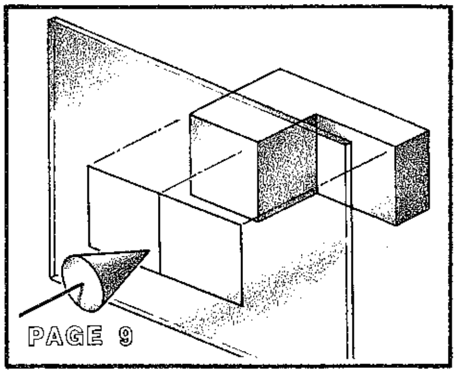
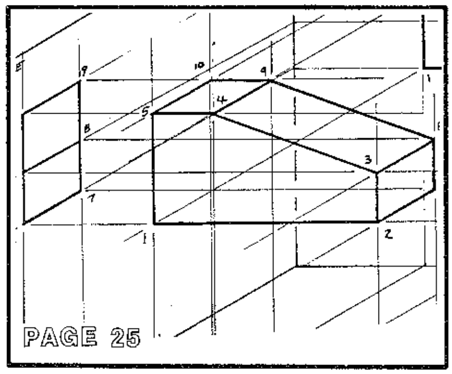
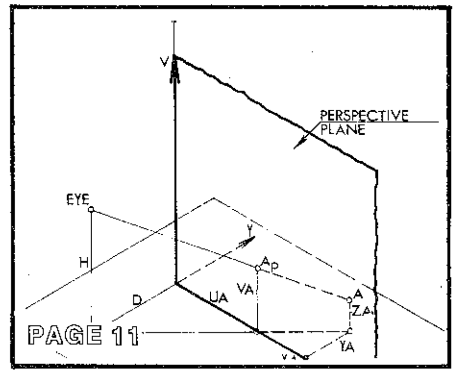


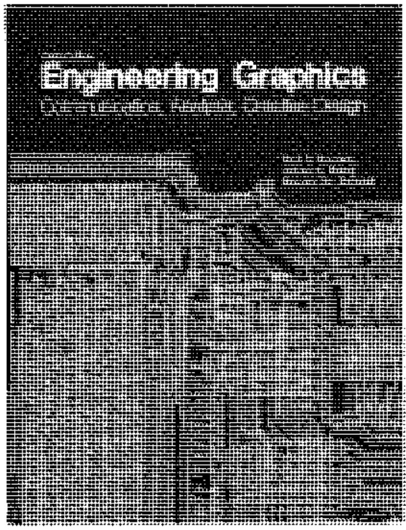




ENGINEERING DESIGN GRAPHICS JOURNAL

SPRING 1983 VOLUME 47 NUMBER 2

ENGINEERING DESIGN GRAPHICS DIVISION



ENGINEERING GRAPHICS:

Communication, Analysis, Creative Design, Sixth Edition

by Paul S. DeJong, James S. Rising, and
Maurice W. Almfeldt
Iowa State University

1983/512 pages/paper/$19.95
ISBN 0-8403-2725-0

The newest edition of **ENGINEERING GRAPHICS** is, as always, a motivating, concise, readable, and readily adaptable textbook. Material has been updated wherever necessary, and the many beneficial suggestions of past users have been incorporated.

NEW MATERIAL
Computer Graphics and its associated technologies are discussed in relation to their increasing importance as a drawing and design tool.
Metrication is emphasized even further in this edition. The proper use of the SI system is stressed, and fasteners are treated as the focus of many areas and supplemented where necessary by their common-unit counterparts. Metric dimensions and units are used as the basis for illustration and problem layout.
Standards Changes are included whenever possible, especially in the area of dimensioning.
New Illustrations and Problems are introduced to help students learn the material.

CONTENTS
Tools of Communication/ Orthographic Projection and Space Geometry/ Presentation of Data/ Description of Parts and Devices/ Pictorial Drawing/ Design Synthesis and Graphical Applications/ Advanced Graphical Topics/ Reference and Data/ Appendix/ Bibliography/ Index

ENGINEERING GRAPHICS will help your students develop the professional literacy every engineer needs in making clear sketches and using and interpreting drawings. Order your complimentary copy for adoption consideration and you will agree. Just complete the attached coupon and mail it today.

Yes, please send me a complimentary copy of **ENGINEERING GRAPHICS: Communication, Analysis, Creative Design, Sixth Edition,** by Paul S. DeJong et al.

Course No. & Name ______________________

____

Enroll./sem./qtr. ______________________

Name ______________________

Affiliation ______________________

Address ______________________

City ______________________

State ______________ ZIP __________

Kendall/Hunt Publishing Company
2460 Kerper Boulevard · P.O. Box 539 · Dubuque, Iowa 52001

7034

CALENDAR

ASEE ANNUAL CONFERENCES

1983 - Rochester Institute of Technology
Rochester, New York

1984 - Salt Lake City, Utah

EDGD MID-YEAR MEETINGS

1984 - Pittsburg, Penneylvania

1985 - Kansas City, Missouri

ENGINEERING DESIGN GRAPHICS JOURNAL is published - one volume per year, three numbers per volume, in Winter, Spring, and Fall - by the Engineering Design Graphics Division of the American Society for Engineering Education, for teachers and industrial practitioners of Engineering Graphics, Computer Graphics, Design Graphics, and Creative Design.

The views and opinions expressed by the individual authors do not necessarily reflect the editorial policy of the ENGINEERING DESIGN GRAPHICS JOURNAL or of the Engineering Design Graphics Division of the ASEE. The editors make a reasonable effort to verify the technical content of the material published; however, final responsibility for opinions and technical accuracy rests entirely upon the author.

YEARLY SUBSCRIPTION RATES:

U.S., Mexico, Canada	
ASEE-EDG members	$ 1.50
ASEE but not EDG members	$ 3.00
Non-members	$ 5.00
Foreign subscribers	$10.00

SINGLE COPY RATES:

U.S., Mexico, Canada	
ASEE-EDG members	$ 1.00
ASEE but not EDG members	$ 1.50
Non-members	$ 2.00
Foreign subscribers	$ 3.50

BACK ISSUES are available at single copy rates (prepaid) and are limited in general to numbers published within the past six years.

Subscription expiration date (last issue) is printed in upper right corner of mailing label, W83 for Winter 1983, S83 for Spring 1983, etc.

ENGINEERING DESIGN GRAPHICS JOURNAL OBJECTIVES:

The objectives of the JOURNAL are:

1. To publish articles of interest to teachers and practitioners of Engineering Graphics, Computer Graphics, and subjects allied to fundamentals of engineering.

2. To stimulate the preparation of articles and papers on topics of interest to its membership.

3. To encourage teachers of Graphics to innovate on, experiment with, and test appropriate techniques and topics to further improve the quality of and modernize instruction and courses.

4. To encourage research, development, and refinement of theory and applications of engineering graphics for understanding and practices.

DEADLINES FOR AUTHORS AND ADVERTISERS

The following deadlines for submission of articles, announcements, or advertising for the three issues of the JOURNAL are:

Fall	September 15
Winter	December 1
Spring	February 15

STYLE GUIDE FOR JOURNAL AUTHORS:

The Editor welcomes articles submitted for publication in the JOURNAL. The following is an author style guide for the benefit of anyone wishing to contribute material to the ENGINEERING DESIGN GRAPHICS JOURNAL. In order to save time, expedite the mechanics of publication, and avoid confusion, please adhere to these guidelines.

1. All copy is to be typed, double spaced, on one side only, on white paper, using a black ribbon.

2. All pages of the manuscript are to be consecutively numbered.

3. Two copies of each manuscript are required.

4. Refer to all graphs, diagrams, photographs, or illustrations in your text as Figure 1, Figure 2, etc. Be sure to identify all material accordingly, either on the front or back of each. Illustrations cannot be redrawn; they are reproduced directly from submitted material and will be reduced to fit the columnar page. Accordingly, be sure all lines are sharply drawn, all notations are legible, reproduction black is used throughout, and that everything is clean and unfolded. Do not submit illustrations larger than 198 x 280 mm. If necessary make 198 x 280 mm or smaller photocopies for submission.

5. Submit a recent photograph (head to chest) showing your natural pose. Make sure your name and addres is on the reverse side. Photographs, along with other submitted material, cannot be returned unless postage is prepaid.

6. Please make all changes in your manuscript prior to submitting it. Check carefully spelling, structure, and clarify to avoid ambiguity and maximize continuity of thought. Proofreading will be done by the editorial staff. Galley proofs cannot be submitted to authors for review.

7. Enclose all material unfolded in a large size envelope. Use heavy cardboard to prevent bending.

8. All articles shall be written using Metric-SI units. Common measurements are permissible only at the discretion of the editorial staff.

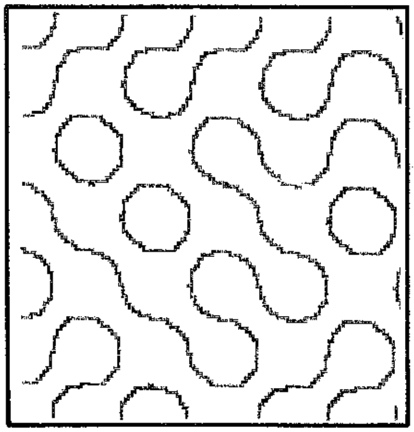
9. Send all material, in one mailing to: Jon M. Duff, Editor, Department of Engineering Graphics, The Ohio State University, 2070 Neil Avenue, Columbus, Ohio 43210.

REVIEW OF ARTICLES

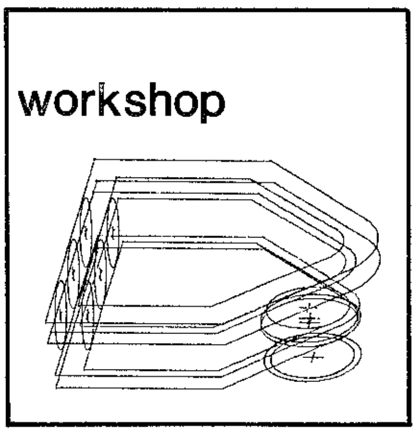
All articles submitted will be reviewed by several authorities in the field associated with the content of each paper before acceptance. Current newsworthy items will not be reviewed in this manner, but will be accepted at the discretion of the editors.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
ENGINEERING DESIGN GRAPHICS JOURNAL

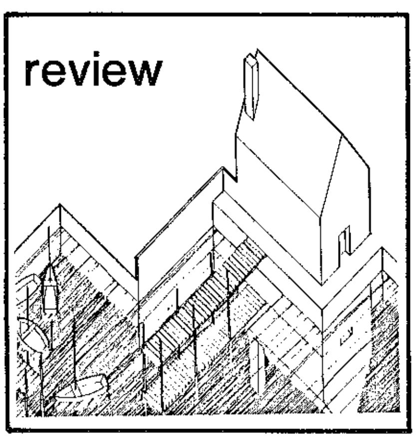
SPRING 1983 VOLUME 47 NUMBER 2



PAGE 31



PAGE 7

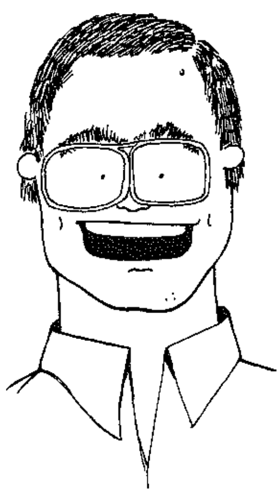


PAGE 6

DEPARTMENTS

FEATURES

EDITOR'S PAGE



I'm going to apologize to my professors at Purdue, here in public, so that the errors of my ways can be exposed in full. As a student, young and brash, I advocated the de-emphasis of descriptive geometry in the graphics curriculum. Now that I am older and wiser, I can approach the subject of descriptive geometry's importance from hopefully a more mature position.

I know now that descriptive geometry is the most important applied orthographic tool. Employers from Northrop Aviation to the Timken Company bluntly state that skill in descriptive geometry separates marginal from superior employees.

There has been a general de-emphasis of descriptive geometry during the past ten years, both in traditional survey courses in engineering graphics and in separate descript offerings as well. This was no doubt due in part to the uninformed, such as I was, working their short-sighted way.

It would seem to me that most traditional graphics subject matter, except orthographic shape description, would be suspect when compared with the developmental benefit of descript. I would sacrifice lettering, sectioning, dimensioning, empirical equations, and graphing if it meant keeping descriptive geometry. The analysis skills that are developed in solving descript problems, as well as the conceptualization processes, are at the core of what is needed to successfully work in the CAD/CAM/CADD environment. But not everything is rosy in descript land.

Let me share with you what I feel is the primary reason descript never made much sense to me as a student. Of course, I had little experience in "the real world" so the geometry wasn't exactly familiar. But beyond this, it was a conflict between view-projection and cutting plane intersections that retarded my understanding of the subject.

Auxiliary views were not views at all, rather they were projections of the views with but two of the orthographic dimensions evident in each of the views. Intersections, however, were real 3-D objects through which cutting planes were passed to reveal points of commonality. I just never understood why we used 2-D fold lines in auxiliary views and 3-D cutting planes in intersections. Then I was shown the light and the world for me was never the same.

all is not rosy in descript land

There is no reason to change one's thinking from 2D to 3D because orthographic is 3D, 24 hours a day*.

All descript should be direct-view experiences. Anything less diminishes the impact of the subject. For your review, a traditional projection theory article is presented on page 25 of this issue. Compare this to the reprinting from the 1954 Journal of Engineering Drawing on page 9.

I invite those of you in the Journal's readership who have a continuing interest in descriptive geometry to explore its place in modern graphical practice and theory. With your help, we just might determine its importance in light of the powerful graphical tools now available.

Professor Eldis O. Reed of the Department of Engineering Graphics at Ohio State died unexpectedly in December after a short illness. Many of you knew "Frenchy" through ASEE and the Society of Women Engineers to be a life-long supporter of engineering and graphics education. His teaching and experience, along with his laugh and smile, will be greatly missed.

*Thanks to Professor Richard Parkinson for his analysis of orthographic space.

DIVISION NEWS

ENGINEERING DESIGN GRAPHICS DIVISION

Papers are sought for the 1983-84 midyear meeting of the Engineering Design Division to be held in Pittsburgh, PA, in January 1984. Paper sessions will evolve around the topic of teaching techniques in design graphics education. Interesting and unique teaching experiments in design techniques in design graphics, incorporation of computer aided instruction, and programs of instruction in design graphics coordinated or supported by industry are sought. Send title and abstract of paper to James T. Weiss, P.O. Drawer E.G., University of Alabama, University, Alabama 35486. The deadline for abstracts is July 1, 1983.

NATIONAL MEETING

MONDAY, JUNE 20, 1983

1137 Creative Engineering Design Display Judges' Breakfast
7:00-8:00 a.m. 4-Cafeteria Breakfast, $6.00
Engineering Design Graphics Division
Moderator: Robert J. Foster, Pennsylvania State University
Orientation procedures will be presented to the judges of the Creative Engineering Design Display.

1237 Creative Engineering Design Display
8:00 a.m.-5:00 p.m. Clark Gymnasium Display
Engineering Design Graphics Division
Co-sponsor: Design in Engineering Education Division
Moderator: Robert J. Foster, Pennsylvania State University
Engineering design projects from the United States and Canada will be presented in an on-going display of creativity and ingenuity. These student projects will be judged and winners presented at the Annual Engineering Design Graphics Division Banquet.

1252 Counseling New Engineering Students
8:00-9:45 a.m. 12-3215 Symposium
Freshman Programs Committee
Co-sponsors: Engineering Design Graphics Division, Women in Engineering and Minorities in Engineering Committees
Moderator: Marianne Mueller, Ohio State University
Discussion of methods and programs for counseling new engineering students to assist them in making career choices. Panelists will briefly outline their techniques and the audience will be invited to join in the discussion.
Speakers:
William K. LeBold, Purdue University
Wayne R. Hager, University of Idaho
Ronald Glenn, Carnegie-Mellon University

1637 Changing Images in Engineering Graphics Instruction
4:00-5:45 p.m. 12-3215 Panel
Engineering Design Graphics Division
Co-sponsor: Freshman Program Committee
Moderator: Frank M. Croft, University of Louisville
During the past twenty years many changes have taken place pertaining to engineering graphics. Speakers will present the changes which have evolved at their institutions and make an attempt to project the future of engineering graphics.
Speakers:
Transformations in the Teaching of Engineering Graphics in the Past Quarter Century: Some Personal Observations,

TUESDAY, JUNE 21, 1983

2236 Creative Engineering Design Display
8:00 a.m.-5:00 p.m. Clark Gymnasium Display
Engineering Design Graphics Division
Co-sponsor: Design in Engineering Education Division
Moderator: Robert J. Foster, Pennsylvania State University
Engineering design projects from the United States and Canada will be presented in an on-going display of creativity and ingenuity. These student projects will be judged and the winners presented at the Annual Engineering Design Graphics Division Banquet.

2552 Freshman Engineering Programs
2:00-3:45 p.m. 12-3105 Symposium
Freshman Programs Committee
Co-sponsors: Computers in Education and Engineering Design Graphics Divisions
Moderator: W. George Devens, Virginia Polytechnic Institute and State University
What should be included in a quality freshman engineering program? Viewpoints from representatives of two and four year institutions, public and private. Should the introductory

WEDNESDAY, JUNE 22, 1983

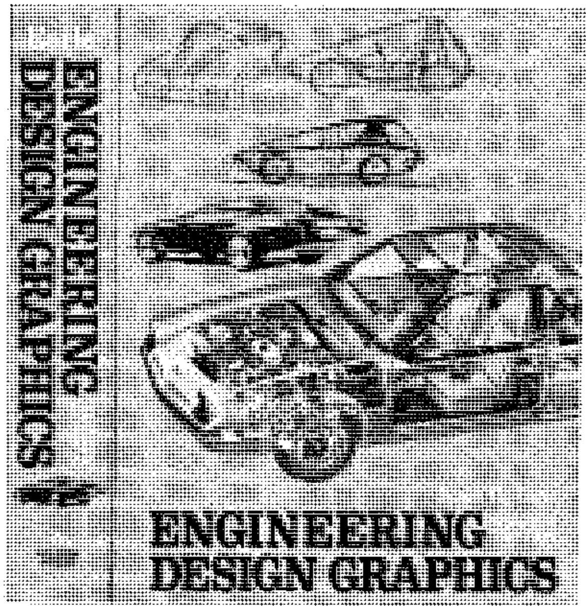
3237 Creative Engineering Design Display
8:00 a.m.-12:00 noon Clark Gymnasium Display
Engineering Design Graphics Division
Co-sponsor: Design in Engineering Education Division
Moderator: Robert J. Foster, Pennsylvania State University
Engineering design projects from the United States and Canada will be presented in an on-going display of creativity and ingenuity.

3269 Open Forum: The Pros and Cons of Engineering Graphics
8:00-9:45 a.m. 6-3244 Discussion Group
Mechanics Division
Co-sponsor: Engineering Design Graphics Division
Moderator: Virgil Snyder, Michigan Technological University
An open forum for the discussion of the role of engineering graphics in engineering education. After introductory comments by two speakers, the floor will be opened for discussion. Come and speak your piece!
Speakers:
The Cons of Engineering Graphics—Jerald M. Henderson, University of California-Davis
The Pros of Engineering Graphics—William B. Rogers, Virginia Polytechnic Institute and State University

3437 Engineering Design Graphics Division Annual Business Luncheon
12:00-1:45 p.m. 4-Clark Dining Room Luncheon $7.25
Engineering Design Graphics Division
Moderator: Arvid Eide, Iowa State University
Open business meeting.

3537 Images from Afar: Engineering Graphics in the People's Republic of China
2:00-3:45 p.m. 12-3215 Lecture
Engineering Design Graphics Division
Co-sponsor: International Division
Moderator: Steve M. Slaby, Princeton University
An overview of engineering graphics, descriptive geometry instruction in the People's Republic of China, and a preview of the Second Annual International Conference on Descriptive Geometry.
Speakers:
Steve M. Slaby, Princeton University
Engineering Graphics and Descriptive Geometry is Alive and Well in the People's Republic of China—Zhu Fu-Xi, South China Institute of China

IN REVIEW



James H. Earle
Engineering Design Graphics
Fourth Edition
Addison-Wesley Publishing Company

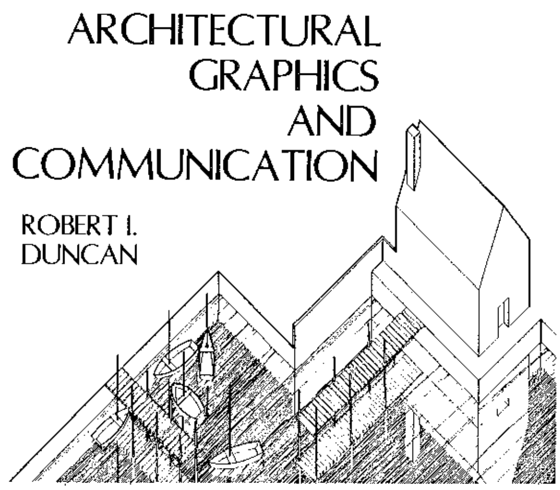
Engineering Design Graphics, Fourth Edition, is a comprehensive text that, according to the author, is a major revision of the third edition. The book contains solid coverage of all traditional topics of engineering drawing and graphics from drawing instruments and lettering through dimensioning, tolerancing, and working drawings. Rather than provide us with just another graphics text, however, Earle has provided an eight chapter foundation detailing the engineering design process from problem identification through refinement and analysis to implementation.

Supplementing the core chapters on engineering drawing principles and practices are chapters on such specialities as welding, pipe drafting, electric/electronics drafting, and computer graphics. Engineers will be pleased to see coverage of descriptive geometry, graphs, and graphical mathematics.

Every page of the book is packed with drawings, illustrations, and/or photographs which illustrate the concepts presented. A second color of ink has been used to highlight or emphasize points being presented. As we have come to expect from Earle, the illustrations are attractive and up-to-date and should do much to both help motivate and teach our students.

The first chapter in the book provides an excellent overview of the various engineering disciplines and should be required reading for all counselors and advisors of prospective engineers. All in all, Earle is to be congratulated on another fine contribution to engineering graphics.

Reviewed by: Leonard O. Nasman
Assistant Professor
Department of Engineering Graphics
The Ohio State University



ROBERT DUNCAN
ARCHITECTURAL GRAPHICS
AND COMMUNICATION
Architectural Graphics
and Communication Problems

The intent of this book is to provide the beginning architectural student with a basic knowledge of engineering graphics and its usefulness as it pertains to the field of architecture.

The content of this book includes basic orthographic projection, via lines, planes, and solid objects, descriptive geometry, and pictorial drawing, via isometric, oblique, and perspective orientations.

Additional coverage includes orthographic and perspective shades and shadows and a light touch of graphic construction and intersections of planes and solids.

The primary mode of instruction seems to be through illustrations and diagrams with supplemental text material. The material is well organized and presented in a way that eliminates misunderstanding of important topics. The reading level would be appropriate for upper high school students.

This text would be appropriate for individuals seeking a very general coverage of engineering graphics as it pertains to architectural applications. Topics such as space utilization and structural drawing and sketching are covered using basic graphical methods.

Technical details - the how to's - such as specific treatments of residential or commercial construction, sectional elevations, plan layouts, exterior elevations, data tables, etc. that one might expect to find in an architectural graphics text are not included.

A problem book accompanies the text as an aid to instruction. The problem book parallels the text and contains worksheets covering all of the text topics. The problem book seems to provide very good coverage of the text material.

In summary, this text and problem book combination will provide a good general coverage of architectural graphics and communication.

Reviewed by: J. Douglas Frampton
Lecturer
Department of Engineering Graphics
The Ohio State University

PUZZLE

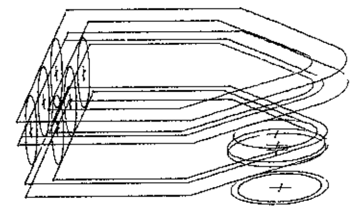
TANGENT CIRCLES PROBLEM

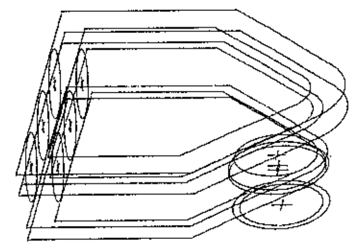
by: William P. Harrison, Jr.
Virginia Polytechnic Institute and State University

GIVEN: Any circle of radius r and two points A and B all located arbitrarily within a plane but such that line AB nowhere intersects the given circle.

continued on page 24

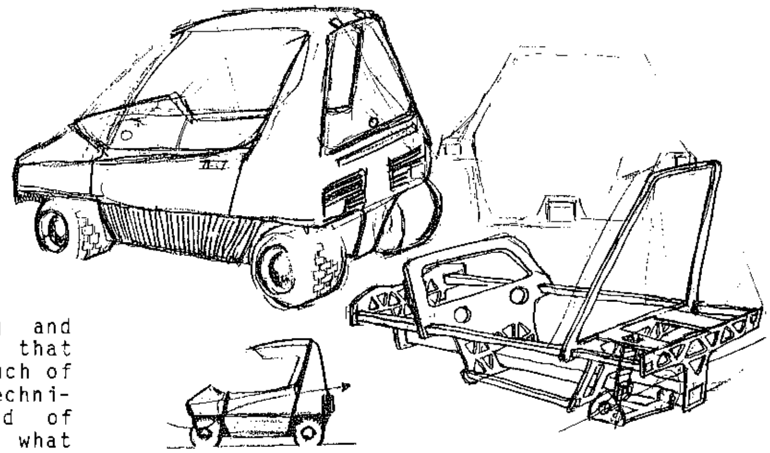
Workshop at Ohio State





A workshop in computer graphics will be given by the Engineering Design Graphics Division of the Ohio State University Department of Engineering Graphics on August 22 - 26, 1983. This workshop will be devoted to (1) discussions of course content and curriculum development for interactive computer graphics courses for engineering technology and engineering; (2) available computing systems and software; and (3) software development. It is expected that several small systems will be available for inspection and use by the participants. The OSU Engineering Graphics Department interactive graphics system will be available for participant use. Programming experience is desirable but NOT required. For aditional information, contact R. D. LaRue, Engineering Graphics OSU, 2070 Neil Ave, Columbus, OH 43210. or phone (614)422-2493. Another contact is Louise Larew, Continuing Education OSU, Fawcett Center, 2400 Olentangy River Road, Columbus, OH 43210 , phone (614)422-8571.

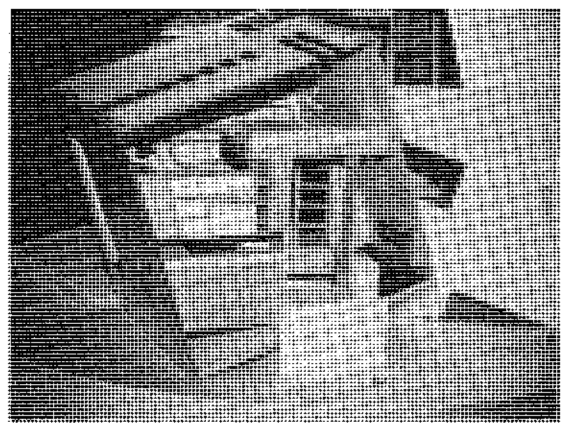
Industrial Design



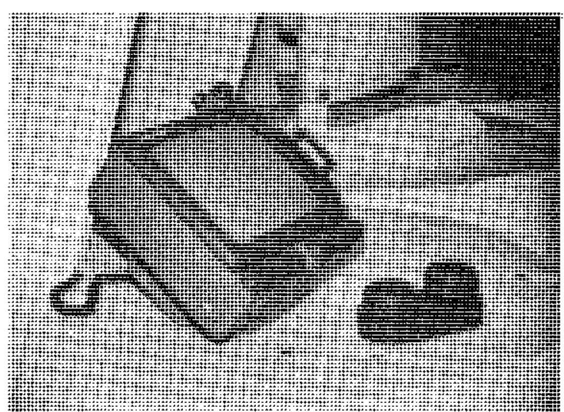
Many teachers in engineering and engineering technology are unaware that a field of study exists in which much of the most sophisticated graphic techniques are requisite. The field of industrial design combines much of what engineers do in a non-mathematical sense with what visual artists do in a technical sense. It is the ideal occupation for someone who has strong technical interests but who has more of a visual/graphic orientation than that normally expected of an engineer.

Many find their way into the practice of industrial design from other technical fields. However, there are programs of study specializing in three general areas of concentration:

1. Product Design
2. Graphic Design
3. Space or Environmental Design



Industrial designers use drawing as a thinking tool, to control the implementation of their designs, and to sell their designs to others. Their drawing has to do visually what mathematical models or equations do for the engineer. The closer to reality is the engineer's equation, the better the engineer can predict the performance of his design. Likewise, the closer to reality are the industrial designer's drawings, the better the designs can predict the performance of his design.



Industrial designers will become prime users of CAD systems. This is due to two factors: 1) design systems have many of the underlying design and engineering principles established in the programming, requiring less continual engineering calculations, and 2) industrial designers are better equipped to make decisions as to the visual or graphic correctness of the design because this is what they are trained to do.

In summary, industrial designers complement engineers and engineering technologists by providing a greater understanding of the visual variables which enter into design decisions.

Jon M. Duff, Editor EDGJ

Taken from the Journal of Engineering Drawing, Vol. 18, No. 3, November, 1954.

On the difference between projection and the direct view

WHY THE DIRECT METHOD
OF DESCRIPTIVE GEOMETRY
(An Older Fogey Strikes Back)
by

Professor Emeritus George J. Hood
University of Kansas

In the May, 1954, Number of the Journal of Engineering Drawing, Professor Henry C.T. Eggers asks: "What do you mean 'Direct' or, An Old Fogey Strikes Back."

An Older Fogey now answers his question. Professor Eggers says he is 61. I am 76. He has taught 35 years. I have taught for 46 years. That makes me an older fogey by 62.7 per cent. Or, is it only by 27 per cent?

Professor Eggers quotes Professor McNeary: "The gradual shift in the teaching of descriptive geometry by the indirect, or plane trace method, to the direct, or auxiliary view method, logically may be claimed to have been caused by the superior transferability of the direct method to engineering practice."

As to "the superior transferability of the direct method to engineering practice" there seems to be quite a general agreement. But the linking together of the words: "direct, or auxiliary view method," aptly illustrates a common misconception of the fundamental principles on which the direct method is based. Spoken and written statements made by some teachers of descriptive geometry indicate a belief that the basic purpose of the Direct Method is to make a general use of auxiliary views. That belief is erroneous. A careful reading of the first few chapters of the textbook on the Direct Method should make this clear.

The two Methods of Descriptive Geometry, Projection and Direct, are founded on two different basic ideas. Each method has its own basic principles, and each requires its own attitude of mind.

The Projection Method specifies that objects are projected on planes. It makes the use of various planes of projection, quadrants, ground lines, traces of planes, and projections on planes. These have no place in the Direct Method, nor are they used by the practicing engineer when he thinks about the structures that he visualizes, designs, and draws.

By the Direct Method, the visualized structure or object is viewed in any desired direction. The lines of sight are parallel. Each view of the object shows what the observer sees when he looks at the object. And, when reading the drawing, each view is visualized so that the object stands out as if it were the three-dimensional object itself. The view is never thought of as a flat projection on a plane. This direct way of thinking about the object and its views promotes thorough visualization and produces better designs.

The absence from the Direct Method of the projection idea, and of all the accompanying impediments of the Projection Method that stand in the way of thinking about the object itself, make the Direct Method direct. This method is now thirty and more years old. It was developed by the writer over a period of years while he was teaching the Projection Method.

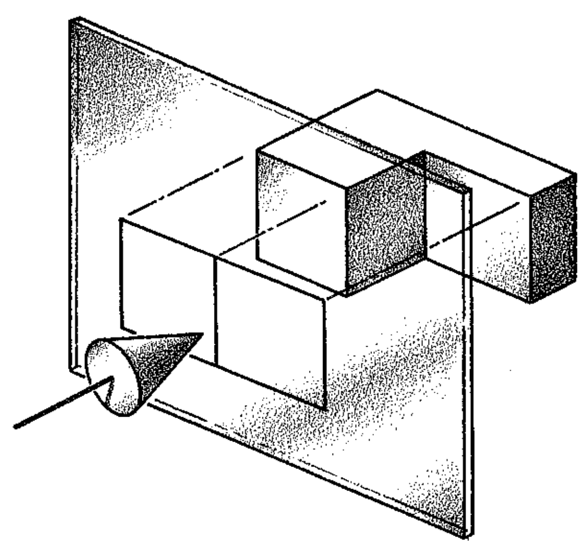


Figure 1 The plane projection method

Twenty years ago, Professor Thomas E. French wrote: "In the Direct Method the student looks directly at the object itself without the conscious intervention of projection planes." Now, as to the linking together of the words: "direct, or auxiliary view method." A projection, or view, is not a Method of Descriptive Geometry. A projection, or view, is but one of the elements of a method. We do not think, or speak of a "vertical projection method," or a "front view method." Likewise, there is no "auxiliary view method." The above quotation links together two dissimilar and incompatible terms.

And, how has it come about that the Direct Method has been considered by some to be an "auxiliary view method?" A teacher thumbs through the textbook on the Direct Method, without carefully reading the printed explanations of the fundamental ideas on which this method is based. He looks mainlv at the illustrations, and he notes a considerable use of auxiliary and oblique views. A reading of the text, however, will show that the greater use of auxiliary views is not a basic purpose or requirement of this method. Such increased use has come about because auxiliary and oblique views often expedite the solutions of problems, and also because such views are used to show the true geometrical relations between certain geometrical parts or elements of the structure of the object. In addition, auxiliary and oblique views are readily drawn by those who think in terms of the flexible Direct Method, by which objects are readily viewed in any desired direction.

Some authors of descriptive geometry textbooks claim to be using the Direct Method, since they use auxiliary views, even though they explain and base the theory on the Projection Method as the foundation for the subject. Other authors even claim that they use both methods. Such claims are unfounded. The two methods are radically different in their basic concepts. Each method requires its own attitude of mind, and its own basic theory, principles, and vocabulary. Logically, the two cannot be mixed.

Each of the Methods of Descriptive Geometry, Projection and Direct, is founded on its own basic principles. And each requires its own attitude of mind toward the object and toward the drawings that represent the object. The Projection Method is based on the idea of projecting objects on planes of projection. The Direct Method is based on the idea of viewing an object in any desired directions. There is no "auxiliary view method."

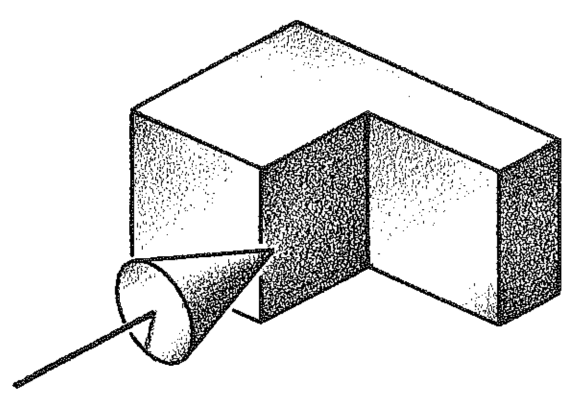
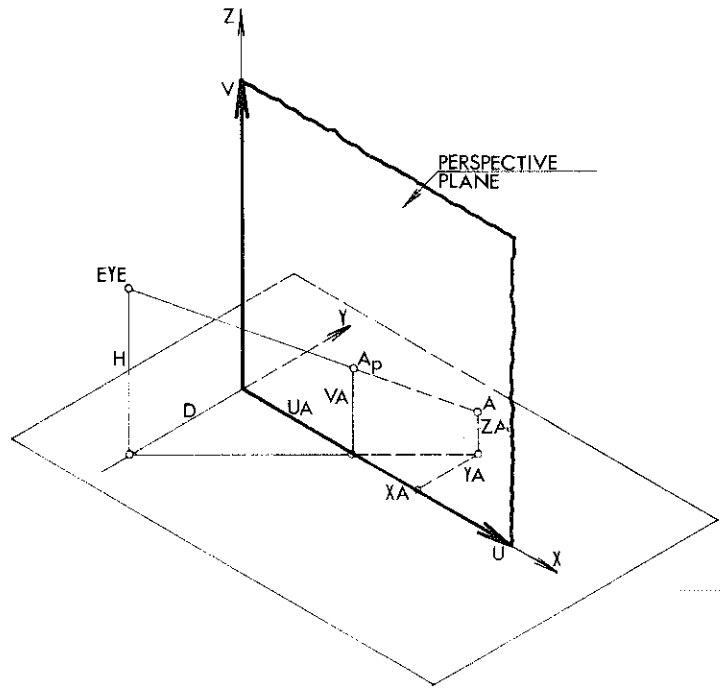


Figure 2 The direct view method

Computer Plotted Perspective View of a Vertical Cylinder of Revolution



$$\frac{UA}{(-D)} = \frac{XA}{YA+(-D)} \Rightarrow UA = -D * XA/(YA-D)$$

$$\frac{H-VA}{H-ZA} = \frac{(-D)}{YA+(-D)} \Rightarrow VA = H-D*(ZA-H)/(YA-D)$$

Figure 1: Perspective plane coordinates of a point, as a function of the point coordinates in its own system.

by Yaacov (Jack) Arwas
TECHNION - Israel Institute of Technology
Dept. of Mathematics
Haifa, Israel

When a designer needs a perspective view of a cylinder of revolution, it would be useful for him to be able to use a computer plotter and software subroutine for plotting a perspective view of the cylinder. This plotter and subroutine could be used for the design of a pump, piston, axle, column, water tower, or for any other purpose.

The Perspective View

The perspective view of a cylinder of revolution would obviously be made out of ellipses representing the bases. These bases would be partly or wholly drawn depending on the location of the observer's eye, and the two extreme cylinder elements tangent to these ellipses. If the cylinder is vertical and the perspective plane is also vertical, these two elements would be vertical as well. An example of such a representation is shown in Figure 4.

The perspective view of any given point A in space could be related to the perspective plane coordinates U,V, depending, of course, on the location of the observer's eye, as shown in Figure 1. This could be translated into a subroutine that could be referred to as PERS, to be fed with the coordinates x,y,z of the point, and giving as feed-back UA,VA. These are the coordinates of that specific point on the perspective plane.

Editor's Note

This article presents a clear description of the bases of computerizing perspective drawing. However, it fails to establish a reasonable axis of vision to a picture plane relationship resulting in the highly distorted perspective images in Figure 4, 5, & 6. If distortion is not acceptable, the axis of vision should be perpendicular to the picture plane.

Thus, all the perspective points of the base circles could be plotted and joined to form the base ellipses. The two extreme tangent elements could also be drawn. Once the tangent points are located the only problem left to be solved is visibility.

<u>The Tangent Points</u>

To differentiate between the visible and the hidden points, projection of the tangent points 1 and 2 will be used.

Points 1 and T1 appear to be projected respectively lower and higher on the perspective plane than points 2 and T2. (See Figure 2). A symmetrical set of points would be obtained if the observer's eye is located at the right of the cylinder axis.

Figure 4 shows the symmetrical set of points that would be obtained if the observer's eye were located at the left. The explanation can be found in the 3-plane projection shown in Figure 3.

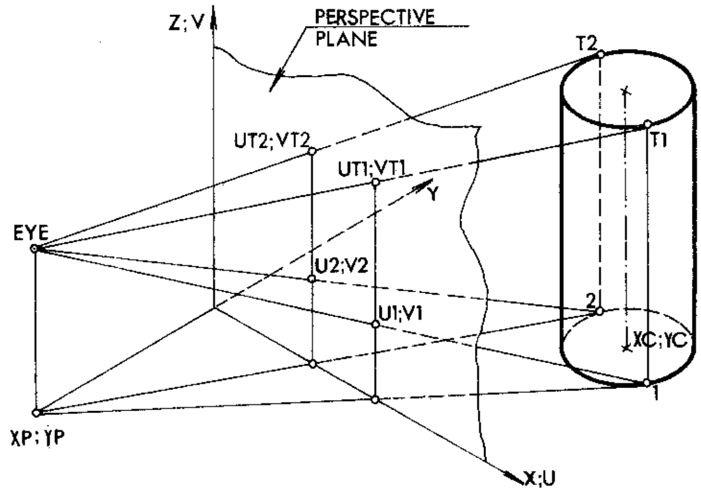


Figure 2: Extreme tangent points on the perspective plane.

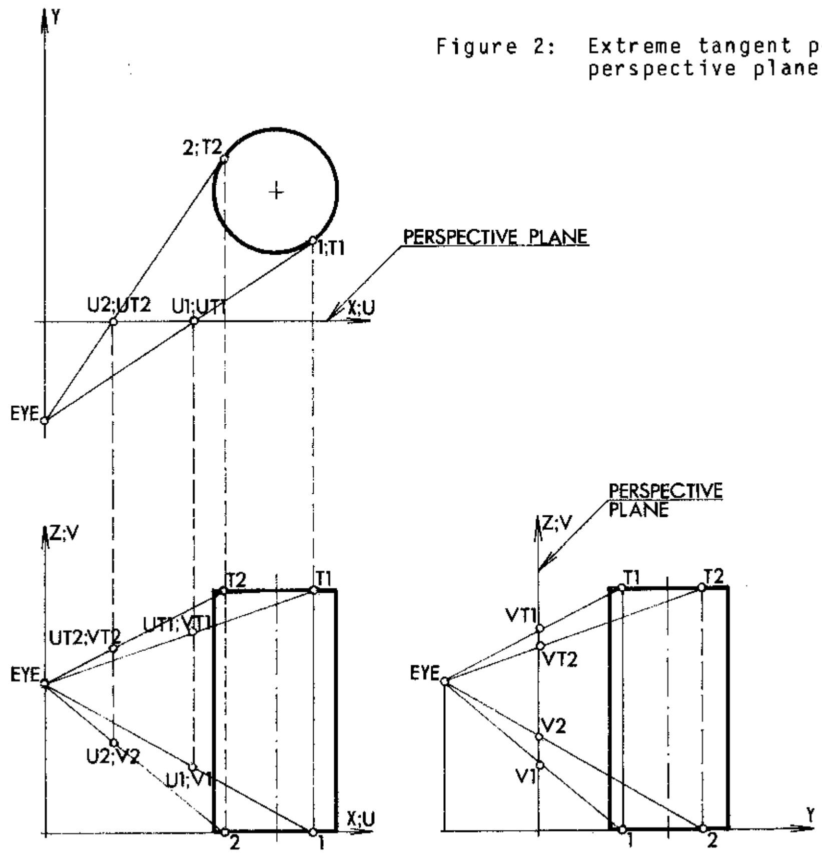


Figure 3: Location of extreme tangent points in perspective view of a vertical cylinder of revolution.

Below is an example of FORTRAN used as the computer language. The coordinates X1,Y1 and X2,Y2 of the tangent points 1 and 2 shown in Figure 2, could be established analytically in relation to the origin point XP,YP. The circle of radius R at center XC,YC is as follows:

```
---------------------------------------

---------------------------------------

DX=XC-XP
DY=YC-YP
Q=R*SQRT(DX**2+DY**2-R**2)
TG1=(DX*DY-Q)/(DX**2-R**2)
TGN1=-1./TG1
TG2=(DX*DY+Q)/(DX**2-R**2)
TGN2=-1./TG2
X1=(DY+XP*TG1-XC*TGN1)/(TG1-TGN1)
Y1=(DX+YC*TG1-YP*TGN1)/(TG1-TGN1)
X2=(DY+XP*TG2-XC*TGN2)/(TG2-TGN2)
Y2=(DX+YC*TG2-YP*TGN2)/(TG2-TGN2)

---------------------------------------

---------------------------------------
```

If the z coordinate equals 0 for points 1 and 2 and ZT for points T1 and T2, the perspective points U1,V1 and UT1,VT1 could be plotted with the subroutine PERS previously mentioned.

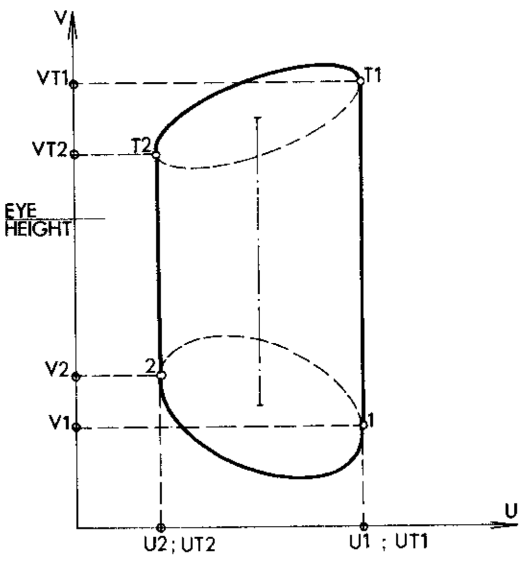


Figure 4: Perspective view of a vertical cylinder of revolution.

Plotting the Cylinder

With these results, the computer could scan a given number of points of the lower base circle, from point 1 moving clockwise at point 2 or infinitely near it. These points would be plotted, through PERS, on the perspective plane and joined together by making V2 higher than any visible point of the perspective projection of the lower base.

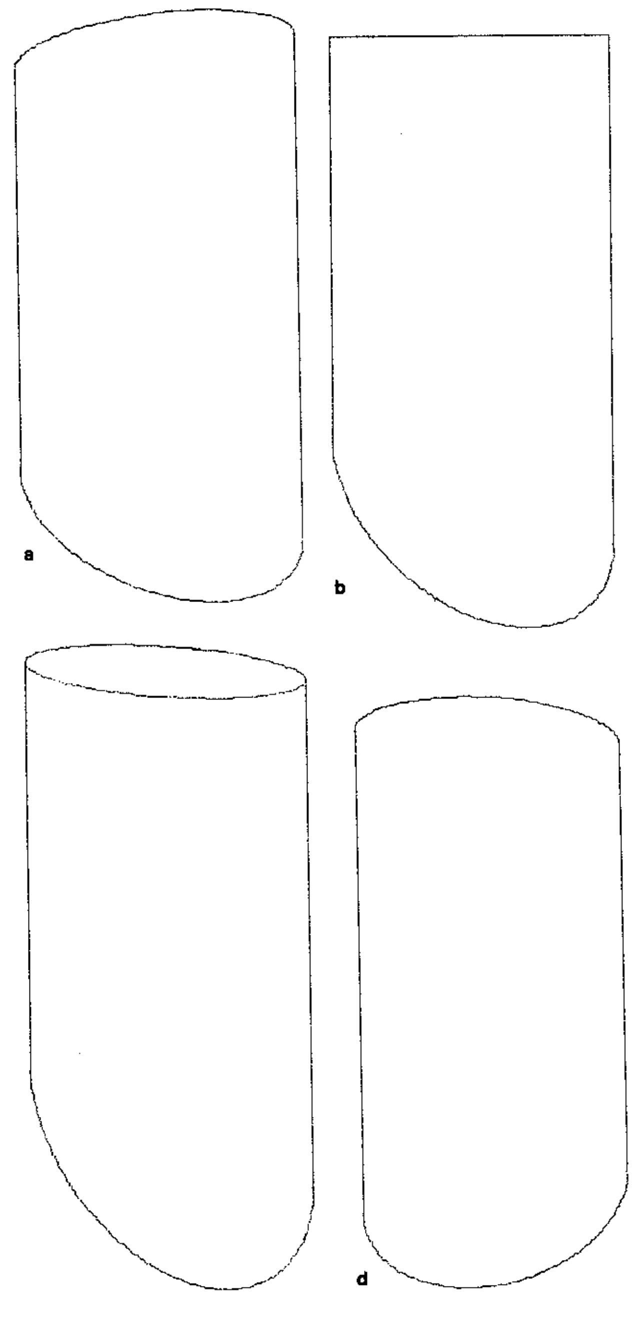


Figure 5: Computer - plotted cylinders

If UE,VE are the coordinates of any point of the lower base ellipse, the visible part of the ellipse would be plotted as follows:

```
     ------------------

     ------------------

     DO  100  I=1,N       starting the loop

     ------------------

     UE=---------------

     VE=---------------

     ------------------

     IF(XC.GT.0..AND.VE.GE.V2)GO TO 100

     ------------------

     CALL PLOT----------

     ------------------

100 CONTINUE             ending the loop
```

The inverse process could be repeated for the upper base starting at point T1 and stopping at T2, preferably by the use of an outer loop.

Finally, the tangent elements could be also plotted to complete the perspective view of the cylinder. A series of "ifs" could be added to the program to provide for:

1) the observer's eye at right of the cylinder axis
2) the observer's eye above upper base height, in which case the upper circle is scanned in its entirety
3) the observer's eye below the lower base, in which case the lower base circle is scanned in its entirety.

All these conditions could be incorporated into a complete subroutine program, called PECYLV for perspective of a vertical cylinder.

Some computer-plotted cases are illustrated in Figure 5:

a) for the observer's eye at left of cylinder axis and between bases.
b) same position but at upper base height.
c) same position but above upper base height.
d) for the observer's eye at right of cylinder axis and between bases.

Application

Let us assume the designer has decided on a bus stop shelter containing a bench, back wall, and roof supported by two cylindrical columns. Having programmed the elements, the designing calls for the columns by simply applying subroutine PECYLV.

Computer-plotted results for two random positions of the observer's eye are shown in Figure 6. The observer's eye could be moved to as many additional positions as required by the designer.

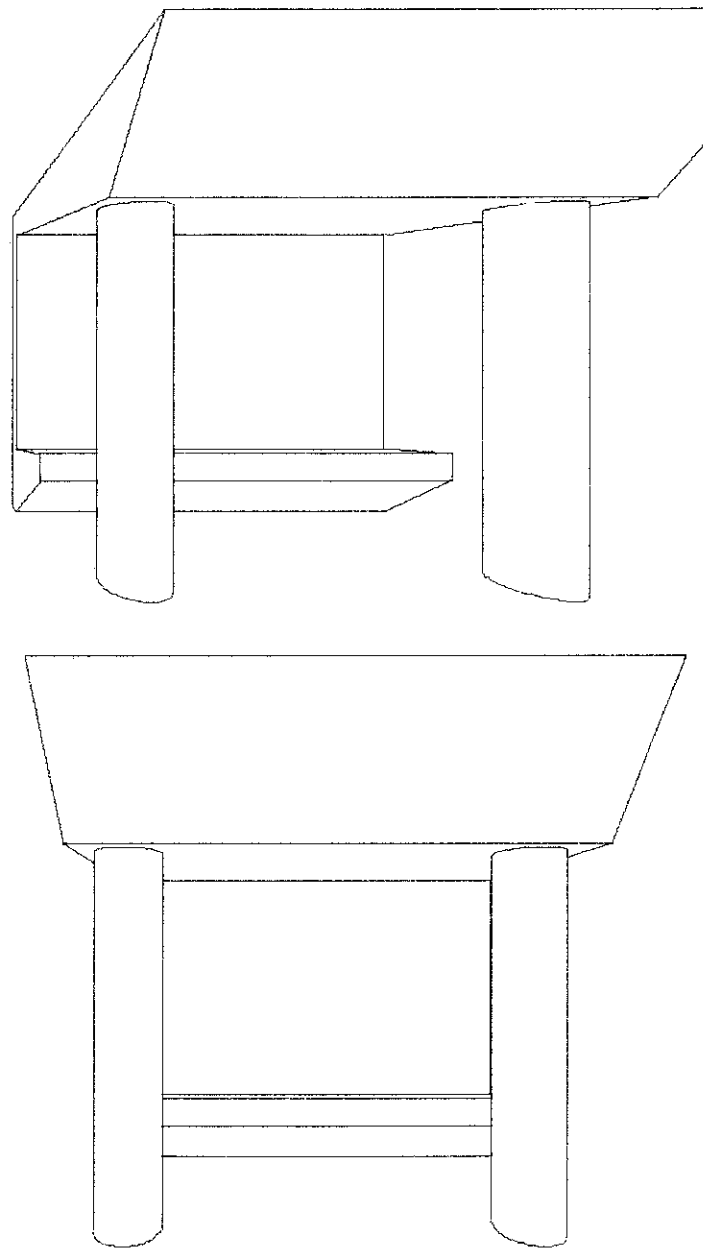


Figure 6: Computer - plotted bus stop shelter

Interactive Procedures for Geometric Data Entry and Modeling on a Small Educational CAD System

by Ronald E. Barr, Davor Juricic, and Tim Lam, Mechanical Engineering Department, University of Texas at Austin, Austin, Texas, 78712

Introduction

Computer-aided design and computer aided manufacturing (CAD/CAM) are new technologies being employed by industry to increase productivity. Computer-aided design involves the use of computers to synthesize, analyze, and test new products without the need to build an experimental prototype. Common analytical tools offered by CAD include kinematic simulation, finite element analysis, and solid geometric modeling. Computer-aided manufacturing deals with the automatic manufacture of products through the use of numerical control, robotics, and other computer-controlled processes. In realizing the full potential of CAD/CAM, the ultimate objective is to use the same geometric data base from design inception, through design analysis, and terminating with design manufacture.

The key communication link between the two technologies of CAD and CAM is computer graphics. Computer graphics involves the computer-generated drawing of an actual physical object or a schematic representation of an integrated system. Interactive computer graphics is the modality used to enter, update, and change geometric data in a CAD/CAM system. Indeed, the graphical interaction between the designer and the computer creates a synergism which is the current key to industrial computer-aided design applications.

Engineering educators generally agree that computer graphics should be incorporated early into the undergraduate curriculum. However, as in the case of most new technologies, the methods and materials for teaching engineering computer graphics are less obvious. Major constraints in the academic implementation of computer graphics include hardware acquisition, software development, and instructional planning. Nonetheless, several lowcost educational systems have been developed that introduce the undergraduate student to computer graphics and CAD early in the curriculum. Demel (1979) was one of the first graphics educators to propose a microcomputer-based CREATOR system for freshman computer graphics projects at Texas A&M. Using a commercially available programmable graphics terminal, Riley (1981) has described a small system at the University of Minnesota that is used for mechanical design and analysis. The use of home microcomputers to teach CAD in an Introductory Structural Design course has been explored at Washington University in St. Louis (Charles, Galambos, Gould; 1982). In addition, our group at the University of Texas at Austin (Barr, Juricic, Waddwlw, Lam, Parokh; 1981) has developed a MINI-CAD system that introduces freshman mechanical engineers to computer graphics' use in the design process, including interactive digitizing and graphics modeling.

Overview of the MINI-CAD System

The MINI-CAD system is intended to be a low-cost CAD training system that is centered around an intelligent graphics terminal with peripheral support devices such as a digitizer board and a pen plotter. The system is configured in a design workstation fashion and is user-friendly through the use of canned software. Software modules have been developed to assist the students in making design drawings, to analyze design features, and to search data bases for potential design parameters.

Hardware Configuration

The hardware configuration of the MINI-CAD system consists of several major components as illustrated in Figure 1. The heart of the system is a Hewlett-Packard 2647A intelligent graphics terminal. The terminal has a raster CRT screen with a pixel resolution of 720h x 360v points. The microcomputer resident in the terminal is based on an Intel 8080 8-bit microprocessor. Approximately 15K bytes of core memory are available for user programming on the terminal. The terminal also contains two cassette tape drives that can each store approximately 110K bytes of data.

A Houston-Instruments HI-7000 digitizer board is interfaced to the graphics terminal through a serial RS-232 port. The active digitizing surface of the HI-7000 is 26 x 19 inches. Hardcopy output of graphical displays can be obtained in two ways. A Hewlett-Packard HP-2631G dot matrix printer/plotter is available for quick raster dump of both alphanumeric and graphics information. For finished quality drawings, an HP-2872 four-pen flatbed plotter can be used.

as presented in Pomona

Software Configuration

Software modules for the MINI-CAD system have been developed for student use in freshman design projects. The software has been developed using BASIC plus AGL, a graphics extension language supplied by Hewlett-Packard. However, the application of

BASIC is somewhat transparent to the user, since all modules can be operated by simply following a series of English-like commands.

In general, the engineering design process can be divided into sequential stages: for example, conceptualization, analysis, decision, and presentation. Each major stage can be further divided into a number of specific activities, as illustrated in Figure 2. Each of these smaller blocks represent a potential module for the MINI-CAD system library. Our group has already developed a number of modules, for instance, to perform a materials data search, to analyze mechanical elements, and to produce detailed multiview drawings. The remainder of this paper will focus on a special set of modules that permit interactive digitizing and modeling on the MINI-CAD system.

Sketch Digitizing Module

The sketch digitizing module was designed to interface the HI-7000 digitizer board with the HP-2647A graphics terminal. Data is transmitted serially via an RS-232-C port in blocks of 15 ASCII characters each time a cursor button in initiated. The lead character is a tag number that represents one of 12 buttons on the cursor that has been pressed. Each X and Y coordinate is represented by six characters, including sign, and there are two field delimiters in the ASCII string.

This first interactive graphics module was developed to offer a twofold capability for design students. In the digitizing mode, students can transform sketches of arbitrary geometry into computer drawings and have the data stored on tape for future use. In a menu selecting mode, the operator can choose line types and can merge standard geometries such as circles and rectangles with the drawing.

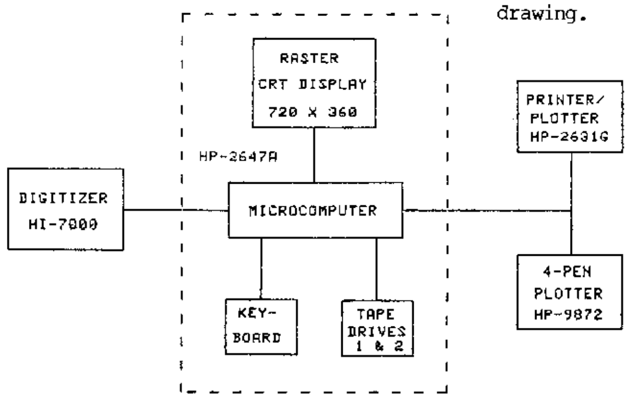


Figure 1 - Hardware Configuration for the MINI-CAD System.

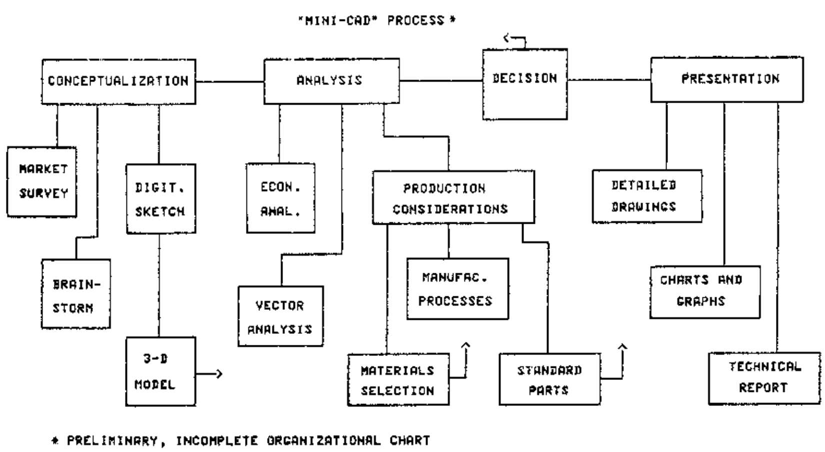


Figure 2 - Software Organization for the MINI-CAD System.

Board and Menu Layout

The layout of the digitizer board is shown in Figure 3. A top strip of the 26" x 19" active digitizing surface has been dedicated to a menu. From the menu, the user can select line types, obtain common symbols and geometries, and perform command functions. Five line types are available: solid, hidden, center, cutting plane, and faint. The common symbols and geometries consist of arrows, circles, arcs, and rectangles. The menu also permits the insertion of graphics text, and performs commands such as plot data, calculate area, and quit. The user only needs to digitize any point (press cursor button) within a specific menu item boundary, and the program automatically sets the appropriate function into action.

Typically a user would tape a rough sketch onto the active digitizer surface. This requires the initialization of certain parameters related to X-Y offset, scale factors, and skew correction angle, as illustrated in Figure 4. In order to define the working frame, the user digitizes three points: (Xmin, Ymin), (Xmax, Ymin), and any point along Ymax. A skew correction angle can then be calculated to account for a horizontal frame border that is not parallel to the digitizer board's horizontal reference. A scale factor to transform incoming digitizer coordinates into arbitrary user-defined units can be calculated using the formula shown in Figure 4.

When selecting a line type menu item, the program also defaults into a line plotting mode. The multi-button cursor is an effec-

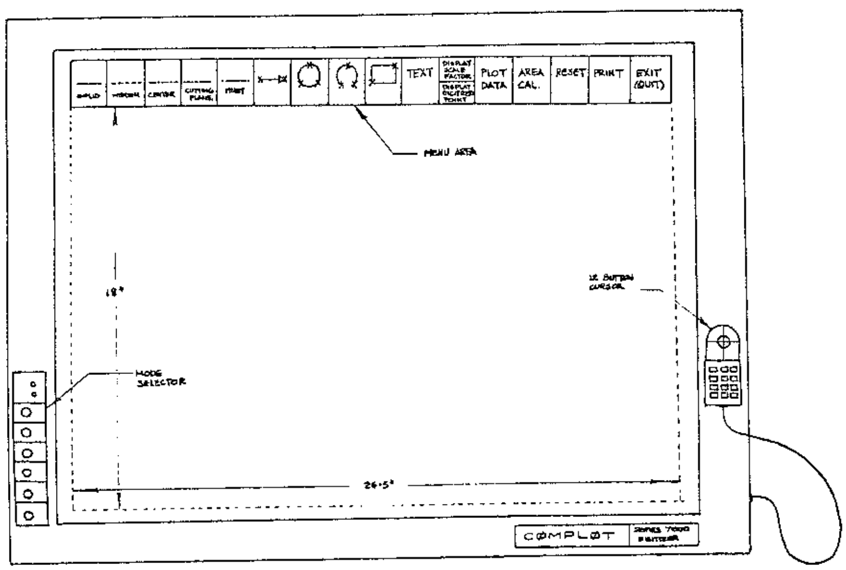
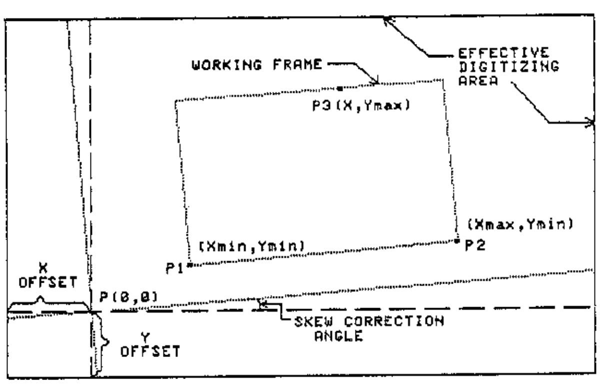


Figure 3 - Board and Menu Layout of the HI-7000 Digitizer.



X SCALE FACTOR = $\frac{\text{(Xmax-Xmin)}}{\text{P2X-P1X}}$ $\frac{\text{in user units}}{\text{in digitizer units}}$

Y SCALE FACTOR IS DETERMINED SIMILARLY.

Figure 4 - Parameters required for digitizer initialization.

tive input device in this line plotting mode. For example, button "1" is used to designate plot with pen up, button "2" designates pen down, and button "3" indicates to show a line temporarily without entering data into storage. In this fashion, the user can digitize an arbitrary sequence of lines, and when the "*" button is pressed, the program returns to the menu.

Special Subroutine Functions for Digitizer

A number of functions in the menu list have been relegated to subroutines that are called by the main program. For instance, the rectangle menu item requires the digitization of two diagonal X-Y coordinates. The subroutine can then use the skew angle, scale factor, and X-Y offset to plot the four sides in user units. A special feature of this, as well as other geometry subroutines, is that the user can temporarily view the figure first before the data is entered into storage.

In order to use the circle subroutine, the user must first digitize three arbitrary points on the circle's circumference. The circle center is determined by finding the intersection of the two perpendicular bisectors of lines joining the first and second points, and the second and third points. This intersection point can be found by solving the two simultaneous equations for center (X0,Y0) below:

$$T_1X0 + T_2Y0 + T_3 = 0$$

$$T_4X0 + T_5Y0 + T_6 = 0$$

where,

$$T_1 = (X2-X1);\ T_2 = (Y2-Y1)$$

$$T_3 = (X1^2-X2^2+Y1^2-Y2^2)/2$$

$$T_4 = (X3-X2);\ T_5 = (Y3-Y2)$$

$$T_6 = (X2^2-X3^2+Y2^2-Y3^2)/2$$

In the above equations, (X1,Y1), (X2,Y2), and (X3,Y3) are the coordinates for the three points digitized by the user. Once the circle center is established, the radius can be determined by computing the distance between the first digitized point and the center. With both the center and the radius determined, a parametric circle can be drawn in the incremental mode.

For the circular arc subroutine, the center and radius of the arc are found in the same way as the circle subroutine. However, additional computation is needed to determine whether to plot the arc clockwise or counterclockwise. This is accomplished by determining and comparing the position of the first and third digitized points, with respect to the middle point, based on the calculated arc center.

The dimension arrow subroutine demonstrates the use of incremental plotting in order to avoid numerous calculations related to the arrowhead geometry. Instead of computing the user-unit positions of the arrowhead points each time, the relative positions of the arrowhead points, which have a fixed geometry, are invoked. Two digitized points are required, starting with the tail and ending with the arrowhead tip. Since the relative coordinates of the arrowhead are fixed, the size does not change regardless of the user units selected or the length of the dimension line.

Data Structure for Digitizing

Each item digitized by the program is displayed on the CRT screen and the data related to that item is also stored immediately on cartridge tape. The tape data file is designed in a way that is compact and yet systematically structured. The beginning of each data file contains information related to the initialization of the working frame. Parameters stored at this time include the X and Y scale factors, the minimum frame point (Xmin,Ymin), and the maximum frame point (Xmax,Ymax).

Each data group starts with a label which is actually the menu number. This label identifies what type of data entries will follow in this particular data group. For instance, in the line plotting mode, the data group would consist of the line type, the (X,Y) coordinate, and the pen action. For circle data, the group would include a label (menu number 7), and the (X,Y) coordinates of the three points digitized along the circle. It should be noted that all data are in user units. An example of a digitized sketch and the accompanying data file is shown in Figure 5.

low cost micro computer-based education

The 2-D to 3-D Reconstruction Module

The second module has been designed to construct a 3-D wire frame model of an object by digitizing its three 2-D orthographic views. The operator is required to follow a set of instructions that include the digitizing order of the views (top, front, and right side) and the establishment of an origin for each view. The order in which the points are digitized in each view is also important since it will determine the line connections in the wire model. Interactive graphical editing and 3-D object rotation are special features provided in this module.

DATA GROUP	INTERPRETATION	COMMENT
0.5 0.5 0 0 3 2	X-SCALE FACTOR Y-SCALE FACTOR X-MIN Y-MIN X-MAX Y-MAX	SETS UP DIGITIZING REFERENCE FRAME
9, 1 0.50, 0.50 2.50, 1.50	MENU 9(RECT.), LINE 1(SOLID) X1,Y1 COORDINATES X2,Y2 COORDINATES	DRAWS RECTANGULAR OUTLINE
7, 1 1.25, 1.00 1.50, 1.25 1.60, 1.20	MENU 7(CIRC.), LINE 1(SOLID) X1,Y1 COORDINATES X2,Y2 COORDINATES X3,Y3 COORDINATES	DRAWS CIRCULAR FEATURE IN CENTER
3, 3 1.10, 1.00 -2	MENU 3(PLOT), LINE 3(CNTL.) X1,Y1 POSITION PEN UP	MOVES TO DRAW HORIZ. CENTERLINE
3, 3 1.90, 1.00 -1	MENU 3(PLOT), LINE 3(CNTL.) X1,Y1 POSITION PEN DOWN	DRAWS HORIZ. CENTERLINE
3, 3 1.50, 0.60 -2	MENU 3(PLOT), LINE 3(CNTL.) X1,Y1 POSITION PEN UP	MOVES TO DRAW VERT. CENTERLINE
3, 3 1.50, 1.40 -1	MENU 3(PLOT), LINE 3(CNTL.) X1,Y1 POSITION PEN DOWN	DRAWS VERT. CENTERLINE
6, 1 1.85, 1.75 1.62, 1.20	MENU 6(ARROW), LINE 1(SOLID) X1,Y1 COORDINATES (TAIL) X2,Y2 COORDINATES (HEAD)	DRAW ARROW
1, 1 1.85, 1.75 -2	MENU 1(PLOT), LINE 1(SOLID) X1,Y1 POSITION PEN UP	MOVES TO DRAW HORIZ. LEADER
1, 1 2.10, 1.75 -1	MENU 1(PLOT), LINE 1(SOLID) X1,Y1 POSITION PEN DOWN	DRAWS HORIZ. LEADER
10, 1 2.15, 1.75 1 DIA.	MENU 10(TEXT), TEXT SIZE X1,Y1 POSITION TEXT ANGLE TEXT NOTE	PRINTS TEXT NOTE

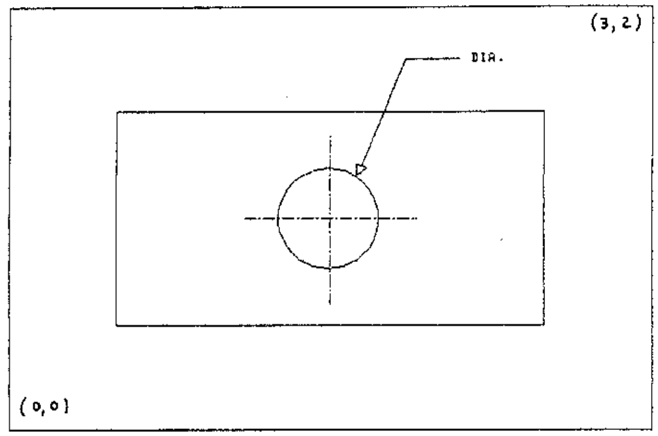


Figure 5 – A digitized sketch and accompanying data file for the figure.

Theory and Program Development for 2-D to 3-D Reconstruction

Encarnacao and Giloi (1973) have described a method for construction of a 3-D model from its three 2-D orthographic views. The method is based on the generation of a points list and then a line list. The points list consists of the three (X,Y,Z) spatial coordinates which are common to all three orthographic views. From this points list, a line list consisting of all possible connections in the wire model is generated.

The program development of the 2-D to 3-D reconstruction module will be described using an example. The operator is requested to digitize three views of an object such as illustrated in Figure 6. The origin of each view (point 1) is set and the digitizing of point connections in each view proceeds. The user should start with the top view first, then the front view, and finally the right side view. This is necessary in order to align the spatial coordinates in their respective XY, XZ, and YZ planes. The numbering of the points in each 2-D view is arbitrary, but should be systematic.

The three view digitizing process generates a set of lists of 2-D view points, as illustrated in Figure 7. A 3-D spatial coordinate list is next generated from the 2-D lists. For example, the Y coordinate of a point in the XY list is taken, and the YZ list is searched for the same Y coordinate. If the search is successful, the XY list is searched for a point whose X and Z coordinates correspond respectively with the X coordinate of the given point from the XY list and the Z coordinate of the given point from the YZ list. Triples of X, Y, and Z values obtained in this manner constitute the coordinates of a spatial point of the 3-D wire model. A label index is next assigned to each of these spatial points. Finally the arbitrary numbers of the three views are replaced with the new corresponding label index, as illustrated in Figure 7.

The second task in this reconstruction process is to generate a list of all line connections of the 3-D object. Such a list is shown in Figure 8. Line connections for each view are based on the digitizing order for that view using the new point index. The 2-D line lists are now searched for possible line connections that exist in all three views, in which case the line is assigned a line index number. The collection of all line indices constitutes all possible connections in the 3-D wire model.

Up to this point, a list of all the possible line connections of the 3-D object is generated and the wire frame model is displayed on the screen. The user is now permitted to rotate the model to a better viewing angle and to delete any incorrect lines found in the 3-D model. Any line

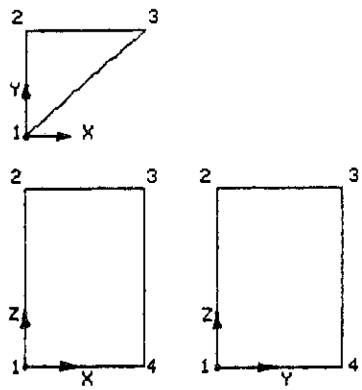


Figure 6 - Three views are digitized by the operator in a pre-established sequence.

POINT NO.	XY-VIEW		POINT NO.	XZ-VIEW		POINT NO.	YZ-VIEW	
Nxy	x	y	Nxz	x	z	Nyz	y	z
1	0	0	1	0	0	1	0	0
2	0	1	2	0	2	2	0	2
3	1	1	3	1	2	3	1	2
			4	1	0	4	1	0

RUNNING INDEX	POINT-COORD.		
N	x	y	z
1	0	0	0
2	0	0	2
3	0	1	0
4	0	1	2
5	1	1	2
6	1	1	0

POINT NO.	XY-VIEW		POINT NO.	XZ-VIEW		POINT NO.	YZ-VIEW	
Nxy	x	y	Nxz	x	z	Nyz	y	z
1,2	0	0	1,3	0	0	1	0	0
3,4	0	1	2,4	0	2	2	0	2
5,6	1	1	5	1	2	4,5	1	2
			6	1	0	3,6	1	0

Figure 7 - A points list is generated for each view and an index of valid spatial coordinates is determined.

deletion is accomplished by digitizing the mid-point of the line to be deleted utilizing the screen cursor.

Program Application and Limitations of the 2-D to 3-D Module

The three views of the object in Figure 9 have been digitized using this module and the wire frame model is shown in a 3-D rotated view. Due to memory constraints, only objects with 30 spatial coordinates or less can be constructed using this module. In addition, due to the slow speed of the 8-bit processor on the graphics terminal, it may take up to 10 minutes to construct the wire frame model.

The 3-D Model Maker Module

The third module enables the student to build a three-dimensional model of a part by piecing together simple 3-D components called primitives. This method is similar to more advanced modeling techniques used in industry (Spur, Krause, Harder; 1982). Although this third module is highly interactive, it does not rely on the digitizer board for input. Instead the user is required to interact directly with the screen through a graphics cursor and keyboard.

3-D Graphics Primitives

The complexity and number of 3-D graphics primitives required in a modeling package depends upon the application and needed exactness. As pointed out by Chasen (1978), a simple set of primitives can be used in solving many engineering problems. In this module, seven primitives were employed:

1. rectangular prism (box)
2. right-triangular prism (wedge)
3. half-pyramid
4. right circular cylinder
5. circular cone
6. circular cone frustrum
7. sphere

This list of primitives is illustrated in Figure 10, along with related graphical data needed for each primitive. Also shown in this primitive figure list is the total number of data points needed to draw each object.

The size of the primitive is defined by shape data supplied by the user. For instance, the size of the box is defined by the lengths (a,b,c) of the box height, width, and depth. As a second example, the size of a sphere is simply defined by a radius. The second type of graphical data required is the origin translation (X0,Y0,Z0) in space. Typically, the origin consists of a point in the middle of the bottom surface of the primitive, as illustrated in Figure 10. Finally, rotational data (1, 2, 3) is needed to describe the primitive's rotational orientaation with respect to the X, Y, and Z axes. The one exception is the sphere which does not require any rotational data.

Program Development of the 3-D Maker Module

The program for the 3-D Model Maker is highly interactive with the user. First, two areas on the screen are assigned as the X-Y plane (top view) and the X-Z plane (front view). The user selects from a nested series of menus that are displayed on the screen, as outlined in Figure 11. Typically, the user would add a primitive object which is selected from the primitive menu. By positioning the cursor on the screen, the user sequentially digitizes the reference point in each

LINE NO.	POSSIBLE CONNECT-ION IN XY-VIEW		LINE NO.	POSSIBLE CONNECT-ION IN XZ-VIEW		LINE NO.	POSSIBLE CONNECT-ION IN YZ-VIEW	
Lxy	pt.	pt.	Lxz	pt.	pt.	Lyz	pt.	pt.
1	1	2	1	1	3	1	1	2
2	3	4	2	2	4	2	4	6
3	1	3	3	1	2	3	2	5
4	2	3	4	2	3	4	2	4
5	1	4	5	1	4	5	3	6
6	2	4	6	3	4	6	4	6
7	5	6	7	2	5	7	5	6
8	3	5	8	4	5	8	3	4
9	4	5	9	5	6	9	3	5
10	3	6	10	1	6	10	1	3
11	4	6	11	3	6	11	1	6
12	1	5						
13	2	5						
14	1	6						
15	2	6						

LINE INDEX	CONN. IN SPACE	
L	pt.	pt.
1	1	2
2	3	4
3	1	3
4	2	4
5	5	6
6	4	5
7	3	6
8	2	5
9	1	6

Note: If a possible connection is found in all three line lists, a connection in space is determined.

Figure 8 - An index list of all possible line connections is obtained by comparing line list of the three views. Refer to Figures 6 and 7 for geometry data.

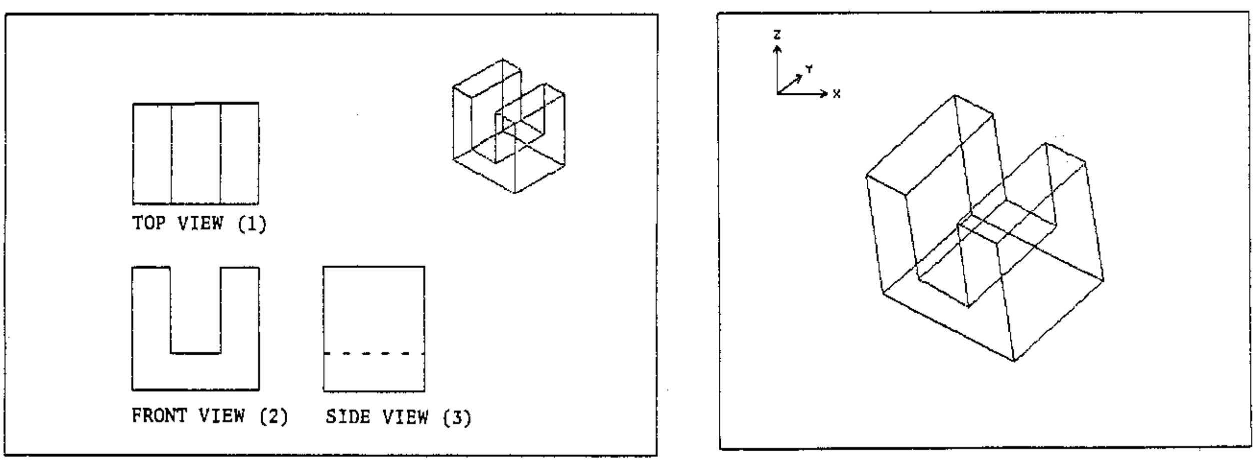
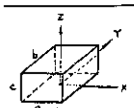
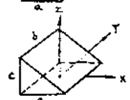
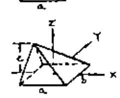
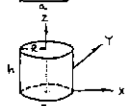
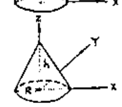
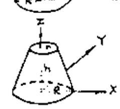
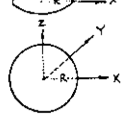


Figure 9 - A three view drawing of an object (above) has been digitized and a 3-D rotated model of the object (below) has been generated using module 2.

of the two views. This process translates the primitive in 3-D space and defines the intitial shape of the object.

The user can next choose from a primitive command menu. For instance, the user can change the shape of the primitive or can rotate it about the three axes. If the user is pleased with the display, he can return to the main menu to add a new primitive. During the meanwhile, a 3-D graphic model of the part is being generated and stored in a geometric display file.

Primitives added in this manner are built in a wire frame model. For curved surfaces, a grid technique is used to adequately depict the contour. Upon user command, the combined primitives that constitute the model can be rotated and then projected in an axonometric projection. An example of a 3-D camera housing that has been built and projected using this module is illustrated in Figure 12.

	PRIMITIVE TYPE	SHAPE DATA [1]	NO. OF GRAPHICAL DATA POINTS
	Box	a,b,c	16
	Wedge	a,b,c	12
	Half-pyramid	a,b,c	10
	Cylinder	R,h	48
	Cone	R,h	30
	Fustrum	R,r,h	48
	Sphere	R	1

[1] With the addition of data Xo,Yo,Zo,A1,A2;A3 to the Shape Data, the Graphic Model Data of a primitive is defined. For example GMD for Box is: Xo,Yo,Zo,A1,A2,A3,a,b,c. An exception to this is primitive Sphere which only has Xo,Yo,Zo,R as GMD.

Figure 10 - Seven building-block primitive shapes are used in the 3-D model maker module.

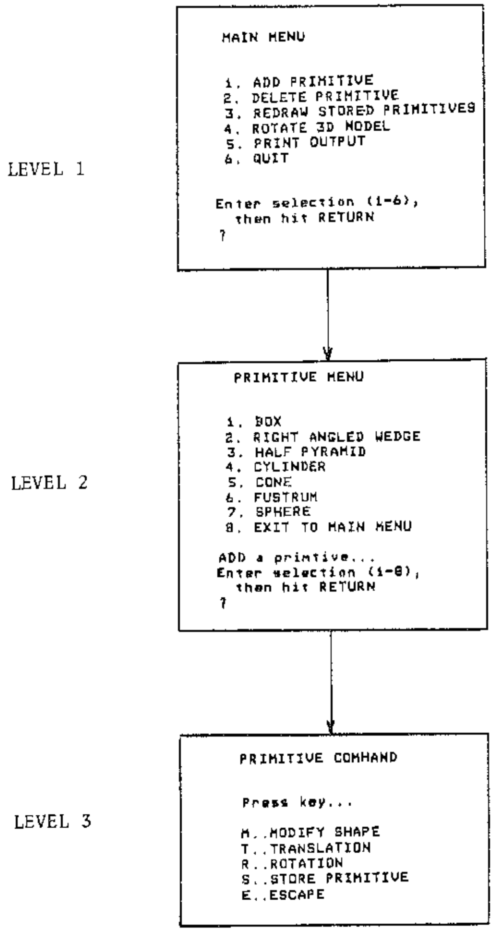


Figure 11 - A sequence of nested menus are displayed on the screen in the 3-D model maker module.

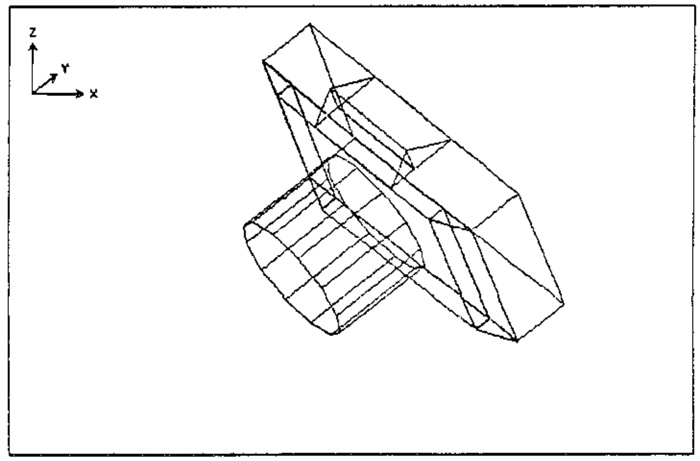


Figure 12 - Application of the 3-D model maker for a camera housing design.

Summary and Conclusions

A MINI-CAD system for undergraduate engineering students has been developed and implemented at the University of Texas at Austin. The system is based on a low-cost hardware configuration that includes an intelligent graphics terminal, a digitizer board, a printer/plotter, and a flatbed pen plotter. As part of the MINI-CAD system, a package of three software modules has been developed that introduces students to interactive computer graphics techniques in the design process. Specifically, the first module interfaces a digitizer board to the graphics terminal in order to facilitate arbitrary geometric or menu-driven graphic data entry. In addition, a second module has been coupled to the digitizer board in order to permit the construction of a 3-D pictorial from the three principal 2-D orthographic views. A third interactive module is used to develop a 3-D graphic model by piecing together sequences of 3-D primitives. The 3-D model can then be viewed from any user-defined rotational angle.

This set of software modules has been tested and incorporated into a freshman Mechanical Engineering course at the University of Texas at Austin. The course combines the three areas of traditional engineering graphics, introduction to engineering design, and computer programming. As part of this course, a freshman design project is assigned which utilizes the MINI-CAD system. In this effort, the interactive graphics modules have been used by design students to digitize design sketches and to create 3-D graphics models that were previously developed by manual means. The students have been very receptive to the interactive computer graphics modules and have incorporated the graphic output into their design reports.

References

1. Demel, J.T., Kent, A.D, and Zaggle, W.H., "Computer Use in Freshman Design Projects," Engineering Design Graphics Journal, Vol. 43, #2, 1979, pp. 2-12.

2. Riley, D.R., and Erdman, A.G., "Computer Graphics and Computer-Aided Design in Mechanical Engineering at the University of Minnesota," Computer and Education, Vol. 5, 1981, pp. 229-243.

3. Charles, B.S., Galambos, T.V., and Gould, P.L., "Microcomputer-Based CAD Systems for Engineering Education," Engineering Education, Vol. 72(8), 1982, pp. 791-793.

4. Barr, R.E., Juricic, D., Waddelow, M., Lam, W., and Parikh, N., "Development of a MINI-CAD System for Education," Proceedings, of 1981 ASEE Annual Conference, Los Angles, CA, June 1981, pp. 776-771.

5. Encarnacao, J., and Giloi, W., "PRADIS - An Advanced Programming System for 3-D Display," American Federation of Information Processing Societies, SJCC, Vol. 40, 1973, pp. 985-998.

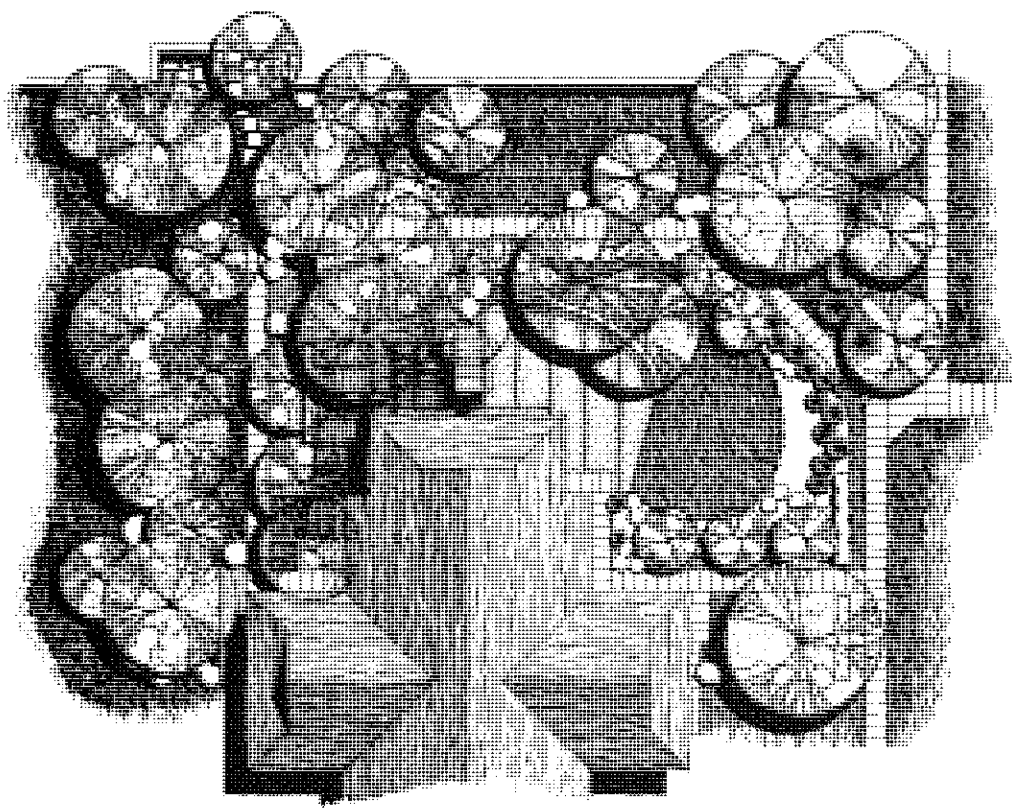
6. Spur, G., Krause, F.L., and Harder, J.J., "The Compac Solid Modeler," Computers in Mechanical Engineering, Vol. 1(2), 1982, pp. 44-53.

7. Chasen, S.H., Geometric Principles and Procedures for Computer Graphics Applications, Prentice-Hall, Englewood Cliffs, New Jersey, 1978.

continued from page 7

REQUIRED: Using compass and straight-edge only*, construct the two circles which, in the general case, will each pass through the two given points A and B, and which also will each be tangent to the given circle, one of the constructed circles containing the given circle within its interior, and the other constructed circle being exterior to the given circle.

*No calculations, no calculator of any type (analog or digital), no french curve, no protractor, no scale, and no trial-and-error or approximation solutions are to be used, needed, required, or allowed.



landscape architecture

Projections and Projection Systems in Engineering Graphics

check out the direct method on page 9

Ravi Durvasula
Pennsylvania State University

One of the objectives of engineering graphics is the two dimensional representation, as multi-view drawings, of three dimensional objects.

One method of doing this is by projecting an object onto a plane. As shown in Figure 1, the "projection" of the plate is a tracing of the outline of what is seen by the eye on a plane in front of or behind the plate. The two projections are mirror images of each other.

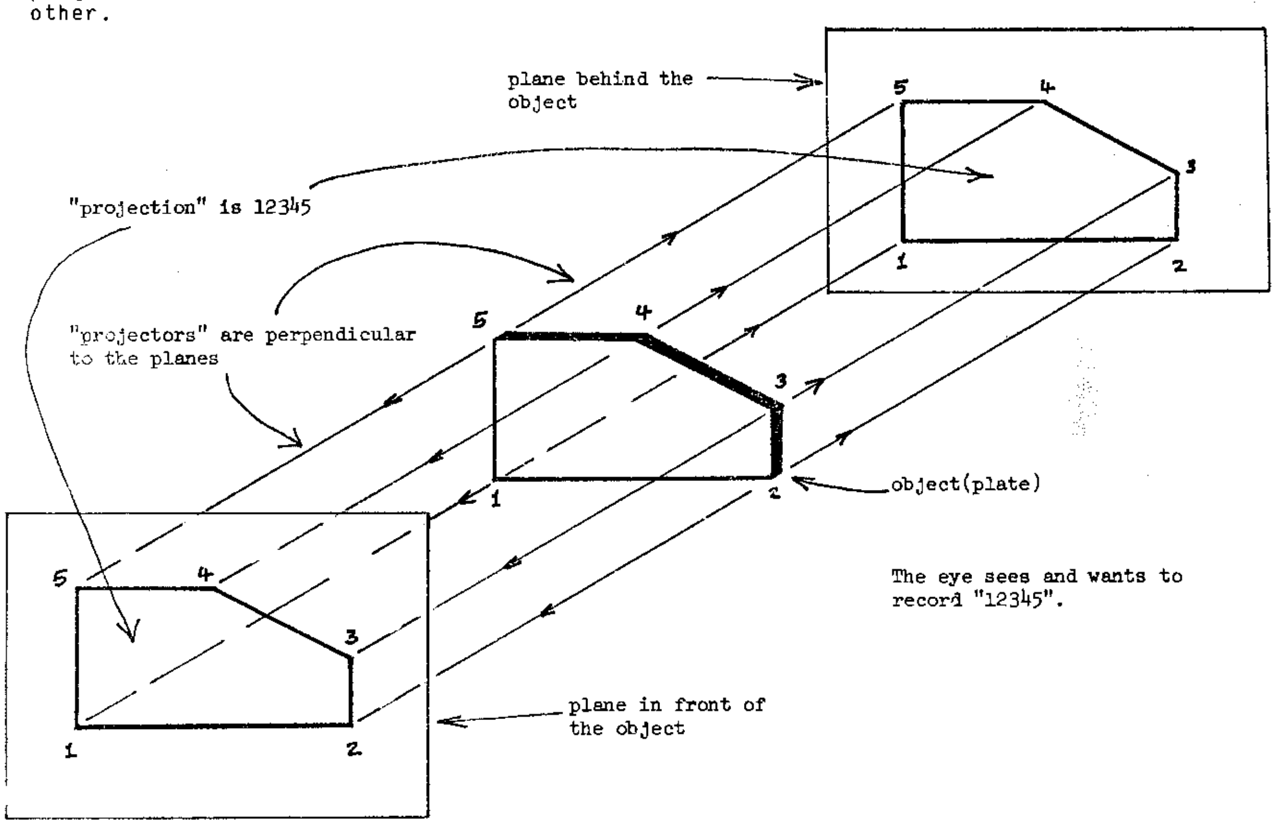
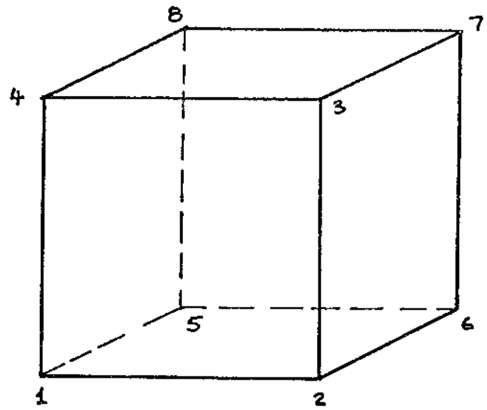
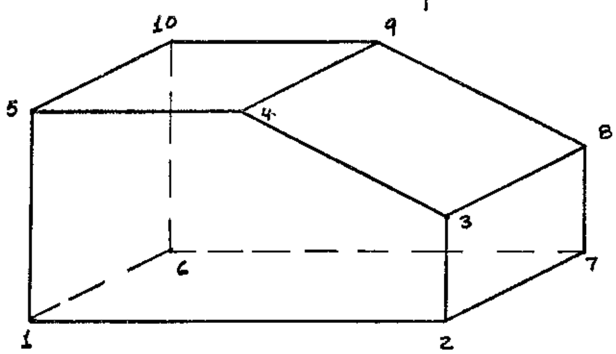


Figure 1 - Projection of an object



(a) cube

plane or face	name of view
1234	front
3487	top
2376	right side
1485	left side
5678	rear
1265	bottom



(b) rectangular solid

plane(s) or face(s)	name of view
1,2,3,4,5	front
3,4,5,10,9,8	top
2,3,4,9,8,7	right side
1,5,10,6	left side
6,7,8,9,10	rear
1,2,7,6	bottom

Figure 2 - Objects used in the drawings and discussions

The objects used in the drawings and discussions in this paper are shown in Figure 2. Also identified are the faces or planes on the objects and the views which would yield a normal or true representation of each.

Based on a particular way of taking projections (either onto a plane in front of or behind the object), a projection system can be used that produces the multi-view drawing of an object.

third angle projection is more logical

Quadrant System

Projection systems can be illustrated by the use of three mutually perpendicular planes (see Figure 3). The horizontal plane is parallel to the ground and the frontal and profile planes are perpendicular to the ground. The intersection of the horizontal and frontal planes produces four quadrants. The object (Figure 2a) is placed successively in each of the quadrants, and the projections are recorded. In all of the quadrants, the horizontal plane is rotated 90° clockwise away from the frontal plane to use the multi-view drawing (Figure 4). In the second and fourth quadrants, the multi-view drawings have views overlapping, and hence these projection systems are discarded as useless. The two useful projection systems that are obtained from this arrangement are called the first angle and third angle projection

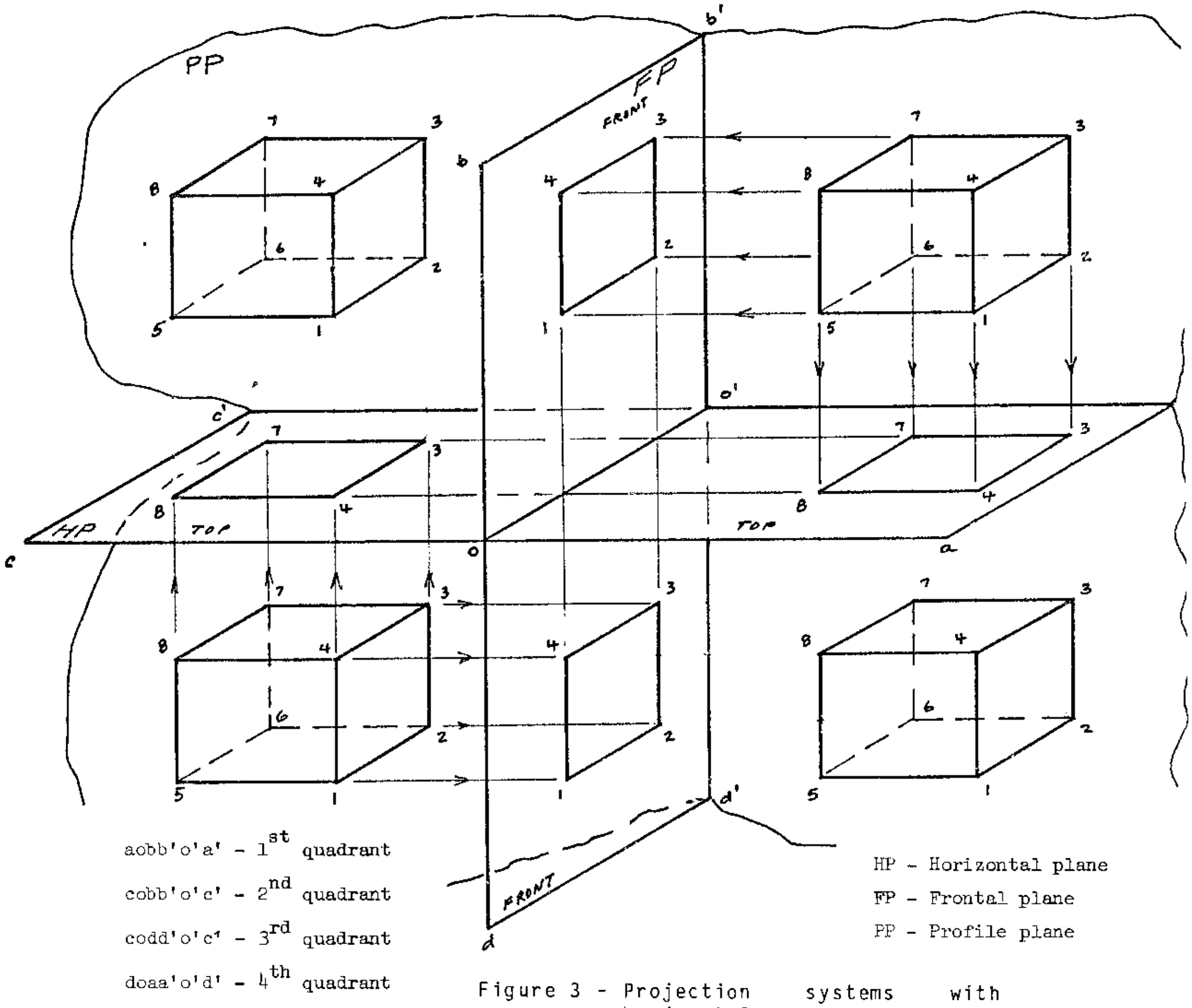
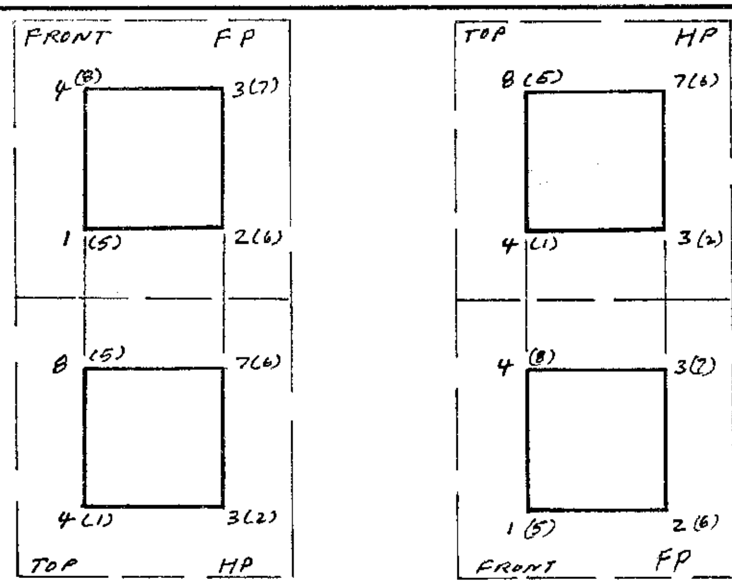


Figure 3 - Projection systems with horizontal, frontal, and profile planes

Figure 4 - Multi-view drawings for the projection systems of Figure 3



First quadrant projection system

Third quadrant projection system

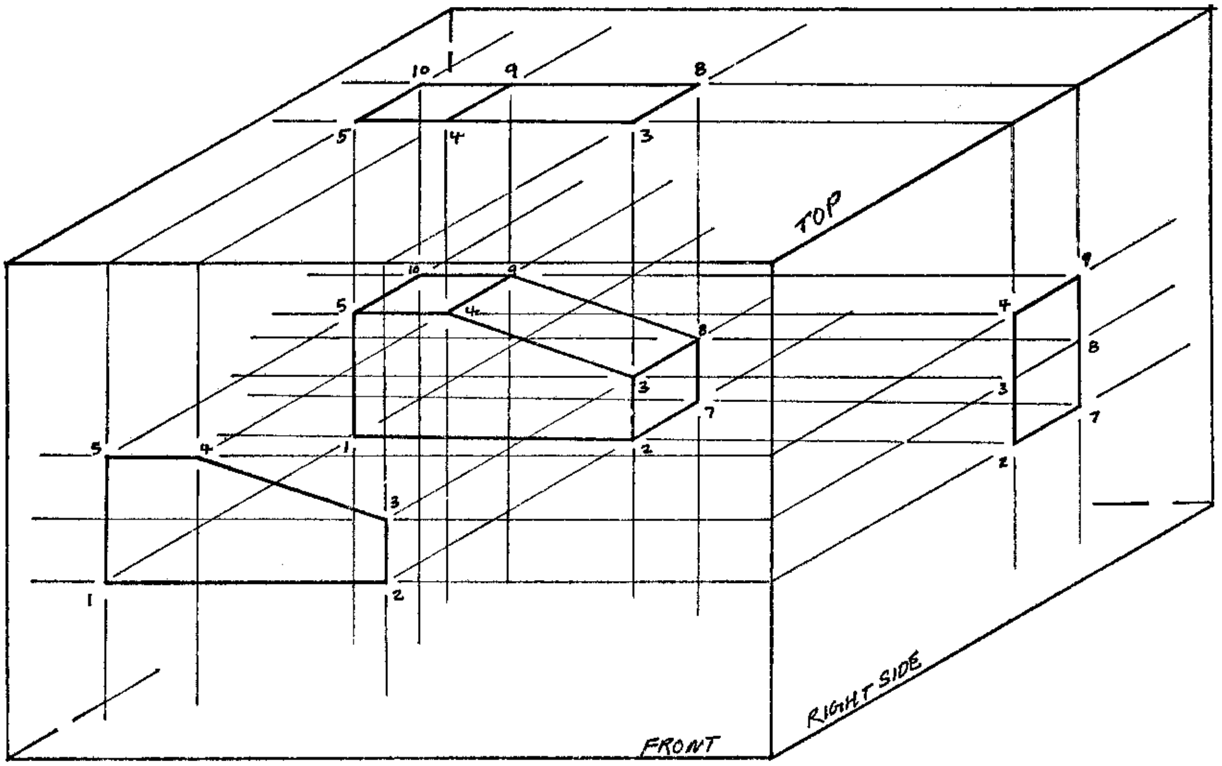


Figure 5a - Glass box arrangement, and the projections taken on a plane in the front of the object

* numbers in parantheses are hidden points

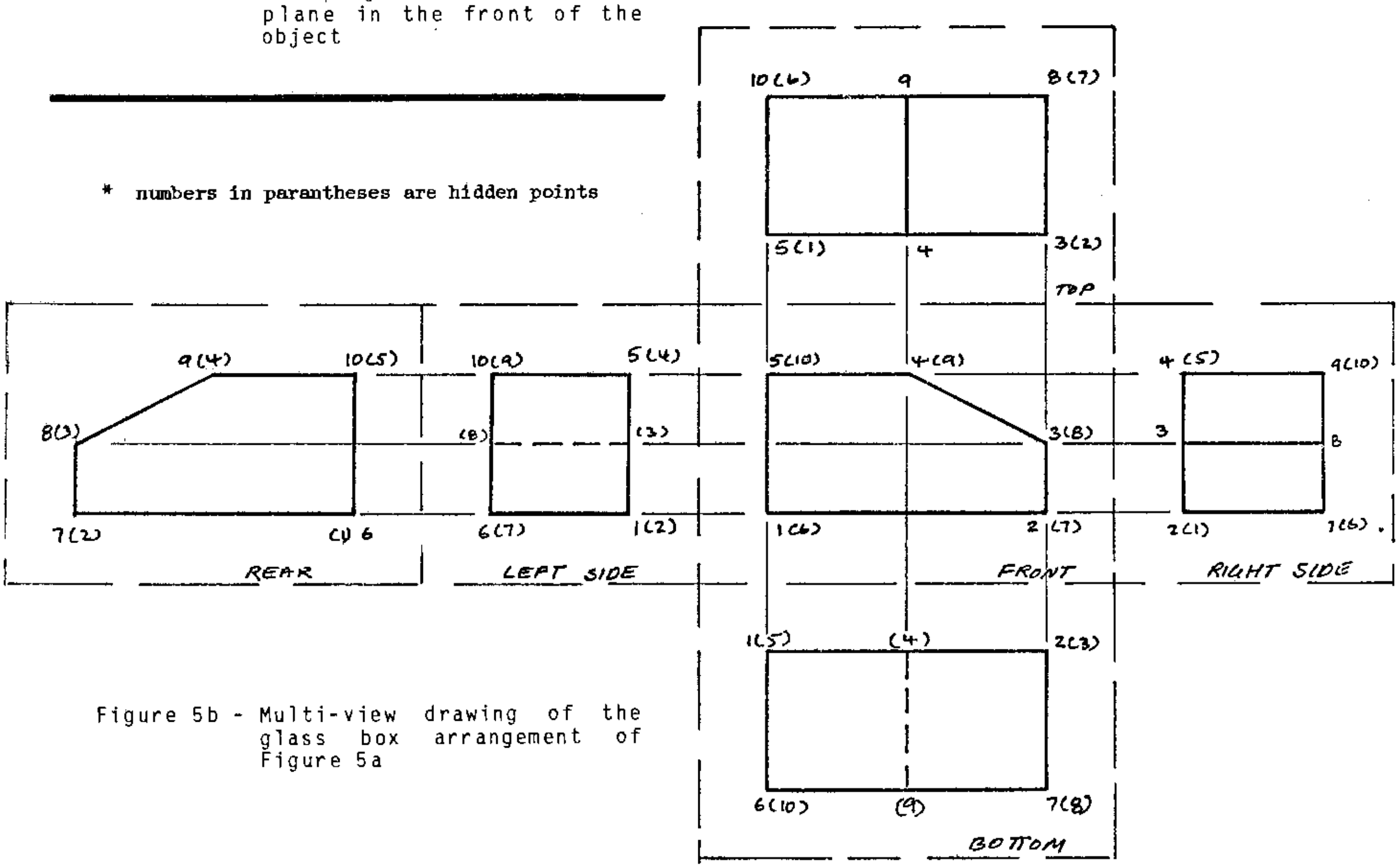


Figure 5b - Multi-view drawing of the glass box arrangement of Figure 5a

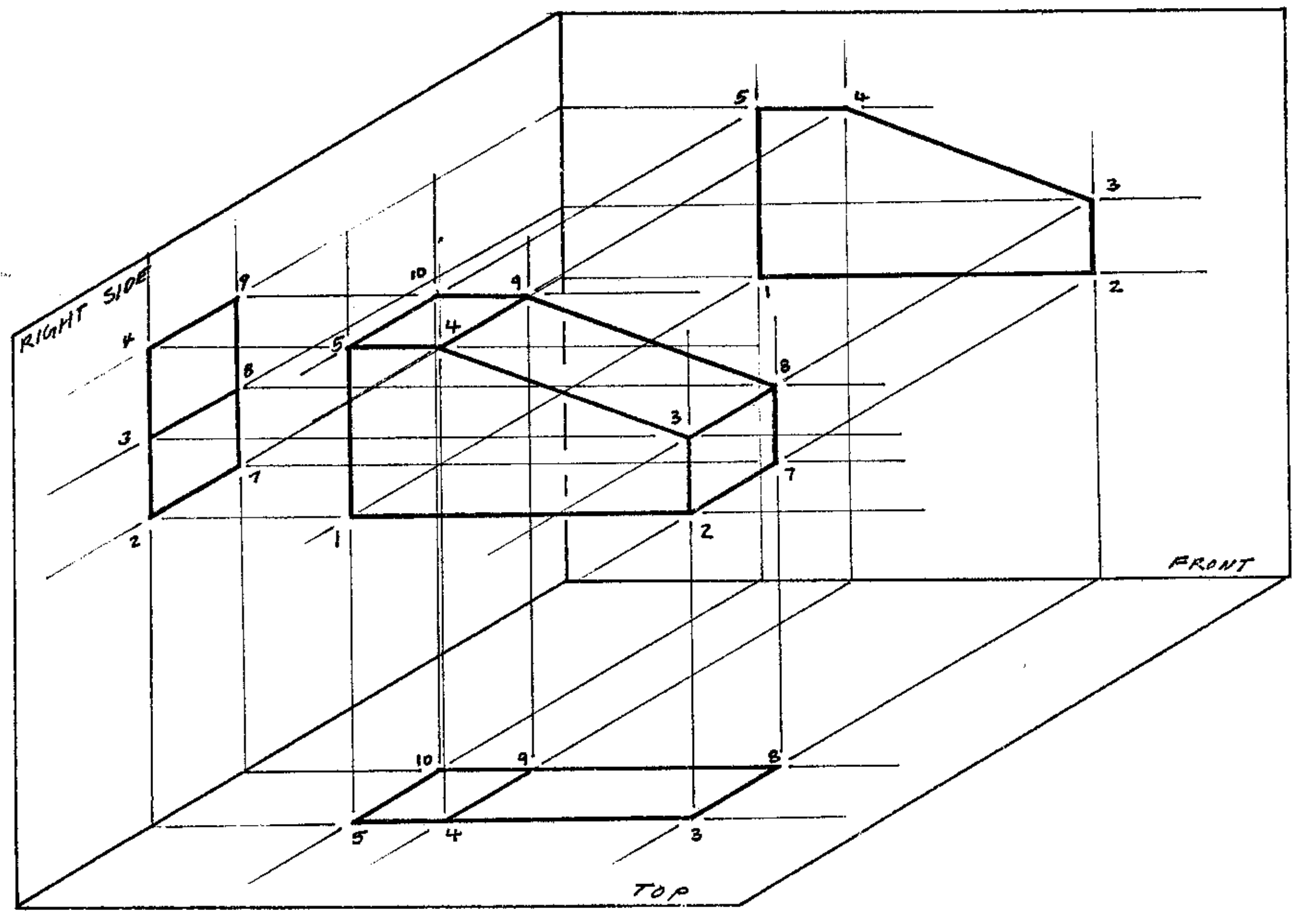


Figure 6a - Glass box arrangement, and the projections are taken on a plane behind the object

systems respectively, being named after the quadrant in which the object is placed. The use of a profile plane(s) enables us to obtain the side view(s) of an object.

Glass Box System

Projection systems can also be illustrated by the use of a glass box. An object is placed in a glass box and looked at from the six different sides of the box. The projections are recorded in the manner described earlier, and the glass box is opened up to obtain the multi-view drawings of the object.

Figure 5a shows the glass box arrangement and projections of the object (Figure 2b) with projections taken on planes in front of the object. Figure 5b shows the multi-view drawing for the glass box arrangement of Figure 5a.

Figure 6a shows the glass box arrangement and projections of the object (Figure 2b) with projections taken on planes behind the object. Figure 6b shows the multi-view drawing for the glass box arrangement of Figure 6a.

The glass box arrangement of Figure 6a is the same as the first angle projection system and the glass box arrangement of Figure 5a is the same as the third angle projection system.

Observations

1 - In both (first and third angle) the projection systems, the front view of the object is used as a reference about which all the other views in the multi-view drawing are pivoted.

2 - In the first angle projection system the top view appears below the front view, the bottom view appears on top of the front view, the right side view appears on the left of the front view, and the left side view appears on the right of the front view. In the third angle projection system the top view appears to the top of the front view, the bottom view appears below the

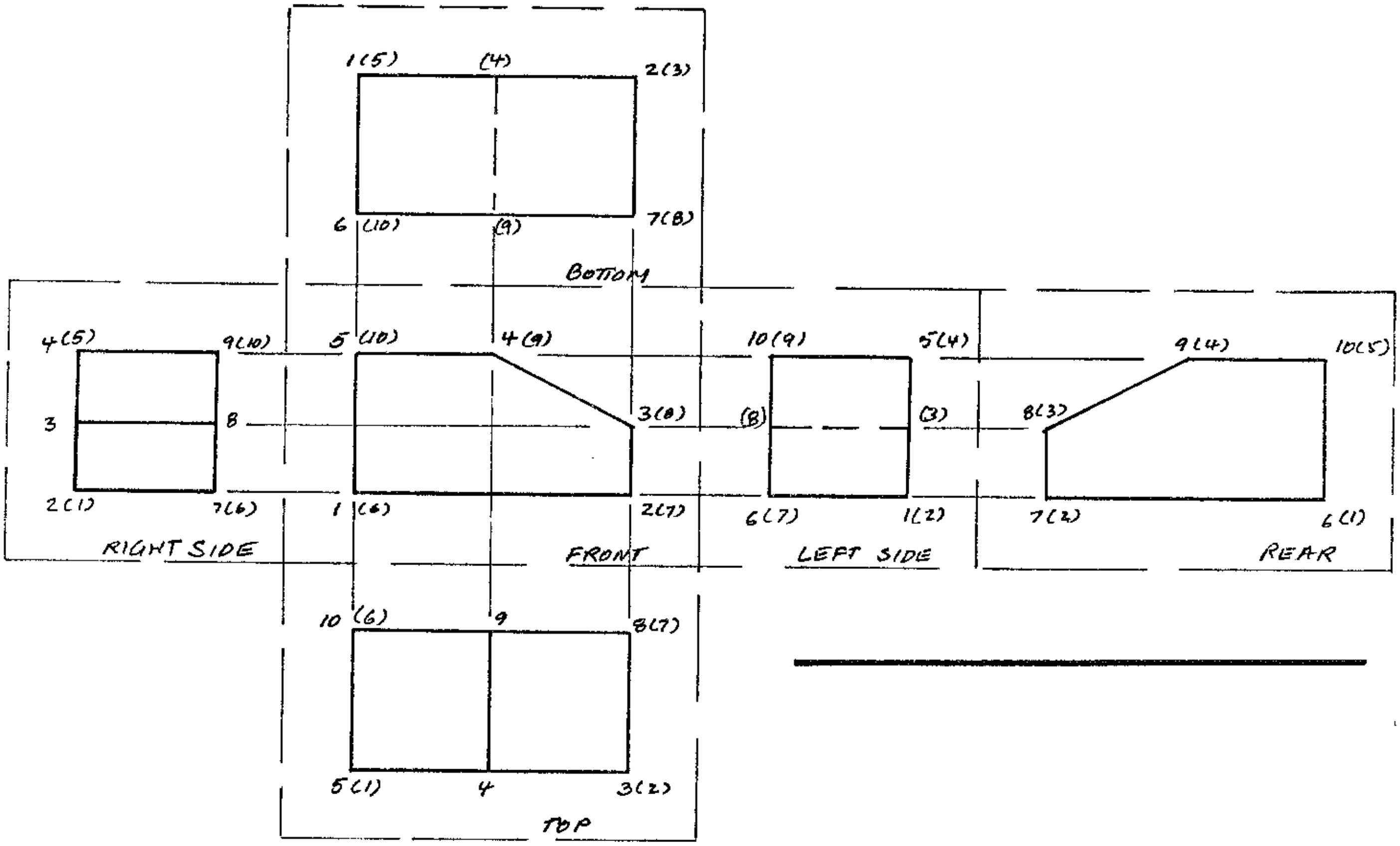


Figure 6b - Multi-view drawing of the glass box arrangement of Figure 6a

front view, right side view appears on the right of the front view, and the left side view appears on the left of the front view. Considering the layout of the multi-view drawing alone, the two projection systems are the opposites of each other while the corresponding views (e.g. the front view in both the multi-view drawings) are mirror images of each other.

3 - The visible points between any two adjacent views in the third angle projection system are in the same order (e.g. points 3, 4, and 5 between the top and front views - see Figure 5b). This is not so in the first angle projection system.

Conclusion

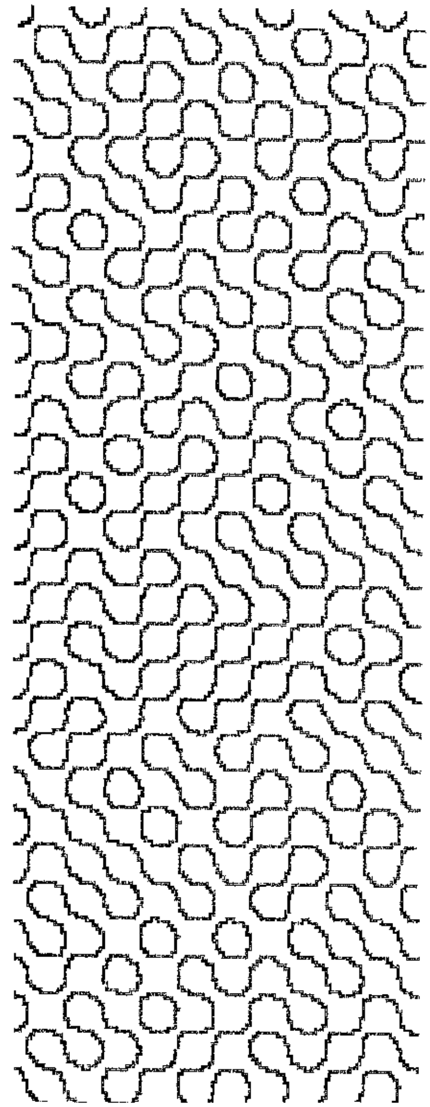
In view of the above observations it is concluded that the third angle projection layout is more logical, and it is easier to construct missing views from given views.

Computer Symbiotic Imagery

William J. Kolomyjec, Ph.D., M.F.A.
Department of Engineering Graphics
The Ohio State University

Symbiosis is the effect where the visual whole is greater than the sum of its component parts. This is an excellent example of a type of imagery naturally suited for the execution using the medium of computer graphics. Any computer with graphics capabilities can be programmed to generate an array of centers upon which individual modules or "tiles" can be centered. Each module is scaled to just touch adjacent modules. The effect is a tesselation where each module is a tile that interacts visually with its neighbor. If properly done, individual modules disappear into the overall composition producing a symbiotic image.

The Applesoft (TM) BASIC program presented below was designed to generate symbiotic imagery. In this case two complementary modules have been incorporated to maximize the effect. The listing consists of a main program and two subroutines. There are sufficient remarks embedded in the code to explain how the program operates.



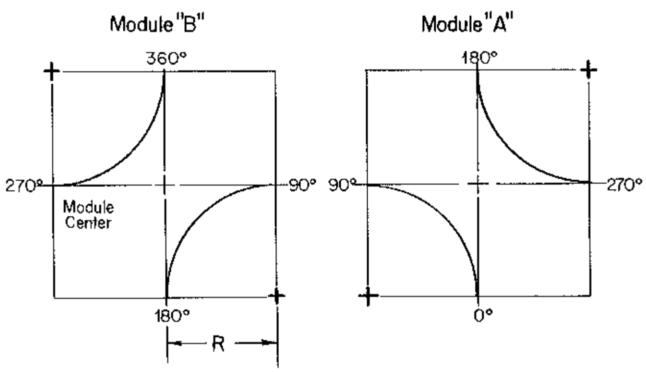


Figure 1: Quarter Circle Modules

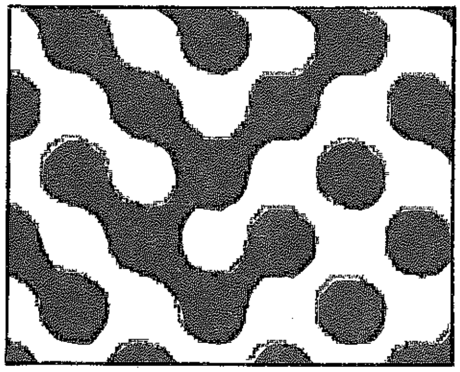
Two modules shown in Figure 1 will demonstrate this powerful graphic effect. The modules consist of two quarter circles or arcs whose centers are in opposite corners of a square. It is significant that the radii of the arcs equal one-half the size of the square in order that contiguous modules align. The center of the square is the center of the module. One module is called "A" and the other "B", and their data is provided to the following program by way of a nifty algorithmic subroutine.

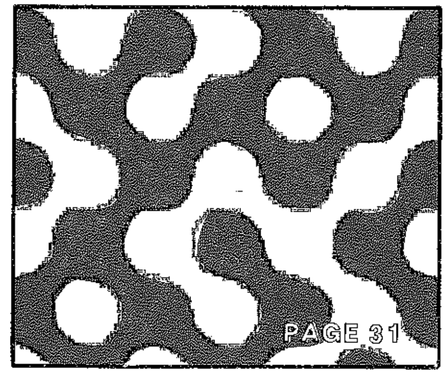
Any number of algorithms could have been devised to produce this or similar data. This particular algorithm allows control over the sampling rate. Increasing the size of the module, or drawing the modules on a higher resolution display, would necessitate increasing the sampling rate of the arcs. The actual points that make up the arcs are calculated within two nested loops utilizing some branching logic. Notice the arithmetic expressions that are utilized in the array subscript parameters. Also note, pen (or beam) control values are generated and stored in arrays as well.

After the data is scaled and stored in manipulation arrays, these are counter translated to their respective screen locations. A one-line coin-flipping algorithm (line 430) employs the pseudo-random number generator to choose one module or the other to be drawn. Thus each run produces a unique image.

```
100  REM  <<<<< SYMBIOSIS >>>>>
110  REM
120  REM  COPYRIGHT 1983 W.J. KOLOMYJEC
130  REM
140  GOSUB 3000: REM  FORMULATE DATA
150  REM  DIMENSION MANIPULATION ARRAYS, O
MIT PEN CONTROL COLUMN
160  DIM M1(1,N),M2(1,N)
170  REM  DEFINE X,Y OFFSET
180 XO =  - R:YO =  - R
190 FTR = 0.2: REM  DATA SCALE FACTOR
200  REM  ADJUST AND SCALE DATA
210  FOR J = 0 TO N
220 M1(0,J) = (A(0,J) + XO) * FTR
230 M1(1,J) = (A(1,J) + YO) * FTR
240 M2(0,J) = (B(0,J) + XO) * FTR
250 M2(1,J) = (B(1,J) + YO) * FTR
260  NEXT J
270  REM
280  REM  DEFINE IMAGE ARRAY CONSTANTS
290 XL = 15:XR = 255
300 YB = 10:YT = 190
310 JX = 13:JY = 10
320  HGR2 : HCOLOR= 3: REM  INIT GRAPHICS
330  REM  ROWS
340  REM  USE DOUBLE LOOP TO DRAW JX BY JY
 ARRAY & GENERATE CENTERS
350  FOR L = 1 TO JY
360 YPCT = (L - 1) / (JY - 1)
370 YCT = (YT - YB) * YPCT + YB
380  REM  COLUMNS
390  FOR K = 1 TO JX
400 XPCT = (K - 1) / (JX - 1)
410 XCT = (XR - XL) * XPCT + XL
420  REM  RANDOMLY BRANCH TO A OR B
430  IF  RND (1) - 0.5 < 0 THEN 500
440  REM  DRAW MODULE A
450  FOR J = 0 TO N
460 X = M1(0,J) + XCT:Y = M1(1,J) + YCT:P
= A(2,J)
470  GOSUB 1000
480  NEXT J
490  GOTO 550
500  REM  DRAW MODULE B
510  FOR J = 0 TO N
520 X = M2(0,J) + XCT:Y = M2(1,J) + YCT:P
= B(2,J)
530  GOSUB 1000
540  NEXT J
550  NEXT K
560  NEXT L
570  REM  TERMINATION, HOLD IMAGE ON SCREE
N UNTIL RETURN IS DEPRESSED
580  INPUT A$: TEXT
999  END
1000  REM  <<<<< PLOTSUBB >>>>>
1010  REM  PARAMETERS: X,Y AND P
1020  REM  P VALUE IS BEAM CONTROL: 1=DRAW
, 2=MOVE
1030  REM  FLIP Y COORD. AND CORRECT ASPEC
T RATIO (0.881)
1040  REM  PLOT AREA: 0<=X<=279,0<=Y<=217
1050 Y9 = 192 - (Y * 0.881 + 0.5)
1060  IF P = 1 THEN  GOTO 1100
1070  IF P <  > 2 THEN  PRINT "PEN ERROR":
 STOP
1080  HPLOT X,Y9
1090  RETURN
1100  HPLOT  TO X,Y9
1110  RETURN
3000  REM  <<<<< QTRCIRCMOD ALGORITHMIC DA
TA SUBROUTINE >>>>>
3010  HOME : VTAB 10: PRINT "GENERATING DA
TA..."
3020  REM  DEFINE QTR ARC SAMPLING RATE (N
S)
3030 NS = 10:N = NS * 2 - 1
3040  DIM A(2,N),B(2,N)
3050 R = 50
3060  DATA  0,0,0,90
3070  DATA  100,100,180,270
3080  DATA  0,100,270,360
3090  DATA  100,0,90,180
3100  FOR K = 1 TO 2
3110  FOR J = 1 TO 2
3120  READ XCT,YCT,FANG,LANG
3130  REM  ADAPTED FROM AN ARC DRAWING SUB
ROUTINE
3140 F = FANG / 57.295779
3150 L = LANG / 57.295779
3160 P = 2
3170  FOR I = 0 TO NS - 1
3180 PCT = I / (NS - 1)
3190 AN = (L - F) * PCT + F
3200 X = R *  COS (AN) + XCT
3210 Y = R *  SIN (AN) + YCT
3220  IF K = 2 THEN 3280
3230  IF J = 2 THEN 3260
3240 A(0,I) = X:A(1,I) = Y:A(2,I) = P
3250  GOTO 3320
3260 A(0,I + NS) = X:A(1,I + NS) = Y:A(2,I
 + NS) = P
3270  GOTO 3320
3280  IF J = 2 THEN 3310
3290 B(0,I) = X:B(1,I) = Y:B(2,I) = P
3300  GOTO 3320
3310 B(0,I + NS) = X:B(1,I + NS) = Y:B(2,I
 + NS) = P
3320 P = 1
3330  NEXT I
3340  NEXT J
3350  NEXT K
3360  RETURN
```

```
200  REM  ADJUST AND SCALE DATA
210  FOR J = 0 TO N
220 M1(0,J) = (A(0,J) + XO) * F
230 M1(1,J) = (A(1,J) + YO) * F
240 M2(0,J) = (B(0,J) + XO) * F
250 M2(1,J) = (B(1,J) + YO) * F
260  NEXT J
270  REM
280  REM  DEFINE IMAGE ARRAY CO
290 XL = 15:XR = 255
300 YB = 10:YT = 190
310 JX = 13:JY = 10
320  HGR2 : HCOLOR= 3: REM  INI
330  REM  ROWS
340  REM  USE DOUBLE LOOP TO DR
```

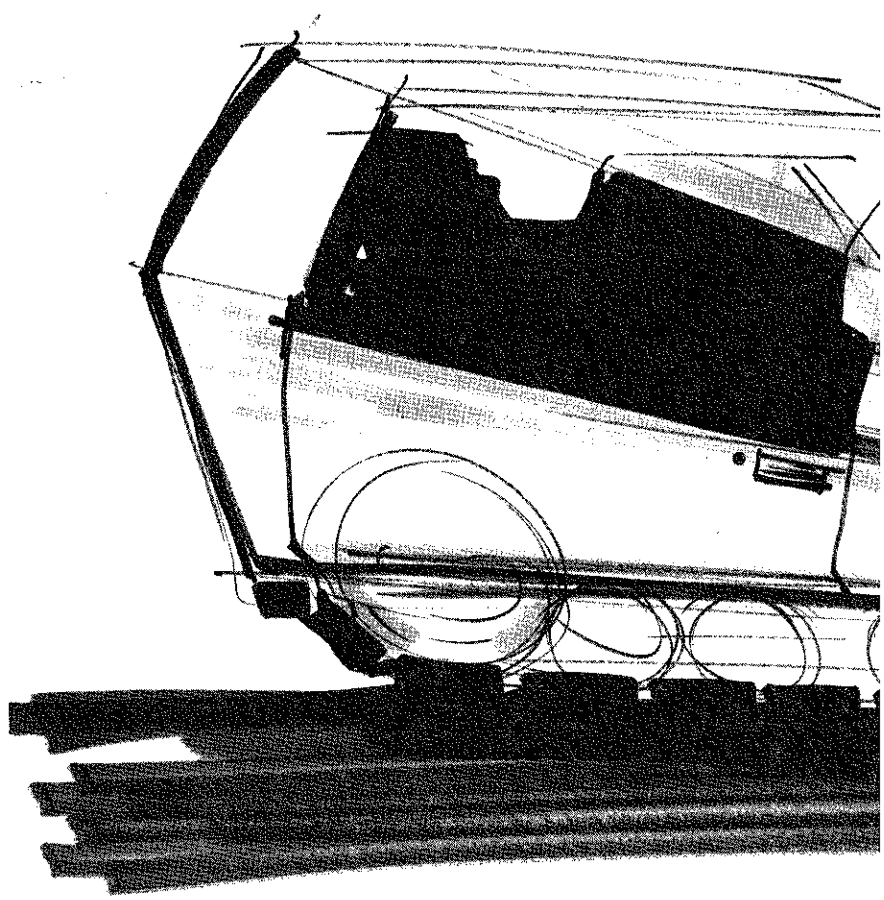




ENGINEERING DESIGN GRAPHICS JOURNAL
CIRCULATION MANAGER
DEPARTMENT OF ENGINEERING GRAPHICS
THE OHIO STATE UNIVERSITY
2070 NEIL AVENUE COLUMBUS,OH 43210
(address correction requested)

Nonprofit Org.
U.S. Postage
PAID
Bulk Rate
Dubuque, Iowa
Permit No. 477

industrial design page 8



AMERICAN SOCIETY FOR ENGINEERING EDUCATION