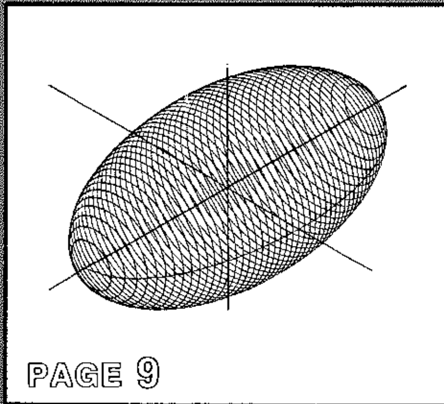
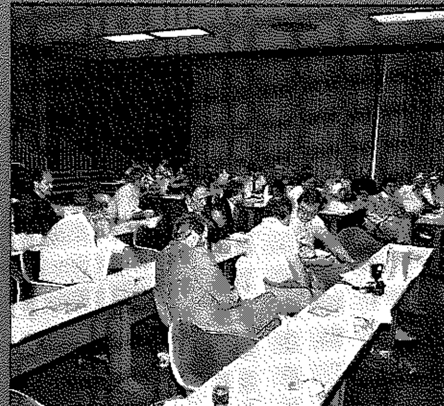
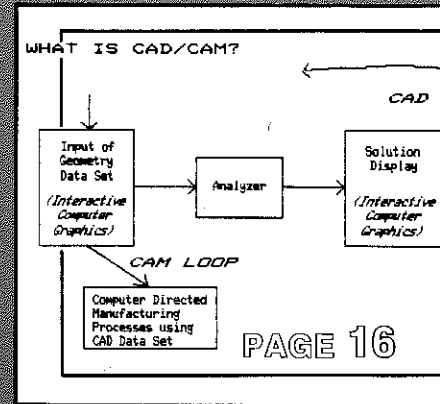
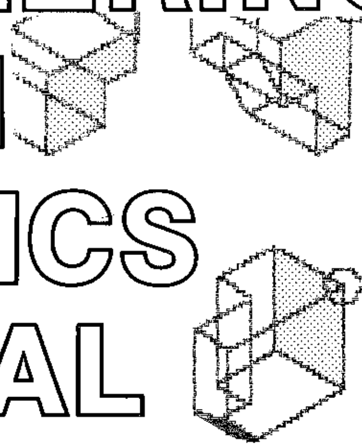


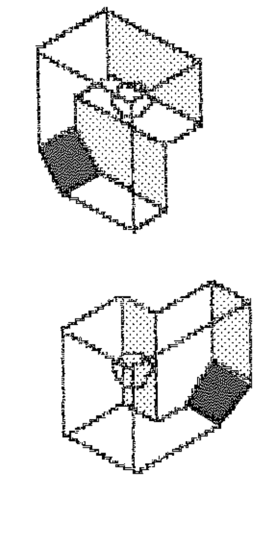


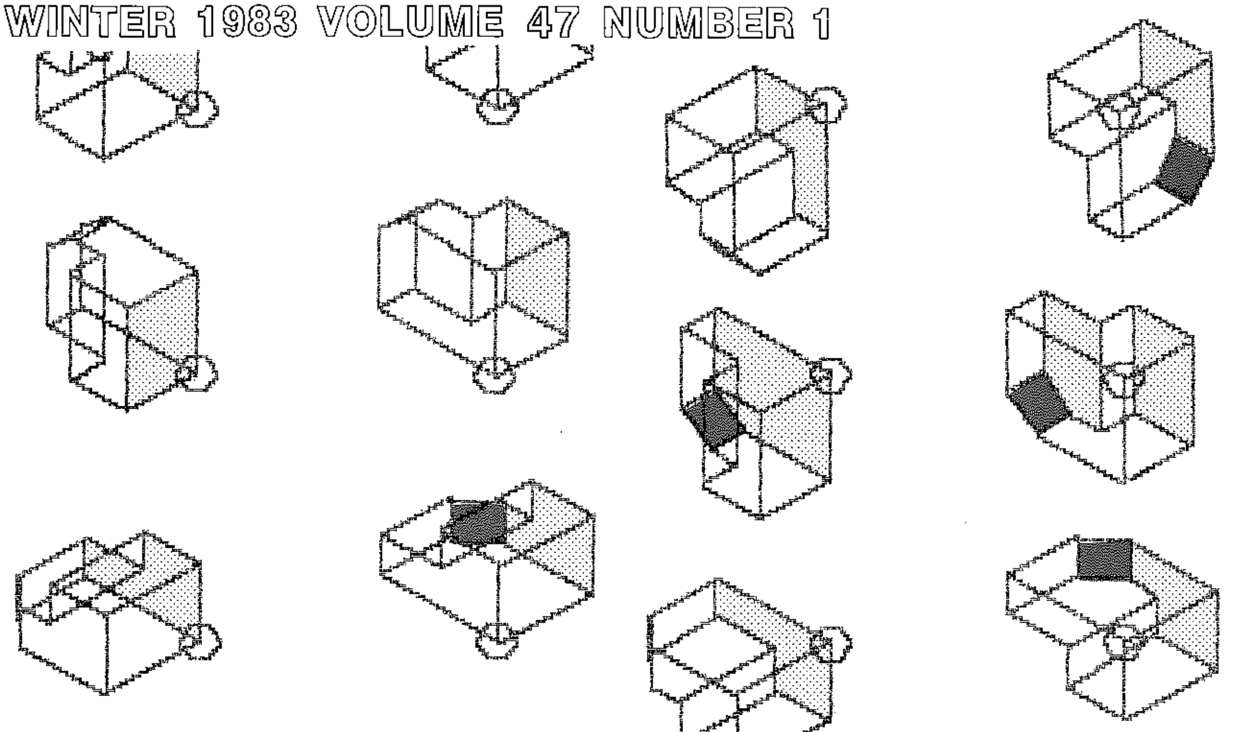


ENGINEERING DESIGN GRAPHICS JOURNAL

WINTER 1983 VOLUME 47 NUMBER 1







isometric madness for your Apple! turn to page 31

ENGINEERING DESIGN GRAPHICS DIVISION

Teach your students to speak the drafter's language.

THE GRAPHIC LANGUAGES OF ENGINEERING

Robert F. Steidel, Jr., University of California, Berkeley
Jerald M. Henderson, University of California, Davis

For engineering students, communicating with designers and drafters has become more important than actually mastering their art. That's why Steidel and Henderson have written a new introductory text for your one-term freshman/sophomore courses.

The Graphic Languages of Engineering gives your students a thorough understanding of the scope and purpose of graphics. And, its innovative approach lets you teach a wide variety of graphical topics without becoming overly involved in any one.

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Text: (0471-86759-4) / January 1983 / 704 pp.

For further information contact Frank Burrows, Depts. 3-8146

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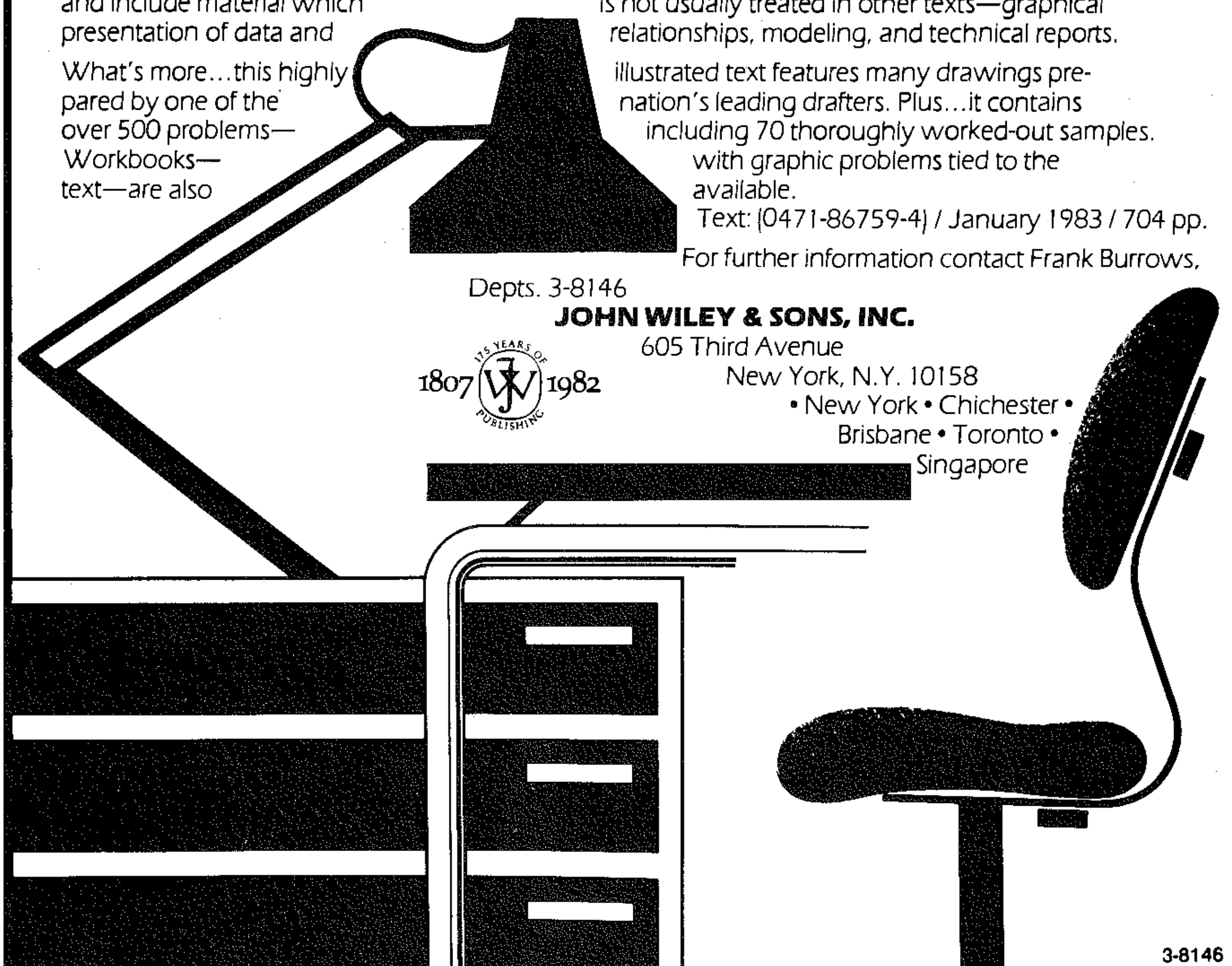

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CALENDAR

ASEE ANNUAL CONFERENCES

1981 - Rochester Institute of Technology
Rochester, New York

1984 - Salt Lake City, Utah

EDGD MID-YEAR MEETINGS

1984 - Pittsburg, Pennsylvania

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.

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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 peper, 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-Sl 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

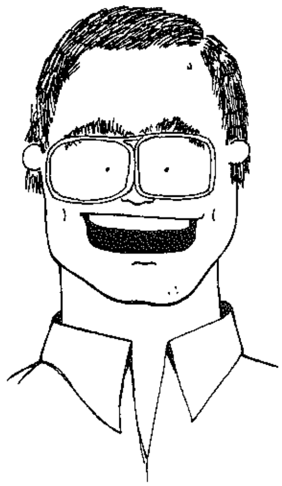
All articles submitted will be reviewed by several authorities in the field associated with the content of each paper before acceptance. Current newsworthy items will not be reviewed in this manner, but will be accepted at the discretion of the editors.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION
ENGINEERING DESIGN GRAPHICS JOURNAL
WINTER 1983 VOLUME 47 NUMBER 1

DEPARTMENTS

FEATURES

EDITOR'S PAGE



Having just returned from the ASEE/EDGD Mid-Year Meeting in Pomona, California, I like many who attended, am both charged and drained. Graphics people from the East, South, and West are doing some really exciting things both in hardware and curriculum design. You will be able to read several of the presentations made there in the next issues of The Journal. What amazes me most is the absolute creativity most must command in teaching modern graphics. Thirty-five students on one graphics terminal with a plotter on another campus 20 miles away! Wow! All I can say is that there are some teachers who are working very hard. It also points out that creativity and energy, lots of energy, can overcome a lack of support.

But then those with creativity and energy usually find support, or it finds them.

Of greater concern was the lack of attendance in an area of 7 million or so people and possibly 75 interested schools within driving distance; maybe it was the economy, or the timing. It certainly wasn't the quality of the conference, and my hat goes off to Bob Ritter of Loyola and Dale Galbraith of Cal Poly. A lot of people missed a very fine and affordable conference.

It appears that some questions have been answered by industry and education talking together at Pomona. You may not have come to the same conclusions as I have, and I welcome your comments to share with the rest of the division, but consider these for engineering and engineering technology programs:

1. We should not teach production graphics. For both automated and manual graphics it is not cost effective to train on production equipment.

2. We should teach the theory behind both manual and automated graphics that is independent of a particular system. This goes for computer systems as well as size description systems.

3. We should teach 3-D graphics. Industry asked: "Don't you teach descriptive geometry any more?" Yes, many do, but generally as a flat (fold lines) 2-D exercise. Flatland graphics is a disservice to students.

4. Engineers and engineering technologists should not be graphics programmers. Programming is an indispensible subject both for the way it teaches you to think and as a technical tool. But at the BS level, students should learn to use the tools, not reinvent the graphical wheel.

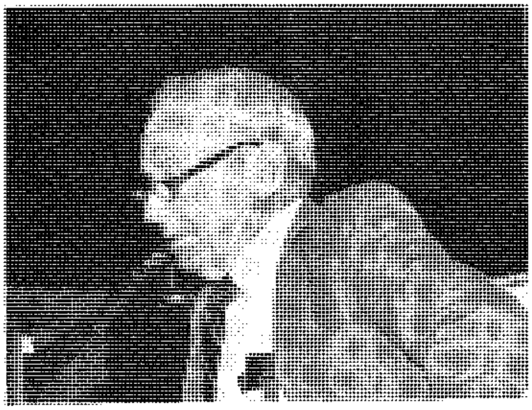
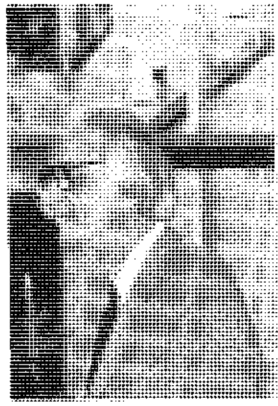
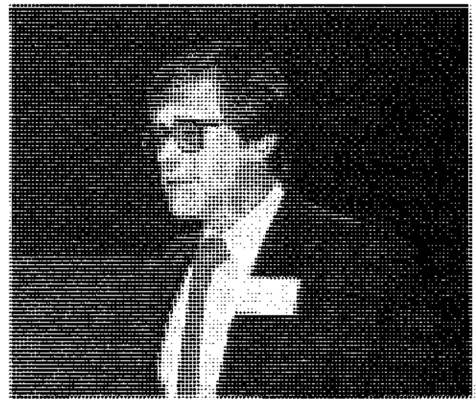
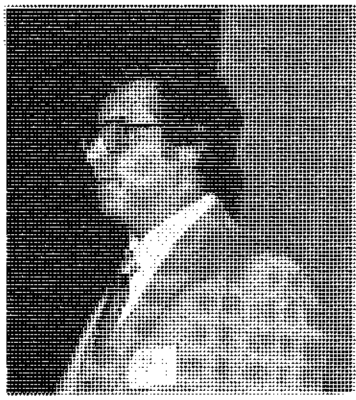
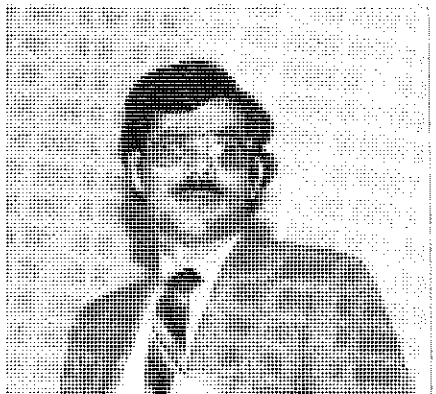
5. You can teach the essentials of automated graphics using inexpensive microcomputers. Outstanding teaching (not production) graphics software is available for most micros. Plus you have the option of teaching graphics programming, if you so desire, on the same machines.

6. The most efficient way to teach basic graphics, especially to a large number of students, is still the traditional manual way. Engineers and engineering technologists are expected to draw and sketch (communicate graphically) with or without mechanical or electronic aids.

A lot of people missed a very fine conference

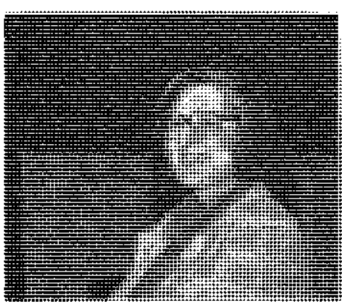
Just in the past year there has been an explosion of graphics delivered by micro and mini computers. Automated graphics will become more available, less expensive, and less dependent on computer knowledge. Requiring users to have knowledge about system operation and configuration, programming, or computer architecture is not a strength of computer graphics, rather it is a serious limitation. Teaching baud rate is as pedagogically silly as teaching 2H graphite adhesive factors for vellum or detail paper. When these ideosyncratic requirements are removed, as they surely will be, what will remain is GRAPHICS.

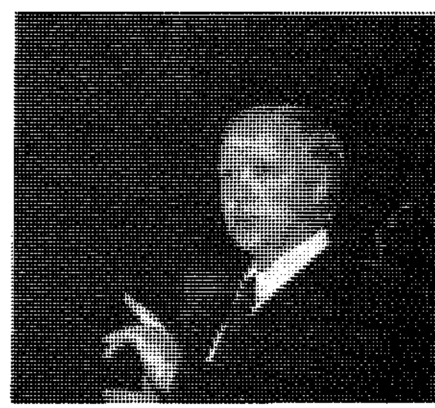
MID-YEAR MEETING

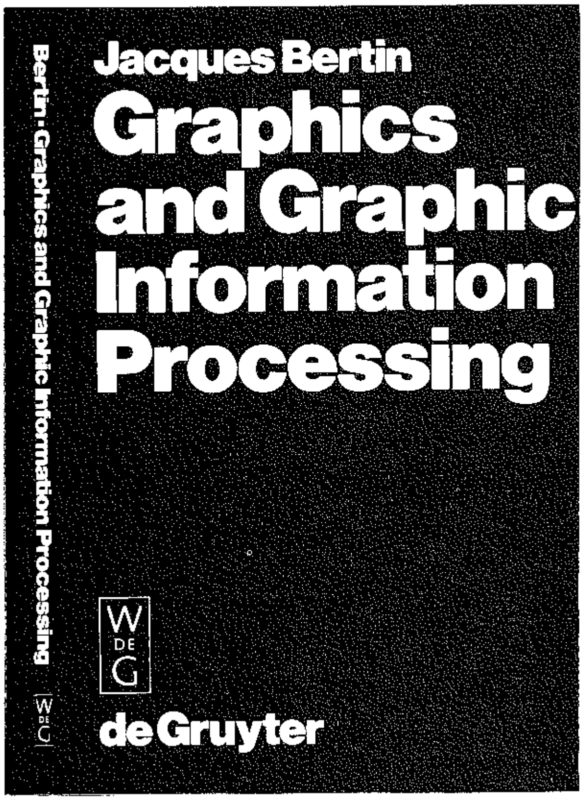








IN REVIEW

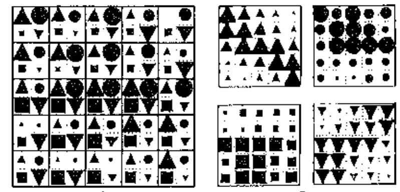


by William J. Kolomyjec, Ph.D., M.F.A.
Department of Engineering Graphics
College of Engineering
The Ohio State University

Bertin, Jacques. Graphics and Graphics Information Processing. Translation of La Graphique et le Traitment Graphique de l'Information. Walter de Gruyter & Co., Berlin, New York, 1981. 267 pages.

This text is a handbook for unique graphical methods in visual data processing. Methods utilize visual perception for the simplification of statistical and social science data using graphics constructions. Translated from the original French version, the techniques presented in this book reflect the visual analysis of data done in France at the Laboratoire de Graphique de l'Ecole des Hautes Etudes en Sciences Sociales, of which the author is director.

The title of the work will be somewhat misleading to the American audience in that graphics information processing has very little to do with computer or automated graphics. Instead, methodologies and schema are presented for the analysis of social science and statistical data using synoptic (fundamental types of) graphics constructions. The first two parts of the text address principal constructions based on transposing data tables to reorderable matrices. The graphical permutation of these matrices along with matrix-files and collections of tables or maps, are the essence of graphics information processing. A figure from the text, reproduced below, illustrates a matrix before and after reordering.



1 2

The third portion of the text has an interesting but esoteric discussion of the graphic sign system – a Semiological Approach. Eight visual variables are divided into two groups: the variables of image and the differential variables. These variables are discussed relative to permutated data constructions.

The remainder of the text addresses the conceptualization of problems into matrix form for analysis. A three step procedure (the drafting of three documents) facilitates the analysis: the apportionment table, the homogeneity schema and the pertinency table. The result is a single table which will contain necessary information so that researchers can discuss and connect relationships graphically. The process allows "reflection based on graphics notation". The essence of graphics is "to see" the author concludes.

This text is an attempt to bring graphics, as a method, into modern context. Perhaps graphics information processing has the potential to be a significant tool in present and future scientific research and in the analysis of data gathered by that research.

JOBS POSTED

SEARCH FOR ENGINEERING GRAPHICS FACULTY

The Department of Engineering Graphics at The Ohio State University is searching for nine-month tenure-track faculty at the assistant and/or associate professor level. Requirements are: degrees in fields appropriate to engineering education, of which at least one should be in engineering; competence in computer programming languages as applied to computer graphics and the solution of engineering problems; professional skills in all phases of graphical representation and communication; verbal fluency combined with talent and inclination toward classroom teaching. Duties include, but are not limited to, preparation, organization, and teaching of engineering graphics courses, supervision of teaching associates, management of multisection courses, advising students; development of instructional methodology, audio-visual materials, and programmed instruction; and performing administrative and committe functions in support of departmental activities. Faculty members will have the opportunity to participate in the development of extensive programs and facilities in computer graphics which both students and faculty will use for educational and research activities. An earned doctorate in an appropriate discipline is desirable; appropriate industrial experience will receive favorable consideration. Salary commensurate with qualifications. Resume and names of three references should be sent to Jon M. Duff, Department of Engineering Graphics, 2070 Neil Avenue, Columbus, Ohio 43210. Position open until filled. The Ohio State University is an equal opportunity/affirmative action employer.

ENGINEERING DESIGN GRAPHICS DIVISION

Papers are invited for the 1983-84 midyear meeting of the Engineering Design Graphics Division to be held in Pittsburgh, PA, in January 1983. Paper sessions will evolve around the topic of teaching techniques in design graphics education. Interesting and unique teaching experiments 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 before July 1, 1983, to James T. Weiss, P.O. Drawer E.G., University of Alabama, University, AL 35486.

CRITERIA FOR THE OPPENHEIMER AWARD

The Oppenheimer Award is presented at each Mid-Year meeting of ASEE/EDGD to the most effective presentation. A cash award of $100.00 is presented along with a suitably engraved certificate.

The evaluation is made on a 0 to 10 scale with 10 being excellent and 0 being poor. The criteria include:

1. Delivery: organized, enthusiastic, convincing, good introduction and closing, could be heard, considered time limit.

2. Visual Aids: effective, high quality, visible, technically correct, pleasing to the eye.

3. Questions: handled effectively, answered questions asked, tactfully rejected unreasonable/irrelevant questions.

4. Paper Content: relevant, appropriate level for audience, significant, thorough, useful result or conclusion.

Presentations are judged by EDGD members in the audience as selected by the Division awards director. The Oppenheimer Award is an honor every division member should aspire to receive.

\- Editor

PUZZLE

PROBLEM I:

There is a heptahedron consisting of seven planes: a horizontal plane, a frontal plane, a profile plane, a horizontal-projecting plane, a frontal-projecting plane, a profile-projecting plane, and an oblique plane. Of the seven planes there are four which form two pairs of planes with equal areas. Draw the necessary views of this heptahedron.

PROBLEM II:

Given: Adjacent orthographic views of two intersecting lines in general positions.

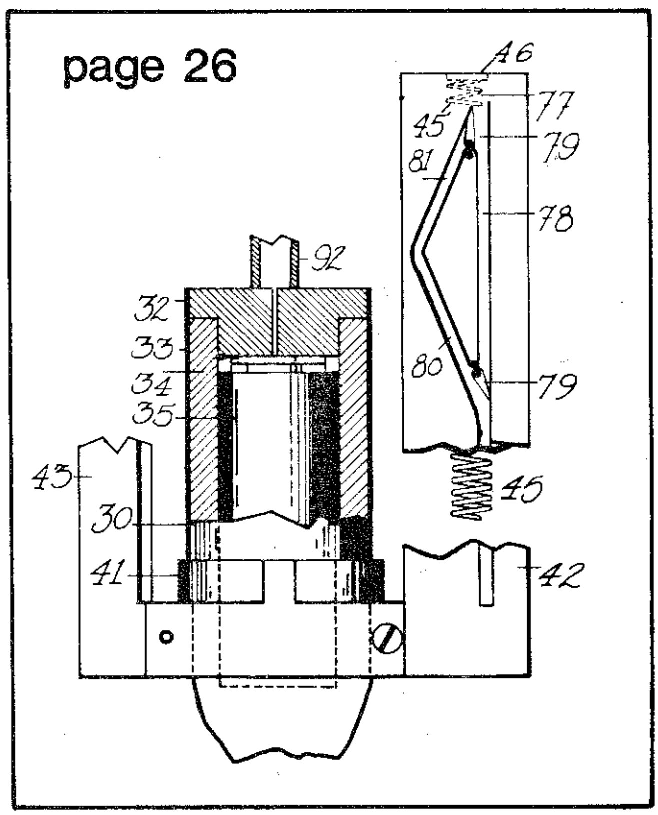
Determine: An orthographic view(s) such that the apparent lengths of the given lines are equal and intersecting, and the apparent angle is equal to that of one of view (projection) of the given two intersecting lines.

PROBLEM III:

Given: Adjacent orthographic views of an arbitrary triangle in general positions.

Determine: An orthographic view(s) such that the apparent triangle is an isosceles triangle and its basic side is specified length.

Chi-Di Lin
Anhwei Institute of Technology
Hofei Anhwei
The P.R. of China



COMMENT

The Graphics Pendulum

by Francis Mosillo

Engineering Design Graphics at the Freshman level? There have been scores of articles in the Journal and elsewhere stating and justifying the usefulness and meaningfulness of design and graphics. However, regardless of how much "proof" is presented and how much the administration and accrediting people express the need and importance of design, there are unspoken features which are actually held against the freshman engineering design teacher rather than giving them credit for all the extra work and dedication needed for such courses. There are two basic reasons for this. First of all there is the deep rooted concern that if design can be taught at the freshman level, why are the other three years needed. A ridiculous premise, but nevertheless, deans and senior faculty members have expressed such. Secondly, the design area has limited research and grant getting potential, and when it comes to a showdown as to support from administrators, they will always opt for the "bucks" and not courses.

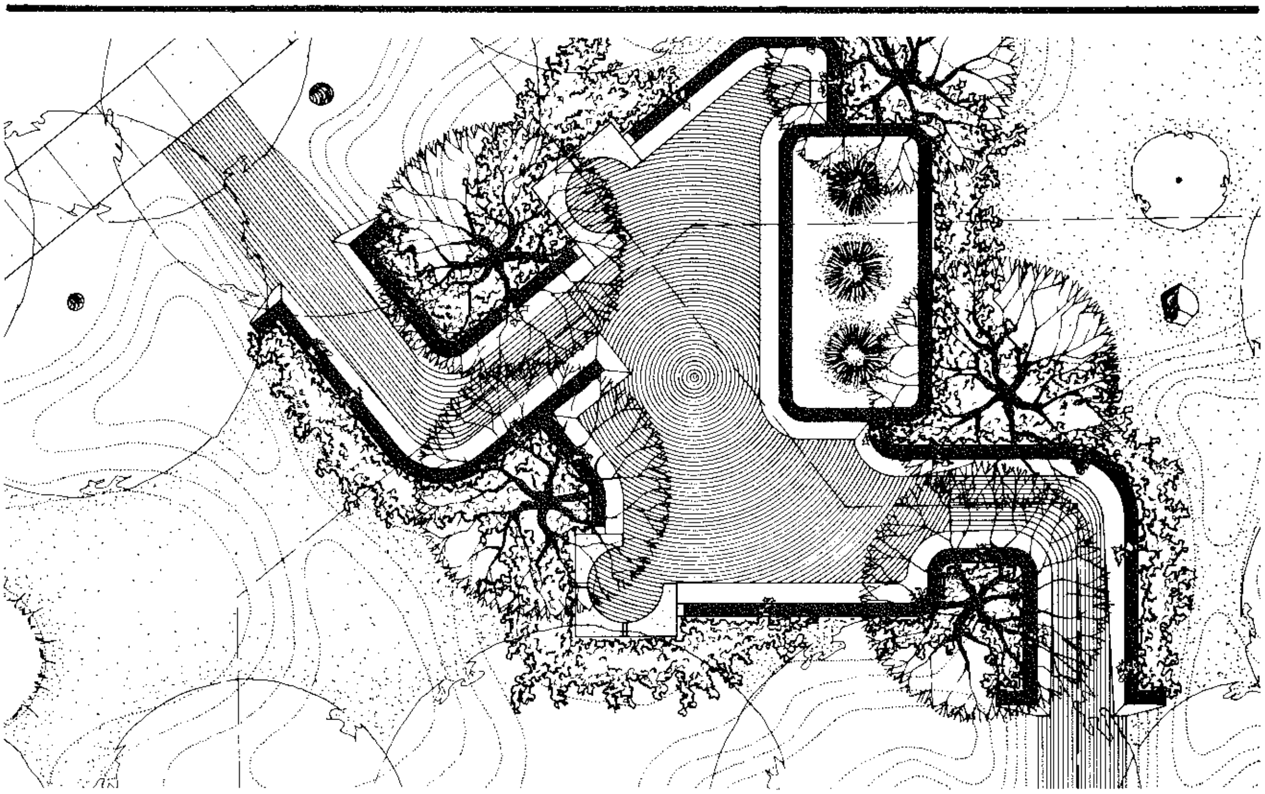
Currently there are those saying that graphics is getting its reputation back. Some say because of design, others because of computer graphics, and still others (the dreamers) because graphics is the engineers' means of communication. Some, the author included, may even believe that the mode of visual thought actually improves thinking, creativeness, and engineering progress. The administrators may believe this but again, when it comes to running a college, the bottom line is money. That is, although they may realize the

visual thought actually improves thinking

importance of graphics, the lack of grant money allows them to hope that the students will somehow learn the engineering communicative and thinking characteristics by themselves or "maybe" somehow during the four years in contact with other engineering courses. The senior faculty complain about the students' deficiencies in this area, but are really not willing to "subsidize" the area either in space in the curriculum nor share their statistics (i.e., grant dollars per faculty member in a department). There was one such small group of senior faculty members at the U of I Chicago who were willing to take on this "burden" for the sake of preserving the area. They were humiliated out of existence.

So, you say "the pendulum is swinging back", very nice, just watch out it doesn't cut your head off.

Now that this piece has made everyone angry, teachers and administrators (assuming there is still an audience read on), what does this mean, give up? Are <u>you</u> serious? Being forewarned is a means of preparing one's self for the task at hand. Recognizing the rules of the game is the only way to protect one's self. So now that you have been warned, get out there and fight!



ORTHOGRAPHIC AND PICTORIAL DRAWING BY COMPUTER GRAPHICS

Robert S. Lang, Associate Professor
Department of Industrial Engineering
and Information Systems, Northeastern
University

Why did I waste 10 years teaching two dimensional computer plotting while at the same time teaching three dimensional graphics drawing? Why did I have my students make computer plots of charts and graphs and other such two dimensional relationships while in my graphics classes I taught them orthographic projection and pictorial drawing?

The answer, of course, is that when I learned Fortran and Computer Plotting, that's what everyone was doing. Like so many of us long-established (read old) Graphics faculty who took on the role of Fortran teaching as Graphics teaching time was reduced, I learned from what was available, and there wasn't much being said about 3D graphics. Maps, charts, electrical schematics, and that sort of drawing prevailed, and so that's what I taught. It was not without a sense of satisfaction, too, that I was able to see my students use the latest up-to-date computer driven plotter to produce drawings.

Probably, I'd still be doing 2D plotting if I hadn't learned 3D while on a sabbatical. But the most pleasant surprise about 3D graphics is how easy it is to make basic orthographic and axonometric drawings. While most computer graphics texts are replete with matrices and matrix manipulation techniques, multi-view and pictorial drawings can be made using simple algebra. During the past year I was able to teach in three one-hour lectures enough computer graphics so that the freshman student could make any set of principle views and pictorial desired. The lectures were given in the middle of the Engineering Graphics course after the students had learned conventional drawing practices. They had either completed one course in Fortran with or without plotting or were taking a Fortran course coincidently with my Graphics course. If they understood DO loops and arrays, they were sufficiently prepared for my Computer Graphics lectures which consisted of one lecture each of data base construction, 3D to 2D conversion, and translation and rotation.

The results of plotting in 3D are much more impressive than 2D plots. Graphs, bar charts, and diagrams so typical of 2D graphics are displaced by automobiles, robots, space vehicles, or equationally defined complex shapes when the third dimension is added. But, best of all, to these images we can add dynamism! Having created the 3D image we can move it. We can make an automobile travel down a road or make the earth rotate on its axis. We can show an assembly being blown apart as in an exploded view; and we can begin to understand how the marvelous new computer graphics we see on our TV and movie screens is accomplished. Here are some fundamentals.

I. CONSTRUCTING THE DATA BASE

Consider Figure 1. It can be described in many ways; as a series of points, lines, or surfaces.

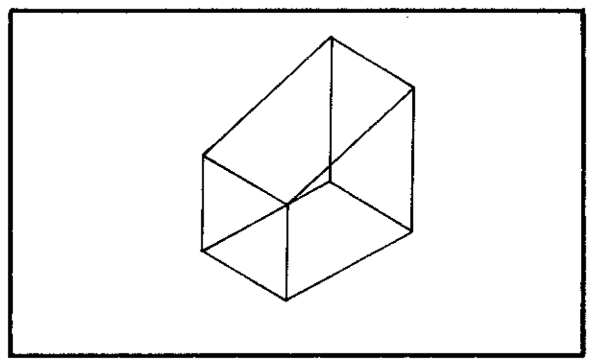


FIGURE 1

Point Description

If we were to draw the object with a pencil, light pen, or electron beam, we would trace a series of points. If the tracing is done by a DO loop statement of the type DO 5 I = 1, N where the index value I, equal to the point number, takes on sequential values 1, 2, 3 . . . N, then the corners must be redundantly numbered as in Figure 2.

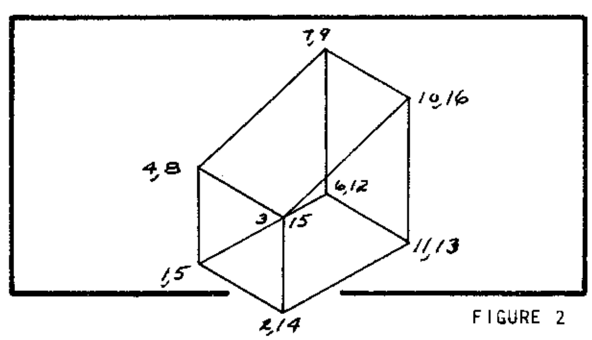


FIGURE 2

The resultant data base would, in this case, assuming a prism of length 1.5", width 1", and heights 1" and 1.5", an origin at point 1, and axes as in Figure 3, be:

PT	X	Y	Z	PT	X	Y	Z
1	0	0	0	9	1.5	0	1.5
2	0	1	0	10	1.5	1	1.5
3	0	1	1	11	1.5	1	0
4	0	0	1	12	1.5	0	0
5	0	0	0	13	1.5	1	0
6	1.5	0	0	14	0	1	0
7	1.5	0	1.5	15	0	1	1
8	0	0	1	16	1.5	1	1.5

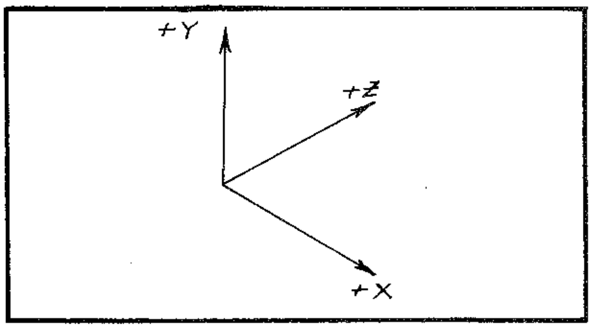


FIGURE 3

Line Description

The same object can be defined as in Figure 4 by a series of lines. This technique will define all lines by their end points, and the order is not important. The actual line drawing may be thought of as a "from" and "to" sequence; i.e., line 1 is made by drawing from point 1 to 2; line 2, from 2 to 3; ...; line 12, from 6 to 3.

The start of some lines will be the end of others which could result in redundancies in the data. However, if a data file is made up of 2 arrays, one consisting of the lines and the other the coordinator of the 8 points, then these can be associated in the program and result in a compact data file. The data file for the line description then becomes:

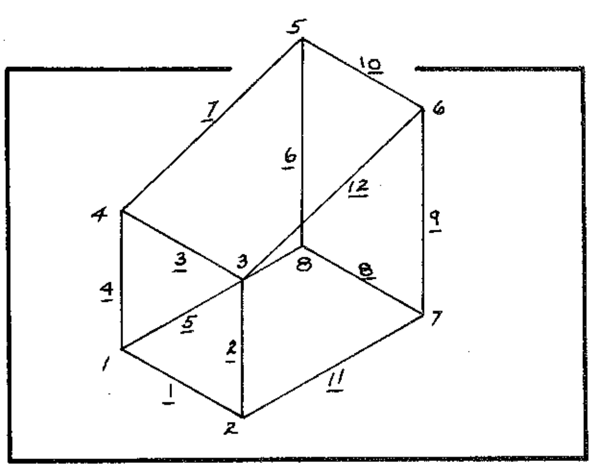


FIGURE 4

LINE

LINE	'FROM' POINT	'TO' POINT
1	1	2
2	2	3
3	3	4
4	4	1
5	1	8
6	8	5
7	5	4
8	8	7
9	7	6
10	6	5
11	2	7
12	3	6

COORDINATES

PT	X	Y	Z
1	0	0	0
2	1	0	0
3	1	1	0
4	0	1	0
5	0	1.5	1.5
6	1	1.5	1.5
7	1	0	1.5
8	0	0	1.5

Surface Description

A third method of defining the object would be by its surfaces. This technique lends itself to visibility determination for objects whose surfaces are convex polygons. Vector algebra involving dot and cross products is required if visibility is to be determined, something which our freshmen have not yet had, so I did not include it in my lectures nor will I describe it here. Notes will be available, however, for my students, and I'm confident the exceptional ones will learn this method which not only determines visibility but allows for shading techniques and other enhancement of the graphics. While the point and line technique will draw all lines as visible, there seems to be no general method of visibility determination without incurring excessive CPU time so this technique is most common and acceptable.

The surface method defines each surface by its polygonal corners and assigns a number to each corner. Numbering the corners is not ordered, but the sequence is since the pen will draw from one point to an adjacent one. For the object of Figure 5 the surface may be defined as follows:

multi-view and pictorial drawing can be done using simple algebra

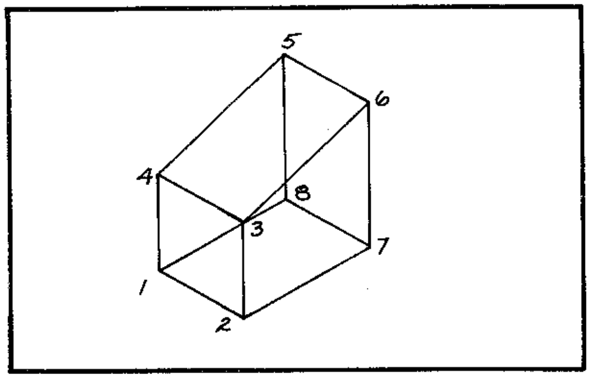


FIGURE 5

SURFACE	TOTAL POINTS	POINT SEQUENCE				
Front	5	1	2	3	4	1
Top	5	4	3	6	5	4
Right Side	5	2	7	6	3	2
Rear	5	7	6	5	8	7
Left Side	5	1	4	5	8	1
Bottom	5	1	8	7	2	1

The first and last points are the same so as to close the polygon and any point can be the start. The coordinate data file will be as in the Line description method.

II. USING THE DATA

Once the object has been defined, much more can be done than draw views. Surface areas and volumes can be calculated, engineering analyses, including moments of inertia and finite elements, can be performed, jigs and fixtures can be designed and numerically controlled machines can produce the part. Constructing the data base is the necessary first step for all the Computer Graphics and CAD/CAM that is to follow. Detailed and time-consuming as it may seem for my simple illustration, its value must be judged by its impact on all the steps of the design and engineering process.

3D to 2D Conversion – Making Orthographic Views

Drawing principle views merely requires that we have the pen trace the series of points defined in X, Y, Z coordinates in each case ignoring the one not applicable for each view. Therefore, for the front view, we will drop the Z coordinate information of the illustration just as in Graphics we ignore the depth dimension. For the top view we will drop the Y, or height, values and for a side view drop the X, or width, values. The coise of labeling the axis is, of course, one's own. For each view a new origin is defined and the pen motions right and left equated to one of the norizontal axis. The following program will plot and annotate the front, top, and right side views of the object shown in Figure 6. The line method of defining is used, and the data shown is used for making orthographic views and the isometric pictorial described later.

```
C      THIS PROGRAM WILL DRAW THREE VIEWS OF AN
C      OBJECT DEFINED BY ITS LINES.  THE DATA BASE
C      CONSISTS OF TWO ARRAYS; ONE, THE COORDINATES
C      OF ALL POINTS AND THE OTHER THE START AND
C      END POINTS OF THE LINES.
       DIMENSION X(13),Y(13),Z(13),L1(21),L2(21)
C      ENTER GRAPHICS MODE
       CALL ENTRY(0.)
C      READ COORDINATES OF ALL POINTS
       READ(5,*)(X(I),Y(I),Z(I),I=1,13)
C      READ START AND END POINTS OF ALL LINES
       READ(5,*)(L1(I),L2(I),I=1,21)
C      REDEFINE ORIGIN FOR FRONT VIEW
       CALL PLOT(0.,2.,-3)
       CALL FACTOR(.5)
C      DRAW FRONT VIEW
       DO 5 I=1,21
       CALL PLOT(X(L1(I)),Y(L1(I)),3)
       CALL PLOT(X(L2(I)),Y(L2(I)),2)
5      CONTINUE
C      ANNOTATE FRONT VIEW
       CALL ANNOT(1.,-1.,.2,0.)
C      REDEFINE ORIGIN FOR SIDE VIEW
       CALL PLOT(4.,0.,-3)
C      DRAW SIDE VIEW
       DO 10 I=1,21
       CALL PLOT(Z(L1(I)),Y(L1(I)),3)
       CALL PLOT(Z(L2(I)),Y(L2(I)),2)
10     CONTINUE
C      ANNOTATE SIDE VIEW
       CALL ANNOT(0.,-1.,.2,0.)
C      REDEFINE ORIGIN FOR TOP VIEW
       CALL PLOT(-4.,3.5,-3)
C      DRAW TOP VIEW
       DO 15 I=1,21
       CALL PLOT(X(L1(I)),Z(L1(I)),3)
       CALL PLOT(X(L2(I)),Z(L2(I)),2)
15     CONTINUE
C      ANNOTATE TOP VIEW
       CALL ANNOT(1.,=.75,.2,0.)
C      EXIT GRAPHICS MODE
       CALL ENDPLOT
       STOP
       END
$
```

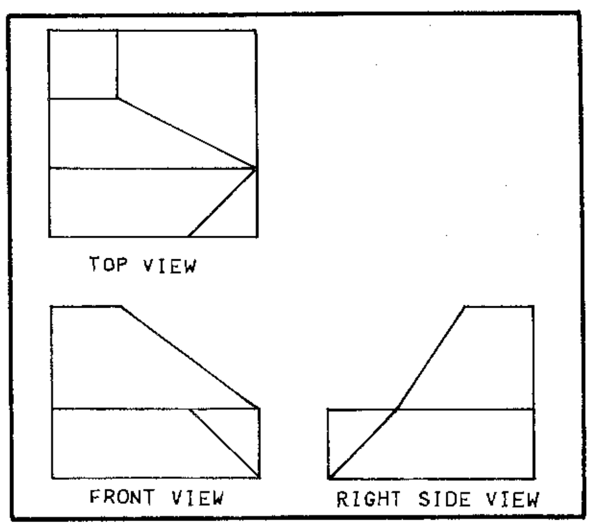


FIGURE 6

```
0 0 0
3 0 0
2 1 0
0 1 0
0 1 1
0 2.5 2.
0 2.5 3.
1 2.5 3.
1 2.5 2.
3 1 1
3 1 3.
3 0 3
0 0 3
1 2
2 3
3 4
4 1
4 5
5 6
6 7
7 8
8 9
9 6
9 10
10 3
10 2
2 12
12 11
11 10
11 8
12 13
13 1
13 7
10 5
FRONT VIEW
RIGHT SIDE VIEW
TOP VIEW
ISOMETRIC
$
```

Making Pictorial Drawings

If the data base is used to make pictorials, the X, Y, Z coordinates must be converted into the two dimensions of the plotter. The left and right measurements of the plotter usually thought of as X, I will call U, and the up and down measurements normally called Y, I will call V. For an isometric drawing to be made with axes as in Figure 7, the U equation is:

$$V = X \cos 30^{\circ} + Z \cos 30^{\circ}$$

$$U = .867(X+Z)$$

and the V equation is

$$U = Y + Z \sin 30^{\circ} - X \sin 30^{\circ}$$

$$V = Y + .5(Z-X)$$

For an oblique pictorial where θ is the depth angle the equations become:

$$U = X + Z \cos \theta$$

$$V = Y + Z \sin \theta$$

Other trimetrics can be similarly made by writing other forms of the U, V equations.

III. MOVING THE OBJECT

Translation

While the foregoing is the traditional type of drawing done, the dynamics of the subject is encountered by programming that makes the part move. This is done by translation and rotation or a combination of both. Translation produces motion along a line and causes the image to be reproduced in a different location, i.e., moving a car along a road.

Programming for translation merely requires that a delta X be included for all X locations of the plotter and a delta Y for all Y locations. The following statements will redraw the 450 points of our theoretical automobile as it moves down the highway.

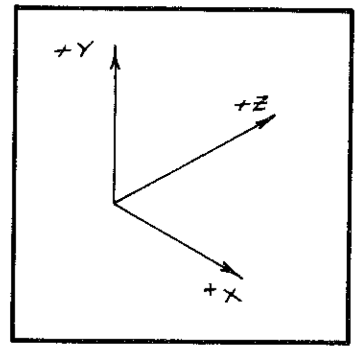


FIGURE 7

```
      X(1) = X(1) + DX
      Y(1) = Y(1) + DY
      Z(1) = Z(1) + DZ
      U(1) = .867*(X(1)+Z(1))
      V(1) = Y(1)+.5*(Z(1)-X(1))
      CALL PLOT(U(1),V(1),3)
      DO 5 K=2,450
      U(K) = .867*(X(K)+Z(K))
      V(K) = Y(K)+.5*(Z(K)-X(K))
      CALL PLOT (U(K),V(K),KON(K))
5     CONTINUE
```

NOTE: KON is connectivity factor
2 = point connected to previous point
3 = point not connected to previous point
KON is part of data base

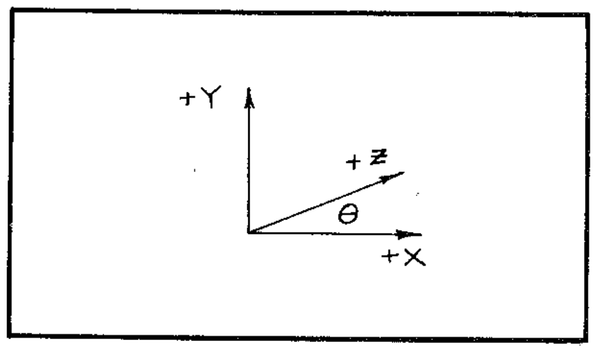


FIGURE 8

Rotation

If we want to view the object from a different angle, we can revolve our data set and redraw it in a new position. Our automobile can be pictorialized as in a conventional isometric then revolved 30° and redrawn repeatedly to show the car in 12 different positions. If combined with translation, the car can be made to move along a curved road.

To rotate a point about the principle axes of Figure 7 through an angle A so that X, Y, and Z become XR, YR, and ZR respectively, the following applies.

To rotate a point about the principle axes of Figure 7 through an angle A so that X, Y, and Z become XR, YR, and ZR respectively, the following applies.

Rotation about the X axis

$$\begin{matrix} XR \\ YR \\ ZR \end{matrix} = \begin{matrix} 1 & 0 & 0 \\ 0 & \cos A & \sin A \\ 0 & -\sin A & \cos A \end{matrix} \quad \begin{matrix} X \\ Y \\ Z \end{matrix}$$

Rotation about the Y axis

$$\begin{matrix} XR \\ YR \\ ZR \end{matrix} = \begin{matrix} \cos A & 0 & -\sin A \\ 0 & 1 & 0 \\ \sin A & 0 & \cos A \end{matrix} \quad \begin{matrix} X \\ Y \\ Z \end{matrix}$$

Rotation about the Z axis

$$\begin{matrix} XR \\ YR \\ ZR \end{matrix} = \begin{matrix} \cos A & \sin A & 0 \\ -\sin A & \cos A & 0 \\ 0 & 0 & 1 \end{matrix} \quad \begin{matrix} X \\ Y \\ Z \end{matrix}$$

Multiplying the matrices row by column gives:

X-axis

$$XR = X$$
$$YR = Y \cos A + Z \sin A$$
$$ZR = -Y \sin A - Z \cos A$$

Y-axis

$$XR = X \cos A - Z \sin A$$
$$YR = Y$$
$$ZR = X \sin A + Z \cos A$$

Z-axis

$$XR = -X \cos A - Y \sin A$$
$$YR = -X \sin A - Y \cos A$$
$$ZR = Z$$

As one would expect, in each case the coordinate associated with the axis of rotation remains unchanged. The sign of the angle is determined by the right hand rule of thumb. A positive angle assumes rotation in the direction of the fingers when the thumb points to the positive end of the axis of revolution.

The following will draw an isometric of the object shown in Figure 6 then revolve it and redraw it multiple times as shown in Figure 9. The data is that of the orthographic drawing program.

```
dTY ROTPAT.FOR
C       THIS PROGRAM WILL DRAW AN ISOMETRIC OF
C       AN OBJECT THEN REVOLVE IT 20 DEGREES
C       AND REDRAW IT.  IT WILL DRAW THE
C       OBJECT IN 6 DIFFERENT POSSITIONS.
C
C
C
        DIMENSION X(13),Y(13),Z(13),L1(21),L2(21)
C       ENTER GRAPHICS MODE
        CALL ENTRY(0.)
C       READ COORDINATES OF ALL POINTS
        READ(5,*)(X(I),Y(I),Z(I),I=1,13)
C       READ START AND END POINTS OF ALL LINES
        READ(5,*)(L1(I),L2(I),I=1,21)
C       REDEFINE ORIGIN
        CALL PLOT(0.,3.,-3)
C       SCALE DRAWING 4:10
        CALL FACTOR(.4)
C       DEFINE ORIGINAL ANGLE OF ROTATION
        ANG=0
C       DRAW OBJECT 6 TIMES
        DO 5 N=1,6
C       CONVERT 3D DATA BASE OF X,Y,Z TO 2D PLOTTER
C       U,V VALUES
        DO 10 I=1,21
        U=.867*(X(L1(I))+Z(L1(I)))
        V=Y(L1(I))+.5*(Z(L1(I))-X(L1(I)))
C       MOVE PEN TO START OF LINE, UP POSITION
        CALL PLOT(U,V,3)
        U=.867*(X(L2(I))+Z(L2(I)))
C       MOVE PEN TO END POSITION, PEN DOWN.  LINE
C       IS DRAWN
        CALL PLOT(U,V,2)
10      CONTINUE
C       DECREMENT ANGLE OF ROTATION
        ANG=ANG-20
C       REVOLVE ALL POINTS THROUGH ANGLE ANG.
        DO 15 K=1,13
        XR=X(K)*COSD(ANG)-Z(K)*SIND(ANG)
        ZR=X(K)*SIND(ANG)+Z(K)*COSD(ANG)
        X(K)=XR
        Z(K)=ZR
15      CONTINUE
C       REDEFINE ORIGIN FOR REVOLVED OBJECT
        CALL PLOT(8.,0.,-3)
5       CONTINUE
C       EXIT GRAPHICS MODE
        CALL ENDPLOT
        STOP
        END
$
```

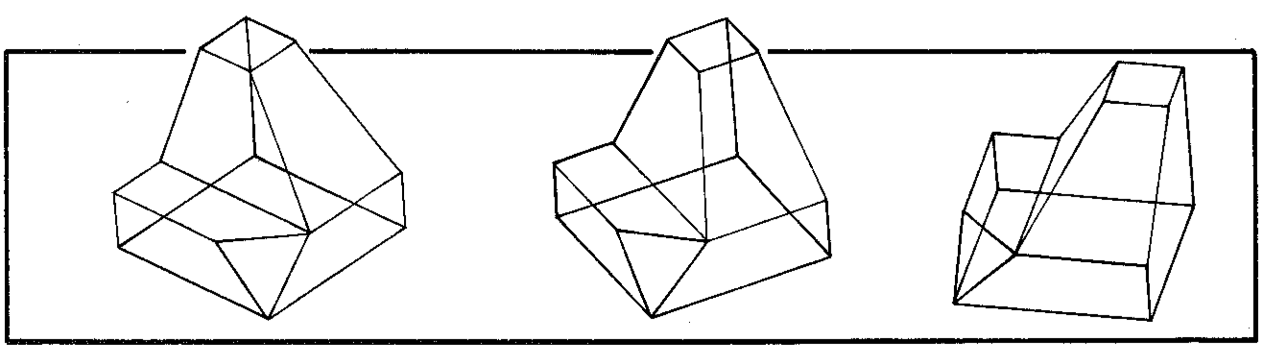


FIGURE 9

The simple equations needed to translate and rotate points and the potency of the technique is what makes the applications so intriguing to me. Merely translating a line can generate a surface. If the line is straight, the surface is a plane; if a circle arc, a single curved surface. But, what if the line is a damped sine wave or more exotic equation? Very interesting surfaces, most difficult to produce manually, can be easily generated, including sculptured contours if the X or Y term is varied as we increment Z. The value of graphics is never more obvious than when the symbology of the mathematics is made more comprehensible by displaying its pictorial equivalent.

If we rotate the line instead of translating it, we generate a different kind of surface. A straight line parallel to a principle axis when rotated about a principle axis can generate a plane or a cylindrical surface. If skewed, the line generates a hyperboloid of revolution. Simply by varying the position and type of lines, surfaces of revolution such as spheres, ellipsoids, paraboloids, and hyperboloids are generated by rotating the conic sections, and combinations of straight lines and circle arcs can produce more complex shapes. A straight line that is both translated and rotated can produce the kind of helicoid I talk about when I teach threads to my students. Some examples of translation and rotation are: Figure 10, a helicoid produced by translating and rotating one line; Figure 11, a hyperboloid produced by revolving one line about the vertical axis; Figure 12, a cylinder resulting by rotating a horizontal line about the depth axis; Figure 13, an ellipsoid of the equation

$$\frac{X^2}{16} + \frac{Y^2}{4} + \frac{Z}{4} = 1,$$

and Figure 14, a torus made by revolving a circle about the Y axis.

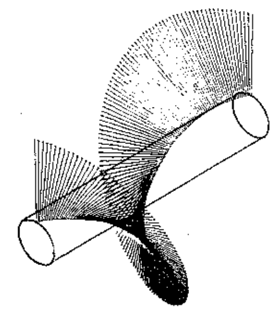


FIGURE 10

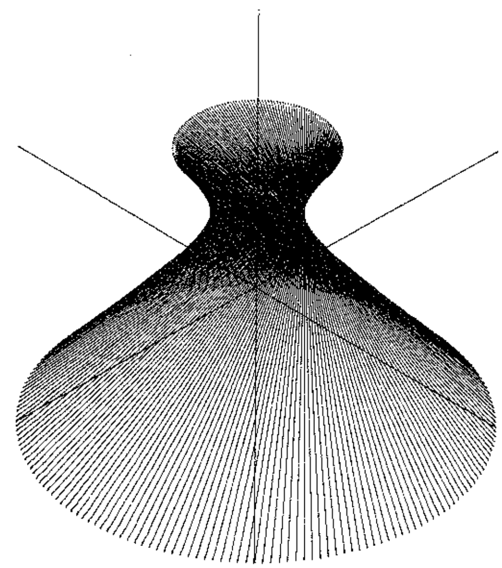


FIGURE 11

Conclusion

Doing computer graphics is the most fun I've had in a long time. But, what strengthens the pleasure is the role that computer graphics can play in the larger scheme of CAD and CAM and its adaptability to freshman courses. A new approach to our courses is required of all of us if we see the future as one in which the drawing no longer will be on paper but rather on an electronic device such as a pad or CRT. Our new Computer-Vision system at Northeastern can store primitive shapes of prisms, cones, cylinders, etc. for instant recall and composition into any shape I now have my freshmen draw. To be consistent with the new technology, we've got to align our teaching to it. We should describe our blackboard illustrations in X, Y, Z terms since a numerical definition of the object will be the descriptor of the future.

To emulate what can be done on a high level graphics system, I've encouraged my students to write subprograms of primitive shapes and display a menu from which I select some and build a new object. It is not difficult to simultaneously, with the graphics, display the surface area, volume, weight, or similar values of interest in engineering calculations. I feel this gives them understanding of what and how the sophisticated

doing computer graphics is the most fun I've had in years

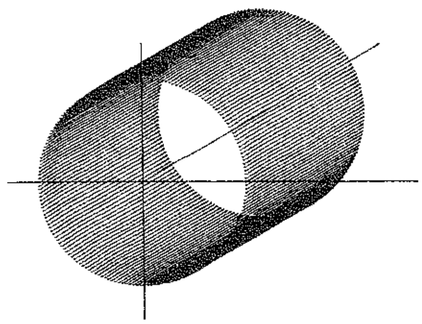


FIGURE 12

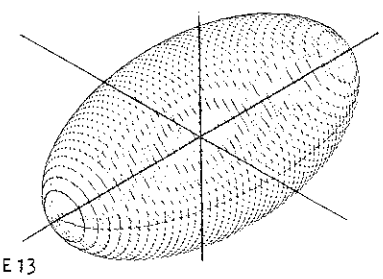


FIGURE 13

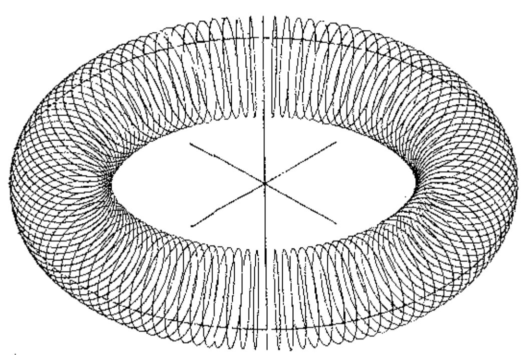


FIGURE 14

systems of Computer-Vision and Applicon work. I don't want them to be just button pushers or overawed by the computer graphics they see on their TV or movie screens.

Computer graphics teaching enhances the value of what we have always proclaimed - the need to think, comprehend, and communicate in spatial terms. Defining all the points, lines, and surfaces of a solid is not easy. One must first visualize and sketch it somehow. Visualizing a solid when all lines are visible, and the object is divided, into subareas for finite element analysis is difficult.

When I talk about revolving a trace to generate a surface, it relates very nicely to the concept of passing a cutting plane I had just explained in my previous lecture on Sections. When I write on the board an equation of an ellipsoid and discuss the effect of setting the Z term equal to a constant, it takes me back 20 years when we said the same thing and the students would then manually plot the sections, traces, and envelope to produce the final drawing.

Nothing I have said requires sophisticated or costly equipment. Presently, our student plotting is all done at one remote Versatek Plotter. The student runs his program from a standard VT101 terminal, then walks and waits at the plotter for the drawing - a primitive way to do computer graphics. This year I hope to acquire a graphics terminal. Next year I hope to have several for our students so that displays will be viewable, interactive, and dynamic.

What is important is that what students are learning is fundamental to their understanding of graphics and the entire manufacturing sequence, reinfroces and gives new value to the programming they had learned in a previous Fortran course, is the first step into CAD, and, most important, the result of their programming is a drawing! - an image a thousand times better than the words and numbers of the usual computer output. What more could a graphics teacher ask?

THE FIRST STEP TOWARD CAD: a freshman design component

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R.D. Jenison, Freshman Engineering, Iowa State

Introduction

Design is the distinguishing feature of engineering. Most of any engineering effort is directed toward a system, process, or device which will satisfy a human need. Successful designs likely occur when a carefully prepared plan is followed from an original statement of a need through the communication of a specific solution. Many designs prove unsuccessful because of a faulty design process (plan) or because the process was not followed. The United States automobile industry has frequently been criticized for not reacting to the apparent shortage of gasoline and the overall economic situation be designing a competitive "small" car. In fact, when the automobile industry did react to the situation, the foreign automakers were in the lead, and in the efforts to catch up quickly, some design errors may have occurred. The resulting effect was that the U.S. industry fell further behind. Today the industry is struggling for survival with the realization that efficient, thorough designs completed in a minimum time frame are absolutely necessary to remain in business.

The automobile industry and other large industries such as farm equipment and aircraft are investing heavily in techniques and equipment that bring about increased productivity, thus regaining a competitive advantage in the world marketplace. Computer aided design/computer aided manufacturing (CAD/CAM) techniques are seen as providing the advantage needed. Engineering education has the charge to keep pace with the rapidly changing approach to design and the use of CAD/CAM techniques in the industry.

Figure 1 represents a generalized functional chart of an industrial design organization. The organization follows a structured design process, the steps of which may be defined as follows:

1. Define the problem
2. Set schedule
3. Define payoff function
4. Establish constraints
5. Verify the design space
6. Find a nominal solution
7. Investigate control variable sensitivity
8. March to best solution
9. Sell the results

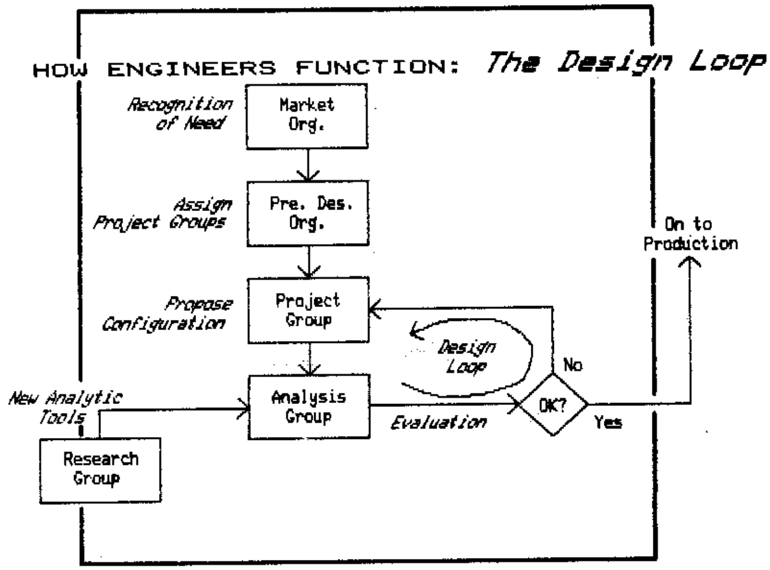

FIGURE 1

The key to success in the design loop is coordination of activities and the assurance that each analysis area (structures, power source, etc.) is aware of design progress at any time. A key element of the design loop is the effectiveness with which new technology is implemented by the research group. The inability to adapt scientific discovery to engineering problem solution is perhaps the greatest deterrent to success.

A closer look at the design loop and the impact of CAD/CAM on the loop is shown in Figure 2. The analysis group depends upon mathematical

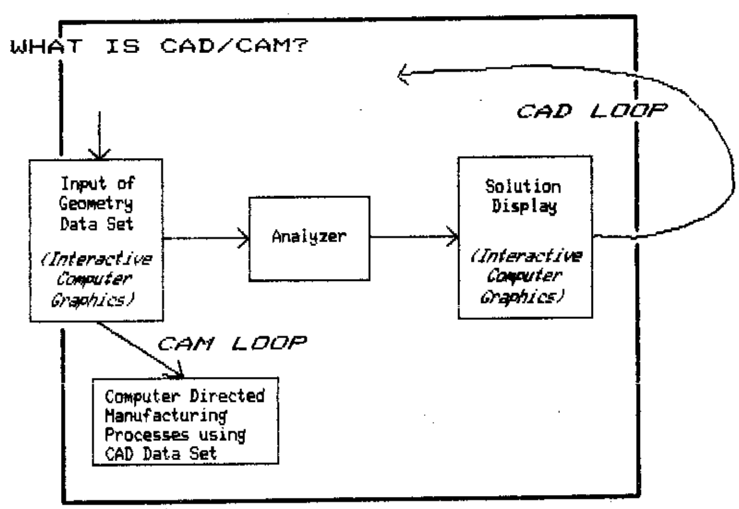

FIGURE 2

models to study variable sensitivity and for optimization techniques leading to a "best" solution. These computer-based "analyzers" have been available for many years. The CAD/CAM revolution that has been taking place recently is the result of the use of interactive computer graphics to visualize the input to the analyzer and to view the solution from the analyzer. The common thread in this CAD/CAM technology is the geometry. The visualization of geometry is a principle objective in any engineering graphics effort. From the engineering education standpoint, there is a definite need for a coordinated design effort.

Need: To expose the engineering student to a modern design process in a CAD environment. This should begin early in the educational effort (freshman year).

Freshman Design

Traditionally, design at the freshman level involves a broad-brush approach to a problem. The students at this point do not have the technical background to cope with equations of motion or optimization techniques. However, in a carefully controlled setting the student can gain valuable experience with regard to the overall design process. Specifically the student at the freshman level should receive from a design effort,

a. an understanding of the importance of the design process in industry.
b. the incentive to study upcoming physical and engineering sciences.
c. an appreciation of the capabilities of computer graphics in the design process.

A structured design process for freshman is set forth in the following steps:

1. Identify need
2. Define problem
3. Search
4. Criteria and Constraints
5. Alternatives
6. Analysis
7. Decision
8. Specifications
9. Communication

These steps are parallel with and similar to the steps previously outlined for a general industrial process. However, certain changes are evident which reduce or circumvent the specific technical requirements. For example, more time is used in a freshman design project to search for alternative solutions and to arrive at a decision. From the industrial point of view the payoff function is used from the beginning to control the alternatives. The industrial setting more specifically outlines the problem statement early in the process.

When the Freshman Engineering Department at Iowa State obtained the GIGI/BARCO computer graphics facility (described in previous papers, specifically reference 2), an experimental graphics course was established. The course was organized parallel with the traditional graphics course, that is three semester credits with one credit devoted to an introduction to engineering design. The authors of this paper were assigned to teach the course for the first time spring semester 1982. Several decisions with regard to the design component were made. First, with a computer facility available, more detailed analysis work could take place with a computer program serving as the analyzer in the CAD loop. In order to do this, much of the initial design process such as criteria and constraints would necessarily have to be in the analyzer. Second, even with a computer graphics facility available, we did not have the typical design stations that exist in industry. We did not have the preprocessing capabilities such as digitizer boards nor the postprocessing ability with plotters, etc. Third, we felt that although the students lacked the technical background, they would be able to understand and work with geometric variables. Specific objectives for the design component were set forth:

a. Seeking an optimum solution to an engineering problem described by a specified set of constrained variables.
b. Using the optimum solution and applying graphics principles to develop specifications for the design.
c. Communicating the design effort via a written report and engineering drawings.

These objectives represent essentially the last four steps of the freshman design process outlined earlier. A strong introduction to the design process is necessary to convey to the student what the process is and how the process was executed to the point where the student now assumes the responsibility for completion.

One other basic difference exists in the design component of the experimental and traditional courses. The experimental course design problem is solved individually rather than as a design team. This change was made because the computer graphics facility has sufficient stations for each student to interactively seek a solution.

With the objectives in mind, a design problem called three point hitch was developed as the analyzer.

A Design Problem

The complete problem assignment as given to the student is shown in Figure 3. Note that the problem assumes a three point hitch solution. This point is covered very carefully in lecture. We believe that the approach is typical to that in industry where the engineer is asked to determine the "best" configuration given the appropriate criteria and constraints and a payoff function.

Three Point Hitch Design Problem

The three point hitch design problem has been introduced in lecture. A solution configuration has beeb established. Your responsibility is to complete the problem solution by following the design process to its conclusion.

In our preliminary design research we have determined the following design constraints:

1. The hitch must lift 2000 lbs.
2. The hitch must lift the load from the lower box to the upper box (boxes are 6" x 1"). Your instructors will give you the specific locations of the boxes.
3. Stress must not exceed 16000 PSI.
4. Pivot point for the arm must be on the so-called pivot block.
5. The driver must be 12" long.

The priliminary design study has also established the criteria which will be used to determine the ideal solution. They are as follows:

1. For reasons of weight and material costs, the weight should be held to a minimum.
2. For quickness of system response, reliability, durability, and low cost the loads on the hydraulic activator should be as low as possible.

Thus, an equation can be established to rate possible solutions as follows:

$$P = (\text{Weight})(\text{Link Load})$$

where P is a performance factor. The lowest value of P is the best solution.

Your immediate task is to find solution to this problem and write analysis report documenting efforts. Requirements of that report are forthcoming. Eventually, you will take the design you have chosen and specify it completely and submit a second report on that effort.

Since most of you are not yet able to calculate stress, bolt loads, etc., your instructors have provided a program named HITCH to do these tasks for you. A figure for identifying the variables is included below. You are allowed as unlimited number of test iterations. However, to save you time and allow you to optimize the solution quickly, we would suggest the following design procedure:

1. Use instruments and find which combinations (a layout drawing) of the six parameters; A, X, Y, L1, L2, L3; meet the geometry constraints. Find several alteratives.
2. Test these alternatives and record the loads, stresses, and weight. Try to determine some trends.
3. Plan some additional test cases and return to Step 2.

There are so many unknowns in this problem that a random approach will never work. Try to be systematic.

FIGURE 3

Figure 4 illustrates the six variables and what is displayed when the student chooses a specific set of variables. Figure 4, although a value of P is indicated, is not a correct solution because the geometry constraints are not satisfied.

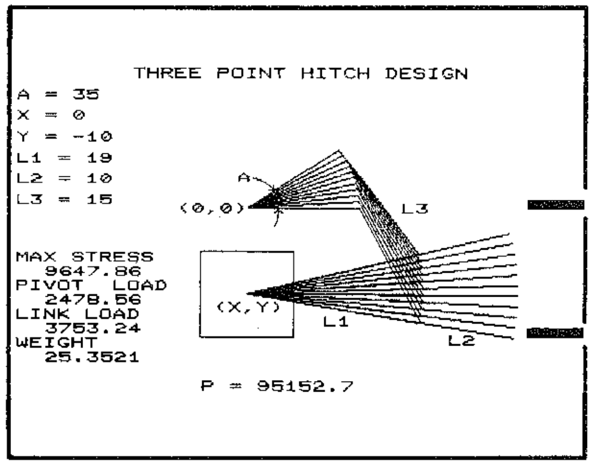

FIGURE 4

Once the design process has been outlined, the students are given the problem handout (Figure 3) and left on their own for a period of time. Most do not realize the magnitude of possible solutions nor do they realize the effect on the performance factor of any of the six variables. After a period of struggling, the students are led through some considerations. First the magnitude of possible solutions is discussed. There are 121 possible locations of (x,y) using integer values alone. Combine that with the possible attachments of L3 to the arm (L1 + L2) and one quickly realizes how the computer can be of great assistance. It also is obvious that, without a formal optimization algorithm, a well defined approach must be made toward achieving a best solution. The student is given Figure 5 to show how a nominal solution can quickly be found from a layout drawing. One procedure that seems to work for most students is to choose an (x,y), find a nominal solution, go to the interactive analyzer and, by adjusting L1, L2, L3, and A, find a "best" solution for the (x,y). The student then divides the pivot block into areas and begins looking at solutions for different (x,y) eliminating those that have a performance factor, P, greater than previously found nominal solutions.

PROJECT REPORT 2

-Purpose: This report documents the necessary specifications for production of your three point hitch.

-Report Contents:

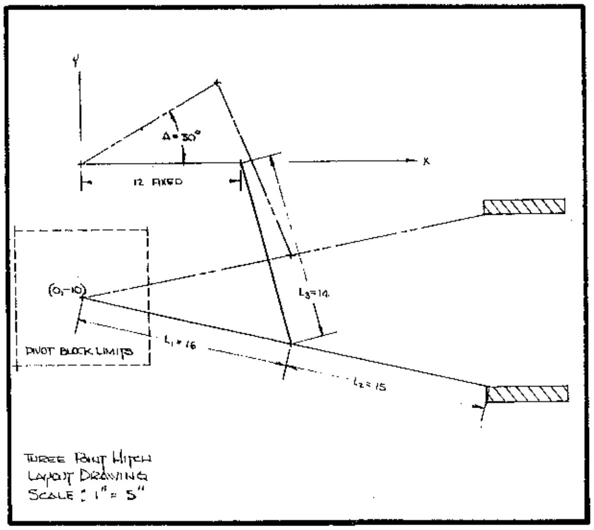

FIGURE 5

Several students, without any assistance from the instructors, write the trigonometric relationships and a computer algorithm to determine a nominal solution. This is encouraged but at this time the student does not have access to the source code for the hitch program, thus preventing any linkup with student-produced facility programs.

After a couple of hours of working on the problem the students begin to note trends. For example, the angle A does not contribute significantly to the performance factor and is adjusted to meet the other geometry constraints. Rather than choose locations to attach L3 to the arm, many students set up the ratio L1/L2 and study the effect of changes in the ratio on stress and performance factor. We consider the plan of attack the most important aspect of the problem. If the plan is not sound and carried out properly, a reasonable value of P will be found. Students who take more time and refine numbers as far as possible may attain a lower P but the final geometry would not be a great deal better from a practical standpoint.

The students are given about eight hours of class time to complete the work and prepare a report. A similar amount of time is expected to be spent outside of class on the project. Figure 6 shows the requirements for the first report, the results of the analysis.

Once the geometry has been established the students specify and communicate the results of the total design effort. The requirements for the second report are stipulated in Figure 7. A total of nine class hours plus an equivalent amount of outside time is devoted to the second part of the design project.

PROJECT REPORT 1

-Purpose: Reporting the preliminary design results and establishing the geometric configuration of the hitch.

-Report Contents:

1. Cover sheet
   Project title, name, date

2. Abstract

3. Introduction
   A brief verbal description of the problem including given information, known and unknown constraints, other factors factors which may influence the solution and the solution conditions. A diagram would be informative.

4. Body
   A description of the plan of attack for solving the problem. Discussion of knowledge gained or changes made to the problem prior to attempting a solution. A concise summary of results, including graphs and tables, which led directly to your final solution. A recommendation for future efforts on this project.

5. Appendix
   Drawings which helped you determine a plan of attack. Tables, graphs, computations which accumulated during the process of determining an optimum solution.

-Report Size:

Estimated 10-15 total pages of which 3-5 would be discussion material. Written material, graphs, and tables are to be on engineering problems paper and drawings should be on green paper from your problems book.

-Grading:

50% Plan of attack, execution of plan of attack, soundness of results

50% Report format, technical writing, graphics (see attached material for information on technical reports)

-Note: A letter of transmittal is not required.

FIGURE 6

1. Cover sheet - project title, your name, etc.

2. Abstract

3. Introduction - an overview of the project. State the solution briefly as described in Project Report 1. State what is included in this report; i.e., assembly drawing, detail drawings, etc.

4. Body - Include the following drawings and any necessary written descriptions for a clear understanding of the drawings: Detail drawings of the arm, link, fastener for arm to pivot, and the fastener for the link; pictorial assembly of arm, link, and fasteners. A bill of materials is needed with nonstandard parts referenced to the appropriate detail drawing and standard parts called out with a correct specification.

5. Conclusions - Describe why your design is the optimum, what are the strongest features, etc. Make any recommendations for additional study or other efforts which may lead to better designs.

6. Appendix - Any layout drawings, research materials and the like you used to arrive at the final specifications.

-Grading:

-50% on the quality of the design; i.e., is design practical? How functional is design? How well were constraints and considerations accounted for?

-50% on the report format, graphical presentation, and written material.

DESIGN CONSTRAINTS AND CONSIDERATIONS

1. The arm is a box beam with outside dimensions 3.0" x 1.5" and 0.25" walls.

2. The link is a 1" Rod. Assume driver end is same as arm end.

3. You will need to design the connection between the link and the arm. One possibility is a yoke. Make sure the connection you design will have clearance throughout the range of motion.

4. You will need to design the fasteners to (1) secure the arm to the pivot plate and (2) hold the link and arm together. For the pivot connection, two possibilities are a shoulder bolt or a cap screw and bushing combination. Make sure that acceptable fits and end play are included. Include any calculations in the the appendix. For the arm-link connection, a pin is a possibility. Once you have the loads and configuration for your design, see the instructors for a pin, bolt, or screw diameter from the standards.

FIGURE 7

Conclusions

The design component incorporating the three point hitch analyzer has been used with a great deal of success for three terms. By making subtle changes in the location of the position boxes and geometry of the hitch members, it is possible to have a variety of problems that yield significantly different geometric solutions corresponding to a low value of performance factor. Student response has been very positive. Students are curious about the algorithm used for the three point hitch and are aware that they could achieve an optimum solution more quickly if they knew and understood the engineering mechanics involved. We hope that this design effort will carry over into the analysis courses taken during the sophomore year. The relationship of analysis to design is a most important one for the engineering student to understand.

The problem, even with the students not completely understanding the mechanics involved, is still within the scope of their ability. Most students quickly grasp the significance of each variable and are able to come up with an effective plan of attack to obtain the best solution. The potential for using the computer to investigate alternative solutions comes across dramatically during the analysis effort. Also a limitation of the computer is noted. The machine does not solve the problem. It is simply a very fast and efficient tool for aiding the engineer. The planning of the steps of solution, the iteractive scheme devised, and interpretation of results still remains very much with the engineer.

We would hope that this brief introduction to design in a CAD environment will serve as an introduction to upper level design. With the engineering college having one computer dedicated to CAD/CAM and a central committee to coordinate and monitor interdisciplinary CAD/CAM efforts, we hope that our freshman efforts will be expanded in the near future.

Specifically in the freshman design component, we hope to have two more design problems on line for the spring semester 1983, one on truck runout for mountain driving and one on antenna design. Hopefully the students will then be able to make a choice after looking briefly at the possibilities.

We are looking into creating basic 2D/3D drafting capability, using the keypad, so that some of the specification drawings can be computer produced. The three point hitch concept can be applied to a wide range of tractor styles and sizes. It is a distinct possibility that the students will, in the future, conduct research on the tractor dimensions and the type of loading encountered, develop an individual set of criteria and constraints, and have the hitch analyzer tailored to their specific problem. This would broaden the first-hand experience with the design process without increasing by a great amount the time spent. The amount of time for fine tuning the solution could be reduced without adversely affecting the quality of the solution.

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A GRAPHICAL TEASER

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Q. What two types of geometric surfaces have no curvature?

A. (1) The plane and (2) the catenoid (a catenary of revolution). May a double curved surface really have no curvature? Note Figs. 28, 29, and text are from Soap - Bubbles: their color and forces which them, by C.V. Boys, circa 1908.

SOAP - BUBBLES

Let us say that I have two large glass rings, between which I can draw out a film of the same kind. Not only is the outline of the soap film curved inwards, but it is exactly the same as the smaller one in shape. As there is now no pressure there ought to be no curvature, if what I have said is correct. But look at the soap film. Who would venture to say that that is not curved? and yet we have satisfied ourselves that the pressure and the curvature rose and fell together. We now seem to have come to an absurd conslusion. Because the pressure is reduced to nothing we say the surface must have no curvature, and yet a glance is sufficient to show that the film is so far curved as to have a most elegant waist. Now look at the plastic model in fig. 28, which is a model of a mathematical figure that also has a waist.

Let us therefore examine this cast more in detail. I have a disc of card that has exactly the same diameter as the waist of the cast. I now hold this edgeways against the waist (Fig. 28), and though you can see that it does not fit the whole curve, it fits the part close to the waist perfectly. This then shows that this part of the cast would appear curved inwards if you looked at it sideways, to the same extent that it would appear curved outwards if you could see it from above. So considering the waist only, it is curved both towards the inside and also away from from the inside according to the way you look at it, and to the extent. The curvature inwards would make the pressure inside less, and the curvature outward would make it more, and as they are equal, they just balance, and there is no pressure at all. If we could in the same way examine the bubble with the waist, we should find that this is true not only at the waist, but at every part of it. Any curved surface like this that at every point is equally curved opposite ways, is called a surface of no curvature, and so what seemed as absurdity is now explained. Now this surface, which is the only kind symmetrical about an axis except a flat surface, is called a catenoid, because it is like a chain, as you will see directly, and, as you know, "catena" is the Latin for a chain.

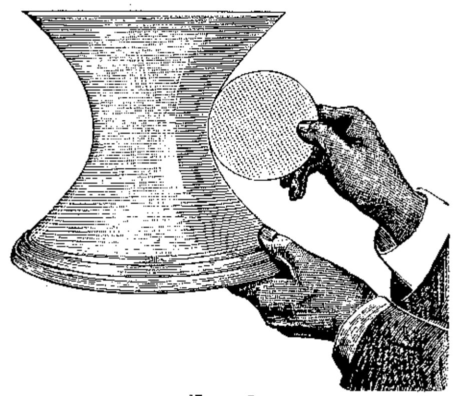


FIG. 28.

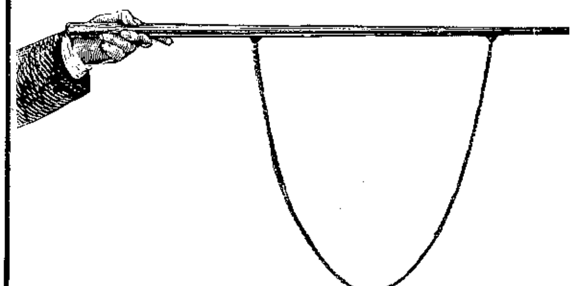


FIG. 29.

ON DEFORGE'S RESEARCH ABOUT TECHNICAL GRAPHISM

Dr. Ing. Guido Laghi
Professor of Technical Drawing
ITIS "Alberghetti" - Imolo (Bologna)

Toward the end of 1981 an original and innovative book appeared in France written by Professor Yves Deforge, a chief inspector of technical education. Deforge, who was at that time a professor at the University in Strasbourg, was also an expert of the Council of Europe for the problems of technical and professional education. The title of the book, Le Graphisme Technique: son Histoire et son Enseignement, emphasizes the author's purpose to talk about technical drawing and the means useful to communicate technical information: sketches, diagrams, mathematical models, symbolic notations, and so on. In the past centuries in France drawing was called "dessein" (in 1567 Philibert Delorme wrote "desseing"). Today this means design, a project in its complexity, while the term "dessein" is reserved for drawing.

Deforge's main idea is that technical graphism is the "trait d'union" or the mediator between technical conception and its practical realization, that is, between liberal and mechanical arts. This intermediation becomes necessary when the designer does not communicate directly with the technician as has happened from the beginning of the Industrial Revolution. Nevertheless, when the complexity of the project exceeds the skills of the workers, technical graphism becomes very important. In this sense design graphics is the meeting point of C.P. Snow's "two cultures": the humanistic-philosophical culture of the conceivers and the technological-practical culture of the executors.

The volume is rich in bibliographical references and is divided into two parts. The first is an historic section, explaining the birth and development of technical graphism from its origins up till today. The second half of the book and a pedagogical-didactic section, concerned with the evolution of the methodologies institutions for teaching technical graphism from the XVIth century till today, concentrating on France. This last part of the book, which is desirable for all of the countries of ancient civilization, is particularly valuable as it explores all types of education, from apprentices to university students and future teachers. From the XIVth century forward, the qualification given to those who had passed the first period of apprenticeship was "compagnon", that is, "compas-gnon" (he who knows how to use the compasses). An analogous inquiry was published by Professor Antonius Lipsmeier in 1971. His book concerns the teaching of technical drawing in the German professional schools in the XVIIIth and XIXth century.

In the first part of Professor Deforge's book there are two notable citations concerning the most ancient technical drawings that appear to have come to us. In the first hall of the temple of Denderah in High Egypt there are grand columns surmounted by capitals higher than four meters, bearing sculptures of the head of Isis on the four faces. The estimated date of construction is 2500 B.C. (6th dynasty) for the capitals. The date of rest of the temple is even more uncertain because the temple was adjusted many times. Jomard, who took part in Napoleon's expedition in Egypt, found a series of figures marked out on the walls of the quarries of Gebel Abou-Fedah in Heptanomide.

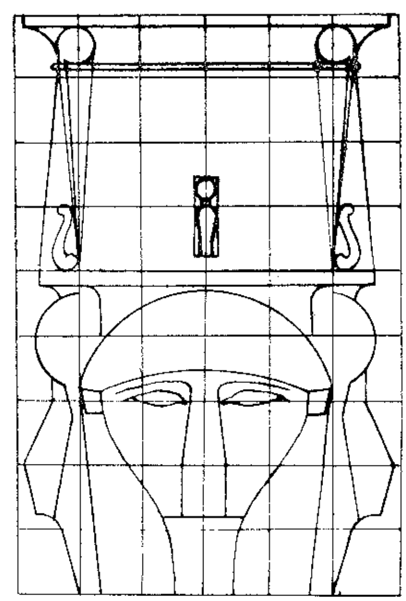


FIGURE 1

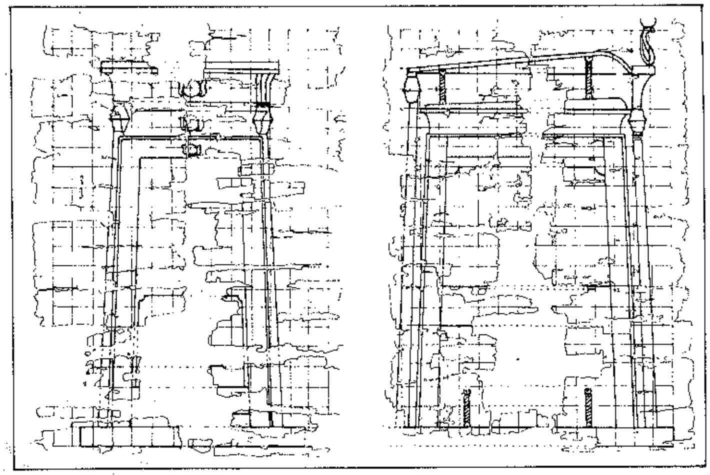


FIGURE 2

These drawings served as a reference to the sculptors who produced the sculptures before the stones were carried to the place of utilization. The most notable drawing copied by Jomard is of a stylized head of Isis on a checkered ground, traced in red with great precision, having dimensions being exactly half of those ones of the capitals. Unquestionably it is the drawing the sculptors used to rough-hew the capitals of Denderah: it is reproduced in Figure 1, taken from another publication of Professor Deforge (1976). The second document, drawn from the papyrus of Gur'Ab, represents the front and side views of a naos (temple) and is traced with black ink on a ground checkered in red.

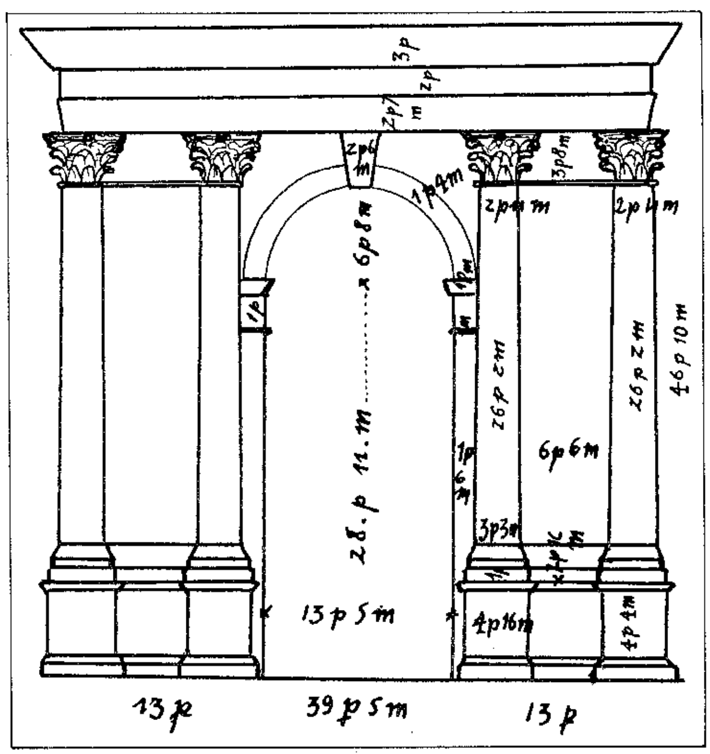


FIGURE 3

In the chapter "Des proportions" the author faces the evolution of the principles of dimensioning through the centuries. The first examples of a representational scale in the modern sense go back only three centuries, to 1607. These scales were found below the figures that illustrated the work of the Italian architect Vittorio Zonca (Padua 1568 - Padua 1602). The book, published posthumously in Padua in 1607, was entitled Novo Teatro di Machine et Edificii.

After Vitruvius, dimensioning was made on the ground of the module, for instance, the center distance between two columns. The radius of the columns was another frequently used module. This classic method is illustrated in Figure 3, representing a door with columns, drawn from De l'Architecture (1561), livre VIII, by Philibert Delorme. From the standpoint of the Strength of Materials this procedure is wrong. Indeed, as Galileo Galilei had already hinted in his Dialogues Concerning Two New Sciences" (Leyden, 1638), the strength characteristics of materials do not vary with the first power of linear dimensions.

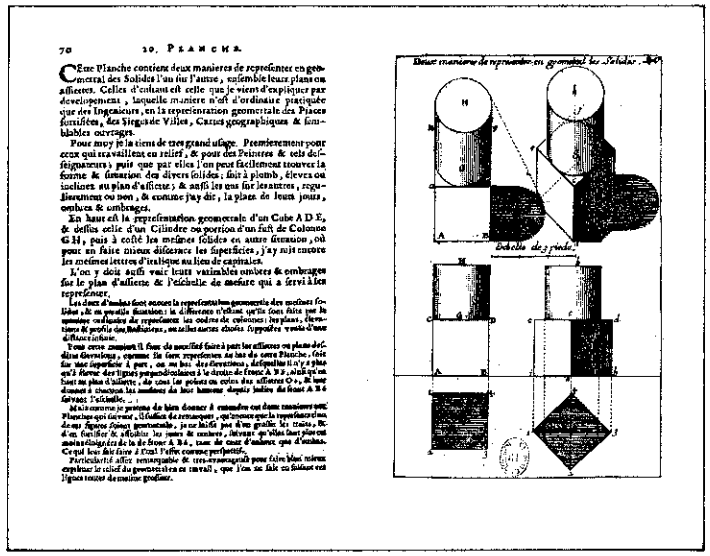


FIGURE 4

In the chapter "A la recherche d'une methode de representation des corps," Professor Deforge considers the representation methods that Abraham Bosse published in his Traite des Pratiques Geometrales et Perspectives (Paris, chez l'auteur, 1665). Figure 4 shows the first method of representing objects on a plane in the upper pictures. They are nothing but axonometric representations "ante litteram". The term "axonometry" was created in 1844 by Professor Ludwig Julius Weisbach to define the cylindrical perspective. The upper image on the right is a representation of a special axonometry that, although nonstandardized by UNI, finds a wide application in Italy. Architecs and land surveyors use this monometric axonometry because it does not distort the building plans. The second method of geometric representation foretold by Bosse , the "method of the engineers", is represented by the lower images in Figure 4. This is the method of orthographic projection of Monge's "ante litteram".

The Bossian anticipations seem very current if compared to those contained in the cabinet projections ("perspectives cavalieres" in the French terminology) of Figure 5 (Needham, 1971). This illustration appeared in the Ying Tsao Fa Shih (Treatise on the Architectural Method), a Chinese book by many compilers, published for the first time in 1097 and republished in 1103 and 1145. This illustration was published by Professor Deforge in a stencilled book in 1976. It preceeds by about six centuries the classic "perspectives militaires" which appeared in Europe in 1853. This thought found justification with the work of Karl Wilhelm Pohlke (Berlin, 1810 - 1876).

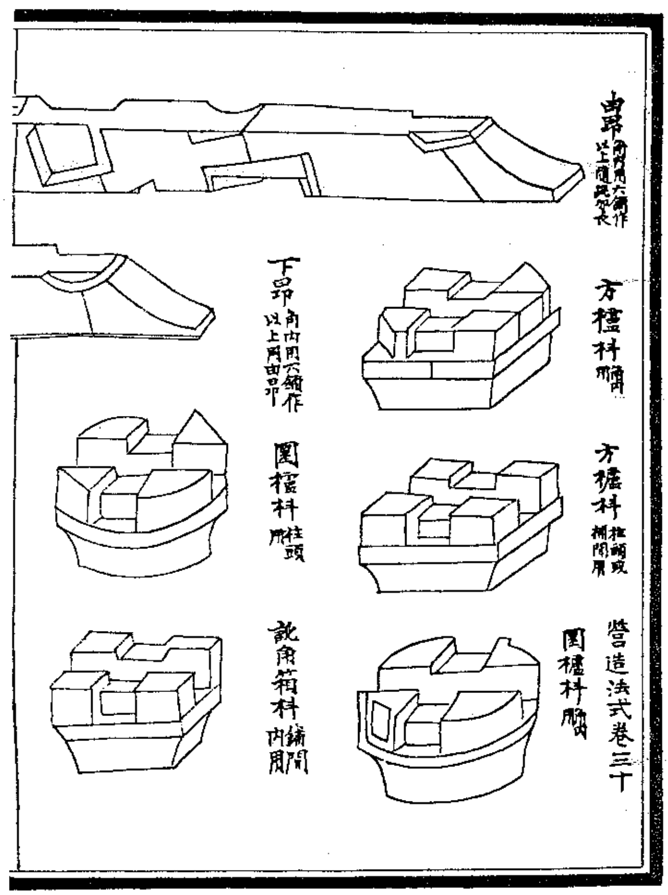
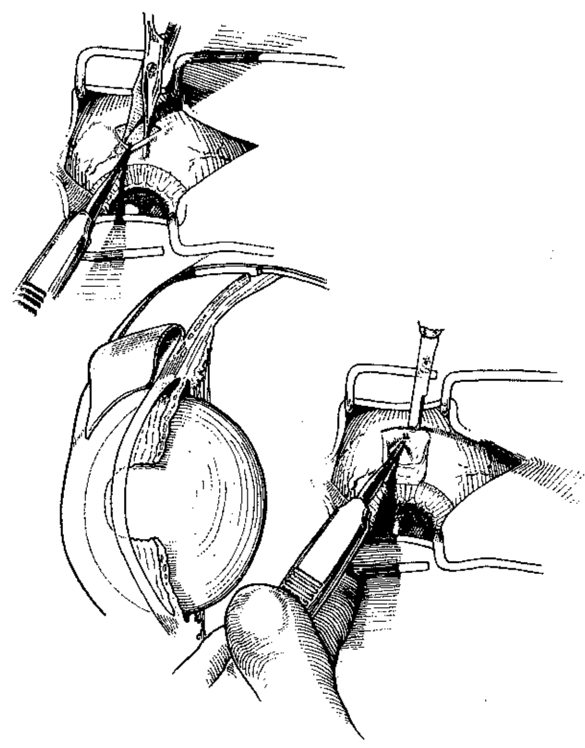


FIGURE 5

In the preface of Deforge's book, Professor Abraham Moles, of the Institute of Communications Psychosociology in Strasbourg, states that the essential contribution of this essay is the settling of the philosophical "querelle" raised by McLuhan and his disciples about the claimed cultural linearity of the western countries. The science of drawing is a bi-dimensional surface-language since the paper sheet extends in length and in width. As Condorcet had already suggested, civilization has not only been the product of the linearity of writing, but also the fruit of the creative bi-dimensional thought of drawers, architects, engineers, artists, inventors, geometricians, and so on. The bi-dimensional (and sometimes the tri-dimensional) chaining of "logos" (rational processes) represents the key of the genesis of forms.

Such basic considerations about the nature and the value of technical graphism find a wider treatment in another publication of Professor Deforge (1976). It is an investigation about the history and the teaching of technical drawing and an exploration into the meaning of design graphics and the need to characterize reality from differing points of view. The communicative and psychological values of the graphic-technical message is treated carefully and thoroughly. In particular, the multi-faceted character of the information are pointed out. In engineering design graphics we can note the coexistence of representative graphics, of symbolic graphics, for example, the conventional and simplified representation of a screw, of nonfigurative graphics, that is, cross-hatching with conventional section lines, symbols of welding and of surface roughness, of dimensional figured information such as dimensioning and tolerancing, and of verbal information in the natural language.



The writer wishes to thank the AEDE (Association Europeenne des Enseignants) - Italian Section - for having put him into contact with Professors Antonius Lipsmeier of Kassel (BRD) and Professor Yves Deforge of Strasbourg (F) through Studiendirektor Rolf Lobert of Braunschweig (BRD). Without these contacts this article could not have been written.

Figures 1, 2, and 3 have been redrawn from the originals by Professor Deforge.

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Lipsmeier, A. Technik und Schule, die Ausformung des Berufsschulcurriculums unter dem Einfluss der Technik als Geschichte des Unterrichts im technischen Zeichnen, Wiesbaden, Steiner, 1971.

Deforge, Y. Le Graphism Technique, 1976 (Stencilled). Diffusion: Librarie Honore Champion, 7, Quai Malaquais, Paris. (Figure 1, Figure 8, and Part C, "Signification").

Needham, J. Science and Civilization in China, Vol. IV-3, Figure 774, Cambridge, University Press, 1971.

PATENTING ENGINEERING DESIGNS

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INTRODUCTION:

As noted by Joenk (1979a), the United States patenting system is based upon the principle of quid pro quo (something for something); in exchange for publicizing his invention, a person receives the right to exclude others from making, selling, or using his invention in the United States for a period of 17 years (non-renewable).

Students in design courses often generate feasible and creative solutions to perplexing engineering problems (this has been true in my course, 09.109 Engineering Design Graphics, at Northeastern University, as described in an earlier paper (Voland, 1981)). United States Patent applications can be easily submitted by our students for their designs if we provide them with a few basic guidelines about such submissions. In this paper, a brief historical review of the patenting process is given, together with information concerning:

- critera for patents;
- requirements for record-keeping and witnesses;
- design disclosures;
- patent searches;
- the U.S. Patent Classification System; and
- requirements for drawings which accompany the application.

BRIEF HISTORICAL REVIEW:

In Athens (during the period of Ancient Greece), franchises were granted to those who invented or introduced new products; in this way, the creative process was encouraged and rewarded.

The first recorded patent to be granted for an invention was awarded by the Republic of Florence in 1421 to the designer of a barge with hoisting gear for loading and unloading marble. Subsequent (early) patents were granted in Venice (1469), in Germany (1484), and in France (1543).

Samuel Winslow was granted, in 1641, the first patent in Colonial America (by the Massachusetts General Court) for a salt-making process. In 1783, the Continental Congress recommended the enactment (by each state) of copyright acts; then, in 1789, the United States Constitution empowered the federal government

> "...To promote the Progress of Science and useful Arts by securing for limited Times to Authors and Inventors the exclusive Right to their respective Writings and Discoveries."

Finally, the first United States Patent Act (April 10, 1790) resulted in the granting of the first U.S. Patent to Samuel Hopkins for "Making Pot and Pearl Ashes" on July 31, 1790.

FOREMOST CRITERIA:

Patent Examiners are particularly concerned with three criteria in determining if an applicant should be granted a patent: novelty, usefulness, and nonobviousness (see the Patent Law listed under 35 U.S.C. 101, 102, 103, i.e., the relevant sections of Title 35 of the U.S. Code; also see Patent Laws, which is available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402).

NOVELTY: the invention must be demonstably different from the 'prior art'. (All work in the field of the invention is the 'prior art'; as a result, an inventor is expected to be familiar with this prior art material.)

In the United States, the person(s) who is (are) recognized as the 'first-to-invent' (as opposed to the 'first-to-file') is granted the patent for an invention. (All inventors of a single invention must apply together for a patent.) In order to receive such recognition, the inventor must demonstrate (i) the earliest date of conception of the invention and (ii) diligence in reducing it to practice without any period of abandonment (Joenk, 1979a). Therefore, it is highly recommended that the inventor keep complete records during the period of development before filing the patent application. As hints on record-keeping, the following list is provided (Franz and Child, 1979):

Records should be written.

Obtain competent witnesses of the recording:

- preferably two or more other persons;
- inventors cannot serve as witnesses to their own inventions.
- each witness should date and sign each page of the inventor's notes and sketches as soon as possible after these records are generated.
- tests and experiments should also be witnessed - with corresponding dated, signed entries in the record book.
- witnesses must be available (i.e., easily located) in the future.
- witnesses should have the technical training or knowledge to understand the invention and its use.
- witnesses should not be related to the inventor.
- an inventor's protection that his witnesses will not 'steal' his work is their signatures as witnesses.

Records should be kept in a bound laboratory notebook with numbered pages.

Entries should be in ink and dated; any delays in conducting the work should be explained in writing.

The advantages and uses of the invention should be identified together with complete descriptions of the design components and specifications.

All related papers (correspondence, sales slips, components' sales literature, etc.) should be saved.

If a correction is necessary, line through the error and initial and date the change.

Later additions should be entered in an ink of a different color, then initialed and dated.

Finally, sign each page as the 'inventor' and enter the date.

The invention must be 'reduced-to-practice' or completed; such a reduction-to-practice can be actual (i.e., a prototype can be built - although expensive, such an actual reduction can lead to improvements and needed modifications in the design) or constructive (i.e., a complete patent application is field which satisfies the requirements of the United States Patent and Trademark Office or U.S. PTO).

The inventor must avoid (i) publishing a description of the invention, (ii) offering a produce in which the invention is incorporated, and (iii) allowing anyone else to use the invention (other than on an experimental basis). In other words, disclosure before filing a patent application must be avoided.

USEFULNESS: a desired objective (or objectives) must be achieved by the invention, i.e., there must be some practical utility associated with the invention. Immoral fraudulent, frivolous, and anti-public policy uses are not patentable (Joenk, 1979a).

NONOBVIOUSNESS: the invention must be deemed to have required more than (a) ordinary skill to design or (b) the mere addition or duplication of components of an existing (patented) design. However, if a new result is achieved through the new application of an old design, then this new application may be patentable.

ADDITIONAL GUIDELINES:

Before applying for a patent, one should consider the advantages of obtaining professional assistance; other than the inventor(s), only the (more than 9000) patent agents and attorneys who are registered to represent inventors may do so before the United States PTO. An annual listing of these agents and attorneys is available from the PTO (Attorneys and Agents Registered to Practice Before the U.S. Patent and Trademark Office). Patent attorneys are knowledgeable about the patent laws and technically competent; Chester Carlson was a patent lawyer at the time he invented the xerographic copying process (Vanderbilt, 1979). A key goal of the agent or attorney is the maximization of the coverage and protection which will be provided by the patent by carefully writing the claims listed in the application (Nussbaumer, 1979).

Secondly, a patent search must be conducted. The public file of the PTO in Arlington, Virginia (two identical files are maintained at the PTO - one for use by the public and one for use by the employees of the PTO, particularly patent examiners), as well as the partial U.S. patent collections located in many libraries throughout the nation, can be examined in order to determine if the inventor has designed a truly 'new' invention. The U.S. Patent Classification System contains approximately 350 distinct classes; the scheme is as follows: a class is listed, followed by a series of subclasses ('mainline' or primary divisions) - each of which is further divided into additional subcategories (there are about 100,000 subdivisions within the system), i.e., the format is of the type

CLASS

MAINLINE (Primary) division

Secondary division

Secondary division

Subcategory

Subcategory

MAINLINE division

Each patent is classified within the system according to the most comprehensive claim contained within the patent. A classification 'label' is given to each patent in the form

CLASS NUMBER --------- SUBCLASS NUMBER

Where the subclass refers to the most distinct category to which the patent belongs. The PTO offers such publications as the Manual of Classification and the Index to U.S. Patent Classification; the reader is also referred to the paper by Dood (1979).

A disclosure (which describes the field of technology in which the invention belongs, the components of the design (and their functions) - with sketches, and the advantages/differences of the new invention relative to the prior art of the field) will aid the searcher (Joenk, 1979a).

The search is crucial since its results will determine if an application should be submitted. If the decision is made to submit an application, the following sections should be included (Joenk, 1979a):

Specification (or text portion) which identifies:

(a) any appropriate previous patents or applications of the inventor which are related to the current application,

(b) the technical field to which the invention belongs,

(c) the prior art of the invention - in order to expedite the search and examination of the application by the PTO,

(d) the problem and its solution by the invention (including advantages over the prior art),

(e) any figures or drawings as necessary,

(f) the invention - via a sufficiently detailed and complete description of the invention and its use(s), and

(g) the claims which are to be protected by the patent.

An abstract which summarizes the disclosure and claims.

An oath or declaration in which the applicant states:

(a) his belief that he is the original and first inventor of the described invention and

(b) his citizenship.

Note that the claims determine the legal coverage which is to be provided by the patent. Each claim is written as a single sentence, beginning with the phrase "I (We) claim" or "What is claimed is" (which is used only once - even if multiple claims are made; all claims after the first one are written as if this phrase is prefixed to them - see the patent examples at the end of this chapter). In addition, claims are ordered from the most general to the most specific. Any element of the invention which is mentioned is a claim should have been described earlier in the specification protion of the application (see Landis (1974) for example).

DRAWINGS:

As required by 35 U.S.C. 113, "When the nature of the case admits, the applicant shall furnish a drawing." (A 'drawing' may consist of several figures.) These figures must show every feature of the invention, although conventional characteristics can be represented by a standard (or labeled) graphic symbol (see Guide for Patent Draftsmen and Joenk (1979b).

Any 'improved' portion of an old device should be shown, both disconnected from and in connection with the main apparatus.

Also, one view of the invention should be representative and suitable as the illustration of the invention which is to be published on the title page of the patent and in the announcement of the patent in the Official Gazette of the PTO.

The standards for the drawing(s) are as follows:

Paper/ink: white paper of a thickness which is equivalent to that of two-ply or three-ply bristleboard with an erasable surface; India ink should be used for black linework.

Size/margins: each sheet should be 8½ inches by 14 inches (21.6 cm. by 35.6 cm.) with a top margin (along one of the edges of 8½ inches in length) of 2 inches (5.1 cm.) and bottom/side margins of 1/4 inch (6.4 mm.). The working space will then be 8 inches by 11-3/4 inches.

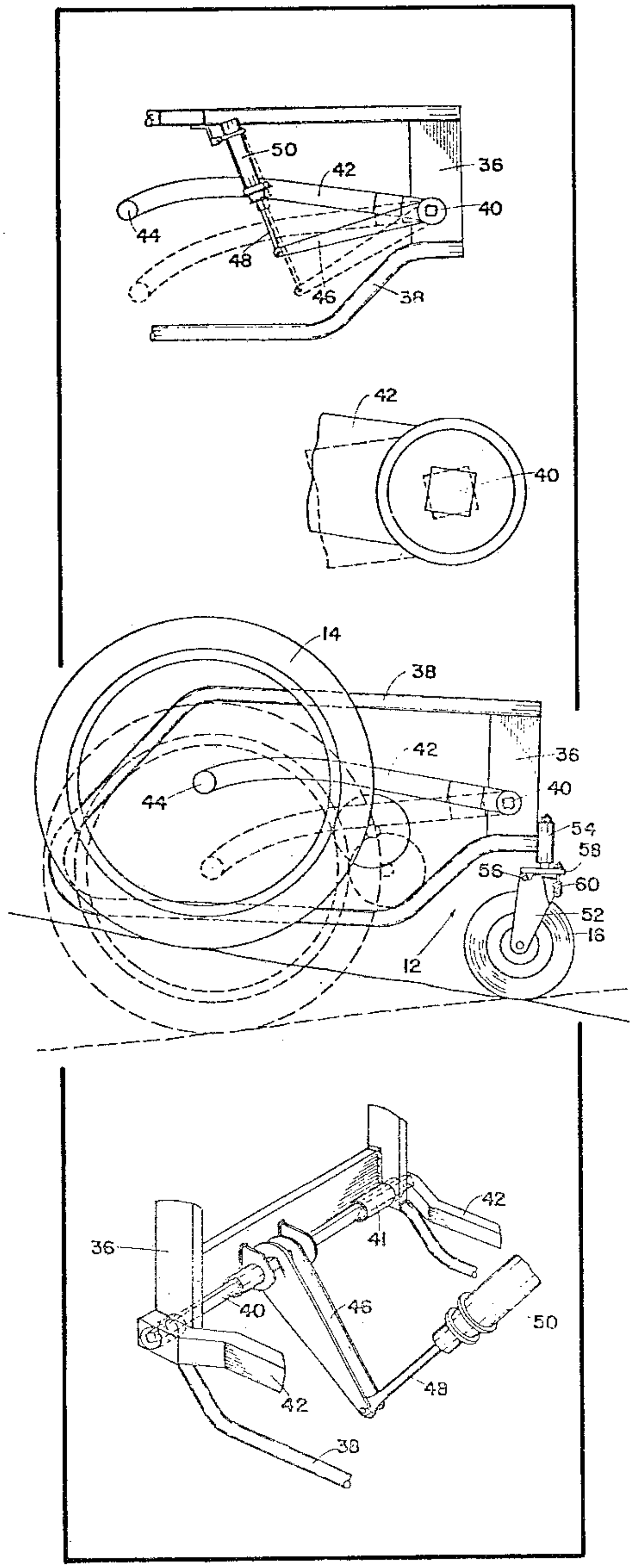

FIGURE 1

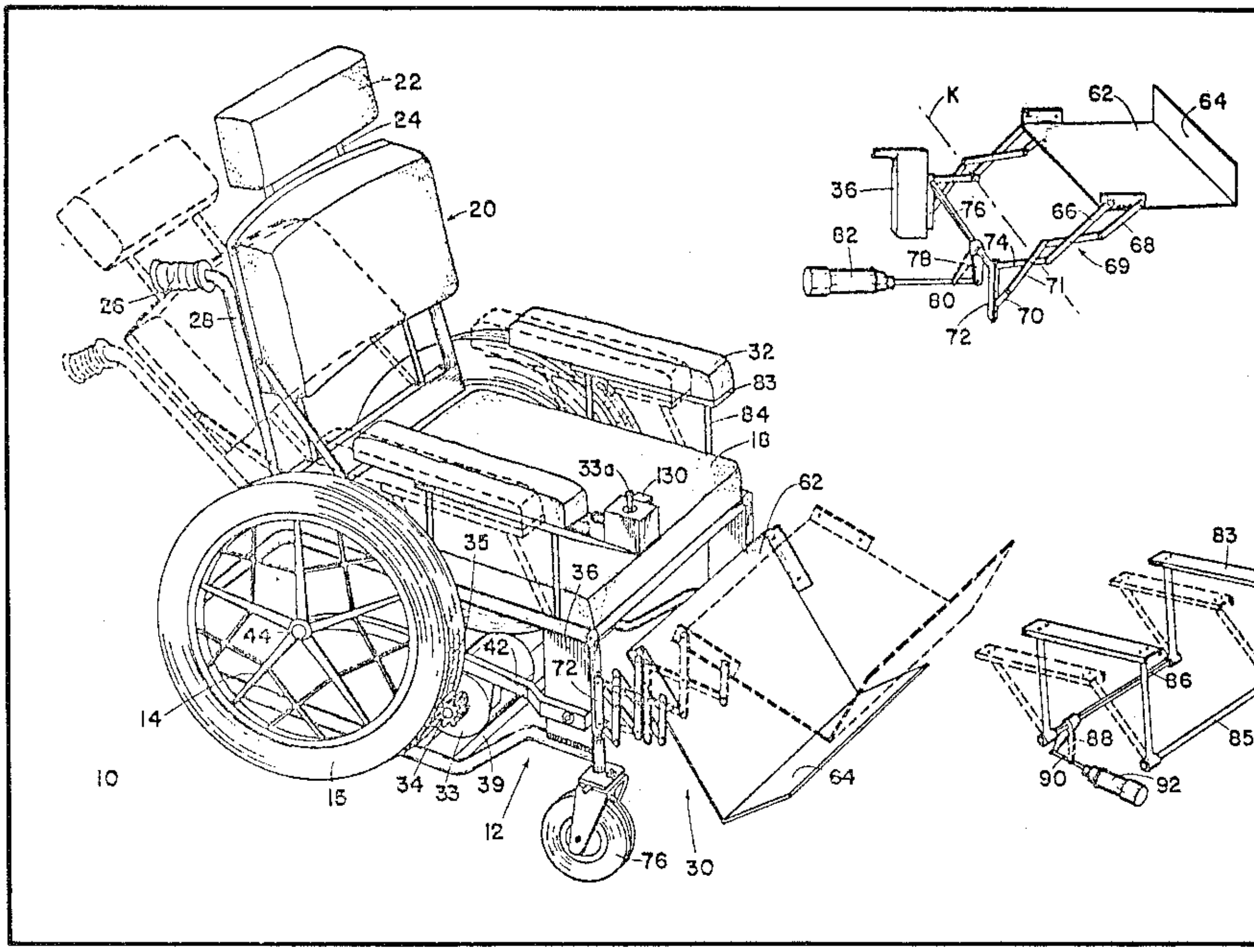

FIGURE 2

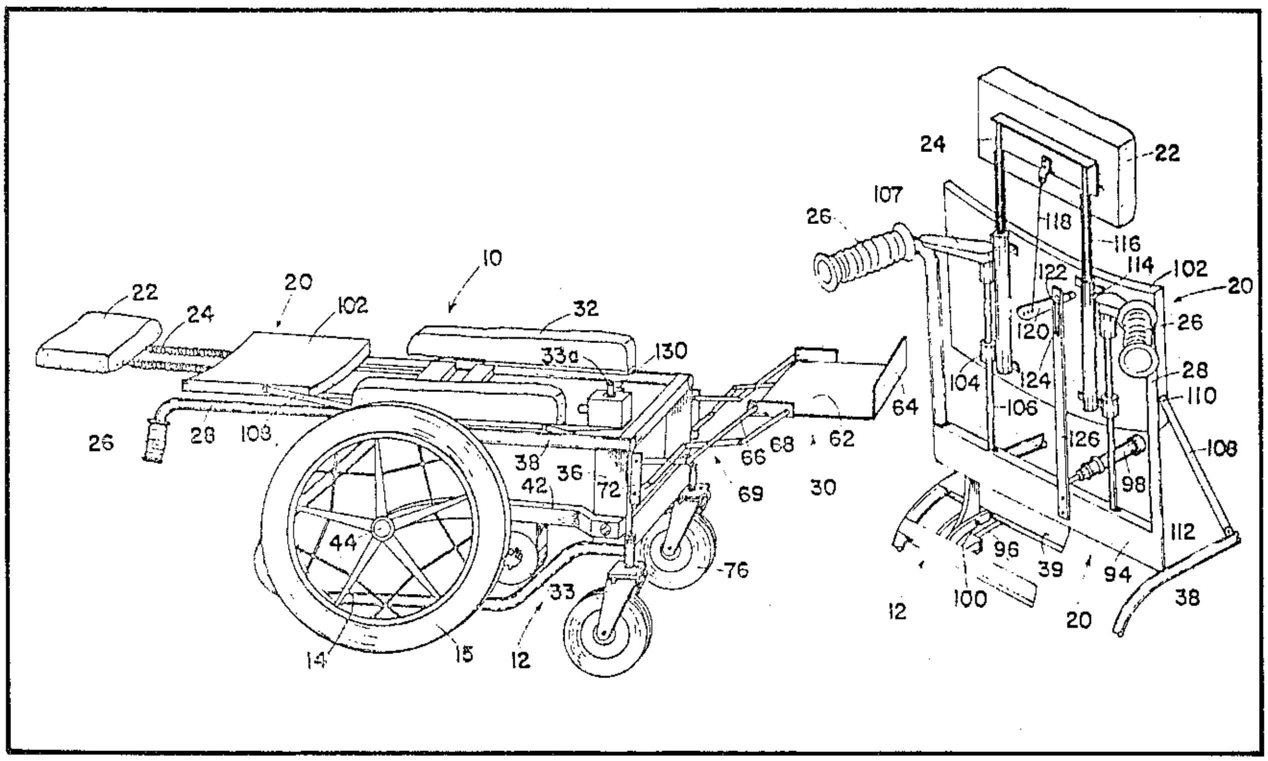

FIGURE 3

Identification block: The identification of the drawing should be contained within a rectangle which is 7.0 cm. in width and 17.5 mm. in height, located at the upper edge of the paper. This identification may consist of the name of the inventor and the case number of the patent attorney's name and the docket number; in addition, the sheet number and total number of sheets (e.g., "sheet 2 of 3") can be included.

Linework: linework is performed with drafting instruments (or by other professional means) for high quality reproduction. Spacing between parallel hatch-work lines should be at least 1.3 mm. Crowding should be avoided; if necessary, several sheets may be used to describe the invention.

Reference characters, symbols, and legends: reference numerals should be at least 3.22 mm. in height and should not be encircled; lines are used to connect the numerals to the parts of the design used to identify a particular component in all views in which that component appears. Standard mechanical and electrical (graphic) symbols can be used to identify conventional components within the design; legends may also be used where needed.

CONCLUSION:

Patent rights can be traded, licensed, sold, or assigned - as can other forms or personal property (Wolber, 1979). As Hill (1970) notes, the U.S. Patent System has provided inventors with the necessary protection, opportunity, and hope of reward to encourage the growth of new technology and industrial products. And we can encourage our students to apply for patents of their designs for their benefit and for the benefit of all those who have need of their solutions to existing engineering problems.

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ISOMETRIC MADNESS

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Editor's Note: This article is an excerpt from a book in progress by Dr. Kolomyjec entitled "Computer Drawing". Brooks/Cole will be the publishers, the data of publication yet to be determined. The cover illustrations were produced by a version of this program.

Isometric Madness will generate the maximum possible isometric pictorial drawing variations of an object through axes reassignment and sign manipulation of the principal dimensions. Trying to do this without the computer would truly be a maddening experience.

Figure 1: The octants of X, Y, Z space

There are eight distinct regions of three dimensional space formed by the intersection of the X, Y, Z coordinate axes. These regions are illustrated in Figure 1. An object can be manipulated in this space two ways. First, by interchanging axes assignments which, in effect, reorients an object within an octant. Second, by manipulating the sign of one, two or all of the object's principal dimensions, it can be flipped between, or mirrored into, any octant.

The program to be presented will allow any wire-frame object (digitized in the proper format) to be manipulated within and between octants. Attempting to see a variation can be potentially maddening due to the "isometric effect". To keep the user from going completely insane, a visual cue will be built into the program, i.e., the object origin will be circumscribed with a small polygon. Fasten your astroid belts, here we go.

Figure 2: Axes assignment possibilities

Flipping an object within an octant is accomplished by plotting the various coordinate values on the different combinations of the coordinate axes. There are six possible combinations. Using elementary probability theory, the number of ways N distinct things can be reordered is N!. Thus, with three axes there can be six possible distinct arrangements. These possibilities are shown in Figure 2.

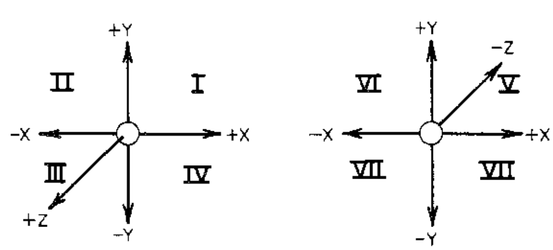


FIGURE 1

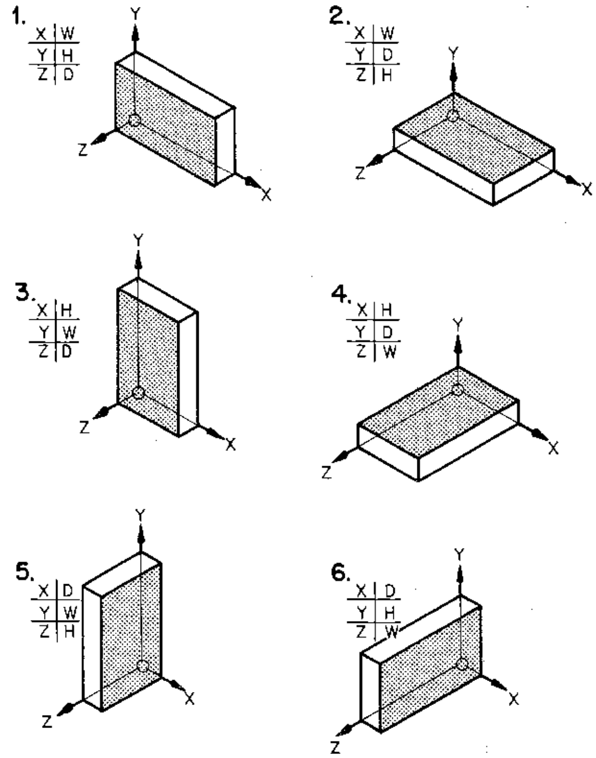


FIGURE 2

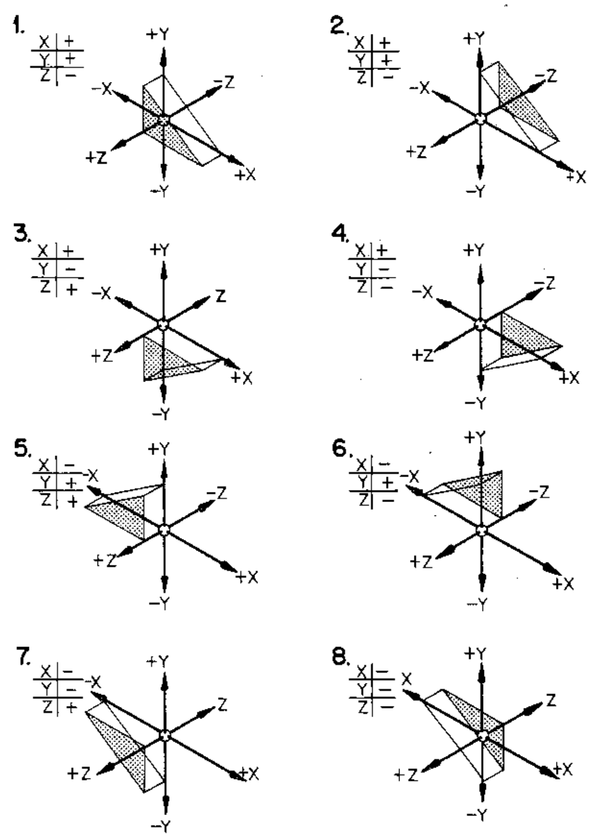
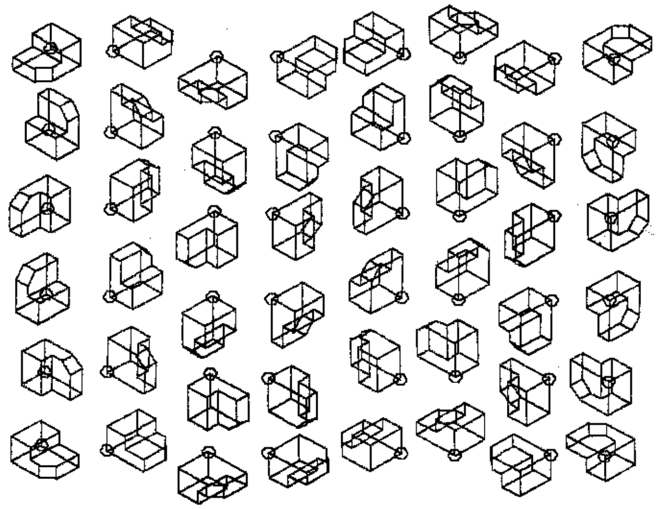


FIGURE 3

Figure 3: Sign variations

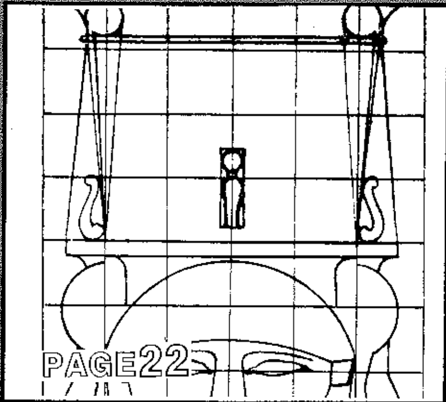


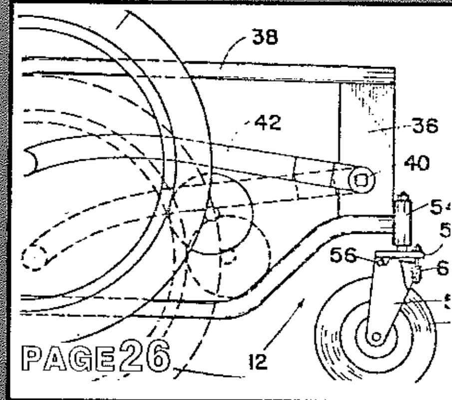
Flipping an object between octants can be accomplished by negating (changing the sign) of all of the values of principal dimension of an object. For example, changing all X, Y, Z coordinates to -X, Y, Z flips an object from the first octant to the second. Again the proof that there are eight possibilities comes from elementary probability theory. The number of distinct possibilities for K variations of N things is: K raised to the N power. Since there are two possible variations in sign (+ or -) and three axes, there are eight possibles. (If nothing else, this also justifies the existence of eight octants.) Figure 3 illustrates the variations of octant flipping by changing sign.

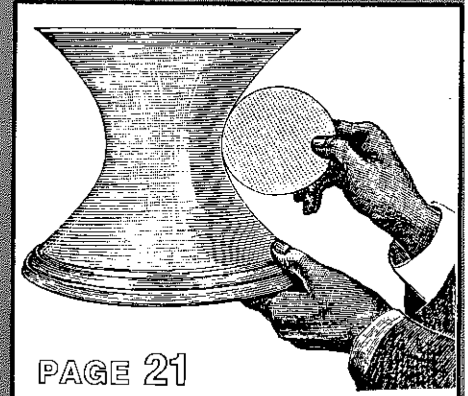
With six variations per octant and eight octants there can be 48 possible orientations of a wire-frame isometric pictorial given these variables. Confused yet?

This information may be of dubious value, and the need for 48 isometric variations equally questionable, but it makes an interesting programming exercise. The following program will allow the user to interactively select any axes/sign combination and display the corresponding isometric drawing.

```
]PR#0
]?CHR$(9);"8042N":LIST


100  REM  <<<<< ISOMETRIC MADNESS >>>>>
110  REM
120  REM  COPYRIGHT 1983 W.J. KOLOMYJEC
130  REM
140  REM  DEFINE ORIGIN INDICATOR CONSTANT
S
150 R = 6:FA = 0:LA = 360:AI = 60
160  GOSUB 1500: REM   DATA & DATA INPUT S
UBROUTINE
170  GOSUB 5000: REM    SETUPS
180  GOSUB 2000: REM  SCALEDATASUB
190  REM  PUT CENTER OF PICTORIAL AT SCREE
N CENTER
200 XCT = 140:YCT = 95
210  GOSUB 4000: REM  ASSIGNMENTS
220  HGR2 : HCOLOR= 3: REM  INIT. GRAPHICS

230  GOSUB 4500: REM  ORIGIN INDICATOR (CI
RCSUB1)
240  GOSUB 3500: REM  MODIFIED ISOMETRIC D
RAWING SUBROUTINE
250  INPUT A$: TEXT : REM  TERMINATE
260  HOME : VTAB 10
270  PRINT "ANOTHER DRAWING? (Y OR N):": G
ET A$
280  IF A$ = "Y" THEN 210
290  IF A$ <  > "N" THEN 260
300  HOME : VTAB 10
310  PRINT "END ISOMETRIC MADNESS"
999  END
1000  REM  <<<<< PLOTSUBA >>>>>
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
1040 Y9 = (191 - Y) * 0.881
1050  IF P = 1 THEN  GOTO 1100
1060  IF P <  > 2 THEN  PRINT "PEN ERROR":
 STOP
1070  REM  NOTE: ROUNDOFF INCLUDED
1080  HPLOT X + 0.5,Y9 + 0.5
1090  RETURN
1100  HPLOT  TO X + 0.5,Y9 + 0.5
1110  RETURN
1500  REM  <<<<< DATA & DATA INPUT SUBROUT
INE >>>>>
1510  REM
1520  REM  NOTCH BLOCK
1530  REM
1540  REM  PRINCIPAL DIMENSIONS:
1550  REM  W = 100, H = 60, D = 80 (PIXELS
)
1560 COLUMNS = 4:ROWS = 28
1570  REM
1580  DATA  0.0,0,2
1590  DATA  0,0,80,1
1600  DATA  75,0,80,1
1610  DATA  100,0,60,1
1620  DATA  100,0,0,1
1630  DATA  0,0,0,1
1640  DATA  0,60,0,1
1650  DATA  0,60,80,1
1660  DATA  0,0,80,1
1670  DATA  0,60,80,2
1680  DATA  50,60,80,1
1690  DATA  50,60,0,1
1700  DATA  0,60,0,1
1710  DATA  50,60,0,2
1720  DATA  50,30,0,1
1730  DATA  50,30,80,1
1740  DATA  50,60,80,1
1750  DATA  50,30,80,2
1760  DATA  75,30,80,1
1770  DATA  75,0,80,1
1780  DATA  75,30,80,2
1790  DATA  100,30,60,1
1800  DATA  100,0,60,1
1810  DATA  100,30,60,2
1820  DATA  100,30,0,1
1830  DATA  100,0,0,1
1840  DATA  100,30,0,2
1850  DATA  50,30,0,1
1860  REM  DIMENSION DATA ARRAY
1870 C1% = COLUMNS - 1:N1% = ROWS - 1
1880  DIM D(C1%,N1%)
1890  REM  READ DATA INTO DATA ARRAY
1900  FOR K = 0 TO N1%
1910  READ D(0,K),D(1,K),D(2,K),D(3,K)
1920  NEXT K
1930  RETURN
2000  REM  <<<<< SCALE 3D DATA SUBROUTINE
>>>>>
2010  REM
2020  REM  USE MANIPULATION ARRAY
2030  REM
2040  DIM M(C1%,N1%)
2050  HOME : VTAB 10
2060  INPUT "ENTER OBJECT SCALE FACTOR: ";
FTR
2070  REM  SCALE DATA (EXCEPT PEN) & DEFIN
E MANIP. ARRAY
2080  FOR K = 0 TO N1%
2090  FOR J = 0 TO C1%
2100  IF J = C1% THEN M(J,K) = D(J,K): GOT
O 2120
2110 M(J,K) = D(J,K) * FTR
2120  NEXT J
2130  NEXT K
2140  RETURN
3500  REM  <<<<< ISOMETRIC PICTORIAL SUBRO
UTINE >>>>>
3510  REM
3520  REM  PARAMETERS:XCT,YCT
3530  REM  ISOMETRIC ANGLE SET TO 30 DEGRE
ES
3540 AN = 30 / 57.295779
3550 C =  COS (AN)
3560 S =  SIN (AN)
3570  FOR J = 0 TO N1%
3580  REM  ***** MODIFIED ISOMETRIC EQUATI
ONS *****
3590 X = M(V0,J) * S0 * C - M(V2,J) * S2 *
 C + XCT
3600 Y = M(V1,J) * S1 - (M(V2,J) * S2 * S
+ M(V0,J) * S0 * S) + YCT
3610 P = M(3,J)
3620  GOSUB 1000
3630  NEXT J
3640  RETURN
4000  REM  <<<<< ASSIGNMENT SUBROUTINE >>>
>>
4010  HOME : VTAB 4
4020  PRINT "<<<<< ASSIGNMENT POSSIBILITIE
S >>>>>": PRINT : PRINT
4030  PRINT "NA  X Y Z     NS  X Y Z"
4040  PRINT "----------------------------"
4050  PRINT "1   W H D      1   + + +"
4060  PRINT "2   W D H      2   + + -"
4070  PRINT "3   H W D      3   + - +"
4080  PRINT "4   H D W      4   + - -"
4090  PRINT "5   D W H      5   - + +"
4100  PRINT "6   D H W      6   - + -"
4110  PRINT "               7   - - +"
4120  PRINT "               8   - - -"
4130  PRINT : PRINT
4140  INPUT "ENTER ASSIGNMENT (NA,NS):";NA
%,NS%
4150  IF NA% < 1 OR NA% > 6 OR NS% < 1 OR
NS% > 8 THEN 4010
4160  REM  DEFINE EXPRESSION VARIABLES
4170 V0 = A%(0,NA% - 1):S0 = S%(0,NS% - 1)

4180 V1 = A%(1,NA% - 1):S1 = S%(1,NS% - 1)

4190 V2 = A%(2,NA% - 1):S2 = S%(2,NS% - 1)

4200  RETURN
4500  REM  <<<<< CIRCSUB1 >>>>>
4510  REM
4520  FOR J9 = FA TO LA STEP AI
4530 RANGL = J9 / 57.295779: REM  CONVERT
DEGREES TO RADIANS
4540 X = R *  COS (RANGL) + XCT
4550 Y = R *  SIN (RANGL) + YCT
4560  IF FA <  > J9 THEN 4590
4570 P = 2: GOSUB 1000
4580  GOTO 4600
4590 P = 1: GOSUB 1000
4600  NEXT J9
4610  RETURN
5000  REM  <<<<< SETUPS FOR AXES AND SIGN
CHANGES >>>>>
5010  REM  AXES ORDERS
5020  DATA  0,1,2,0,2,1,1,0,2
5030  DATA  1,2,0,2,0,1,2,1,0
5040  REM  SIGN POSSIBILITIES
5050  DATA  1,1,1,1,1,-1,1,-1,1,1,-1,-1
5060  DATA  -1,1,1,-1,1,-1,-1,-1,1,-1,-1,-
1
5070  REM  EFFICIENT ARRAY STORAGE
5080  DIM A%(2,5),S%(2,7)
5090  FOR K = 0 TO 5
5100  FOR J = 0 TO 2
5110  READ A%(J,K)
5120  NEXT J: NEXT K
5130  FOR K = 0 TO 7
5140  FOR J = 0 TO 2
5150  READ S%(J,K)
5160  NEXT J: NEXT K
5170  RETURN
```







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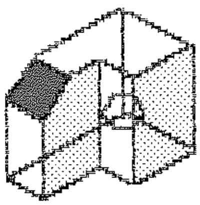
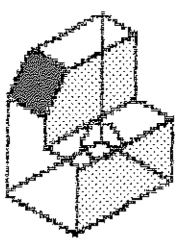
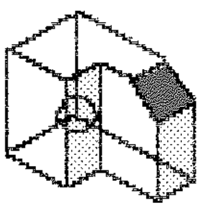
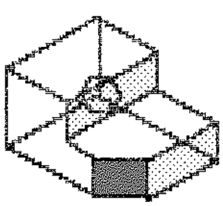
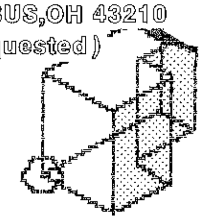
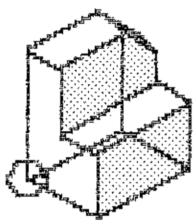
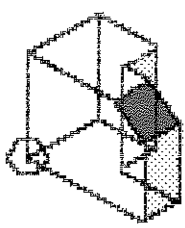
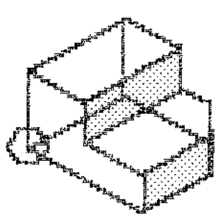
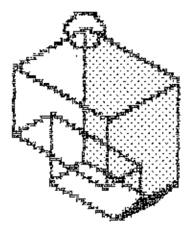
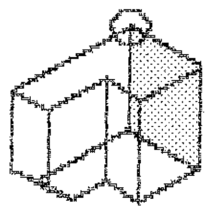
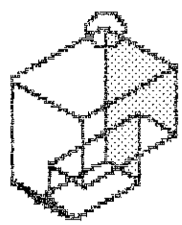
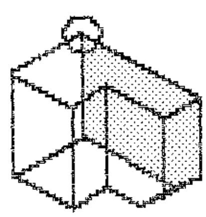
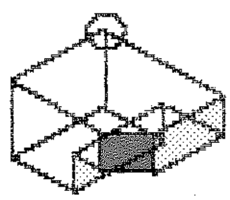
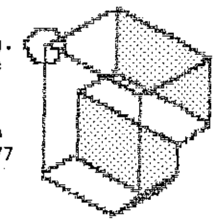
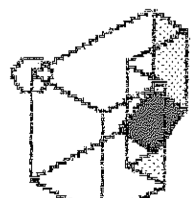
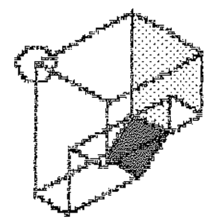
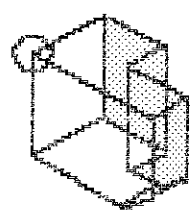
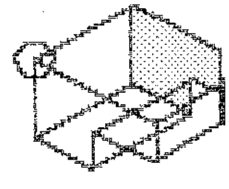

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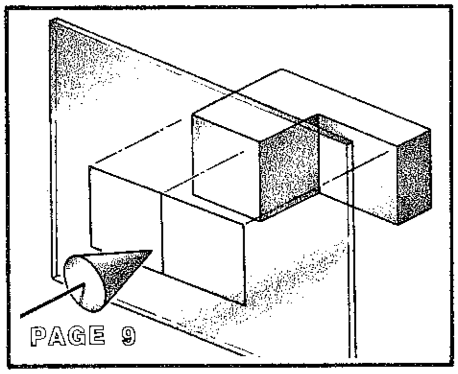

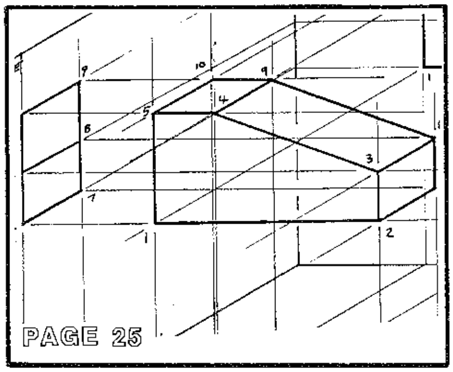

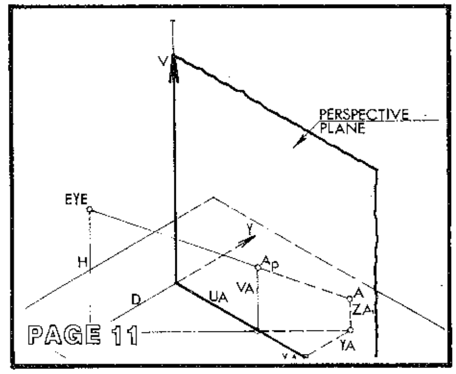

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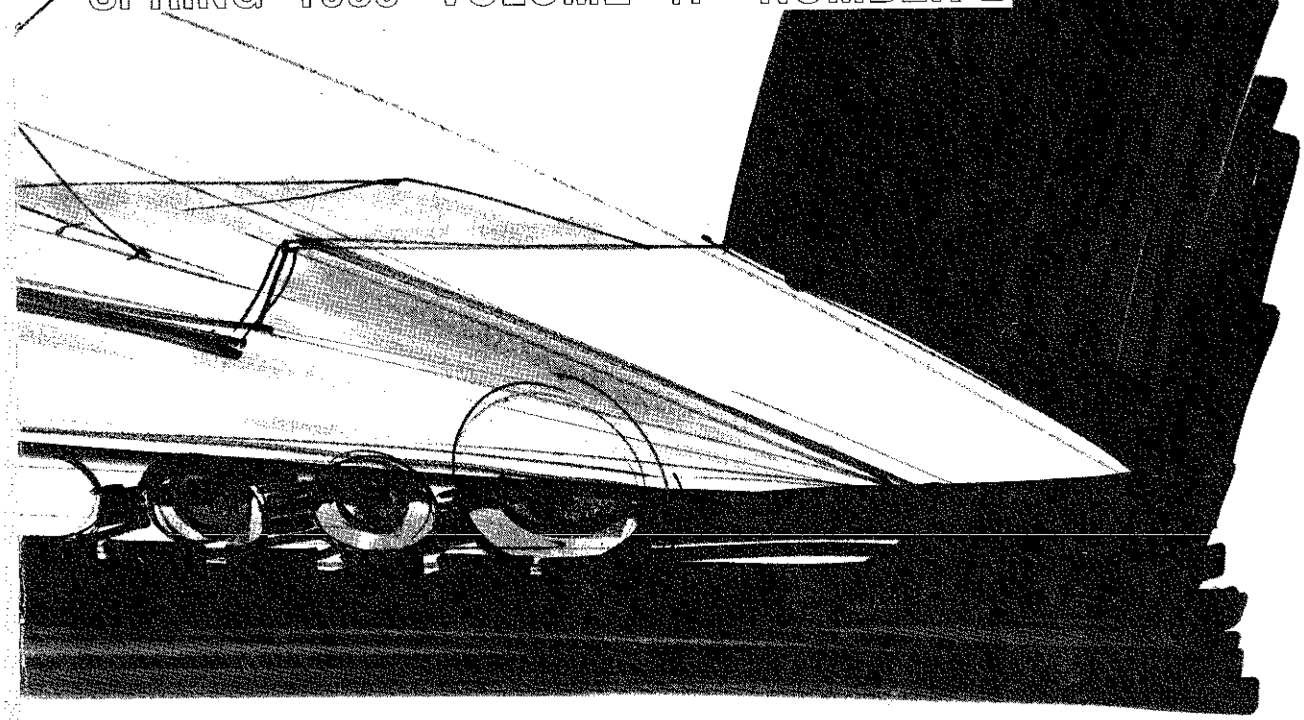
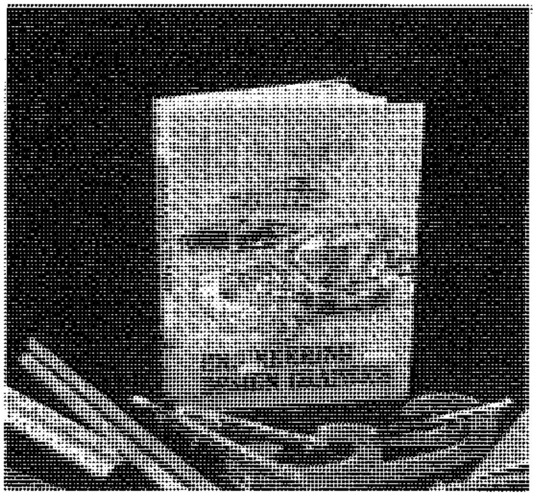


ENGINEERING DESIGN GRAPHICS DIVISION



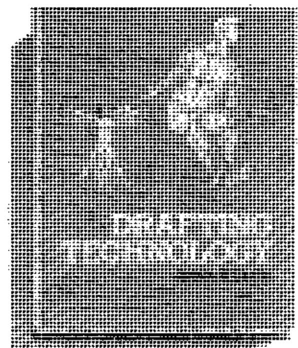
Tools of the Trade.

Engineering Design Graphics, Fourth Edition

James H. Earle, Texas A&M University

For nearly fourteen years, **Engineering Design Graphics** has been an effective tool in teaching thousands of engineering students about the design process. And now the book that focuses on the interrelationship of graphical methods in engineering design is in an all new Fourth Edition. Appropriate for a design-based graphics course, an engineering drawing course, or a descriptive geometry course, **Engineering Design Graphics, Fourth Edition** carefully guides students step-by-step through the design process—from problem identification to the design and analysis of a solution.

0-201-11318-X, Hardbound,
704 pp. (tent.), 1983



Drafting Technology James H. Earle, Texas A&M University

Appropriate for students in engineering technology programs, this text covers the basic principles of drafting, engineering drawing, and graphical problem solving. Advanced topics, such as design, descriptive geometry, specialty drafting, and computer graphics, are also discussed. 0-201-10233-1, Hardbound, 823 pp., 1982

Workbooks—Several problems books are available to accompany the Earle texts. For more information, please write Creative Publishers, Inc., 407 Timber St., College Station, Texas 77840 or call (713) 846-7907.

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Addison-Wesley Publishing Company, Inc.
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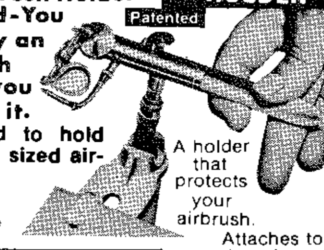

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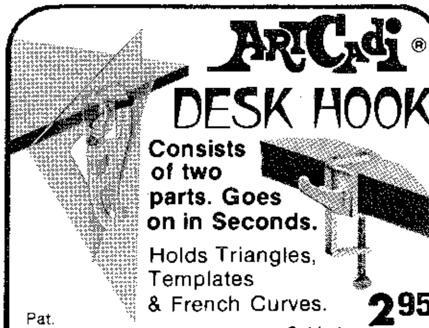

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1984 - Salt Lake City, Utah

EDGD MID-YEAR MEETINGS

1984 - Pittsburg, Pennsylvania

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.

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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

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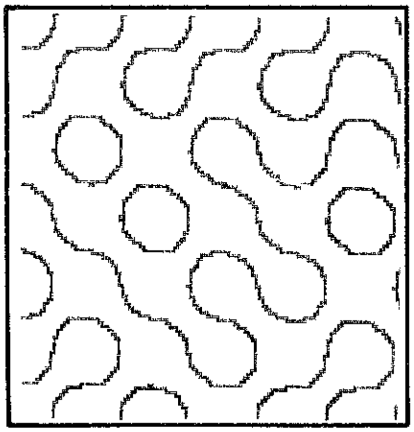

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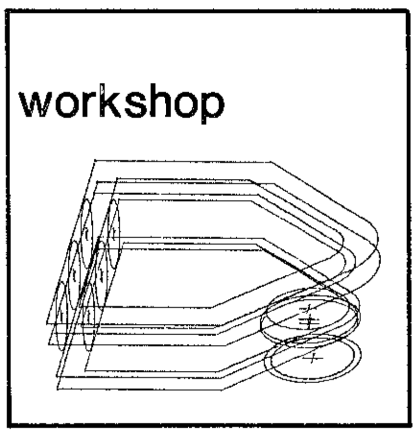

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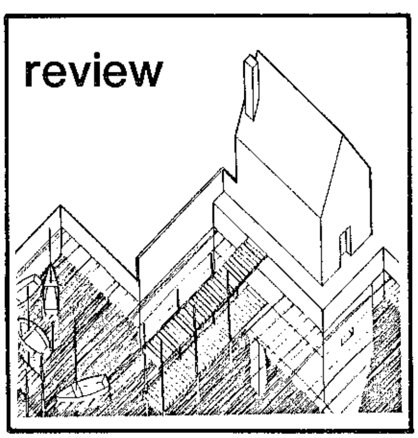

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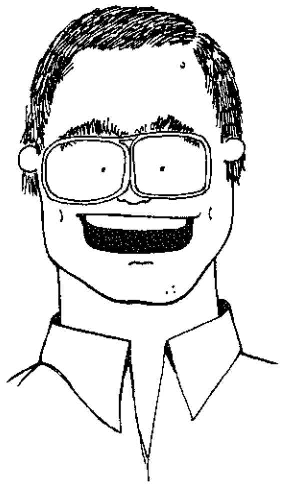
DEPARTMENTS

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

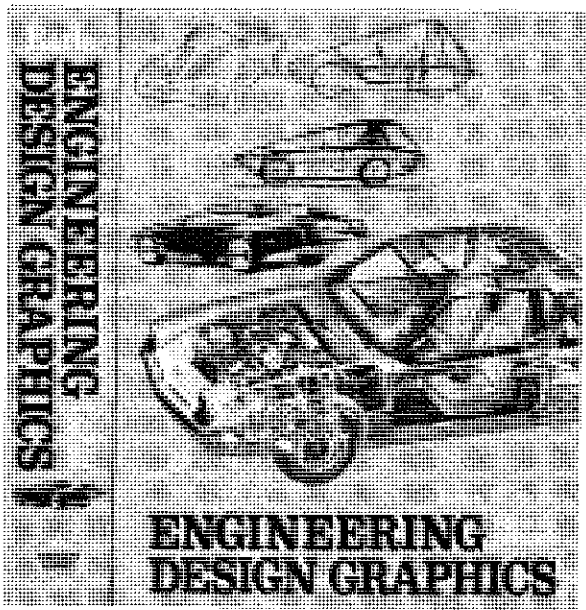
3237 Creative Engineering Design Display
8:00 a.m.-12:00 noon Clark Gymnasium Display
Engineering Design Graphics Division
Co-sponsor: Design in Engineering Education Division
Moderator: Robert J. Foster, Pennsylvania State University
Engineering design projects from the United States and Canada will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

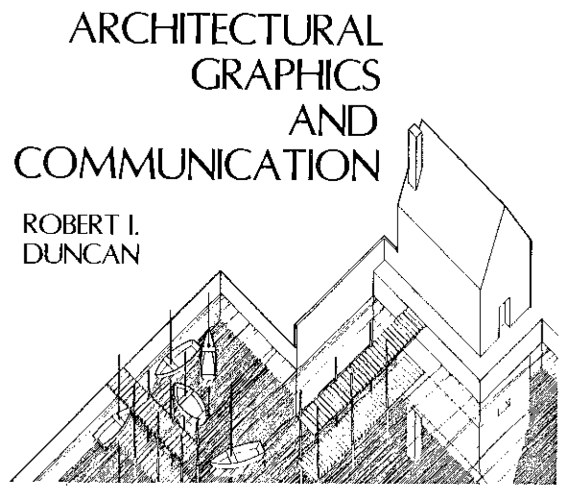
Engineering Design Graphics, Fourth Edition, is a comprehensive text that, according to the author, is a major revision of the third edition. The book contains solid coverage of all traditional topics of engineering drawing and graphics from drawing instruments and lettering through dimensioning, tolerancing, 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
Oepartment of Engineering Graphics
The Ohio State University

PUZZLE

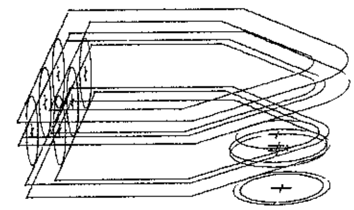
TANGENT CIRCLES PROBLEM

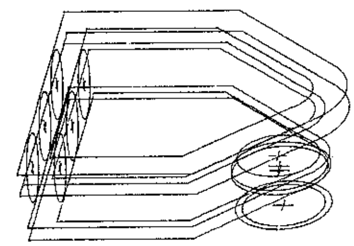
by: William P. Harrison, Jr.
Virginia Polytechnic Institute and State University

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

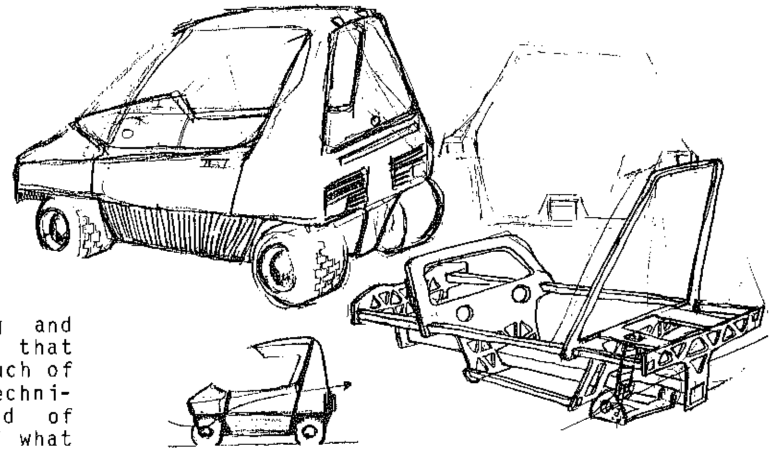
Workshop at Ohio State





A workshop in computer graphics will be given by the Engineering Oesign 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.

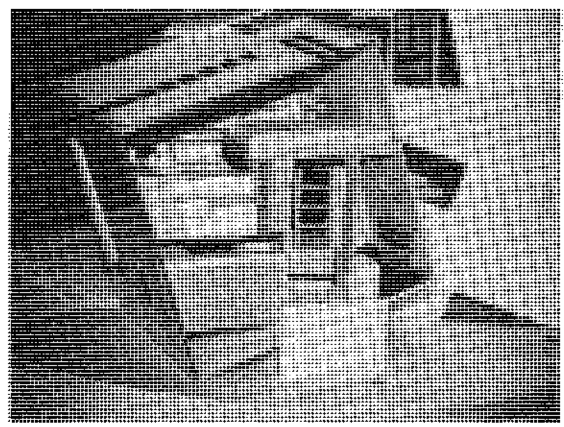
Industrial Design



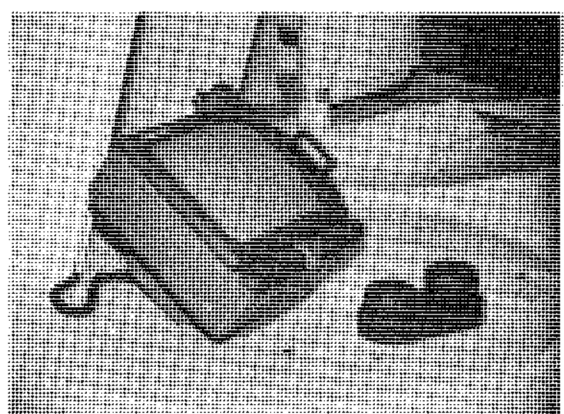
Many teachers in engineering and engineering technology are unaware that a field of study exists in which much of the most sophisticated graphic techniques are requisite. The field of industrial design combines much of what engineers do in a non-mathematical sense with what visual artists do in a technical 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.

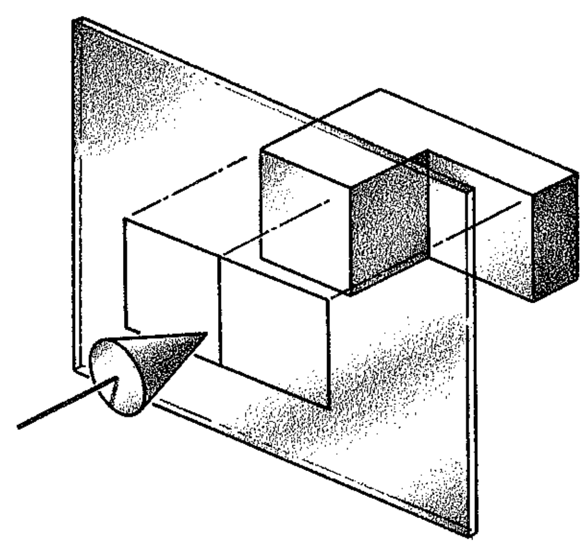


Figure 1 The plane projection method

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."

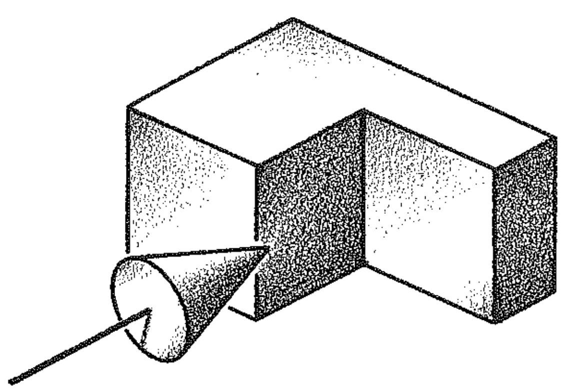


Figure 2 The direct view method

Computer Plotted Perspective View of a Vertical Cylinder of Revolution

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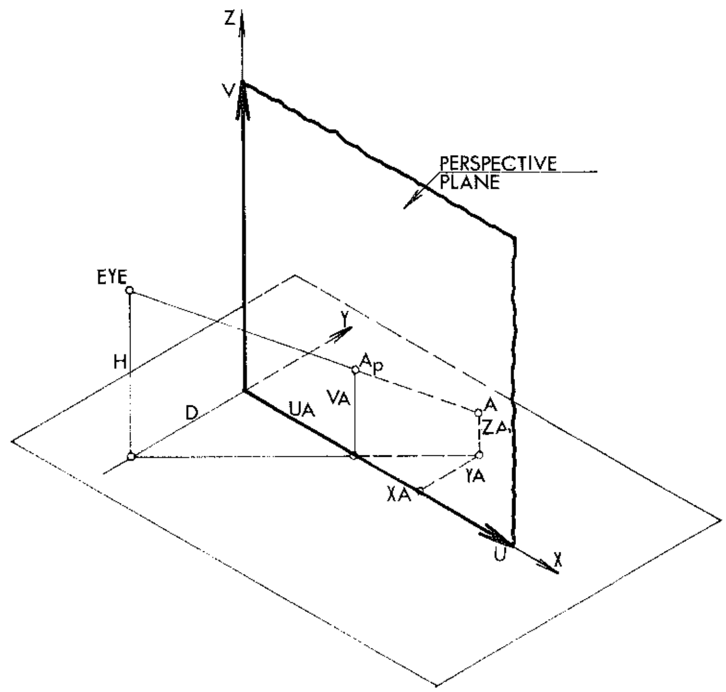
When a designer needs a perspective view of a cylinder of revolution, it would be useful for him to be able to use a computer plotter and software subroutine for plotting a perspective view of the cylinder. This plotter and subroutine could be used for the design of a pump, piston, axle, column, water 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 feedback UA,VA. These are the coordinates of that specific point on the perspective plane.



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

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

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

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.

The Tangent Points

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.

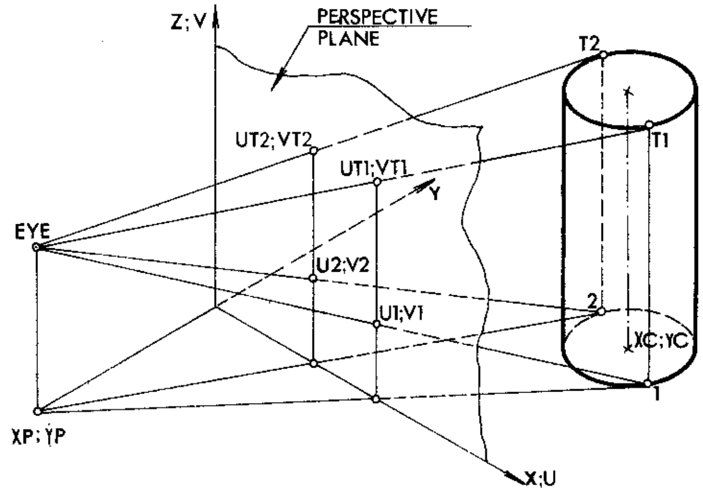


Figure 2: Extreme tangent points on the perspective plane.

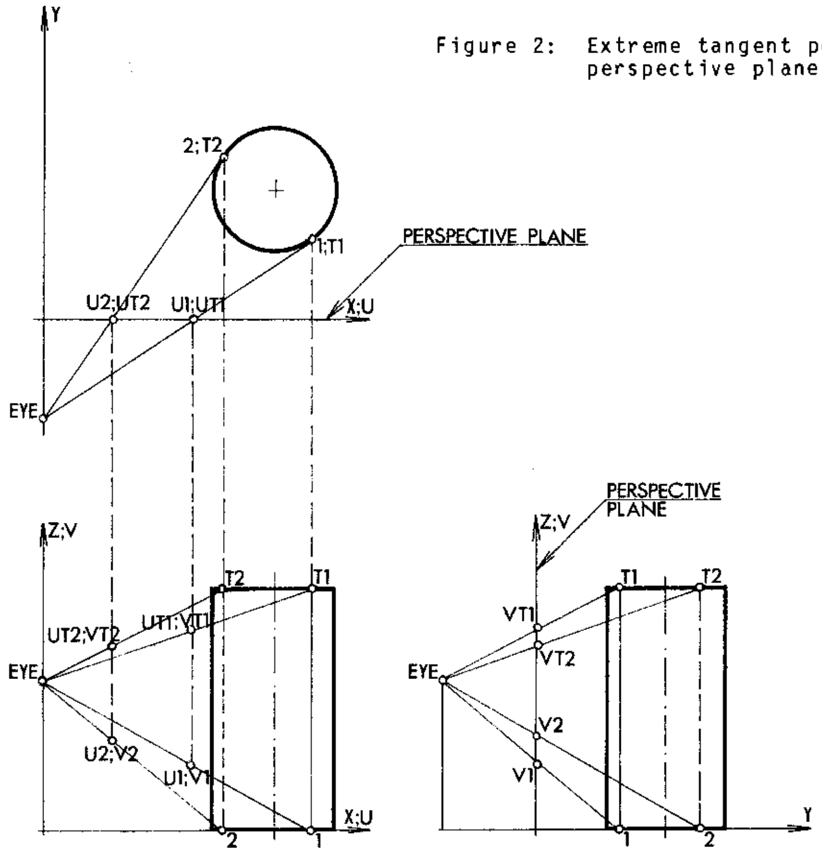


Figure 3: Location of extreme tangent points in perspective view of a vertical cylinder of revolution.

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.

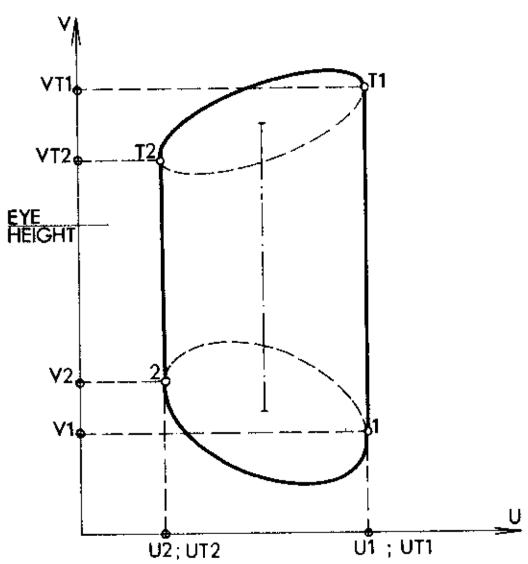
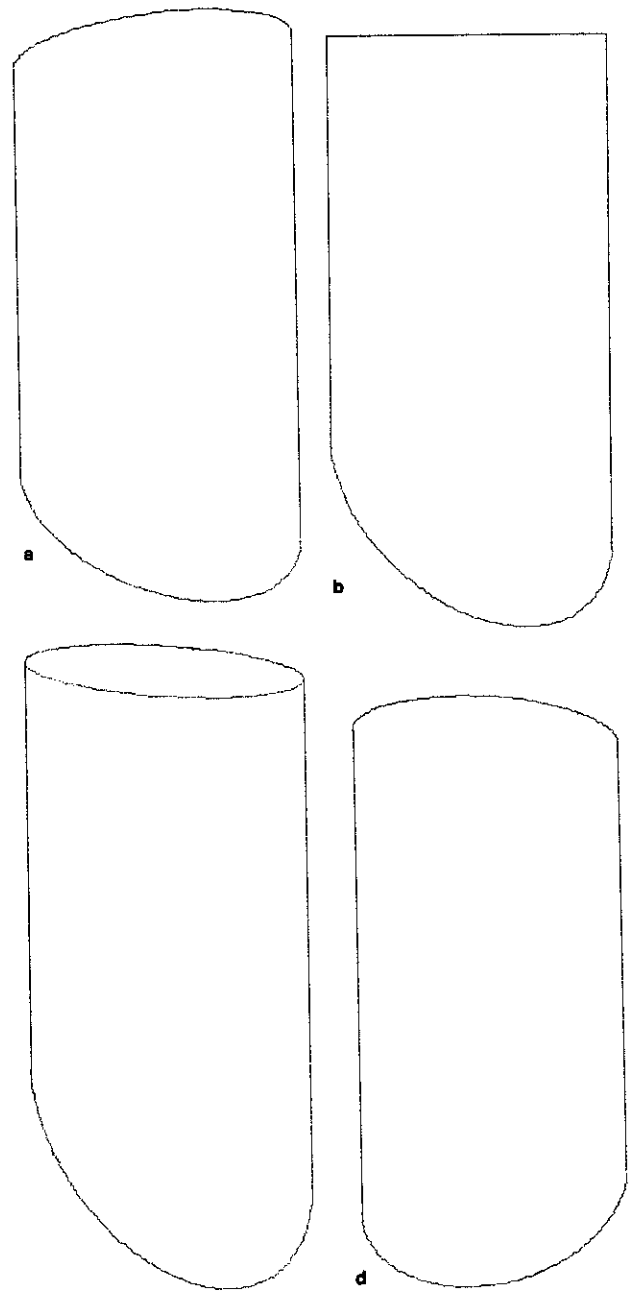


Figure 4: Perspective view of a vertical cylinder of revolution.

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.



c

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.

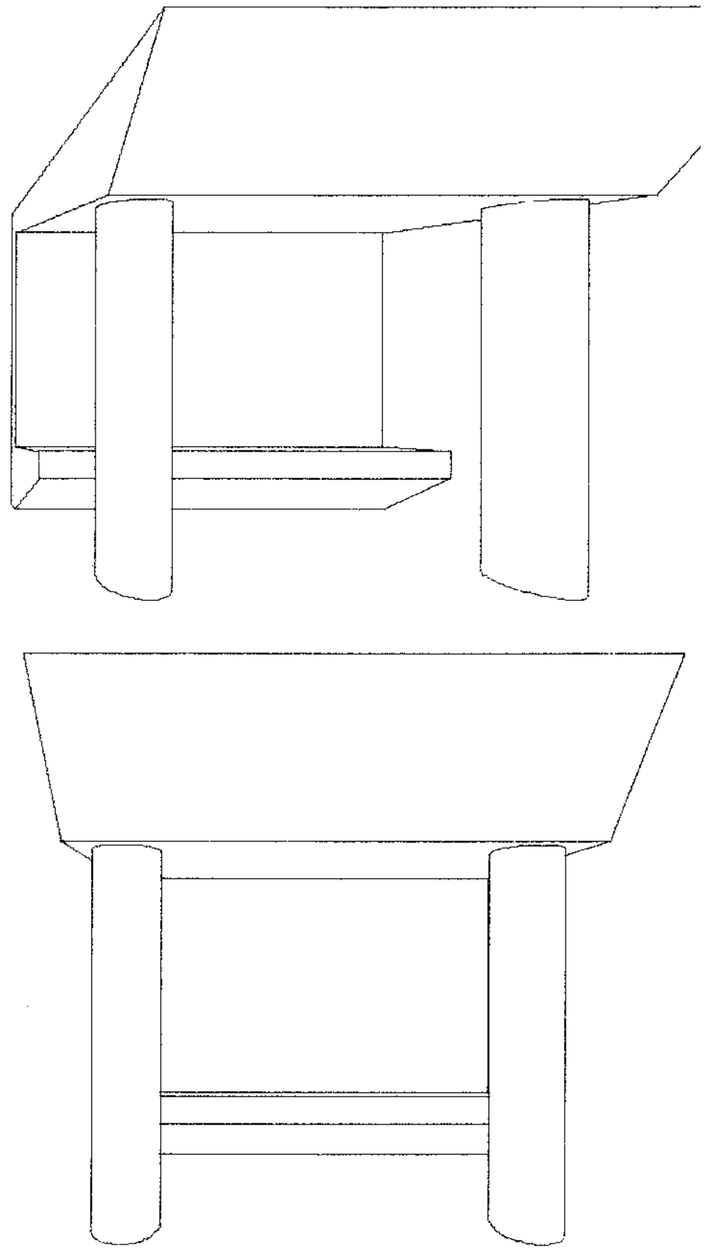


Figure 6: Computer - plotted bus stop shelter

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

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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.

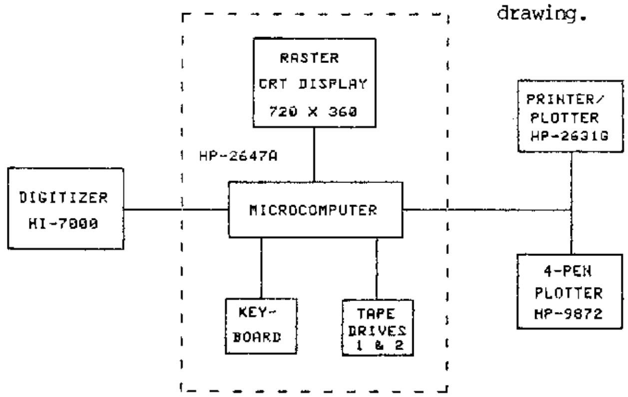


Figure 1 - Hardware Configuration for the MINI-CAD System.

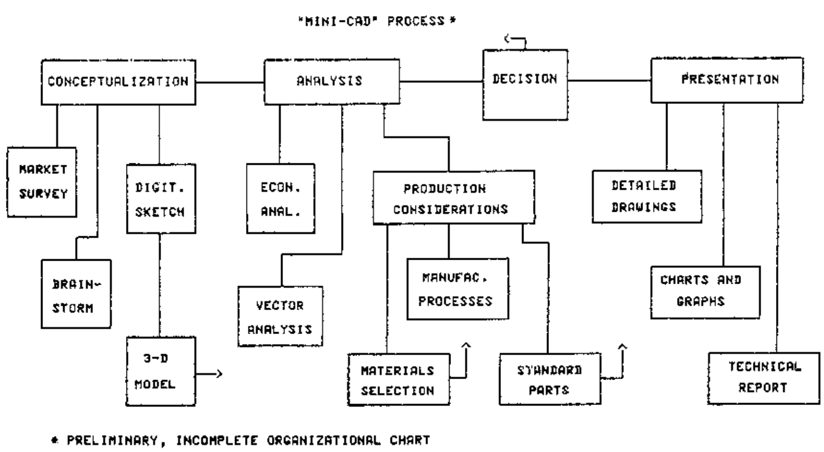


Figure 2 - Software Organization for the MINI-CAD System.

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-

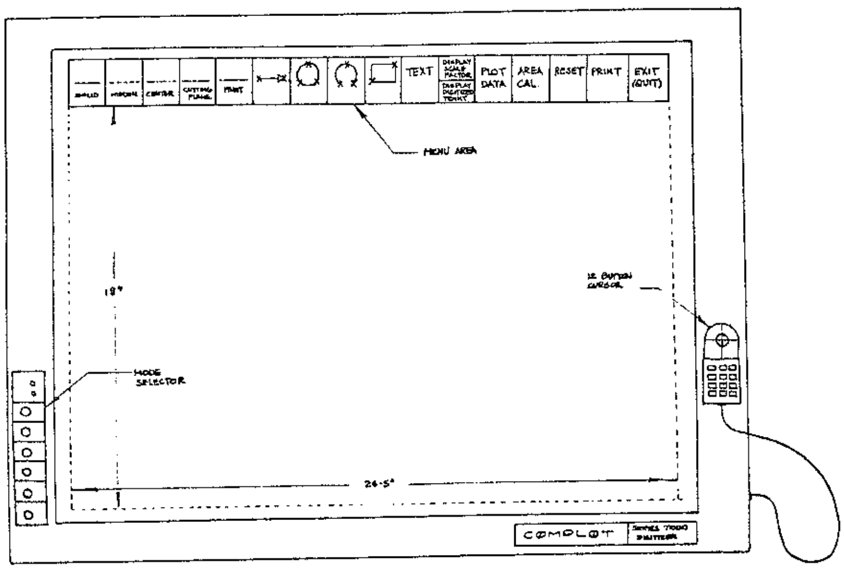
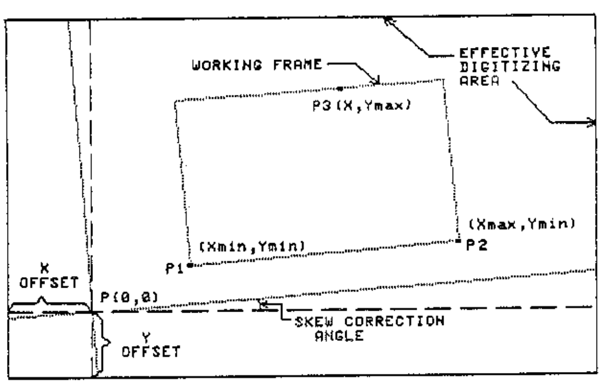


Figure 3 - Board and Menu Layout of the HI-7000 Digitizer.



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

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 1.60, 0.60 -2	MENU 3(PLOT), LINE 3(CNTL.) X1,Y1 POSITION PEN UP	MOVES TO DRAW VERT. CENTERLINE
3, 3 1.60, 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

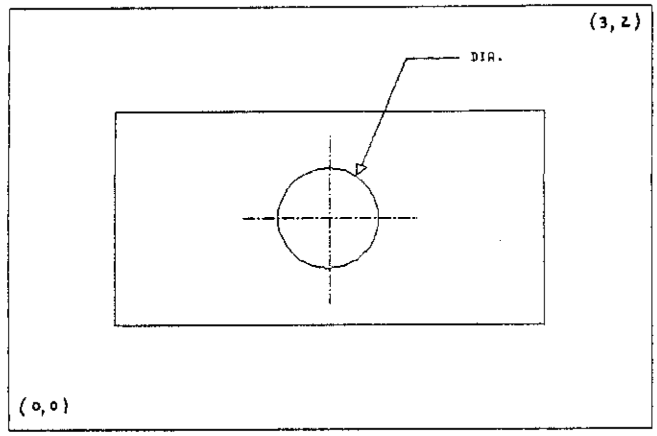


Figure 5 - A digitized sketch and accompanying data file for the figure.

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

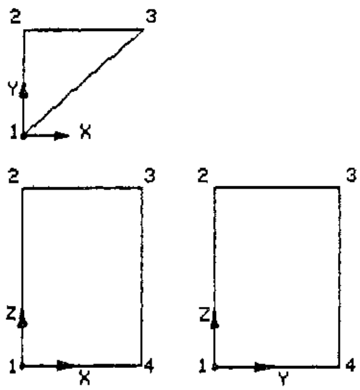


Figure 6 - Three views are digitized by the operator in a pre-established sequence.

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	5
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.

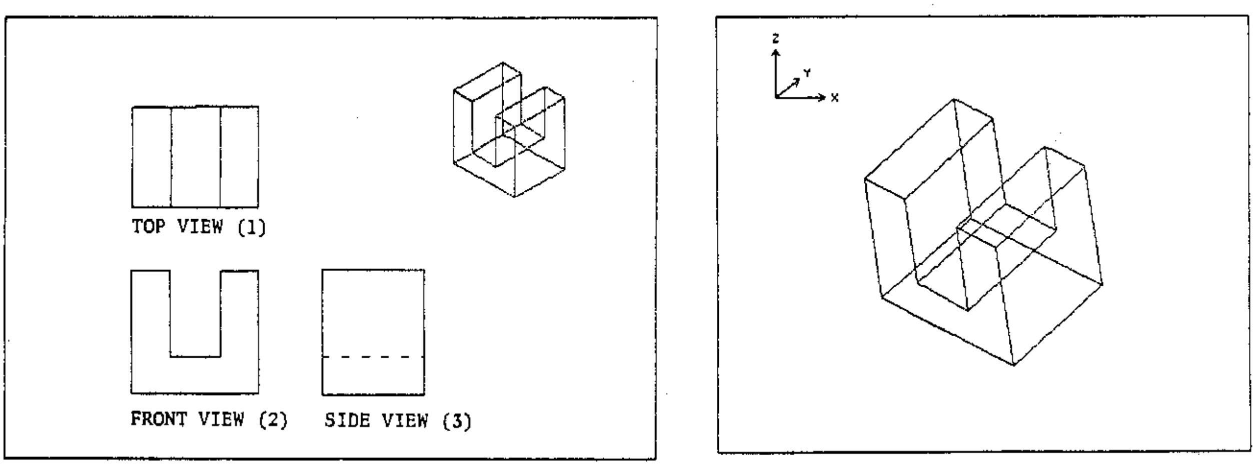
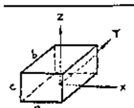
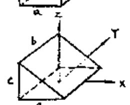
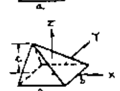
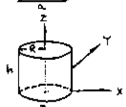
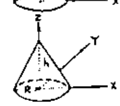
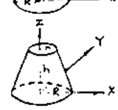
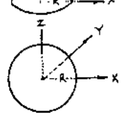


Figure 9 - A three view drawing of an object (above) has been digitized and a 3-D rotated model of the object (below) has been generated using module 2.

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.

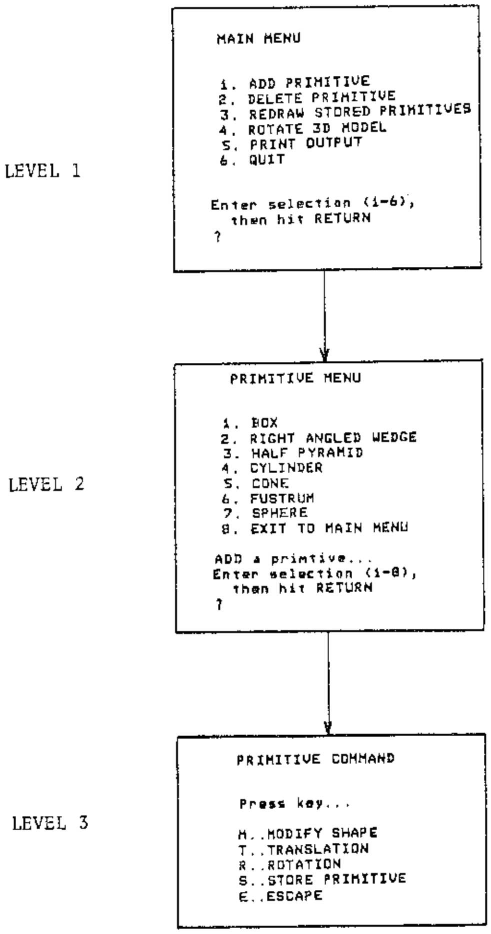


Figure 11 - A sequence of nested menus are displayed on the screen in the 3-D model maker module.

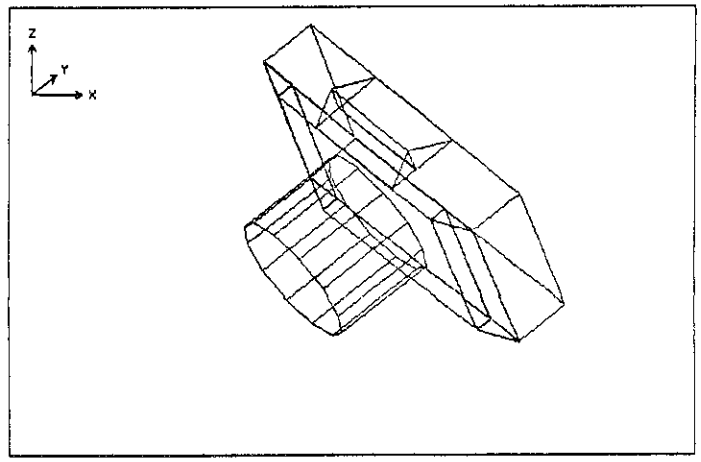


Figure 12 - Application of the 3-D model maker for a camera housing design.

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

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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.

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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.

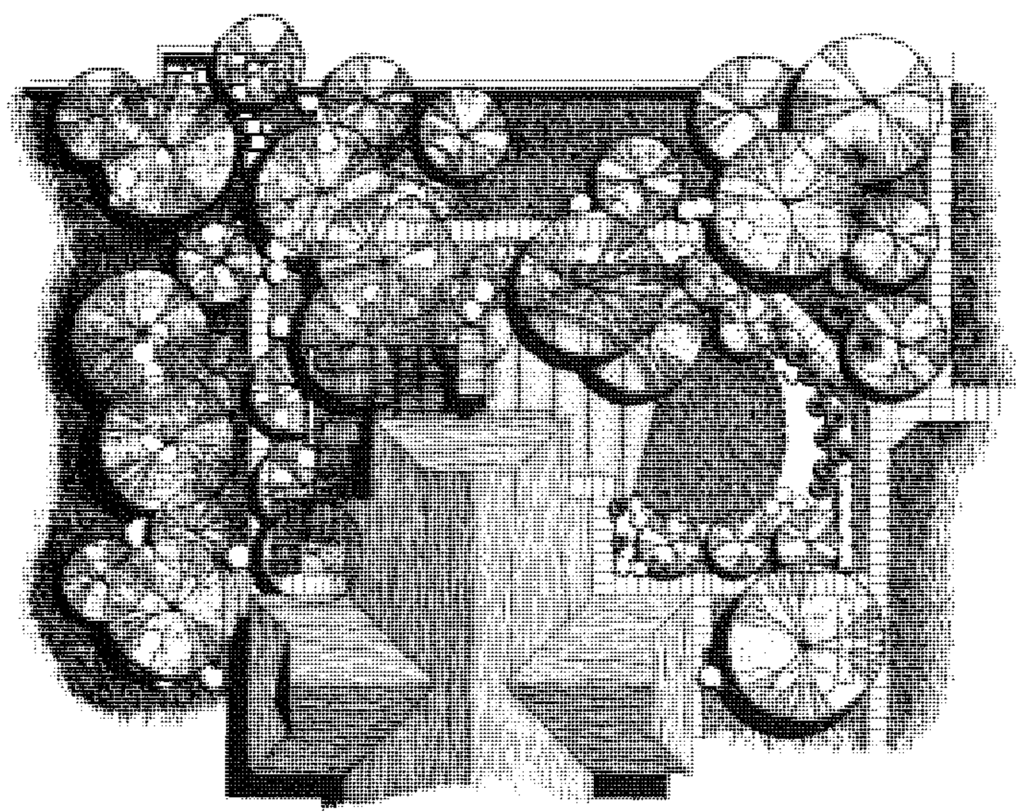
6. Spur, G., Krause, F.L., and Harder, J.J., "The Compac Solid Modeler," Computers in Mechanical Engineering, Vol. 1(2), 1982, pp. 44-53.

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 Ourvasula
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.

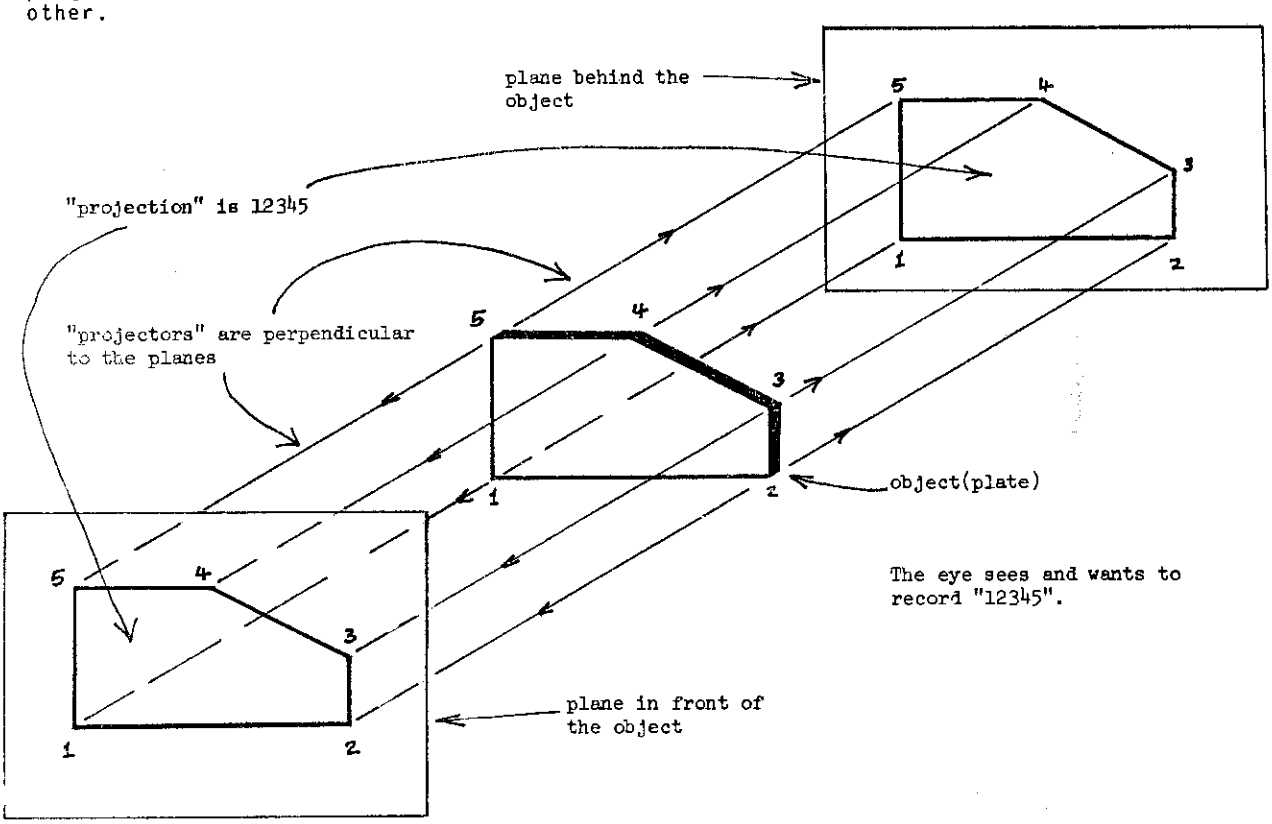
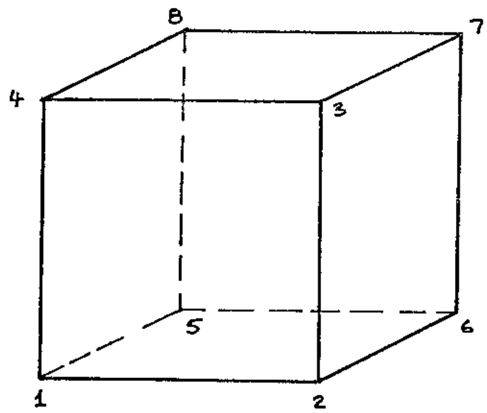
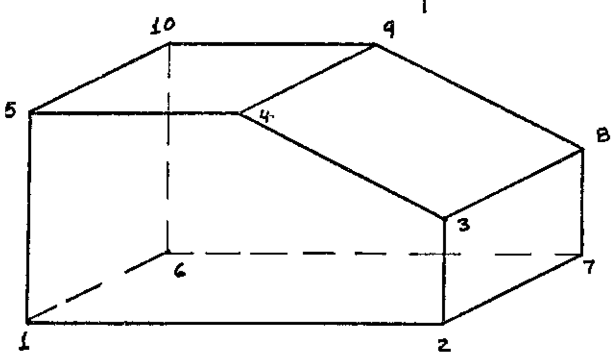


Figure 1 - Projection of an object



(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

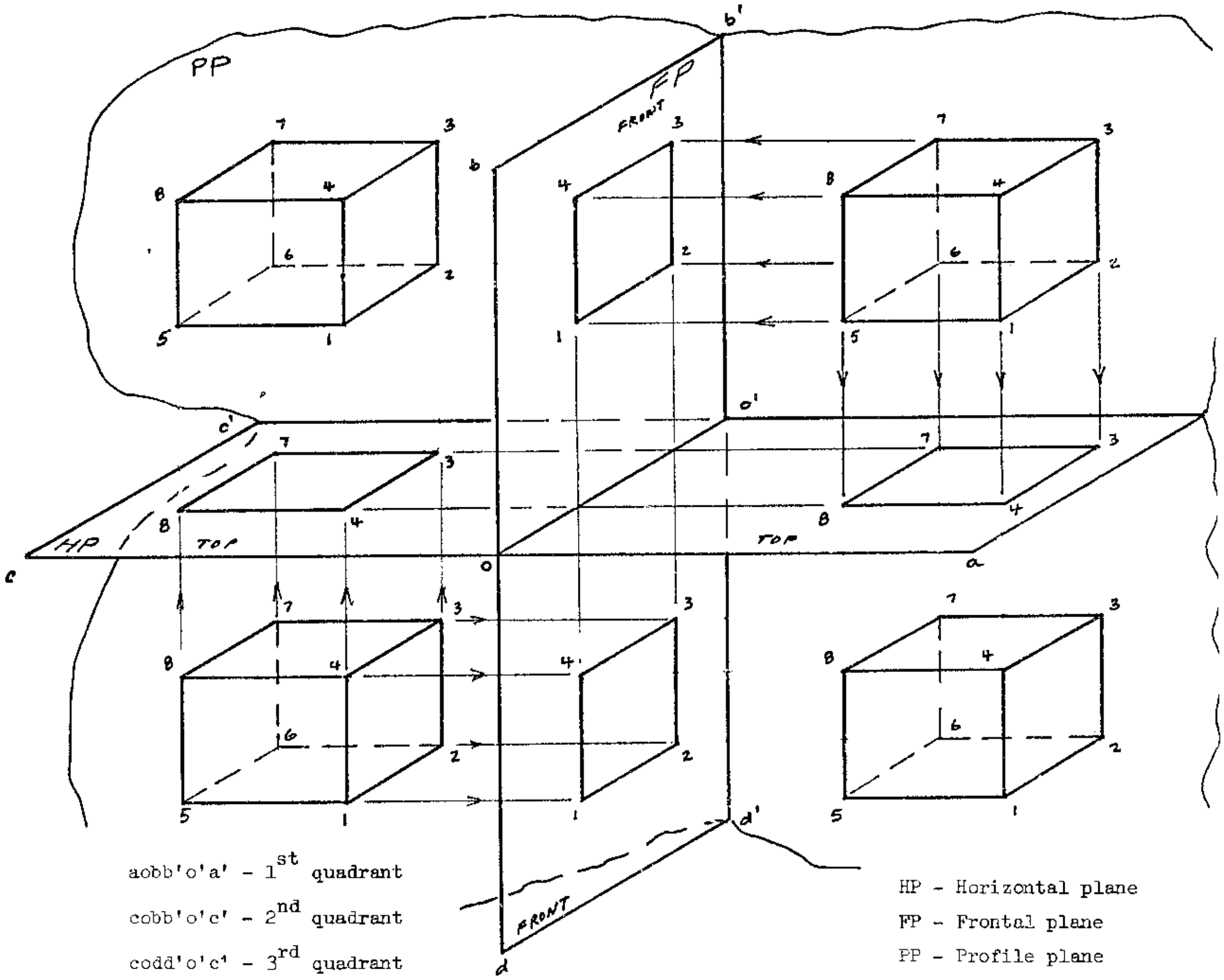
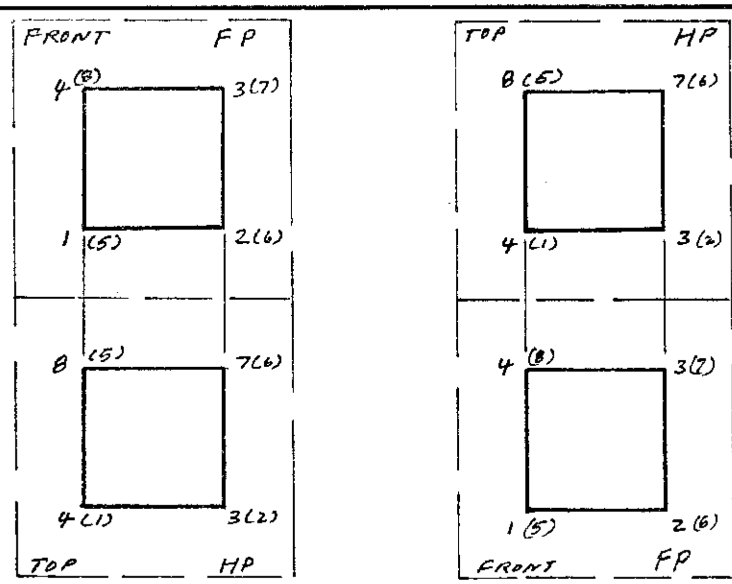


Figure 3 - Projection systems with horizontal, frontal, and profile planes

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



First quadrant projection system

Third quadrant projection system

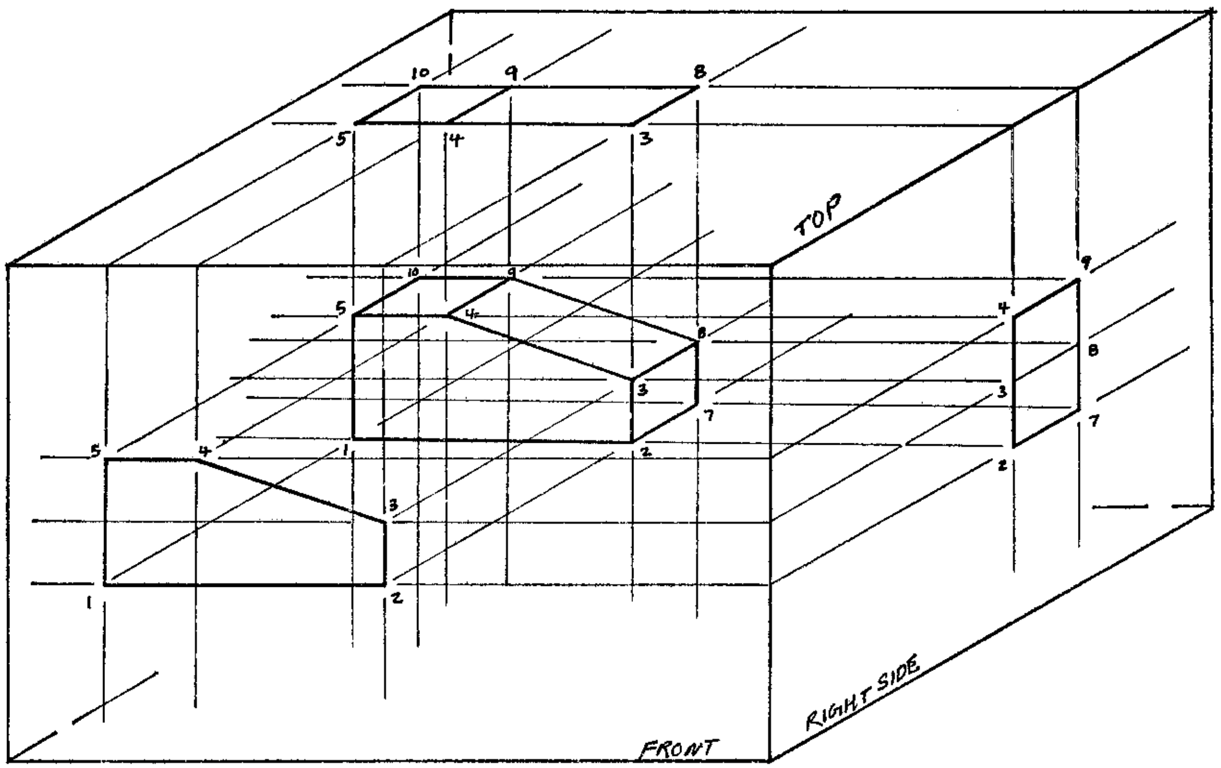
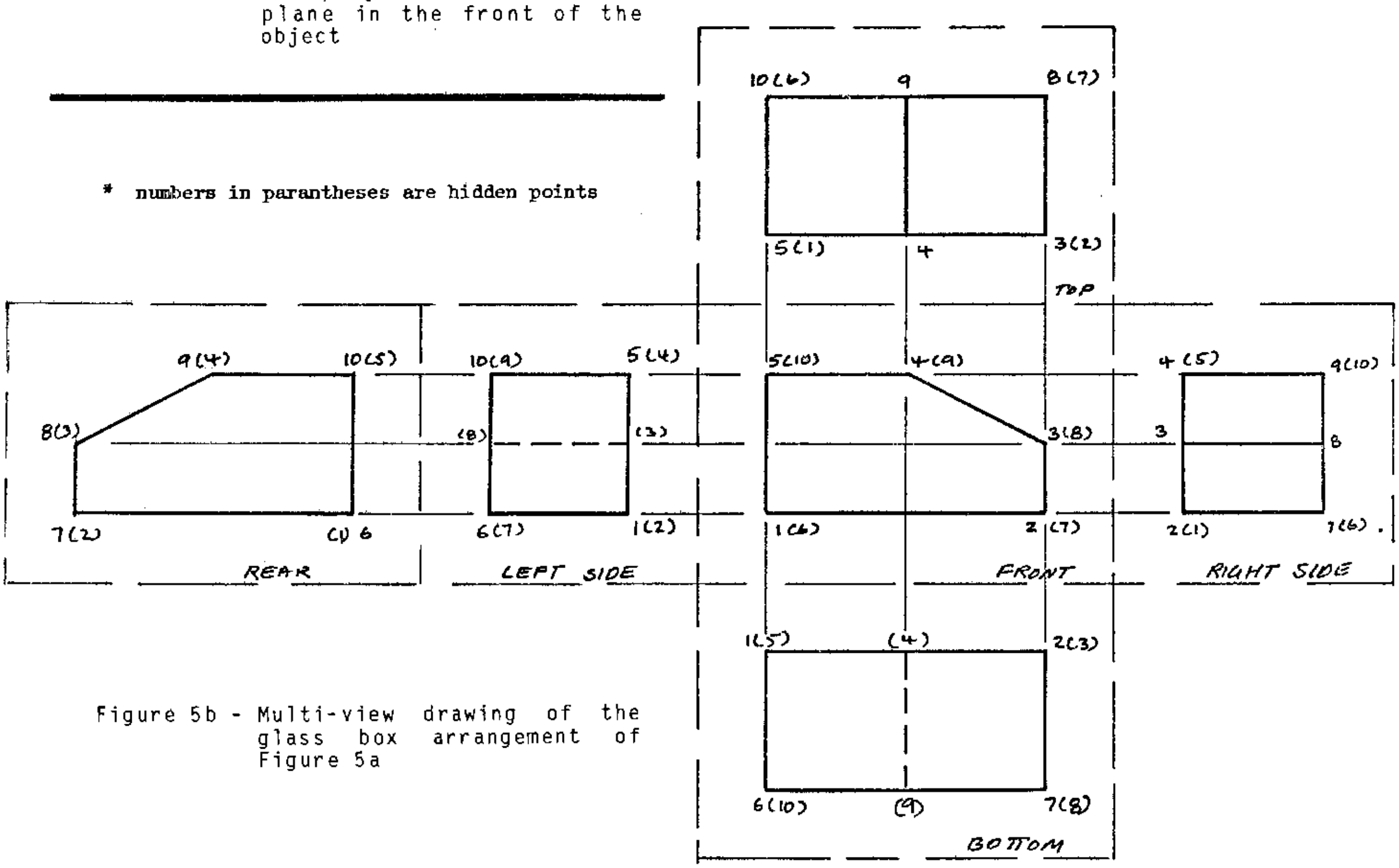


Figure 5a - Glass box arrangement, and the projections taken on a plane in the front of the object



* numbers in parantheses are hidden points

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

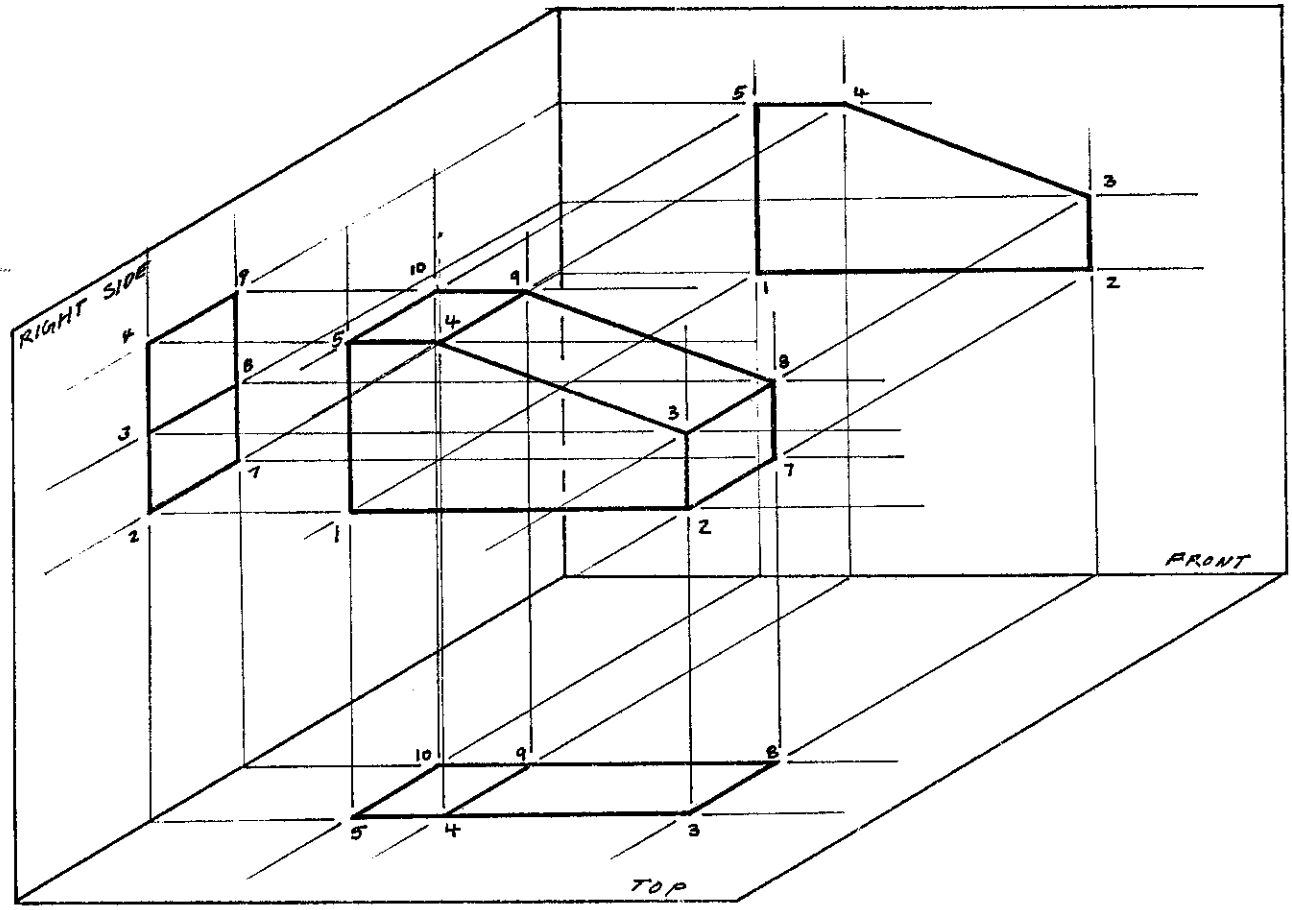


Figure 6a - Glass box arrangement, and the projections are taken on a plane behind the object

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

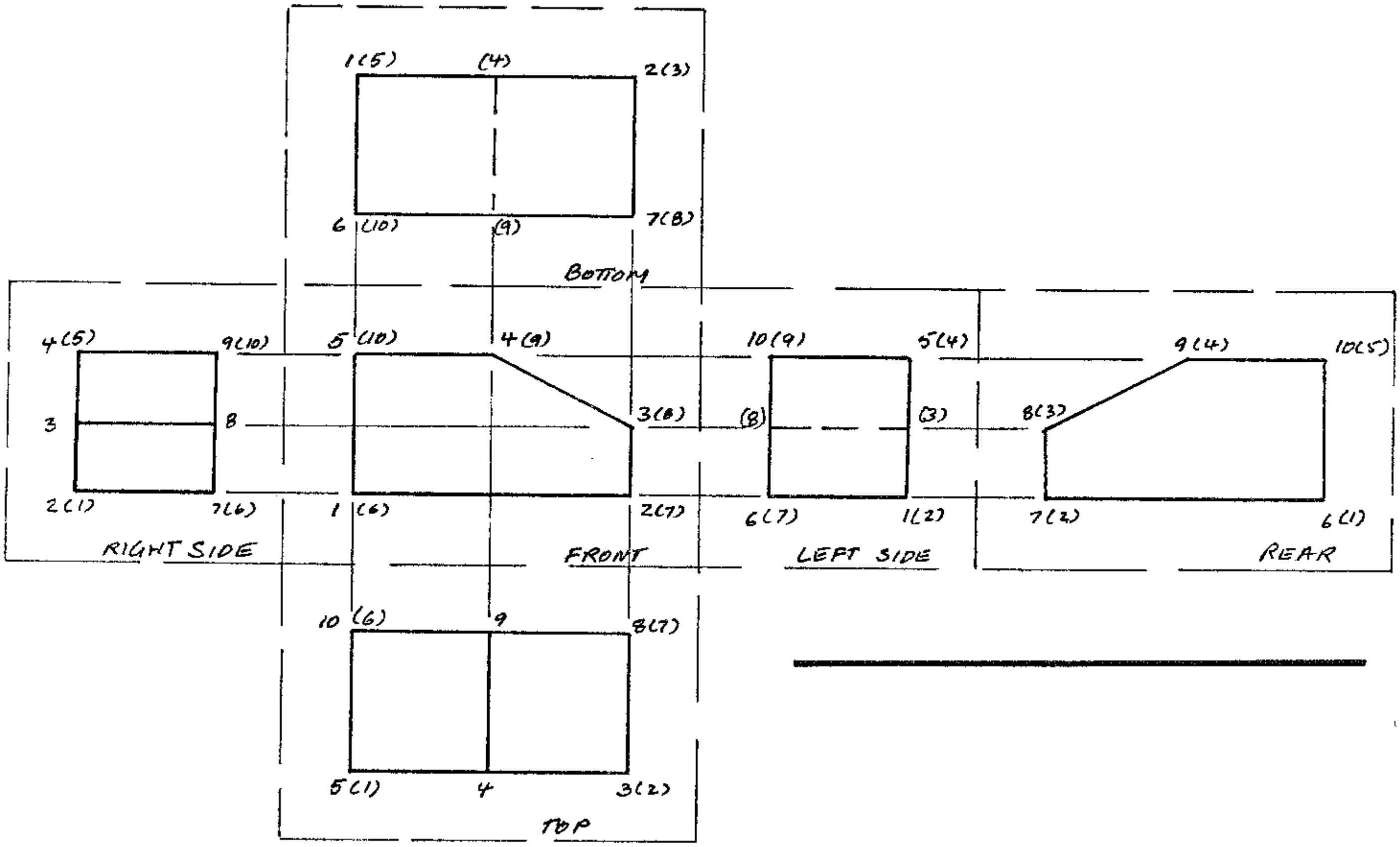


Figure 6b - Multi-view drawing of the glass box arrangement of Figure 6a

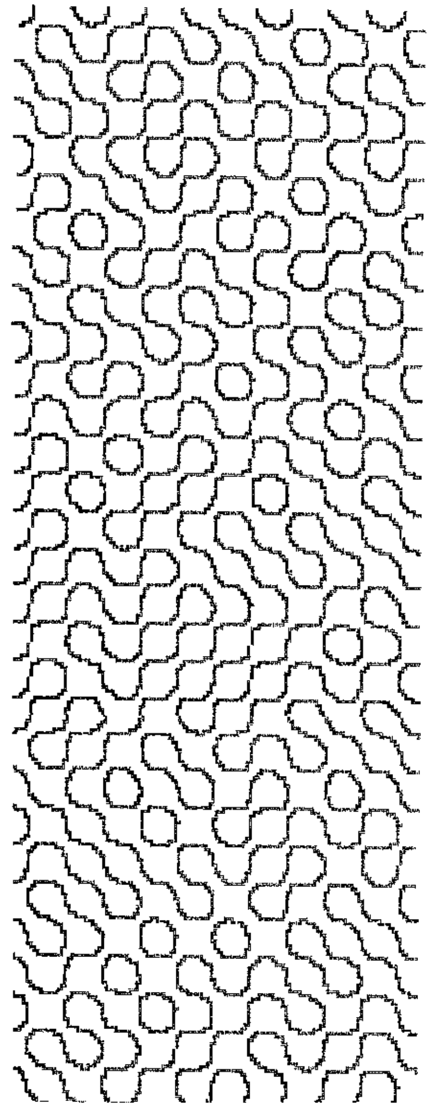
front view, right side view appears on the right of the front view, and the left side view appears on the left of the front view. Considering the layout of the multi-view drawing alone, the two projection systems are the opposites of each other while the corresponding views (e.g. the front view in both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



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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.

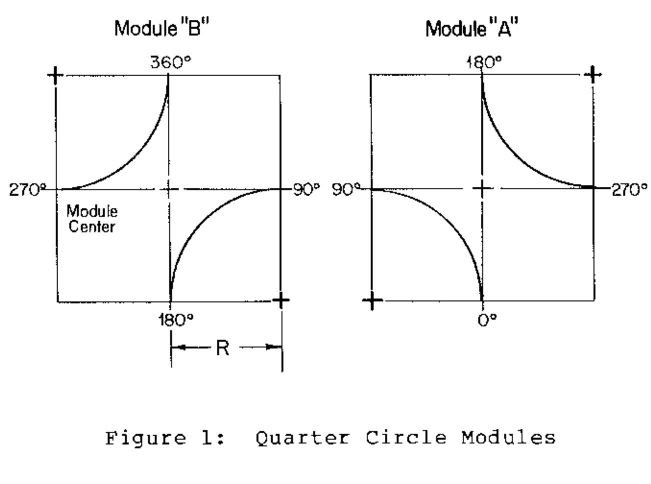


Figure 1: Quarter Circle Modules

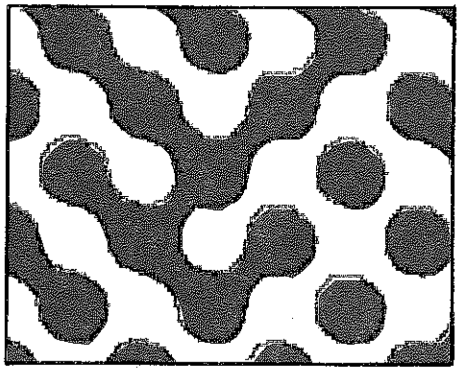
Two modules shown in Figure 1 will demonstrate this powerful graphic effect. The modules consist of two quarter circles or arcs whose centers are in opposite corners of a square. It is significant that the radii of the arcs equal one-half the size of the square in order that contiguous modules align. 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.

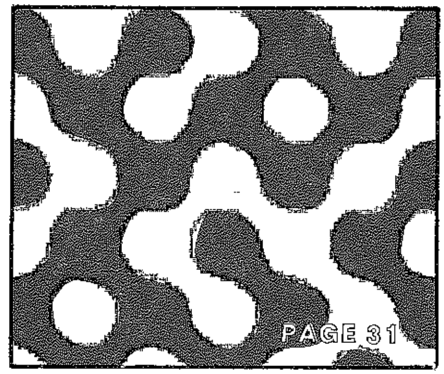
Any number of algorithms could have been devised to produce this or similar data. This particular algorithm allows control over the sampling rate. Increasing the size of the module, or drawing the modules on a higher resolution display, would necessitate increasing the sampling rate of the arcs. The 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
```





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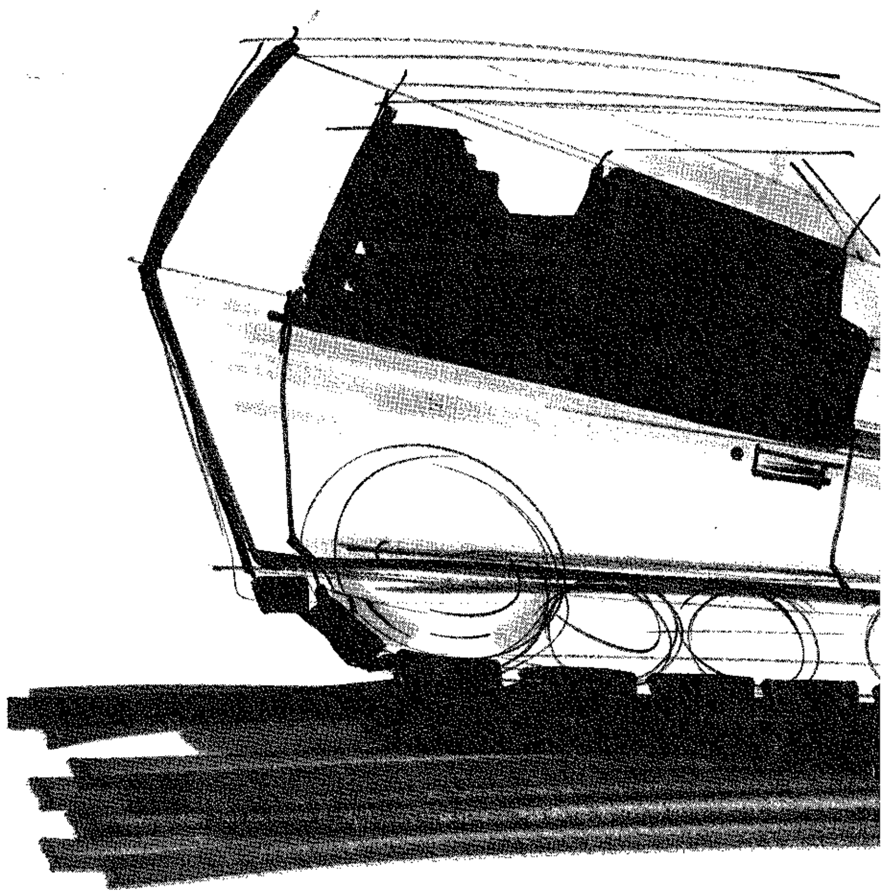

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