To the Graduate Council:

I am submitting herewith a dissertation written by Eddie Huston Butler entitled "A Comparison of Achievement and Attitudes of Students Taught Technical Drafting Using Computer Aided Drafting Versus Traditional Drafting." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Technological and Adult Education.

Gerald Cheek

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We have read this dissertation and recommend its acceptance:

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Vice Provost and Dean of the Graduate School

A COMPARISON OF ACHIEVEMENT AND ATTITUDES OF STUDENTS TAUGHT TECHNICAL DRAFTING USING COMPUTER AIDED DRAFTING VERSUS TRADITIONAL DRAFTING

A Dissertation

Presented for the

Doctor of Education

Degree

The University of Tennessee, Knoxville

Eddie Huston Butler

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Dedication

This dissertation is dedicated to my loving family. Their encouragement and support provided the motivation to complete this terminal degree. My wife, Sandra, had no qualms about moving all over the country as I pursued my education. When I had reservations about that pursuit, she lovingly reassured me and supported my decisions.

My son, David, had to live with this dissertation, also. It probably seemed like I had to work on the dissertation every time he needed me to help him, answer questions or throw the baseball for the last four years.

My parents have also been special. Physically and financially, their assistance helped through *lean* times. They have always supported my career. My extended family also deserves a portion of this dedication. Everyone has assisted in ways that I can't list here.

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Ms. Karen Callahan's statistical analysis and computer assistance was always ready for changes and provided support that I could not get anywhere else. The support of the entire faculty of Appalachian State University has been tremendous.

Abstract

Education must maintain timely and appropriate curriculum content. Industrial Education and Technology Education (IET) are in the midst of a debate that reaches to the foundations of each discipline. The impacts of technological changes in business and industry have necessitated the updating of IET curriculum to keep content relevant. The personal computer has revolutionized the workplace and is affecting education in a significant way. Computer applications in schools have grown from general word processing and data analysis to specific applications such as computer aided drafting.

The basic question of this study was, Are there differences in the achievement and attitudes of students taught drafting using traditional equipment and those who are taught drafting using the VersaCAD computer software system? This research looked at differences in drafting achievement and attitudes of students taught introductory level technical drafting with two different methodologies: Computer aided drafting methodology and traditional drafting methodology.

A sample was selected from the students registering for four of the seven sections of TEC 1001, Introduction to Technical Drafting, at Appalachian State University. Students were taught using the traditional course outline and text. Pretest/posttest were administered to measure cognitive drafting knowledge using the *Ohio Drafting Achievement Test* and attitudes toward technical drafting using the *Gable-Roberts Attitude Toward School Subjects* inventory.

Drafting skill problems were evaluated to provide drafting skill achievement data. An analysis of covariance was used to statistically determine any significant differences between the CAD group and the TRAD group.

The findings of this research determined there was no significant difference in the cognitive achievement level and attitudes of students taught using different methodology and tools. There was, however, a significant difference in the drafting skill evaluations between the CAD and TRAD groups. The CAD drawings were evaluated significantly lower than the TRAD drawings.

As prior research had concluded, this research illustrated technical drafting cognitive knowledge could be taught as effectively using computer aided drafting methodologies as traditional methodologies. There was also no difference in the students' attitudes toward technical drafting between the two methodologies. From the analysis of the data, however, it can be concluded that drafting students achieve higher drafting skill levels when taught traditionally using traditional tools and methodologies than those taught in a traditional manner using computer aided drafting tools and methodologies.

Further research should be conducted to determine the benefits of incorporating CAD in introductory drafting classes, particularly in the area of drafting skills. Research should be conducted to determine the most effective curriculum to incorporate CAD into the technical drafting course. Research is also needed to determine the current and future needs of drafting employers for better IET course development.

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CHAPTER I

INTRODUCTION

Education is in a constant state of change. The attempt to maintain timely and appropriate curriculum content is an on-going challenge. Teachers of Industrial Education and Technology Education (IET) are in the midst of a debate that reaches to the foundations of each discipline. The impacts of technological changes in business and industry necessitate the updating of IET curriculum to maintain relevant content. Facing the challenge, education, particularly IET, must revamp classroom instruction to make it relevant to the outside world.

The personal computer has revolutionized the workplace, affecting industrial education in a significant way. The use of computers in schools has evolved from general word processing and data analysis to specific applications such as computer aided drafting. As early as 1984, educators recognized the importance of microcomputers. An article in the October 1984 issue of *Industrial Education*, entitled "Computers in Voc-Ed—Four Case Studies," stated:

> Microcomputers are playing an increasingly large role in industry and manufacturing related jobs. There has been a shift from the electrical/mechanical technology. This is commonly referred to as the High Technology Approach to manufacturing. The implications for educators are obvious. Students need to be provided with experiences which will simulate the industrial systems and technologies that they will find in the workplace. (Rodenstein, 1984, p. 12)

In an article written in 1984, Melmed declared that the use of computers in education is "a unique opportunity for improving education by improving student achievement" (p. 82). In the same year an article entitled "Education and Computers: The Situation Today and Some Possible Futures," Bork wrote that the computer is a learning device that should not be limited by the perception of it as only a technological device, overshadowing its educational implications. He emphasized that utilizing the microcomputer as a learning tool should be a higher priority than increasing the availability. Smelser (1981) forecasted that many teachers would resist increased involvement in computer use. Ideally, though, he envisioned microcomputing systems as a constant element in education and emphasized the importance of determining their most effective utilization (pp. 94-95).

The application of the computer as a tool for technical drafting has created a dilemma that IET educators are trying to resolve. Traditionally, drafting holds a fundamental position in technological education. "Today, drawing is the primary method of communication between designers and clients, architects and builders, engineers and production personnel, and between advertisers and customers" (Wallach & Chowenhill, 1989, p.2). Most products, buildings, and designs begin as drawings on a drawing board or computer.

Drawings have been used for communication since early man drew on cave walls to document significant events in their society. As early as 4000 B.C., design and design plans were used construct buildings. "By the first century

A.D., Romans were using detailed and dimensional drawings as guides in building their structures and roadways." During the fifteenth century orthographic projection was used for technical designs. "Leonard Da Vinci used pictorial and two-dimensional drawings to develop his inventions" (Wallach & Chowenhill, 1989, p.2). The Industrial Revolution necessitated the development of detailed drawings to meet the demand of developing manufacturers (Wallach & Chowenhill, 1989, p. 1).

Traditional drafting (TRAD) uses drafting tools and instruments developed over the last 100 years; drafting board/T-square, pencils/lead-holders, triangles, compass/divider, scales, inking pens, etc. In 1987, *Design News,* a publication of the drafting and design industry, conducted a survey to assess the use of CAD by its readers. Robert Boggs reported that 65% of *Design News* readers responding to the survey used computer applications such as computer-aided drafting and design (CAD), computer-aided manufacturing (CAM), and/or computer-aided engineering (CAE). He also anticipated an increase use up to 90% within the next three years (p. 117).

The growing use of personal computers as a tool for drafting has significant implications for drafting instruction. One of the major debates among IET professionals centers on the merits of introducing technical drafting to students using computer aided drafting (CAD). While some educators follow the traditional approach and teach drafting as they have for the last 50 years. Those educators view CAD as an advanced application. The traditional viewpoint is that students should first have the conventional introduction to technical drafting before exposure to CAD. Those with this viewpoint believe that traditional manual skills are a prerequisite for understanding CAD output. To support the necessity for basic drafting skills before learning CAD, Isbell and Lovedahl (1988) wrote:

> One must remember that the CAD system is nothing more than a tool in the hands of the modern draftsperson. . . .Therefore, the most important goal of the teacher remains to teach drawing fundamentals. Recognizing the necessity for students to develop competencies in basic drawing fundamentals, it is the authors' opinion that CAD should be a major part of the advanced drafting course(s), while devoting most of the time in the beginning course to instruction in drawing fundamentals and the use of basic drawing tools. (p.14)

Increases in speed, memory, and ease of operation, coupled with decreasing costs for CAD systems, make the transition from TRAD to CAD economically feasible for many business and industry users. IET, however, is slow to adopt the full use of CAD systems. Many schools are in the midst of making decisions that will have an impact on the future of industrial/ technology education; but the hardware and software purchasing decisions that are made with curriculum modifications will have a lasting financial impact on school budgets.

In the 1985 article, "Incorporating CAD Into the Curriculum," Kurt Becker wrote, "Administrators may be hesitant in channeling additional funds to elective areas. This means that electives must be more relevant to today's hi-tech world than ever before"(p. 16). Becker reports that more than half of the representatives of corporations surveyed in Houston thought that high schools should teach CAD. He also cites other studies that project a need for more than 100,000 CAD drafters between 1983 and 1987. Industry expressed concern regarding the financial responsibility corporates would have to bear to train CAD drafters: "The average cost of training a competent designer in CAD is $10,000 or more, but educational experiences involving CAD works to reduce the cost of training industrial employees" (p. 16).

"In the field of technical graphics, computer-aided drafting is the most significant development of our time." CAD eliminates the "repetitive tasks of manual drafting. . . .it expands the drafter's horizons and creates exciting, new opportunities" (Scott, Foy, Schwendau, 1988, p. 357).

Statement of the Problem

The problem addressed by this research is that educators continue to teach drafting using traditional methods of teaching without knowing whether or not they are superior. Innovations and new technologies found in the workplace have not been incorporated into the classroom.

Rationale

Educators and administrators are divided on the issue of which approach —TRAD versus CAD—is the better method to teach students basic drafting concepts and skills. Some have strong convictions that students need a foundation of traditional knowledge and skills provided by conventional techniques before being introduced to computer-aided drafting. On the other hand, with the improved power of personal-computer (PC) based drafting applications over the past ten years there are a growing number of authorities that believe students can learn basic drafting skills and knowledge using personal computers. In a 1990 study Resetarits reported, "Students in both the TRAD and the CAD groups obtained similar achievement scores on the *Ohio Drafting Achievement Test*." Resetarits also found "Students in both the TRAD and the CAD groups provided similar attitude scores on all three factors of General Interest, Usefulness, and Relevancy on the GRASS attitude measure" (p. 68-69). In part, Resetarits concluded:

> The results of this study indicate that there is no significant difference in achievement or attitude between students who learn drafting by the TRAD or the CAD method. Students can learn the principles and concepts of drafting while using a CAD system rather than traditional equipment. The results of the study demonstrate that beginning students in drafting who use CAD will achieve at an equal rate of success in comparison to students who use traditional drafting tools. (p. 70-71)

Data are needed to determine if students taught basic drafting skills using CAD technology have an acceptable foundation for basic drafting and subsequent technical drafting experiences. The research presented here can provide data to assist decision making about future directions for IET departments. In addition, the findings can serve as a reference for curriculum decisions of college and university IET departments.

The findings of this study can be directly implemented by the Department of Technology at Appalachian State University. The department is currently evaluating drafting course offerings. If the findings substantiate the comparable effectiveness of CAD instruction with traditional drafting instruction, the Department of Technology will move to request additional computer lab facilities as well as replacing existing drafting facilities with computer laboratory facilities. This change would upgrade course offerings and curriculum development plus provide needed computer facilities for the entire Department of Technology. On the other hand, if data does not support the effectiveness of CAD instruction, technical drafting may continue to be taught in the traditional manner.

Purpose of This Study

The purpose of this study was to ascertain whether teaching CAD meets the requirements for a fundamental understanding of technical drafting. This study originated from recommendations in the 1990 doctoral dissertation by Paul J. Resetarits.

Resetarits' research at the University of Connecticut used PC CADKEY instruction as a comparison with traditional methodologies. One of the recommendations Resetarits made in his dissertationentitled, *A Comparison of Computer-Aided Drafting (CAD) and Traditional Drafting With Respect to Achievement and Attitudes,* was:

> This study also should be replicated using other types of CAD systems. Other possible micro-computer based software that could be used would include *AutoCad, Drafix, MicroCADAM, Microstation,* and *VersaCAD.* (p. 73)

VersaCAD is one of the software programs currently used to teach CAD at Appalachian State University. The present study originated from presentations of Resetarits' dissertation, but using *VersaCAD* software with students in the ASU Department of Technology's "TEC 1001—Introduction to Technical Drafting" course.

Research Questions

The overall question that this study sought to answer was:

> Are there differences in the achievement and attitudes of students taught drafting using traditional equipment and those who are taught drafting using the VersaCAD computer software system?

To identify the specific directions of this study the following questions were asked:

1. Are there differences in cognitive drafting achievement levels between students who are taught technical drafting using traditional methods and those taught technical drafting using CAD?

2. Are there differences in drafting skill achievement levels between students who are taught technical drafting using traditional methods and those taught technical drafting using CAD?

3. What is the relationship between student achievement and the instructor who provided instruction?

4. Are there differences in the attitudes toward drafting by students taught technical drafting using traditional methods and those taught technical drafting using CAD?

5. Are there differences in students's attitudes toward drafting between those who are taught drafting by different instructors?

6. What is the relationship between student attitude toward technical drafting and the instructor who provided instruction?

Delimitations and Limitations

The following delimitations/limitations were inherent in this study:

1. Generalizability of the results was delimited to schools with similar facilities, software, and objectives as Appalachian State University.

2. The sample population used for this study was delimited to the students enrolled in TEC 1001.

3. The population and sample represented one school using VersaCAD software for the computer assisted drafting.

Assumptions

The study used the following assumptions:

1. After appropriate control precautions were taken, each TEC 1001 Introduction to Technical Drafting section used the same course outline and syllabus, regardless of teaching methodology.

2. Since both of the Department of Technology faculty members teaching TEC 1001 for this study taught drafting and CAD in the last year, each is equally experienced in teaching both CAD and traditional drafting to meet the course outline.

3. Extraneous variables of the sample students's prior experience with CAD or drafting will not affect on the outcome of the study due to the statistical treatment using an analysis of covariance.

Definitions

1. **Achievement** - the measure of a student's ability to demonstrate successful drafting skills on timed drafting tests.

2. **Attitude** - the measure of a student's feelings or emotions toward drafting, as measured by the Gable-Roberts Attitude Toward School Subjects (GRASS) instrument.

3. **Computer-Aided Drafting (CAD)** - The use of computers to prepare technical drawings (Wallach & Chowenhill, 1989, p. 547).

4. **CAD System** - The computer hardware and software used to develop drawings.

5. **Software** - Computer programs which contain specific instructions for the functioning of a computer system for technical drafting (Wallach & Chowenhill, 1989, p. 552).

6. **Computer** - An electronic machine that processes information digitally or graphically. The microcomputer was used for this research.

7. **Input device** - A device used to point to locations, select commands, and "draw" when connected to a computer. Common input devices for CAD applications are the keyboard, mouse, digitizing tablet, etc.

8. **Printer/Plotter** - A device that converts computer data into printed alphanumeric or graphic images (Wallach & Chowenhill, 1989, p. 553).

9. **Traditional Drafting (TRAD)** - Developing technical drawings using a drawing board, paper, pencils, pens, scales, compass, triangles or drafting machines, etc.

CHAPTER II

LITERATURE REVIEW

In his dissertation, Resetarits' review of related literature and research was organized into five areas: the theoretical framework, traditional drafting, computer-aided drafting (CAD), the CAD system, the role of CAD in teaching drafting, and methods of teaching CAD (p. 11-25). This study, which originated from the Resetarits dissertation, reviewed additional relevant literature beyond that reviewed by Resetarits. This review of literature will focus on three topics: the theoretical framework, the effectiveness of CAD instruction, and comparisons between CAD and TRAD.

Many articles relating to computer applications have been written over the last 10 years in professional journals and periodicals. As computer drafting systems become entrenched in industrial applications, citations related to CAD applications in industrial drafting/engineering publications exceed 300 various listings. A search of *Dissertation Abstracts International* (1978-1989) yielded ten citations over the last ten years, and an *ERIC* database provided more than 50 references under the heading "computer-aided design/drafting and/or drafting education."

Theoretical Framework

The difficulty of isolating specific independent variables that can be controlled necessitates a framework consistent with the research questions. As Resetarits (1990) stated:

> The literature on the variables of achievement and attitude shows that these variables are dependent upon or greatly influenced by the learning process. The extent to which one does well or achieves a higher score on a test is directly related to how well the individual has learned the subject matter content. Attitude is also related to learning. If a positive learning environment is developed, a student is more likely to have a positive attitude toward the subject. (p.11)

Stephen Brookfield (1986), a strong advocate of participatory learning, is the author of several books concerning adult learners. His model for facilitating learning includes the six "Principles of Effective Practice." These principles provide a theoretical framework that can be used to study the variables of achievement and attitude. The six principles are:

1. Participation in learning is voluntary; adults engage in learning as a result of their own volition.

2. Effective practice is characterized by a respect among participants for each other's self-worth.

3. Facilitation is collaborative. Facilitators and learners are engaged in a cooperative enterprise in which, at different times and for different purposes, leadership and facilitation roles will be assumed by different group members.

4. Praxis is placed at the heart of effective facilitation. Learners and facilitators are involved in a continual process of activity, new activity, further reflection and collaborative analysis, etc.

5. Facilitation aims to foster in adults a spirit of critical reflection. Through educational encounters, learners come to appreciate that values, beliefs, behaviors, and ideologies are culturally transmitted and that they are provisional and relative.

6. The aim of facilitation is the nurturing of self-directed, empowered adults. (pp.9-11)

In regards to participatory learning, Brookfield (1986) wrote, "The importance of ensuring that new knowledge, concepts, skills, or frameworks of interpretation are presented to adult learners in a manner that is comprehensible in terms of their own experiences is a major reason for using participatory learning methods" (p. 12).

Concerning discussions of mutual respect, Brookfield stated, "A fundamental feature of effective facilitation is to make participants feel that they are valued as separate, unique individuals deserving of respect" (p. 13). The individual's uniqueness, self-worth, and separateness must be addressed to effectively facilitate learning .

In a discussion of the principle of *action and reflection,* Brookfield mentioned the ideas of Paulo Freire. Freire, although primarily associated with the development of literacy programs, has developed important ideas relevant to education in general. "Central to this concept, however, is a process long ago recognized as fundamentally educational by such philosophers of education as Dewey (1916) and Neill (1960)." Brookfield's discussion continued:

> This process centers on the need for educational activity to engage the learner in a continuous and alternating process of investigation and

> exploration, followed by action grounded in this exploration, followed by reflection on this action, followed by further investigation and exploration, followed by further action, and so on. (p. 15)

Brookfield discussed the benefits of the last principle "*Self-Direction*" by stating:

> Despite the initial frustration, ambiguity, and resentment felt by learners who are asked to depart from their normal pattern of teacher dependence and to take control over aspects of their learning, the majority of learners and facilitators end up approving the introduction of techniques of self-directed learning. (p. 84)

These principles have implications for teaching and this research in particular. In reference to this framework, Resetarits (1990) wrote:

> The principles of effective practice provide a theoretical framework from which the variables of achievement and attitude can be studied. The two different methods of drafting used in the study were examined using this theoretical framework to determine whether one method or the other offers greater opportunities for learning. (p. 13-14)

In a dissertation entitled *The Study of Interaction Between Student Characteristics and Teaching Methods On Achievement of Selected Drafting Concepts,* Tai (1988) concluded there was a significant positive difference of posttest achievement scores of students exposed to computer-assisted drafting instruction. "There were significant interactions between the treatment and aptitude in relation to subject's score on the post-drawing achievement tests. . . .On the posttest, the mean of the experimental group scores was significantly higher than that of the control group." Tai continued, "From the results of this study, one can expect that CAI can contribute to instructional efficiency and be more cost-effective than conventional instruction" (p. 67).

Computer Aided Drafting

"Computer-aided design (CAD) 'may represent the greatest increase in productivity since electricity,' according to the National Science Foundation" (Burns, 1986, p. 10). In an article for the September, 1986, *Industrial Education Magazine* entitled "Computer-Aided Design (CAD)," Burns discussed career possibilities in CAD, CAD applications, CAD history, the job outlook, and training. Burns stated, "The principal users of CAD systems are in manufacturing areas such as the aerospace and automobile industries" (p. 10). He also noted that CAD is used in the electronics industry, architectural, engineering, construction areas, and is also an effective tool in the petroleum industry for planning and maintenance of power and pipeline systems and in cartography.

In the article entitled "Introducing CAD Into the Traditional Drafting Program," Isbell and Lovedahl (1988) wrote:

> It is, therefore, necessary that the secondary drafting instructor have as his goals for teaching CAD:
>
> - to give the students an informative overview and
> - to provide the students with some hands-on experiences.

Additionally, "The proliferation of micro-CAD has placed virtually every post-secondary drafting program into the position of being able to introduce students to CAD" (p. 13).

Donald Voisinet (1987), in the preface to *Computer-Aided Drafting and Design*, described the move to computerization:

> The integrated circuit chip has revolutionized the way we work and play. Its introduction has led to an era which is often referred to as the technical revolution. . . .the IC chip is on our wrist (quartz digital watches). It is used to solve math problems (hand-held calculators). It entertains (video games), and it helps to run businesses. The technological changes it has launched are affecting many careers,. . . .Drafting and design are in the forefront of the changes. CAD (computer-aided drafting) and CADD (computer-aided drafting and design) are familiar acronyms that have swept through the profession.(p. xi)

Historically, computers were used for drafting and design in the 1960s. The first systems were large, complex mainframe systems. Mainframe computer costs were prohibitive so only the largest industries could afford the luxury. The development of the microcomputer by IBM in the early 1970s began the potential proliferation of CAD. Concerning the future of computer aided drafting, Burns wrote:

> The use of CAD hardware and software has experienced tremendous growth since the early 1970s. The U.S. Office of Technology Assessment (OTA) states that "between 1973 and 1981, the CAD system market grew from under $25 million in annual sales to over $1 billion," a 40 times increase. (p. 11)

In 1980 there were approximately 5000 CAD systems in use in American industries in 1980. "The market projection is that the number of workstations added each year will grow from 12,000 in 1983 to over 63,000 in 1988" (Voisinet, 1987, p. 2). In a paper presented to the 1989 American Vocational Association Annual Conference, Brian Duelm stated ". . .business and industry are converting to CAD faster than once projected. The growing demand for CAD operators reflects this conversion—with an estimated over 1.2 million new jobs created by 1990" (p. 3). Duelm predicted that more than one million CAD systems will be running by the mid 1990s due to the growth of low-cost PC CAD.

Computer-aided drafting (CAD) is firmly entrenched as the basic drafting tool in many industrial/commercial drafting firms. A CAD system is used as a tool to replace the tools of manual drafting traditionally used by the drafter. The computer system does not draw the design for the drafter, ". . . .the CAD system is only a tool, as are a pencil, triangle, and eraser" (Duelm, 1986, p. 5). In respect to the conversion to personal-computer CAD, some surveys estimate that the worldwide PC-CAD market will grow from $303 million in 1990 to $800 million by 1995 (Meilach, 1991, p. 6).

In reference to his research, Resetarits (1989) wrote:

> Heerman [*Personal Computers and the Adult Learner* (1986)] gives an example of using the computer as a tool for learning rather than for teaching: "Physics students equipped with spreadsheet programs are able to focus on the principles of physics rather than on the calculus customarily needed to learn physics. The effect is that a much wider audience of students is able to complete the course." The computer in CAD serves a similar purpose. Students who previously would not have done well in drafting because they lacked the coordination and manual dexterity skills required to letter perfectly and draw lines of the same weight, no longer need to concentrate on these skills. The need for these skills is replaced by the accuracy of the computer and the consistency of the plotter. The student can instead concentrate on the principles of drafting. (p. 93)

The conclusion of several writers is that CAD is very important to education. According to a 1988 report by Jim Pollard, ". . .virtually all design work in architecture, mechanical engineering, civil engineering and electrical engineering is done with a computer, with very little currently done on traditional drafting table" (p. 5).

Pollard listed six reasons for switching to CAD in the introduction to his report. The six reasons given are:

- **Speed.** An experienced user of a CAD system can produce a finished drawing in much less time than it would take an experienced drafter using manual tools.

- **Ease of editing.** Only the parts of a drawing which must be changed need to be redrawn in case of a change of plans or a new project which builds on an old one.

- **Stored symbols.** Much of drafting involves redrawing the same basic figures many times. In traditional drafting, specialized templates are available to make this redrawing easier. In CAD, a symbol library is used like these templates. A figure can be drawn once in great detail, stored in the library, called into the current drawing, and scaled to fit the rest of the drawing.

- **Accuracy.** Some CAD systems allow the drawing to be accurate to a tiny fraction of an inch. The computer can compute perfect ellipses, draw an exact tangent or draw a line at an angle which is precise to a fraction of a second.

- **Less tedious.** Some actions such as lettering and hatching are time-consuming and boring. With a computer lettering is as easy as typing and hatching can be done with a keystroke.

- **Less manual skill.** There are many potentially good drafters (and engineers and architects) who were discouraged from entering the profession because of their inability to draw a uniformly wide line or properly slanted letters.
(Pollard, 1988, p. 5)

Pollard's review of the *VersaCAD Design* Version 5.2 concluded that the software program is actually intended for use as a professional system. Educationally, it allows the students "experience on the type of system which they are likely to encounter in the workplace" (p. 15). *VersaCAD's* main advantages include speed, ease of use, and the wide variety of options available. "The greatest weakness of the program which was cited by the reviewers was the overwhelming set of options which are available" (Pollard, 1988,p. 16).

Brian Duelm (1989) stated that the benefits of "CAD systems over traditional drafting stem from the use of computers. . . .With pencil and paper, the traditional drafter is limited in speed and quality of drawing. With CAD, the drafter can work many times faster, with greater accuracy" (Duelm, 1989, p. 16). According to Duelm, there are four main benefits of using CAD:

1. **Speed** - The number of drawings produced in a given time is much higher when using CAD systems. The basic reason for increased speed is the removal of tedious work.

2. **Quality** - CAD increases the quality of your design in many ways: Line quality, neatness, legibility, accuracy, and quality of the design.

3. **Modifications** - A CAD system provides for quicker customer modifications.

4. **Communications** - The use of a CAD system improves communications between different departments of a company. Information about the drawing can be stored in a main computer. (Duelm, 1989, p. 18)

Duelm summarized that a majority of industries use CAD for product development and manufacture because of the many benefits over traditional drafting methods. Those benefits stem from "the best use of both human skills and computers. The drafter is capable of visualizing a product. The computer is then used to lay out the design. This shows that the process of drafting still requires the technical knowledge of the drafter" (p. 21).

William Burns (1986) projected, "Persons desiring to enter this field [CAD] should first obtain a good, solid base in the fundamentals of drafting and design. . . .However, a drafting and design background is essential for CAD studies" (p. 11). Burns concluded with his views on the importance of CAD, "Since computers and plotters eliminate much of the less skilled work, drafters of the future may well become designers. This may necessitate a higher level of training and experience" (p. 11).

In an article entitled "CAD/CAM Comes of Age," Suzanne Loeffelholz (1988) wrote, ". . . the trend in CAD today is to give the design engineer the software tools to predict how his design will behave under real world conditions and so create optimum manufacturing instructions" (p. 38).

Paul Collins and Donald King (1988), in *The Journal of Applied Behavioral Science,* report a study by IBM of the implications of computer-aided design for work and performance after installing a CAD system at one of their new plants, IBM reported "a 4:1 improvement in the generation of new drawings and a 12:1 improvement in engineering change capability" (p. 174). In reference to the effects of CAD on the work place, they observed:

> CAD is also a technological intervention directly affecting performance through its technical superiority over conventional design and drafting technology. It indirectly affects performance by altering employees' perceptions of job characteristics and work group structure. (p. 176)

In the review of their CAD related research, Collins and King state:

> We suggest that CAD may have the greatest effect on job designs involving routine technology. When a drafter whose job has typically entailed repetitious manual tasks—such as placing numbers on blueprints— suddenly confronts tasks requiring new and diverse cognitive skills, this person perceives the job as having become more meaningful. . . .This may mean that drafters whose work involves more routine technology will derive more motivational benefits from CAD than will designers whose work typically has many exceptional requirements and demands solutions not readily known. (p. 182)

Writing about the function of CAD systems, Scott, Foy and Schwendau (1988) summarized:

> A company uses a CAD system because such a system is fast, does quality work, and requires less labor than drafting by hand. Some experts estimate that CAD is 2 to 10 times faster than manual drafting methods. . . .However, a CAD system is not a replacement for the drafter. It carries out the commands that drafters give it. A CAD system is a tool, and it does only what it is told. Nevertheless, a CAD system is a superb drafting aid. The name best describes CAD's function, making drawings with the help of a computer. (p. 331)

CAD Education

Various approaches exist to incorporate CAD into drafting education. One approach, widely used today, involves offering CAD instruction as a separate level of instruction after a pre-requisite introductory course in traditional drafting instruction. A second approach offers a "curriculum unit" of CAD instruction within a traditional drafting course. A third approach teaches drafting on CAD systems alone. Another technique establishes "elementary competency in a drafting discipline using freehand sketching, then utilizing CAD and manual skills for industrial quality work" (Duelm 1986, p. 10).

The summary in the text *Drafting Fundamentals* (1988) concluded:

> CAD operators need special training to use a particular system. However, drafting supervisors with CAD experience agree on one point. They recognize that a CAD system is a tool. As such, it is only as good as the person who operates it. To use CAD systems efficiently, operators should have a thorough knowledge of drafting. In particular, they should know the theory of multiview drawing (orthographic projection) and the principles of dimensioning." (p. 357)

Brian Duelm's 1986 research found that the "most common integration of CAD appears after students have developed proficiency in manual skills (use of pencil, triangle, etc.) and a drafting discipline. . . .it is commonly agreed upon that CAD will become the primary drafting tool with manual skills developed only as backup. Therefore, educators are advised to take a different approach" (p. 10).

The sketching/CAD approach has merit because many of the "fundamental drafting concepts do not require the precision of drafting tools" (p. 10). Duelm further explained:

> Visual perception is best learned using freehand sketching as the student is not limited to the tools and can experiment both in and out of the classroom. Usually home-work in a drafting course is unheard of. This approach makes better use of class time as drill and practice is done outside the classroom. (p. 10)

Duelm echoed the sentiments of many drafting instructors:

> . . . a foundation in a drafting discipline is necessary for a student to apply the tools of drafting. The drafting skills and CAD skills may be developed concurrently. This eliminates "lettering for the sake of lettering" or "linework for the sake of linework" and makes drafting work relevant to the field of study. (p. 10)

In the summary of the introductory chapter of *Technical Graphics*, the authors wrote:

> Technical design graphics will become increasingly important as automation continues to mechanize the workplace. . . .While the designer may be drawing by moving a mouse rather than triangles and a pencil, the graphics principles are the same. The designer must be able to visualize and graphically describe three-dimensional objects. Sketching will also continue to be very important since designers continue to create designs on paper even if they modify them on a CADD system. (p. 58)

Depending on the specific situation, Gary Lewis (1990) concluded from his experience implementing CAD at the secondary T&I drafting level, that computer aided drafting curriculum may benefit from:

- Increased student creativity toward assignments,
- Higher degree of accuracy and neatness,
- Expanded student enrollment in the program,
- Expanded uses of computers other than for CAD.(p. 18)

In *Drafting in A Computer Age,* Wallach and Chowenhill (1989) stated that sketching skills are necessary, even when using CAD systems. They determined that:

> Highly developed manual drafting skills are not required for the preparation of CAD drawings; however, a competent CAD operator must possess a thorough understanding of the principles of drafting and be skilled in technical sketching. The ability to quickly and legibly sketch ideas and products is needed by CAD operators.(p.48)

In the final report of the Missouri Department of Education Research Project, *Review and Update Contents of Drafting Curriculum Guides,* Sherrell (1983) researched whether the "basic contents of drafting had changed, brought about by the technological developments of industry. . . ." (p. 3). Sherrell surveyed a sample from the membership of the American Institute of Design Drafting (AIDD). Two hundred and seventy-seven members were sent the survey questionnaire, with 128 responding (pp. 8-9). Sherrell (1983) concluded:

> Although the methods of reproducing and storing drawings are changing and will need more in the next few years, the basic content and knowledge needed by the drafter has not. This basic knowledge will only be handled differently because of the hardware and resulting software that is and will be available. . . .Schools should turn more to computer graphics as a method of producing drawings and a source of storing and reproducing drawings. These methods should completely replace the drafting table and normal drafting equipment when the price of computers and computer graphics equipment becomes more affordable. (pp. 9-10)

Likewise, research presented at the 1987 American Vocational Association to the Trade and Industrial Education Research Committee by Dennis Murphy (1987) compared drafting achievement of beginning drafting students using traditional equipment and students using computer aided design and drafting equipment. Murphy's research at Utah State University, using two groups of drafting students, found no significant differences in the drafting competencies between the two groups.

Tai (1987) researched specific characteristics that correlate with achievement and attitudes between traditional lecture and computer-assisted instruction (CAI). For her 1986 research, 98 freshman drafting students at Iowa State University comprised the research subjects. After analyzing the resulting data from pretest/posttest scores of orthographic projection problems and attitude scores, it was concluded the CAI groups show significantly greater gains in learning orthographic projection.

Most of the literature reviewed cited significant advantages of teaching drafting using CAD for speed, efficiency, and accuracy. Much of the "industrial literature" lauds the advantages of CAD and the inevitability of the adaptation of traditional drafting to CAD applications. Industrial education is now addressing the needs of business and industry while trying to decide the best approach for the future.

CHAPTER III

METHODS AND PROCEDURES

Population and Sample Identification

The population of this study consisted of students enrolled in eight sections of the Department of Technology (TEC) TEC 1001 -Introduction to Technical Drafting, 1990 Spring Semester, at Appalachian State University, Boone, North Carolina. The population represented students who were Technology majors, Technology Education majors, and majors from various departments in the University. The sample of the population was students registering for four of the eight sections of TEC 1001. Registration was completed without students prior knowledge of the research project. Instructors and advisors were not informed which sections would be involved in the study.

The registration schedule listed "Staff" to identify the instructor. The four sections of TEC 1001 were limited to 15 students in each due to hardware/software limitations of 15 CAD workstations. The two 8:00 a.m., and the two 10:00 a.m. sections were randomly scheduled into an experimental and control group at each hour.

Research Design and Sampling Technique

In this study, two different research methodologies were utilized. Therefore, two research designs describe the study: Campbell and Stanley's (1963) "Design 6, The Posttest-Only Control Group Design" (p. 195) and "Design 4, The Randomized Control-Group Pretest-Posttest Design" (p. 183).

The primary research focused on the difference in drafting achievement between student groups taught technical drafting using two different teaching methods. Group A sections, the "research group, or experimental group," was taught technical drafting using computer aided drafting methodology. Group B sections, the "control group," was taught technical drafting using traditional methodology. The "control group" is typical of true experimental designs where the control group is used "as a baseline against which to compare the group(s) receiving the experimental treatment" (Issac & Michael, 1975, p.24).

The "Posttest-Only Control Group Design," as illustrated by Campbell & Stanley (1963), answered research question numbers 2 and 3 related to drafting skills achievement using drawing problems evaluation. Research questions 2 and 3 were:

2. Are there differences in drafting skill achievement levels between students who are taught technical drafting using traditional methods and those taught technical drafting using CAD?

3. Is there a relationship between student achievement and instructor who provided instruction?

$$\begin{array}{ccc} R & X & O_1 \\ R & & O_2 \end{array}$$

Figure 1, Research Design 6

The Posttest-Only Control Group Design
(Campbell & Stanley, 1963, p. 195)

Figure 1 illustrates Research Design 6. The "R" represents random selection of the groups. The "O_1" and "O_2" represent the posttest observations and "X" represents the treatment given to Group A. Although the pretest/posttest design is most commonly used in educational research, the pretest is "not actually essential to true experimental designs." Campbell and Stanley (1963) wrote:

> For psychological reasons it is difficult to give up "knowing for sure" that the experimental and control groups were "equal" before the differential experimental treatment. Nonetheless, the most adequate all-purpose assurance of lack of initial biases between groups is randomization. (p. 195)

Research Design 6 was used due to the lack of appropriate pretest measures. The measures of achievement included two areas: cognitive knowledge and drafting skills. Design 6 does avoid the "experimenter-introduced pretest session, and in avoiding the 'giveaway' repetition of identical or highly similar unusual content" (Campbell & Stanley, 1963, p. 196).

The posttest-only is superior to the pretest-posttest design "because no interaction effect of pretesting and X can occur." It also controls "the effects of history, maturation, and pretesting. It is particularly useful when pretests are unavailable, or inconvenient; when subjects anonymity must be kept; and when a pretest may interact with X" (Isaac & Michael, 1975, p. 42). The final *ODAT* posttest measured achievement in cognitive knowledge. The evaluations of drawing skill problems indicated achievement in manipulative drafting skills.

Research Design 4 answers research questions 1, 4, 5, and 6, pertaining to student attitudes toward drafting between the two teaching methodologies. Research questions 1, 4, 5, and 6 were:

1. Are there differences in cognitive drafting achievement levels between students who are taught technical drafting using traditional methods and those taught technical drafting using CAD?

4. Are there differences in the attitudes toward drafting of students taught technical drafting using traditional methods and those taught technical drafting using CAD?

5. Are there differences in students' attitudes toward drafting between those who are taught drafting by different instructors?

6. Is there a relationship between student attitude toward technical drafting and the instructor who provided instruction?

Research Design 4 controlled all of the extraneous variables that can be considered a threat to internal validity. As a caution, Campbell & Stanley wrote:

> Even though Design 4 is the standard and most widely used design, the tests of significance used with it are often wrong, incomplete, or inappropriate. . . .The most widely used acceptable test is to compute for each group pretest-posttest gain scores and to compute a *t* between experimental and control groups on these gain scores. Randomized "blocking" or "leveling" on pretest scores and the analysis of covariance with pretest scores as the covariate are usually preferable to simple gain-score comparisons. (pp. 192-193)

Campbell and Stanley's Design 4, the "Pretest-Posttest Control Group Design" was used for this part of the research, also. (See Figure 2) This design is a true experimental design in which the equivalent groups are selected by random selection. The "R" represents random selection of the groups. "O_1" and "O_3" represent the pretest observations, "O_2" and "O_4" represent the posttest observations and "X" represents the treatment to the Group A sections.

$$\begin{array}{lll} RO_1 & X & O_2 \\ RO_3 & & O_4 \end{array}$$

Figure 2, Research Design 4 The Pretest-Posttest Control Group (Campbell & Stanley, 1963, p. 183)

The experimental and control groups were given the *ODAT* as a measure pretest/posttest of cognitive achievement and the *GRASS* attitude inventory as a measure of any changes in students' attitudes toward technical drafting. The scores from the posttest were compared statistically to determine if there were significant relationships between teaching methods and students' cognitive achievement or attitude toward drafting. The statistical analysis also determined if significant interaction exists between method and teacher on posttest differences.

Instrumentation

Three instruments provided data for this study. The instrument used to measure the manipulative component of the dependent variable of drafting skills achievement was a series of drafting performance problems. The drawings represented the curriculum content covered in the course and were evaluated using a 100-point rating form. This form was adapted from the formats used for drafting competition evaluations by the Technology Student Association (TSA) (1990, p. 39) and the Vocational Industrial Clubs of America (VICA) (1990, p. 21-B-3). The criteria evaluated was the "grading" criteria used in TEC 1001. Three Department of Technology faculty evaluated the drawing problems providing numeric data for analysis. The student drawings were placed in a notebook, identified only by a control number, and were evaluated using the evaluation form developed for the project. The evaluators did not see each others evaluations.

The drawing evaluation form evaluated five generic drafting criteria: a) *Problem Solution,* 40 points maximum, evaluating standard views, view orientation, feature details, and completeness of solution, b) *Overall Appearance,* 30 points maximum, evaluating line style and type, line width, view alignment, view spacing and placement, c) *Accuracy,* 10 points maximum, evaluating detail location, detail sizing, and detail projection, d) *Lettering,* 10 points maximum, evaluating appropriate lettering, location, line width, centering and spacing, and e) *Dimensioning,* 10 points maximum, evaluating placement, accuracy, and completeness (See Appendix A).

The drafting skills drawings were evaluated by three individuals, the two instructors and the Department of Technology Chairman. The evaluators had both traditional and CAD drafting instruction experience. The drawings were collected at the end of the period assigned for evaluation. Student numbers assigned at the beginning of the project were used to identify the drawings. Independently, the evaluators evaluated the drawings on the form provided by the researcher. The drawing evaluation scores were totaled and averaged arithmetically to yield a numeric value for each participant's drawings.

An adaptation of the *Ohio Drafting Achievement Test, Part 1,* (1986) was given as a pretest and the scores used as a covariate (See Appendix B). Permission was obtained from the Instructional Materials Laboratory (IML), at The Ohio University, to extract the questions that were not applicable to the curriculum material covered in TEC 1001. The *ODAT* is part of a series of tests developed by the Instructional Materials Laboratory for teachers and counselors to evaluate achievement in technological subjects. The reliability estimates for this test, obtained from the IML using the Kuder-Richardson 20 and 21 scales, range from 0.966 to 0.974 (Gable & Roberts, 1983, p. 289).

The use of drafting performance evaluations and the modified *ODAT* more accurately measured achievement than the *ODAT* alone, which measured only cognitive knowledge. A student might be able to answer multiple choice questions well, yet not be able to perform basic drafting skills satisfactorily. A student might possess basic drafting skills without a cognitive understanding of technical drafting.

The *Gable-Roberts Attitude Toward School Subjects (GRASS)* was used to measure student attitudes toward school subjects on three factors: General Interest, Usefulness, and Relevance (See Appendix C). Electronically scored answer sheets with a Likert-like scale of agreement from 1 to 5 were used for this instrument. The scores of the individual responses were stored in data sets on the ASU *VAX* for later statistical analysis. The GRASS instrument was developed by Drs. Robert Gable and Arthur Roberts of the University of Connecticut. They documented the instrument 's validity, thus:

> The content validity of the *GRASS* instrument was examined by reviewing the attitude literature (Triandis, 1971) and studies dealing with attitudes toward school subjects. Following some of the work of Remmers (1960), 30 item stems were written to reflect two dimensions of attitude toward school subjects: General Interest and Usefulness. Subsequently, the 30 item stems were reviewed by four university faculty members from the social studies, curriculum, and English areas. The judgmental screening and editing of items resulted in 23 usable ones which purported to measure the two attitude dimensions. (Gable & Roberts, 1983, p. 290)

The *GRASS* instrument was validated using 893 eleventh- and twelfth-grade students in two high schools. "The construct validity of the *GRASS* scale was examined by generating a 23 by 23 item intercorrelation matrix for the response data and by employing a principal component analysis followed by an oblique rotation" (Gable & Roberts, 1983, p. 290). The Alpha Reliability is .94, .70 and .59 for the factors of *General Interest, Usefulness, and Relevance,* respectively. The *GRASS* test may be used in a variety of course content applications for research in the affective domain of learning.

Procedures

Students who enrolled in four sections of TEC 1001 had no prior knowledge of the research being conducted or of the instructors for each section. Two instructors were assigned two of the four randomly selected groups, "sections." Each instructor had one CAD section and one TRAD section. The Wednesday/Friday, 8:00 a.m. to 9:50 a.m. sections had Instructor 1 using traditional drafting methodology to teach his Group B section while Instructor 2 taught drafting using CAD methodology to his Group A section. The Wednesday/Friday, 10:00 a.m. to 11:50 a.m. section had Instructor 1 teaching the CAD Group A section and Instructor 2 teaching the traditional drafting Group B section. This scheduling arrangement nullified any instructor bias by having each instructor teach a Group A section and a Group B section.

The students were given the pretests of the *GRASS* attitude scale and the *ODAT* during the first class meeting. Standardized, machine-scored *Scantron* answer sheets were used to record responses on the *ODAT* and *GRASS*. During the eighth and fifteenth week of the semester, all sections were given drafting achievement problems. The *ODAT* as a posttest to evaluate drafting achievement, and the *GRASS*, indicating attitude changes, were given as posttests in the fifteenth week. The student answer sheets were machine scored and the data directly input into *SPSS* files. The researcher checked a random sample of the answer sheets manually to authenticate the results. All students were given identical tests.

To assure confidentiality and meet The University of Tennessee requirements for research using human subjects, the research was explained and all students were asked to sign a *Research Participant Consent Form* during the first class meeting (See Appendix D). The students were assigned random identification numbers to eliminate students' names being associated with the evaluations and test answer sheets.

Class instruction was given by two teachers: an associate professor and an instructor in the Department of Technology. Both were chosen to participate in this study because they had taught traditional drafting and CAD during the previous year. The instructors were not identified to the students by name until the first class meeting.

Group A used *VersaCAD* software to learn technical drafting. Group B learned technical drafting using traditional equipment and drafting techniques. The random section assignment, comprised of two treatment groups and two control groups, was assumed to make the groups homogenous. Random selection of the experimental and control groups was assumed to provide internal validity.

The textbook used in TEC 1001 is *Technical Drawing*, Eighth Edition, by Giesecke, Mitchell, Spenser, Hill and Dygdon (1988). This text was used by all students as the course textbook. The course outline for TEC 1001, shown in Appendix E, provided the direction for the development of course materials. Both the CAD and TRAD sections were taught using the same course syllabus (See Appendix F).

In the study both groups were introduced to sketching and technical drafting conventions using pencil and gridpaper. Sketching was emphasized as a method of problem solving. Students were required to plan the instrument/CAD drawings and have sketches approved before proceeding to "instrument" drawing. The different methodologies were implemented to accommodate the students' move to instrumental drafting. In collaboration with the instructors, the researcher developed a laboratory manual of drawing assignments for the TRAD groups; the CAD groups had the same assignments on a data disk (See Appendix G).

Weekly meetings between the two instructors and the researcher were conducted to maintain continuity within the project and consistency of curriculum presentation. The Wednesday classes consisted of lectures, demonstrations, and problem solving developing sketching assignments. Friday classes were traditional drafting or computer drafting, respectively. The Friday classes met in either the traditional drafting laboratory or the computer laboratory.

Scheduled open drafting lab/computer lab times were provided. Graduate assistants supervised the labs during scheduled lab sessions. The computer lab assistants were assigned supervision/tutoring responsibility and were available during scheduled lab times and only students enrolled in departmental computer-related courses, with ASU computer accounts, were permitted to use the lab facilities.

Null Hypotheses

To answers the research questions, the following null hypotheses were tested:

H_o1 There are no significant differences in drafting achievement between students who are taught technical drafting using traditional methods and students taught drafting using CAD.

H_o2 There are no significant differences in drafting achievement between students who are taught technical drafting by instructor 1 and instructor 2.

H_o3 Student achievement will show no significant interaction between drafting instruction method and instructor.

H_o4 There are no significant differences in attitudes toward drafting between students who are taught technical drafting using traditional methods and students who are taught using CAD.

H_o5 There are no significant differences in attitudes toward drafting between students who are taught technical drafting by instructor 1 and instructor 2.

H_o6 Student attitudes toward drafting will show no significant interaction between drafting instruction method and instructor.

Statistical Treatment

A X^2 test of independence was conducted on the pretest scores of the *ODAT* and *GRASS* to substantiate the assumption that the groups were homogeneous and the groups pretest scores were independent of group assignment.

An analysis of covariance (ANCOVA) was used to test the hypotheses relating to significant differences between the TRAD and CAD instruction in the areas of achievement and attitudes. The *Ohio Drafting Achievement Test*

(ODAT) pretest scores were used as the covariate and the drafting skill achievement evaluations were the dependent variable to test null hypotheses 2, and 3.

The *GRASS* pretest scores were used as the covariate and the *ODAT* posttest was the dependent variable to test null hypotheses 1, and 3. Additionally, the *ODAT* pretest scores were used as the covariate and the *GRASS* posttest was the dependent variable to measure differences in attitude toward drafting, testing null hypotheses 4, 5, and 6.

Campbell & Stanley (1963) wrote that the analysis of covariance is a statistical rather than an experimental method used to "'control' or 'adjust for' the effects of one or more uncontrolled variables, and thereby permit a valid evaluation of the outcome of the experiment." The analysis of covariance may be used to "increase the precision of the experiment by reducing the error variance" (pp. 358-359). The analysis of covariance with pretest scores as the covariate "are usually preferable to simple gain-score comparison" (p. 193).

About covariate analysis, Neuter, Wasserman and Kutner (1985) wrote:

> The basic idea is to augment the analysis of variance model containing the factor effects with one or more additional quantitative variables that are related to the dependent variable. This augmentation is intended to reduce the variance of the error terms in the model, i.e., make the analysis more precise.(p. 844)

The analysis of covariance determined if any significant difference in achievement existed between the different teaching methods, between instructors and any interaction between the instruction method and instructor.

Ferguson (1981) explained the use of the covariate this way:

> The influence of the covariate is removed using a straight-forward linear regression method. . . . Adjusted means on *X* may be obtained. These adjusted means show what part of the variation in the means of *X* remains after the variation due to the covariate *Y* is removed. The analysis of covariance is in part a correlational procedure. It combines both regression and analysis of variance methods. (p. 359)

Several assumptions are acknowledged in use of the analysis of variance/covariance as a test of significance between two group means. The assumptions are:

1. The distribution of the dependent variable in the population from which the samples are drawn is normally distributed.

2. The variance within the populations from which the samples are drawn is equal. (Homogeneity of variance)

3. The effects of various factors on the total variation are additive.

4. Reasonable departures from the assumptions of normality and homogeneity may occur without seriously affecting the validity of the inferences drawn from data. (Ferguson, 1981, pp. 245-246)

CHAPTER IV

ANALYSIS OF DATA

The presentation of data analyses is described in this chapter. The statistical interpretation, described in Chapter 3, was used to answer the six research questions of the study. The *Statistical Package for the Social Science* (*SPSS-X*) on Appalachian State University's VAX 8550 was used to analyze the data.

Data collected from the *ODAT* posttest were compared statistically, using the analysis of covariance, to determine significant differences in achievement levels. The *GRASS* pretest scores were used as the covariate. Two drafting skill evaluations were given, the first near mid-term and the second at the end of the term. The scores were calculated for each student and compared statistically using the *ODAT* pretest scores as the covariate. The analyses of data collected from the *ODAT* and drafting skill problems were used to answer the primary research questions:

1. Are there differences in cognitive drafting achievement levels between students who are taught technical drafting using traditional methods and those taught technical drafting using CAD?

2. Are there differences in drafting skill achievement levels between students who are taught technical drafting using traditional methods and those taught technical drafting using CAD?

3. Is there a relationship between student achievement and instructor who provided instruction?

Data were collected from the pre/posttest of the attitude instrument. The answers to the posttest attitude inventory instrument were totaled and compared to the totaled pretest attitude scores using an analysis of covariance, with the *ODAT* pretest scores as the covariate, to determine differences in attitudes toward drafting. The results of the ANCOVA determined differences in attitudes toward drafting between the experimental group and the control group. These data were analyzed to answer the secondary research questions:

4. Are there differences in the attitudes toward drafting of students taught technical drafting using traditional methods and those taught technical drafting using CAD?

5. Are there differences in students' attitudes toward drafting between those who are taught drafting by different instructors?

6. Is there a relationship between student attitude toward technical drafting and the instructor who provided instruction?

Pretest Data

Table 1 displays the data of pretest scores of the *ODAT* and *GRASS*. The mean score for the *ODAT* pretest scores of the CAD group, with 20 students, was 16.60 with a standard deviation of 9.55. The mean for the TRAD group, with 23 students, was 20.65 with a standard deviation of 7.92.

The *GRASS* pretest scores for the CAD groups had a mean score of 96.50 with a standard deviation of 13.88 while the TRAD groups had a mean score of 97.74 and a standard deviation of 18.63.

Table 1, Means and STANDARD DEVIATIONS of *The Ohio Drafting Achievement Test* and *The Gable-Roberts Attitude Toward School Subjects* Pretests Scores for Assigned Traditional and CAD Groups

	ODAT Scores	*GRASS* Scores
Group A — CAD	$\bar{x}$ = 16.60 n = 20 SD = 9.55	$\bar{x}$ = 96.50 n = 20 SD = 13.88
Group B — TRAD	$\bar{x}$ = 20.65 n = 23 SD = 7.92	$\bar{x}$ = 97.74 n = 23 SD = 18.63

A X^2 test of independence was conducted to test the null hypothesis: There is no relationship between group assignment and drafting achievement pretest scores. A X^2 value for the *ODAT* pretest was 6.60, with 3 degrees of freedom, and an α=.086. From this test results, it was determined the *ODAT* pretest scores were independent of group assignment, therefore the null hypothesis was retained.

A X^2 test of independence was also used to test the null hypothesis: There is no relationship between group assignment and initial attitudes toward drafting. The X^2 value for the *GRASS* pretest scores was 1.62, with 3 degrees of freedom, and an α=.654. There was no significant relationship between group assignment and *GRASS* pretest scores, therefore the null hypothesis was retained.

Posttest Data

At the conclusion of the semester, the *ODAT* posttest, the *GRASS* posttest, and the drafting skills achievement problems were administered to the four sections. Table 2 shows a summary of mean scores and standard deviations, of the *ODAT* and *GRASS* posttest scores and the drafting skill problems evaluations.

Table 2, Means and STANDARD DEVIATIONS of the *Ohio Drafting Achievement Test* Posttest Scores, *Gable-Roberts Attitude Toward School Subjects* Posttest Scores, and Drafting Skill Problems Evaluations for Assigned Traditional and CAD Groups

	ODAT	*GRASS*	Drafting Problems
Group A - CAD	$\bar{x}$ = 50.4 n = 20 SD = 10.5	$\bar{x}$ = 98.6 n = 20 SD = 17.6	$\bar{x}$ = 70.7 n = 20 SD = 9.5
Group B - TRAD	$\bar{x}$ = 53.0 n = 23 SD = 9.7	$\bar{x}$ = 101.2 n = 23 SD = 1.2	$\bar{x}$ = 83.2 n = 23 SD = 7.9

The CAD group had a mean score of 50.4 with a standard deviii5iation of 10.5 on the *ODAT* posttest. The CAD group had a mean score of 98.6 with a standard deviation of 17.6 on the *GRASS* posttest. The CAD group had a mean score of 70.7 with a standard deviation of 9.5 on the drafting skills evaluations. The TRAD group had a mean score of 53.0 with a standard deviation of 9.7 on the *ODAT*. The TRAD group had a mean score of 101.2

with a standard deviation of 16.2 on the *GRASS*. The TRAD group had a mean score of 83.2 with a standard deviation of 7.9 on the drafting skills evaluations. Numerically, the TRAD group scores were higher than the CAD group on all three measures, and smaller standard deviations.

Three statistical analyses were performed: (a) the posttest *ODAT* scores as the dependent variable and the pretest *GRASS* as the covariate, (b) the posttest *GRASS* scores as the dependent variable with the posttest *ODAT* scores as the covariate, and (c) drafting skills achievement as the dependent variable, with the initial *ODAT* scores as the covariate. Instructional method (CAD versus TRAD) was the independent variable in each case.

When conducting an analysis of covariance, it is first necessary to test the validity of the assumption of parallel slopes of regression lines for the data sets. The initial analysis, using an ANCOVA, tested the assumption of parallel slopes of regression among the treatment groups; that assumption is that a change in the pretest scores will affect the posttest scores in the same way across all treatment groups. The ANCOVA indicated the assumption of homogeneous slopes was warranted for the *ODAT* and *GRASS* posttests. Therefore, a standard ANCOVA was run to analyze those posttests scores. The initial analysis of the drafting skill evaluations indicated the assumption of homogeneous slopes was not warranted, so the ANCOVA, fitting separate slopes, was used for that analysis.

The ANCOVA computed with the *ODAT* posttest scores as the dependant variable, with the *GRASS* pretest scores as the covariate, resulted in an $F = 2.15$ with a significance level of .15 and 1,40 degrees of freedom. The ANCOVA of the *GRASS* posttest scores, with the *ODAT* pretest scores as the covariate, resulted in an $F = .96$ with a significance level of .333 and 1,40 degrees of freedom. Using the *ODAT* pretest scores as the covariate, the ANCOVA of the drafting skills evaluations, with an $F = 11.88$ at a significance level of .001 and 1,40 degrees of freedom, indicated the assumption of homogenous slopes was not warranted. Therefore, an ANCOVA, fitting separate slopes, was used for the analysis.

An analysis of covariance was used to test the null hypotheses—there is no difference in drafting cognitive achievement between students taught technical drafting using CAD methodology and those taught technical drafting using traditional methodology. The *ODAT* posttest scores, the dependant variable, were analyzed using an analysis of covariance (ANCOVA). The independent variable was the instructional methodology and the *GRASS* pretest scores were the covariate for the analysis.

Table 3 illustrates the results of the analysis of the *ODAT* posttest scores using the *GRASS* pretest scores as the covariate. The F=.61 at a significance α=.44, with 1,40 degrees of freedom, proved there was no significant difference in the posttest cognitive achievement scores between the two groups. Therefore, the null hypothesis was retained.

Table 3, Results of the ANALYSIS OF COVARIANCE of the *Ohio Drafting Achievement Test* Posttest Scores Using the *Gable-Roberts Attitudes Toward School Subjects* Pretest Scores as the Covariate

	SS	DF	MS	F Value	Sig. of F
Group	57.66	1	57.66	.61	.44
Within Cells	3781.63	40	94.54		

The *ODAT* pretest scores were used as the covariate in an ANCOVA analysis to test the null hypothesis—there are no significant differences in student attitudes toward technical drafting, as measured on the *GRASS* posttest scores, between students taught technical drafting using CAD methodology and those taught using traditional methodology. The *GRASS* posttest scores were the dependant variable and instructional methodology was the independent variable.

Table 4 illustrates the summary of the computed ANCOVA of the *GRASS* posttest scores. An F=.02 at a significance of α=.883 was calculated with 1,40 degrees of freedom. There was no significant group effect on the student attitudes toward technical drafting between the groups using the *ODAT* posttest scores as the covariate factor. Therefore, the null hypothesis was retained.

Table 4, Results of the ANALYSIS OF COVARIANCE of the *Gable-Roberts Attitudes Toward School Subjects* Posttest Scores Using the *Ohio Drafting Achievement Test* Pretest Scores as the Covariate

	SS	DF	MS	F Value	Sig. of F
Group	5.05	1	5.05	.02	.88
Within Cells	9272.29	40	231.81		

The drafting skill achievement drawing problems evaluations, the dependant variable, with the *ODAT* pretest scores the covariate, was used to compute an ANCOVA to test the null hypothesis—there was no difference in drafting achievement between students taught technical drafting using CAD methodology and those taught technical drafting using traditional methodology. Drafting skills problems were developed by the researcher that were similar to the drafting skill problems that were used as partial evaluation of the traditional TEC 1001 course. The midterm evaluations included the drafting skills covered in the curriculum to that point. The evaluations were given a numeric value by each evaluators. A mean score for the evaluations was recorded and used in the final computations. The final evaluation problems represented the curriculum content over the semester. An overall mean score was assigned each student and used in the statistical calculations as an evaluation of drafting skill.

Table 5 provides the ANCOVA results of the drafting skills evaluations. The drafting skills drawing evaluations mean scores were analyzed using the *ODAT* pretest scores as the covariate. The analysis revealed there was a significant difference in the achievement levels on the drafting skills problems between the two groups. The $F = 19.77$, with 1,40 degrees of freedom, was significant at the $\alpha < .00005$ level. This significance illustrates there was significant group effects and therefore, the null hypothesis was rejected.

Table 5, Results of the ANALYSIS OF COVARIANCE of Drafting Skills Problems Evaluation Scores Using the *Ohio Drafting Achievement Test* Pretest Scores as the Covariate

	SS	DF	MS	F Value	Sig. of F
Group	1815.63	1	1815.63	19.77	.000*
Within Cells	3580.86	40	91.82		

* Significance $\alpha < .005$

As previously mentioned, Table 2 provides the summary of the mean scores and standard deviations for the two groups. The CAD group's drafting skills problems evaluations had a mean score of 70.7 with a standard deviation of 9.5. The traditional drafting group had a mean score of 83.24 with a standard deviation of 7.9.

To further isolate the differences in drafting skill, a final ANCOVA was used to analyze the data from the drafting skill achievement evaluations for each instructor as the dependant variable and the instructional methodology as the independent variable. The CAD evaluations and the TRAD evaluations were compared for each instructor. The small *n* limits the generalizability of these ANCOVA results. The *ODAT* pretest was again used as the covariate and the method of fitting separate slopes was also used for this analysis.

Table 6 is a summary of the data from the drafting skills evaluations for Instructor 1 and instructor 2. The mean scores and standard deviations for the CAD and TRAD groups for each instructor are illustrated. In each instructor's case, the mean score for the CAD group is less than the mean score for the TRAD group.

Table 6, Means and STANDARD DEVIATIONS of the Drafting Skill Problems Evaluations for Traditional and CAD Groups for Instructor 1 and Instructor 2

	Instructor 1	Instructor 2
Group A - CAD	$\bar{x}$ = 76.5 n = 11 S.D. = 18.0	$\bar{x}$ = 63.7 n = 9 S.D. = 14.8
Group B - TRAD	$\bar{x}$ = 83.1 n = 8 S.D. = 5.6	$\bar{x}$ = 83.3 n = 15 S.D. =5.3

The mean score of the CAD group taught by Instructor 1 was 76.5 with a standard deviation of 18. The mean score of the TRAD group taught by Instructor 1 was 83.1 with a standard deviation of 5.6. The mean score of the CAD group taught by Instructor 2 was 63.7 with a standard deviation of 14.8. The mean score of the TRAD group taught by Instructor 2 was 83.3 and a standard deviation of 5.3.

Table 7 illustrates the results of an ANCOVA applied to test scores of students taught by Instructor 1 and Instructor 2. There appears to be no significant differences between the drafting skills achievement between the groups of Instructor 1, at the significance level $\alpha<.05$ and 1,15 degrees of freedom. Whereas, the statistical data from the ANCOVA of the drafting skills achievement evaluations of Instructor 2 appears to illustrate a significant difference between the CAD and TRAD groups. The $F = 36.95$, with 1,20 degrees of freedom, for the group has a significance level of $\alpha<.00005$. Therefore, it was concluded that a significant difference in drafting skills evaluations exists between the CAD and TRAD groups for Instructor 2.

Table 7, Results of the ANALYSIS OF COVARIANCE of Drafting Skills Problems Evaluation Scores for Each Instructor Using the *Ohio Drafting Achievement Test* Pretest Scores as the Covariate

		SS	DF	MS	F Value	Sig. of F
Instr. 1	Group	382.70	1	382.70	2.21	.158
	Within Cells	2596.09	15	173.07		
Instr. 2	Group	1514.78	1	1514.78	36.95	.000*
	Within Cells	819.92	20	41.00		

* Significance

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter summarizes the problem, the procedures used for the research, and a discussion of the findings. From those findings, conclusions were drawn and recommendations for future research espoused.

Summary of Study

The purpose of this research was to determine the feasibility of teaching an introduction to technical drafting course using CAD tools. Questions have arisen over the last five years concerning the effective use of facilities and resources. The research was conducted to determine if the achievement level of students were significantly different between groups that were taught using computer aided drafting instruction and groups who were taught technical drafting using traditional tools and methodology.

The procedure was to take a representative sample of students enrolled in the introductory level technical drafting course and determine if there was a significant difference in the achievement levels of students between the teaching methods of traditional instruction versus computer aided drafting instruction. The sample was randomly assigned into experimental groups, who were taught using computer aided drafting methodology, and control groups, who were taught using traditional methodology and tools. The primary research questioned the difference in achievement levels while a secondary research looked at attitude differences between the groups.

The *Ohio Drafting Achievement Test* was administered as a pretest to determine pre-existing drafting knowledge levels. The *ODAT* was also administered as a posttest to determine gains in cognitive drafting achievement. Drafting skill performance problems were drawn and evaluated as another measure of drafting achievement.

The *Gable Roberts Attitude Toward School Subjects* inventory was administered as a pretest and posttest. The posttest scores were analyzed to measure differences in attitude between the groups. The class mean scores of the two groups were compared statistically to determine significance in differences. *SPSS,* statistical software program, was used to analyze the data from the pretest and posttest to determine significant differences and to determine significant changes in student attitudes toward drafting. The statistical treatments were done on the Appalachian State University VAX.

All sections, or groups, were taught using the same syllabus and using the same drawing assignments and exercises. Care was taken to assure the presentation of similar material in the groups. Weekly meetings with the two instructors of the research groups and the research coordinator aided the consistency of instruction. The two instructors were both qualified to teach traditional drafting and CAD and had done so previously at ASU. Each instructor taught one section of CAD and one section of TRAD.

The content taught in all sections was the content normally taught in the TEC 1001 "Introduction to Technical Drafting" course. The TRAD groups were given "hard copy" exercises while the CAD groups were given the same problems as *VersaCAD* files on floppy disk. Sketching was an integral component of the curriculum emphasizing problem solving requirements to both the TRAD and CAD groups. Sketching was used to promote creative thinking and problem solving before the actual technical drawing was begun.

The text used in TEC 1001 is *Technical Drawing*, eighth edition, by Giesecke, Mitchell, Spenser, Hill, and Dygdon (1988). This text was used by all sections as the course text. The CAD groups were given supporting materials and handouts for the computer applications.

The primary research focused on the difference in drafting achievement between student groups taught technical drafting using two different teaching methods and answered research questions 1, 2 and 3 (See page 8). The Group A sections, the "research groups," or "experimental groups," were taught technical drafting using computer aided drafting methodology. The Group B sections, the "control groups," were taught technical drafting using traditional methodology and traditional drafting tools. The secondary research answered research questions numbers 4, 5, and 6, (See page 8) relating to student attitudes toward drafting between the two teaching methodologies.

Summary of Analysis of Data

Data were collected during the first class meeting on the *ODAT* and *GRASS* pretests. Data from the pretest were used at the conclusion of the research period as covariates in the analyses of covariance. Initial analysis consisted of a X^2 test of independence in reference to the group assignments. The results of the X^2 test led to the acceptance of the null hypothesis there were no differences in drafting knowledge and the groups were homogeneous.

The analysis of covariance was used to test statistically the significance of any difference in the groups with respect to drafting achievement and attitudes as tested by posttests at the conclusion of the semester. The *ODAT* pretest scores were used as the covariate in analysis of the drafting skills achievement posttest evaluations. The *GRASS* pretest scores were used as the covariate in the analysis of the *ODAT* posttest of cognitive drafting knowledge and posttest *GRASS* scores were analyzed using the *ODAT* pretest scores as the covariate.

The ANCOVA of the *ODAT* posttest scores determined no significant differences in the cognitive achievement levels of students taught using different methods of drafting instruction. The ANCOVA of the *GRASS* posttest scores determined there were no significant differences in the mean scores of the attitudes of students toward technical drafting.

There was, however, a statistically significant interaction between the teaching method and the pretest *ODAT* covariate in the analysis of the drafting skills achievement evaluations. The TRAD group had a significantly higher level of achievement in drafting skills evaluations than the CAD group.

Further statistical analysis, though limited in inferential impact by a small *n*, used an ANCOVA to analyze each instructor's groups. The ANCOVA determined a significant difference in the drawing skill achievement scores of the experimental, CAD, group of Instructor 2. The mean scores of the drawing skill achievement problems for the experimental group of Instructor 1 and the control, TRAD, groups of both instructors were not significantly different.

Summary of the Findings

The analysis of data from this research supported most of the null hypotheses. However, data analysis for the primary area of research, drafting skill achievement, determined that null hypotheses $H_0 2$ and $H_0 3$, could be rejected. There was a statistical difference in the drafting skill drawing evaluations. The group taught technical drafting using traditional methodology showed superior drafting skills in the evaluations of drafting problems administered at the conclusion of the research period.

There were no significant differences in the attitudes and cognitive achievement levels between the CAD group and the TRAD group taught using traditional methodology and tools. Students taught technical drafting using two different methodologies had no significant difference in cognitive knowledge or attitudes toward technical drafting. Therefore null hypotheses $H_0 1$, $H_0 4$, $H_0 5$, and $H_0 6$ were accepted.

Conclusions

As prior research had concluded, this research illustrated technical drafting cognitive knowledge could be taught as effectively using computer aided drafting methodologies as traditional methodologies. There was also no difference in the students' attitudes toward technical drafting between the two methodologies.

From the analysis of the data, however, there was a significant difference in drawing evaluations. It was concluded that drafting students achieve higher drafting skill levels when taught traditionally using traditional tools and methodologies than those taught in a traditional manner using computer aided drafting tools and methodologies.

Recommendations

The following recommendations are provided by the researcher in concert with the instructors of the research groups. These recommendations evolved during the planning, presentation, and evaluation of this research and considers the observations and statistical findings of this study. The recommendations are:

1. Further research should be conducted to determine the benefits of incorporating CAD in introductory drafting classes, particularly in the area of drafting skills.

2. Further research is needed to provide student demographic profiles of successful CAD drafting course completers to assist in the development of curriculum.

3. Research is needed to determine the current and future needs of drafting employers for better IET course development.

4. Research should be conducted to determine the most effective curriculum to incorporate CAD into the technical drafting course.

Observations

Certain extraneous variables could not be controlled. Facility limitations did not allow both instructors to teach using the same methodology concurrently, and the limited computer laboratory stations imposed a limit on class sizes. One instructor had two years teaching experience with no public school teaching experience, while the other had 15 years teaching experience. The difference in the general teaching experience of the two instructors may have impacted on the findings. Additionally, the majority of the students enrolled in the 1990 Spring semester were not Technology majors.

Students appear to enroll in 8:00 a.m. sections as a last resort. The 8:00 a.m. sections did not have full enrollment and the one section that scored lower on the drafting skills achievement evaluations was an 8:00 a.m. section. That section had only nine completers for the semester and those students had numerically lower *ODAT* pretest scores.

From the review of literature and personal experience in teaching technical drafting, the CAD system's potential was not fully utilized due to the limits of the research procedures being held to traditional drafting techniques. For example, geometric construction was cumbersome if traditional construction techniques were used with the CAD systems, automatic projection transfer from one view to adjacent views was not used on the CAD systems to maintain continuity with the TRAD techniques, and manual isometric projection was time consuming on the CAD system when the automatic isometric projection feature of the CAD system was not used.

The use of standard drafting problems, both on disk and hardcopy, was an innovation for TEC 1001 that will be incorporated in the course. The development of a drawing workbook to support the course text will be used in future TEC 1001 classes. The use of sketching as a problem-solving technique as a precursor to actual drafting was another methodological approach that will be incorporated in the introductory technical drafting course.

CAD is being incorporated into more and more drafting applications. The review of literature and research remains divided on the adequacy of CAD as the basic tools for instruction in technical drafting. The results of this research provided needed direction for the study of the transition to drafting instruction using computer tools.

The problem faced by industrial/technology education, both at the public school level and higher education, is the modifying curriculum to meet the changes in technology and the demands of the workplace. Technical drafting curriculum is faced with the challenge of incorporating the computer into a very traditional curriculum. Many schools are faced with increased demands on facilities and budget requirements. As a result of this research, better utilization of traditional drafting labs, if converted to computer-equipped labs, substantiates the rationale of this research. The significance of the study might be changes in drafting curriculum.

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APPENDIXES

APPENDIX A

Drafting Skills Achievement Problems Evaluation Sheet

Evaluator No. _______

Appalachian State University
Department of Technology
Drafting Evaluation Rating Sheet

Criteria	Max.	Student I.D. Number																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Problem Solution	40																				
Overall Appearance	30																				
Accuracy	10																				
Lettering	10																				
Dimensioning	10																				
Total	100																				

Criteria	Max.	Student I.D. Number																			
		21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Problem Solution	40																				
Overall Appearance	30																				
Accuracy	10																				
Lettering	10																				
Dimensioning	10																				
Total	100																				

Criteria	Max.	Student I.D. Number																			
		41	42	43	44	45	46	47	48	49	50	51	52								
Problem Solution	40																				
Overall Appearance	30																				
Accuracy	10																				
Lettering	10																				
Dimensioning	10																				
Total	100																				

Drafting Evaluation Rating Criteria

A. Problem Solution
(40 pts. max.)
Standard views
View orientation
Feature details
Completeness of solution

B. Overall Appearance
(30 pts. max.)
Line style/type
Line width
View alignment
View spacing/placement

C. Accuracy
(10 pts. max.)
Detail location
Sizing of details
Detail projection

D. Lettering
(10 pts. max.)
Appropriate lettering
Location
Centering/spacing
Line width

E. Dimensioning
(10 pts. max.)
Placement
Accuracy
Completeness

APPENDIX B

The Ohio Drafting Achievement Test

APPALACHIAN STATE UNIVERSITY
Department of Technology
Drafting Achievement Test

Adapted, with permission, by Eddie H. Butler from the
Ohio Drafting Achievement Test ©

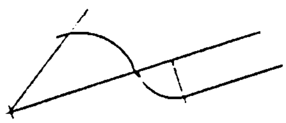
DRAFTING ACHIEVEMENT TEST

Adapted from the Ohio Drafting Achievement Test

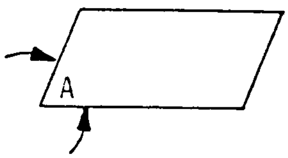
PART I

SECT. 1 - GEOMETRIC CONSTRUCTION

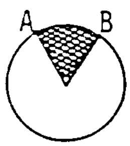
1. The following is:
   a. an arc tangent to two arcs.
   b. a line tangent to a circle and an arc.
   c. an arc tangent to a line and an arc.
   d. a line with two arcs tangent to it.



2. In the following polygon, angle A is:
   a. an acute angle.
   b. an obtuse angle.
   c. a complimentary angle.
   d. a supplimentary angle.

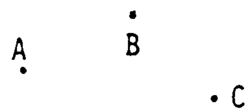


3. The shaded portion of the circle shown below is called:
   a. a segment.
   b. a sector.
   c. a chord.
   d. an arc.



4. When a regular hexagon is inscribed within a circle, the length of each side is equal to the:
   a. segment.
   b. circumference.
   c. diameter.
   d. radius.

5. The preferred way to pass a circle through points A, B, and C as shown below is:
   a. use a template.
   b. apply triangulation using lines A-B and A-C.
   c. measure equal distance from each point.
   d. use the perpendicular bisector of lines A-B and B-C.



6. The long axis of an ellipse is the :
   a. Major axis.
   b. Minor axis.
   c. diameter.
   d. radius.

7. An obtuse angle has:
   a. less than 90°.
   b. more than 90°.
   c. less than 45°.
   d. more than 45° but less than 90°.

8. The sum of the interior angles of a triangle is always:
   a. 90°.
   b. 180°.
   c. 270°.
   d. 360°.

9. Two angles are complementary if they total:
   a. 90°.
   b. 180°.
   c. 270°.
   d. 360°.

10. A quadrilateral figure is a:
    a. trapezoid.
    b. heptagon.
    c. triangle.
    d. hexagon.

11. A series of circles which share the same center point are called:
    a. spiral circles.
    b. eccentric circles.
    c. concentric circles.
    d. truncated circles.

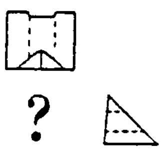
SECT. 2 - ORTHOGRAPHIC PROJECTION

12. A hidden line always takes precedence over a:
    a. visible line.
    b. cutting plane line.
    c. center line.
    d. broken line.

13. The right side view of an object is projected onto the :
    a. frontal plane.
    b. profile plane.
    c. horizontal plane.
    d. reference plane.

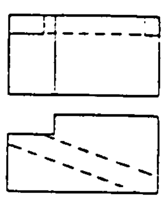
14. The top view of an object is projected onto the:
    a. horizontal plane.
    b. auxiliary.
    c. profile plane.
    d. vertical plane.

15. Choose the correct front view of the following multiviews.

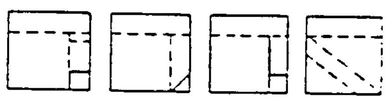


a. b. c. d.

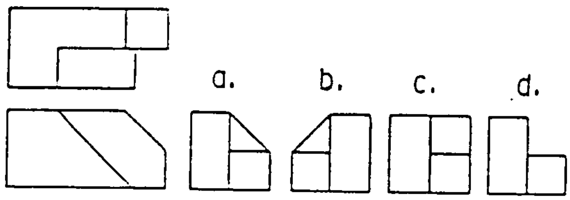
16. Choose the correct side view.



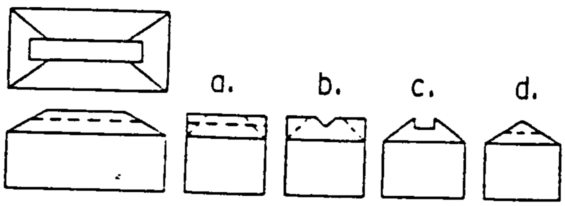
a. b. c. d.



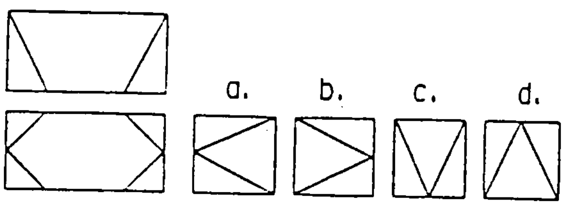
17. Choose the correct side view.



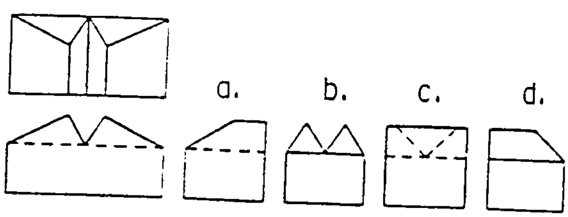
18. Choose the correct side view.



19. Choose the correct side view.

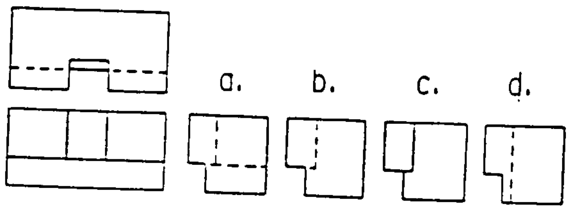


20. Choose the correct side view.

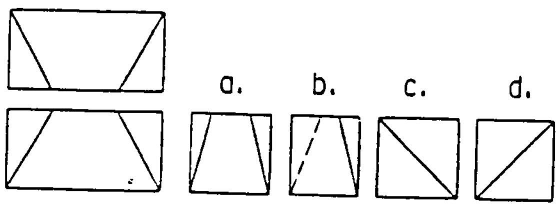


3

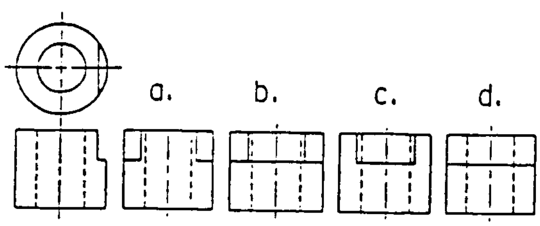
21. Choose the correct side view.



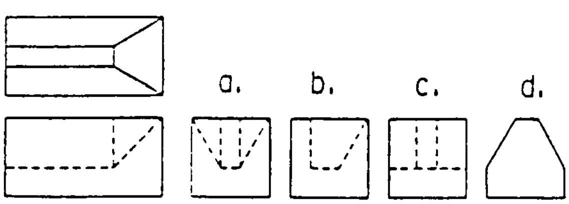
22. Choose the correct side view.



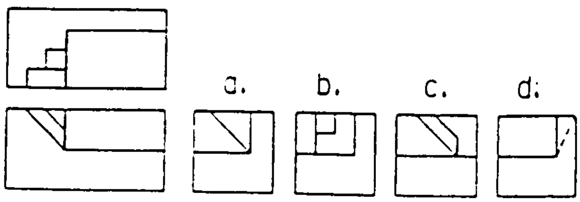
23. Choose the correct side view.



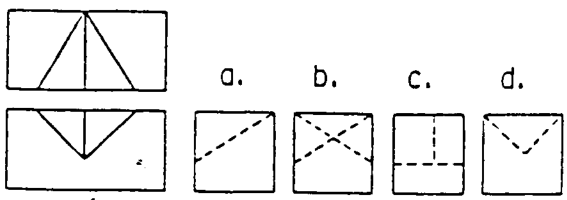
24. Choose the correct side view.



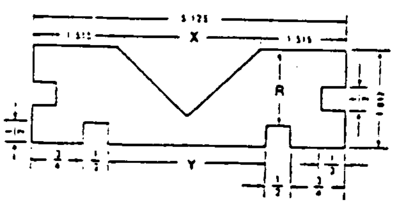
25. Choose the correct side view.



26. Choose the correct side view.



27. From the drawing below, the dimension of X is:
   a. .2095
   b. 1.095
   c. 2.095
   d. 2.95



28. The dimension Y in the drawing above is:
   a. .2625
   b. 1.2625
   c. 2
   d. 2.625

29. The dimension R in the drawing above is equal to:
   a. .1231
   b. .1321
   c. 1.312
   d. 1.321

30. Any one multiview of a three dimensional object can show only:
   a. one principal dimension.
   b. two principal dimensions.
   c. three principal dimensions.
   d. four principal dimensions.

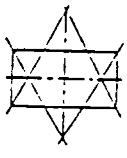
31. The general rule for selecting the front view in orthographic projection is to show the :
   a. holes in object.
   b. characteristic shape.
   c. the most hidden lines.
   d. largest surface area.

SECT. 3 - PICTORIAL DRAWING

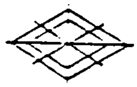
32. Pictorial drawings are used extensively in the field of:
   a. structural drafting.
   b. technical illustration.
   c. mechanical drafting.
   d. electronic drafting.

33. The usual method of locating centers when drawing isometric circles is shown in figure:

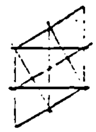
a.



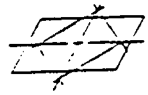
b.



c.

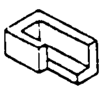


d.

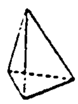


34. Which of the following isometric drawings would most likely be made using the coordinate method?

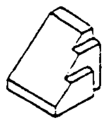
a.



b.



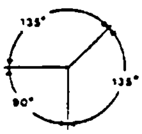
c.



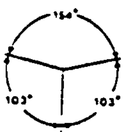
d.

35. Which of the following figures represents the correct isometric axes?

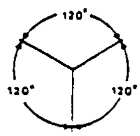
a.



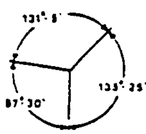
b.



c.

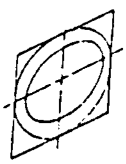


d.

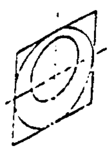


36. Which of the following figures represents an isometric drawing of concentric circles?

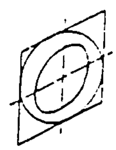
a.



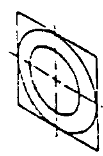
b.



c.

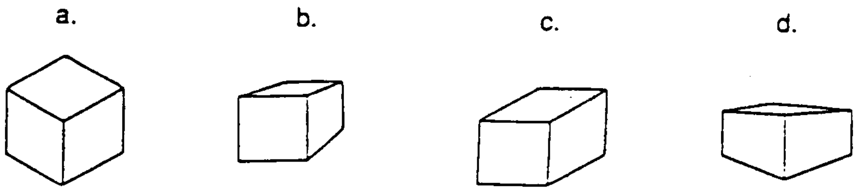


d.

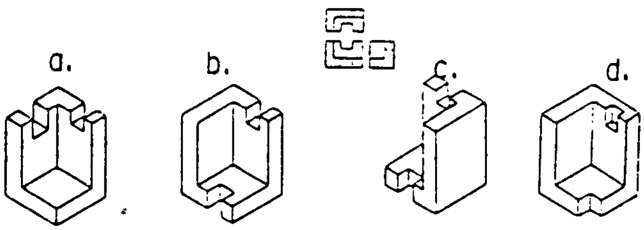


6

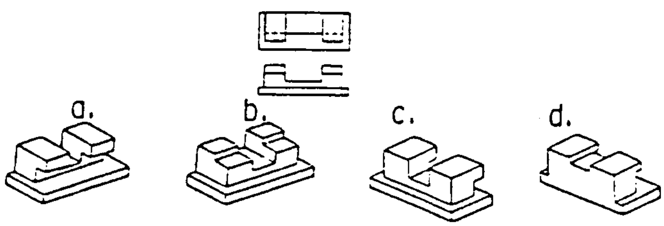
37. Which of the following is an oblique drawing?



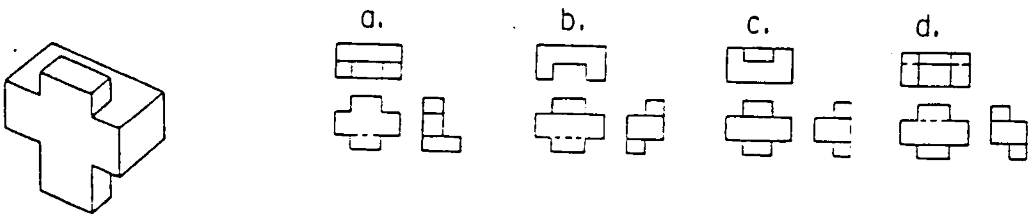
38. Which pictorial view corresponds with the orthographic drawing shown below?



39. Choose the correct pictorial view of the following orthographic drawing?

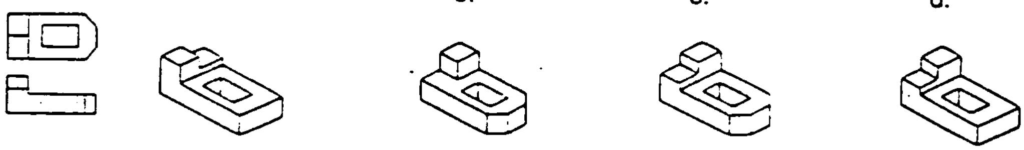


40. Which of the following orthographic views corresponds with the isometric shown?



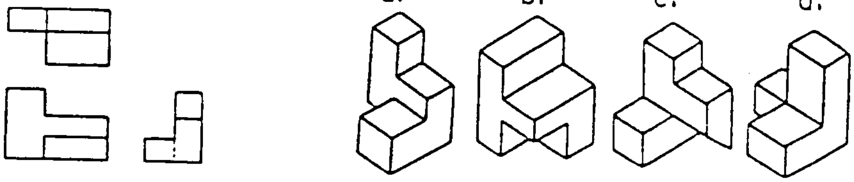
41. Choose the correct isometric projection for the given orthographic drawing:

a. b. c. d.



42. Which pictorial view corresponds with the orthographic drawing shown below?

a. b. c. d.



43. When drawing an oblique drawing, the surface drawn true-size is the:
   a. profile.
   b. rear.
   c. front.
   d. top.

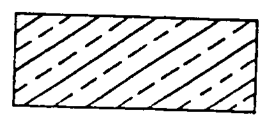
44. Pictorial drawings used to show the parts of an assembly and how they fit together are:
   a. exploded assemblies.
   b. sectional assemblies.
   c. general assemblies.
   d. design assemblies.

45. General, Cavalier, and Cabinet projections are different types of:
   a. axonometric drawings.
   b. oblique drawings.
   c. multiview drawings.
   d. isometric drawings.

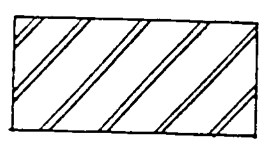
46. The observer is considered to be at a finite distance from the object in:
   a. multiview projection.
   b. an axonometric projection.
   c. an oblique projection.
   d. a perspective.

SECT. 4 - SECTIONAL VIEWS

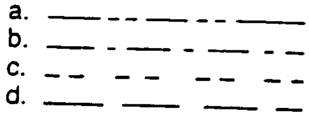
47. This section lining symbol represents:
   a. zinc.
   b. steel.
   c. bronze.
   d. aluminum.



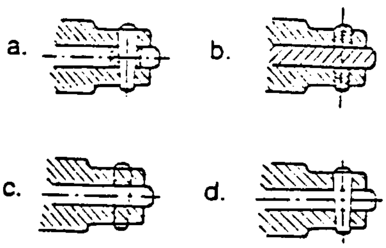
48. This section lining symbol represents:
   a. cast iron.
   b. brass.
   c. steel.
   d. lead.



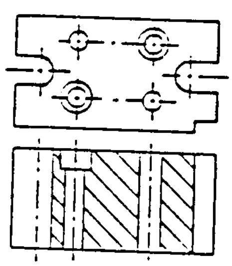
49. Which line below represents a cutting plane line?



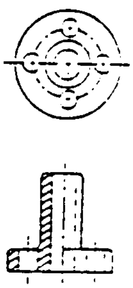
50. In the following drawings, which view best represents the features?



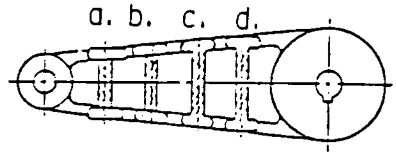
51. On the drawing below, the front view is:
   a. an offset section.
   b. a full section.
   c. a half section.
   d. a detail section.



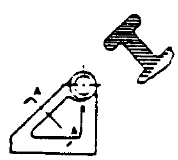
52. On the drawing below, the front view is:
   a. a broken out section.
   b. a quarter section.
   c. a half section.
   d. an aligned section.



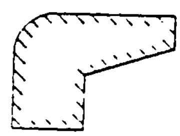
53. Which section is correct?
   a.
   b.
   c.
   d.



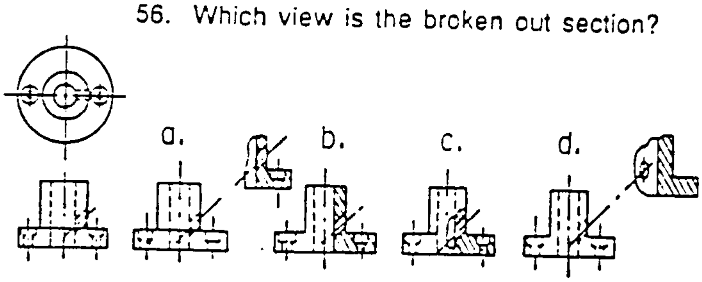
54. The view below shows:
   a. an auxiliary section.
   b. a broken out section.
   c. a revolved section.
   d. a detailed section.



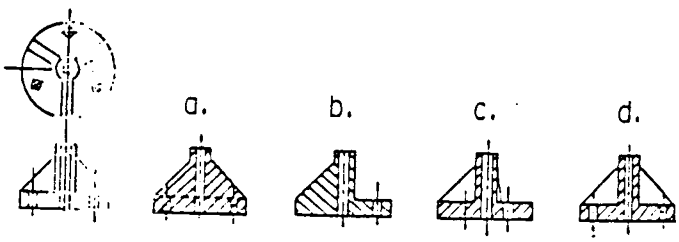
55. This type of section lining is used when the part is:
   a. contoured.
   b. thin.
   c. small.
   d. large.



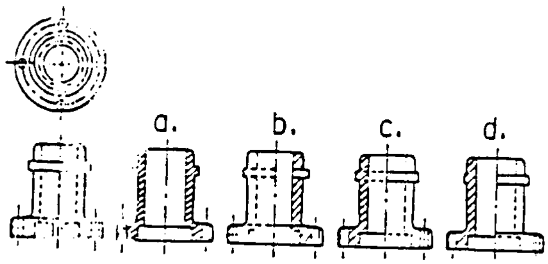
56. Which view is the broken out section?



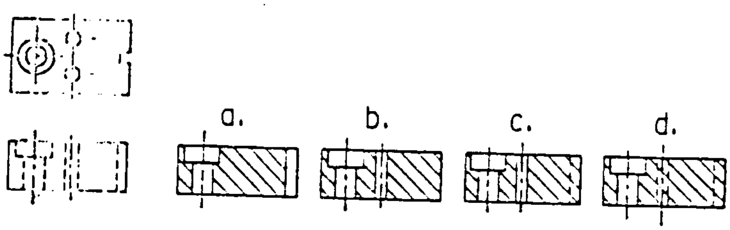
57. Which view is the correct section?



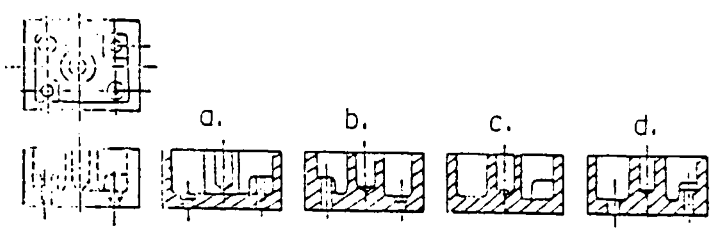
58. Which view shows the correct half section?



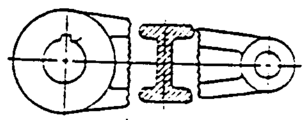
59. Which view shows the correct full section?



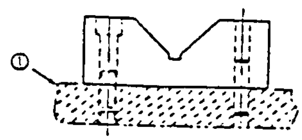
60. Which is the correct offset section?



61. The drawing to the right shows:
   a. a removed section.
   b. a broken out section.
   c. a revolved section.
   d. an auxiliary section.

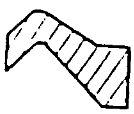


62. On the drawing to the right, number one indicates:
   a. a removed section.
   b. an outline section.
   c. a broken out section.
   d. a phantom section.

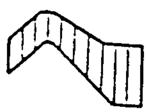


63. In the drawings below, the best direction for the Section lines to be drawn is:

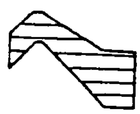
a.



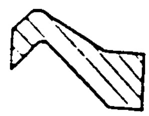
b.



c.



d.



64. The view needed to show the interior construction of a part is:
   a. sectional.
   b. auxiliary.
   c. assembly.
   d. oblique.

65. Thin material should be sectioned:
   a. in solid black.
   b. at a different angle.
   c. at a different direction.
   d. vertically.

SECT. 5 - PRODUCTION/WORKING DRAWINGS

66. A drafter's work is first checked by the:
   a. group leader.
   b. designer.
   c. chief drafter.
   d. drafter.

67. A unit assembly or sub-assembly drawing shows:
   a. the trial assembly of one group of moving parts.
   b. a small object as an assembly on one sheet.
   c. the whole object as one unit.
   d. an assembly of a related group of parts.

68. Which of the following is usually omitted on a general assembly drawing?
   a. Dimensions
   b. Center lines
   c. Standard parts
   d. Part numbers

69. The part of a drawing used to give specifications and number of required units, etc., is referred to as:
   a. bill of materials.
   b. record strip.
   c. title block.
   d. specifications chart.

70. The purpose of a section assembly is to:
   a. omit drawing obvious parts.
   b. show shape description.
   c. show the number of parts.
   d. show interior details.

71. Standard parts on assembly drawings are:
   a. always detailed.
   b. not detailed.
   c. shown in three views.
   d. shown in single view.

72. Parts must be identified on the detail drawing so that:
   a. they may be located on the assembly drawing.
   b. the number of parts can be counted.
   c. dinensions can be found.
   d. tolerances may be checked.

73. A drawing that identifies dimensions by letters, and gives actual dimensions elsewhere is a:
   a. detail drawing.
   b. tabular drawing.
   c. Topo drawing.
   d. erection drawing.

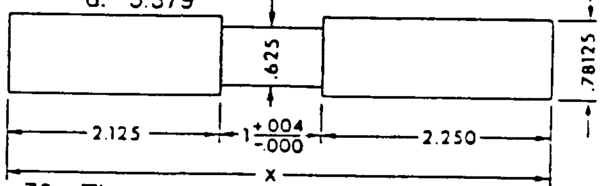
74. A detailed assembly drawing shows:
   a. pattern shape.
   b. all information.
   c. center to center dimensions.
   d. only clearance between moving parts.

75. The written instructions that explain the drawings are called:
   a. dimensions.
   b. blueprints.
   c. floor plans.
   d. specifications.

SECT. 8 - DIMENSIONING AND TOLERANCING

76. The spacing between the letters of words should:
   a. be equally spaced.
   b. have areas that appear to be equal.
   c. be one-half the height of the letters.
   d. be equal to the height of the letters.

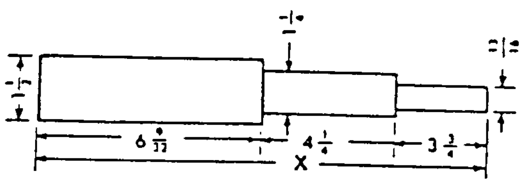
77. From the drawing below, the largest allowable dimension of X is:
   a. 4.375
   b. 4.379
   c. 5.375
   d. 5.379



78. The most common single stroke lettering style in engineering drafting is:
   a. script.
   b. Gothic.
   c. Roman.
   d. Old English.

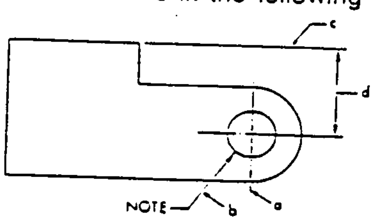
79. Extension lines should be placed approximately:
   a. 1/8" from the view.
   b. 1/16" from the view.
   c. 1/8" from the view and extended 1/4" beyond the outermost arrow.
   d. 1/16" from the view and extend 1/8" beyond the outermost arrow.

80. From the drawing below, the difference between the largest diameter and the smallest diameter is:
   a. 9/16
   b. 5/8
   c. 11/16
   d. 3/4



81. From the drawing above, the dimension of X is:
   a. 13-13/32
   b. 13-21/32
   c. 14-9/32
   d. 14-7/8

82. Identify the leader line in the following sketch.
   a. a
   b. b
   c. c
   d. d

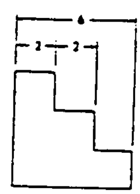


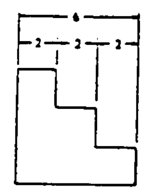
83. The abbreviation ANSI stands for:
   a. American National Systems Institution.
   b. American Naval Standards Instructions.
   c. American National Standards Institute.
   d. American National Scale and Instrument.

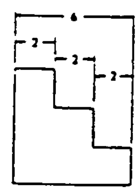
84. Unidimensional dimensions are placed to be read:
   a. from right side of sheet only.
   b. from the bottom of the sheet.
   c. from the right side and the top.
   d. from the right side and bottom side of the sheet.

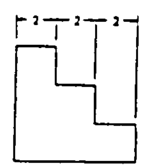
85. The necessary dimensions on a cylinder or shaft requires the:
   a. diameter and length, preferably shown on the rectangular view.
   b. diameter and length shown on the profile view.
   c. diameter on the rectangular view, and length on the profile view.
   d. length given on profile view, and diameter on rectangular view.

86. Which of the following views shows the preferred way to dimension?

a.


b.


c.


d.


APPENDIX C

The Gable-Roberts Attitude Toward School Subjects

APPALACHIAN STATE UNIVERSITY
Department of Technology

Attitudes Toward Drafting

Adapted, with permission, by Eddie H. Butler from the
Gable-Roberts Attitude Toward School Subjects Test
University of Connecticut

ATTITUDES TOWARD DRAFTING Student Number ________________

The following items survey your opinions about the subject of Drafting. Bubble in the letter that best describes your opinion on the corresponding number on the answer sheet. Please indicate your opinion of each item using the following code:

A -- means *"strongly agree"*
B -- means *"agree"*
C -- means *"uncertain"*
D -- means *"disagree"*
E -- means *"strongly disagree"*

To what extent do you agree or disagree with the following statements with respect to Drafting:

1. I like to study the subject of drafting.
2. The subject is fundamental to my major.
3. The subject fascinates me.
4. I find the subject to be a real bore.
5. The subject is of great value to me.
6. The subject does not hold my interest.
7. The subject is the most understandable subject taught in college.
8. The subject gives students the ability to interpret situations they will meet in life.
9. I look forward to my class in this subject.
10. The subject is not useful in today's workplace.
11. I wish that I did not have to take the subject.
12. The subject is beneficial to everybody who takes it.
13. I find the subject to be dull.
14. The subject will help me in my other subjects.
15. I really enjoy the subject.
16. The subject has many practical applications.
17. The subject is not relevant to my life.
18. The subject helps me develop good reasoning ability.
19. The subject is interesting.
20. The subject teaches me to be accurate.
21. Any student who takes this subject is not going to be benefited.
22. I am not interested in the subject.
23. The subject does not apply to real life.
24. The subject does not teach problem solving skills.
25. Upon graduation, there is a great chance that I will use the subject in my job.
26. The subject does not teach me to pay close attention to details.

APPENDIX D

Research Participant Consent Form

Appalachian State University
DEPARTMENT OF TECHNOLOGY

Selected Department of Technology drafting classes, "TEC 1001 Introduction to Technical Drafting," have been designated to participate in a research project to determine the effectiveness of computer aided drafting instruction during the Spring semester, 1990. The Department of Technology is attempting to update course content offering to better serve the student and better prepare Department of Technology students in their careers. Randomly selected sections will be taught similar content using either traditional drafting instruction or computer aided drafting instruction. The benefits derived from this research will provide data to assist the Department of Technology plan for future directions for drafting instruction.

There will be no physical or mental risk to the students participating in this research. Course material will be presented in the usual and normal process. The records, identifying students, will be manintained by the instructor in a standard manner. The data from achievement tests and pre/posttest will be identified only by a random identification number, assigned by the research coordinator. Confidentiality will be maintained, as with normal class records.

Participation in this research is voluntary; if you choose not to participate, no penality or loss of benefits will be imposed. You are free to drop the TEC 1001 course without penality.

If there are any questions, or concerns, please contact Eddie H. Butler, Research Coordinator, 113 Kerr Scott Hall, 262-6355.

I have read the above disclaimer and understand I am participating in a drafting research project in the Department of Technology at Appalachian State University.

____
Signature

____
Date

APPENDIX E

TEC 1001 Course Outline

APPALACHIAN STATE UNIVERSITY
DEPARTMENT OF TECHNOLOGY

TEC 1001 Technical Drafting

TENTATIVE COURSE OUTLINE

Week	Date	Title
1 -	1/17,19	Introduction, Orientation
2 -	1/24,26	Sketching & Technical Drafting Conventions
3 -	1/31, 2/2	Geometric Construction
4 -	2/7,9	Multiview Projection
5 -	2/14,16	Multiview Problems
6 -	2/21,23	Multiview Problems
7 -	2/28, 3/2	Isometric Projection
8 -	3/14,16	Isometric Problems **MID-TERM EXAM 3/16**
9 -	3/21,23	Oblique Projection
10 -	3/28,30	Oblique Problems
11 -	4/4,6	Dimensioning
12 -	4/11	Sectioned Views
13 -	4/18,20	Design & Working Drawings
14 -	4/25,27	Lab Times
15 -	5/2,4	Lab Times

APPENDIX F

TEC 1001 Introduction to Technical Drafting Syllabus

APPENDIX B
ASU DEPARTMENT OF TECHNOLOGY
TEC 1001 -- Technical Drawing I
Spring Semester - 1990

COURSE OBJECTIVES

To provide the information necessary for the understanding of equipment, techniques, and principles of drafting technology.

To provide the instruction, demonstration, and practice necessary for the production and interpretation of accurate technical and working drawings.

To provide the information necessary for the understanding and proper use of the terminology of drafting technology.

To provide the information necessary for the application of drafting technology to other skill areas (i.e., architecture, electronics, metals, woods, etc.).

To provide for the development of problem solving skills in the solution of drafting problems.

REQUIRED TEXT

Giesecke, Mitchell, Spencer, Hill and Dygdon (1986). Technical Drawing, 8th Ed. New York: MacMillian.

COURSE REQUIREMENTS

Attendance - You are expected to attend every class session. Instruction, demonstration, or other information will be given at each class and you are responsible for the material covered. Your final grade will be lowered by 1/3 letter grade for each absence.

Examinations and Quizzes - There will be two comprehensive examination, a mid-term and final. The final examination date and time will be posted on the "Course Outline" sheet. Quizzes may be given at any time covering classroom instruction or assignments. Missed quizzes **will not** be made up. Examinations missed by unexcused absences will not be made-up. University policy states the rescheduling of a final examination is to be done only in emergency situations and at the convenience of the instructor.

Assigned Drawings - A list of assigned drawings is attached. It is your responsibility to read and clearly understand each textbook unit before attempting to draw the assigned plates. Before beginning a plate, be sure to note the type of paper to be used and whether the plate is to be sketched freehand or drawn with instruments. Please submit each unit's assigned drawings (stapled together) with a title page. Observe all due dates. Your instructor is under no obligation to accept late assignments and grading penalities will be assessed on late work if it is

Materials - The following materials will be provided for each student: (a) 8 1/2 x 11 drafting paper, (b) 8 1/2 x 11, 4x4 (1/4") quadrille paper, (c) 8 1/2 x 11 isometric grid paper, (d) drafting tape.
You are responsible for purchasing: drafting equipment,including: architects scale, metric scale, triangle (30/60 & 45/90), erasers, pencils or lead holder & lead, eraser shield, isometric ellipse template, Ames lettering guide, and drafting instruments. A T-square is optional but recommended for work outside the lab.

Lab Fee - A laboratory fee of $6.00 will be assessed each student's account at the conclusion of the semester. This fee covers the cost of paper, tape and other consumable items.

Grading - The following weights will be given to class requirements:

50% - Drawing Assignments
20% - Course Notebook
20% - Examinations (Mid-term 10%, Final 10%)
10% - Quizzes and Instructor's Evaluation

Notebook - A notebook should be maintained to be turned in at the final examination period for evaluation. All materials from this course should be included in the notebook; i.e., graded assignments, notes, quizzes, homework, examinations, reports, etc. The notebook should be a "tang" folder, organized with a title page and table of contents by page numbers. The cover may be individually designed and should include the course name/number, your name and the semester/year.

ASSIGNED DRAWINGS

Page	Figure	Title	Notes
Introduction		------------ Graphic Language/Lettering ------------	Chapters 1 & 3
Unit I		------------------- Sketching/Drawing ------------------------	Chapter 5 (5.1-5.10)
60,62	2.86, 2.96		Unit I Assignment Due 1/31
Unit II		-------------------- Geometric Construction --------------	Chapter 4
	To be assigned by instructor		Unit II Assignment Due 2/7
Unit III		------------------Multiview Sketching/Drawing ---------	Chapter 5 (5.19 - 5.31) & Chapter 6
151	5.51 (2,7,10,11)		In class assignments
151	5.51 (1,3,9,14)		In class assignments
153,154	5.53 (5,7,9,22), 5.54 (2,8,14*,18*) ------------		Unit III Assignment Due 2/28
Unit IV		---------------- Isometric Sketching/Drawing ------------	Chapter 5 (5.11 - 5.14) & Chapter 16
153	5.53 (4,8,12)		Sketch only
153, 540	5.53 (14*,16,17), 16.52 (10) --------------------		Unit IV Assignment Due 3/21
Unit V		----------------- Oblique Sketching/Drawing -------------	Chapter 5 (5.15 - 5.16) & Chapter 17
151	5.51 (4,5)	Unit IV Cavalier @ 45_o	
153	5.53 (3,31)	Unit IV Cabinet @ 45_o	
			Unit V Assignment Due 4/4
Unit VI		--------------- Dimensioning ----------------------------	Chapter 11
	To be assigned by instructor		Unit VI Assignment Due 4/11

(NOTE: All remaining drawings must include dimensions)

Page	Figure	Title	Notes
Unit VII		---------------- Sectional Views -------------------------	Chapter 7
223	7.39 (1,3,12,17)		Unit VII Assignment Due 4/20
Unit VIII		------------------Design & Working Drawings -----------	Chapter 14
	Assignment to be given by instructor.		Unit VIII Assignment Due 5/4

APPENDIX G

Student Information Sheet

ASU Department of Technology
STUDENT INFORMATION SHEET

NAME ______________________________ BIRTHDATE ______________
SOCIAL SEC. #______________________ CLASSIFICATION __________ SEX__________
MAJOR ____________________ HOME TOWN ______________________
LOCAL ADDRESS ____________________ PHONE ______________________
____

DRAFTING EXPERIENCE: (Please check all appropriate boxes)

___ None
___ High School (__ sem.)
___ College Drafting (__ sem.)
___ Junior High IA
___ Post Secondary Tech.
___ Work Experience (__ yr)

Type of drafting experiences: (Please check all appropriate boxes)

___ Mechanical Drafting
___ Sketching
___ CAD
___ Architectural
___ Descriptive Geometry
___ Design

INDUSTRIAL EDUCATION/TECHNOLOGY EDUCATION BACKGROUND

Please check the appropriate areas of educational experience:

	How long?
___ IA/T Communications	________
___ Construction	________
___ Crafts	________
___ General Shop	________
___ Graphic Arts	________
___ Machine Shop	________
___ Manufacturing	________
___ Metalworking	________
___ Photography	________
___ Plastics	________
___ Power Mechanics	________
___ Woodworking	________
___ Other, ____________	________

Average Industrial/Technology Education Grades: ___ A, ___ B, ___ C, ___ D

Related work experience ____

____

APPENDIX H

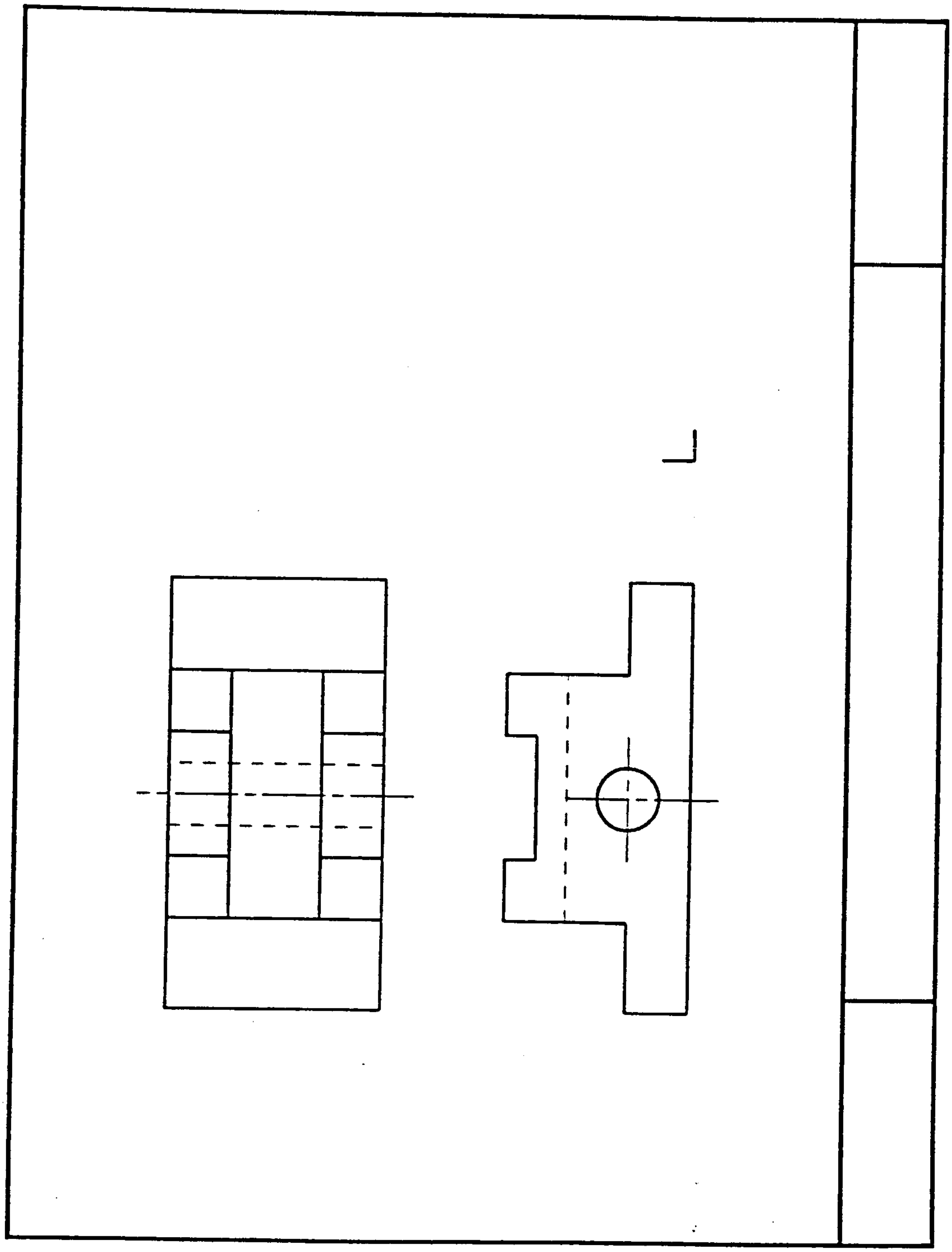
Drafting Assignments Workbook

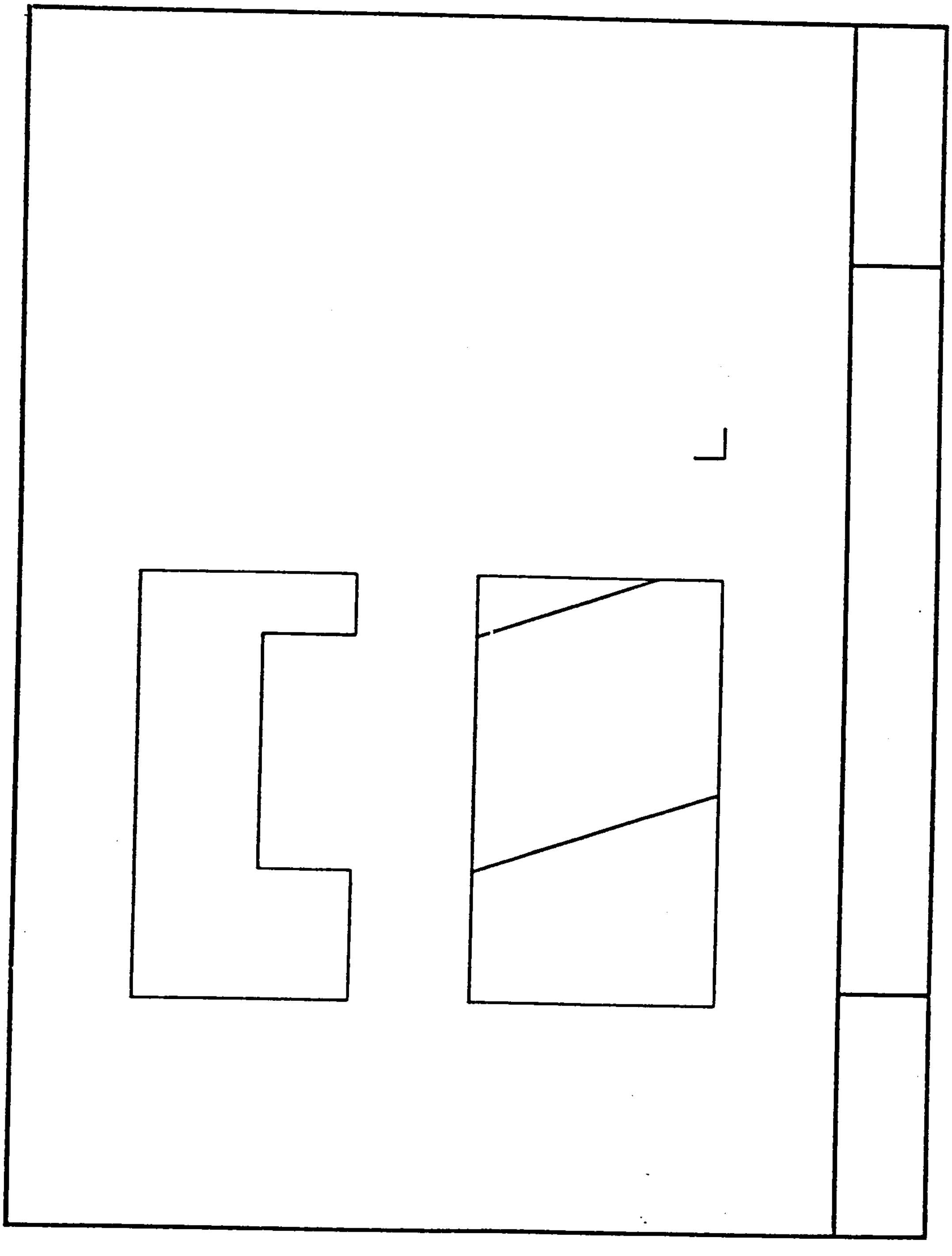
LINE WEIGHT MUST BE KEPT UNIFORM. THE PENCIL MUST BE SHARPENED FREQUENTLY. TO ACHIEVE THE APPEARANCE OF BALANCE, THE RELATIONSHIP OF LETTER HEIGHT AND WIDTH MUST BE OBSERVED. BECAUSE OF THEIR SHAPE, SOME LETTERS ARE WIDER THAN OTHERS. THE SPACING BETWEEN LETTERS IS IMPORTANT TO GOOD APPEARANCE. TO GET A PLEASING APPEARANCE, THE SPACE BETWEEN THE LETTERS MUST APPEAR EQUAL. THE LETTERS CANNOT BE SPACED AN EQUAL DISTANCE APART. THEIR SHAPE MAKES SOME APPEAR CLOSER THAN OTHERS. THE DISTANCE BETWEEN WORDS IN A SENTENCE IS EQUAL TO THE HEIGHT OF THE

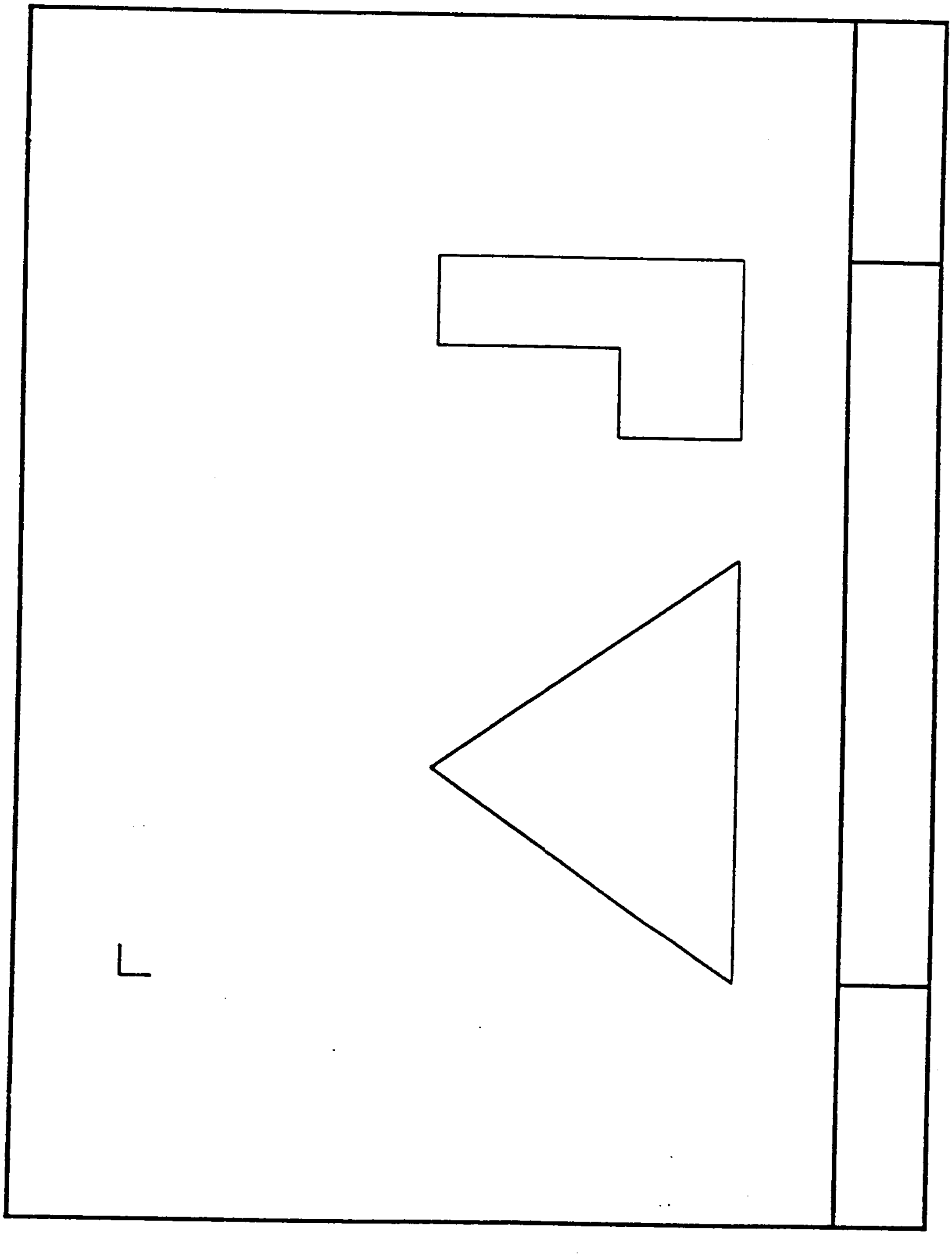
2/2/90	UNIT 1 LETTERING	GID

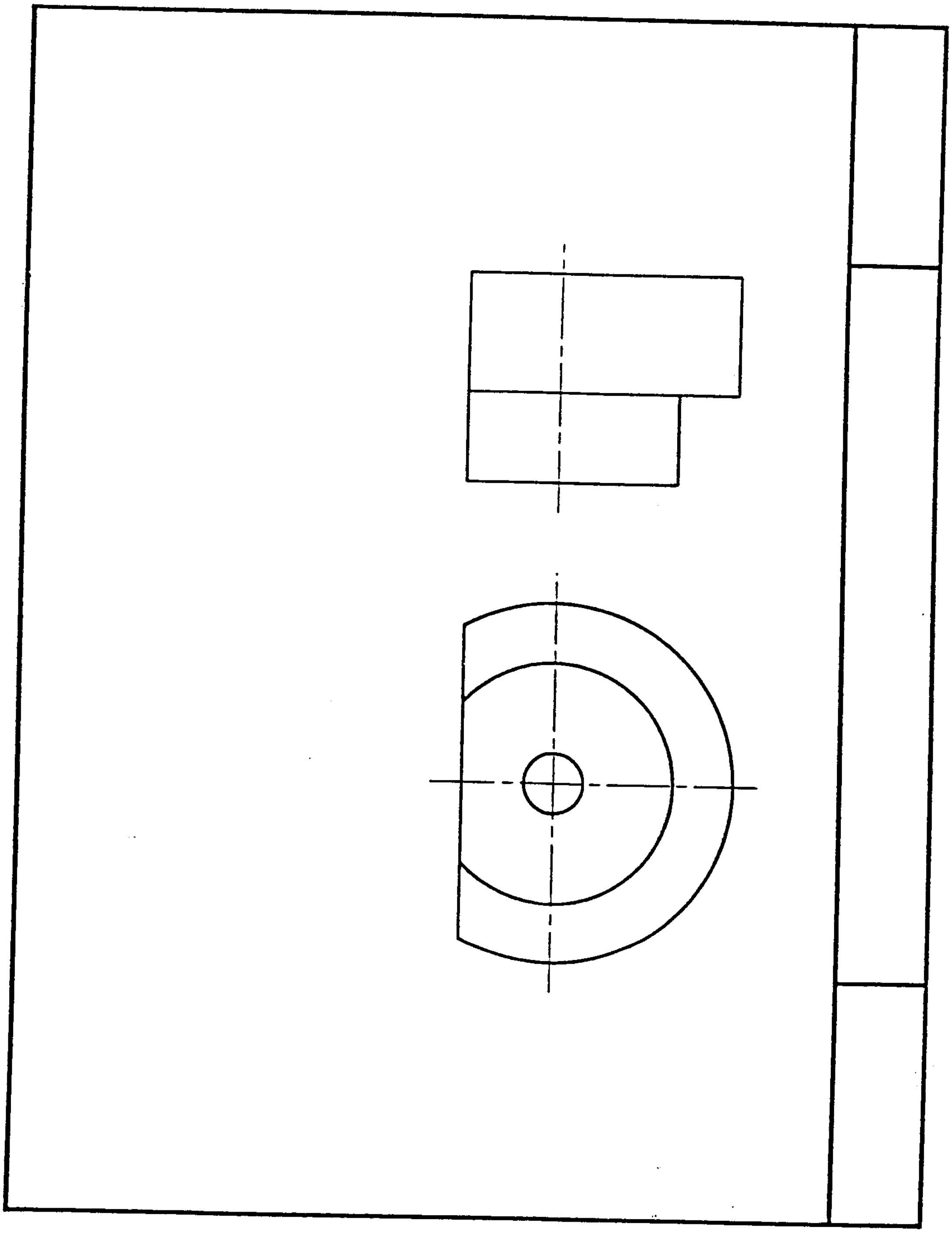
LETTER. THE HEIGHT OF THE LETTERS DEPENDS UPON HOW THEY ARE TO BE USED. GOOD LETTERING REDUCES THE CHANCE FOR ERROR WHEN READING A DRAWING.

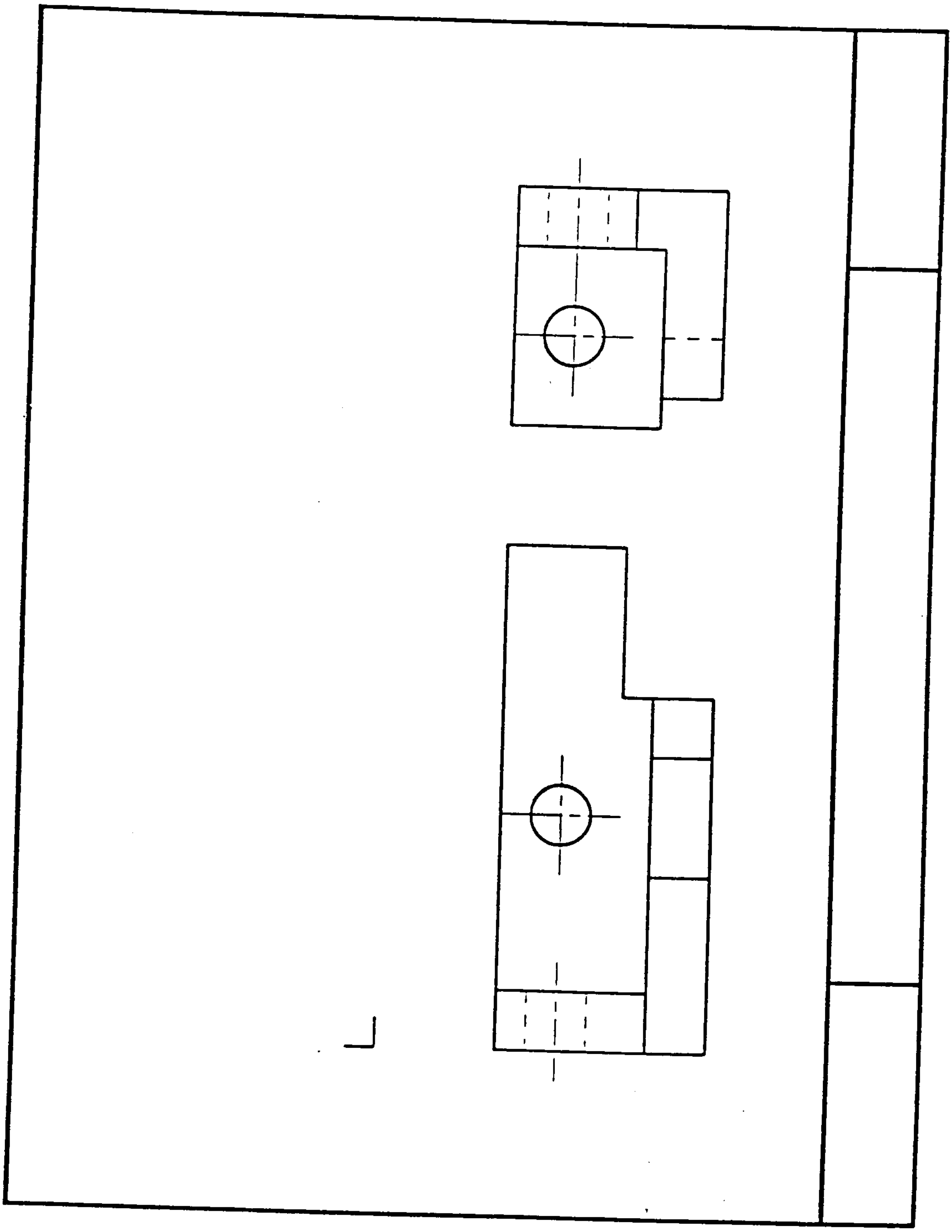
2/2/90	UNIT 1 LETTERING	GTD

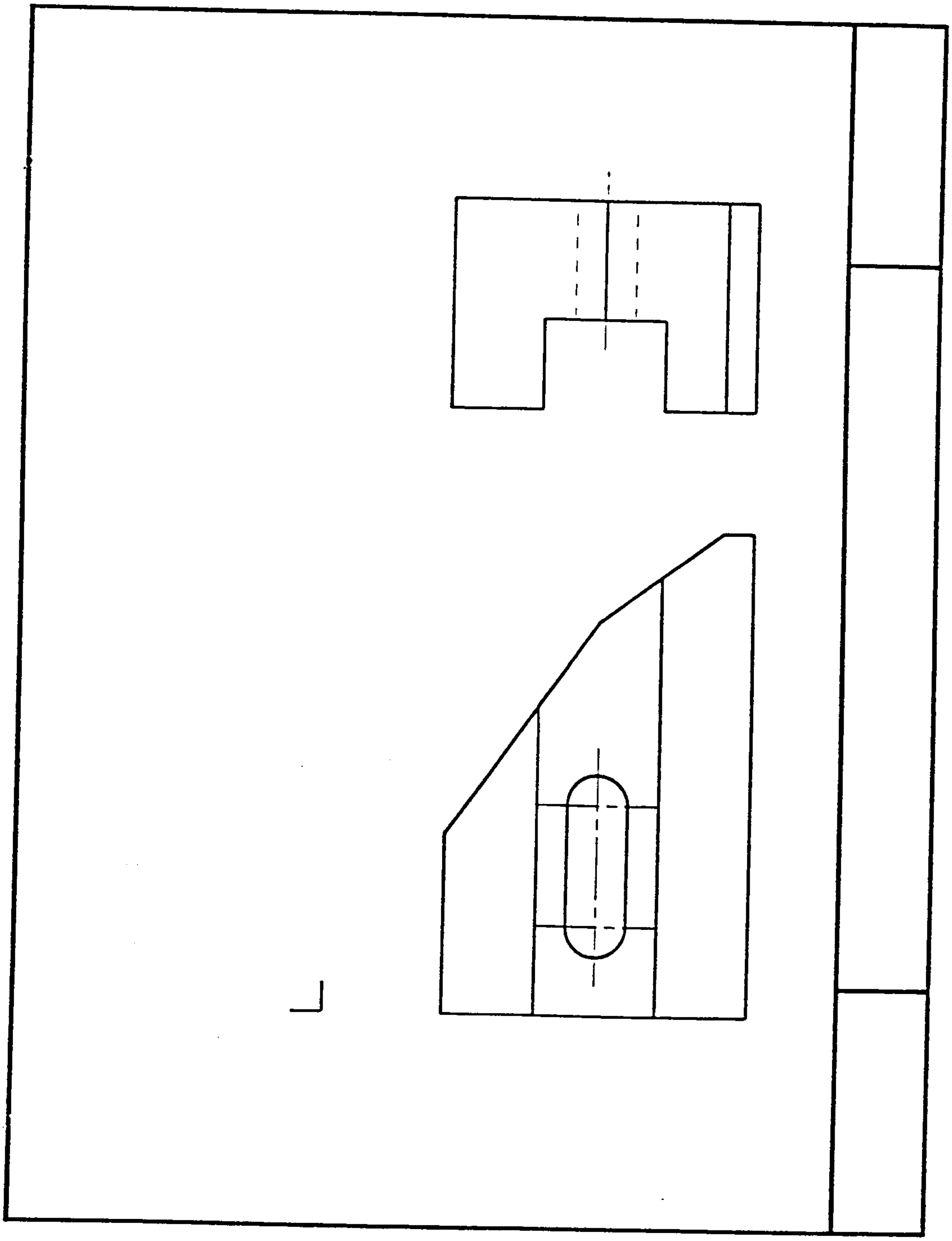


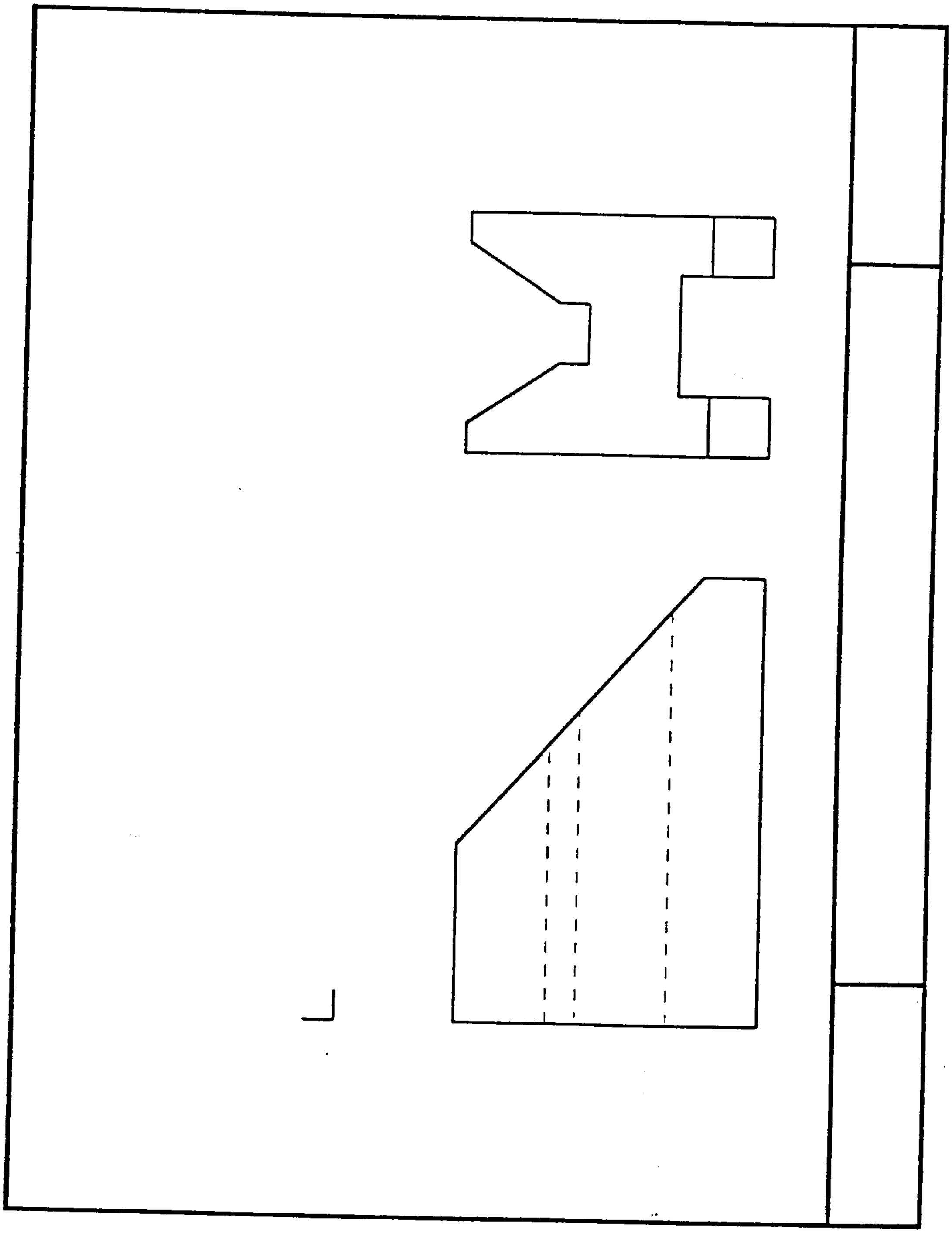


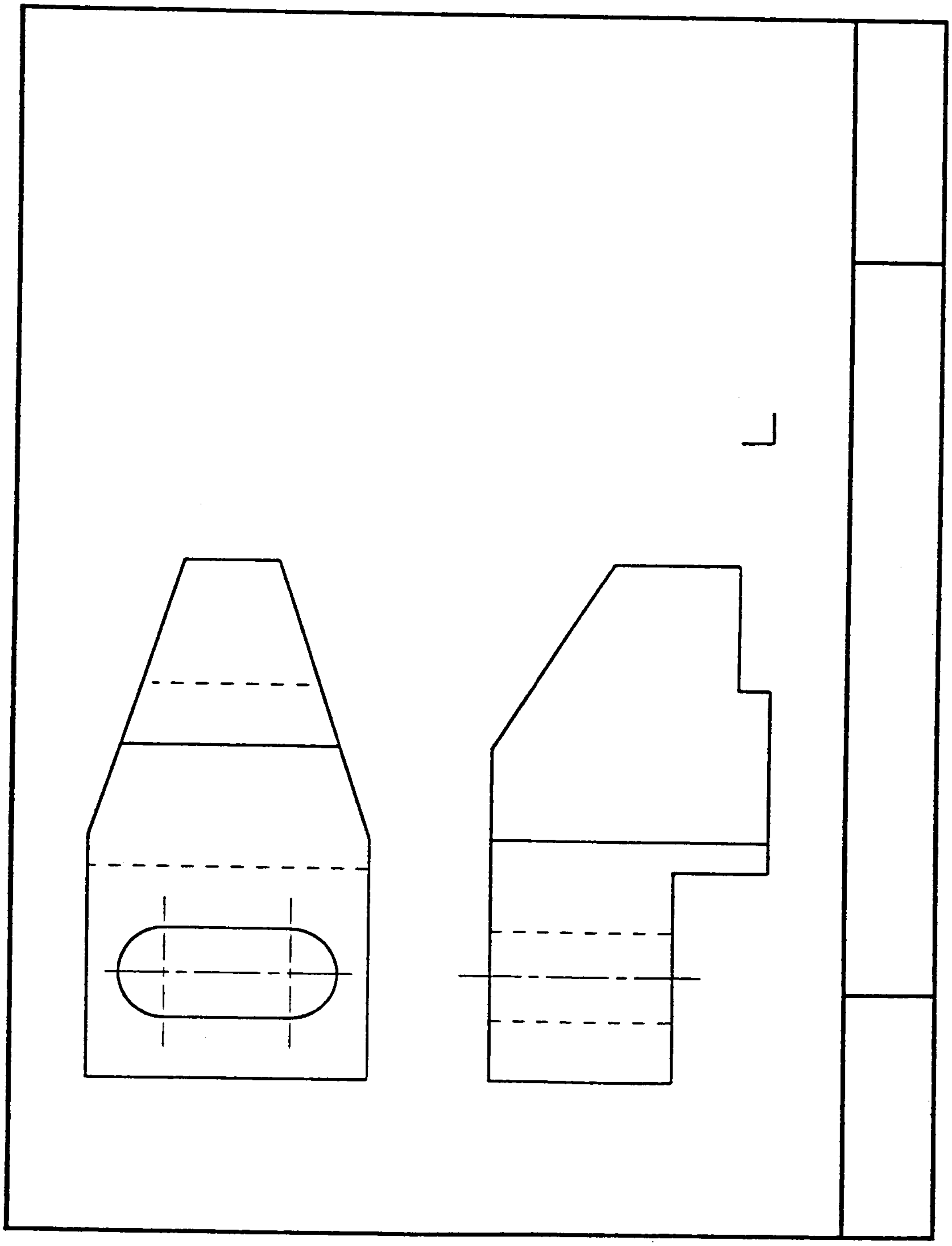


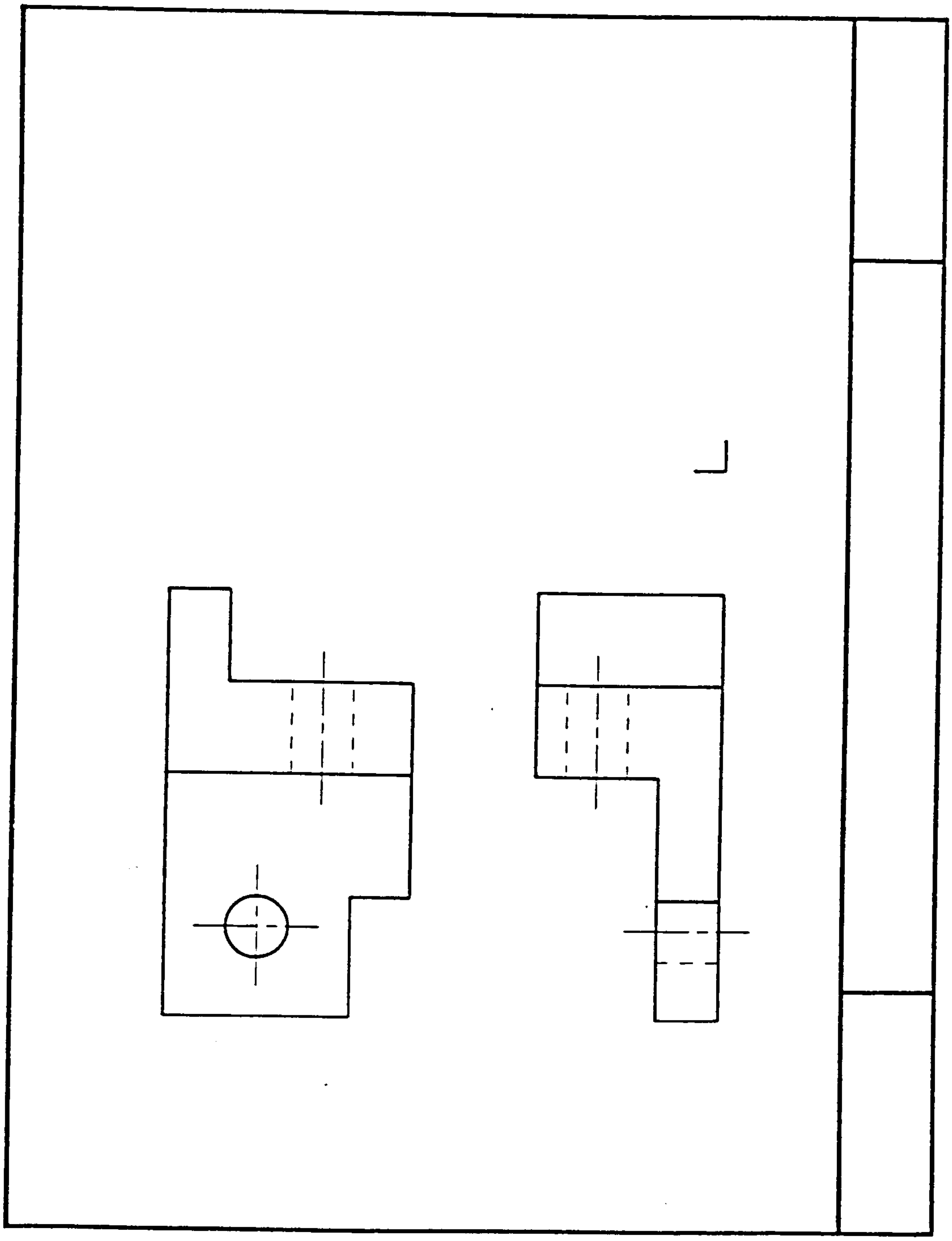


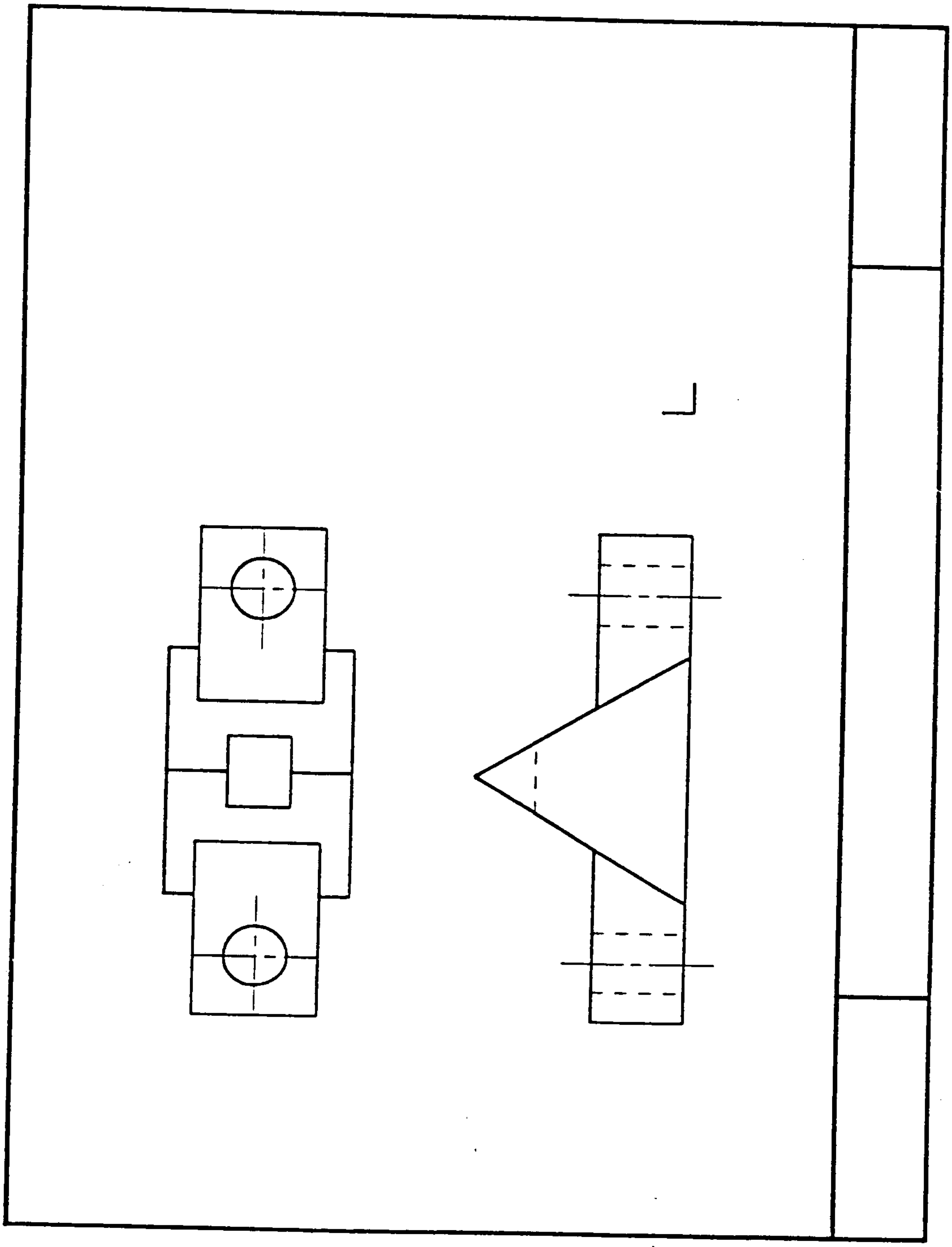


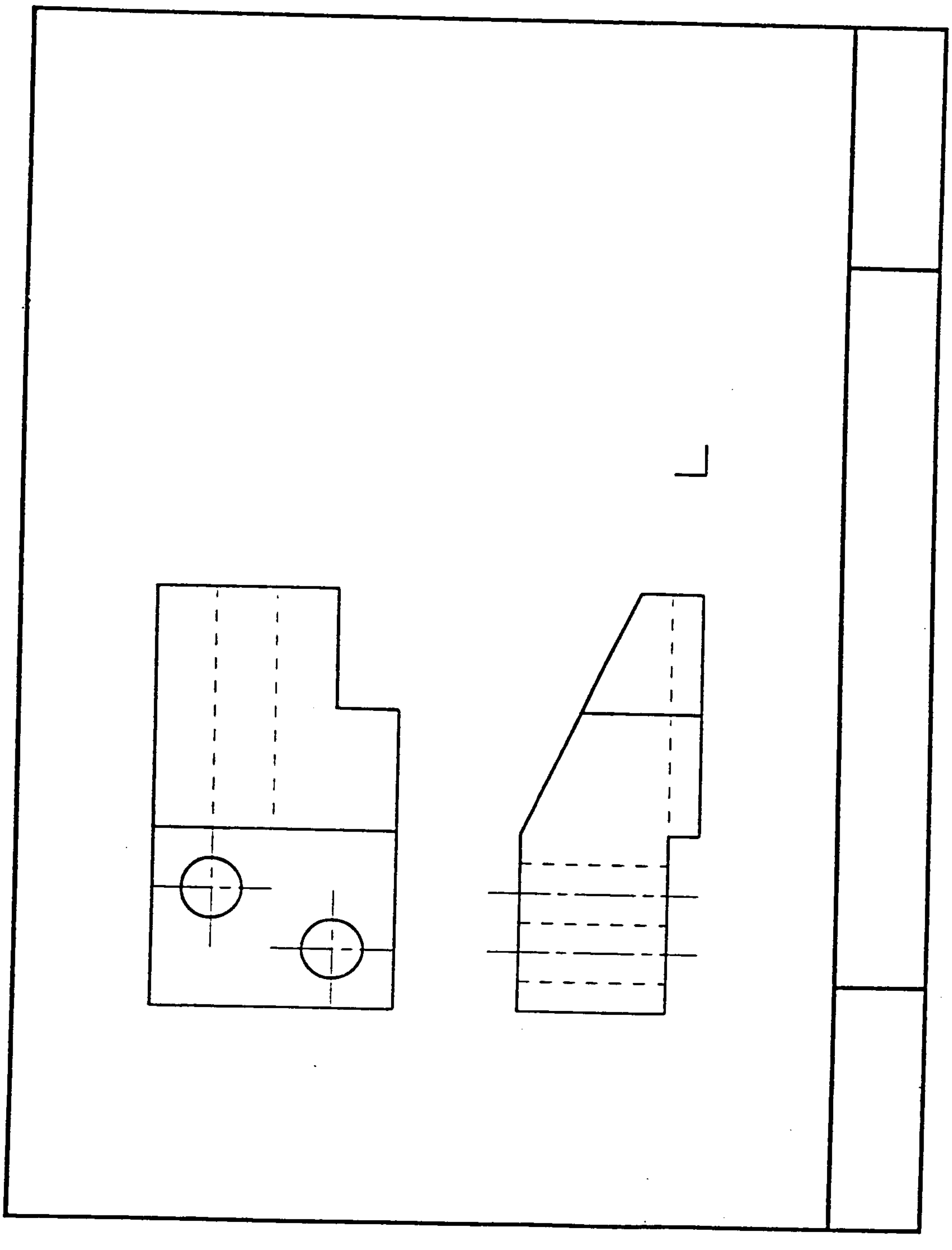


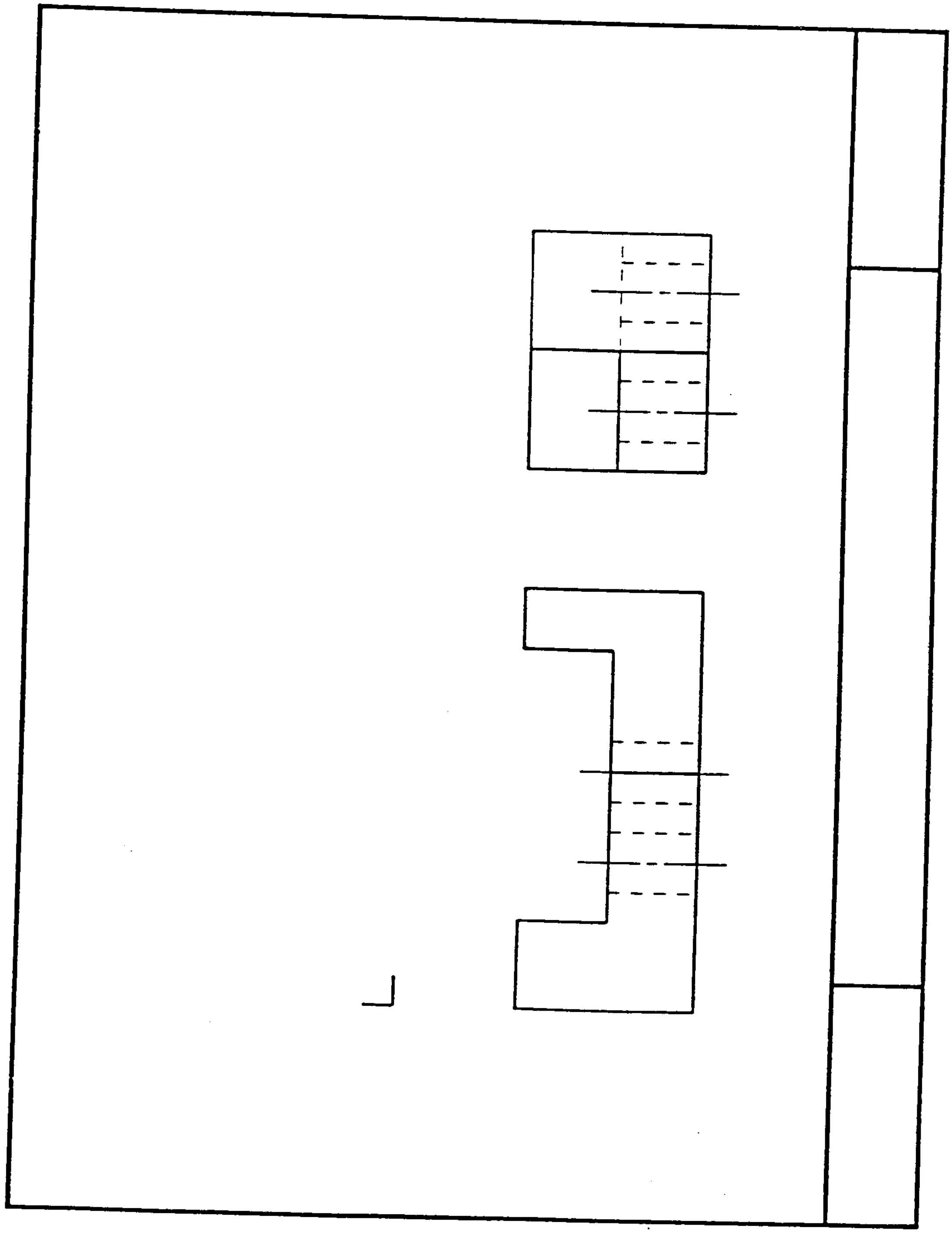


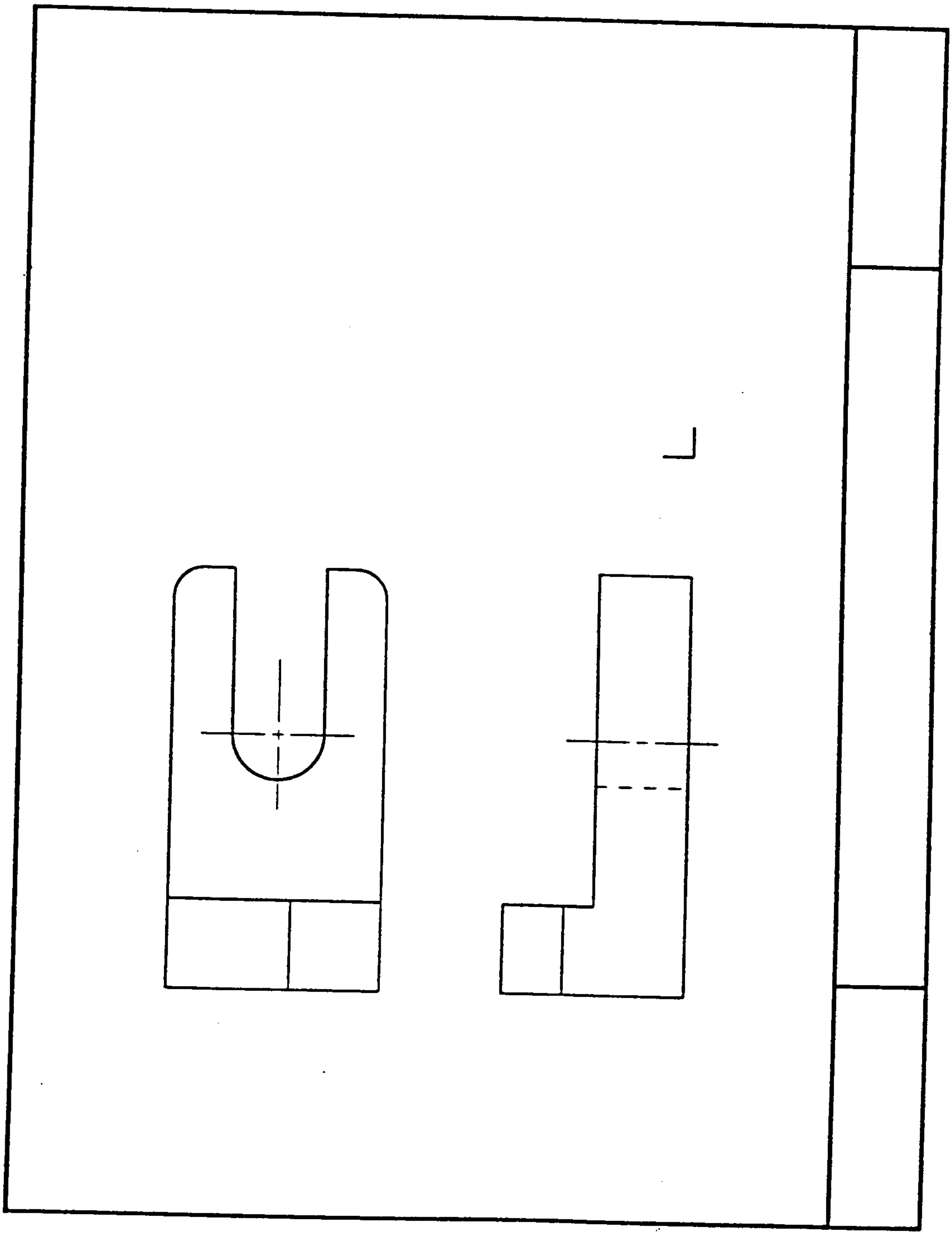


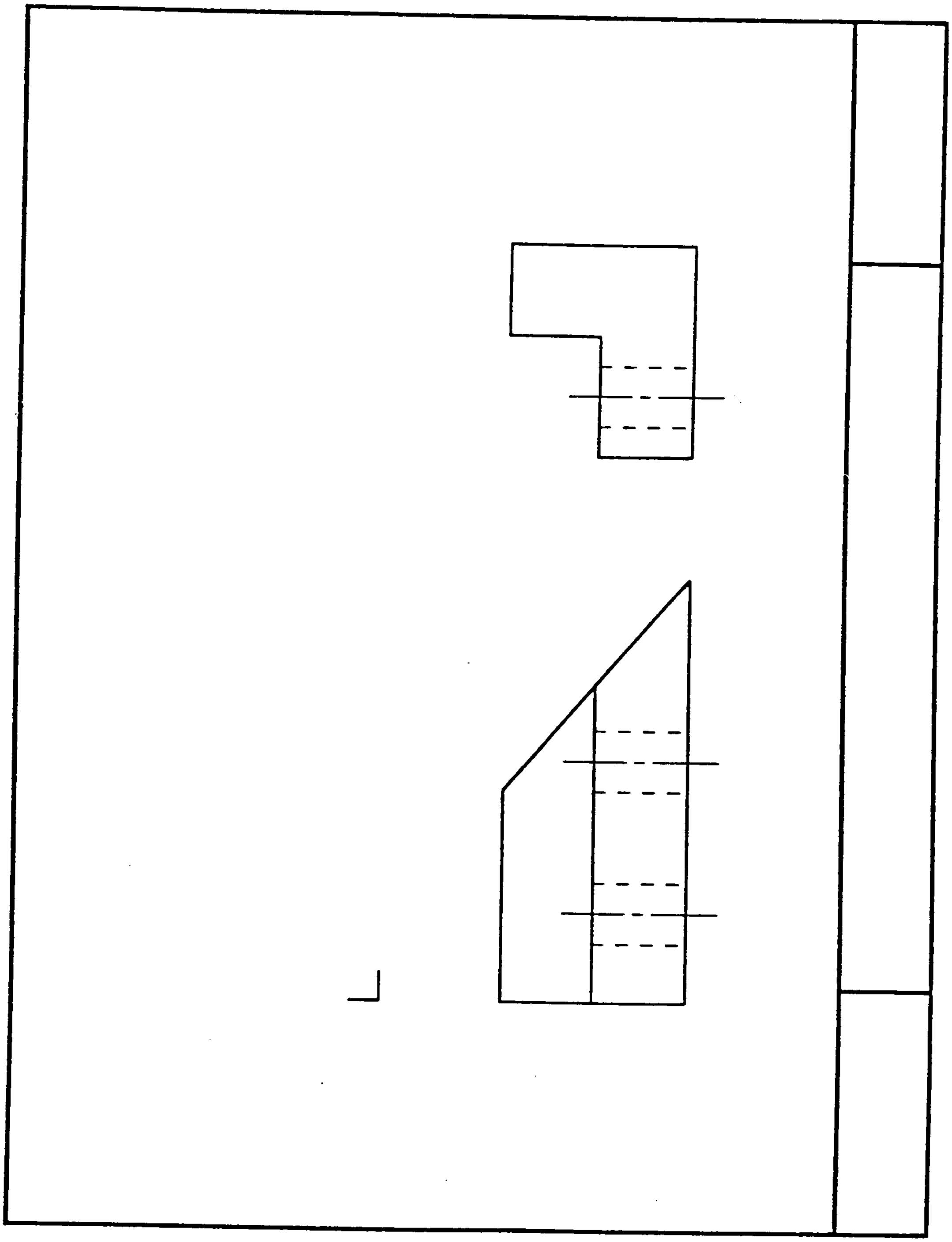


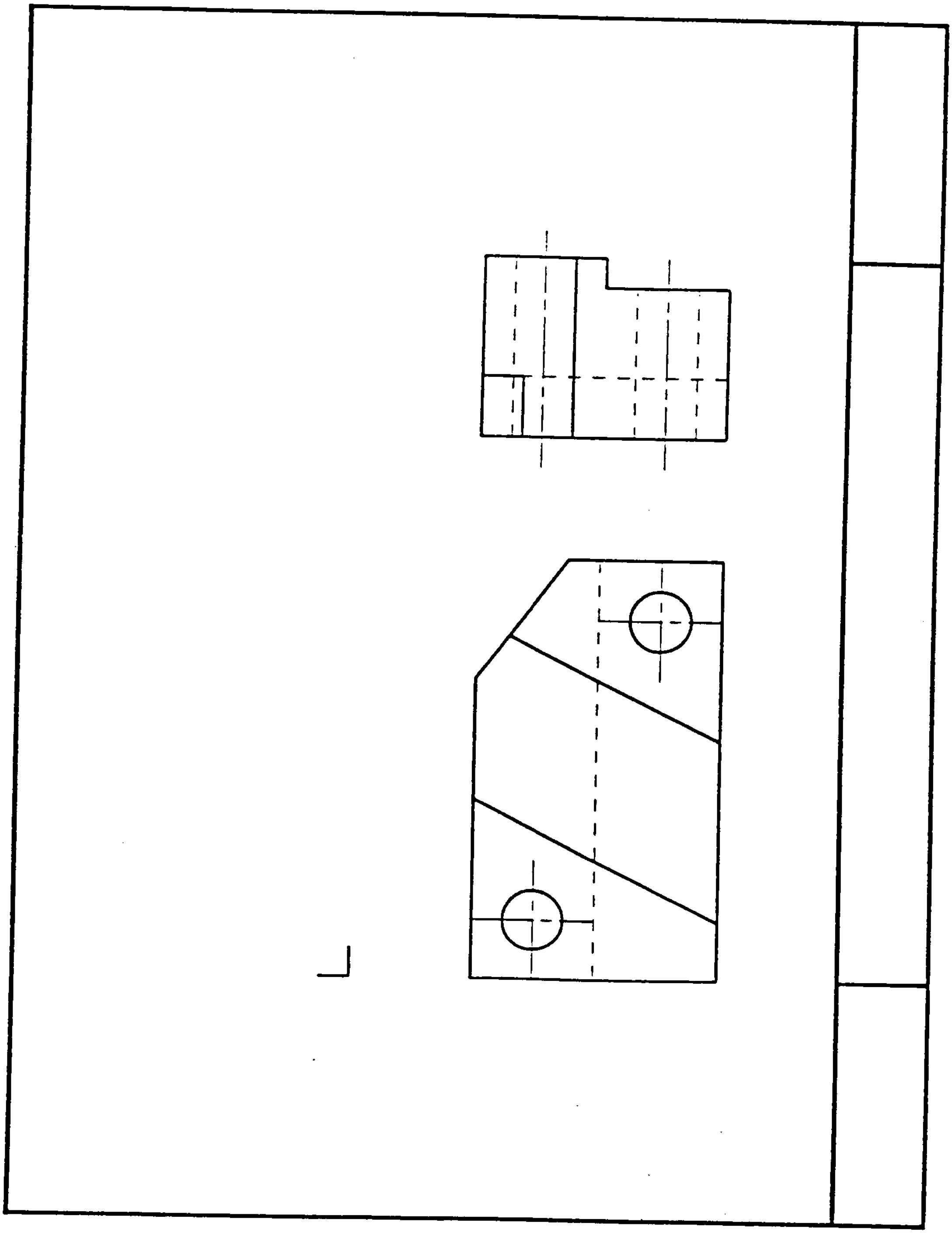


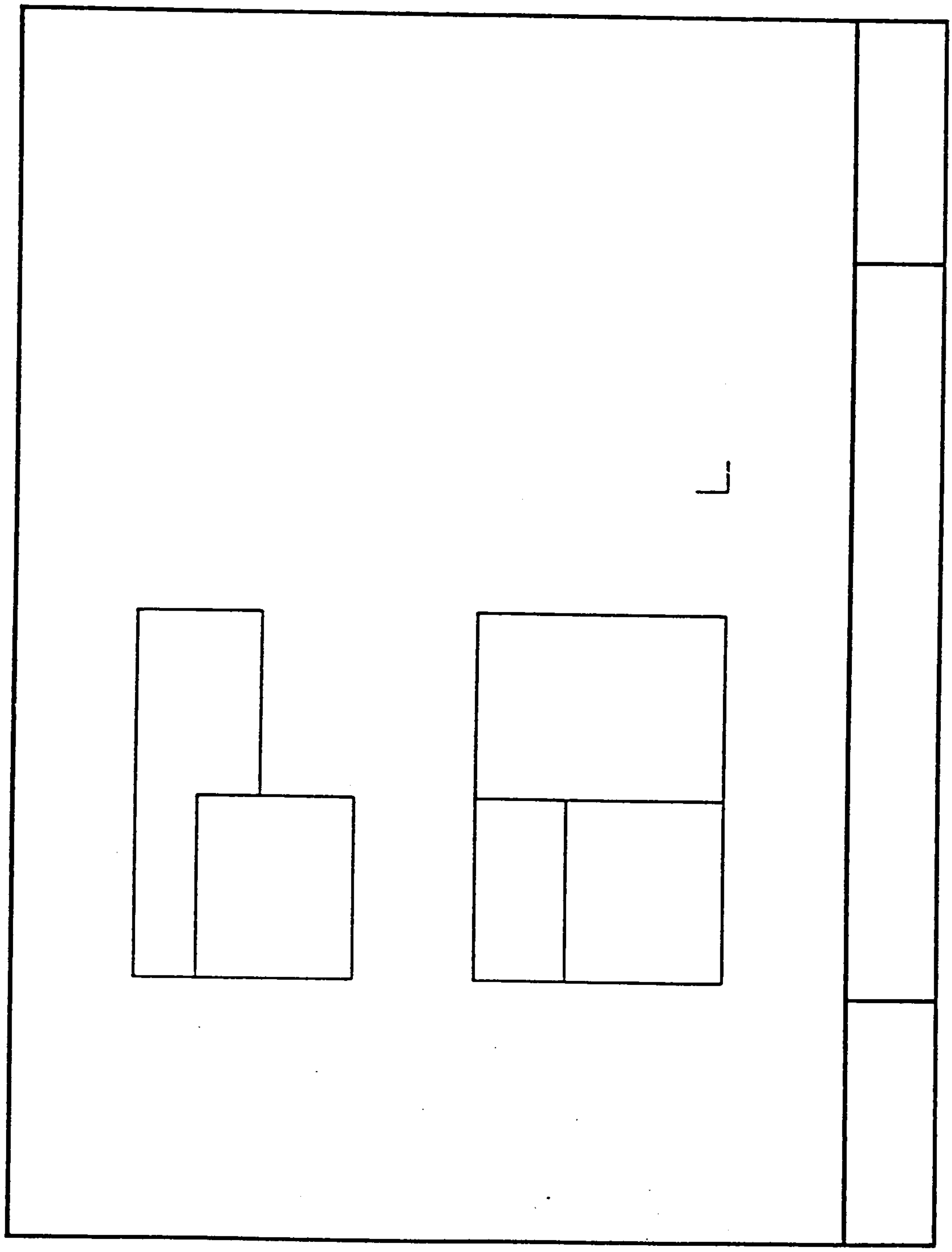


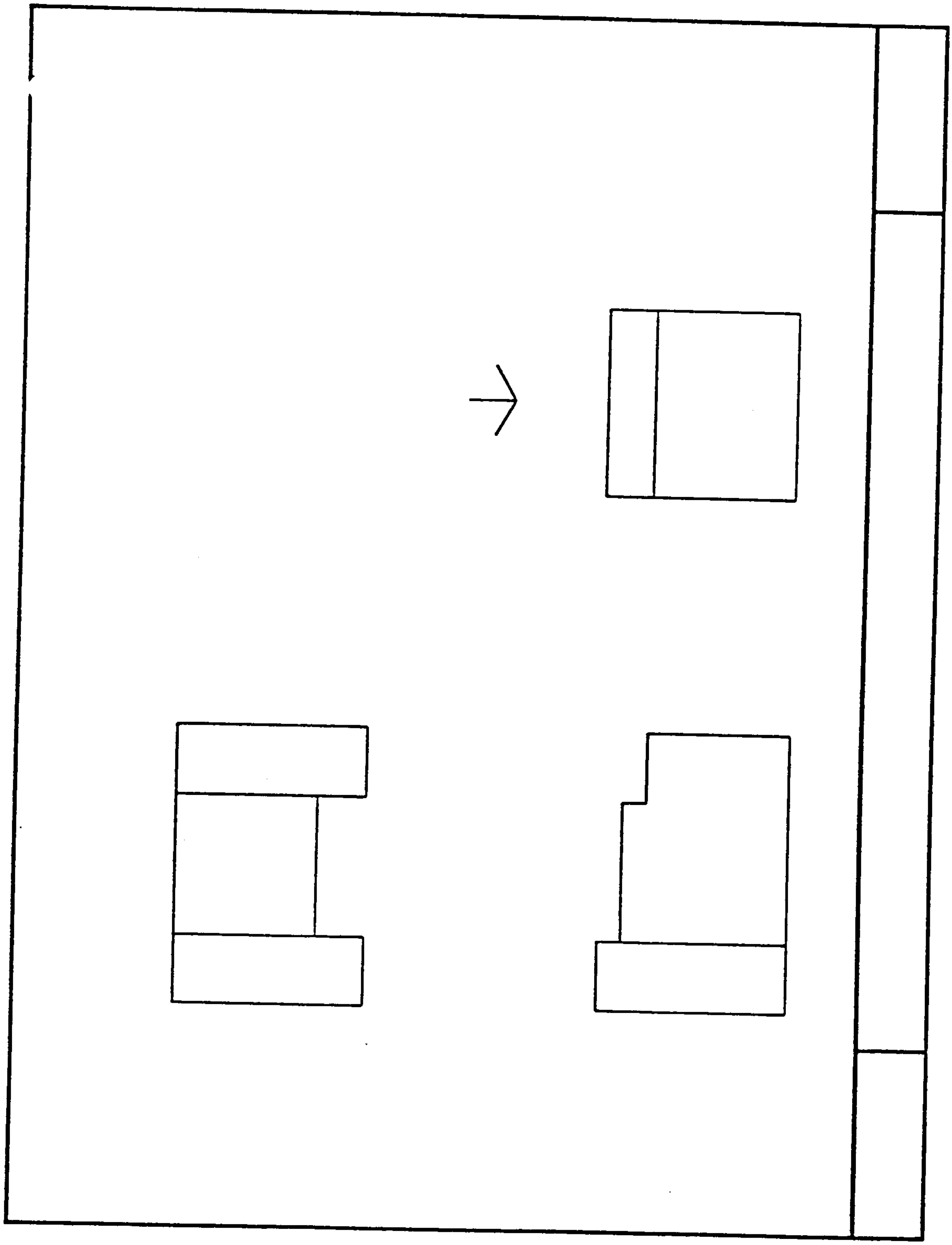


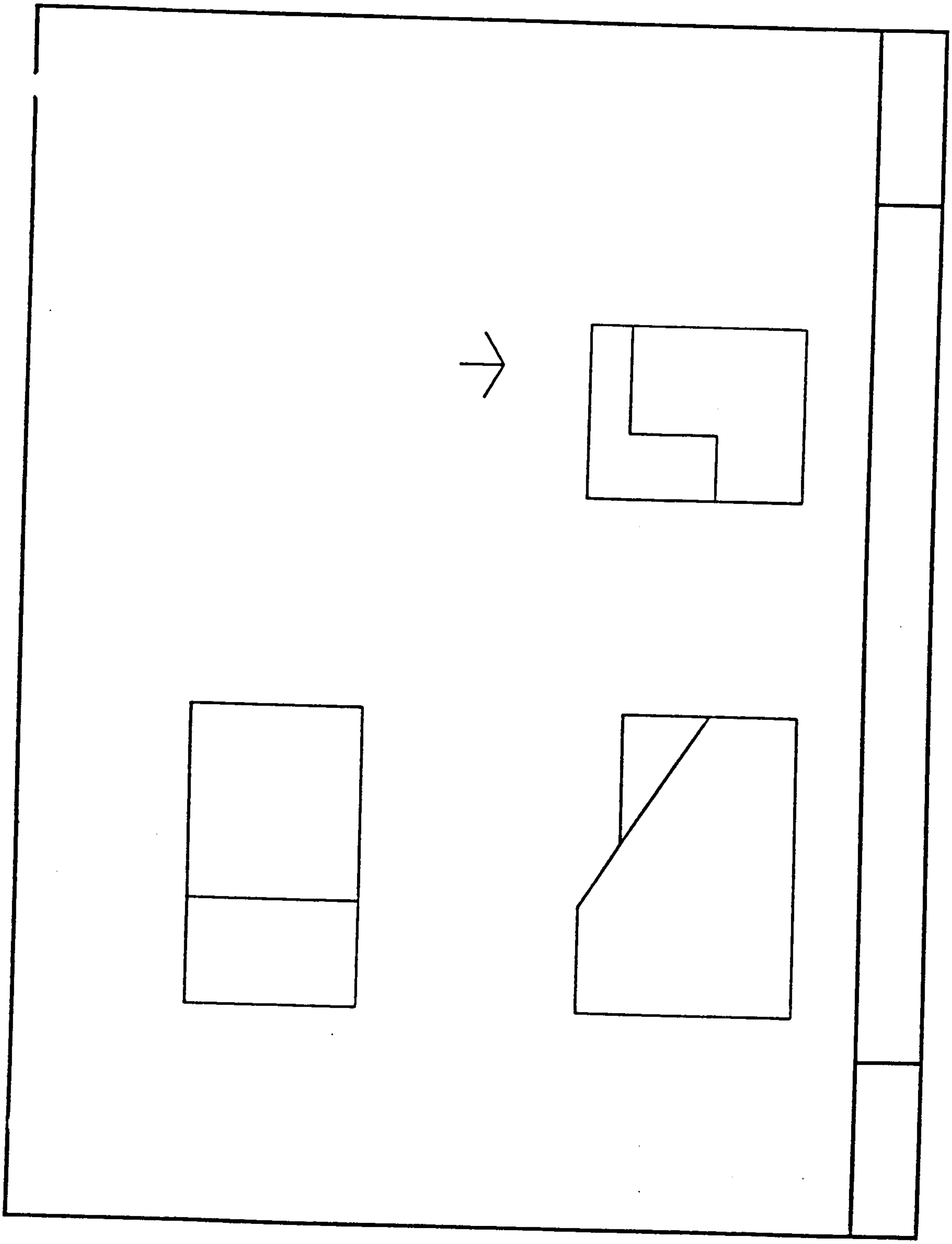


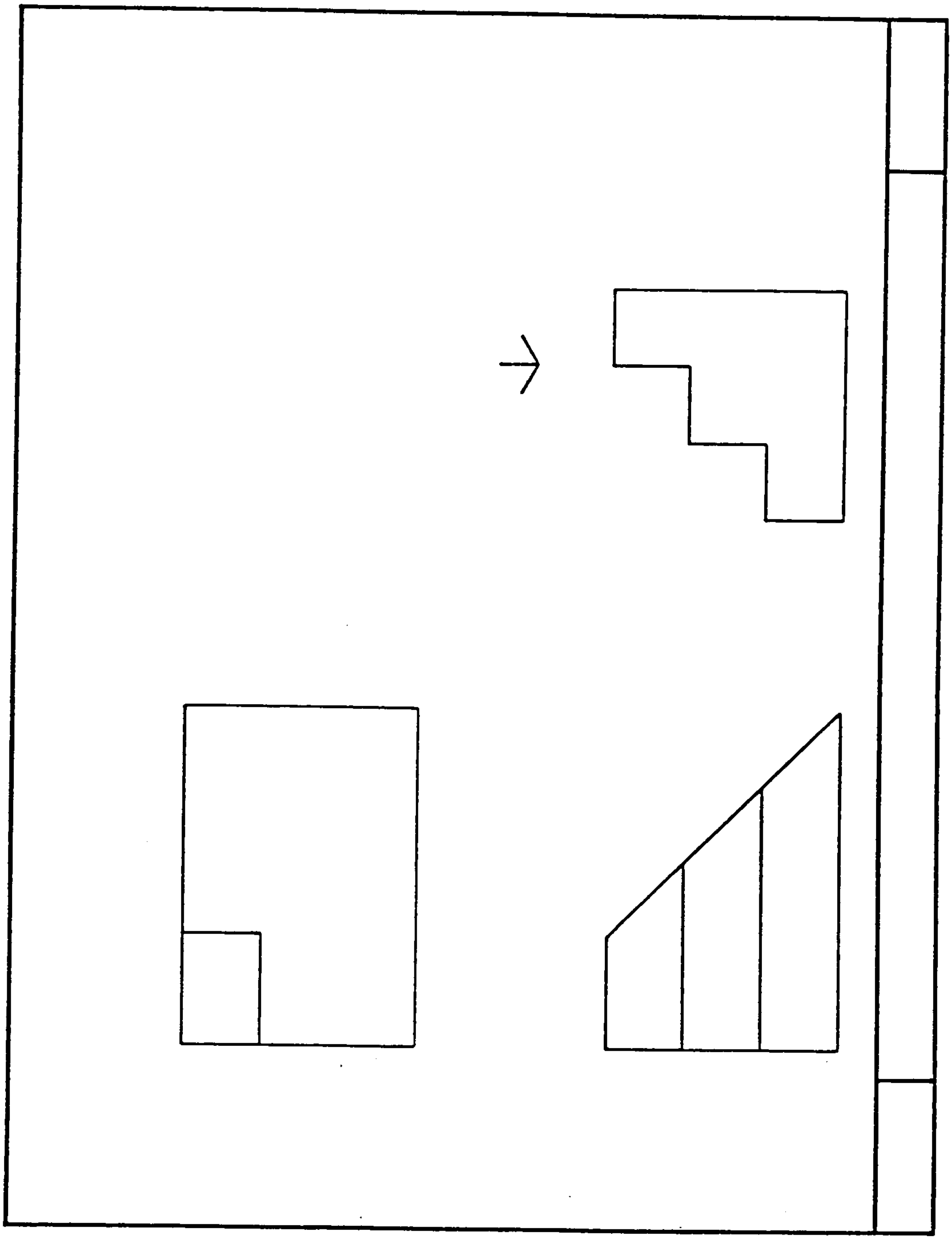


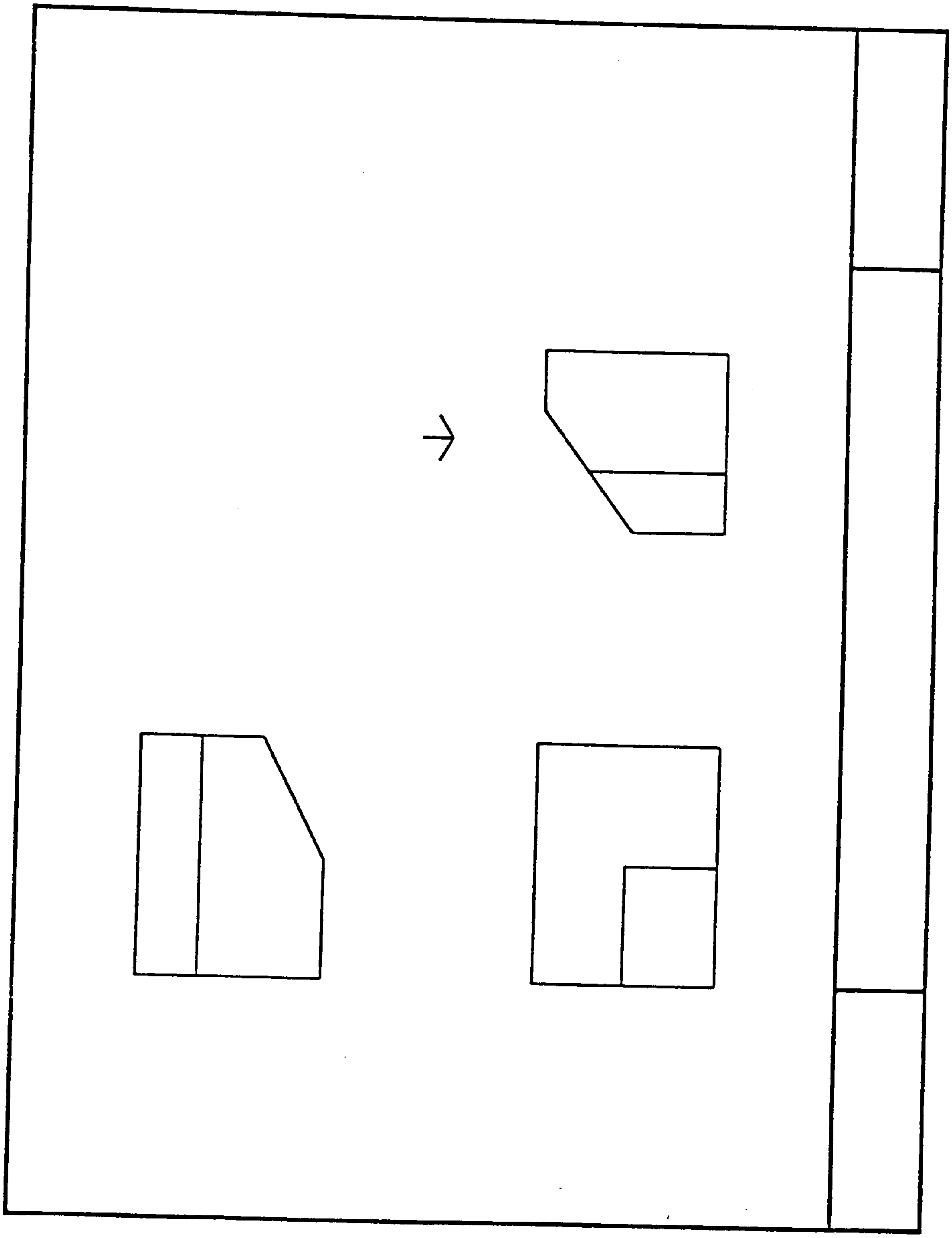


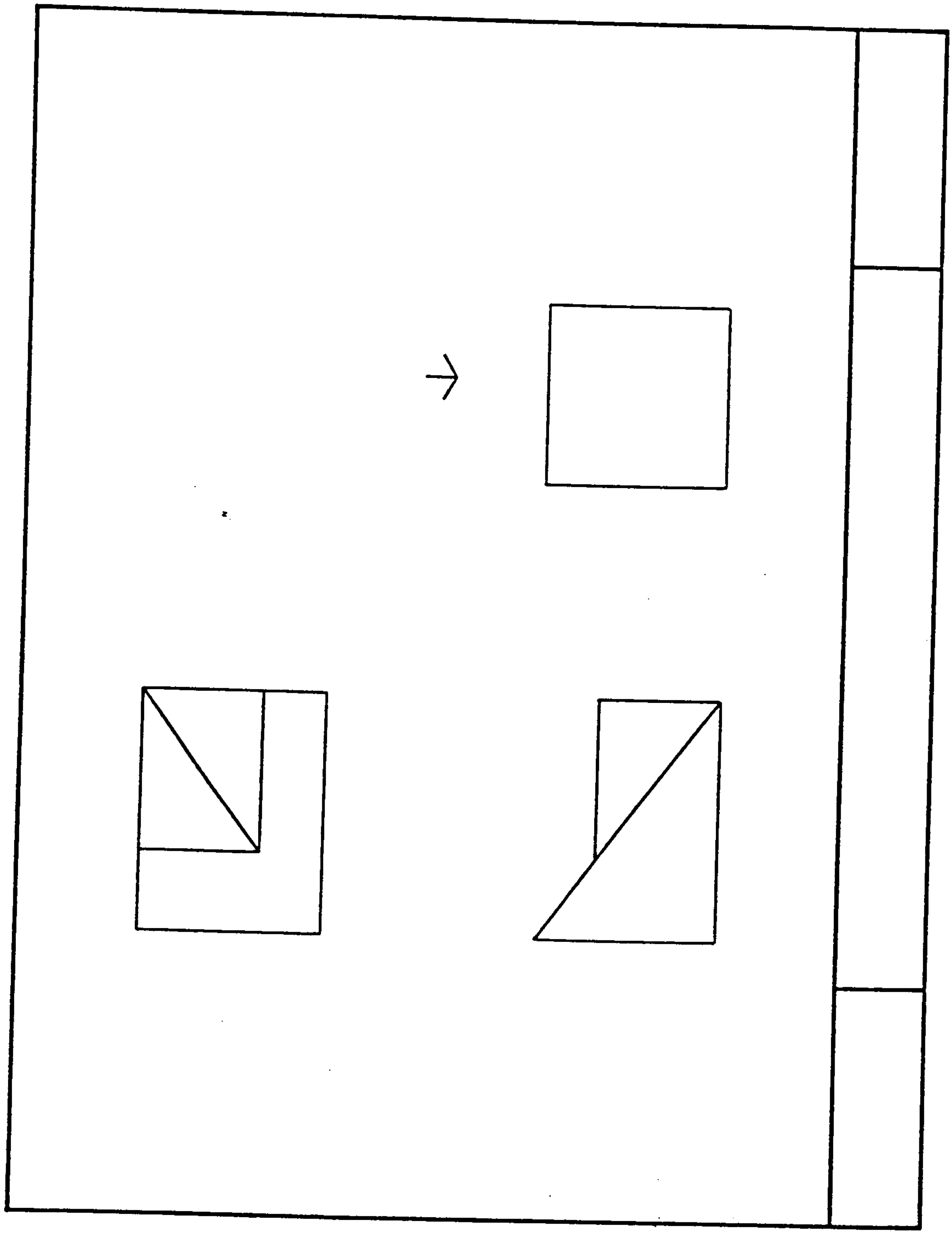


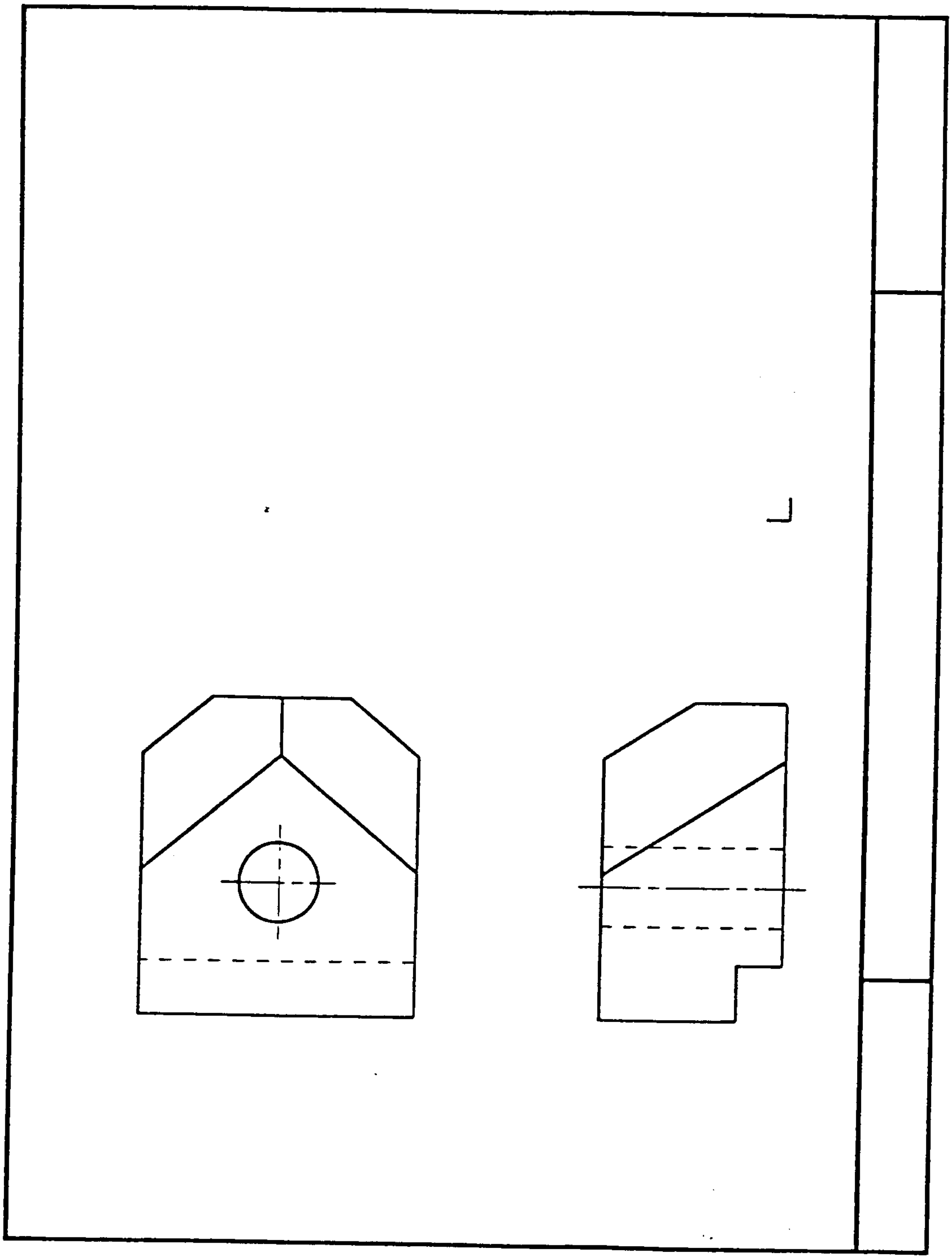


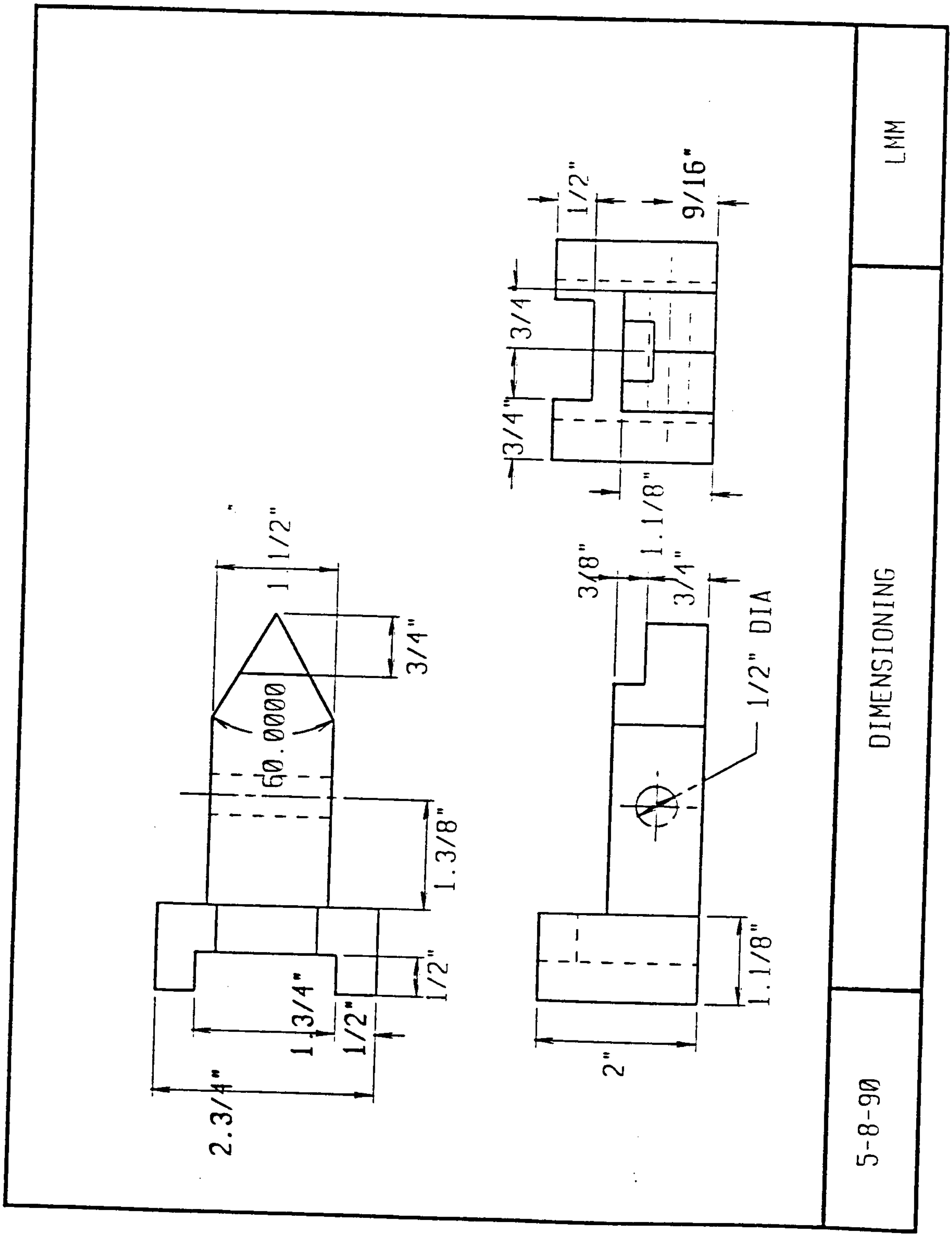




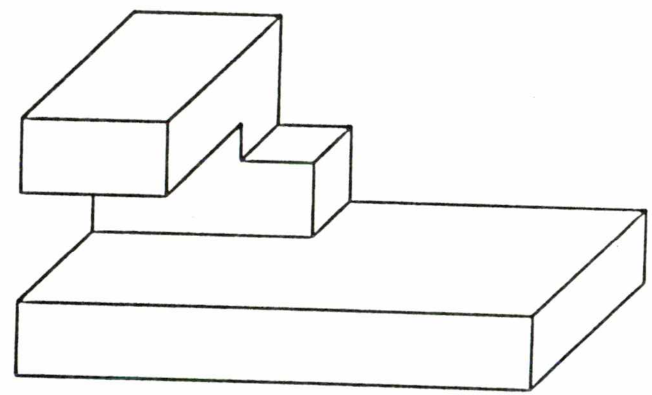




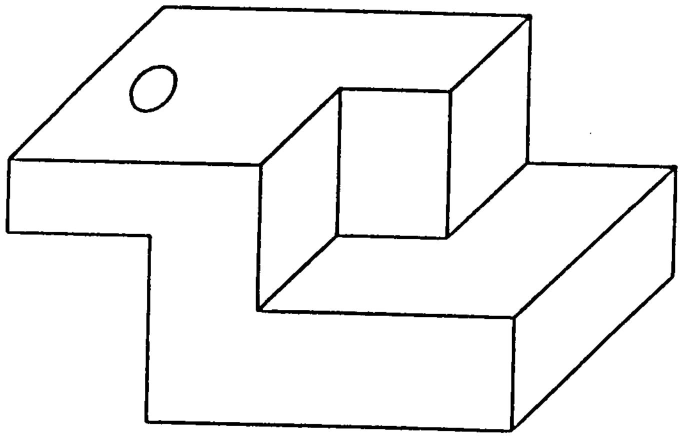




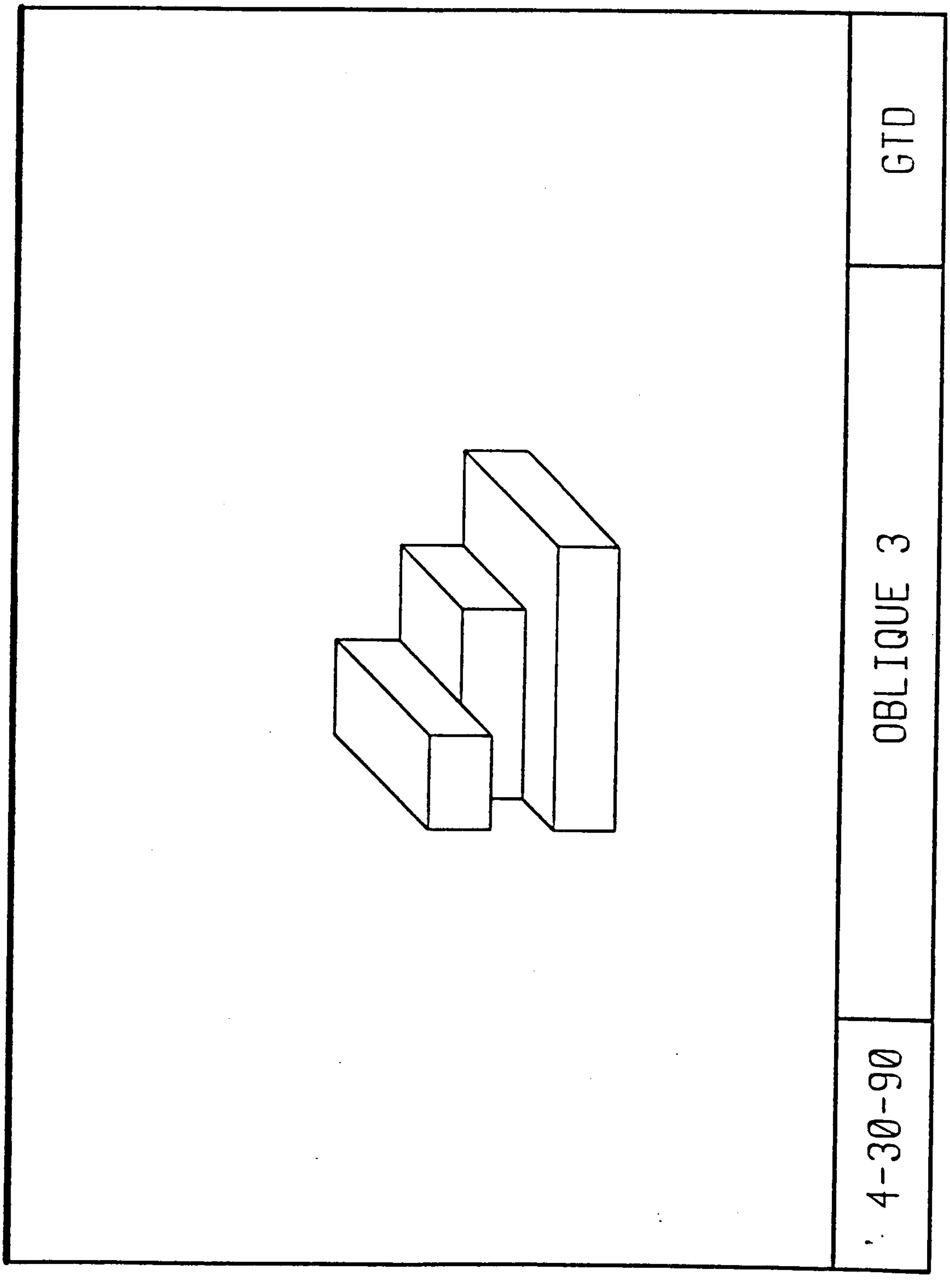
DIMENSIONING
5-8-90
LMM
2.3/4"
1.3/4"
1/2"
1/2"
1.3/8"
60.0000
3/4"
1 1/2"
2"
1.1/8"
1/2" DIA
3/8"
3/4"
1.1/8"
3/4"
3/4
1/2"
9/16"

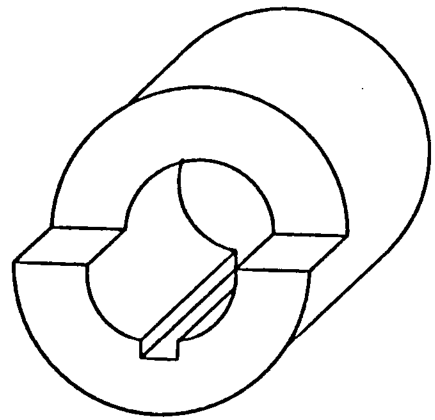


4-27-90	OBLIQUE 1	GTD

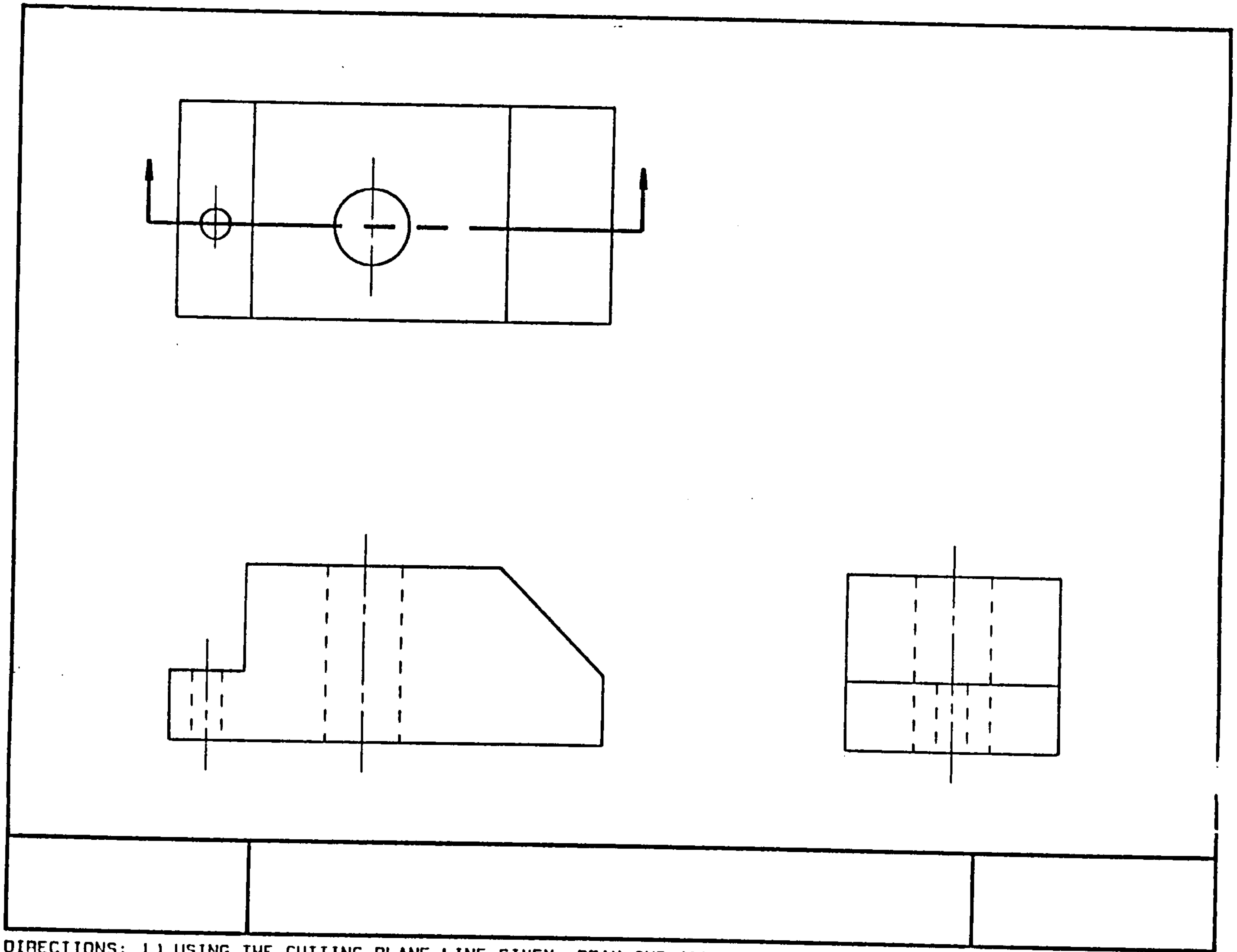


4-30-90	OBLIQUE 2	GTD

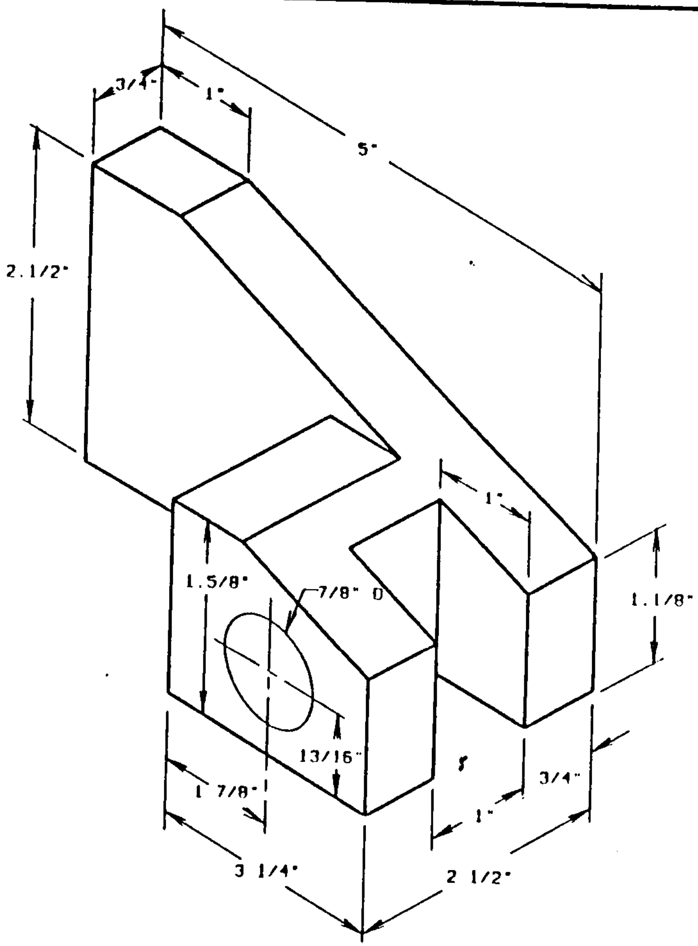

GTD
OBLIQUE 3
4-30-90



4-30-90	OBLIQUE 4	GTD

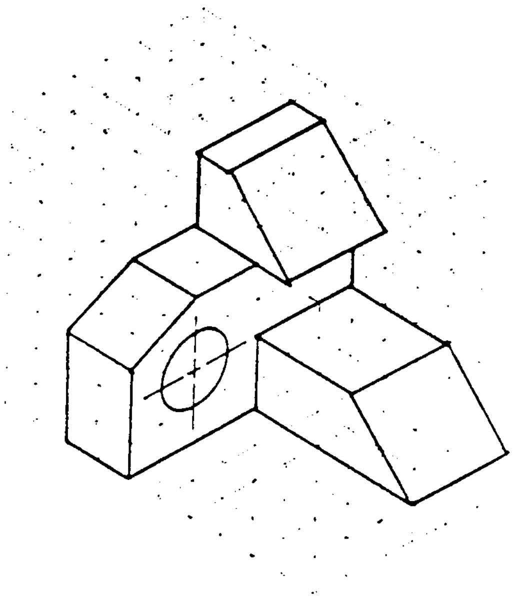


DIRECTIONS: 1) USING THE CUTTING PLANE LINE GIVEN, DRAW THE APPROPRIATE SECTIONED VIEW IN THIS EXISTING MULTIVIEW. 2) DIMENSION THE MULTIVIEW APPROPRIATELY. (TO THE CLOSEST 1/16")



DIRECTIONS: DRAW TO SCALE A THREE-VIEW MULTIIVIEW OF THE ABOVE ISOMETRIC

PROBLEM 2



DRAW MULTIVIEW OF THIS OBJECT.

Vita

VITA

Eddie Huston Butler was born in Marion, Kentucky on October 4, 1947. He attended elementary schools in that town and was graduated from Crittenden County High School in June 1965. The following January he entered Murray State University, and in January 1971 he received a Bachelor of Science Degree in Industrial Education. He taught industrial arts at Meadowbrook Junior High School, Orlando, Florida from September 1971 to June 1983. He returned to Murray State to complete a Master of Science in Industrial Education in May, 1984. Staying at Murray State, he taught on a one-year temporary appointment. In August 1985, he took a teaching position in the Department of Science, Math, and Technology at Adams State University, Alamosa, Colorado.

After teaching industrial education for one year, he returned to The University of Tennessee, Knoxville to pursue a Doctorate of Education in the Department of Technological and Adult Education. After completing the coursework and being admitted to candidacy, he worked for the State of Tennessee as a Curriculum Writer, developing and implementing high school vocational curriculum guides across the state.

In August 1988 he accepted a position in the Department of Technology, Appalachian State University, where he presently teaches drafting and design and is involved with the teacher education programs in North Carolina. He received the Doctorate of Education in August 1991.

The author is the trustee for Epsilon Pi Tau, Gamma Epsilon chapter. He is a member of the International Technology Education Association, the American Vocational Association, the Council of Technology Teacher Educators and is President of the North Carolina Council of Technology Teacher Educators. He is also a Major in the U.S. Army Reserves and is assigned to the Office of the Chief of Public Affairs, the Pentagon, Washington, D.C.