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ENGINEERING DESIGN GRAPHICS
JOURNAL, VOLUME 51 NUMBER 2
SPRING 1987 ********

THE ENGINEERING DESIGN GRAPHICS Journal

Winter 1987 Volume 51 Number 1

ENGINEERING DESIGN GRAPHICS DIVISION

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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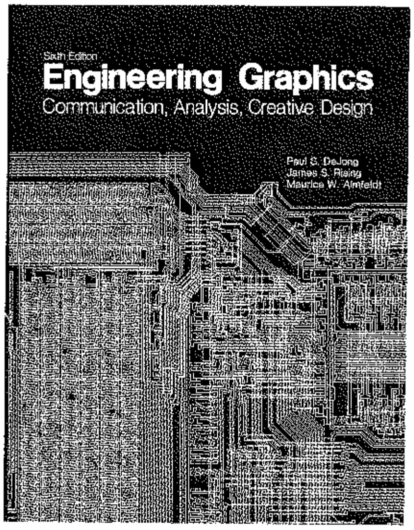

ENGINEERING GRAPHICS:

Communication, Analysis, Creative Design, Sixth Edition

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

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

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

NEW MATERIAL

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

CONTENTS

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

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OBJECTIVES OF THE JOURNAL

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 the fundamentals of engineering graphics education and graphic technology.
2. To stimulate the preparation of articles and papers on topics of interest to its membership.
3. To encourage teachers of graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses.
4. To encourage research, development, and refinement of theory and application of engineering graphics for understanding and practice.

DEADLINES

The following are deadlines for submission of articles, announcements, and advertising: FALL-September15; WINTER-December1; SPRING-February 1.

STYLE GUIDE FOR JOURNAL AUTHORS

1. All copy is to be typed, double spaced, on one side only using white paper with black ribbon in standard English. Dot matrix copy is acceptable if high quality.
2. All pages of the manuscript are to be numbered consecutively.
3. TWO copies of each manuscript are required.
4. Refer to all graphics, diagrams, photographs, or illustrations in your text as Figure 1, Table 1, etc. Be sure to identify all material. Illustrations cannot be redrawn. Accordingly, be sure that all linework is black and sharply drawn and that text is large enough to be legible when reduced. Good quality photocopies of sharply drawn illustrations are acceptable.
5. Submit a recent, glossy black and white photograph (head to chest). Make sure that your name and address is on the back. Photographs, illustrations or other submitted materials cannot be returned without postage prepaid.
6. The editorial staff will edit manuscripts for publication after return from the board of review. Galley proofs cannot be returned for author approval. Authors are encouraged to seek editorial comment from their colleagues before submission.
7. Enclose all material, unfolded, in a large envelope. Use heavy

Continued inside back cover.

VOLUME 51 NUMBER 2

THE ENGINEERING DESIGN GRAPHICS Journal

ENGINEERING DESIGN GRAPHICS DIVISION

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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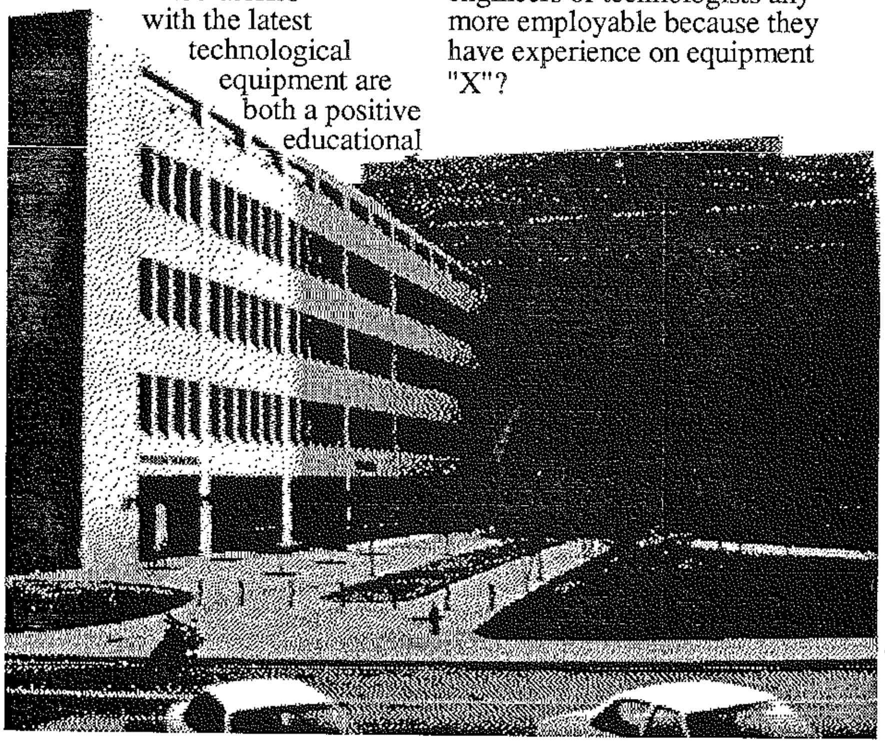
FEATURES

FROM THE DESK OF THE EDITOR

The State of the Laboratory

As our technical subject matter changes from skill-based to knowledge based, it may be time for rethinking our orientation—nay our almost religious worship—of laboratories and their associated equipment. There is no denying that modern laboratories with the latest technological equipment are both a positive educational and institutional factor. But to what extent do these labs add only to bragging rights? There are several questions that need be addressed. What is gained by having industrial production equipment over simulation equipment? At what level of education does it become relatively unimportant *what* equipment is used?



Have we ever resolved the training vs. education dichotomy? Are there fundamental differences in research facilities and educational facilities? Is it even feasible attempting to maintain cutting-edge laboratories? What does industry *really* want? Are engineers or technologists any more employable because they have experience on equipment "X"?

President Reagan just visited Purdue, specifically our School of Technology and Engineering CIM Labs. After the dust had settled, after a great deal of pride, there were rumblings from the rest of the campus of Purdue becomming nothing more than a high-powered trade school. To be sure, the rest of the campus has a misunderstanding of engineering education—its goals and accomplishments. The focus of this misunderstanding, I believe, is the devotion we have to equipping laboratories. Other disciplines function with only a sage professor interacting with hungry minds in a lecture hall. After all, knowledge and understanding is independent of equipment, right? Critical thinking, analysis, synthesis, insightful deduction, planning, reporting, scheduling—all characteristics of an educated engineering mind, can be developed without a 2.5 million dollar robotics laboratory, right? Or can it?

There are some professions, professional pilots for instance, that must eventually be trained on the real thing. Oops! That sounds an awful lot like trade school talk. Does a university train pilots, or do trained pilots come to a university to study and be educated?

— continued on page 6 —

chairman

A MESSAGE FROM THE DIVISION CHAIRMAN

In the autumn issue of the Journal, I indicated that a study group consisting of division members would meet and discuss division goals and activities with an eye toward improved service to the membership. I will summarize the results of that session with the hope that this will prompt additional discussion and proposed actions from the membership.

Ron Barr, Del Bowers, Frank Croft, George Devens, Bob Foster, Larry Goss, and Garland Hilliard gave up three precious hours of free time at the Austin meeting to brain-storm on division organization, engineering graphics, engineering design, membership, and division visibility. At the end of the session, the group was asked to prioritize the items.

There was unanimous agreement that three areas must be emphasized for continued success and growth of the Engineering Design Graphics Division (EDGD). These areas are: membership, visibility, and recognition of graphical communication by the Accreditation Board for Engineering and Technology (ABET).

Membership is a ongoing concern for all volunteer organizations. Currently, the EDGD lists 538 members of which 372 indicate the EDGD as their first or second choice. More than one in five of our members is retired from active teaching. EDGD members support many other divisions within ASEE with Computers in Education (COED), Mechanical Engineering (ME), Design in Engineering Education (DEED, Engineering Technology Division (ETD), and Educational Research and Methods (ERM) ranking as the top five.

The study committee suggested several possibilities for increasing membership.

☐ The EDGD should seek more members from the technical programs across the country.

continued on next page

" a lack of a positive statement for the criteria for accreditation published by ABET."

☐ Encourage current members to seek new members within their institution. New ASEE members should be sought but current ASEE members who are working in graphics/computer graphics/design should be persuaded to become members of the EDGD.

Rollie Jenison is Professor of Engineering Fundamentals at Iowa State University and outgoing Chairman of the Engineering Design Graphics Division of ASEE.

Chairman

from page 5

- ☐ Extra copies of the Engineering Design Graphics Journal should be made available to prospective members.

A great deal of effort will be expended to increase our membership over the next two years. Jim Leach, Director of Liaison, and Bill VanderWall, new chair of the membership committee, are developing plans which you will be hearing about soon. We would appreciate your help in seeking out new members.

Division visibility received a great deal of attention from the study group with the following recommendations.

- ☐ Strive to increase participation in the Creative Engineering Design Display (CEDD) at the annual meeting.

- ☐ Establish EDGD as the prime division to support computer graphics within ASEE. The paper presentations at recent midyear and annual meetings have been primarily on computer graphics and related topics. However, very few EDGD members have presented similar papers at other division sessions (such as ME, ERM, COED, DEED, and ETD). This type of cross-over will be promoted in the future.

- ☐ Plan an advertising campaign for the attendees at the national ASEE meetings. This could include an insert for the packet handed out at registration or a booth to attract prospective members.

Many graphics educators believe that the reason for a decline in the amount of graphics in engineering curricula is the lack of a positive statement in the criteria for accreditation published by ABET. The study group strongly recommended that the EDGD establish a task force, seek support from the disciplines (ME, CE, etc.), and propose a revised statement for the selection of ABET criteria where written and oral communication is discussed. This statement should include graphical communication, thus placing graphics in the appropriate light in the accreditation criteria.

Space limitations prevent me from discussing other items that are important to you regarding EDGD activities. The year has passed rapidly and I did not get to discuss with you all the thoughts I have for the support and growth of the division.

The next message from the chair will be written by Ron Barr. You will find Ron a hard worker who will carry out his responsibilities in a thorough and professional manner. The excellent Midyear Meeting in Austin is evidence of Ron's organizational capabilities. Please provide him the same great support you have given me this past year.

Editor

from page 4

Surely in-plant industrial training must be largely equipment-specific; after all, a company has a vested interest in a worker learning on the equipment that will be used on the job. Technical schools, which often provide technicians for specific local industries, also are justified in establishing laboratories equipped with the latest tools of industry. What about technologists? How much skill, how much understanding is necessary? And for engineers?

Obviously industry must play a greater role in the future of laboratories in higher education. Rather than equip your own robotics laboratory, could a robotics company take over such training through workshops, seminars, or internships? What would be gained, and what would be lost?

As technology advances at an increasingly rapid rate, and as laboratories become outdated almost before newly purchased equipment is installed, the institutional burden of maintaining laboratories must be re-evaluated. New and innovative solutions must be identified.

division

NEWS OF THE EDGD

IN MEMORIAM

ALEXANDER S. LEVENS

Alexander S. Levens, a faculty member at Berkeley for 26 years and Assistant Dean of Students from 1961-62, was an authority on engineering graphics. He was professor emeritus of mechanical engineering at Berkeley from 1967 until his death (December 10, 1986).

He was the author of five textbooks on engineering graphics and descriptive geometry, all widely used internationally and regarded by as classics in their field. In addition to his textbooks, Professor Levens wrote a number of workbooks for engineering drawing classes and was the author of more than 100 technical papers.

Professor Levens was noted as an outstanding teacher and a friend to his students. As one colleague noted, "His painstaking preparation for class, his masterful presentation of spatial relationships, and the relevance of his classroom work to the engineering world were always sources of inspiration and guidance to his students and to staff members who worked with him."

Continued on Page 24

review

A REVIEW OF NEW PRODUCTS AND MATERIALS

Computer Graphics

Prentice-Hall 1986 351 pp
Donald Hearn
M. Pauline Baker

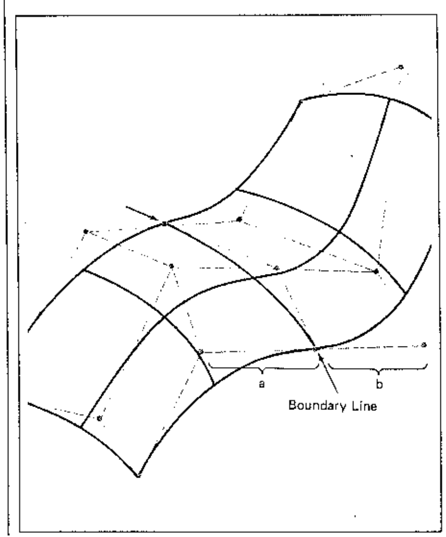
This book may be thought of as an introduction to the classic Newmann and Sproul text, written at a more appropriate level for beginners. The text is repleat with color photographs and illustrations and includes surveys of both computer graphics applications and equipment. Some of the more obscure happenings inside a graphics computer are diagrammed and explained in easy to understand terms.

Getting into the algorithmic chapters, one finds both the development of equations and Pascal pseudo code. This assumes that an interested reader is conversant in whatever graphics programming language is resident on his computer and is able to translate the Pascal structure into actual code. This is a better approach in the long run but effectively removes this text as an aid for the programming novice. Iconic diagramming of the algorithms would have been welcome.

Probably the greatest difficiency in the structure of *Computer Graphics* is the lip service paid to developing the user interface, the final chapter in the text. Snappy routines, great matrix transformations, and tight code are all important in graphics applications, but of greater import is the manner in which the eventual user interacts with the geometry. Most of these graphic algorithms have been around for twenty or more years. Why is it then that 90% of all CADD programs make graphics a more difficult operation to learn and execute than when it was done manually? The answer is that not enough research has gone into the user interface.

Lastly, there is a fundamental question as why write and publish a computer graphics text at all. Most would agree that it isn't necessary to write a text on how to code a word processing program. Select from the hundred or so writing applications, plunk down your money, and start cranking. Does knowing how sentences are parsed, text is searched and found, or how keyboard ROM routines are displayed as characters on the screen make you a better writer? How many word processor authors are out there? There are a sufficient number of computer graphics tools currently available that a book like *Computer Graphics* is an enigma: what, and to whom, is the benefit of being able to write Pascal code to make graphics?

Reviews continued on page 24



GRAPHICAL PROBLEMS AND SOLUTIONS

Smallest Sphere Tangent to Four Unlimited Skew Lines in General Positions

Chen Hongzhi
South China Agricultural University
People's Republic of China

In the days when 'CORNER was a regular feature the last unresolved teaser was:

Given: Four unlimited skew lines (A/B/C/D) in general positions.

Determine: The smallest sphere tangent.

The following is a solution submitted in 1986 by Chen Hongzhi of the South China Agricultural University, The Peoples Republic of China. The drawings are First Angle Projections. For convenience, Chen establishes one of his lines, A), as a vertical line. Figure 1.

His approach is: pass a Horizontal plane (P_o) perpendiculary through an arbitrary point (a_o) on line A, noting that all spheres (centers) tangent to A-at-a lie on P_o. P_o appears as an EV in the horizontal view, Figure 2. Chen then determines the trace, on P_o, of the centers of all spheres tangent to B/A-at-point-a. Also the trace of the centers of spheres tangent to C/A-at-a. These are the two curves in Figure 2 intersecting at points $(abc)_o$ and unmarked. $(abc)_o$ and the unmarked point are the centers of the only (two) spheres possible which are tangent to B/C/A-at-a.

Chen then repeats the process for D/A-at-a, Figure 8. The intersection at point $(abd)_o$ -- his curves do not extend quite far enough to intersect twice -- identifies the center of one (of two possible) the spheres tangent to B/D/A-at-a.

The entire process above is repeated with planes (P_1, P_2, P_3, P_4) parallel to P. Figure 14 is a pictorial. Traces are formed of points B/C/A-at-a-(now 5 points) and B/D/A-at-(now 5 points). The intersection of these two traces is the center of one of two spheres symmetrically tangent to A/B/C/D. Figure 15.

It is noted that because horizontal cutting planes are employed and because line A is vertical, the TL of the sphere radius will appear in the Top View if a horizontal cutting plane is used through point Q. If the four given lines are rotated in turn such that each is vertical then four more pairs of symmetrically located spheres may be determined and the TL found. Chen then submits that the smallest such sphere radius may be determined by comparison.

Pat Kelso
Louisiana Tech Univ.

BRIEF

This article addresses four skew lines, A/B/C/D, and their inscribed sphere. The approach is to draw spheres tangent to two lines, then three, and then four. The lines are grouped as follows:

1. A/B and A/C
2. A/B and A/D
3. A/B/C and A/B/D
4. A/B/C/D

Analysis by Groupings

1) A/B and A/C. There are an infinite number of spheres tangent to two skew lines through an arbitrary point on one of the lines, e.g., B/A-at-point-a. The center of these spheres will lie on a plane (P_o) perpendicular to A-at-a. There are an infinite number of spheres tangent to C/A-at-point-a. The center of these spheres will also lie in plane P_o. The trace of the spheres (center) tangent to B/A-at-a and the trace of the spheres (center) tangent to C/A-at-a intersect at point $(abc)_o$ in P_o. This is the center of the sphere tangent to B/C/A-at-a. Figure 2.

2) <u>A/B and A/D</u>. There are an infinite number of spheres tangent to D/A-at-a, the center trace of which lies on P_0. The trace of the spheres (centers) tangent to B/A-at-a and the trace of the spheres (centers) tangent to D/A-at-a intersect at point $(abd)_0$ in P_0. This is the center of the sphere tangent to B/D/A-at-a. Figure 8.

It is seen from 1) and 2) above there are two spheres which may be constructed, one each of B/C/A-at-a, the centers of which lie in P_0. If other planes are constructed parallel to P_0 through A other spheres tangent to A/B/C and A/B/D may be defined. The traces of these spheres (centers) will intersect at a point which is the center of a sphere tangent to A/B/C/D. Figure 14.

3) <u>A/B/C and A/B/D</u>. Using planes P_1 - P_4, each parallel to P through arbitrary points of A, the centers of the

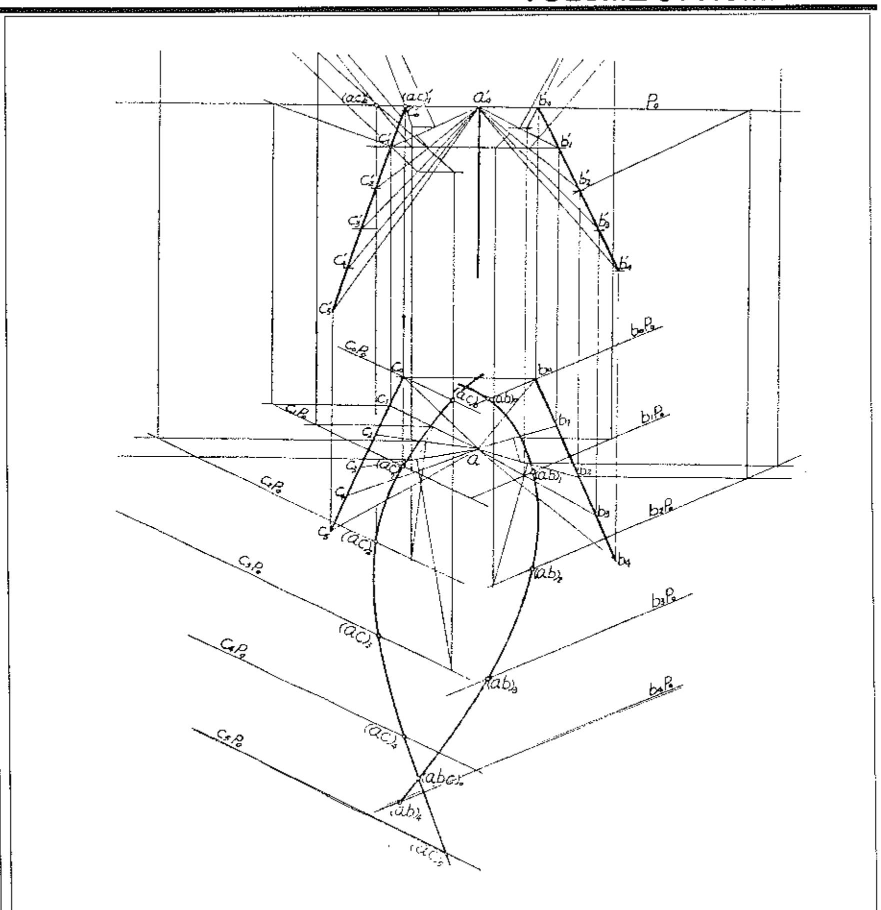


Figure 2

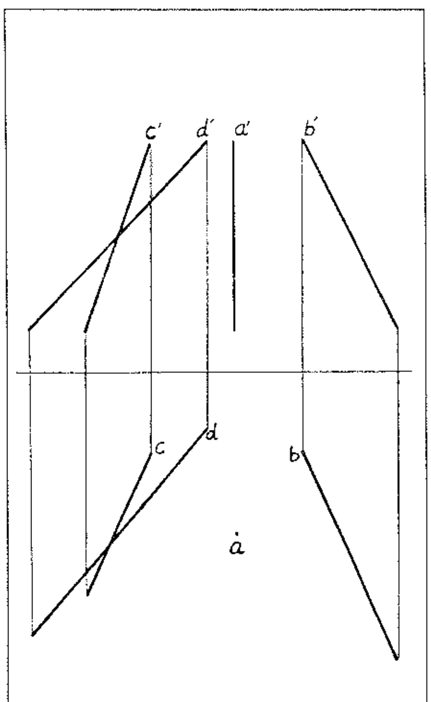
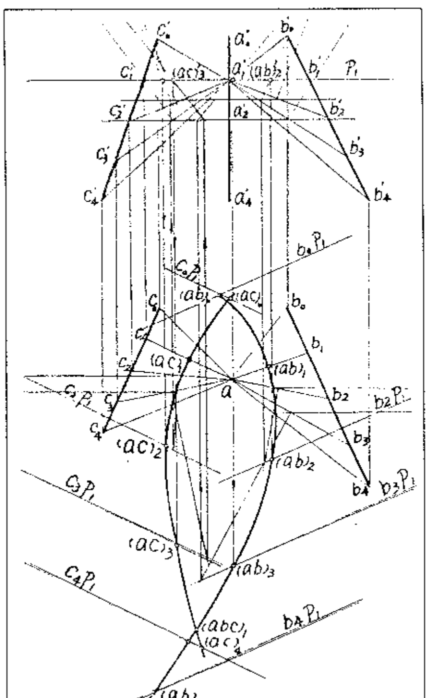


Figure 1



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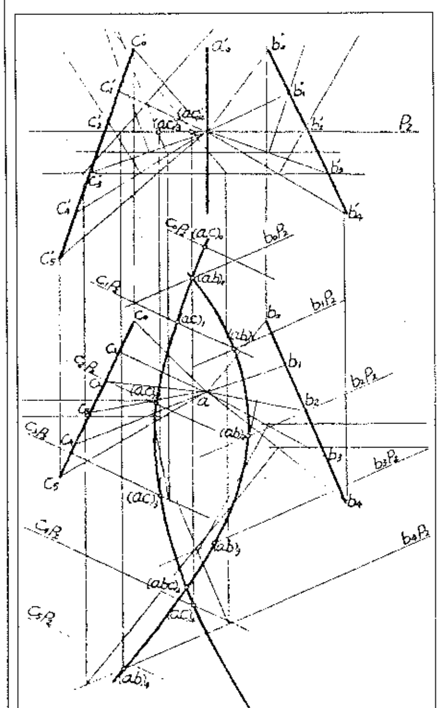

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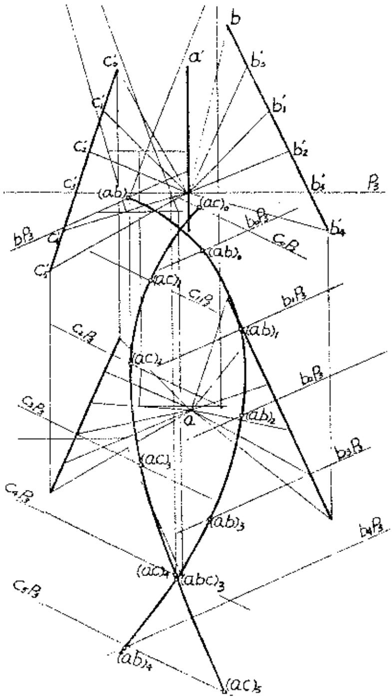

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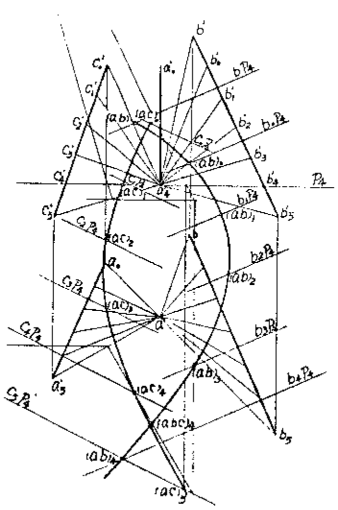

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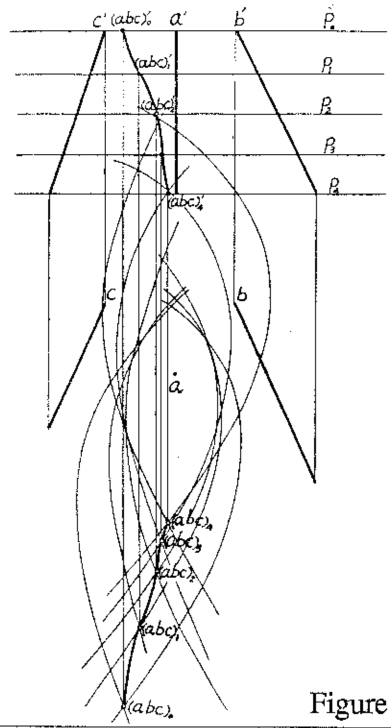

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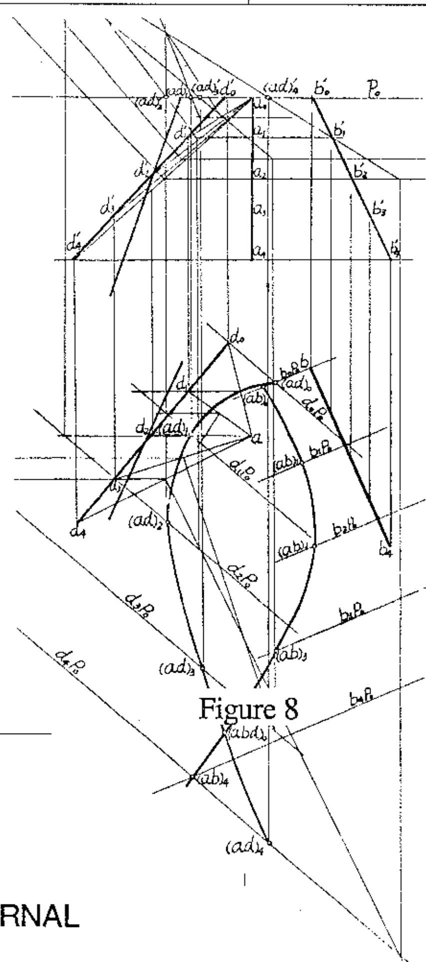

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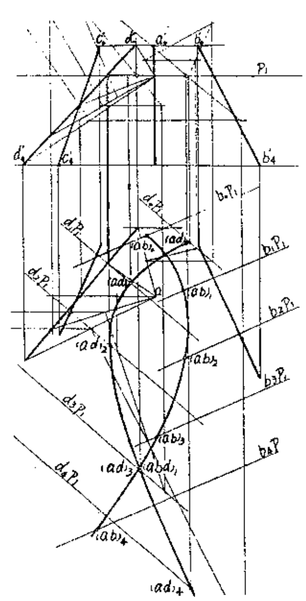

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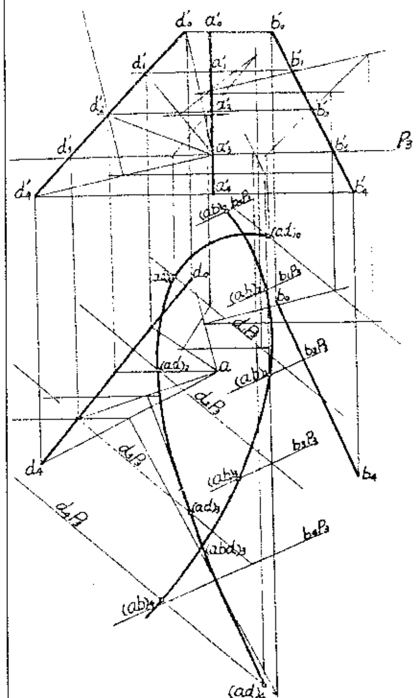

Figure 11

$(ABC)_1$, $(ABC)_2$, $(ABC)_3$, and $(ABC)_4$. Figure 14. The constructions of these points are shown in Figs. 3 - 6. The trace of these points is shown in Figure 7. The centers of the spheres tangent to A/B/C are $(ABD)_1$, $(ABD)_2$, $(ABD)_3$, and $(ABD)_4$. The constructions of these points are shown in Figures 9 - 12. The trace of these center points is shown in Figure 13.

4) A/B/C/D. The intersection of the two traces found in 3), Point O in Figure 15, determines the centers of two spheres each tangent to A/B/C/D. The true Length of the radii will appear in the Horizontal View on the horizontal cutting plane through Point O. By repeating the solution with , C and D rotated, in turn, to the vertical position the True Length of the respective radii may be obtained and the smallest sphere identified.

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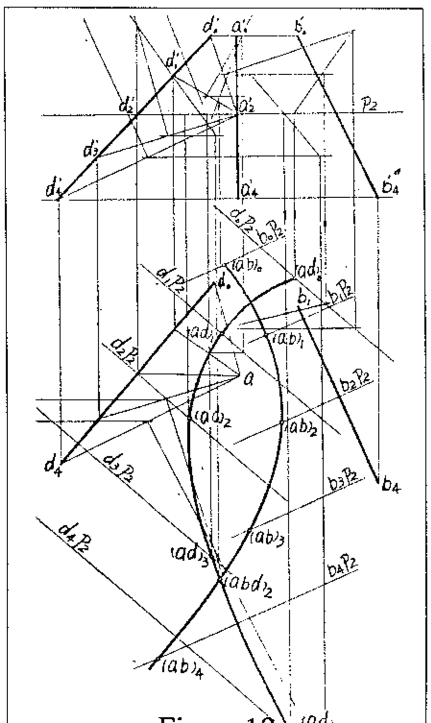

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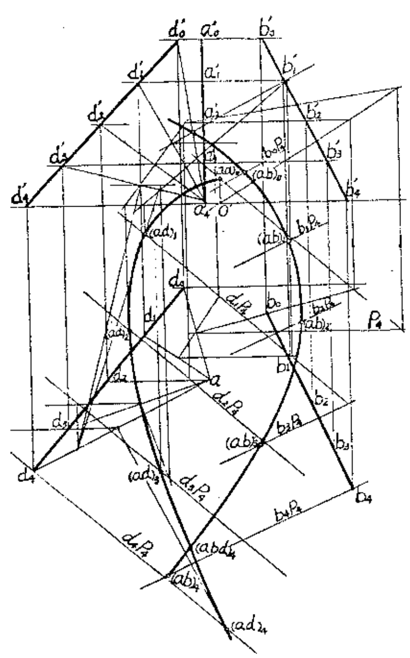

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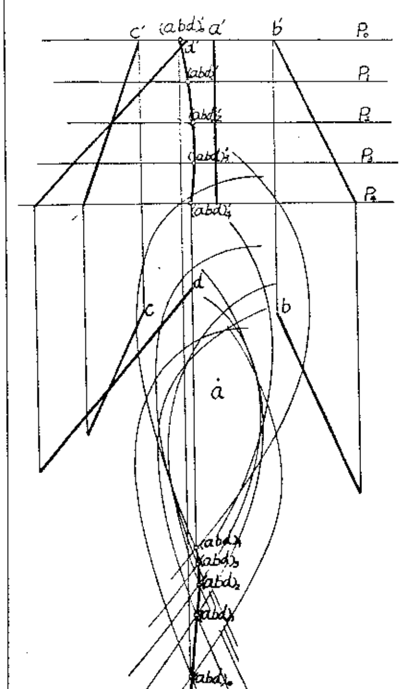

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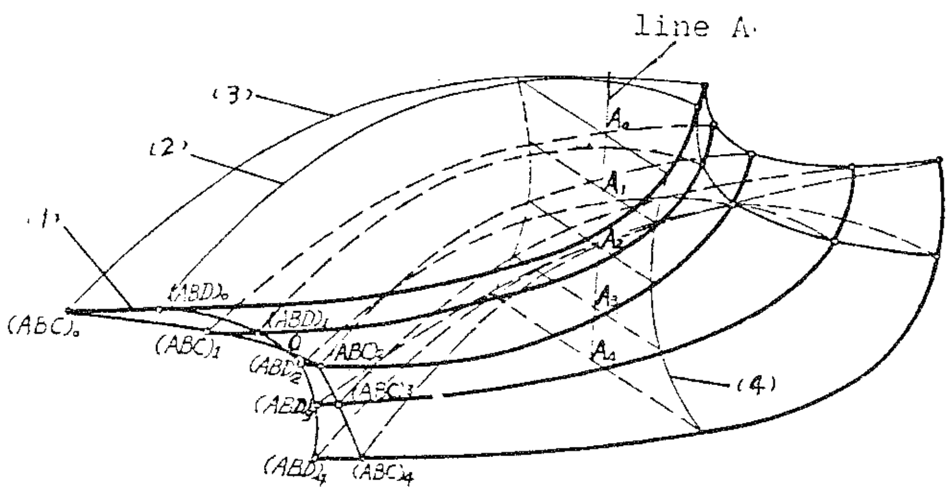

Figure 14

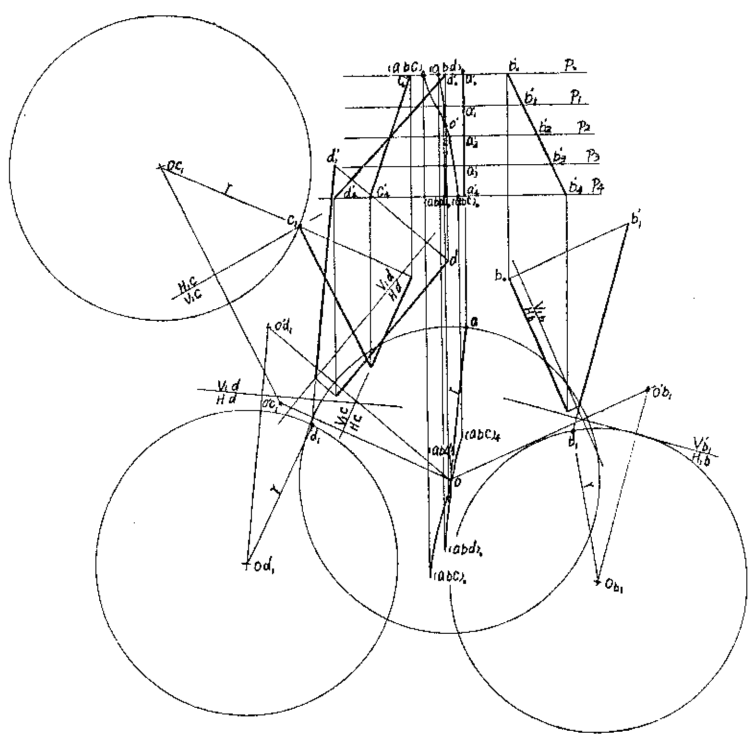

Figure 15

CREATIVITY AND PROBLEM SOLVING

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West Lafayette, IN 47907
(317) 494-8206

In the past few years there have been tremendous advances in the field of computer graphics, CAD, and CADD/CAM. These advances have forced many engineering graphics departments to make changes which have created curriculum-related problems. These problems concern budget, equipment, software, programming languages, classroom space, computer space, terminal time, and micro versus mainframe, as well as various pedagogical questions.

Along with the increasing technological changes, decreasing budgetary funds, increasing student loads, and decreasing faculty, educators are being asked to change, adapt, and find solutions for problems that did not previously exist. Many educators are entranced or entrapped with the idea of how things used to be instead of attempting to find new solutions. Often our own attitudes prevent us from seeking new ways of doing things. As graphic educators we need to be creative and innovative in our approach to solving problems both within and outside the classroom. Old problems as well as new problems can benefit from unlocked minds and flexible thinking.

Creativity has been called the spark or the "Aha!" that solves the problem. Depending on the problems and how they are solved, the solutions may change our lives or the lives of others. Too many of us accept the idea that we are not creative. We accept the statement that creativity is possessed by only those few people lucky enough to be born with it. Artists and designers are believed to have some kind of inborn ability which allows them to create.

Perhaps it is the definition of creativity which needs to be examined. The New World Dictionary defines creativity as "artistic or intellectual inventiveness." Creative is defined as "able to create", and "stimulating the imagination and inventive powers." As educators we need to focus on 'intellectual inventiveness' and 'stimulating the imagination and inventive powers.' The artistic community does not have exclusive rights to the term 'creativity.' We are all creative in our own way, and that creativity can be further developed as a skill. Creativity is not static, rather it is a process. It is something that we do with purpose. It is a skill or ability that can be learned and taught. We as educators need to develop our own creative skills and foster those of our students. We can use creative thinking to help solve both new and old problems.

The real key to creativity deals with what you do with your knowledge. According to Roger von Oech, knowledge is the stuff from which new ideas are made. He goes on to say, however, that knowledge alone does not make you creative. Creative thinking is the process of combining existing elements into something new. It requires an attitude which allows you to search for ideas and manipulate your knowledge and experiences.

It sometimes requires breaking what are often thought of as unbreakable rules. By adopting a creative outlook, you can open yourself to both new possibilities and also to change. According to von Oech...

"Discovery consists of looking at the same thing as everyone else and thinking something different."

One aspect of creativity that often gets overlooked is that if it's new to you then it is creative. Because something has been done before does not diminish its creativity. There are really very few absolutely new ideas or solutions to problems. Instead, we must find solutions that are considered unique because the approach was different, or the approach combined several aspects that had not been combined before.

It is important to realize that creativity is not synonymous with new. There really is no need to search for new and undiscovered solutions to problems. Rather, we should realize that everything already exists, and that even scientific discovery uncovers what is already there.

"*Creativity is that act of seeking and finding new and unusual ways of combining existing elements.*"

The more you know, the more elements you have at your disposal to combine, which gives you more alternatives from which to choose.

As educators we need to be concerned with developing a creative climate within our departments and classrooms. A creative climate provides an attitude which is conducive to freer use of imagination, supportive responses and a willingness and eagerness to examine points of view. We can help students begin to actively and deliberately seek new relationships between facts, feelings, figures and ideas. These new relationships can lead to taking effective and meaningful action on problems both in and outside the classroom.

A creative climate is an optimistic climate. You must realize that you can make the difference. You can foster an optimistic or creative climate by being open and receptive to new ideas. You must be ready to search for what is good and useful in a suggestion rather than always looking for what is bad.

It is not necessary for us to be creative all the time; however, when there is a need for a creative solution, we must be ready to try something different. We cannot let our own attitudes get in the way. We must become aware of our attitudes and lock them away while we are trying to generate ideas and solutions.

Most of our education is aimed at teaching students the one right answer to each problem. This is fine for the classroom, but in actuality there is generally a myriad of solutions to most problems. The best answer for a problem is the one that best solves all of the conditions which are present. When these conditions change, a different set of solutions may be needed. To further explain the ambiguity of the right answer, look at the four shapes and answer the question.

Which one shape is different from all the others?

If you selected A, thinking that A is different from all the others because it is the only figure which has no curves, you are correct. However, you might have chosen B, thinking that it is unique because it is the only figure that has a combination of both straight and curved edges. You would also be correct. If instead of A or B, you had chosen C since it is the only figure to be asymmetrical, you would still have a correct answer. As a matter of fact, you would have been correct in selecting D, since it is the only figure to have a negative space enclosed within a positive space. In other words, according to your argument, each of the figures could provide a

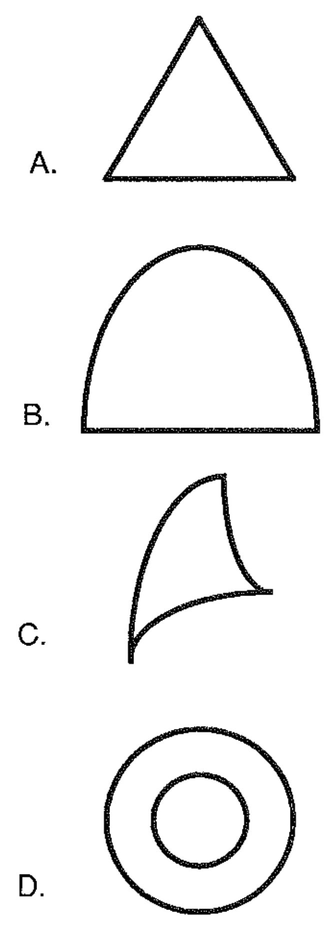

Figure 1

correct answer. This applies when searching for solutions. You must stop thinking that there is one right answer to each problem.

The search for innovative answers cannot cease after the first answer is found. Many times the initial solution can serve

"Nothing is more dangerous than an idea when it is the only one you have."

as a springboard for many solutions which are better than the first. The French philosopher, Emile Chartier, defined the problem quite succinctly when he said,

"As we deal with problems we must learn to unlock our minds and try new approaches. We must learn not to discard an idea because it does not seem practical. Sometimes an adaption of a non-practical idea turns out to be the best solution. Each one of us can be creative, but we need to try alternative methods that we have not tried before."

We must acknowledge that not only do most problems have more than one solution, but that different people look at things in different ways. For example, what do you see when you look at the figure on the right?

At a first glance, you might have seen a white question mark on a black background, or you might have first seen a bird. To make things even more confusing, your first opportunity to see this figure might have been hands. In that case the possibility exists that you saw it upside down. If that is the case, you probably saw a seal juggling a ball. As educators, we must remember that our students do not always see things the way we do. This does not necessarily mean that they are wrong, only that their approach or frame of mind is different from our own. We can apply this knowledge when

Figure 2

solving problems. Look at the situation from different angles. Try to see from the other person's point of view. Do not accept your first idea as the best and only solution.

Examine the following graphic problems. Possibly you have seen them before, but this time think about your initial response. What different answers might you give if you didn't already know what you should answer? Sometimes the right answer does not seem to be correct even though we know that it has to be.

For each of the following figures, choose the correct answer:

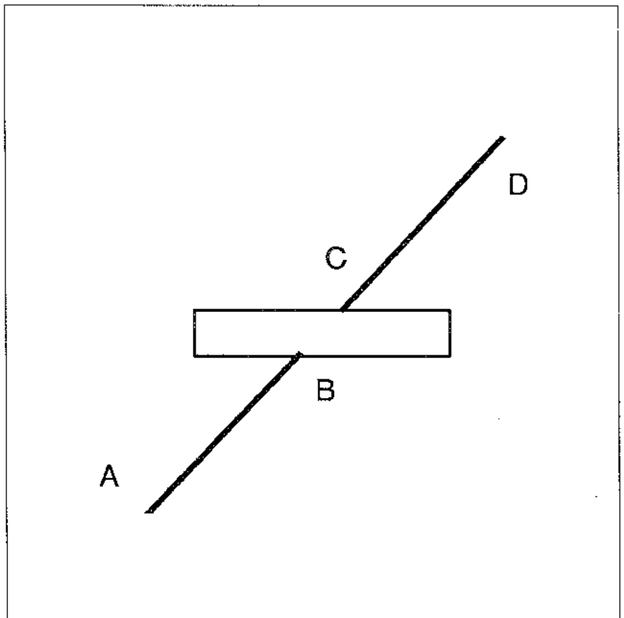

Figure 3

1. Lines AB and CD are parallel and CD is displaced to the right of AB.
2. AB and CD are not parallel.
3. AB and CD are segments of the same line.

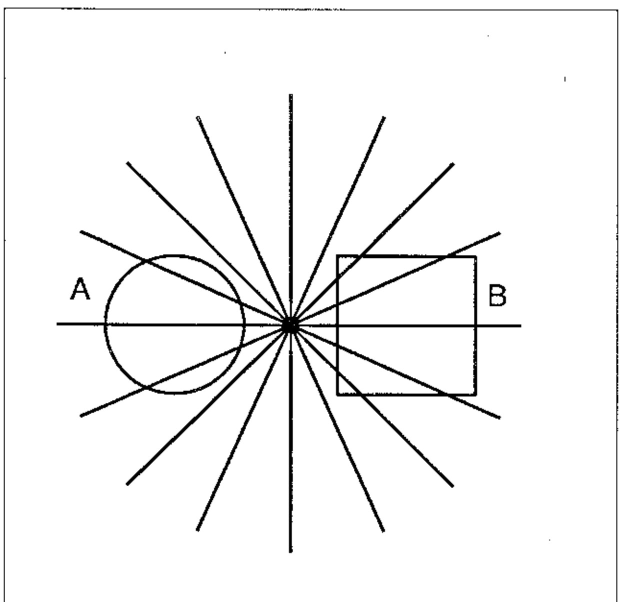

Figure 4

1. Figure A is a circle and Figure B is a square.
2. Figure A bulges near the center; Figure B is a parallelogram with the side nearest the center longer than the side away from the center.
3. Figure A is bigger than Figure B.

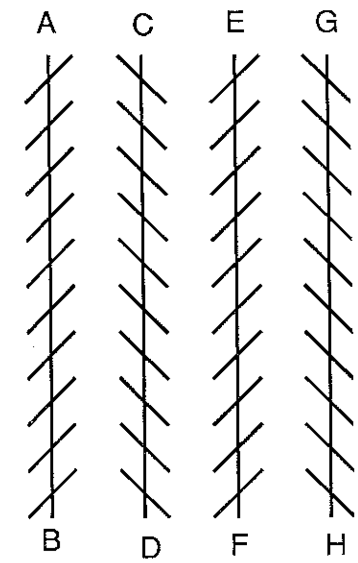

Figure 5

1. Line segments CD and EF are closer to each other at the top and farther apart at the bottom; line segments AB and GH are closer to CD and EF at the bottom and farther away away at the top.

2. Line segments AB, CD, EF, and GH are parallel and equally spaced.

3. AB, CD, EF, and GH are not parallel and equidistant.

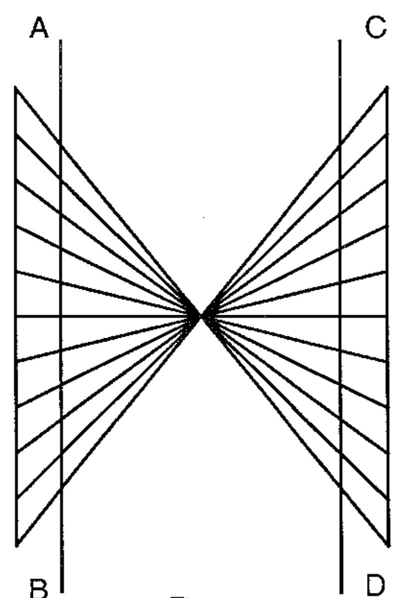

Figure 6

1. AB and CD are curved lines; they are farthest from each other at the center.

2. AB and CD are curved lines; each is farthest from the other at the ends.

3. AB and CD are straight lines and parallel to each other.

— Continued on page 23 —

Engineering Graphics in Education

Programming and Ready Programs

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Abstract

This paper includes examples of engineering graphics produced by ready (commercial) programs and others produced by high level language programming in a limited credit hour segment of an educational program. Although there are programs of this sort for all popular microcomputers which could be used equally in the educational process, the schematic drawings and graphs which are presented here are produced by programs for the Apple IIe's and IBM PC's. Thus, the two versions of BASIC used in producing the examples in the paper are Applesoft BASIC and IBM BASIC version 3.0. Regardless of what microcomputer is used and what high level programming language is is used we believe that with careful consideration and judicious implementation we can integrate teaching microcomputer based graphics -- by using both ready commercially available programs and high level language programming -- in our engineering curricula without encroaching on the fundamental engineering courses.

Introduction

Graphics as sketches, schematics, visual presentation of data, and engineering drawings have been used extensively by engineers, architects, and other professionals. The use of graphics varies from a support role such as to reinforce and clarify a presentation to a detailed workshop drawing (1, 2). Engineering educational institutions have been teaching graphics as an integral part of curricula since they started. The introduction of mainframe computers and minicomputers created great potentials in research, education, and industry. But, the cost of hardware and software and the space and maintenance requirements have limited the extent of utilization of these machines in education.

However, ever since the introduction of microcomputers into the market educators have been introducing them into the educational process with widening scope and varying degrees of enthusiasm. In mechanical engineering education, these microcomputers have been used successfully in engineering computations, in computer-aided instruction, and in engineering graphics among other applications. Educators have also used these tools as word processors in preparing quizzes and handouts, as grade books, in recording class attendance, and as notebooks for gathering information. Students used these machines to develop the assigned programs for their courses and as word processors to write their lab and other reports.

In the area of engineering graphics, the microcomputer has been used in three distinctive applications: in preparing workshop-ready engineering drawings of machine parts (3,4), in preparing schematic diagrams for illustrative purposes, and in presenting data graphically using bar charts, pie charts and curves of functional relationships.

With the exception of engineering drawings, our experience shows that all other forms of engineering graphics could be incorporated at an introductory level in less than four credit hours of course work in a mechanical engineering curriculum.

The first wave of microcomputer based software focused on word processors and spreadsheets. The second wave included a number of topical application programs. One of these topics is microcomputer based graphics. These programs are usually menu driven: they operate interactively with the user selecting an option and entering data from the keyboard or importing such data from a data file.

Although these general purpose ready programs are useful in engineering applications we believe that the educational objectives will be served better by requiring the students to write graphics programs of their own. Such an experience helps students, among other benefits, understand the inner workings of commercial programs and teaches them the fundamentals of developing their own perhaps specialty programs.

This paper includes illustrations of the work of students in engineering graphics through programs they wrote and through the use of commercially available general purpose programs. The programs students developed were part of a junior level microcomputers applications core course. The ready programs used by the students were covered in a small segment of a laboratory required course.

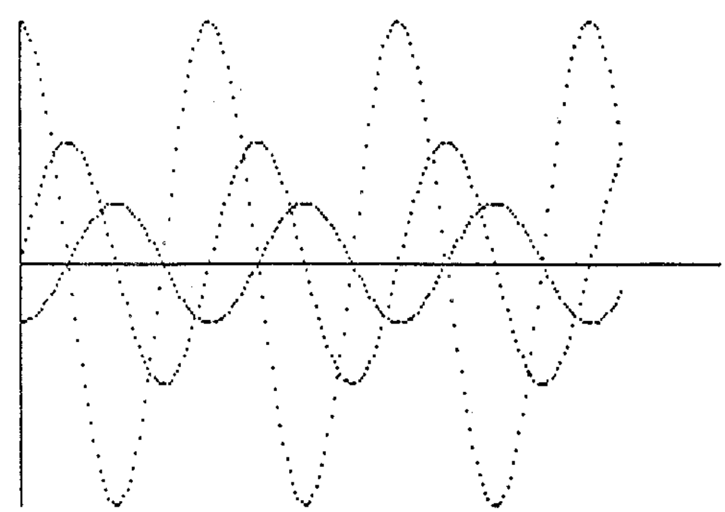

Figure 1

Programming

In a microcomputer applications course given to the juniors, students have been taught, in about one third of the course, programming techniques and structured applications programs. The rest of the course has been focusing on writing applications programs which have included engineering computational techniques, information bases, and engineering graphics.

When the course was first taught in Fall 1983, Apple IIe microcomputers were used and the programming language was Applesoft BASIC. This programming language supports low resolution and high resolution graphics. The terms low and high resolution graphics are relative. There is no standard which is used by all microcomputer manufacturers.

Figure 1 displays the displacement, velocity and acceleration of an undamped mass. This was produced on the screen by running an Applesoft BASIC program. Writing text on the graphics of this version of BASIC is not easy. If text is desired as is the case in most engineering applications, one should resort to using one of a number of approaches:

There are two main programming methods to include test on a graphics screen: bit pattern text and shape table text (5). Both methods are cumbersome and time consuming. However, routines are available that could be included in programs. Instead, some students developed their own text characters by writing subroutines to generate all the characters of the alphabet by using high resolution graphics commands. The text in Figure 2 is generated by such designs.

On the other hand, IBM BASIC supports two modes of graphics: a medium resolution graphics mode and a high resolution mode. Again, this designation of resolution is applicable to IBM BASIC only. Figures 3, and 4, are produced by medium resolution graphics. One outstanding advantage of this version of BASIC over the other is its handling of text in the graphics mode. In writing text on the screen, using IBM BASIC 3.0, there is no difference between the text mode and the graphics mode. Thus the cursor may be moved to any position. It must be noted however that in medium resolution graphics a row for text is equivalent to eight rows

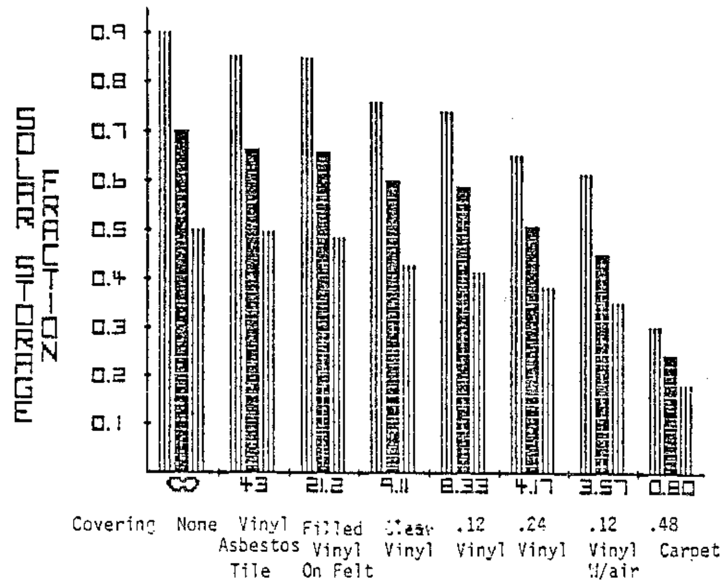

Figure 2

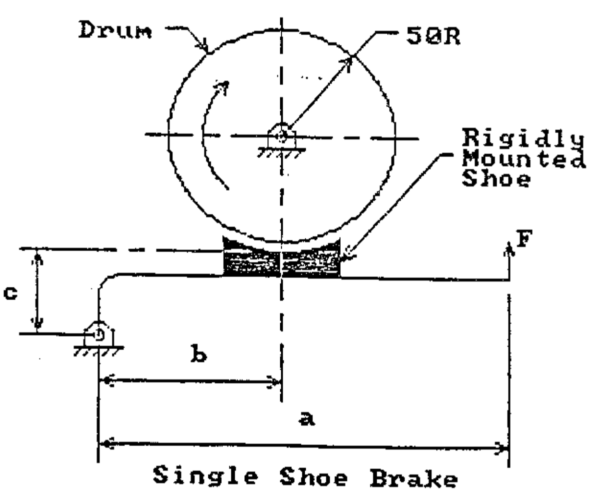

Figure 3

in graphics and a column is equivalent to eight columns.

Moreover, in using Applesoft BASIC we had to save the graphics screen on diskette using a BSAVE command; then by using a graphics dump program we were able to produce a hard copy of the graphics screen. In using IBM BASIC, however, by proper initiation of the operating system one can dump the graphics screen directly onto a printer. Figures 3, and 4 were produced by this procedure.

Ready Programs

There are a number of microcomputer-based commercial programs and software packages that could be used in engineering education. These can be grouped into four categories.

1) There are programs which could be used to produce schematic diagrams and illustrations. These programs have, in general, ten to twenty commands, which are easy to learn and use. The graphics of Figures 5 and 6 were produced by such programs. Figure 5 was produced using a digitizer as the input device; Figure 6 was produced using a joy stick.

2) There are programs with several tens of commands and a wide range of capabilities. These are generically called computer-aided drafting software packages. Some of these programs will be introduced into our curriculum starting the Spring semester of 1987 as part of a computer-aided design course. The basic result of such programs is an engineering workshop drawing of a desired product. But they can also be used in preparing graphics for other applications.

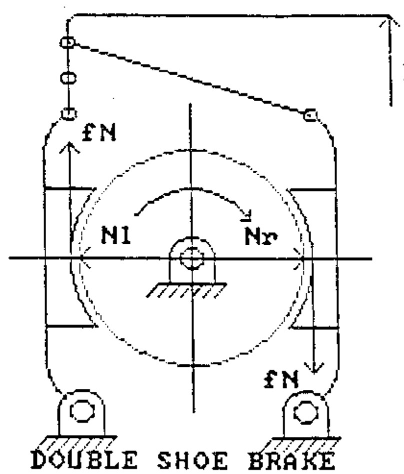

Figure 4

3) There are programs which combine drafting and design capabilities. These are generally called computer-aided design packages. The current design capabilities of these programs are very limited. Moreover, the design and analysis part of the computer-aided design programs come as separate packages that interface with some of the drafting packages. More development in this area is desired.

4) There are programs which in effect simulate work-sheets; the so called electronic spreadsheet software packages. These are well known in the commercial software market.

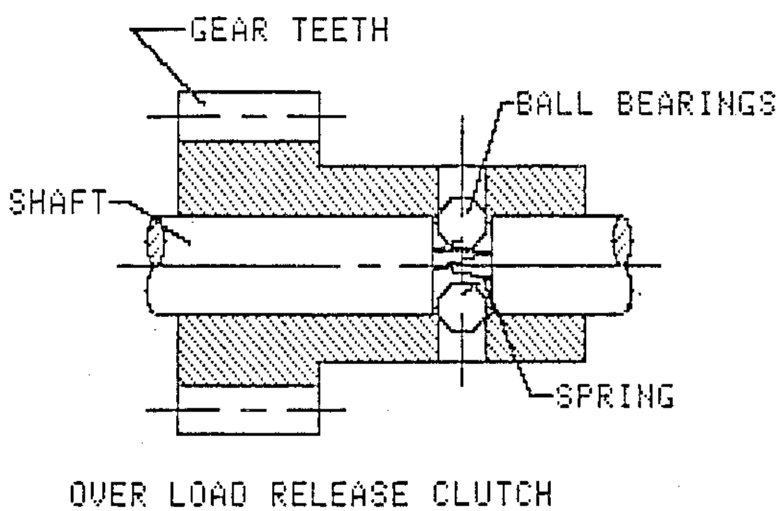

Figure 5

The current generation of these programs include several advanced features. Some of them incorporate analysis of linear algebraic systems which are widely used in optimization of processes in engineering and other professions. The incorporation of graphics capabilities into these packages is very common now. The graphics of Figure 7 is produced by two programs. The first program includes a spreadsheet which was used to analyze the data; the second program imported the results of analysis from the spreadsheet and displayed them on the screen as graphs.

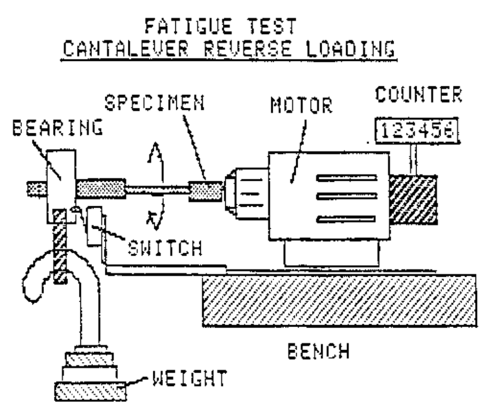

Figure 7

In presenting the ready programs in the above categories no attempt was made to enumerate all the capabilities of the software packages that could be used in engineering and other application. Only points of significance to the subject of the paper are underscored.

Ready programs of the first and fourth categories were first used in our curriculum in the Spring semester of 1986. The applications of such programs were taught in a time equivalent to about 2/7 of a credit hour. Presentation, discussion, and illustration of a software package took about half of the time; then the students used the remainder of the time to produce useful applications.

Concluding Remarks

The availability of microcomputers with their ever increasing capabilities at affordable prices has given educators an opportunity and a challenge. The opportunity lies in equipping our graduates with computer handling capabilities that could make the difference between successful and mediocre professionals. The challenge lies in how to incorporate the use of these tools in the ever crowded curricula and in how to teach the application of these tools without harming the basic pedagogical principles.

In taking the latter challenge we have been trying to stress fundamentals, approaches, and commonalities among various hardware and software versions and products. But there is still a lot to be done in this area to assure a broad educational scope rather than the narrow training track in the instructional process.

In meeting the crowded curricula challenge we teach a core course in microcomputer applications to our juniors. This course is mainly on advanced programming techniques, program structure, and engineering applications. We teach commercial software applications as a small part of general mechanical engineering laboratory courses. The use of drafting programs will be taught for the first time in our curriculum in the Spring of 1987 as part of a general elective course on microcomputer based computer-aided design. At a later state analysis at an introductory level using some supporting programs will be added to the course. In addition, faculty members have been making part of the homework they assign computer dependent problems.

The students acceptance of the new addition to the curriculum has been taken with increasing levels of approval. When we started the microcomputer applications course in the Fall of 1983, the students were dismayed by the large amount of work and the time they had to put into a three credit hours course. After three years, the course contents and homework requirements have stabilized to the desired level of challenge and time requirement.

Acknowledgement

The graphics presented in this paper were parts of assignments given to students of the MET 315 course during the period from Fall 1984 through Fall 1986, and MET 303 course in the Spring semester of 1986. These students deserve my appreciation and gratitude for their invaluable contribution to the development of these courses.

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CONCLUSION

In conclusion, as you approach problems, do not be afraid to try new things. The best solution might be something you have never tried before. Do not fall in love with your ideas. Ideas are meant to be altered, improved, revised, and sometimes thrown away. Be an idea hunter and do something different to get out of the same old routine. Realize that there is not one right answer. And above all, don't ever say that you are not creative!

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* The package now displays a list of rotational transformations which can be performed on the object for the purpose of changing its orientation.

```
ROTATIONS:

1. About X-axis
2. About Y-axis
3. About Z-axis
4. Continue

CHOOSE ONE
```

* After a selection is made, the angle of rotation is entered:

```
BY HOW MANY DEGREES?

COUNTER-CLOCKWISE?
```

The selection of any particular transformation and angle of rotation leads to the drawing of the object in its new evolved configuration, with hidden lines removed. An understanding of rotation about the X, Y, and Z axes is provided by this transformation technique (Figure 2).

* Further, to better conceive the shape of the object, a list of viewpoints is displayed so that the user can view the object from different vantage points.

```
CHOOSE A DIFFERENT
VIEW POINT:

1.(23.0,24.0,24.0)

2.(25.0,23.0,23.0)

3.(-23.0,24.0,22.0)

4.CONTINUE
```

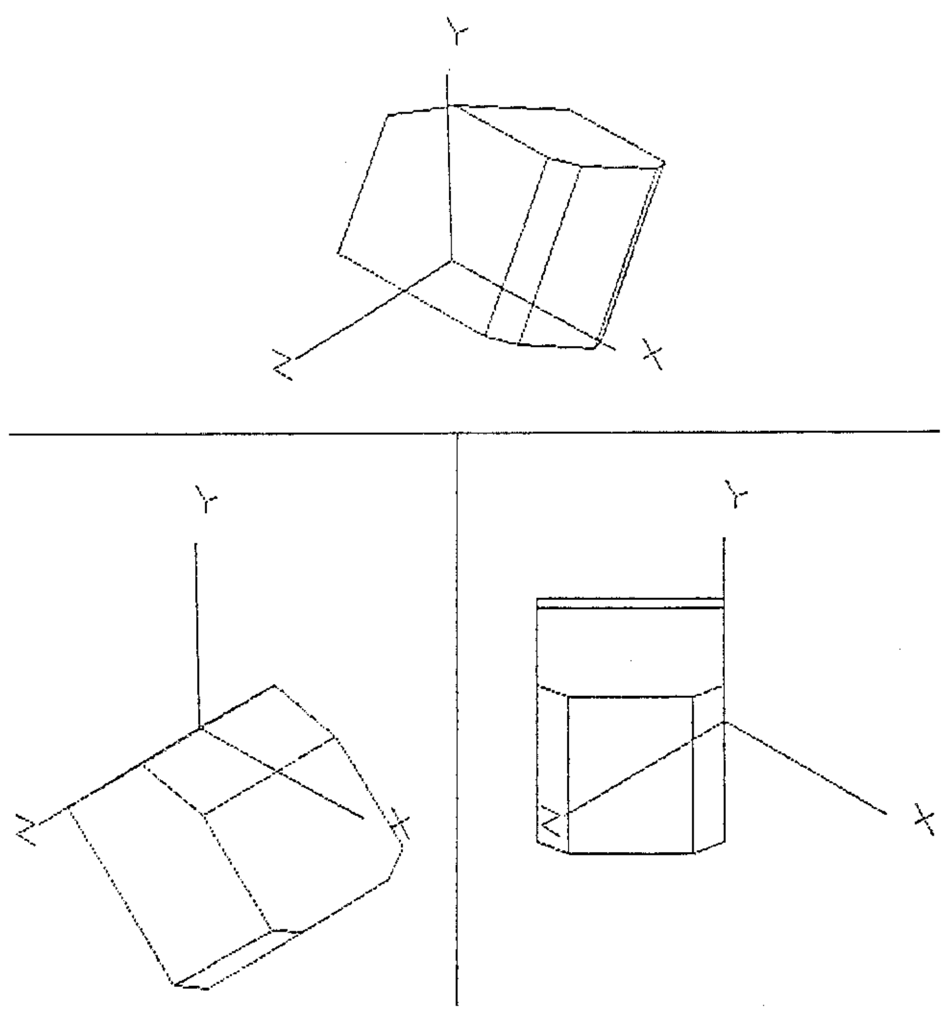

Figure 2

When the viewpoint is selected, the object is drawn again as seen from that direction, with hidden lines removed (Figure 3). The choice of rotational transformations and/or viewpoints can be repeated until the user becomes familiar with these concepts.

* Orthographic projections are next displayed on the screen, with a pictorial of the object kept in the upper-right hand corner (Figure 4).

Practice Exercises

To reinforce the concepts learned in the demonstration package described above, another user-friendly program was developed. Its general outline is almost the same as the one used in the demonstration program; however, it incorporates provisions to feed the data of any object chosen by the user. This data is stored in a file which is accessed by the main program at the start of the execution.

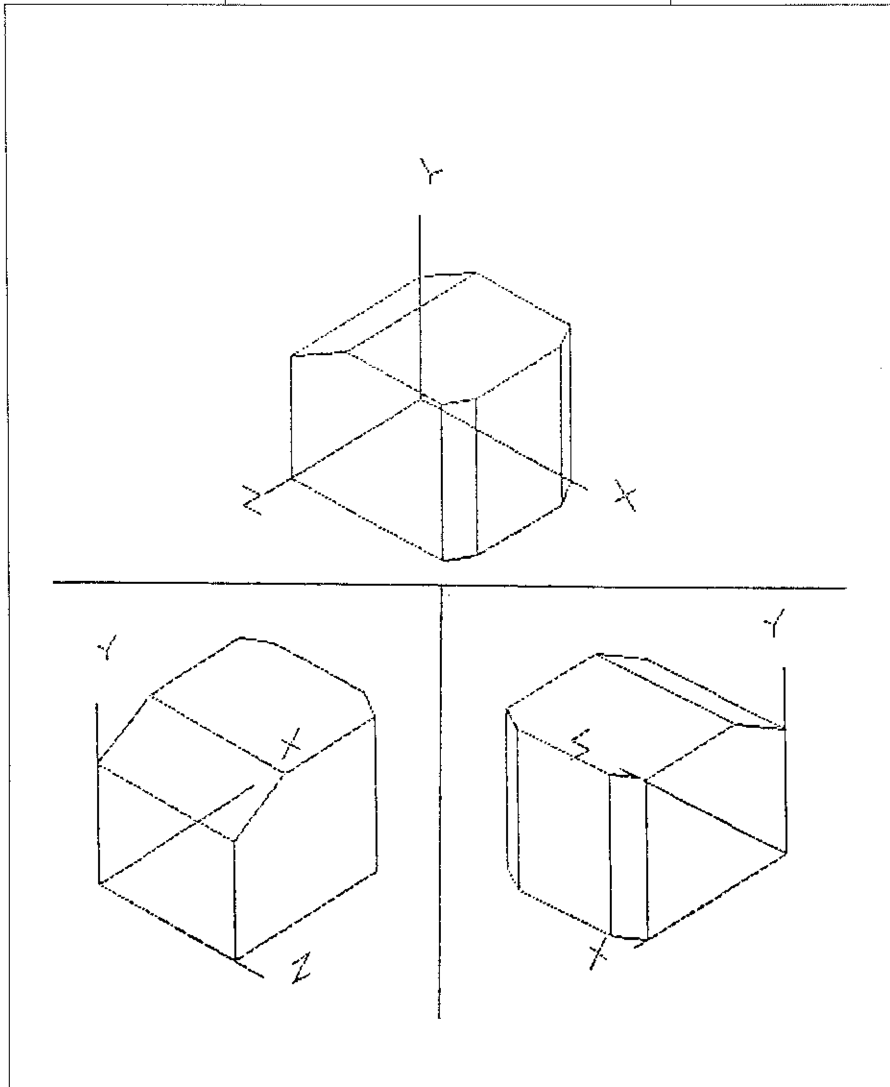

Figure 3

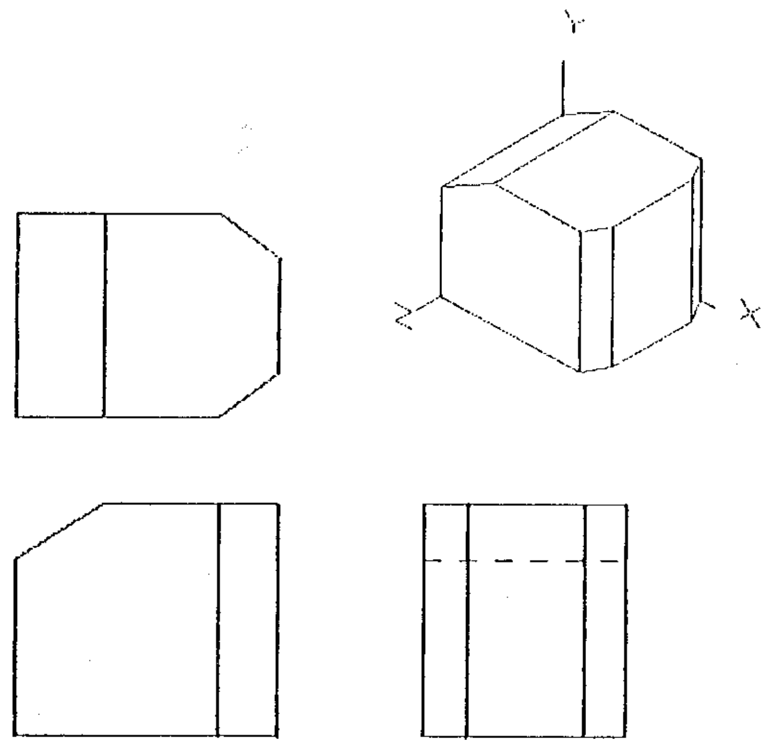

Figure 4

CODE DEVELOPMENT

The source code for the programs outlined above was written in FORTRAN, and made use of the FORTRAN-callable subroutines available in DI-3000. The data for object description is stored in a separate file accessed by the main program, and is formed by an array describing the vertex coordinates, and a surface connectivity array. For example, for the object called "wedge" (Figure 5), the data is stored as follows:

Vertex Coordinates		Surface Connectivity	
V1	0.,0.,4.	S1	1 4 3 2
V2	6.,0.,4.	S2	3 4 5 3
V3	6.,0.,0.	S3	1 6 5 4
V4	0.,0.,0.	S4	1 2 6 1
V5	0.,4.,0.	S5	2 3 5 6
V6	0.,4.,4.		

For this particular object, the main program reads the data with the statements:

```
READ (1,*),((NSURF(I,J),J=1,4),I=1,5

READ (1,*),((CN(II,JJ),JJ=1,3),II=1,6
```

A hidden line detection algorithm that uses the dot product-surface normal vector method was developed for this package. All the information required for this algorithm is extracted from the topological and geometric data base of the object.

The hidden line removal routine calculates the normal vector of all the surfaces in the object, then determines the dot product of this vector with the vector established between a point on the surface and the viewing point. For the case of convex objects, a surface is hidden, i.e., is facing away from the viewer, if the dot product is negative. The surface is viewed as an edge if the dot product is zero. As the user changes the orientation of the object and/or the viewing direction, the hidden line routine is accessed and calculations are performed for the new conditions.

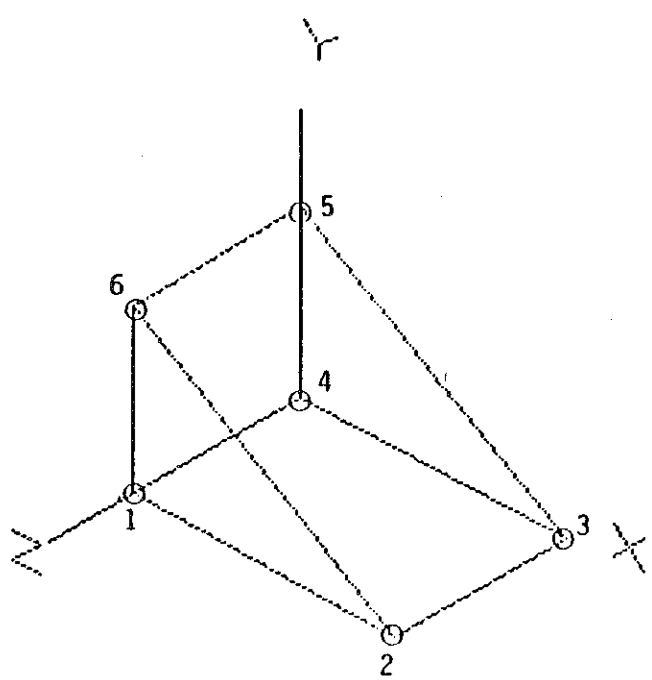

Figure 5

SOFTWARE UTILIZATION

At Clemson University this software is being used in the introductory graphics courses as a means to improve spatial visualization skills of engineering students. By rotating an object, or by viewing it from different points, the student's understanding of pictorials, orthographic projections, and auxiliary views is improved. In addition, the concept of 3-D space is better understood. Since the software is totally interactive no previous knowledge of computer graphics programming is necessary.

The lab facility used to run the visualization exercises consists of sixteen 4107-CX Tektronix color terminals, connected to a VAX host by direct lines, sixteen graphics tablets, and two ink-jet printer-plotters. Figure 6 shows one of these workstations. The routines needed to set-up the system and initialize DI3000 have been put in a batch file, which is easily accessed by the students.

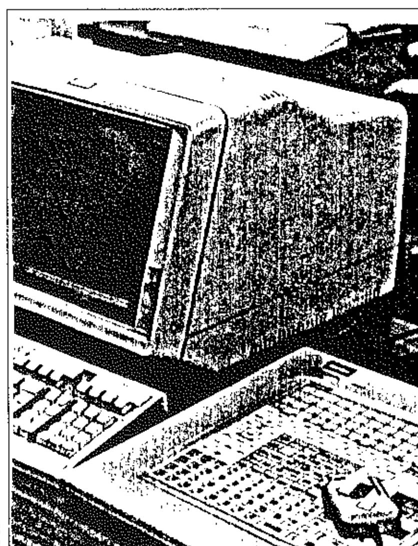
Figure 6

An Intelligent Graphics System

The AIM project is currently at the point of integrating training graphics into the automated authoring and documentation formatting process. This, of course, presents a completely different set of problems than does text. However, the current approach is an extension of the *troff* text formatting approach (Figure 5). Sun bit map graphic files are created from SolarPaint raster files by creating a "filter". This works, sort of. If the author is not at a graphics station, like the Sun, a preview of the text and image cannot be seen, necessitating printing at least one copy to check alignment. A long-term solution to the problem lies in a graphical rather than textual approach. The future graphics requirements of the AIM project should include 1) identifying the graphic need, 2) identifying whether or not the image exists within the Navy system, 3) creating the graphics if necessary, and 4) bringing the graphics and instructional text together in an IG or TG.

Identifying the Graphic Need. This is where an obvious parallel exists with the subject matter matrix used at GLNTC. The subject matter matrix is divided into the major areas of *system, program, and component*, a breakdown that fits a graphic matrix very well. The first level of the expert graphic system would then lead the author through an exhaustive series of questions concerning subject matter, target population, delivery technology, and expected outcomes (Figure 6). At the end of this session the computer would (theoretically) have the same information about the graphic image as would an expert on the subject.

Identifying If the Image Exists Within the Navy System. If a graphic image that satisfies the criteria established by the graphic matrix exists, it should be used. It is estimated that at least 25% of the graphics produced for training already exists somewhere within the Navy system and this by itself, provides strong justification for a central data base of training images. How to build an intelligent graphic data base is a problem that can be solved using existing relational theory. Of greater import is the interface: how the author will interact with the data base to peruse images and select, edit, and place the graphic in the IG or TG.

Creating the Image If One Does Not Exist. Several methods exist for creating new images. The most rapid is to scan an existing graphic and either edit the image as a bit map or complete a raster to vector conversion and edit the image in a vector graphics environment such as at a traditional CADD workstation.

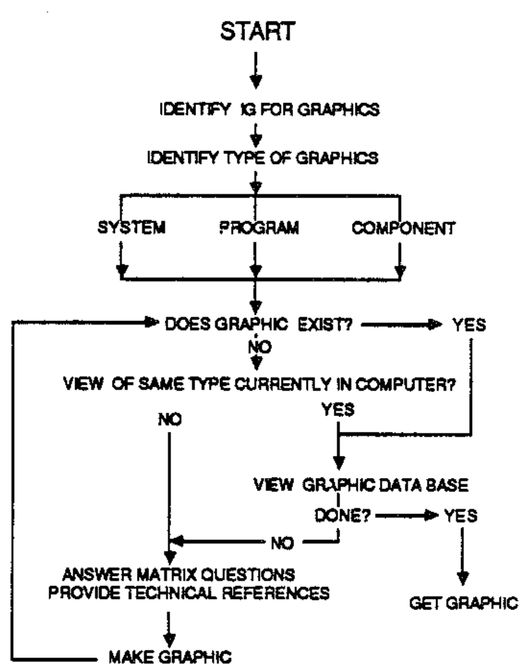

Figure 6

The raster to vector process is expensive and often incomplete. Furthermore, phototypesetters accept raster files or page description language instructions (Postscript, Impress, Scribe, etc.) for printing, so vector to raster conversion must be done before sending graphics to a printer. It is a very interrelated process. It would appear that the best solution would be one where bit-mapped images could be combined with vector (object) CADD drawings and together sent as a raster file to the printer.

Bringing the Graphics and Text Together In an IG or TG. The problem of composition still exists. It is the goal of the AIM project to remove individual differences from training documents, to make creation and production bulletproof. At this time, all existing composition tools require at least some artistic sensibilities and discretion. Previewing the page in a What You See Is What You Get mode is a desirable feature of the eventual configuration, necessitating low-cost bit mapped graphic workstations. Because Navy authors are not graphic artists, commercial technical tools such as Interleaf's TPS® system are felt to have too many drawbacks, though with adequate operator training are capable of producing adequate results.

The Future of the Aim Project

The AIM project has several demonstration locations, each implementing various levels of an expert authoring system. The graphic component still remains unsolved and waits for several political problems to be solved within the Navy. There will remain ground rules around which it would appear that any future solution must operate:

- any text workstation must be able to support the subject matter matrix
- any text application must minimize intuitive format decisions
- any graphics workstation must operate in a UNIX environment
- any graphic file must eventually be a raster file sent to a printer

Conclusion

The continuing training documentation problem in the Navy is massive. The service has been directed to reduce manpower and at the same time reduce shore time. This means that on-shore training must be more efficient and that training must be *transportable* to shipboard instruction. Political pressures within the Navy may make it impossible to design and implement an ideal expert authoring and graphics system, resulting in a fragmented solution. The near-term future suggests that:

- Text will continue to be formatted rather than composed until more sophisticated UNIX text tools are available.
- Graphics and text will be brought together as separate files, quite possibly in the traditional method of manual paste-up.
- Until the design of the graphic matrix with its related intelligent data base and user interface is completed, complete text-graphics integration will be impossible.

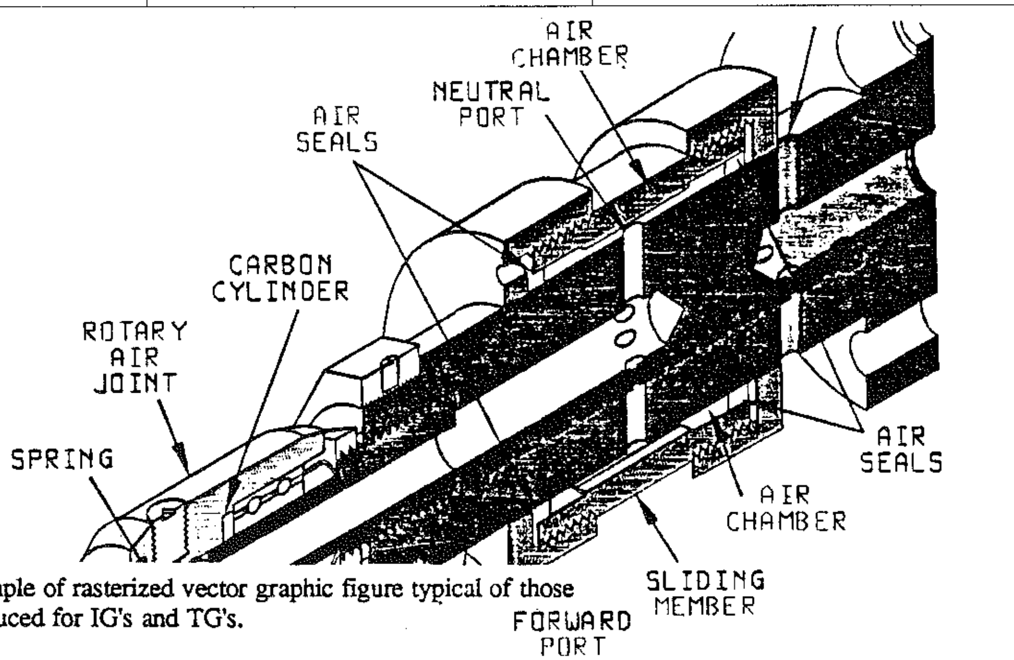

Figure 7—Example of rasterized vector graphic figure typical of those produced for IG's and TG's.

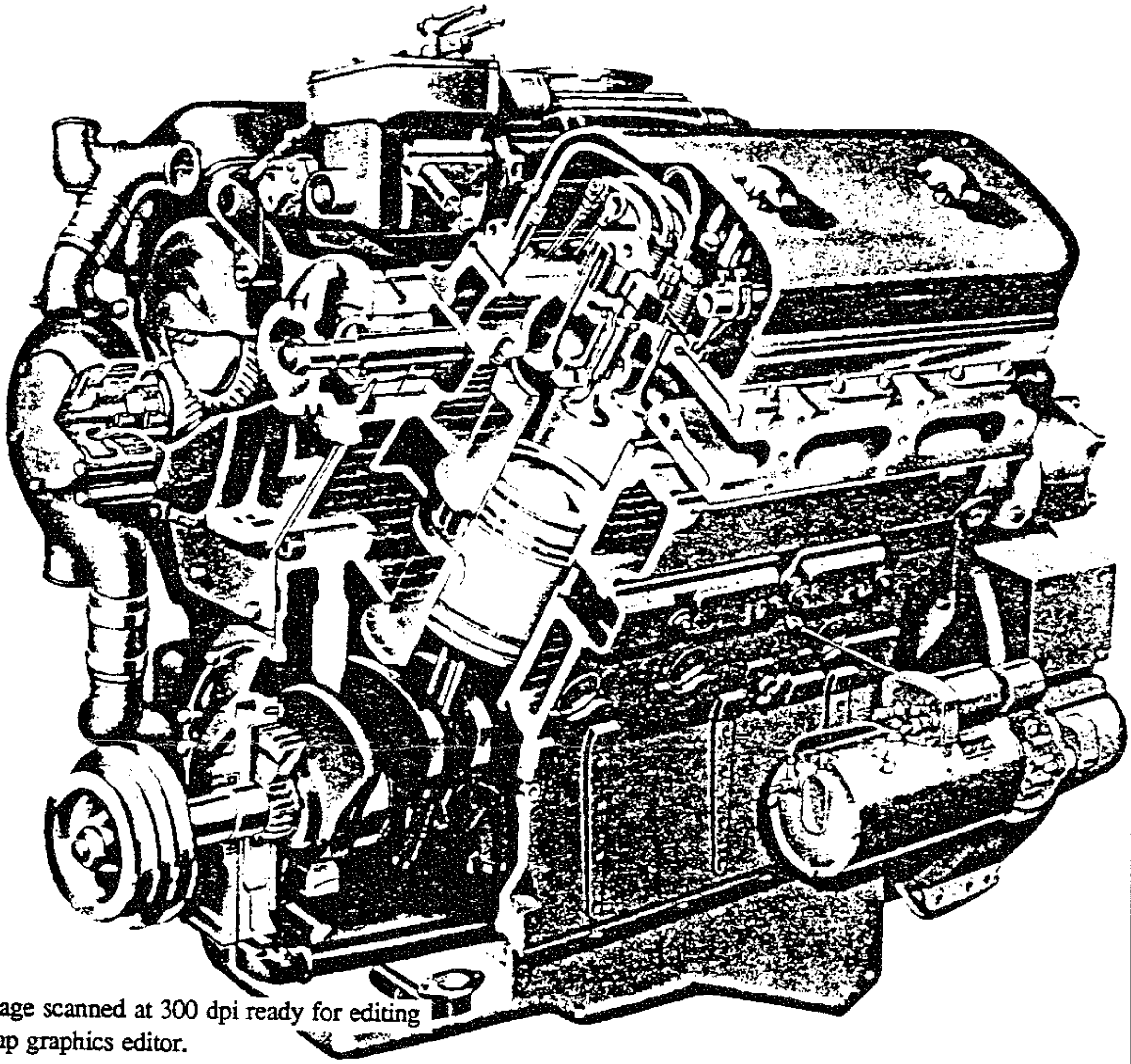

Figure 8—Image scanned at 300 dpi ready for editing using a bit map graphics editor.

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EDGJ Asks Readers to Sound Off

reader survey to help chart future

Why a reader survey? Too often we work in a vacuum. Under the pressure of deadlines we often ignore the obvious and deny the inevitable. Plus, everyone's got good ideas; only occasionally do we get a forum to express them. Here is your chance.

On the next page is a survey for you to consider. As you have probably seen, there have been considerable changes in The Journal over the past several years. Changes in review procedures have brought papers under a set of increasingly stringent criteria. The Journal now only accepts for publication 32% of the papers entered into review. The Editor has taken a more vocal stance on sometimes controversial matters and the Chair of the Division now regularly contributes a message. There also has been a change in production techniques—not without growing pains of its own. All of these have signaled in this, the longest-standing ASEE publication, change and hopefully, growth.

Not only is the subject matter of graphics constantly changing, our role as graphics educators and professionals is evolving into something quite different from the previous norm—even as recently as ten years ago—and certainly unlike that of the era of T.E. French, et al. Yet, are not many of our departments structured and operated with 1940's methods, procedures and grading systems? These are some of the things the survey asks you to consider.

The EDGJ has fullfilled a vital role in graphics education since day one, and will continue to do so...with your help. A reader surver is an excellent way for you to sound off about the way you feel The Journal should work for you, the Division, and our Society. Many of the questions have been left intentionally open-ended, to let you define the universe of possible questions and answers. Don't hesitate to ask your own questions.

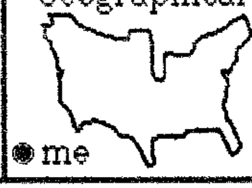
The small amount of demographic data requested will allow The Journal to predict trends and direction in our readership . Please include this information.

Take time to respond to the survey and remove the page of The Journal or photo copy it, keeping your response for the eventual comparison with what actually happens. Mail it at your earliest convenience. The results will be published in a future issue of The Journal. -ed

EDGJ 1987 Reader Survey

ASEE Member [y] [n]
EDGD Member [y] [n]
AGE ☐
Academic ☐ Industry ☐

Geographical



Published in EDGJ? [y] [n]
Teach at: Community College ☐
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Chairman's Message	High	Indifferent	Low

What are your feelings on the content of papers published in the EDGJ?

What topic or topics would you like to see more of? Less of? None at all?

If you were Journal Editor for a day what would you want to accomplish?

Do you have any ideas for other EDGD publications or projects?

Use additional sheets if necessary

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8. All articles shall be written using Metric-SI units. Common measurements will be accepted at the descretion of the editorial staff.

9. Send all material in one mailing to:

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REVIEW OF ARTICLES

All technical articles are submitted to the EDGJ Board of Review for blind review. This board represents national authority on graphic technology, engineering education, and technical specialties within engineering and technology. Authors will be notified as to the results of the review. Manuscripts may be accepted as submitted, accepted with provisions, or not accepted for publication.

The Journal reserves the right to refuse letters to the editor due to space constraints, because the material is potentially libelous, because the issues discussed are no longer of a timely nature, or because of a large number of similar letters on the same topic. Letters may be edited for spelling, punctuation, and style, and may be shortened or abstracted although meaning and tone will not be changed.

Circulation Manager
The Engineering Design Graphics Journal
The Ohio State University
2070 Neil Avenue Columbus, OH 43210
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