter, twenty firms or 31 per cent of the originally selected sample indicated that they were currently using the CRT system. All twenty firms, indicating CRT usage were sent the questionnaire devised to obtain information about current utilization of the system. Eleven firms or 55 per cent responded to the original mailing of the questionnaire. A second mailing brought one additional response. The total of twelve firms comprises 60 per cent of the group which had indicated CRT usage. Two of the twelve firms declined to answer the questionnaire due to the priority information it requested.

The total questionnaire return may be summarized as follows. Of the sixty-four firms originally contacted, thirty-four or 53 per cent responded. Twenty or 31 per cent indicated CRT usage. Ten firms furnished usable replies to the questionnaire procedure. Usable replies comprise 50 per cent of the firms indicating CRT usage and 16 per cent of the original selected sample.

A comprehensive view of the application areas was obtained since the firms responding to the questionnaire represent varied industries. In many cases several applications of the CRT system are used by one firm. A more definite classification of uses and the personnel concerned will be provided later in this chapter. The function of the firms responding to the questionnaire is shown in Table I.

The size of firms can to some degree be denoted by the number of people employed. The responding firms ranged from four thousand to one hundred and sixty thousand employees with the exception of a private research organization employing 1,140 people. Almost half or 525 people on the staff of this research organization were considered to be employed on a professional level.

I. COMPUTERS, CRT SYSTEMS AND PERIPHERAL EQUIPMENT

The CRT units may be designed by either specialists who work only with the CRT and its peripheral equipment or by manufacturers who design the CRT as an integral part of a computing system. The IBM Corporation, for example builds computers, CRT's and peripheral equipment. The advantage of equipment provided by a single manufacturer lies in its complete compatability. The units are designed to work together, operate on the same software and data bit configu-

TABLE I

FUNCTIONS OF SURVEYED FIRMS

Function	Number of Firms
Aerospace	2
Aircraft design and manufacture	1
Automobile manufacturing	1
Chemical information service	1
Electrical equipment manufacture	1
Missile range contractor	1
Petro-chemical products	1
Research	2
Total	10

ration. The "specialist", in CRT design, adapts the CRT and peripheral equipment to any computing system. His market is largely confined to computing systems which do not offer the CRT as a manufacturing option or to older computers which were not originally designed for CRT use.

To identify the type and amount of equipment being used, the questionnaire sought information as to the manufacturer, series, and model number of computers, cathode ray tubes, and peripheral devices used by the respondents. The series and model number may be used to identify the recentness and capacity of the concerned equipment. Excluding the IBM Corporation, a larger series number denotes a more recent computer of greater size than a smaller series number. In the IBM Corporation, the series 360 is designed for graphic data processing applications and a larger model number would indicate a larger internal storage capacity.

The dominance of IBM computers in the survey is to be expected as the corporation controls the majority of the computer market. The survey identified fourteen IBM computers, seven of which are designed specifically for graphic data processing equipment. The other complete line computer manufacturers, the Radio Corporation of America and the Control Data Corporation, built twenty-three per cent of the computers used by the respondents. Combined with IBM (64 per cent) a total of eighty-seven per cent of the computers used by firms in the survey were built by complete computer line manufacturers. Thirteen per cent of the computers used were built by UNIVAC which presently does not manufacture the CRT.

TABLE II

COMPUTERS

No. of units	Manufacturer	Series	Model no.
2	Control Data Corporation	3600	n.
2	Control Data Corporation	3300	n.
1	Control Data Corporation	3100	n.
1	IBM	360	65
1	IBM	360	50
5	IBM	360	40
1	IBM	1401	n.
1	IBM	1410	n.
1	IBM	1440	n.
1	IBM	1620	n.
1	IBM	7044	n.
1	IBM	7080	n.
1	IBM	7094	II
1	R.C.A.	3301	n.
1	UNIVAC	418	n.
1	UNIVAC	494	n.
22	Total		n. = none

The IBM Corporation also dominates the number of displays being used with thirty-five per cent, closely followed by the Control Data Corporation (24 per cent) and the Radio Corporation of America (16 per cent). The Digital Equipment Corporation (8 per cent) is the only other complete line manufacturer. Only seventeen per cent of the cathode ray tubes were provided by the specialists who adapt the CRT system to any computer.

Three plotters, one recorder and one scanner were identified through the questionnaire. Two of the plotters were built by the Calcomp Corporation and one by the Benson-Hehner Corporation. Both are specialists in plotter design and manufacture. The recorder, an IBM 2280, is a standard item of the IBM Corporation while the scanner is of special design by the Phillips Company.

The more common peripheral equipment such as alphanumeric and program function keyboards, operator consoles, and light pens are summarized in tables IV through VII.

Three character generators were used by the firms and were supplied by Burroughs, IBM, and Information Displays, Incorporated. The CRT system's market has a much wider distribution than the IBM dominated computer market. Many of the complete line manufacturers such as Control Data Corporation, Digital Equipment Corporation, and Stromberg-Carlson provide a system of comprehensive peripheral devices equal to that of IBM. The specialists deal in unique applications and adaptations. The result is a wide range of quality equipment which must be selected according to the application.

TABLE III

CATHODE RAY TUBES

No. of units	Manufacturer	Series
1	Burroughs (special purpose)	
4	Control Data Corporation	211
5	Control Data Corporation	270
3	Digital Equipment Corporation	340
5	IBM	2250
8	IBM	2260
1	Information Display, Inc.	10,000
4	Raytheon	402-406
6	R.C.A.	T-6050-1
37	Total	

TABLE IV

ALPHANUMERIC KEYBOARDS

No. of units	Manufacturer	Percentage of total
2	Control Data Corporation	32
1	IBM	17
1	Information Displays, Inc.	17
1	R.C.A.	17
1	UNIVAC	17
6	Total	100%

TABLE V

PROGRAM FUNCTION KEYBOARDS

No. of units	Manufacturer	Percentage of total
5	Control Data Corporation	62
2	IBM	25
1	UNIVAC	13
8	Total	100%

TABLE VI

OPERATOR CONSOLES

No. of units	Manufacturer	Percentage of total
4	Control Data Corporation	66
1	R.C.A.	17
1	UNIVAC	17
6	Total	100%

TABLE VII

LIGHT PENS

No. of units	Manufacturer	Percentage of total
5	Control Data Corporation	50
1	Digital Equipment Corporation	10
3	IBM	30
1	Information Displays, Inc.	10
10	Total	100%

CRT Capabilities and Applications

The CRT system may be used to display alphanumeric data, such as numbers and letters, graphical data, such as bars and charts, or it may be used for the function of design. The design function is differentiated from graphical representation by the vast amount of complex programming necessary in the former. Table VIII shows the present and future capabilities as indicated by the firms.

To more specifically define the capabilities of the CRT system, the firms were asked to indicate their areas of application. The areas most widely indicated were those which lend themselves to the alphanumeric capability such as information inquiry and management. The areas of design, engineering, and scientific computation which originally led to the development of the CRT were also heavily indicated. Table IX presents the number of firms working in each area.

CRT Advantages and Disadvantages

Of primary concern to future wide spread CRT system applications are the reasons for the incorporation of the CRT and the problems involved during this incorporation. The surveyed firms were asked to rate suggested advantages and problems as to their importance or severity. The addition of problems or advantages particular to the individual firms were also requested. Table X presents the rating of problems.

Programming seems to be the major obstacle to the incorporation of the CRT system. One firm indicated that the major

TABLE VIII

CRT CAPABILITIES

Capability	Present use	Planned future use
Alphanumeric	7	3
Graphical	7	3
Design	3	3

TABLE IX

AREAS OF APPLICATION

No. of firms	Area of Application	No. of firms	Area of Application
5	Information inquiry	1	Numerical control
4	Management	1	Machine analysis
5	Design	1	Traffic control (air)
4	Engineering	1	Education
6	Scientific computations	1	Graphic proofing

responsibility for software support should be assumed by the manufacturer of the CRT unit. Cost of the system and lack of personnel are of little importance. Of the thirty responses in Table X, sixty-six percent were in the None and Some brackets while thirty-four percent were in the Many and Major brackets. This indicates that the majority of firms feel that the problems encountered are not of a serious nature.

A similar rating scale used to evaluate both the investigator's suggested reasons for incorporation and the additions of particular firms is shown in Table XI. The only reason not rated with a high degree of importance was that of on-line control. Ease of operation, speed and graphic representation were rated as very important reasons for the incorporation of the CRT system. Accuracy, elimination of redundent effort and aid to creative ability pertaining to design were suggested by the firms. Of the thirty-two responses in Table XI, twenty-five per cent were in the limited importance and important brackets while seventy-five per cent were in the very important and essential brackets. This indicates that the suggested reasons are very necessary to computer communication.

II. PERSONNEL NEEDS, THEIR TRAINING AND EDUCATIONAL REQUIREMENTS

In addition to the formerly identified areas of application, it was felt that additional information as to the people working with the system, their approximate use and the projected need of these people should be acquired. Table XII shows the type of personnel

TABLE X

PROBLEMS IN CRT USAGE

Problem	Rating*			
	None	Some	Many	Major
Programming	0	4	1	3
Acquiring of specialized personnel	3	3	0	1
Retraining of present personnel	3	3	0	1
Utilization in respect to cost	2	2	2	1
Lack of software support	0	0	0	1
Total	8	12	3	7

* A category designated as few was included in the original questionnaire. It was eliminated from the table since it was not indicated by any firm.

TABLE XI

REASONS FOR THE INCORPORATION OF CRT

Reason	Rating*			
	limited importance	important	very important	essential
Ease of operation	1	0	5	0
Speed	0	1	5	2
Graphic representation	1	0	5	2
On-line control	2	1	1	2
Accuracy	0	1	0	0
No redundent effort	0	0	1	0
Aid to creative ability	0	0	1	0
Total	4	3	18	6

* A category called Not Applicable with a rating of 0 was included in the original question. It was omitted from the table since it was not indicated by any manufacturer.

working with the system and the approximate average weekly use of each person in the classification.

With the exception of the projected use of chemists (58 per cent), the programmers (13 per cent) form the largest group of users. They are followed by the engineers (10 per cent), specialists (5.8 per cent) and service groups (5.8 per cent). The equally combined groups of numerical control and miscellaneous form 5.8 per cent while the remaining 1.6 per cent is absorbed by sales and management.

The amount of time the CRT system is used seems to be related to the size of the groups. The largest groups also use the CRT system most on a per individual basis. The chemists, whose projected use is 21 per cent, are followed by the programmers (17 per cent), engineers (15 per cent), specialists (14 per cent), and service groups (11 per cent). The remaining 22 per cent of individual usage is shared by management, sales, numerical control, and a miscellaneous classification.

Though the present employment needs are somewhat limited due to the almost experimental nature of the CRT, future employment possibilities seem unlimited. The firms were asked to project their personnel needs for the next five and ten years. The needs will grow slowly for the next five years, except in programming, indicating the present developmental stage of the CRT system. The range of personnel needs increased from 500 to 3,700 per cent between the projected five and ten year periods. This projected need is due to both the growth of the suggested classifications and the necessity of CRT

TABLE XII

POSITION AND USAGE OF CRT PERSONNEL

Personnel classification	No. of personnel	Approximate weekly use per individual
Management	1	3.0 hrs.
Engineers	17	20.6 hrs.
Programmers	22	23.2 hrs.
Specialists	10	20.0 hrs. projected
Chemists	100	30.0 hrs. projected
Service	10	15.0 hrs.
Numerical Control	5	10.0 hrs.
Sales	2	8.0 hrs.
Miscellaneous	5	10.0 hrs.

training in these areas. Table XIII provides additional information concerning future personnel needs.

Specialized Training

The need of specialized training is defined as the inplant instruction necessary before any use of the CRT system may be attempted. The amount of training deemed necessary by the firms for their various personnel concerned with the CRT system is shown in Table XIV. The casual use of management does not necessitate a great deal of prior training. By referring to Table XII, it can be noted that as use of the CRT system increases, there is an increase in the need of training.

Educational Status and Responsibility

It is difficult to access the specific major educational area of the people comprising the various classifications of CRT users. People having majored in an engineering discipline may currently be identified in a managerial position. Draftsmen may have had little educational experience leading to their occupation. The amount of education or the degrees earned was, however, determined by the questionnaire. The results are presented in Table XV. Currently there is little need in CRT systems for the person without a sound educational background. A college degree is presently held by fifty-two percent of the people working in CRT. The master's degree (20 per cent) and doctorate (23 per cent) combine to form a large majority of the highly educated people working with this media. No attempt was made to see if this trend will continue.

TABLE XIII

FUTURE PERSONNEL NEEDS

Classification	No. needed in 5 years	No. needed in 10 years	Percent of increase
Management	10	100	1,000
Engineering	30	1,010	3,700
Drafting	50	1,000	2,000
Sales	10	50	500
Programming	125	690	550

The data in Table XIII is limited in that only 5 out of the 10 responding firms were able to project their needs.

TABLE XIV

PRIOR TRAINING NECESSARY OF CRT PERSONNEL

Classification	Necessity of prior training				
	not necessary	helpful	needed	important	essential
Management	0	2	4	1	0
Engineering	1	1	1	1	2
Drafting	0	0	1	1	1
Programming	2	0	0	0	3
Specialists	0	0	0	1	0
Chemists	0	0	0	0	1
Numerical control	0	0	1	0	0
Totals	3	3	7	4	7

TABLE XV

LEVEL OF EDUCATIONAL ATTAINMENT

Educational level	No. of persons	Percent
Less than 12th grade	6	3
High School diploma	10	5
Technical school graduate	3	1.5
College Degree	106	50
Master's Degree	40	19
Doctorate	46	21.5
Total	211	100%

TABLE XVI

BASIC INTRODUCTION TO COMPUTERS AND THEIR DEVELOPMENT

Educational level	Rating				
	not necessary	limited importance	important	very important	essential
Senior High School	0	1	5	0	0
Vocational School (9-12)	1	5	0	0	0
Technical School (2 yrs. post high school)	1	3	3	0	0
College, 2 years	0	0	3	3	1
College, engineering	0	0	0	2	4
College, non-engineering	0	0	3	2	1
Graduate School	0	0	1	0	4

Though the use of the CRT is only beginning, the computer has been continually developed since World War II. Computer uses presently find over six hundred uses in all phases of business, industry and education. Despite this growth and importance, there is a lack of computer knowledge in the schools. The surveyed firms were asked, therefore, to rate the importance of computing experiences in the schools and the level at which they should be introduced.

Four broad experiences were suggested. Two of these experiences reflected in Tables XVI and XVII are education oriented. The first is simply an orientation to computers while the second would provide a knowledge of computers as it is applied to a specific subject area such as mathematics or science. The third or fourth experiences, as suggested in Tables XVIII and XIX are computer oriented. These experiences would introduce and develop computer programming techniques and provide a knowledge of systems design and analysis.

These Tables indicate that importance should be placed upon the introduction of basic computer knowledge in the schools and that this importance becomes more necessary as the educational level rises. This same pattern is true of the knowledge of computer developments as they apply to particular subject areas. Course work in cybernetics is of little importance to those persons seeking a limited education. It quickly rises in importance for those persons seeking a four year college education or more. Systems design and capability is again of little importance to persons receiving less than a college

TABLE XVII

KNOWLEDGE OF COMPUTER DEVELOPMENTS AS THEY APPLY TO A PARTICULAR SUBJECT AREA

Educational Level	Rating				
	not necessary	limited importance	important	very important	essential
Senior High School	3	0	3	0	0
Vocational School (9-12)	1	4	2	0	0
Technical School (2 yrs. post high school)	0	2	3	1	0
College, 2 years	0	2	2	2	1
College, engineering	0	0	0	3	4
College, non-engineering	0	1	2	2	0
Graduate School	0	0	2	2	3

TABLE XVIII

FORMAL COURSE WORK IN CYBERNETICS

Educational Level	Rating				
	not necessary	limited importance	important	very important	essential
Senior High School	3	1	2	0	0
Vocational School (9-12)	3	1	2	0	0
Technical School (2 yrs. post high school)	1	3	1	1	0
College, 2 years	0	4	0	2	0
College, engineering	0	1	1	3	2
College, non-engineering	1	1	1	4	0
Graduate School	0	0	1	2	2

TABLE XIX

FORMAL COURSE WORK IN SYSTEMS DESIGN AND CAPABILITY

Educational Level	Rating				
	not necessary	limited importance	important	very important	essential
Senior High School	3	1	2	0	0
Vocational School (9-12)	3	1	2	0	0
Technical School (2 yrs. post high school)	1	3	1	1	0
College, 2 years	1	2	2	1	0
College, engineering	0	0	3	2	2
College, non-engineering	3	3	1	0	0
Graduate School	0	0	1	2	3

Responses to Tables XVI through XIX are incomplete.

degree or a non-engineering degree. Knowledge in this area is important to the graduate or engineering student.

In summary, the introduction to computers and a knowledge of them as they apply to particular subjects is important at all educational levels. In practice these areas should be presented as early in formal education as possible. Formal course work in cybernetics and systems design and capability should be provided for those who will work in these areas. Normally these areas will be confined to the engineering and graduate student.

III. DRAFTING KNOWLEDGE, SKILLS AND COMPETENCIES

There is presently little application of the CRT system as a design or drafting media. The capabilities of the system do however lend themselves to these areas. It was felt that some indication of future drafting requirements should be determined. Since only five firms responded to the drafting portion of the questionnaire, they can hardly be thought of as a comprehensive representation of the industry. All five, however, did feel that computer aided design will significantly effect the future competencies of draftsmen and designers. The five firms were asked to rate suggested competencies as to their future importance. The results are displayed in Table XX.

The mathematical background was rated as helpful by three firms and essential by two. It is to some degree a current requirement of draftsmen. The rating of programming and operational

TABLE XX

FUTURE DRAFTING COMPETENCIES

Competency	Rating				
	not necessary	helpful	needed	important	essential
Strong mathematical background	0	3	0	0	2
Programming background	0	3	0	2	0
Operational knowledge of the computer and supporting peripheral devices	1	1	0	2	1
Creative design abilities	0	0	2	1	2
Knowledge of N/C machines	0	3	1	1	0
Manufacturing methods	0	1	0	0	0

TABLE XXI

CURRENT DRAFTING KNOWLEDGE AND SKILLS

Knowledge or skill	helpful	needed	important	essential
Use of instruments	0	1	3	1
Dimensioning techniques	0	0	3	2
Geometric constructions	0	0	3	0
Multiview projections	0	0	2	0
Section drawings	0	1	2	0
Perspective drawings	1	0	2	0
Machine drawings	0	0	2	0
Sheet metal	0	0	2	1
Principles of design	0	0	0	4
Present reproduction methods	0	0	3	0

knowledge of the computer including peripheral devices indicates these competencies as future requirements. Except for unique applications, these competencies are not currently required. Creative design abilities will become increasingly necessary as the draftsman is freed from routine tasks by the computer. The knowledge of numerical control machines and their manufacturing methods will increase as they assume a larger part of industry.

In order to evaluate the present knowledge and skills developed in the various drafting programs, the firms were asked to evaluate current practices. Their evaluation is displayed in Table XXI. This Table shows that all of the skill and knowledge presently developed in the drafting program is important. Areas of particular significance are dimensioning techniques and principles of design.

In summary, many computing and CRT systems are available which must be selected on the basis of application and needs. The people working with these systems will require an extensive educational background and should be introduced to the computing field early in their formal education. Lastly, although current drafting room practices are important, we should look to the inclusion of materials which will provide for future drafting competencies.

CHAPTER V

THE CURRENT UTILIZATION OF THE CATHODE RAY TUBE SYSTEM IN SELECTED EDUCATIONAL INSTITUTIONS

A questionnaire was sent to seventy-two institutions whose selection was described under the heading of Acquisition of Data from Selected Educational Institutions in Chapter Two. The questionnaire inquired as to CRT uses and developments in computer assisted instruction. The first mailing brought twenty-two responses or a 31 per cent reply while the second mailing brought fourteen additional responses bringing the total reply to thirty-six or 50 per cent.

Of the surveyed institutions, thirteen (36 per cent) are presently working in computer assisted instruction, four (11 per cent) are presently using the CRT system, four (11 per cent) plan on future use of the CRT system while sixteen (46 per cent) do not plan to use the CRT system or computerized instruction. The responding institutions, unfortunately had little experience in the formerly described areas which resulted in a spasmodic completion of the questionnaire.

The data acquired refers mostly to the type of equipment used and the relative size of the computer assisted programs. While the results of the questionnaires indicate a lack of well developed computer assisted instruction and wide spread CRT usage, they do not present the depth reached by certain institutions in these media. An attempt will be made later in this chapter to present these developed programs, from reports acquired through initial inquiry so that a true

representation of current utilization will be realized.

I. COMPUTERS, CRT SYSTEMS AND PERIPHERAL EQUIPMENT

The computers used in educational institutions show an almost complete reliance on the IBM Corporation. The majority of IBM computers, however, are not specifically designed for the quick reacting and time-sharing capabilities necessary for the operation of the CRT system. Thirteen or 68 per cent of the computers used were manufactured by the IBM Corporation. Only five or 26 per cent are of a recent vintage compatable with the corporation's graphic data processing units. The General Electric and Systems Donner Corporations each manufactured two computers while the Radio Corporation of America and the Control Data Corporation each supplied one computer. A complete listing of the computers used appears in Table XXII.

Except for the Calcomp plotter and Beckman recorder, the equipment used was provided by complete line computer manufacturers. The IBM Corporation provided five alphanumeric keyboards in their 1050 series and three 2260 cathode ray tubes while the General Electric Corporation provided forty alphanumeric keyboards. A listing of the Philco equipment follows:

1 Light pen

5 Alphanumeric keyboards

3 Operator consoles

3 Program function keyboards

3 Cathode ray tubes

The previously discussed equipment was reported as owned by six (40 per cent) institutions, rented by three (20 per cent), leased by three (20 per cent), and time shared by three (20 per cent).

CRT Capabilities and Applications

The Carnegie Institute of Technology was the only institution responding as to the areas of application of the CRT system and the classification of the staff members concerned with its use. Scientific computation, text editing, the management game, the library and design as applied to basic architecture were designated as areas of application. A classification of staff uses follows:

	number of staff	hours used weekly
Administrators	2	2
Programmers	3	130
Supportive personnel	3	180
Text editing	3	40
Management game	3	10

Prior specialized training before any CRT system use could be attempted was indicated as being helpful for text editing and management personnel while being considered as important for administrators. The main problem in the utilization of the CRT system was considered to be programming. Also rated by the institute were the following reasons

TABLE XXII

COMPUTERS USED IN EDUCATIONAL INSTITUTIONS

Units	Manufacturer	Series	Model No.
1	Control Data		G-21
1	General Electric	235	
1	General Electric	600	625
1	I.B.M.	360	65
1	I.B.M.	360	50
2	I.B.M.	360	40
1	I.B.M.	1100	
4	I.B.M.	1401	
3	I.B.M.	1620	
1	I.B.M.	7074	
1	R.C.A.		301
1	Systems Donner		40
1	Systems Donner		910
19	Total		

for the incorporation of the CRT system.

Ease of access to information	essential
Speed	very important
Graphic displays	essential
Computer assisted education	limited importance
Increased effectiveness of computing system	important
Experimentation by engineers	important

II. LIMITATIONS OF COMPUTER ASSISTED INSTRUCTION

The final section of the questionnaire sought to evaluate the limits and advantages of computer assisted instruction. Information was requested concerning the size of institutions, subjects currently being taught, and opinions pertinent to future development. Though only four institutions rendered their opinions as to the limitations of computer assisted instruction, all presented different points of view. One institution reported that the computer could only be used for drill or tutorial work while a second suggested the computer will become a dynamic teaching medium. A middle of the road approach suggested that subject matter could be taught through pre-programmed course work formulated by a prediction of pupil error. One institution simply stated that a lack of research in this area prevented any statement.

Current subjects being taught are indicative of the institutions they represent. The response to this section of the questionnaire

was typical of the engineering institutions which completed it. The emphasis is placed upon mathematics, physics and computer languages. One medical institution also contributed to the following subject areas:

Research and Development	Physics
Clinical patient management simulation	Physical Science
Basic science problem simulations	Statistics
Computer Programming	College Algebra
Fortran	German
Numerical control	APT language

The cost of computerized education seemingly has no bearing on the size of institutions concerned with its development. Student enrollment of institutions using computer assisted instruction ranged from 725 to 27,500. Programs fluctuated from those experimental in nature to one serving 2,500 students. A complete listing of total student enrollment and faculty as compared to computer assisted student enrollment and faculty is shown in Table XXIII.

Again due to insufficient experience, only two institutions completed the section of the questionnaire dealing with the advantages of computer assisted instruction and its comparison with conventional teaching methods. The computer assisted program was rated as being equal and far superior to conventional methods in the comprehension of materials; equal and superior in the retention of materials; equal

in the transfer of material learned; far superior in the acceptance of method; and inferior in the thoroughness of material covered.

In the rating of advantages of computer assisted instruction, the institutions recognized the regulation of pupil error as being important; individualized learning as being important to very important; immediate evaluation and logical progression as being of limited importance, and direct participation as being very important.

Additional comments to the questionnaire recognized the CRT system as having great potential in the industrial applications of numerical control and computerized design. The comments also indicated that real time use and time sharing will render the CRT unsurpassable in areas of graphic presentation. Tremendous possibilities were also available in dealing with lower elementary students having reduced reading abilities. In view of the general lack of data, it is difficult to draw conclusions from the surveyed sample.

III. CURRENT DEVELOPMENT IN CRT AND COMPUTER ASSISTED INSTRUCTION

This section of the chapter will attempt to indicate the depth of some of the more well developed computer assisted instruction programs. The institutions represented were originally contacted to provide an insight to computer assisted instruction and cathode ray tube use. Though these schools represent many different areas in which the computer is used for instruction and related educational needs, they should not be considered as indicative of all work in this field.

TABLE XXIII

SIZE OF INSTITUTION AND CAI PROGRAM

No. of Students	No. of Faculty	No. of Students in CAI*	No. of Faculty in CAI*	Percentage of total Student body in CAI*
1200	300	30	5	25
4000	500	3	1	.075
20,000	500	200	5	1
27,500	1,000	experimental	10-R + D	
1,200	125	860	25	67
33,000	2,800	1,000	50	3
2,000	93	60	2	3
3,000	400	1,000	20	33
3,600	180	1	2	
4,000	146		3	
15,000	1,800	2,500	75	17
3,236	240	100	3	3
5,000	150	100	4	2
725	72	3	2	.4

*CAI, Computer Assisted Instruction Program

The Florida State University

The Florida State University Computer Assisted Instruction Center, directed by Dr. Duncan N. Hansen, is currently developing programs in both research and instruction. Research projects described by their Quarterly Progress Report ending June 30, 1966 included studies to determine the feasibility of using computer assisted instruction in concept formation, to determine the effect of post and advance organizors on discovery and non-discovery learning, and to investigate student machine interaction. Two future proposals include the development of Junior High School Science Curriculum materials and a program to be used with adult illiterates.[1]

Instructional research projects as described by their Quarterly Report ending September 30, 1966 included college physics, computer assisted college physics testing, applied statistics, and computer languages.[2]

The projects at the University are conducted by both faculty and staff, including graduate assistants. Several of the projects have received Federal support and several have been used as topics for doctoral dissertations.

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[1]W. H. Stoker and D. L. Hartford, "Quarterly Progress Report of the Computer Assisted Instruction Center, Institute of Human Learning," (Tallahassee, Florida: Florida State University, June 30, 1966), p. 1. (Mimeographed)

[2]Dr. Duncan N. Hansen, "Quarterly Progress Report of the Computer Assisted Instruction Center, Institute of Human Learning," (Tallahassee, Florida: Florida State University, September 30, 1966), *et passim*.

The University of Texas

The University of Texas is striving to develop all areas in the application of computers to university problems. The computer assisted education laboratory, however, organized under Dean Wayne H. Holtzman, is a separate function of the University. The instructional program is divided into three areas, that of student assistance, that of instructor assistance and that of assistance to the researcher. Student assistance is subdivided into drill,and practice, tutorial, simulation or gaming and real time computer communication. Teacher assistance will keep the instructor informed as to the current progress of his students and enable testing to become more of a learning experience. Assistance to the researcher is designed to help in the presentation and documentation of student responses in the concerned projects. Initial developments included, the programming necessary for computer assisted instruction, methods of presentation, and the subject fields of chemistry, German, statistics and music.[3] An intense interest in chemistry has led the University to concentrate on this area in which it is serving as a National Center. The overall program is well diversified and the progress thus far realized is encouraging to the field of computer assisted instruction.

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[3]"Progress Report, March-June 1966" (Houston: The University of Texas, 1966) et passim.

The University of Michigan

The University of Michigan is the only institution identified that is currently offering course work in computer graphics. These courses are offered by Professor B. Herzog, as a regular part of the University's Summer Engineering Conference of 1967. Topics included in the basic course as indicated by correspondence with the University are:

Introduction to Computer Aided Design

Description of the use of:

Sketch pad on the T X 2 Computer

DAC-I at General Motors Research

On-line programming systems

Introduction to programming

Basic

Fortran

The analysis of drawings

Drafting languages

Detailed description of graphic input/output systems

Introduction to List Structures

The need for data structures

Surfaces in computer aided design

Animated Movies

An additional course provides experiences in hardware and software systems including topics such as numerical control machining, the use of lines

in computer graphics and movies by computer. Five courses comprise the total offering in graphics. There are of course many other related computer courses concerned with engineering needs. In addition to the course offerings, the University is working toward the reduction of hardware costs and a greater software capability.

Stanford University

Program development at Stanford University is aimed at the teaching of reading and mathematics in the elementary school. Initial development began in 1963 and was funded by the Carnegie Institute of New York. The program links the Stanford University with the Brentwood Elementary School which houses a laboratory capable of presenting programmed instruction to sixteen students at one time. The laboratory hardware consists of two computers, an IBM chip system, Philco scopes, and a Westinghouse Audio system.[4] The expense of the project presently totals one million dollars which is equally divided between curriculum development and hardware costs which include the price of the building. Objectives of the program are a greater utilization of teacher time and allowance for individual students to proceed at their own rate. The project uses various data transmission lines to extend its experimentation to various schools including the University Breckinridge School at Morehead State University.

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[4]Patrick Suppes, "Tomorrow's Education?", Education Age, January-February 1966, p. 25 et passim.

Use of the program has been very successful to date, but it is difficult to estimate the length of time, necessary before the system can be applied to a number of schools.

The Pennsylvania State University

The Pennsylvania State University is applying computer assisted instruction to technical education. Early in this study the investigator interviewed Dr. David A. Gilman, research coordinator for the program, to gain an insight into the problems of computerized education and its relation with the cathode ray tube. Various topics pertinent to hardware and software development were discussed.

The computer assisted instruction laboratory is presently using an IBM 1410 computer on a time-sharing basis within the University. This results in some difficulty in acquiring computer time when necessary and an elimination of use in the case of general computer failure on the campus. Future plans call for an IBM 1130 and eight cathode ray tubes complemented with alphanumeric keyboards and light pens to be used for laboratory purposes only.

The University is presently using computer assistance in the subject areas of Modern and Technical Mathematics, Engineering Sciences, and Technical Communication. The main difficulty in preparing materials for computer presentation is the vast amount of necessary programming. This tedious, time consuming process can only be beneficial if the completely written and debugged program can be applied to a great many students.

Dr. Gilman feels that at the present stage of development the computer assisted education program is equal to conventional methods in the comprehension and retention of materials, and the acceptance of method. He feels that the advantages of this medium lie in its ability to present individualized instruction and develop direct participation on the part of the student. A logical rate of progression and immediate evaluation aid the continuity of material thus presented. Though the CRT is not presently used at the University its future implementation will allow a more efficient and greater inclusion of visual projections. The opinions of Dr. Gilman may be verified by the student completed questionnaires requested of all those concerned with the computer assisted education program.

Summary

Although the sampling procedure did not identify well established computer assisted education programs and a wide use of the CRT system, it did show that a majority (58 per cent) of the responding surveyed institutions are working to implement further usage of these educational aids. Some of the more well developed current programs are offered as examples of the future possibilities of both the CRT and computer assisted instruction. Though it is difficult to predict the outcome of any new innovation, the investigator believes that the computer and its related devices will become an integral part of the educational system.

CHAPTER VI

IMPLICATIONS AND RECOMMENDATIONS FOR THE TEACHING OF INDUSTRIAL ARTS

The basis of this study was to determine any possible effects of graphic data processing upon the content, methodology and curriculum of industrial arts. Though the study has not identified a great number of applications in education or industry, the capabilities of the system are self evident. The present developments are indications of future possibilities in which trends are already discernible. The present state-of-the-art of the CRT system can be compared to the once ignored educational value of movies and television. As with these media, the computerized CRT system will not be considered a sound educational tool until proven and will not be proven until its acceptance is voiced by a great many leading educational institutions and industrial firms. It is from the current diversified applications and unlimited future uses that the implications for industrial arts will be drawn.

I. IMPLICATIONS AS TO CONTENT OF INDUSTRIAL ARTS

The industrial arts subjects are completely committed to the representation of industrial tools, materials and processes. This commitment does not only lie in past and current representation but more so to future innovations that the youth of today will be concerned with upon completion of their formal education. The cathode ray tube system is one of the many innovations which will be instrumental in the shaping of industry and education and should be represented

in our institutions in content and as a guidance function through industrial arts. The area most significantly affected by the CRT system will be that of technical drawing.

Technical drawing closely allied to the field of engineering for which the CRT system was originated will soon be engulfed by the outgrowths of graphic data processing. The competencies and work routines of the draftsman will be altered to fully utilize the advantages of the computer. Repetitious redrawing of engineering ideas and manual retrieval of past drawings will be eliminated as the CRT system extends beyond experimentation.

Through the use of recorders, scanners, alphanumeric and program function keyboards, the draftsman will be freed for creative design of a professional nature. Microfilm libraries will allow for the instant retrieval of an unlimited number of drawings previously stored as hard copy. This retrieval will result in a CRT display to be altered and realtered at the will of engineer or draftsman. Sections will be easily deleted or transposed without any use of current drafting equipment. When the new design is agreed upon by engineering, management, production and other concerned staff, it will be referred to the computer for the initiation of a punched paper tape to be used in a numerically controled production machine. If necessary, a hard copy may be produced at any time during the design process, even through the use of currently available microfilm equipment. Initial drawings will be produced by the draftsman in an off-line setting through the use of transparent grids and overlays.

If technical drawing is to represent these industrial methods, then it should through lecture, films, and field trips, if not by actual manipulation, impress upon the student the capabilities of computerized drawing. With the institution of new course materials should come the deletion of unnecessary current practices. The present emphasis on lettering is even currently unnecessary when ones considers the legibility and neatness of typed notes and specifications. This emphasis will be rendered obsolete by future use of the alphanumeric keyboard in drawing description. The teaching of present reproduction methods will be eliminated by recorders, scanners, and transparent grids. While it is true that present microfilm methods require line texture suitable for miniaturization, this need will be eliminated when the computer reads a transparent grid and stores or reproduces the necessary drawing as digitized information. Drafting programs should concentrate more upon the theories and concepts necessary for multiview and perspective presentation instead of the quantity and quality of hard copy drawings. Notes, specifications, tolerances and possible methods of production will be necessary accompaniment for any drawing, present or future. Mathematics, programming, general knowledge of computers and numerically controlled machines will support the creative design abilities of the future draftsman. Lettering, neatness, and line texture will only be the laborious routine of the student in the now typical drafting program.

Metal processing will also be affected by the CRT system and computerized drawing. The greatest implication here lies in transformation of a CRT design to a finished product via the computer, punched paper tape, and numerical control machining. The emphasis once again should shift to the "why and how" of metal removal instead of the current emphasis of project construction. In the use of a lathe, milling machine or other metal removing device, there is no doubt that the student is familiarized with its principles of operation. But, is this the most efficient utilization of student time or is it the result of a lax instructor who is not cognizant of current and developing methods of metal removal and machine operation? The student should certainly be taught the history in the development of such machines but there is no need to subject him to their operation to develop an awareness of out-dated equipment. The field of metal working, of course, has other pertinent developments such as electrical discharge and electrochemical machining which are particular to its own processes nulifying present machining techniques. As a consumer of blueprints, even the sheet metal worker will become a user of computer generated drawings. Small drawings may be duplicated from microfilm and large drawings can be generated through computer driven plotters, both of which can be used for sheet metal patterns. Once again the emphasis should be placed on feeds, speeds, and feasible production techniques so that a thorough understanding of the various concerned process will be formed instead of a working knowledge of one machine constituting only one form of metal removal.

The graphic arts industry presently relies upon the computer for the setting of type and control of paper making. Though the CRT is not presently used, it is conceivable that as an on-line device the CRT system could present data concerning the composition and thickness of paper in graphic form so that it could be easily and quickly understood. Through the alphanumeric and program function keyboards, necessary changes in the manufacturing processes could be made seconds after the output data is displayed.

In the computer typesetting procedure, the operator composes the desired text on a typewriter which punches a paper tape. This tape is then fed into a computer for line justification which includes hyphenation when necessary. The computer then generates another tape which is fed into a standard linotype machine for composition. The one drawback of the system is that the proofing takes place after the type is cast. With the CRT system, an operator could use the alphanumeric keyboard for composition and the CRT to visually check his work before tapes are made and the lines are cast. Line justification systems are also used for typewritten letters and offset paper mats. Though these are projected uses of the CRT system, the computer is currently being used in these areas and the graphic arts student should be cognizant of these developments.

The incorporation of the CRT system in electricity-electronics can be thought of as proceeding in two directions. One is the use of the CRT system to design various electrical circuits and the other is the reverse use of knowledge acquired in electricity-electronics to design computer and CRT circuits. The CRT system can be used to vary the capacities of various components necessary in electrical circuits by allowing the computer to perform the necessary calculations and then displaying the results in the form of a graph. Both the input and output of various components such as capacitors and resistors can be displayed in a system presently used by the IBM Corporation. Complex printed circuits can be drawn and component values tested without the diagram even leaving the face of the CRT.

There is no doubt that the computer field is presently important but, as it grows more so, the industrial arts program should include more of the electrical knowledge necessary for computer circuit design and operation. The entire storage system of the computer, for instance, consists of magnetized bits which are electrically charged to a positive or negative polarity leading to the use of the binary system. This simple illustration of computer knowledge can proceed to the complex circuitry necessary for the operation of the CRT system. By combining the knowledge of electricity and the ability of the CRT system to design circuits, the system can in fact, be used to design future CRT systems or other computer components.

One of the more recent proposals in industrial arts places emphasis upon manufacturing processes and is not subdivided according to materials as is the present curriculum. Such a representation of industry, as developed at Indiana State University, will include all levels of personnel concerned with mass production. As indicated by suggested CRT applications and those identified by the questionnaire, (Table IX) varied uses of the system can be discussed when management, sales, research and development, and other personnel groups are brought into the industrial arts picture. The CRT and the computer can also be thought of as controlling devices of automation. Applications of the CRT system are unlimited in this area and will no doubt be included in the future industrial arts curriculum.

In summary, the greatest CRT implication for the teaching of industrial arts lies in technical drawing for it is the subject most concerned with graphic representation. Other subject fields such as electricity-electronics, graphic arts and metal working will interpret segments of CRT uses or systems design. As new applications of the CRT system are developed they will no doubt cause a greater concern in the industrial arts curriculum and as new concepts in the teaching of industrial arts are developed they may have a greater need for the representation of computerized drawing.

II. IMPLICATIONS AS TO THE METHODOLOGY OF INDUSTRIAL ARTS TEACHING

Computer uses stretch from income tax collection to medical technology effecting almost every phase of our lives. One cannot but stop and wonder as to how this device will assist education. In the teaching of industrial arts the computer can be used as both an educational and industrial tool. The industrial applications applicable to industrial arts content were discussed in section one of this chapter and as costs of the computer and CRT system are offered a "hands-on" learning experience will become possible.

Applications and advantages of computer assisted instruction were presented in Chapter V and include such subjects as technical mathematics and communications skills presently taught at The Pennsylvania State University which will have direct bearing on the teaching of industrial arts.

In technical drawing for instance, the computerized CRT system can be used in computer-assisted instruction, for actual design problems existing in the construction of new buildings, or to familiarize the student with equipment used by industry. These same uses can be applied to graphic arts, metal working and electricity-electronics. The most widely used application will lie in computerized education where all industrial arts subject areas can utilize the tutorial, problem solving, and programmed instruction techniques to full advantage.

An example can be drawn from the teaching of dimensioning. The instructor could work out preprogrammed instructions and related visual displays to originally present new material to the class. This material could then be stored for future presentation or for review by the student whenever necessary exemplifying the tutorial function of computerized instruction. Various diagrams, which are not dimensioned could then be presented to the student for his completion thus utilizing problem solving techniques. The advantages of computer use in such a situation are regulated pupil error, immediate evaluation, and direct participation.

Another related area is the student use of library facilities. The CRT system could be used to record and recall any current literature conveniently stored on microfilm or microfiche. Cost of such literature would be greatly reduced as would be the access time necessary for its use by the student. The same equipment could also be used to order, record, and pay for any textbook or other library materials. No doubt the reader can suggest many applications in both computer-assisted instruction and related educational areas.

III. IMPLICATIONS FOR THE CURRICULUM OF INDUSTRIAL ARTS

As more and more of the industrial and business world becomes concerned with computer utilization, industrial arts will be forced to provide formal course work in cybernetics and systems analysis. We cannot adequately discuss the methods by which the CRT generates a design and the way a numerically controlled machine shapes a complex part without a knowledge of the software and hardware involved. When industrial arts truly represents industrial processes, a thorough understanding of the computer will become a reality.

Basic courses in Fortran and Cobol should be provided in the industrial arts curriculum so that an introduction to computing languages necessary for CRT data manipulation, numerical control machining or other pertinent processes. There is not, of course, any reason to exclude management or sales applications. Of equal importance to cybernetics is systems design and analysis. The industrial arts student should know the function of each peripheral device. He should understand the relationship between these devices, the capabilities of each, and why they are included in the computing system. Though systems design and analysis can comprise a complete college curriculum in itself, an introduction necessary to a basic understanding of peripheral devices is not beyond the capability of the student.

IV. SUMMARY

The findings and implications of this study reveal that graphical data processing will significantly influence the field of industrial arts in content, methodology and curriculum. These findings and implications are based upon:

1. The capabilities of the computerized cathode ray tube system as identified by the manufacturers of the system and current users in industrial firms and educational institutions.

2. The applications of the computerized cathode ray tube system as identified by the manufacturers of the system and current users in industrial firms and educational institutions.

3. The personnel needs and their suggested educational background as reported by the industrial firms using the CRT system.

Since the sample of this study has been somewhat limited due to the recentness of the CRT system and its applications in both industry and education, widespread generalizations as to the length of time necessary for common industrial and educational utilization of this medium are not possible. This common utilization will however be hastened through the time-sharing procedures, data communication lines, software development and lower costs due to volume production.

BIBLIOGRAPHY

A. BROCHURES

Cathode Ray Tube Displays. A Brochure Prepared by the Digital Equipment Corporation. Maynard, Massachusetts: Control Data Corporation, 1965.

Control Data, Diographic 270 System. A Brochure Prepared by the Control Data Corporation. Minneapolis, Minnesota: Control Data Corporation, n.d.

Direct View Displays. A Brochure Prepared by the Stromberg-Carlson Corporation. San Diego, California: Stromberg-Carlson, Data Products Division, n.d.

G.E./PAC 4020, Operating Specifications. A Brochure Prepared by the Industry Control Department, Process Computer Section. Phoenix, Arizona: General Electric, n.d.

Information Display, Systems and Equipment. A Brochure Prepared by the Federal Laboratories. I. T. T. Federal Laboratories, n.d.

RCA Spectra 70/35. A Brochure Prepared by the R.C.A. Corporation. Van Nuys, California: Radio Corporation of America, n.d.

S-C-4020 Computer Recorder. A Brochure Prepared by the Stromberg-Carlson Corporation. San Diego, California: Stromberg-Carlson, Data Products Division, n.d.

S-C 4060 Stored Program Recording System, Description and Specifications. A Brochure Prepared by the Stromberg-Carlson Corporation. San Diego, California: Stromberg-Carlson, Data Products Division, n.d.

SM-2A Data Display. A Brochure Prepared by the Laboratory for Electronics, Inc. Boston: LFE Electronics, n.d.

Series 200 Display System. A Brochure Prepared by the Bunder-Ramo Corporation. Samford, Connecticut: Bunker-Ramo Corporation, n.d.

Series 200, Visual Information Projection. A Brochure Prepared by the Honeywell Corporation. Newton, Massachusetts: Software Support, nd.

Technical Description of the DIDS-400, Digital Information Display System. A Brochure Prepared by the Equipment Division, Raytheon Company. Wayland, Massachusetts: Surface Radar and Navigation Operation, Raytheon, April 1966.

B. MANUALS

IBM Application Program. 1620 Drafting Program Application System. White Plains, New York: Technical Publications, International Business Machines Corp. n.d.

IBM Corporation. IBM System/360 System Summary. Poughkeepsie, New York: Customer Manuals, IBM Corporation, 1964.

IBM Corporation. IBM System/360 Component Description, IBM 2250 Display Unit Model I. Kingston, New York: Product Publications, IBM Corporation, n.d.

IBM Corporation. IBM System/360 System Component Description IBM 2280 Film Recorder, IBM 2281 Film Scanner, IBM 2282 Film Recorder/Scanner. Kingston, New York: Product Publications, IBM Corporation, n.d.

IBM Corporation. The IBM 2282 Film/Recorder/Scanner Unit. A circular by the IBM Corp. New York: IBM Corporation, n.d.

IBM Corporation. Use of the 2250 Display Unit. White Plains New York: Technical Publications, IBM Corp., n.d.

IBM Data Systems Division. Applications of Data Image Processing Techniques to Traffic Acquisition. Kingston, New York: IBM Development Laboratory, 1964.

IBM Corporation. N/C 360 APT, Application Description. White Plains, New York: Technical Publications, International Business Machines Corp., n.d.

C. PERIODICALS

Abzug, Irving. "Graphic Data Processing," Datamation, January, 1965.

"Auto Designer Can Now Exchange Information with a Computer," Electronics, 37: 25-6, November 16, 1964.

"Automatic Drafting and Plotting Units Produce Drawings from Digital Information," Iron and Steel Engineering, 41:166, April, 1964.

Beard, R. G. and A. E. Singfield. "Computer Produces Precision Drawings," Tool and Manufacturing Engineering, 56:76-7, June, 1966.

"Casual Conversation with a Computer May Help GM Design Cars," Machine Design, 36:6+, November 5, 1964.

"Cathode Ray Tube Input-Output Station for Computers," Electronics, 37:58-9, March 6, 1964.

"Computer Designs and Makes Engineering Drawings," Iron and Steel Engineering, 42:172, July, 1965.

"Computer Masterminds Automatic Drafting Machine," Machine Design, 37:223, October 14, 1965.

"C.r.t. Display Consoles for Digital Computers," Electronics Engineer, 38:435, July 15, 1966.

Davis, M. R. and T. O. Ellis. "Rand Tablet; A Man-Machine Graphical Communication Device," Instruments and Control Systems, 38:101-3, December, 1965.

"Drafting by Computer Comes Off the Shelf," Machine Design, 37:12, June 10, 1965.

"For Drafting or Digitizing," Automation, 12:10+, September, 1965.

"General Motors Computer Facility to Help Create New Automotive Designs," Automotive Industries, 132:73-5, January 15, 1965.

Gilbert, G. O. "Geometric Computing; Electronic Geometry for Semi-Automated Design," Machine Design, 37:152-9, March 18, 94-100, April 1, 1965.

Gotterer, M.H. "Use of Automatic Displays in Computer Based Management Information Systems," Automation, 12:171-4, May, 1965.

Hoberecht, V. L. "Computerized Design Information Systems and Their Impact on Draftsmen," The Journal of Industrial Arts Education, May-June, 1966, (reprint).

Holstein, David. "Are You Ready for Computer-Aided Design," Product Engineering, 35:66-76, November 23, 1964.

Houdlin, Russell J. "IBM Graphic Display System," Information Display, September-October, 1966, pp. 34-40.

Howard, M.A. "Design with Computers," Mechanical Engineering, 87:31-4, May, 1965.

"IBM Demonstrates System to Aid Computerized Design," Steel, 155:70-1, November 9, 1964.

"IBM Graphic Data Processing System Commercially Available," Steel, 157:33, December 13, 1965.

"Man Computer Teams Add New Dimension to Design," Steel, 156:78-85, May 10, 1965.

Mirris, D. K. "New Approaches to Computer Aided Design," Product Engineering, 35:84-7, February 3, 1964.

Mosley, Robert. "Industrial c.r.t. Data Display," Electronic Engineer, 4:323-7, July, 1966.

Potter, G. B. et. al. "Integrated Scatch Pads Sire New Generation of Computers," Electronics, 39:118-26, April 4, 1966.

Quirk, William J. "Productive Graphic Data Processing," Computing Report, September, 1966, pp. 12-16.

Schulte, John C. "Man-Machine Interface Studies for Improving System Speed," Data Systems Design, February, 1964, (reprint).

Smith, Christopher F. "Graphic Data Processing," Machine Design, 37:117-23, May 27, 1965.

"Sophisticated Device Will Accept Graphic Data and Simultaneously Display Data on Screen," Electronics, 38:42, June 14, 1965.

"Step Closer; Car Drawings by Computer," Steel, 155:139-40, November, 1964.

Suppers, Patrick. "Tomorrow's Education?" Education Age, January-February, 1966.

Talkington, Joe E. "Computer Graphics in the Schools," The Journal of Industrial Arts Education, May-June, 1966.

Tilton, H. B. "Principles of Cathode Ray Tube Display," Control Engineering, 13:74-8, February, 1966.

Vorhaus, Alfred H. "General Purpose Display," System Development Corporation Magazine, August, 1965, pp. 1-15.

D. REPORTS

Allen, Thomas R. and James E. Foote. "Input/Output Software Capabilities for Man-Machine Communication and Image Processing System," GM DAC-I. A published report presented at the 1964 Joint Computer Conference. Warren, Michigan: Research Laboratories, General Motors Corporation, 1964.

Brearly, H. C. "Computers, Computing, and Careers," Report Number 171. Urbana, Illinois: Department of Computer Science, University of Illinois, March, 1965.

Cole, Phyllis M., Philip H. Dorn and C. Richard Lewis. "Operational Software in a Disk Oriented System," GM DAC-I System. A published report presented at the 1964 Joint Computer Conference.

Computer-Aided Design. A Publication Prepared by the United Aircraft Research Laboratories. East Hartford: United Aircraft Corporation, n.d.

Dugar, V. F. "Our Experience with Automated Drafting," Paper read at the University of Wisconsin Extension Engineering Institute, Madison, Wisconsin, October 20-21, 1966. (mineographed)

Hansen, Duncan N. "Quarterly Progress Report of the Computer Assisted Instruction Center, Institute of Human Learning," Tallahassee, Florida: Florida State University, June-July, 1966. (mimeographed)

Hannom, T. J. B. and G. Kaskey. "The Digital Computer as a Design Tool," A Reprint from the 1965 IEEE International Convention Record, Part 6. Blue Bell, Pennsylvania: UNIVAC Division of Sperry Rand Corporation, 1965.

Hargreaves, Barrett and others. "Image Processing Hardware for a Man-Machine Graphical Communication System," GM DAC-I System. A published report presented at the 1964 Joint Computer Conference. Kingston, New York: Data Systems Division, International Business Machines Corporation, 1964.

Hoberecht, Verlin L. Application of Data Processing to Revision of Engineering Drawings. A published report presented to the Design Engineering Conference, 1965. New York: The American Society of Mechanical Engineers, March, 1965.

Jacks, Edwin L. "A Laboratory for the Study of Graphical Man-Machine Communication," GM DAC-I System. A published report prepared for the 1964 Joint Computer Conference. Warren, Michigan: Research Laboratories, General Motors Corporation, 1964.

Krull, Fred N. and James E. Foote. "A Line Scanning System Controlled from an On-Line Console," GM DAC-I System. A published report presented at the 1964 Joint Computer Conference. Warren, Michigan: Research Laboratories, General Motors Corporation, 1964.

Lourie, Janice R., John J. Lorenzo, and Abel Bomberault. "On-Line Textile Designing," New York: IBM Corporation, 1966. Offset.

"Progress Report, March-June 1966." Austin: The University of Texas, March-June, 1966.

Stoker, W. H. and D. L. Hartford. "Quarterly Progress Report of the Computer Assisted Instruction Center, Institute of Human Learning." Tallahassee, Florida: Florida State University, April-June, 1966. (mimeographed)

Wolpe, Harold. Graphic Displays Through Computers. A published report at the International Communication Congress held in Philadelphia, December 7-11, 1962. Poughkeepsie, New York: IBM Corporation, 1962.

APPENDIX A

1. American Bosch Arma Corp.
   Arma Division
   Garden City, New York

2. Mr. Earl A. Robertson*
   Bunker-Ramo Corp.
   445 Fairfield Avenue
   Stamford, Connecticut

3. Mr. Kenneth H. Stacey*
   Applications Engineer
   Control Data Corporation
   2401 North Fairview Avenue
   Saint Paul, Minnesota

4. Mr. Robert L. Fronk*
   District Manager
   Digital Equipment Corporation
   3853 Research Park Drive
   Ann Arbor, Michigan

5. Mr. G. W. Iler*
   E.P. 6-128
   General Electric Company
   Syracuse, New York

6. Mr. Richard Speers*
   Software Support
   151 Needham Street
   Newton, Mass.

7. IBM Products Development Lab.*
   Data Systems Division
   Poughkeepsie, New York

7B. Mr. Carl Machover*
   Information Displays, Inc.
   102 E. Sandford Boulevard
   Mount Vernon, New York

8. Mr. J. Sabo
   Manager, Display Marketing*
   I.T.T. Federal Laboratories
   3700 East Pontiac Street
   Fort Wayne, Indiana

9. Mr. George F. George*
Product Manager
Laboratory for Electronics
1075 Commonwealth Avenue
Boston, Massachusetts

10. Marquardt Corp.
Pomona Division
2709 North Garey Avenue
Pomona, California

11. Mr. G. J. Pastor*
Manager, Engineering Design
Philco-Ford Corp.
1002 Gemini Avenue
Houston, Texas

12. Mr. K. D. Gowin, Marketing*
Surface Radar & Navigation
Raytheon Co., Equipment Division
Wayland, Massachusetts

13. Mr. Thomas V. Curan*
Marketing Manager
Radio Corporation of America
8500 Balboa Boulevard
Van Nuys, California

14. Mr. William H. Pothen, Jr.*
Data Systems Division
Sanders Associates, Inc.
95 Canal Street
Nashua, New Hampshire

15. Sargent Industries
General Offices
2533 East 56th Street
Hunting Park, Calif.

16. Scientific Data Systems, Inc.
1542 Fifteenth Street
Santa Monica, Calif.

17. Mr. H. W. Holmerud*
Manager of Marketing Education
Stromberg-Carlson Corp.
P. O. Box 2449
San Diego, Calif.

18. Mr. M. E. Forgey*
Information Systems
Tasker Instruments Corp.
7383 Orion Avenue
Van Nuys, Calif.

* Asterisk indicates companies which responded.

APPENDIX B

1. Bunker-Ramo

Capability: Alphanumeric

General Description: The CRT system is designed for business applications which have a need for information storage and retrieval. Bunder-Ramo equipment may be interfaced with most computing systems and data communication lines. Design features allow for a storage system which may be easily expanded. Additional display units may be added to the system at any time.

Available Equipment: CRT display units; interface equipment; alphanumeric keyboard; function keys and central units.

Software: Not specified.

2. Control Data Corporation

Capability: Alphanumeric, graphic, and design.

General Description: A complete line of computers, CRT systems and related peripheral equipment is available. Systems are designed for alphanumeric, general purpose, and design applications. Hard copy printers, film processors, and microfilm readers are included as an integral part of the CRT system. With the use of storage and buffering equipment, the CRT can effectively be used as an off-line device. This is the only manufacturer that offers a unit specifically developed for design.

Available Equipment: Computers; CRT display units; alphanumeric and program function keyboards; track balls, switch indicators; microfilm readers and printers; and hard copy printers.

Software: Determined by installation.

3. Digital Equipment Corporation

Capability: Alphanumeric, graphic and design.

General Description: Digital provides a comprehensive line of large and small computers to complement various CRT units. The CRT systems- are designed to be used as computer driven displays or buffered satellite units. A unique feature is the "moving window: which has the ability to select a small area from a large drawing.

Available Equipment: Computers; CRT displays; light pen; alphanumeric and program function keyboards; various types of symbol and character generators.

Software: Full software support including Fortran and Cobol. Pre-programmed subroutines aid the searching and use of storage.

4. General Electric Corporation

Capability: Alphanumeric

General Description: Both computers and CRT systems are provided. The CRT systems are also adaptable to computers produced by other manufacturers. Since only the alphanumeric capability is available, applications are limited to business and monitoring operations such as the supervision of blending, refining, and steel making. Comprehensive software support is provided.

Software: Process Assembler languages, Fortran compilers, Tabular sequence control, mathematical routines, debugging aids, and hardware diagnostic programs.

5. Honeywell Corporation

Capability: Alphanumeric

General Description: Honeywell provides both computers and CRT systems used in business and information storage and retrieval applications. The firm is also presently working in computer assisted instruction and library applications.

Available Equipment: Computers; CRT displays; Light pen; alphanumeric and program function keyboards.

Software: Both Cobol and Fortran are available.

6. IBM Corporation

Capability: alphanumeric, graphic and design.

General Description: IBM is the largest manufacturer of computers and CRT systems. The company provides a complete line of large to small computers. CRT systems are specifically designed for alphanumeric, graphic, or general purpose applications. The firm maintains an excellent sales and systems staff. CRT systems are available which may be used as off-line equipment.

Available Equipment: Computers; CRT displays; recorders and scanners; alphanumeric and program function keyboards; plotters; drafting machines; microfilm readers, photo plotters; and motion picture devices.

Software: Fortran, Cobol, specially written programs for tracking and sketching techniques, subroutines for buffer storage, ALPACA, G-PAC, EXPRESS and BASIC Languages are available.

6B. Information Displays, Inc.

Capability: Alphanumeric, graphic, and design.

General Description: Builds CRT systems which may be adapted to any computer. The Company has the most comprehensive line of equipment of the firms which do not manufacture computers. The system are designed from low performance, low cost to high performance, high cost. All CRT system options are available. The firm maintains an excellent sales and service staff.

Available Equipment: CRT consoles; light pen; alphanumeric and program function keyboards; interfaces; contained storage; various character and vector generators; size and intensity controls.

Software: Determined by application.

7. I.T.T. Federal Laboratories

Capability: Alphanumeric, graphic, and design.

General Description: A comprehensive line of equipment is provided for varied and unique applications. Color displays, slide projections, and 6 foot viewing screens are typical of the varied applications.

Available Equipment: CRT displays; slide projector; alphanumeric and program function keyboards; light pen; and color processor.

Software: (MACC) Modular Alter and Compose Control is a Cobol oriented language used to control the various displays.

8. Laboratory for Electronics

Capability: Alphanumeric

General Description: Present applications include Military command and control, our traffic control range, safety training devices and other types of control displays. Drafting and design are not included. The equipment can be adapted to most computers. Cost is determined by software and peripheral equipment requirements.

Available Equipment: CRT displays; alphanumeric keyboard; light pen.

Software: Not specified.

9. Philco-Ford

Capability: Alphanumeric, graphic, and design.

General Description: The firm provides both computers and CRT systems. A great deal of emphasis is placed upon computer assisted instruction. Equipment is suited for any application where capabilities are required.

Available Equipment; Computers; CRT displays; alphanumeric and program function keyboards; light pen; microfilm and projection equipment.

Software: Basic routines have been devised, other software under development. (SAVI) Student Audio-Visual Interface is a special system used for computer assisted instruction.

10. Raytheon

Capability: Alphanumeric.

General Description: The CRT system is designed for areas which lend themselves to the alphanumeric capability. Displays can be adapted to most computers. The firm specializes in storage and readout tubes which may be connected with data transmission lines of all types.

Available Equipment: CRT displays; interface; alphanumeric keyboard; and hard copy printer.

Software: Not specified.

11. Radio Corporation of America

Capability: Alphanumeric and graphic.

General Description: The RCA system translates machine language to narrative form for high speed data processing. A sophisticated software support program is offered. Unique features include a message composer and a split screen function with hard copy capability.

Available Equipment: Computers; CRT displays; alphanumeric keyboards; buffers, ligh pens, and hard copy devices.

Software: Fortran IV, Cobol, Sort Merge, Diagnostic Library Maintenance, Communication Control, Report Program Generator, Job Control, Assembly System Peripheral Control, and File Control Processor.

12. Sanders Corporation

Capability: Alphanumeric.

General Description: A business oriented display. It has the unique feature of self-contained storage which allows for some data manipulation without the use of the computer. Typical applications include accounting, budgets, deliveries, personnel records, production reports and specifications.

Available Equipment: Control unit; display units; typewriter style keyboard; and memory units.

Software: Not specified.

13. Stromberg-Carlson

Capability: Alphanumeric, graphic, and design.

General Description: The firm designs and builds complete CRT Systems for specific displays or computer output. Their systems have found application in design, the proofing of numerical control tapes, tool path drawings, business graphs, and scientific curves.

Available Equipment: Computers; CRT displays; alphanumeric and program function keyboards; 16 and 35 MM recording cameras; printers; hard copy devices; magnetic tape and card reading units; paper tape readers; projection screens; character and vector generators, plotters, film processors, microfilm recorders, and a microfiche inquiry station.

Software: Fortran, S-C4060 Symbolic language, test and maintenance programming, Pert, and Global mapping programs.

14. Tasker

Capability: Alphanumeric, Graphic.

General Description: Tasker is a builder of CRT consoles and systems which interface with standard computers. Although their systems can be adapted to punched paper tape machines and plotters, they have only limited applications in engineering.

Available equipment: CRT consoles; interface units; light pen; transparent grid; film projector; symbol writer, vector and format generator; hard copy printer; and alphanumeric keyboard.

Software: Not specified.

The above information has been taken from information provided by the manufacturers. Additional information can be obtained by writing the manufacturer as listed in Appendix A.

APPENDIX C

1. A. C. Electronics
   Milwaukee, Wisconsin

2. Aeronautronic Corp.
   Newport Beach, Calif.

3. Aerospace Corp.**
   Los Angeles, California

4. Department of the Air Force I*
   Washington, D. C.

5. Airborne Instruments Laboratory
   Deer Park, L.I., New York

6. AMF Tuboscope Inc.
   Houston, Texas

7. American Air Lines, Inc.
   New York, New York

8. Analytic Services Inc.*
   Falls Church, Va.

9. Applied Data Research, Inc.*
   Princeton, N. J.

10. U. S. Army Electronics*
    Ft. Mammouth, N. J.

11. Department of the Army II**
    Washington, D. C.

12. Atlantic Research Corp.
    Costa Mesa, Calif.

13. Battelle Memorial Institute**
    Columbus, Ohio

14. Bell Aerosystems Co.
    Buffalo, N. Y.

15. Bendix Industrial Controls*
    Detroit, Michigan

16. Boeing Simulation Center
    Huntsville, Alabama

17. Boeing Corp.***
Seattle, Washington

18. Bolt, Beranek, & Newman, Inc.
Cambridge, Mass.

19. Chemical Abstracts Service***
Columbus, Ohio

20. Chrysler Corp.***
Detroit, Michigan

21. Cincinnati Milling Machine Co.*
Cincinnati, Ohio

22. Communications Satellite Corp.*
Washington, D. C.

23. Control Data Corp.
Burlington, Massachusetts

24. Data Corporation*
Dayton, Ohio

25. Data Processing Center-6*
Washington, D. C.

26. Douglas Aircraft, Inc.**
Santa Monica, Calif.

27. E. I. Dupont
Wilmington, Delaware

28. Fairchild Cameras & Instrument
Syorset L. I., New York

29. Ford Motor Co.**
Dearborn, Michigan

30. General Dynamics
Groton, Conn.

31. General Electric Co.
Schenectady, New York

32. General Motors Corp.***
Warren, Michigan

33. Grumman Aircraft Corp.
Bethpage L. I., New York

34. Hughes Aircraft Corp.
    Culver City, Calif.

35. Link Group, G.P.I.
    Binghampton, New York

36. Litton Industries, Inc.*
    Beverely Hills, Calif.

37. Lockheed Aircraft Corp.**
    Burbank, Calif.

38. Lockheed-Georgia Co.***
    Marietta, Ga.

39. Lockheed Propulsion Co.
    Redlands, Calif.

40. Lockheed Missiles & Space Co.
    Sunnyvale, Calif.

41. Magnavox Co.*
    Fort Wayne, Ind.

42. Martin Company**
    Denver, Colorado

43. McDonnell Aircraft***
    St. Louis, Mo.

44. The 3-M Corp.
    St. Paul, Minn.

45. Motorola, Inc.
    Chicago, Illinois

46. N.A.S.A.*
    Washington, D. C.

47. N.A.S.A. Research Center*
    Cambridge, Mass.

48. National Cash Register Co.
    Dayton, Ohio

49. North American Aviation Corp.
    Los Angeles, Calif.

50. Pan Am-Guided Missiles***
    Cocoa Beach, Fla.

51. Phillips Petroleum Co.***
Bartlesville, Okla.

52. Radio Corp. Of America
Cherry Hill, N. J.

53. Rand Corp.***
Santa Monica, Calif.

54. Reliance Electric**
Cleveland, Ohio

55. Rust Engineering Co.*
Pittsburgh, Pa.

56. Space & Information Systems
Downey, Calif.

57. Sperry Gyroscope Co.
Great Neck L. I., New York

58. Strategic Communications Command
Washington, D. C.

59. Systems Research Lab.
Dayton, Ohio

60. Texas Instruments Inc.
Dallas, Texas

61. United Aircraft Corp.**
Norwalk, Connecticut

62. United Air Lines
Chicago, Illinois

63. Univac***
Blue Bell, Pa.

64. Westinghouse Electric Corp.***
Pittsburgh, Pa.

* Indicates those companies which responded to the original letter of inquiry.

** Indicates those companies responding as users of the CRT to which the industrial questionnaires were sent.

*** Indicates those companies responding to the questionnaire.

APPENDIX D

Persons contacted through personal interview:

1. Mr. Samuel M. Masta
   Manager, IBM Advanced Scientific Center
   United Nations Plaza
   New York, New York

2. Mr. Richard Speers
   Software Support
   Honeywell Corporation
   Newton, Massachusetts

3. Mr. Carl Machover
   Information Displays, Inc.
   Mount Vernon, New York

4. Dr. Edward Ramey
   Massachusetts Institute of Technology
   Boston, Massachusetts

5. Mr. David A. Gilman
   Pennsylvania State University
   University Park, Pennsylvania

6. Mr. James Stevens
   Westinghouse Corp.
   Pittsburgh, Pennsylvania

7. Mr. Lee Presscott
   United Aircraft Corp.
   East Hartford, Connecticut

APPENDIX E

ENGINEERING INSTITUTIONS

Auburn University
Auburn, Alabama

University of California, Berkeley 4
Berkeley, California

Carnegie Institute of Technology 2, 4
Pittsburg, Pennsylvania

Case Institute of Technology 1
Cleveland, Ohio

Clemson University
Clemson, South Carolina

U. S. Air Force Academy 1
Colorado Springs, Colorado

University of Connecticut
Stores, Connecticut

John Hopkins University 1
Baltimore, Maryland

University of Kansas 1
Lawrence, Kansas

Lehigh University
Bethlehem, Pennsylvania

Marquette University
Milwaukee, Wisconsin

University of Maryland 2
College Park, Maryland

University of Missouri at Rolla 4
Rolla, Missouri

Montana State College
Bozeman, Montana

New Mexico State University
University Park, New Mexico

Ohio State University
Columbus, Ohio

Oregon State University
Corvallis, Oregon

Rensselaer Polytechnic Institute
Troy, New York

Seattle University 1
Seattle, Washington

South Dakota School of Mines 2
Rapid City, South Dakota

South Dakota State University 1
Brookings, South Dakota

University of Southern California 2
Los Angles, California

University of Southwestern Louisiana
Lafayette, Louisiana

Tulane University
New Orleans, Louisiana

University of Virginia
Charlottesville, Virginia

Washington State University
Pullman, Washington

1. Responded to the questionnaire as not using computer assisted instruction or the CRT.

2. Responded to the questionnaire as using computer assisted instruction.

3. Responded to the questionnaire as future users of the CRT.

4. Responded to the questionnaire as present users of the CRT.

5. The institutions originally contacted to provide an insight to computer assisted instruction.

APPENDIX F

EDUCATIONAL INSTITUTIONS

Adelphi University 1
Garden City, New York

University of Akron 3
Akron, Ohio

Austin College
Sherman, Texas

Bemidji State College 2
Bemidji, Minnesota

Brooklyn College of the City University of New York 1
Brooklyn, New York

Junior College of Broward County 3
Fort Lauderdale, Florida

Bowdoin College 1
Brunswick, Maine

University of Chattanooga
Chattanooga, Tennessee

University of Cincinnati 1
Cincinnati, Ohio

The Citadel
Charleston, South Carolina

Columbia University
New York, New York

Cooke County Junior College 1
Gainsville, Florida

Darthmouth College 4
Hanover, New Hampshire

Eastern New Mexico University 2
Portales, New Mexico

Florida State University 5
Tallahassee, Florida

The George Washington University
Washington, D. C.

The University of Houston
Houston, Texas

University of Illinois at the Medical Center 2
Chicago, Illinois

Iowa State University 2,3
Ames, Iowa

The John Hopkins University
Baltimore, Maryland

King's College
Wickes Bane, Pennsylvania

Lane Community College
Eugene, Oregon

Massachusetts State College
Westfield, Massachusetts

Michigan State University
East Lansing, Michigan

University of Michigan 5
Ann Arbor, Michigan

University of Missouri at Kansas City
Kansas City, Missouri

University of New Mexico
Albuquerque, New Mexico

New York University
New York, New York

North Orange County Junior College
Fullerton, California

Northwestern University
Evanston, Illinois

Oakland Community College 2
Bloomfield Hills, Michigan

Oklahoma Christian College
Oklahoma City, Oklahoma

Pacific Lutheran University 1
Tacoma, Washington

Pennsylvania State University 5
University Park, Pennsylvania

University of Pennsylvania 3
Philadelphia, Pennsylvania

Pfeiffer College 1
Misenheimer, North Carolina

University of Pittsburg
Pittsburg, Pennsylvania

Purdue University 2
Lafayette, Indiana

Randolph-Macon College
Ashland, Virginia

Saint Peter's College
Jersey City, New Jersey

University of Southern California
Los Angeles, California

Stanford, University 5
Stanford, California

Syracuse University
Syracuse, New York

Tarleton State College 2
Stephenville, Texas

Texas Christian University
Fort Worth, Texas

The University of Texas 5
Austin, Texas

Washburn University of Topeka 2
Topeka, Kansas

Wayne State University
Detroit, Michigan

Western Kentucky University 1
Bowling Green, Kentucky

Wilson College 2
Chambersburg, Pennsylvania

Wisconsin State University 1
Oshkosh, Wisconsin

1. Responded to the questionnaire as not using computer assisted instruction or the CRT.

2. Responded to the questionnaire as using computer assisted instruction.

3. Responded to the questionnaire as future users to the CRT.

4. Responded to the questionnaire as present users of the CRT.

5. The institutions originally contacted to provide an insight to computer assisted instruction.

FORM 1 - INDUSTRIAL APPLICATIONS AND IMPLICATIONS

Name of firm ______________________________

Address ______________________________
street city state

Name or respondent ______________________________

Position or respondent ______________________________

Function of firm ______________________________

Approximate number of employees in firm ______________________________

Approximate number of employees involved with the use of the cathode ray tube system (CRT) __________

1. Please state the number of units, the manufacturer, the series, and model number of the following hardware equipment used in your system.

A. Computer(s)

No. of units	Manufacturer	Series	Model no.
________	________	________	________
________	________	________	________
________	________	________	________

B. Cathode Ray Tube

________	________	________	________
________	________	________	________
________	________	________	________

C. Periperal Equipment

	No. of units	Manufacturer	Series
( ) plotter	______	______	______
( ) light pen	______	______	______
( ) recorder	______	______	______
( ) scanner	______	______	______
( ) operator console	______	______	______
( ) alphanumeric keyboard	______	______	______
( ) program function keyboard	______	______	______
( ) character generator	______	______	______
( ) other______	______	______	______
( ) other______	______	______	______

2. Is your hardware equipment:

( ) owned? ( ) rented? ( ) leased? ( ) time shared?

3. Please indicate the present and future capabilities of your CRT system.

Capability	Presently used	Planned future use
a. alphanumerics	( )	( )
b. graphics	( )	( )
c. design	( )	( )

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4. Please indicate the area(s) of application of your CRT system.

( ) information inquiry

( ) management

( ) design

( ) engineering

( ) scientific computation

( ) process control

( ) test monitoring

( ) education

( ) other________________

( ) other________________

5. Indicate the number of personnel in each classification that are directly involved with the CRT and amount of their usage.

	Total no. of personnel	No. of hours used weekly
a. management	________	________
B. engineering	________	________
c. drafting	________	________
d. sales	________	________
e. programming	________	________
f. other________	________	________
g. other________	________	________

6. Indicate the number of your personnel that fall within each educational classification who use the CRT system.

Educational level	Number of personnel
a. less than twelfth grade	________
b. high school graduate	________
c. technical graduate	________
d. college graduate	________
e. master's degree	________
f. doctorate	________
g. other________	________

7. Please rate the necessity of prior specialized training* in the use of the CRT system for the following personnel by placing a circle around the appropriate number.

	Not necessary	Helpful	Needed	Important	Essential
a. management	0	1	2	3	4
b. engineering	0	1	2	3	4
c. drafting	0	1	2	3	4
d. programming	0	1	2	3	4
e. other	0	1	2	3	4
f. other	0	1	2	3	4

*Specialized training is defined as the implant instruction necessary before any use of the CRT system may be attempted.

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8. Please rate the problems associated with the utilization of the CRT system.

Problem	Rating				
	No	Few	Some	Many	Major
a. programming	0	1	2	3	4
b. acquiring specialized personnel	0	1	2	3	4
c. retraining of present personnel	0	1	2	3	4
d. utilization in respect to cost	0	1	2	3	4
e. other	0	1	2	3	4

9. Please rate the reasons for the incorporation of the CRT system in your firm.

Reason	Rating				
	not applicable	limited importance	important	very important	essential
a. ease of operation	0	1	2	3	4
b. speed	0	1	2	3	4
c. graphic representation	0	1	2	3	4
d. on-line control	0	1	2	3	4
e. other	0	1	2	3	4
f. other	0	1	2	3	4

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10. Do you have a need for personnel to fill existing employment opportunities concerned with the use of the CRT?

yes ( ) no ( )

11. Do you feel that additional personnel will be needed within the next five to ten years?

yes ( ) no ( )

If yes, please indicate the approximate number of personnel needed within each classification.

Classification	No. of personnel needed in 5 years	No. of personnel needed in 10 years
a. management	(____)	(____)
b. engineering	(____)	(____)
c. drafting	(____)	(____)
d. sales	(____)	(____)
e. programming	(____)	(____)
f. other__________________	(____)	(____)
g. other__________________	(____)	(____)

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12. Please indicate the educational level at which the following experiences should be introduced and their degree of importance.

a. basic introduction to computers and their development

	Rating				
	not necessary	limited importance	important	very important	essential
senior high school	0	1	2	3	4
vocational school (9-12)	0	1	2	3	4
technical school (2 yr. post high school)	0	1	2	3	4
college, 2 year	0	1	2	3	4
college, engineering	0	1	2	3	4
college, non-engineering	0	1	2	3	4
graduate school	0	1	2	3	4

b. knowledge of computer developments as they apply to a particular subject area.

	Rating				
	not necessary	limited importance	important	very important	essential
senior high school	0	1	2	3	4
vocational school (9-12)	0	1	2	3	4
technical school (2 yr. post high school)	0	1	2	3	4
college, 2 year	0	1	2	3	4
college, engineering	0	1	2	3	4
college, non-engineering	0	1	2	3	4
graduate school	0	1	2	3	4

c. formal course work in cybernetics

	Rating				
	not necessary	limited importance	important	very important	essential
senior high school	0	1	2	3	4
vocational school (9-12)	0	1	2	3	4
technical school (2 yr. post high school)	0	1	2	3	4
college, 2 year	0	1	2	3	4
college, engineering	0	1	2	3	4
college, non-engineering	0	1	2	3	4
graduate school	0	1	2	3	4

d. formal course work in systems design and capability

	Rating				
	not necessary	limited importance	important	very important	essential
senior high school	0	1	2	3	4
vocational school (9-12)	0	1	2	3	4
technical school (2 yr. post high school)	0	1	2	3	4
college, 2 year	0	1	2	3	4
college, engineering	0	1	2	3	4
college, non-engineering	0	1	2	3	4
graduate school	0	1	2	3	4

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NOTE The final section of this questionnaire will be concerned with the determination of competencies required of future draftsmen and/or designers. Please disregard this section if drafting and/or design do not apply to your area of application.

13. Do you feel that computer aided design will significantly effect the required competencies of future draftsmen and/or designers?

yes ( ) no ( )

If yes, please rate the following suggested competencies:

competency	Rating				
	not necessary	helpful	needed	important	essential
a. strong mathematical background	0	1	2	3	4
b. programming background	0	1	2	3	4
c. operational knowledge of the computer and supporting peripheral devices	0	1	2	3	4
d. creative design abilities	0	1	2	3	4
e. knowledge of numerically controlled machines	0	1	2	3	4
f. other	0	1	2	3	4
g. other	0	1	2	3	4

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14. The following skills and knowledge are developed in the typical drafting program. Please rate each as they will apply to future draftsmen and/or designers.

	not necessary	helpful	needed	important	essential
a. use of instruments	0	1	2	3	4
b. dimensioning techniques	0	1	2	3	4
c. geometric constructions	0	1	2	3	4
d. multiview projections	0	1	2	3	4
e. section drawings	0	1	2	3	4
f. perspective drawings	0	1	2	3	4
g. machine drawings	0	1	2	3	4
h. sheet metal drawings	0	1	2	3	4
i. principles of design	0	1	2	3	4
j. present reproduction techniques	0	1	2	3	4

15. Please enter any additional comments you wish to make concerning the cathode ray tube and its effect upon the draftsmen and/or designers.

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FORM II - EDUCATIONAL APPLICATIONS AND IMPLICATIONS

Name of institution ____________________

Address ____________________
street city state

Name of respondent ____________________

Position of respondent ____________________

Approximate number of students attending your institution ____________

Approximate number of faculty at your institution ____________

Approximate number of students involved with computer assisted instruction ____________

Approximate number of faculty involved with computer assisted instruction ____________

Are you presently using the cathode ray tube as an instructional device? yes ( ) no ( )

If yes, how many students are involved with the cathode ray tube (CRT) system? ____________

If no, do you plan on implementing the cathode ray tube system (CRT) in the near future? yes ( ) no ( )

If yes, how soon do you plan on implementing the CRT system? ____________

1. Please state the number of units, the manufacturer, the series, and the model number of the following hardware equipment.

A. Computer(s)

No. of units	Manufacturer	Series	Model no.
____	____	____	____
____	____	____	____
____	____	____	____

B. Cathode Ray Tube

________	________	________	________
________	________	________	________
________	________	________	________

C. Peripheral Equipment

	No. of units	Manufacturer	Series
( ) plotter	________	________	________
( ) light pen	________	________	________
( ) recorder	________	________	________
( ) scanner	________	________	________
( ) operator console	________	________	________
( ) alphanumeric keyboard	________	________	________
( ) program function keyboard	________	________	________
( ) character generator	________	________	________
( ) other________	________	________	________
( ) other________	________	________	________

2. Is your hardware equipment:

owned? ( ) rented ( ) leased ( ) time shared ( )

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3. Please check the area(s) of application of your cathode ray tube system.

( ) administration　　( ) scientific computations

( ) design　　( ) other

( ) programmed learning　　( ) other

( ) library　　( ) other

4. If design is one of your areas of application, is it used:

( ) by the instructor or other qualified staff members to solve existing design design problems? (e. g. beam loads of a new building to be construction on campus)

( ) as a communication media to teach design to a class? (computer assisted instruction)

( ) in a design class to familiarize the student with the operation and capability of this system?

5. Please indicate the approximate number of your staff in each classification that are directly involved with the CRT system and the amount of their usage.

		Total no. of staff	No. of hours used weekly
a.	administrators	______	______
b.	instructors	______	______
c.	programmers	______	______
d.	operational or supportive personnel	______	______
e.	library staff	______	______
f.	other	______	______
g.	other	______	______

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6. Please indicate and rate the necessity of prior specialized training* in the use of the CRT system for the following members of your staff by placing a circle around the appropriate number.

	not necessary	helpful	needed	important	essential
a. administrators	0	1	2	3	4
b. instructors	0	1	2	3	4
c. programmers	0	1	2	3	4
d. librarians	0	1	2	3	4
e. other	0	1	2	3	4
f. other	0	1	2	3	4

*Specialized training is defined as instruction necessary before any use of the CRT system may be attempted.

7. Please rate the following problems associated with the utilization of the CRT system.

Problem	Rating				
	No	Few	Some	Many	Major
a. programming	0	1	2	3	4
b. acquiring specialized personnel	0	1	2	3	4
c. retraining of present personnel	0	1	2	3	4
d. utilization in respect to cost	0	1	2	3	4
e. other	0	1	2	3	4
f. other	0	1	2	3	4

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8. Please rate the following reasons for the incorporation of the CRT system at your institution.

	not applicable	limited importance	important	very important	essential
a. ease of access to information	0	1	2	3	4
b. speed	0	1	2	3	4
c. graphic displays	0	1	2	3	4
d. computerized education	0	1	2	3	4
e. increased effectiveness of computing system	0	1	2	3	4
f. other	0	1	2	3	4
g. other	0	1	2	3	4

NOTE The final section of this questionnaire deals with computer assisted education. Please disregard this section of the questionnaire if it does not apply to your area of application.

9. Please list the subject areas in which you presently offer computer assisted instruction. Also indicate those subjects which lend themselves to CRT developments.

Subjects currently being taught with computer assistance	Those which also lend themselves to CRT
a.__________	__________
b.__________	__________
c.__________	__________
d.__________	__________
e.__________	__________

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10. In your opinion, what are the limitations as to the subject matter areas that can be adapted to computer assisted instruction?

11. How would you compare computer assisted instruction to conventional teaching methods in the following areas?

Area	far less	less	equal	superior	far superior
a. comprehension of materials	0	1	2	3	4
b. retention of material	0	1	2	3	4
c. transfer of learned material	0	1	2	3	4
d. acceptance of method	0	1	2	3	4
e. throughness of material coverage	0	1	2	3	4
f. other	0	1	2	3	4

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12. How would you rate the following advantages of computer assisted instruction?

Advantage	Rating				
	fairly important	limited importance	important	very important	essential
a. regulation of pupil error	1	2	3	4	5
b. individualized learning	1	2	3	4	5
c. immediate evaluation	1	2	3	4	5
d. logical rate of progression	1	2	3	4	5
e. direct participation	1	2	3	4	5
f. other	1	2	3	4	5

13. Please enter any additional comments you wish to make concerning the CRT as an educational media.

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MOREHEAD STATE UNIVERSITY

MOREHEAD, KENTUCKY 40351

SCHOOL OF APPLIED SCIENCES
AND TECHNOLOGY

December
Thirteen
1966

Gentlemen:

I am contacting you for information concerning your developments of the cathode ray tube in its utilization as a means of computer communication.

This media is of mutual interest to both the University and myself. My own interest will develop into a Master's Thesis surveying industrial applications and emerging educational implications while the University is concerned mainly with the latter educational implications as a possible source for future curriculum revision.

At present, I am trying to locate and secure information pertaining to the cost, capability and application of the cathode ray tube from manufacturers such as yourself. More specifically, I need material on your complete operating system including related hardware equipment such as recorders, scanners, and light pens.

Future plans for this study include a questionnaire to be sent to industrial firms using the cathode ray tube. If competitive reasons do not require that such information be kept confidential, I would greatly appreciate the names of any such firms you care to disclose.

Thank you for your cooperation and any help you provide.

Sincerely,

Chester S. Rzonca
Research Assistant

Dr. C. Nelson Grote, Dean
School of Applied Science
and Technology

MOREHEAD STATE UNIVERSITY

MOREHEAD, KENTUCKY 40351

SCHOOL OF APPLIED SCIENCES AND TECHNOLOGY

Gentlemen:

I am contacting you as a possible source of information concerning your firms developments of the cathode ray tube in its utilization as a means of computer communication.

This media is of mutual interest to both the University and myself. My own interest will develop into a Master's Thesis surveying industrial applications and emerging educational implications while the University is concerned mainly with the latter educational implications as a possible source for future curriculum revision.

At present, I am trying to locate and secure information pertaining to the cost, capability, and application of the cathode ray tube from firms such as yours. I realize that it is not the function of your office to deal in computer services, but I would greatly appreciate your forwarding this letter to the appropriate department.

Thank you for your cooperation and help.

Sincerely,

Chester S. Rzonca
Research Assistant

Dr. C. Nelson Grote, Dean
School of Applied Sciences
and Technology

dw

MOREHEAD STATE UNIVERSITY

MOREHEAD, KENTUCKY 40351

SCHOOL OF APPLIED SCIENCES AND TECHNOLOGY

January 17, 1967

Gentlemen:

This letter is a second request for your assistance. I am contacting you as a possible source of information concerning your firms developments of the cathode ray tube in its utilization as a means of computer communication.

I realize that it is not the function of your office to deal in computer services, but I would greatly appreciate your forwarding this letter to the appropriate department. At the present, I am trying to locate and secure information pertaining to the cost, capability, and application of the cathode ray tube.

This media is of mutual interest to both the University and myself; my own interest will develop into a Master's Thesis surveying industrial applications and emerging educational implications while the University is concerned with the latter educational implications as a possible source for future curriculum revision.

Again, thank you for your cooperations and any help you may provide.

Sincerely,

Chester S. Rzonca
Research Assistant

Dr. C. Nelson Grote, Dean
School of Applied Science
and Technology

sc

MOREHEAD STATE UNIVERSITY

MOREHEAD, KENTUCKY 40351

SCHOOL OF APPLIED
SCIENCES AND TECHNOLOGY

March
Eighth
1967

Thank you for the information you provided concerning your company's development and use of the cathode ray tube system. This information was originally requested in the interest of the University and for use in my Master's Thesis centering about the educational implications of the CRT. The material has been very helpful in the justification and organization of my study.

To further judge the educational implications and system capabilities, I have enclosed a questionnaire partially completed from the information originally provided. Would you, at your convenience, recheck this information and complete the questionnaire? You are probably aware that your firm is one of the few working in this area. Your cooperation is essential to the success of this study. For your convenience, I have enclosed a stamped, self-addressed envelope.

When completed, an abstract of the study will be sent to you. Any additional information you may request will gladly be provided. Again, thank you for your time and much needed help.

Sincerely,

Chester S. Rzonca
Research Assistant

C. Nelson Grote, Dean
School of Applied Sciences
and Technology

bjp

Enclosure

MOREHEAD STATE UNIVERSITY

MOREHEAD, KENTUCKY 40351

SCHOOL OF APPLIED
SCIENCES AND TECHNOLOGY

March 23, 1967

I am contacting you in reference to a questionnaire sent to you on March eighth. To briefly reorient you, it concerned your firms utilization of the cathode ray tube as a means of computer communication.

The material requested will be used in the interest of the University and as part of the data to be included in my Master's Thesis.

I realize the many important affairs you deal with, many of which are no doubt time consuming. I would, however, ask for a few minutes of your time to complete this questionnaire. Since your firm is one of the few dealing in this area your response is essential to the completion on this study.

I have enclosed a second questionnaire in case you have misplaced the first. Your consideration and efforts will definitely be appreciated.

Sincerely,

Chester S. Rzonca
Research Assistant

C. Nelson Grote, Dean
School of Applied Sciences
and Technology

sc

Enclosure

MOREHEAD STATE UNIVERSITY

MOREHEAD, KENTUCKY 40351

SCHOOL OF APPLIED
SCIENCES AND TECHNOLOGY

March 31, 1967

I am in the process of collecting data for a Master's Degree Thesis concerned with the question of current industrial and educational uses of the cathode ray tube system and its future implications for Industrial Arts Education. This topic has the approval of my Committee composed of Dr. Robert Needham, Mr. Clyde Hackler, and Dr. C. Nelson Grote, who serves as director of the thesis.

I am presently surveying selected educational institutions to gain information on the various applications of the cathode ray tube system including its ability to assist computerized instruction, storage and retrieval, and engineering education.

Your institution is one of the few presently using the computer in these areas. Due to the uniqueness and present limited applications of this media, your help is essential to the success of this study. Would you complete the enclosed questionnaire or refer it to another qualified staff member? For your convenience, you will find a stamped, self-addressed envelope. I realize that your office has many important matters to which it must attend. However, I would ask that you deal with this questionnaire by April Fourteenth.

Thank you for your time and cooperation.

Sincerely,

Chester S. Rzonca

C. Nelson Grote, Dean

sc

Enclosure

MOREHEAD STATE UNIVERSITY

MOREHEAD, KENTUCKY 40351

SCHOOL OF APPLIED SCIENCES AND TECHNOLOGY

April 13, 1967

I am contacting you in reference to a questionnaire sent to you on March 31. I realize you have many important matters to which you must attend and that my requested return date for the questionnaire was April 14th. However, I thought this letter might serve as a reminder to secure your valuable assistance.

I am in the process of collecting data for a Master's Degree Thesis concerned with the question of current industrial and educational uses of the cathode ray tube system and its future implications for Industrial Arts Education. This topic has the approval of my Committee composed of Dr. Robert Needham, Mr. Clyde Hackler, and Dr. C. Nelson Grote, who serves as director of the thesis.

I am presently surveying selected educational institutions to gain information on the various applications of the cathode ray tube system including its ability to assist computerized instruction, storage and retrieval, and engineering education.

Your institution is one of the few presently using the computer in these areas. Due to the uniqueness and present limited applications of this media, your help is essential to the success of this study. Would you complete the enclosed questionnaire or refer it to another qualified staff member? For your convenience, you will find a stamped, self-addressed envelope.

Thank you for your time and cooperation.

Sincerely,

Chester S. Rzonca
Research Assistant

VITA

Chester Steven Rzonca was born January 13, 1943 in New Britain, Connecticut. His elementary and secondary education were completed in that city where he graduated from the New Britain Senior High School in June of 1960. He received his Bachelor of Science Degree in Industrial Arts Education from Central Connecticut State College in June of 1965. From November of 1964 to June of 1965, he taught at the Woodrow Wilson Junior High School in Middletown, Connecticut. From September of 1965 to January of 1966 he was employed as a drafting instructor in the West Haven High School, West Haven, Connecticut.

In February of 1966, he began graduate study at Morehead State College, now known as Morehead State University. During 1966-67, he was employed as a graduate assistant in the School of Applied Sciences and Technology.