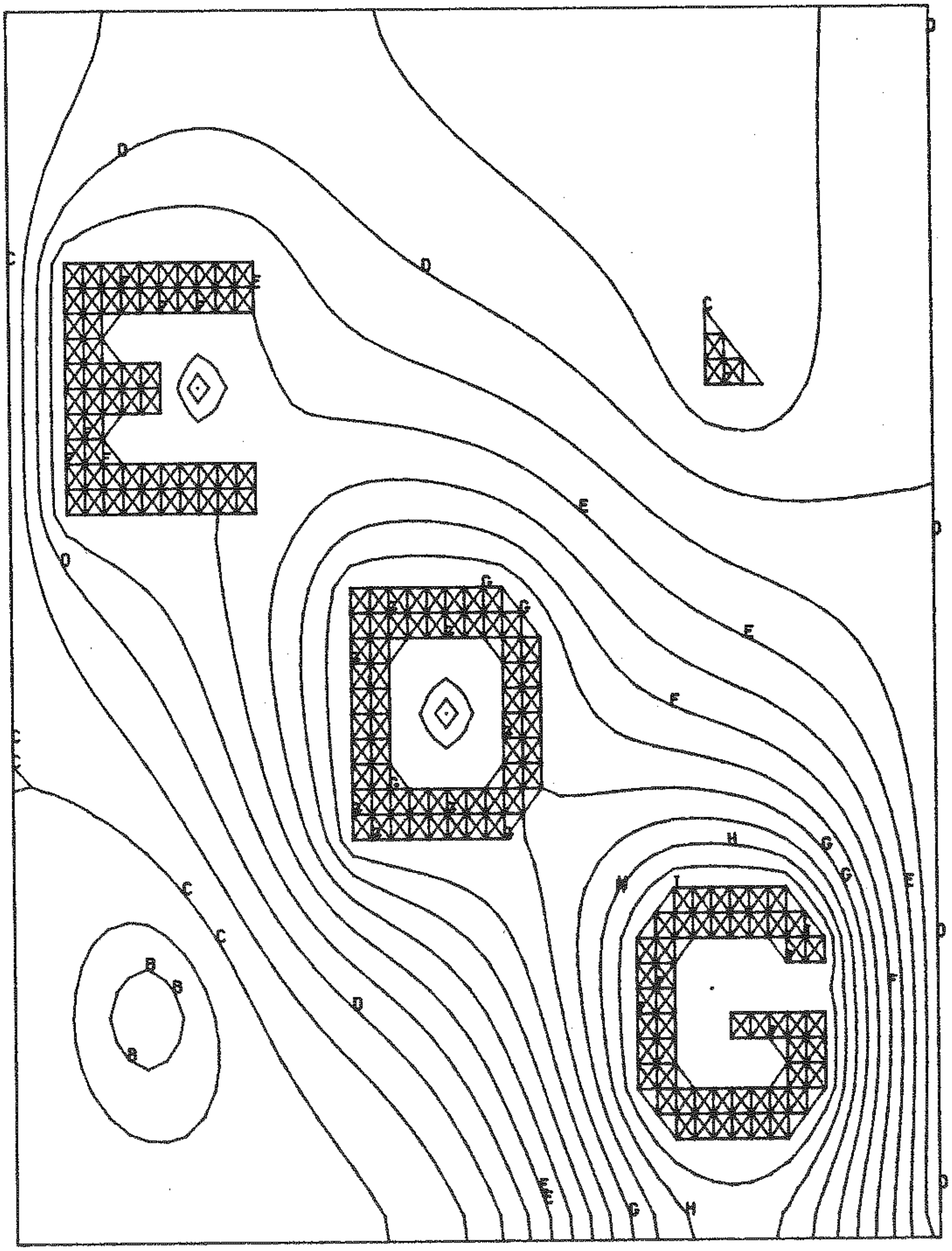
ENGINEERING DESIGN GRAPHICS JOURNAL

WINTER 1977, VOLUME 41, NUMBER 1, SERIES 122



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by **Milton L. Rogness,**
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Iowa State University

This workbook is a collection of 109 problems which are correlated with the textbook described above. The problems are designed to be thought provoking, logical, and practical. The alternate assignments permit added drill when necessary, and variation of assignments for different classes. In order to emphasize the practical value of the fundamentals, special effort was made to provide architecturally oriented problems.

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ENGINEERING DESIGN GRAPHICS JOURNAL

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 practioners of Engineering Graphics, Computer Graphics, and 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 ASEE. The editors make a reasonable effort to verify the technical content of the material published; however, final responsibility for the opinions and the technical accuracy of each article 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 practioners of Engineering Graphics, Computer Graphics and allied subjects.
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 quality of and modernize instruction and courses.
4. To encourage research, development, and refinement of theory and applications of engineering graphics for understanding and practice.

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 on the basis of the judgement of the editors.

DEADLINES FOR AUTHORS, COORDINATORS, AND ADVERTISERS

The following deadlines for the submission of articles, announcements, or advertising for the three issues of the JOURNAL:
Fall--October 1
Winter--December 1
Spring--February 1

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 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. Each page of the manuscript is to be consecutively numbered.

3. Two copies of each manuscript are required.

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Engineering Design Graphics Journal

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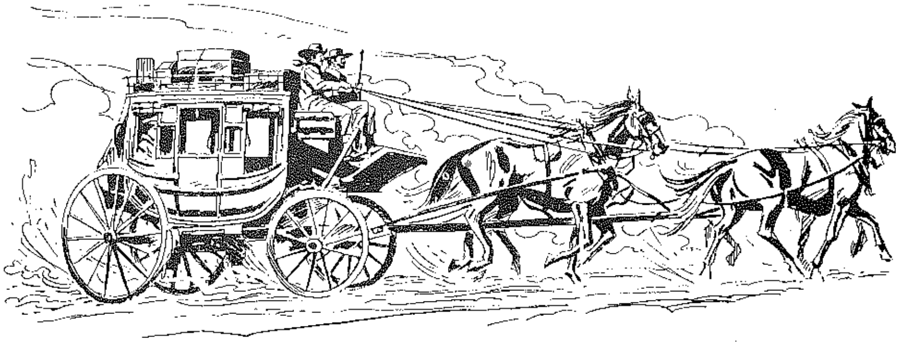

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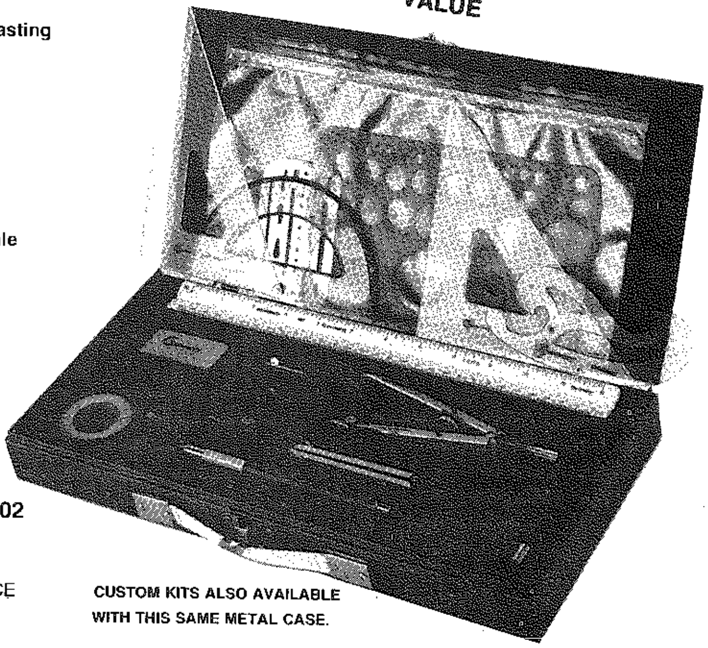

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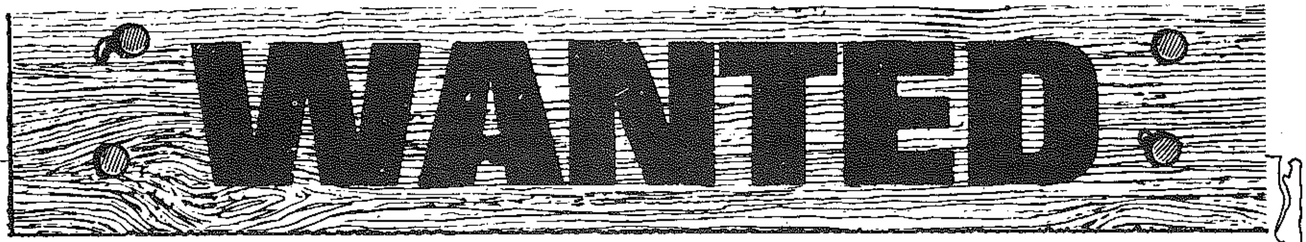

Put Earle and the gang on your most wanted list for complete coverage of Engineering Design Graphics.

ENGINEERING DESIGN GRAPHICS, THIRD EDITION

An updated version of Earle's well-known introductory text. Two-color illustrations guide the student through the design process from problem identification to design and analysis of the solution. Team dynamics, data gathering, human engineering, patents, technical reports, oral presentation, and final implementation are discussed. Major modifications to the third edition include revision of statistical figures on engineering professions, greater emphasis on preparation of working drawings, and the introduction of the metric system. English units are also used, leaving the choice to the instructor.

Contents: Introduction to Engineering and Technology. The Design Process. Problem Identification. Preliminary Ideas. Engineering Drawing Standards. Design Refinement. Fundamental Spatial Relationships. Primary Auxiliary Views. Successive Auxiliary Views. Revolution. Intersections. Developments. Design Analysis. Vector Analysis. Analysis of Design Data. Design Documentation. Pictorial Presentation. Decision and Presentation. Implementation. Design Problems.

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DESCRIPTIVE GEOMETRY, SECOND EDITION

Descriptive geometry is presented as a problem-solving tool and as a means of developing solutions to technical problems. Photos of products and equipment demonstrate various practical applications, and programed instruction techniques enable students to move at their own pace. The second edition uses both English and SI units throughout, providing a choice for the instructor, and a second color to highlight significant topics.

Contents: Introduction to Descriptive Geometry and Graphics. Application of Descriptive Geometry. Fundamental Spatial Relationships. Primary Auxiliary Views. Successive Auxiliary Views. Revolution. Intersections. Developments. Vectors. Analysis of Design Data. Appendices.

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This book covers all the necessary fundamentals for a first course in mechanical drawing. Practical applications, photographic examples, and a chapter showing the relationship of design to drafting contribute greatly to student interest and motivation. A unique and extremely useful feature of the text is a chapter on careers in engineering technology and drafting.

Contents: Introduction to Drawing. Technical Careers. Lettering. The Use of Instruments. Geometric Construction. The Design Process. Orthographic Projection. Orthographic Sketching. Pictorials. Auxiliary Views and Revolutions. Sections and Conventions. Fasteners. Dimensioning. Working Drawings. Cams, Gears, and Sprints. Graphs and Data Analysis. Intersections and Developments. Technical Illustration. Architectural Drafting. Introduction to Descriptive Geometry.

Price: $13.56

ENGINEERING DESIGN GRAPHICS PROBLEMS I

by James Earle, Samuel Cleland, Lawrence Stark, Paul Mason, North Bardell, and Timothy Coppinger

A design-oriented problems workbook filled with a variety of problems in both engineering graphics and descriptive geometry. Gets freshmen thinking and communicating in graphics. Features include: numerous photos keyed to appropriate problems, industrial examples to add realism to the problems, SI units incorporated throughout, and answers to all problems available in a solutions manual.

Contents: General. Lettering. Instruments. Scales. Geometric Construction. Orthographic Sketching. Pictorial Sketching. Orthographic Projection. Auxiliary Views. Sections and Conventions. Points, Lines, and Planes. True Length of Lines. Edge Views of Planes. Cut and Fill and Outcrop. Angles Between Lines and Planes. Skewed Lines. Angle Between Line and Plane. Revolution. Intersections and Developments. Vectors. Data Analysis. Empirical Equations. Nomograms. Graphical Calculus. Dimensioning. Threaded Fasteners. Working Drawings. Computer Graphics. Working Drawings.

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EDITOR'S PAGE

When the Fall issue was being assembled, Christmas seemed quite far away. Now it is apparent that this issue will not be in the mail until well after the holidays; still, it seems appropriate to extend the Season's Greetings and best wishes for the New Year from the Journal staff.

We regret that the Fall issue was so late in getting out. The W. C. Brown Company, who helps us so greatly in producing the Journal, had unavoidable production problems just as the Fall issue was received for printing. This problem made apparent to the staff, however, that our deadlines need some revising to distribute the issues over the academic year and prevent them from piling up on each other. This is one of the most important problems to be discussed at the Montreal Conference.

In the meantime, we want to re-encourage your participation in the Journal and the Division. Read it thoroughly and send your comments. Perhaps you will become interested enough to develop your own ideas, experiment, and write an article about your findings. If you want to become involved in the Division, you will find many requests for help in this and past issues, and an organization chart on page 14. If you would like to serve on a committee, make it known to its Chairperson.

I hope you will find this issue informative and enjoyable. May the New Year be a prosperous and happy one for all mankind.

Paul DeJong

ABOUT THE COVER

TAKING THE TEMPERATURE OF EDG

The isothermal map on the cover is a digitally-plotted output of a program written by Clair M. Hulley of the Engineering Analysis Department at the University of Cincinnati to map a 50 x 50 grid having any combination of insulated or constant temperature sides and a variety of different heat source and sink shapes.

On the cover, E is at 200°; D, 400°; G, 600°. The left side is at zero and the right side at 100°; the top and bottom sides are insulated. The circular sink in the lower left and triangular sink in the upper right are at -195°. The small sources within the letters EDG are at 350°, 500°, and 500° respectively. The contour interval is 50°.

Professor Hulley wrote all the software and program for the plot, and is the author of an article on computer contouring which will appear in the Spring issue of the Journal.

Chairman's Page

Clarence E. Hall
Louisiana State University

As educators, we must be accountable for much of what transpires within our institutions of learning, especially for that portion with which we are directly involved. This responsibility is inescapable, since the education community is one of the primary propagating agencies of our culture, especially that which is technical. Although industry is at the very center of the world of work providing the setting for most of the technological development and progress, we in engineering education have, through the years, assumed the role of evaluators and disseminators of such technical knowledge.

As teachers of mechanical drawing or engineering graphics, we must assume full responsibility for the academic posture and educational value attributed to descriptive geometry by other engineering educators and practicing engineers. Somehow we have failed to keep the discipline closely associated with kindred subjects such as calculus, differential equations, and vector analysis. As a result, its relative status has been diminished. In reality, the rigor of descriptive geometry is sufficient to challenge the keenest of minds, and there is a very positive correlation between one's ability to comprehand the projection of an object onto three mutally perpendicular spatial planes and one's potential success as a design engineer. Descriptive geometry is the cornerstone of the educational foundation on which creativity is developed, and creativity is that one outstanding attribute of the professional engineer that causes him to be recognized as a potential problem-solver of many of society's technical and environmental ills. The discipline serves a two-fold purpose in education: 1) it introduces the student to the science of graphical language of industry, and 2) it is a problem-solving tool for use in both education and industry.

Although design graphics has fared poorly during the past three decades, a glimmer of hope seems to be appearing on the horizon. Practicing engineers, through the National Society of Professional Engineers (N.S.P.E.), have indicated an interest in becoming involved in the activities of E.C.P.D. and the accreditation process. In a report to the N.S.P.E. Board of Governors pertaining to long-range strategy for N.S.P.E. involvement in E.C.P.D., it was stated that there is a need for a more practice-oriented, design-related program in engineering education. The tenor of the report was that if N.S.P.E. had been more active in the accreditation process of the past decade, many of the present undergraduate engineering degree programs would be more practice-oriented, and therefore more responsive to the needs of industry. The need for the practice-oriented program to function concurrently with the more theoretical curricula stems from the fact that only about 20% of engineering graduates follow research-oriented careers.

As members of the Engineering Design Graphics Division, we have for too many years listened to each other extol the values of design graphics while other educators in charge of degree programs continued to delete it from their courses of study. It seems that we now have a real opportunity to renew our efforts toward strengthening the role of this discipline in engineering education by working with engineers in practice who need and appreciate young engineers proficient in the use of design graphics.

We must shake off the old attitude of lethargy and accept this challenge. This can be done by an astute teacher well-versed in the disciplines of design graphics and knowledgeable of the historical development of descriptive geometry and its role in engineering education during these last 200 years. No other engineering discipline has enjoyed a more colorful history; and no other subject has had a more profound effect upon the technological economy of engineering.

* * *

Leading Introductory Texts

NEW EDITION

ENGINEERING: An Introduction To A Creative Profession, Third Edition

George C. Beakley, Arizona State University, and **H. W. Leach**, Consulting Engineer

The *third edition* of this leading introductory engineering text has been thoroughly revised and updated to include the most current information available on various branches of engineering, methods of problem-solving, and types of design problems encountered by today's professional.

While the text continues to offer a large number of problems in English units, this edition pays particular attention to S.I. units and the process of conversion. Over 1500 problems of varying levels of difficulty are provided for student solution, approximately half in S.I. units and half in English units. These problems encompass a large number of engineering situations and are designed to develop the student's decision-making abilities.

The problem-solving method introduced so successfully in earlier editions has been expanded to include many of the creative phases of engineering and every effort is made to motivate the student to think imaginatively and realistically.

Some of the important new features of the third edition include:

- a completely new chapter; *The Modeling of Engineering Systems—Mechanical, Electrical, Fluid, and Thermal*
- a revised and expanded examination of the technological team with emphasis on the roles of the technologist in modern industry
- a new chapter with 100's of problems on *Using Hand Calculators*
- updated information on career fields, including new material on bioengineering, ceramic engineering, mining and geological engineering, naval architecture, and marine engineering.

The text is abundantly illustrated with drawings and photographs, the majority of which are new to this edition. An *Instructor's Manual* containing answers and solutions to quantitative problems accompanies the text, *gratis.*

1977 608 pages (approx.)

CONTENTS

Part One: Engineering—The Profession In Review
1. Historical Perspectives of a Developing Profession
2. Serving The Needs of a Constantly Changing Society
3. The Technological Team
4. The Spectrum of Engineering Work Opportunities
5. Career Fields in Engineering

Part Two: Preparation For A Career In Engineering
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NEW EDITION

DESCRIPTIVE GEOMETRY, Fifth Edition

Eugene G. Paré, Washington State University, Pullman; **Robert O. Loving** *and* **Ivan L. Hill**, both, Illinois Institute of Technology

The revised *fifth edition* of this leading text presents all of the fundamental principles of descriptive geometry including orthographic projection, auxiliary views, lines and planes, intersections, parallelism and perpendicularity, concurrent vectors, developments, pictorial shades and shadows, and pictorial intersections, perspective, conics, map projection, and spherical triangles. Each topic is carefully developed, often with step-by-step procedures and numerous illustrations to aid the student in visualizing complex shapes from various views. Textual material is divided into relatively short, homogeneous chapters and arranged in a logical order.

These significant changes are featured in the Fifth Edition:

- the text is now *entirely metric*
- 60% of the text's over 500 illustrations have been revised to simplify drafting procedures or utilize metric units — 15 new illustrations have been added
- innovative new material on pictorial intersections and pictorial shades and shadows is included
- a simplified notation system is utilized

As in past editions, many of the illustrations throughout the text are broken into steps in order to make the construction easy to follow. Wherever possible, solutions are provided in pictorial form to aid visualization. Emphasis is focused on those applications that serve to illuminate fundamentals and introduce new engineering experiences.

Problems for student solution and self-testing problems follow each chapter. Self-testing problems provide students with an excellent means of systematically evaluating their comprehension of fundamentals. Carefully delineated solutions to self-testing problems are given in the Appendix.

1977 400 pages (approx.)

To accompany the text:

DESCRIPTIVE GEOMETRY WORKSHEETS, Series A, Fourth Edition, and Series B, Third Edition

Eugene G. Paré, Washington State University, Pullman; **Robert O. Loving** and **Ivan L. Hill**, both, Illinois Institute of Technology

These comprehensive workbooks are designed to accompany *Descriptive Geometry*, Fifth Edition, (by the same authors), or any standard textbook featuring the direct method. Each worksheet contains from one to six problems with sufficient material for one laboratory period.

Now in a revised edition, *Series A* contains 71 sheets and a total of 174 problems, 50 of which are new to this edition. All dimensional problem sheets have been converted to S.I. metric units and approximately one-third of the worksheets have been revised to simplify graphical notation. *Series B* contains 76 sheets and approximately 194 problems.

Both workbooks introduce new topics with theoretical problems. Practical problems involving actual engineering situations follow. The wide range of topics covered is made possible in part by the large number of printed layouts. Because each workbook offers a completely different set of problems, they may be used together to provide flexibility and variety.

NEW—Series A (Fourth Edition) 1977 71 Sheets
Series B (Third Edition) 1973 76 Sheets

TECHNICAL DRAWING, Sixth Edition

the late **Frederick E. Giesecke**, the late **Alva Mitchell**,
the late **Henry Cecil Spencer**, and **Ivan Leroy Hill**,
Illinois Institute of Technology

The *sixth edition* of this renowned book retains those features that have made previous editions so successful while incorporating changes necessary to bring it completely up-to-date with the latest trends in engineering education and the newest developments in industry.

Drawing on their long experience, the authors have included all the fundamentals of the field needed by scientists and engineers. Current educational emphasis on the design function is reflected throughout the text, most clearly in the chapter on design and working drawings. Much new material is integrated to give the student a better understanding of fundamentals of the design process. Other significant changes in this edition include: a new two-column layout; addition of a second color; use of the most recent American National Standards (including ANSI-Y14); and the addition of many new illustrations and problems.

1974 867 pages

And, to help your students get the most out of *Technical Drawing:*

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Third Edition 1974
TECHNICAL DRAWING PROBLEMS, Series 3,
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ENGINEERING GRAPHICS, Second Edition

the late **Frederick E. Giesecke**, the late **Alva Mitchell**,
the late **Henry Cecil Spencer**; **Ivan Leroy Hill**, and
Robert Olin Loving, both, Illinois Institute of Technology

The *second edition* of this leading text has been completely revised and updated to incorporate the latest trends in engineering education and newest developments in industry. The text is organized in a logical sequence of chapters dealing with design concepts and the graphic language through fundamentals of projection and representation, design applications, fundamentals of descriptive geometry, and an extensive coverage of graphical computations. The *second edition* places emphasis on the design function of the engineer, with new information on the design process added to the chapters on design and working drawings. Chapters on descriptive geometry have been expanded with additional figures and revised text matter. Many problems and illustrations have been updated, many of the illustrations have been converted to decimal-inch dimensions and metric equivalent tables are included.

1975 879 pages

An excellent complement to the text:

ENGINEERING GRAPHICS PROBLEMS,
Series 1, Second Edition 1975

A *Solutions Manual* is available, *gratis.*

FUNDAMENTALS OF ENGINEERING GRAPHICS

Joseph B. Dent, W. George Devens, Edward A. Bender,
Frank F. Marvin, and **Harold F. Trent,** all, Virginia
Polytechnic Institute and State University

Suitable for a one- or two-term introductory course, this textbook-workbook leads the beginning student from lettering, sketching, and pictorial drawing through use of instruments, scales (including metric), and geometric construction. Next, the authors present orthographic projection and auxiliary views in a straight-forward, integrated manner. The progression from points to lines, then planes and solids, provides the student with a "building block" approach to descriptive geometry or applied spatial relationships.

Vectors, intersections, developments, technical practices, working drawings, graphs, and graphical calculus complete the text portion.

Practical application of principles is emphasized in the 109 printed problems following the text. Problem sheets are arranged sequentially with the text material to permit variety in scheduling laboratory and homework assignments.

An *Instructor's Manual* is available, *gratis.*

1974 400 pages

INTRODUCTION TO ENGINEERING DESIGN AND GRAPHICS

George C. Beakley, and **Michael J. Nielsen,** both, Arizona State University; and **Ernest G. Chilton,** Stanford University

This exciting introductory text combines design and graphics in a modern, meaningful way, reflecting the current approach to teaching graphic skills. The use of models, materials and processes of design, decision processes, economic considerations, and design parameters for human satisfaction are explored in depth. Each chapter forms a separate "mini-text" complete with instructional material, bibliography, and problems, giving students in-depth coverage. Eight appendices offer a wealth of useful tables, graphs, and data. This is the only book that gives students an opportunity to learn the fundamentals of engineering design. A complete *Instructor's Manual* is available on adoption.

1973

Two excellent workbooks particularly coordinated with INTRODUCTION TO ENGINEERING DESIGN AND GRAPHICS are:

GRAPHICS FOR DESIGN AND VISUALIZATION, PROBLEMS, Series A,
George C. Beakley, Donald D. Autore, and **John B. Hawley,**
all, Arizona State University
1973

GRAPHICS FOR DESIGN AND VISUALIZATION, PROBLEMS, Series B,
George C. Beakley and **Donald D. Autore,** both, Arizona State University
1975

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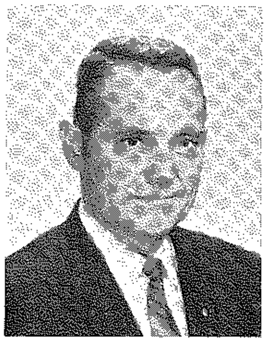


William H. Eubanks, P.E.
Mississippi State University

In the past many members of the Engineering Design Graphics Division have expressed confusion regarding the duties and responsibilities of the Director of Zones. Therefore, before accepting this Directorship in December of 1975, I attempted to find out more about what would be expected of me in this position. This article will hopefully serve to clarify to our members the duties and responsibilities of this office as well as the activities that take place within the zone and sectional levels.

Revisions to the bylaws adopted in 1975 listed in Sec. 2d (3) Specific Duties of Directors, states the following:

> Sec. 2d (3e) Director: Zones Activities
>
> The Director shall encourage and suggest activities by maintaining contact with all zone chairmen to inform them of special activities being accomplished in other zones as reported to the director by those chairmen.

Also listed under Sec. 2a (5) Zone Activities

> Committees in this category are to increase and promote section and local activities of division members within the various zones. There shall be a committee from each of the sections in the particular zone.

If you are a well-informed ASEE member, you probably already know that the fifty United States and Canada are divided into four zones for geographic convenience. In the October, 1975, issue of Engineering Education on pages 83 and 84, the boundaries of these zones are shown and also the boundaries of the three sections assigned to each zone. From this general layout, planned and approved by the Board of Directors of ASEE, membership balance has been attempted by these boundaries.

As pointed out by our retiring chairman, Bob LaRue, there is more potential here for committees than in any other area, and with this more opportunities for members to work for the Division.

My first act after accepting this position was to establish some goals and objectives. I felt that from our bylaws, Article V, Section 4, should be directly related to this position.

This section of the bylaws is stated as follows:

> Division members are urged to plan group meetings of Engineering Design Graphics instructors in connection with sectional conferences of ASEE, and are urged to make those meetings of interest to instructors in technical education and of junior and senior college levels with a view of including such instructors as members of the Division.

With this in mind, we set as our first goal to try and establish graphics meetings at the sectional meetings of ASEE. We realize now that this is not easy to do. There are many sections who discourage and in some cases even prohibit division meetings. We realized we needed some additional goals. A second goal is to try and get a member of the Graphics Division on the Executive Committee of each section: this might well be the elected chairman of the graphics group within the section. A third goal, especially for those sections who don't have separate division meetings, is a graphics speaker on the program as a part of their overall section meeting.

To coordinate all of this and to try to keep all of our Division members informed, I plan to use the Journal and maybe a newsletter periodically to let members of the Engineering Design Graphics Division know what progress is being made.

We have appointed zone chairmen from each of the four zones and they are as follows:

Zone I—Henry B. Metcalf, University of Maine; Zone II—Francis A. Mosillo, University of Illinois-Chicago; Zone III—Louis C. Skubic, South Dakota State University; Zone IV—Dr. Clayton Chance, Northern Arizona University.

These chairmen will organize their zone by recommending the appointment of a section chairman and, if it is felt desirable, two or more members in addition to the chairman from each section to serve as a committee from each section.

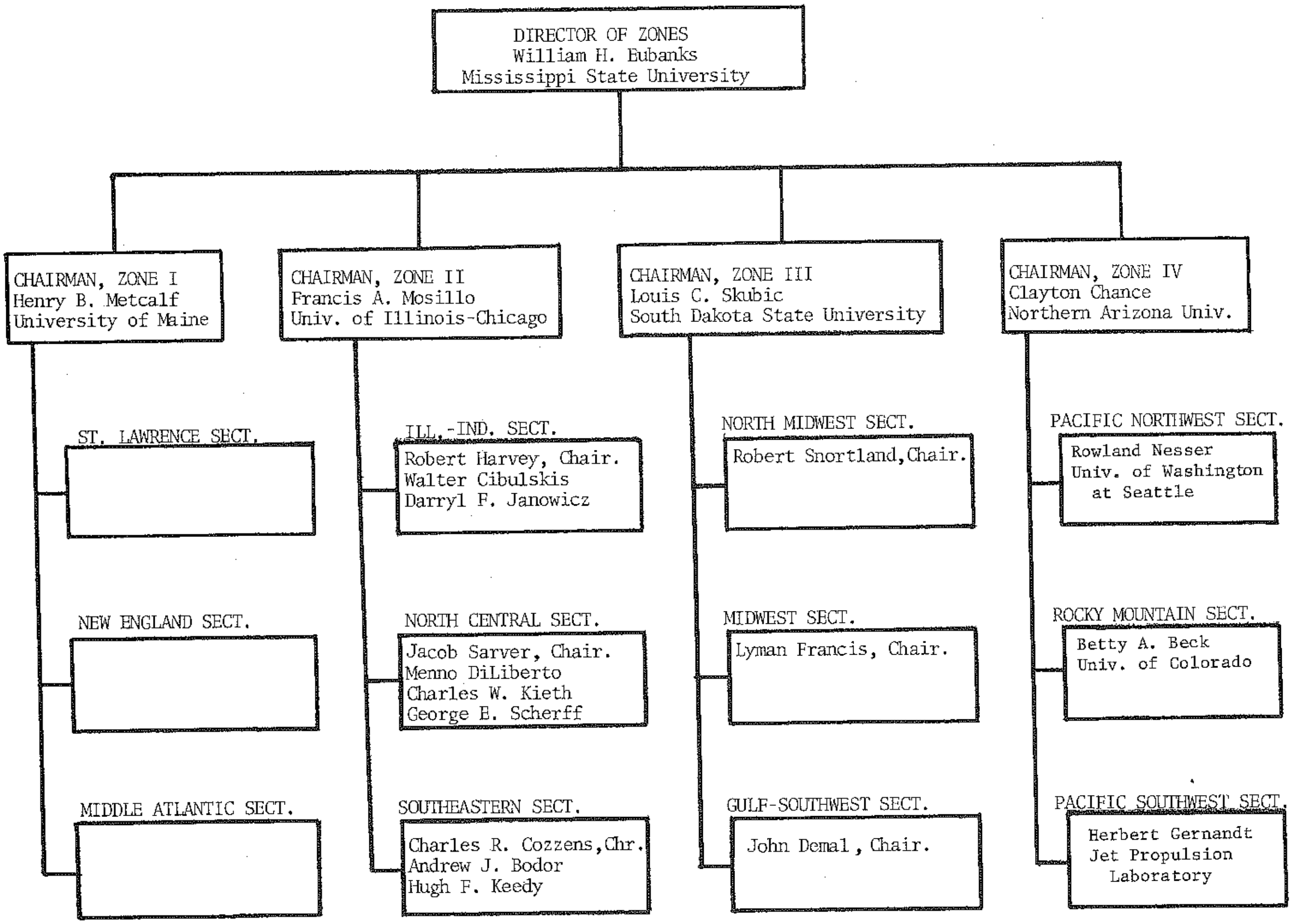
This committee will have the principal responsibility of helping us reach our goals. If possible, they will attend their section meeting and inform all graphics members in their particular section of the time and place where the section graphics division will meet. They will take an active part in organizing their group at this meeting by electing officers and a program chairman for the next section meeting. If separate meetings are not permitted, they will request and secure from graphics members in their section someone who is willing to take a part in the overall section meeting and they will request representation on the Executive Committee of their ASEE Section.

If your section, during its meeting, will permit a graphics division meeting, do your part by attending and encouraging other graphics members of your institution to attend. Get involved — elect graphics officers of your section and plan a program that will be both stimulating and interesting.

I would be happy to hear from any of you who would like to see this area take on a new meaning and be more meaningful than ever before, and I especially have an offer for your assistance in helping us reach these goals. If you are interested in serving on a sectional committee, contact your zone chairman listed on the organizational chart in Figure 1.

I think each of you will agree that if we are in any way successful in reaching these goals, our Division will be stronger and better than ever. A grass roots effort is needed. There are too many members of this division who are unable to attend the national ASEE meetings. Sectional meetings being closer to home should attract many more graphics instructors who we hope will get involved and with whom we can share information for the benefit of all.

Figure 1 - Organization of Zones



Involved?

Garland K. Hilliard, Associate Editor
North Carolina State University

A short article appeared in the Fall issue of the Journal encouraging involvement in the several Technical-Professional Committees of the Engineering Design Graphics Division of ASEE. In this issue and successive issues of the Journal we want to publicize in more detail the activities of the various committees. Hopefully this will accomplish two goals. First, Division members and Journal readers ought to be informed and abreast of our goals, accomplishments and activities. Many members are unable to attend our regional, annual and mid-year conferences where current information is disseminated. The Journal should serve as the mouthpiece of Division activities through which we are informed and united behind common goals.

Secondly, if you are informed and abreast, we would hope that your personal contribution and involvement in Division activities would follow. The very strength and effectiveness of the Division is dependent upon each and every one's input, however small or seemingly insignificant.

A remark, frequently expressed, is that the Division and ASEE in general seem to be run by the same group of persons. To an extent this is true. However, it did not happen by accident. If you were to examine these persons' history of involvement in the Division and in ASEE, you would find that once upon a time, like so many others, they were just a part of the general dues-paying membership. The difference is that they took the initiative to become more involved in what was going on. Very likely they became members of a committee, possibly in a less active role at first, but as a result of experience, initiative and circumstance acquired more active roles.

The Division needs you. There is enough variety among its many committees to appeal to the interests of almost everyone. Your input, participation and personal involvement is welcomed in promoting the goals, ideals and stature of Engineering Design Graphics to even newer heights of excellence in engineering education.

Engineering Design Education Committee

The Editors of the Journal have allocated this space to the Engineering Design Education Committee for the purpose of encouraging EDG Division members to share their ideas on design, creativity, methods of teaching creative design, and methods of evaluating the creative efforts of the engineering student. These are just a few topics which could be "sounded out" in this column.

Many of you have been teaching creative design for years and have collected data to support this teaching activity. Share your experience!

Some members of the Division are relatively new to creative design education, but what they lack in experience, they make up in enthusiasm. Share your innovative ideas!

Elsewhere in this issue of the Journal the Design Education Committee is presenting the report of the "Creative Design Display Study and Evaluation Committee." This committee, chaired by Percy H. Hill, was constituted to perform an in-depth story of the National Creative Design Display, held annually at the summer meeting of the ASEE.

The final report of the committee was approved at the Knoxville meeting (June, 1976), during the meeting of the Executive Committee. The Creative Design Display Committee has the responsibility of implementing most of the recommendations of the report. However, input/feedback from Division members involved in teaching design is needed.

Air your views and use this column as a "soapbox." Address comments on the "Hill Report" or other facets of engineering design education to:

Mary A. Jasper, Assistant Professor
Department of Engineering Graphics
Mississippi State University
Drawer EG
Mississippi State, Miss. 39762

Graphics Technology Committee

The Graphics Technology Committee has been relatively inactive for the past several years; but in light of the recent emphasis by ASEE on Engineering Technology programs, it is considered that this committee has a most important responsibility. In June of 1973, the Committee under the chairmanship of Frank Marvin of the Virginia Polytechnic Institute and State University established its goals as being:

1. To establish liaison with those post-high school programs that offer an academic major or specialty in graphics and to encourage those faculties to join in the promotion of Graphics Technology.
2. To establish this liaison through a biannual survey aimed at determining the typical graphics curriculum.
3. To compile a listing of recommendations and procedures for establishing two-year and four-year post-high school graphics technology curricula.

In 1973 approximately 95 colleges and universities within the United States that offered a Bachelor's degree in Engineering Technology had been identified. Those institutions were contacted and asked to support the Committee's efforts by supplying as much information as possible relative to their own engineering graphics curriculum. The responses were to be compiled in an effort to establish the two and four-year post-high school graphics technology curricula.

John Crittenden of VPI and SU is currently the Committee Chairman. Five persons have expressed an interest in serving on the Committee, but greater participation is certainly desired. If you are interested in serving on the Committee, if you have ideas for additional goals or if you have questions regarding the Committee's activities, contact:

Professor John B. Crittenden
Division of Engineering Fundamentals
Virginia Polytechnic Institute and
State University
Blacksburg, Virginia 24061
Telephone: (703) 951-6555

Computer Graphics Committee

The Computer Graphics Committee is currently in the process of preparing a report which attempts to describe courses having computer graphics content available to freshmen and what equipment is utilized. This is considered only the first step toward getting computer graphics information to the membership at large. The material now being compiled is tentatively planned to be presented at the June meeting at a session entitled Computer Graphics "Freshmen." The term "Freshmen" here is meant for teachers who are freshmen in the area of computer graphics as well as the students and the courses themselves. Hopefully, this material will be disseminated by other means as well (the *Journal*, newsletter, etc.). Opinions of the membership here would be appreciated.

Future committees could easily expand this study to courses of higher levels, but care must be taken so that the information can be understood by those who are not "computer buffs." As most of you are well aware, computer people have a tendency to talk like the machines they associate with and seem to forget that the machines are to be made to adapt to us not we to them.

Another area which this committee could investigate which would be of immense value to the membership is how and where to apply for grants so one can obtain needed computer equipment for our individual institutions. This is an area in which the chairman is completely ignorant and would appreciate volunteers to begin such a study or even a volunteer to be the chairman for a future year, at which time this type of study can be undertaken and the material be disseminated to the membership.

Francis Mosillo is currently chairman of the Computer Graphics Committee. If you are interested in serving or have questions regarding the Committee and its goals, contact:

Professor Francis Mosillo
Department of Systems Engineering
University of Illinois at Chicago Circle
Box 4348
Chicago, Illinois 60680
Telephone: (312) 996-3444

Announcement

Human Factors in Design Committee

The Human Factors in Design Committee will be running a session called (oddly enough) Human Factors in Engineering Design at the Annual meeting in Grand Forks, N. D. The session will be held Wednesday, June 29, 1977, from 3:45 to 4:30 p.m. and will feature the following highly experienced designers of people-oriented systems.

Mr. Thomas Cannon, President
INDESIGN

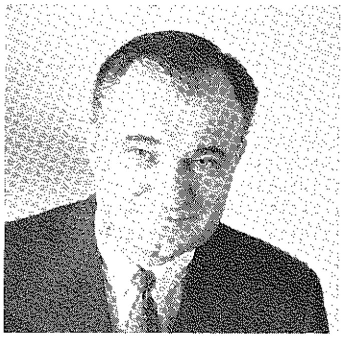
Mr. Charles Kubokawa, Director
Office of Technology Utilization
NASA-Ames Research Center

Mr. Stephan Habsburg
GM Design Staff
GMC

Because of the caliber of these professionals, the session should be both highly informative and entertaining. I would especially urge those interested in design graphics and human factors to attend these talks which will be followed by a short discussion session.

John G. Kreifeldt, Chairman
Human Factors in Design

1978 International Conference on Descriptive Geometry



Steve M. Slaby
Princeton University

Engineering Graphics and Design rests on the solid theoretical base of Descriptive Geometry. The history of Descriptive Geometry is well-known to us through some of the early work that Gaspard Monge developed in the Eighteenth Century. Actually some of the basic principles of this science were being used as early as the Twelfth Century, before Monge formalized Descriptive Geometry into a science. If one examines the manuscript (working) drawings of the early geometers (engineers) who designed and built the magnificent Gothic cathedrals we know throughout Europe, it becomes obvious that Descriptive Geometry principles were being applied to the layout of the self-supporting arches which are critical to the structural integrity of the Gothic cathedrals.

Figure 1 and Figure 2 show examples of actual graphic layouts which were used to design and construct complex arches in two cathedrals (names unknown). A close examination of these figures shows that a version of the concept of rotation was used to determine the true lengths and true shapes necessary to lay out these arch forms. The method here resembles the "direct" approach largely used today.

Monge's development of Descriptive Geometry through the "trace of a plane" method remained the standard in this field until the Twentieth Century when the "direct method" was finally formalized and became the new standard used in engineering and engineering education. The direct method (with variations on its "theme") continues to be the main thrust in the science of Descriptive Geometry today.

The theoretical aspects of Descriptive Geometry has not reached its limit and important work in this area is being done by a number of contemporary scholars. In 1929, for example, Ludwig Eckhart published his "Four-Dimensional Space" treatise (see translation by Arthur Bigelow and Steve M. Slaby published by the Indiana University Press, 1968) in which he introduces "the reader to the secrets of the Four-Dimensional concept....by way of representational procedure, to familiarize himself with it step-by-step and thus to acquire a clear perception of the seemingly unrepresentable." (Preface, op. cit.)

In 1965, Dr. Louisa Bonfiglioli (of the Technion in Israel) while a visiting professor in the Department of Graphics and Engineering Drawing at Princeton published a number of papers as a result of her research including one entitled "Parallel Projection for Euclidean Geometry of Four Dimensions." Likewise, C. Ernesto Lindgren, as a research scholar in the same department at Princeton, published numerous research papers in this area including a major monograph (with Steve M. Slaby) entitled "Four-Dimensional Descriptive Geometry" (McGraw-Hill, 1968).

More theoretical development is needed and possible in Descriptive Geometry. Significantly, some of the most interesting work is being done by physicists who are trying to develop visual-spatial configurations of concepts such as Einstein's space-time (Four-Dimensional) concepts of relativity. In addition, artists are finding multi-dimensional special concepts enticing and intriguing from their creative perspective. For example, David Brisson of the Rhode Island School of Design has written a number of books on the subject of visualizing multi-dimensional configurations. His most recent book is "Hyperstereograms" (Brisson, May 1976). Likewise, another artist, Dennis Finch, who has been doing work in multi-dimensional space recently published an article on "N-Space" in "Perception" (Volume 4, 1976).

As an example of the seriousness with which this discipline is being viewed by many scholars, a "Symposium on Hyper-Graphics" will take place at the Rhode Island School of Design between January 14-16, 1977. The participants in this symposium will include physicists, mathematicians, artists and descriptive geometry scholars.

The International Conference on Descriptive Geometry which is being planned and organized by a committee of the Engineering Design Graphics Division under the chairpersonship of Amogene DeVaney (vice-chairperson of our Division) is another example of the continuing and critically necessary involvement of our Division in this basic area of study and research.

In order for the discipline of Engineering Graphics and Design to grow and nurture its intellectual strength, it is necessary that continuing development take place in the theoretical and applied aspects of Descriptive Geometry. As time goes on, it is imperative that more members of our Division and profession make scholarly contributions to this development. With the advent and power of computer graphics more exciting vistas lie before us in this field. The Planning Committee for the International Conference on Descriptive Geometry looks forward to the support of all the membership of the Engineering Design Graphics Division in its planning, organizational, and implementation efforts for the Conference which is to take place on June 15-18, 1978, on the campus of the University of British Columbia, Vancouver, British Columbia.

In addition to making a major contribution to the science of Descriptive Geometry the International Conference on Descriptive Geometry will also commemorate the <u>Fiftieth Anniversary</u> of our Division.

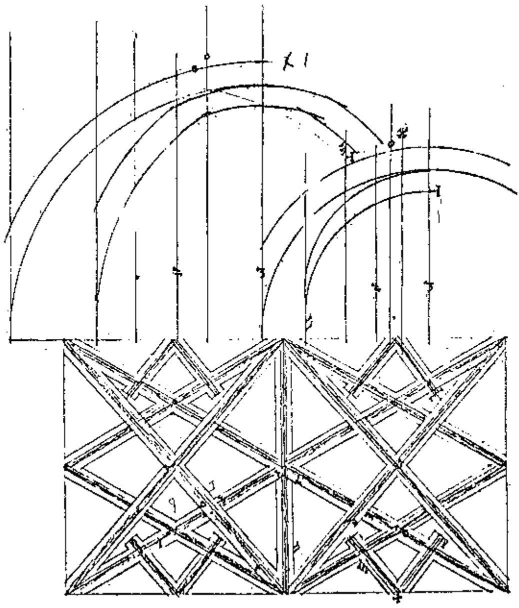


FIGURE 1

Call for Papers

In commemoration of its 50th Anniversary, the Engineering Design Graphics Division is sponsoring an International Conference on Descriptive Geometry, June 15-18, 1978, just prior to the Annual ASEE Conference in Vancouver, British Columbia.

This is a call for papers from members of the Division and their colleagues who are interested in presenting research papers and/or papers of pertinent related subjects at the Conference. Papers should be restricted to either the historical developments of descriptive geometry or theoretical papers dealing with research. Of particular interest will be those papers which are highly theoretical and describe applications to current societal problems.

The Division would also like to receive some papers from your colleagues in other engineering disciplines who feel that an in-depth knowledge of descriptive geometry is indispensable to their discipline. Last, but not least, we would be interested in receiving papers from some of your industrial colleagues where it is emphasized that design graphics and/or descriptive geometry play a significant role in their everyday activities.

Anyone interested in preparing and delivering a paper at the International Conference should send a 200-500 word synopsis of their paper to:

Dr. Clarence E. Hall
Louisiana State University
Rm. 142, Atkinson Hall
Baton Rouge, La. 70802

The deadline for submission of synopses is June 1, 1977.

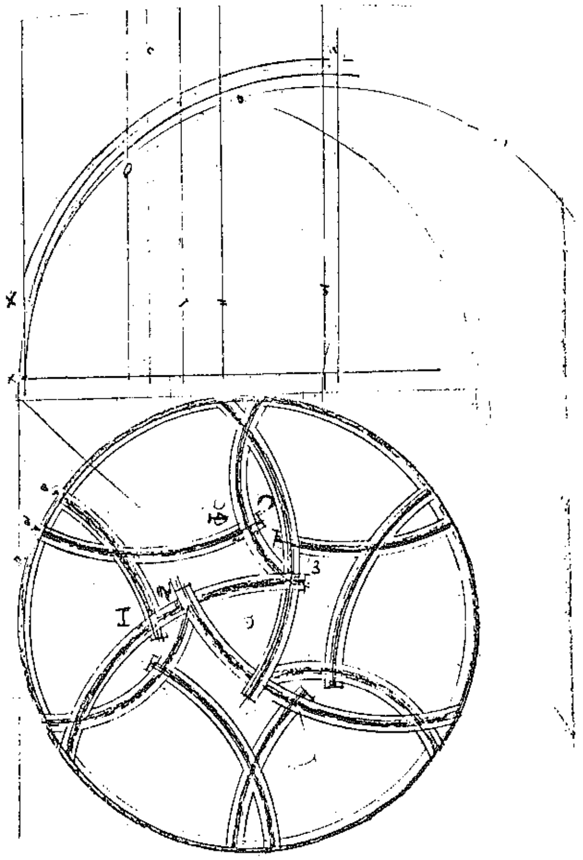
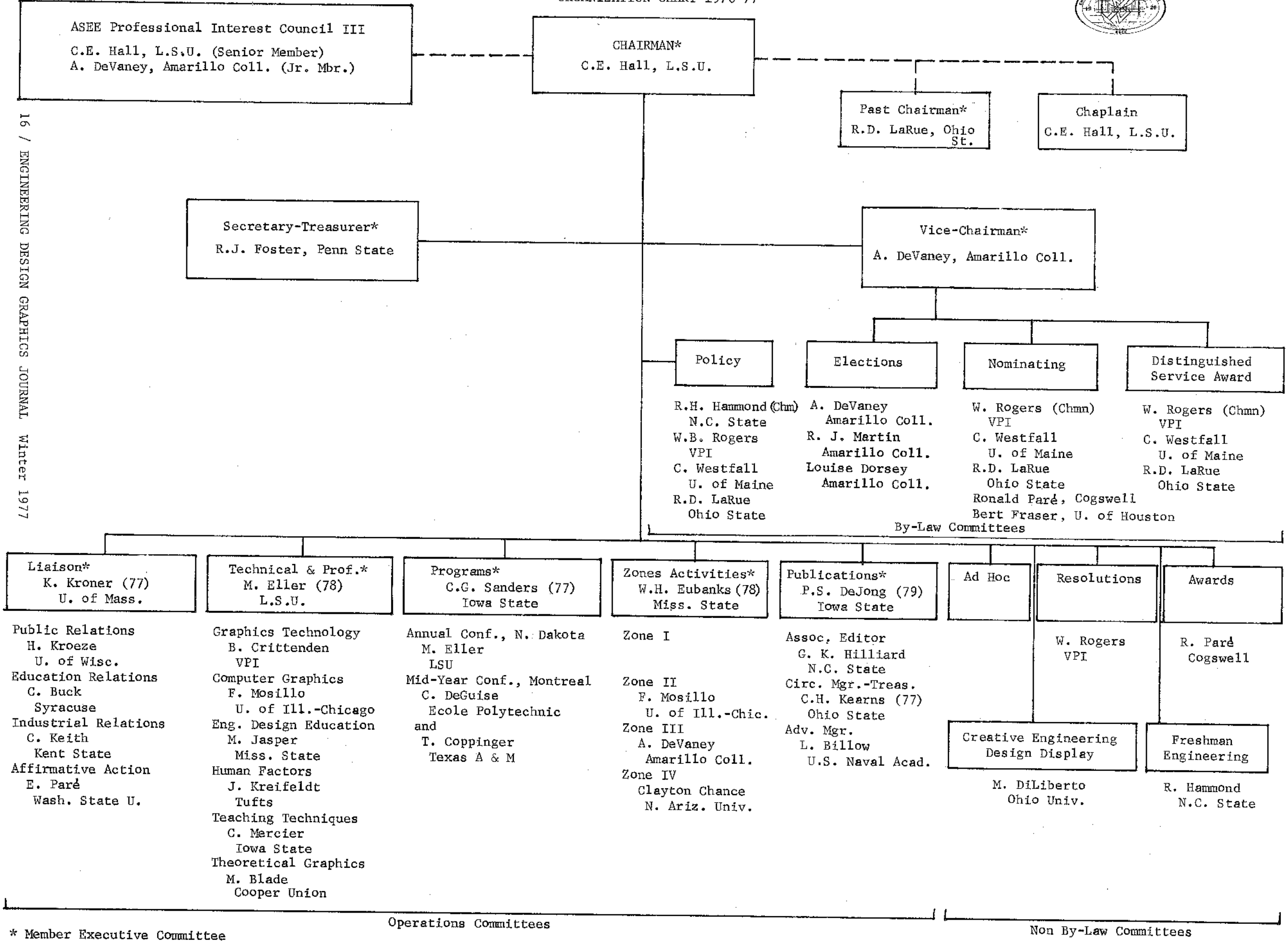


FIGURE 2

ENGINEERING DESIGN GRAPHICS DIVISION

ORGANIZATION CHART 1976-77



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A. DeVaney, Amarillo Coll. (Jr. Mbr.)

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Amarillo Coll.

Nominating
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Ohio State
Ronald Paré, Cogswell
Bert Fraser, U. of Houston

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C. Westfall
U. of Maine
R.D. LaRue
Ohio State

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Cogswell

Creative Engineering Design Display
M. DiLiberto
Ohio Univ.

Freshman Engineering
R. Hammond
N.C. State

Non By-Law Committees

* Member Executive Committee

NEW MEMBERS

The Engineering Design Graphics Division of ASEE is proud to announce that fifteen new members have joined the Division since July 1976. We welcome each of the following to the Division, its goals, ideals and activities. May each of you grow with the Division in seeking new heights of excellence in engineering design graphics education.

Prof. William P. Beley
Dept. of Civil Engineering
University of Manitoba
Winnipeg, Manitoba, Canada R3T 2N2

Mr. James E. Bolluyt
Dept. of Fr. Engineering
Iowa State University
Ames, Iowa 50011

Mr. Thomas E. Ciavarella
1308 Monroe Avenue
Altoona, Pa. 16602

Mr. Barron L. Deetscreek
1544 Johnson Street
Nanty Glo, Pa. 15943

Dr. Donald L. Elfert
McNeese State University
School of Engineering
Lake Charles, La. 70601

Mr. Jack E. Ferguson
Sumter Area Technical College
506 N. Guignard Rd.
Sumter, S. C. 29150

Prof. Robert G. Finkenaur
Dept. of Graphic Science
Northeastern University
Boston, Mass. 02115

Ms. Barbara A. Gsellman
2372 Elizabeth Drive
Stow, Ohio 44224

Dr. Ming H. Land
Industrial Education Dept.
Miami University
Oxford, Ohio 45056

Prof. Anthony J. Laus
Deanza College
21250 Stevens Cir. Blvd.
Cupertino, Calif. 95014

Prof. John J. McDonough
University of Maine
Engr. Tech./122 E. Annex
Orono, Me. 04473

Dr. Gordon R. Mon
Potomac State College
Engineering and Technology
Keyser, W. Va. 26726

Mr. John Parks Newby
N. C. State University
Freshman Engineering
118 Riddick Hall
Raleigh, N. C. 27607

Ms. Minnie L. Pritchard
Engineering & Science Division
Akron University
Akron, Ohio 44325

Asst. Prof. Bruno W. Strack
4439 Wooddale Ave., Apt. 2
Memphis, Tenn. 38118

Call for Papers

INTERNATIONAL CONFERENCE ON
DESCRIPTIVE GEOMETRY

VANCOUVER, B. C., CANADA
JUNE 15-18, 1978

The Engineering Design Graphics Division of the American Society for Engineering Education is sponsoring the International Conference on Descriptive Geometry to commemorate the 50th Anniversary of the Division. The purpose of the Conference is to bring together persons concerned with new developments in theoretical descriptive geometry, with innovation and research in teaching, and with the relevance of descriptive geometry to the solution of problems which satisfy societal needs and to engineering education. Papers are invited in the following areas:

Recent developments in theoretical descriptive geometry

Innovation and research in teaching

Applications of descriptive geometry to such areas as computer graphics, medical research, human factors engineering, environmental design, biomedical engineering, etc.

Relevance of descriptive geometry to engineering education.

One of the purposes of the Conference is to provide an opportunity for personal involvement and interaction of those attending the Conference. All paper presentations will be followed by interaction in small discussion groups and workshop type activities.

Authors wishing to present papers should send a synopsis (200-500 words) describing the scope of the paper to:

Dr. Clarence E. Hall, Chairman
Dept. of Engineering Graphics
Louisiana State University
Room 142, Atkinson Hall
Baton Rouge, Louisiana 70803

Deadline for submission of synopses is June 1, 1977. Persons whose papers are accepted will be notified by August 30, 1977. Final draft will be due on February 1, 1978, and will be published in the Conference Proceedings. All presentations and publications will be in English.

CREATIVE ENGINEERING DESIGN DISPLAY STUDY AND EVALUATION COMMITTEE

FINAL REPORT

I. Introduction:

It is not clear to this committee why an in-depth study and evaluation of the Creative Engineering Design Display is required at this time. One initiates a study when something is wrong, is not effective, or needs to be improved. In the opinion of the committee, the Creative Design Display along with the Journal is the most important activity of the Division, with the exception of two meetings (conferences) held each year. The Display is physical evidence that Engineering Design is alive and well at a number of institutions. Faculty visitors to the display area are exposed to the nature of design problems assigned and are naturally encouraged to attempt this style of teaching at their institutions.

The Creative Engineering Design Display was initiated by Division Chairman Eugene Pare in 1968 following the successful 1967 Engineering Design Summer School at Michigan State. The purpose of the Display was to encourage attendees at the summer school to begin to practice in the classroom techniques of design instruction learned at the school. The Display was then to serve as a creative outlet where student design work would be exhibited and judged competitively by A. S. E. E. invited faculty from interdisciplinary interests. Another intended purpose was to make the influence of the Division more visible to membership of A. S. E. E. In the opinion of the committee, these objects have been unquestionably met. This report will, therefore, address itself to a tightening up of definitions and policies involved with the displays and make recommendations for smooth operation in the future.

II. Objective:

The primary objective of the Creative Engineering Design Display was to continue the effort of the 1967 Design Summer School to provide an exhibit of students' design efforts for the purpose of encouraging Division members to experiment with this type of instruction in their classrooms. The Display would also provide a forum for dialogue among educators (a meeting place for conversation) to discuss techniques of instruction in creative design. Additional objectives intended to be advanced by the Displays include:

1. Provide an effective vehicle to enhance the prestige of our Division in the eyes of the representatives of other disciplines.
2. Encourage other disciplines to recognize a desirable shift to a more design-oriented program.
3. Provide somewhat continuous public relations activities.
4. Stimulate graphic design teachers to expand the creative design aspects of their courses.
5. Encourage our students to expend their best efforts on projects to be displayed and recognized nationally.
6. Demonstrate to A. S. E. E. leaders the directions that our annual meetings should take to provide a more purposeful educational experience to the attending membership.

In the opinion of the Committee, these objectives have been advanced since the inception of the Displays.

III. Funds:

Since the schools are supporting the cost of getting their entries to the displays, it is doubtful that any additional funds can be expected from this source. Contributions from industry, drafting instrument companies, publishers, etc., seem to be the only logical sources of funding. Based on spiraling inflation and the fact that money will be tight in the near future, it is recommended that funds be solicited for the purchase of plaques and certificates only.

These funds are to be deposited in the Division treasury and drawn upon as needed to conduct the displays. They should be thought of as Division funds -- not Display funds. This fund is to be used by the Division Chairman and the Executive Committee for the purpose of advancing the quality and impact of the Design Display. In order to manage this fund (although small) efficiently, the Display Chairman should file a budget request with the Executive Committee early in the year.

IV. Prizes:

It is important to continue to award certificates and plaques for winners in each division, but cash prizes are not needed. Besides, it is an unnecessary expense in the opinion of the Committee. Since each school has entered the best of their students' work, and in some cases judged through local competition, the Committee feels that all non-winners should receive an honorable mention certificate.

V. Display Committee:

The Display Committee should be considered one of the most important in the Division, in that the results of their efforts are on public display at each annual conference and subject to criticism. One method of minimizing this perennial negative dialogue from displayers and other faculty is to structure the Committee so that it is of a continuing nature with continuing leadership. This may be accomplished by appointing the Chairman for a two year term and requesting that he appoint subchairmen for (a) physical display and publicity, (b) judging and awards, and (c) fund raising. It seems logical that one of these sub-chairmen would move up to the chairmanship of the overall activities.

VI. Alternative Pre-defined Design Project:

The present format of the Design Display is to accept any and all design projects from institutions in the undergraduate and graduate categories and judge them as a whole in each division (freshman, sophomore, etc.). In some cases, the judge may be swayed by the cleverness of the problem assigned as opposed to the solution. He may be excited about energy conservation or waste disposal and score a project in this area high while one on automotive safety devices low. This is done subconsciously, of course, but does not represent a true score. There is a strong feeling among many professional designers that one cannot judge fairly a variety of solutions to a variety of problems. Judging should be directed at a number of solutions to a single problem.

The Study Committee recommends that an alternative scheme of design projects be tried on an experimental basis in each judging category. This scheme will involve the mailing out in early September to all participating institutions a number (two) pre-defined design problems to be entered at the Display in June. These pre-defined problems will be in addition to the pre-set institution defined problems now entered in the Display and should be judged in a special category.

It is felt that this scheme of pre-defined problems will be welcomed by many institutions who may have difficulty finding the right problems for their classes. It will also give the Display Committee some insight into the judging of competitive design solutions.

VII. Individual and Team Projects:

Judges have difficulty comparing projects worked on by one student and those with four or five students involved. The total time spent on a project varies widely. It can be said that the quality of creative work may be a direct function of the number of individuals working on a project and the total time spent. Certainly the chance of a significant solution is increased. A judge should expect more creative work in a project completed by four students than from a single student project.

A system of scoring projects should be devised to take into account the number of individuals and the time spent on the project. One system might be the listing of the number of students involved and the time each spent, so that the judge may take these factors into consideration. Another system might be by "handicap" -- adjusting the judge's score to a "time-spent-on-project factor".

VIII. Presentation and Models or Mock-ups:

All displays have a written report, but not all displays include a model of the project solution. Clearly a good model causes a judge to vote more favorably for that project, while a poor model or none at all has the opposite effect. This is also true with visuals (poster boards and drawings), literary style in the technical report, and analytical analysis supporting the solution.

It is recommended that the Design Committee provide some guidance to faculty in urging competitive and creative presentations be made by their students. In fact, one may estimate that the acceptance of a design project be divided into 70% on uniqueness of solution and 30% on its presentation (model, graphics, written report). This is a fact in the real world. It is a pity to see a truly good idea turned down because of a poor presentation and at the same time see a weak solution be accepted because of a good presentation.

Recommendations:

A. Funds in modest amounts should be continued to be solicited from industry, drafting instrument companies, publishers, etc. to support the expenses of the displays. These funds are to be deposited in the Division treasury and requested as a budget item by the Display Chairman early in the year (September).

B. Awards in the form of plaques and certificates are to be given to winners in each category. NO cash awards are to be made. The custom of giving honorable mention awards is to be continued.

C. Invite all judges to the Division's Annual Banquet with complimentary tickets (not spouse), but do not provide a free luncheon.

D. The Chairman of the Display Committee is to be appointed by the Executive Committee for a two-year term. The Display Chairman will assume the responsibility of appointing sub-chairmen of (a) physical display and publicity, (b) judging and awards, and (c) fund raising. Successor to the Display Chairman is to be chosen from these sub-chairmen.

E. In September 1976 the Display Committee should send to all participating institutions two pre-defined design problems and establish a separate category for judging solutions in June 1977. Following this judging, a questionnaire would be distributed to determine faculty and judges opinions of this possible alternate design project entry in the display. This pre-defined problem entry should be continued on an experimental basis until enough data can be determined either to continue it permanently or drop it from the present format.

F. The Design Committee should attempt to incorporate into its scoring procedure a technique to determine the quality of a design project solution which accounts for the number of students involved and the time devoted to the solution.

G. The Design Committee, through its general mailing, should urge participating schools to instruct their students in the techniques of design project presentation (models, graphics, report writing).

H. This recommendation deals with details of the Display itself and is presented here as a guide to the Committee in structuring present and future Displays. Much of what is contained here already exists as operational procedure, but is repeated so that the organization of the Display may be seen as a whole.

1. Physical display of students' work
   (a) The display should be held during a meeting of engineering educators-preferably during the annual ASEE conference.
   (b) The designs should be entered in standard categories:
      1) Freshman
      2) Sophomore
      3) Junior
      4) Senior
      5) Graduate
      6) Special category for pre-defined design problems
   (c) Each institution is to be responsible for the projects of its students with respect to the following:
      1) Delivery to the Display
      2) Setup of the display of projects of their own students
      3) Return of their students' projects to the institution

2. Judging of students' designs
   (a) Judging shall be done according to a set form as determined by the Design Display Committee
   (b) The team of judges shall have members to equally represent industry and engineering education
   (c) No judge shall be a teaching member of the Engineering Design Graphics Division, ASEE.

3. Awards
   (a) Awards shall be made according to the average evaluation scores given by the judges.
   (b) First, second and third place awards are to be given in any category that has more than fifteen (15) entries.
   (c) First and second place awards are to be given in any category that has between 10 and 15 entries.
   (d) Only a first place award is to be given in any category with less than 10 entries.
   (e) Designs that do not receive first, second or third place awards will be awarded Honorable Mention.

I. The Study and Evaluation Committee feels that its assignment is complete with this report and requests that it be dismissed.

Submitted by:

John Barylski
Southeastern Massachusetts University

James Earle
Texas A & M University

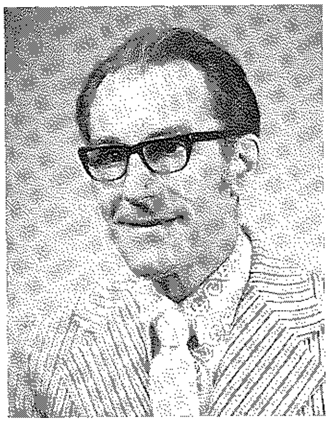
Wayne Felbarth
University of Detroit

Edward Knoblock
University of Wisconsin-Milwaukee

Eugene Pare
Washington State University

William Weisel
Cincinnati Milacron

Percy H. Hill, Chairman
Tufts University



Fred O. Leidel
Engineering Freshman Office
University of Wisconsin - Madison

We've Got Those Metrication Blues

OR

"TO SCALE THE HIGHEST MOUNTAIN"

One of the details that seems to have been neglected in the volumes of literature on metrication is the choice of drafting scale that is the metric replacement if not the equivalent of the three scale types used in the English system. The purpose of this paper is to supply that detail through logical reasoning.

Traditionally the mechanical engineer's scale, the architectural scale and the civil engineer's chain scale of the English system are identified in terms of either the size of the resultant drawing compared with the size of the object drawn (for example 1/2 size) or the number of some units on the drawing that represent some other

REVIEWER'S COMMENT

Wayne C. Dowling
Iowa State University

The prospective reader should not be mislead by the facetious title of this article. The selection of standard metric drafting scales is indeed a serious topic, and the thought and discussion which the author aims to stimulate is very timely. Whether by design or by chance, the available scales will rapidly become standards. If a poor choice is made now, its later removal will be difficult if not impossible.

The author presents extensive data on presently available scales, both English (for comparison) and metric. No indication is made as to whether the comparison, made on the basis of ratios, is intended for exact replacement, that is to permit metric measurements to be made on a pre-metric drawing; or whether it is a study of the present system, evolved through years of experience, to determine the desirable (approximate) distribution of scale-factors needed to permit the convenient delineation of any size object on any size drawing. Either way, the data provide a desirable basis for thought. The use of the "most prolific" supplier as a measure of scale popularity is questionable. This supplier is probably catering to the most specialized needs. Scales available only from others have a valid but disconcerting entry of (0) in the tabulation.

This reviewer does not agree with all of the author's conclusions, but one can hardly stimulate involved discussion without raising some dissention. These differences of opinion are more appropriately presented as a part of the ensuing discussion which this paper is intended to provoke. It is this reviewer's belief and hope that this article will succeed and that the EDG JOURNAL will be a forum for a continuing sharing of ideas on this vital topic.

Traditional Scale Identification	Scale Ratio
1/8" = 1" or 1/8 size	1:8
1/4" = 1" or 1/4 size	1:4
3/8" = 1" or 3/8 size	1:2.66
1/2" = 1" or 1/2 size	1:2
3/4" = 1" or 3/4 size	1:1.33
1" = 1" or full size	1:1

TABLE 1

Mechanical Engineer's Scales

unit on the object drawn (for example, one quarter inch equals one foot) or the number of subdivisions of one inch (for example, one inch equals fifty units). The scales of the metric system are traditionally identified by the ratio of the size of the drawing to the size of the object drawn (for example, 1:2 500).

An accurate comparision of the available English system scales to the available metric scales is possible if the English system scale identification is reduced to the ratio of the metric system scale. This is done in Tables 1, 2, and 3.

Traditional Scale Identification	Scale Ratio
1/32" = 1'	1:384
1/16" = 1'	1:192
3/32" = 1'	1:128
1/8" = 1'	1:96
3/16 = 1'	1:64
1/4" = 1'	1:48
3/8" = 1'	1:32
1/2" = 1'	1:24
3/4" = 1'	1:16
1" = 1'	1:12
1-1/2"= 1'	1:8
3" = 1'	1:4

TABLE 2

Architectural Scales

Note that the scales of Tables 1 and 2 have specified units, while the scales of Table 3 do not. Therefore, the scales of Table 3 can be used with any units. Not only can they be used for the units indicated, but also for decimal submultiples and whole multiples of those units providing decimal subdivisions are acceptable. This includes usability as a metric scale as the last three columns indicate.

The catalogs of the major suppliers of drafting supplies list the availability of metric scales in the ratios of Table 4.

Traditional Scale Identification	Scale Ratio If Each Unit of Scale Is Assumed To Be:					
	Inch	Foot	Mile	Centimeter	Decimeter	Meters
10	1:1	1:120	1:63,360	1:0.394	1:3.937	1:39.37
20	1:2	1:240	1:126,720	1:0.787	1:7.874	1:78.74
30	1:3	1:360	1:190,080	1:1.181	1:11.811	1:118.12
40	1:4	1:480	1:253,440	1:1.575	1:15.749	1:157.49
50	1:5	1:600	1:316,800	1:1.969	1:19.686	1:196.86
60	1:6	1:720	1:380,160	1:2.362	1:23.623	1:236.23

TABLE 3

Civil Engineer's or Chain Scales

1:1(4)
1:2(2)
1:2.5(1)
1:5(7)
1:10(5)
1:20(8)
1:25(3)
1:33-1/3(1)
1:40(0)
1:50(8)
1:75(3)
1:80(0)
1:100(10)
1:125(2)
1:200(6)
1:250(2)
1:300(2)
1:400(2)
1:500(6)
1:625(0)
1:750(0)
1:1 000(4)
1:1 250(6)
1:1 440(0)
1:1 500(2)
1:2 000(2)
1:2 500(6)
1:2 880(0)
1:3 000(0)
1:10 000(2)
1:10 560(2)

TABLE 4

Available Metric Scales

In Order of Descending Ratio

The numbers in parenthesis indicate the number of different standard scales available from the most prolific supplier, with subdivisions in that particular ratio, and therefore might be an indication of the popularity of that ratio.

The redundancy of the above available metric scales is made apparent in Table 5, by reordering the listing of Table 4.

What appears to be 31 available metric scales of Table 4, is in reality the 15 scales of Table 5 (counting rows only), with 6 of the scales (rows) available in various multiples of 10.

There are several conclusions that can be drawn from the above tabulations of scale availability.

1:1	1:10	1:100	1:1000	1:10000
				1:10560
		1:125	1:1250	
			1:1440	
			1:1500	
1:2	1:20	1:200	1:2000	
1:2.5(1)	1:25	1:250	1:2500	
			1:2880	
		1:300	1:3000	
	1:33-1/3			
	1:40	1:400		
1:5	1:50	1:500		
		1:625		
	1:75	1:750		
	1:80			

TABLE 5

Available Metric Scales

Reordered for Ease of Comparison

Metric Scale Ratio	Mechanical Engineer's Scale	Architectural Scale	Civil Engineer's Scale
1:1	Full Size		10
1:2	1/2 Size		20
1:3*			30
1:4*	1/4 Size	3" = 1'0"	40
1:5			50
1:8*	1/8 Size	1 1/2" = 1'0"	

*Listed in Tables 4 and 5 as 1:300, 1:40, 1:80

TABLE 6

Metric and English Scale Equivalencies

First, there appears to be a more logical and systematic range of scale ratios available under the English system than under the metric system.

Second, there are a few available scale ratios under the metric system that are identical to the available scale ratios of the English system, as tabulated in Table 6.

Third: the metric scales ranging from 1:1 to 1:10 (which include also 1:2, 1:2.5, and 1:5) are usable as mechanical engineer's scales.

Fourth: the metric scales ranging from 1:5 to 1: 400 (which includes also 1:10, 1:20, 1:33-1/3, 1:40, 1:50, 1:75, 1:80, 1:100, 1:125, 1:1200, 1:250, and 1:300) are usable as architectural scales.

Fifth: the English civil engineer's chain scale is usable as a metric scale. If the major divisions are assumed to be centimeters or decimeters, the civil engineer's scale can be used as a metric mechanical engineer's scale (ratios 1:0.787 to 1:7.874); if the major divisions are assumed to be decimeters or meters, it can be used as a metric architectural scale (ratios 1:3.937 to 1:236.23); and if the major divisions are assumed to be kilometers, it can be used as a metric civil engineer's scale (ratios 1:78 744 to 1:236 231). Likewise there are metric ratios (1:1, 1:2, 1:300, 1:400, 1:500) equivalent to (or usable for) the ratios of the civil engineer's scale.

Sixth: in all cases, where there are not metric ratios available that are identical to English scale ratios, there are those available that are sufficiently close for all practical purposes. It is assumed that if we are to think metric, certainly we will cease thinking fractions; rather, we will think decimals.

Seventh: most of the available metric ratios are usable as a civil engineer's chain scale.

Eighth: there are avilable scale ratios under both the English system and the metric system that have limited utility.

Ninth: the single most useful metric scale would be the scale of 1:1 ratio. Probably the most useful triangular metric scale would contain scales of 1:1, 1:2, 1:3, 1:4, 1:5 and 1:6 ratios, put the decimal point where you will.

It is hoped that the above presentation will stimulate thinking and discussion of metric scales and aid in the selection of an appropriate metric scale for each drawing task.

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CRITICAL REVIEW of PICTORIAL DRAWING in U.S. GRAPHICAL LITERATURE

AND GENERAL CALCULATION FORMULAE FOR AXONOMETRIC PICTORIALS

REVIEWER'S COMMENT
L. J. Genalo
Iowa State University

This paper contains a well presented geometrical proof of a rather well known, but little used, concept of pictorial drawing. This concept involves the proper foreshortening ratios which should be applied along each axis of a pictorial drawing.

Although this information has been known for some time this paper presents a general proof which, with one small addition, could be of considerable practical use. When scaling the pictorial drawing is essential for determining the true length of an object along each axis, the author suggests a procedure to determine the foreshortening ratios based on knowledge of the angle ϕ (Fig. 1) which is a function of the viewing angle. It is suggested here to calculate the foreshortening ratios through the use of the apparent angles between the axes of the axonometric drawing as these angles are more readily available to the reader than is ϕ.

In U. S. engineering-graphical literature, Pictorial Drawings using parallel rays of projection are divided into axonometric and oblique projections. The word "axonometric" is thus interpreted to mean orthographic, as opposed to oblique, an interpretation incorrect in both geometrically and linguistically.

In the geometrical sense, axonometry is defined as the "measuring by means of axes". Prof. Dr. F. Hohenberg of the Technological University in Graz, Austria, divides such projections into "orthographic axonometric" and "oblique axonometric" projections. *

In the method of axonometry, a Cartesian (rectangular) coordinate system, with arbitrary scales for the 3 axes, is chosen. This coordinate system together with the scales are projected by means of parallel rays (orthographic or oblique) onto the picture plane. An object, with its three principal dimensions parallel to the axes of the above space coordinate system, can now be pictorially constructed by means of the projections of those coordinate axes and their distortion factors. The projection of the Z-axis is always drawn vertically.

---

*"Konstruktive Geometric in der Technik" by F. Hohenberg

With the geometrical meaning of axonometry clarified, the general geometrical formulae for the oblique axonometric projection may be derived with the orthographic axonometric projection as a special case.

Referring to Fig. 1., the 3 rectangular axes OX, OY, OZ cut the plane of projection P in points A, B, and C. The oblique projection of O on P is D and so the 3 lines DA, DB and DC are the oblique projections of the X, Y and Z axes which are called x, y, and z. The angle which the direction of projection makes with the plane P is ϕ. The line OH is drawn perpendicular to P and makes the angles λ_1, μ_1, ν_1 with the space axes (μ_1 and ν_1 are not shown in Fig. 1). The angles of OD with the space axes are λ, μ, and ν.

The foreshortening factors are $\frac{DA}{OA} = p$, $\frac{DB}{OB} = q$ and $\frac{DC}{OC} = r$ for the axes x, y and z respectively.

In triangle ODA:

$$DA^2 = OA^2 + OD^2 - 2OA \cdot OD \cdot \cos\lambda$$

or

$$\left(\frac{DA}{OA}\right)^2 = 1 + \left(\frac{OD}{OA}\right)^2 - \frac{2OD}{OA}\cos\lambda$$

In right triangles ODH and OAH, we have:

$$\frac{OH}{OD} = \sin\phi \qquad \frac{OH}{OA} = \cos\lambda_1 \qquad \text{or} \qquad \frac{OD}{OA} = \frac{\cos\lambda_1}{\sin\phi}$$

Consequently

$$p^2 = 1 + \frac{\cos^2\lambda_1}{\sin^2\phi} - \frac{2\cos\lambda\cos\lambda_1}{\sin\phi} \qquad \text{(I)}$$

Similarly, we obtain the foreshortening factors for the axes y and z as follows:

$$q^2 = 1 + \frac{\cos^2\mu_1}{\sin^2\phi} - \frac{2\cos\mu\cos\mu_1}{\sin\phi} \qquad \text{(II)}$$

$$r^2 = 1 + \frac{\cos^2\nu_1}{\sin^2\phi} - \frac{2\cos\nu\cos\nu_1}{\sin\phi} \qquad \text{(III)}$$

Summing up three formulae (I), (II) and (III) and considering that for the vectors OD and OH

$$\cos^2\lambda_1 + \cos^2\mu_1 + \cos^2\nu_1 = 1$$

and

$$\cos\lambda\cos\lambda_1 + \cos\mu\cos\mu_1 + \cos\nu\cos\nu_1 = \cos\left(\frac{\pi}{2} - \phi\right) = \sin\phi$$

we obtain

$$p^2 + q^2 + r^2 = 3 + \frac{1}{\sin^2\phi} - 2$$

or

$$p^2 + q^2 + r^2 = 2 + \cot^2\phi \qquad \text{(IV)}$$

In order to obtain the directions of axes x, y and z (which is drawn vertically), we only need to calculate the angles α and β (Fig. 2).

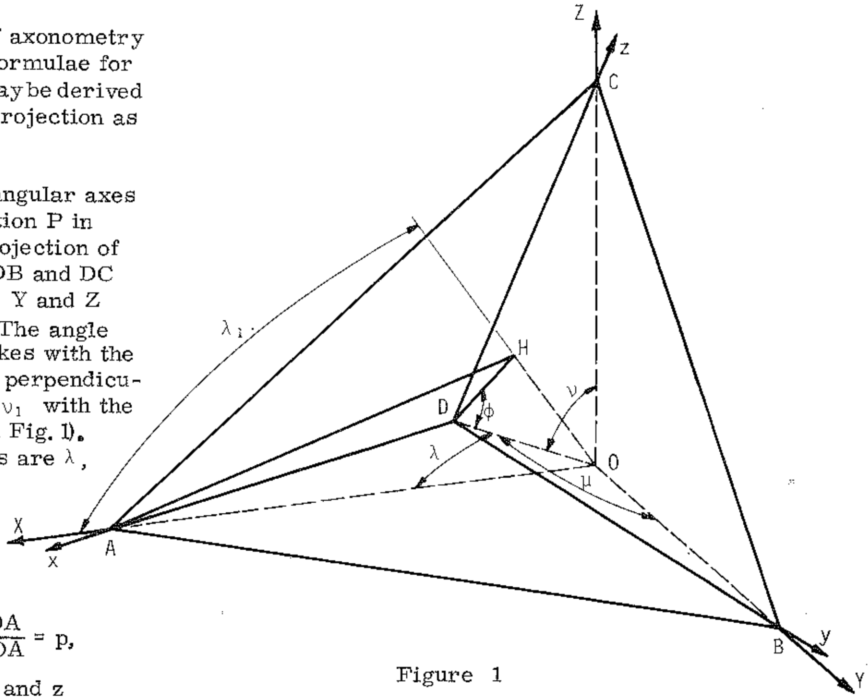


Figure 1

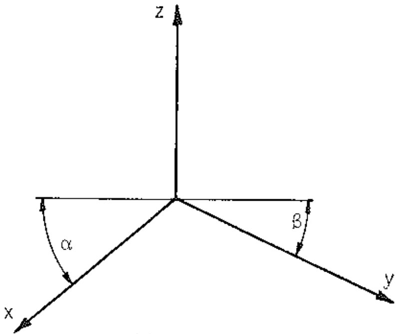


Figure 2

From Fig. 1 we have:

$$OA^2 + OC^2 = DA^2 + DC^2 - 2DA \cdot DC \cdot \cos\left(\frac{\pi}{2} + \alpha\right)$$
$$= DA^2 + DC^2 + 2DA \cdot DC \cdot \sin\alpha$$

From the formulae for the foreshortening factors

$$DA = p \cdot OA \qquad DC = r \cdot OC$$

Substituting we obtain:

$$OA^2(1-p^2) + OC^2(1-r^2) = 2OA \cdot OC \cdot p \cdot r \cdot \sin\alpha$$

Consequently

$$\sin\alpha = \frac{OA^2(1-p^2) + OC^2(1-r^2)}{2OA \cdot OC \cdot p \cdot r}$$

Since

$$OA = \frac{OH}{\cos\lambda_1} \qquad \text{and} \qquad OC = \frac{OH}{\cos\nu_1}$$

$$\sin\alpha = \frac{\frac{1}{\cos^2\lambda_1}(1-p^2) + \frac{1}{\cos^2\nu_1}(1-r^2)}{\frac{2pr}{\cos\lambda_1\cos\nu_1}}$$

or $$\sin\alpha = \frac{\cos^2\nu_1(1-p^2)+\cos^2\lambda_1(1-r^2)}{2pr\cdot\cos\lambda_1\cdot\cos\nu_1} \qquad \text{(V)}$$

and in the same way

$$\sin\beta = \frac{\cos^2\nu_1(1-q^2)+\cos^2\mu_1(1-r^2)}{2q\cdot r\cdot\cos\mu_1\cdot\cos\nu_1} \qquad \text{(VI)}$$

Practical cases:

1) Orthographic projection with $\phi = \frac{\pi}{2}(\cot\phi=0)$ and $p=\sin\lambda_1$, $q=\sin\mu_1$, $r=\sin\nu_1$:

From (IV)

$$p^2+q^2+r^2=2+\cot^2\phi=2 \qquad \text{(VII)}$$

From (V)

$$\sin\alpha = \frac{\cos^2\nu_1(1-p^2)+\cos^2\lambda_1(1-r^2)}{2p\cdot r\cdot\cos\lambda_1\cos\nu_1}$$

$$=\frac{(1-r^2)(1-p^2)+(1-p^2)(1-r^2)}{2p\cdot r\sqrt{(1-p^2)(1-r^2)}}$$

or $$\sin\alpha=\frac{\sqrt{(1-p^2)(1-r^2)}}{p\cdot r} \qquad \text{(VIII)}$$

and from (VI)

$$\sin\beta = \frac{\cos^2\nu_1(1-q^2)+\cos^2\mu_1(1-r^2)}{2q\cdot r\cdot\cos\mu_1\cdot\cos\nu_1}$$

$$=\frac{(1-r^2)(1-q^2)+(1-q^2)(1-r^2)}{2q\cdot r\sqrt{(1-q^2)(1-r^2)}}$$

or $$\sin\beta=\frac{\sqrt{(1-q^2)(1-r^2)}}{q\cdot r} \qquad \text{(IX)}$$

a) Isometric Projection with $p:q:r=1:1:1$

From (VII)

$$3p^2=2 \qquad p=\sqrt{\frac{2}{3}} \approx 0.8166$$

(In practice it is taken that $p=q=r=1$)

and from (V) and (VI)

$$\sin\alpha=\sin\beta=\frac{\sqrt{(1-\frac{2}{3})^2}}{\frac{2}{3}}=\frac{1}{2} \qquad \alpha=\beta=30^\circ \qquad \text{(Fig. 3)}$$

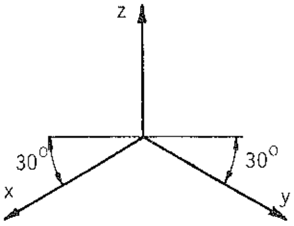


Figure 3

b) Dimetric projection with $p:q:r=\frac{1}{2}:1:1$

From (VII)

$$p^2+4p^2+4p^2=2$$

$$p=\frac{\sqrt{2}}{3}\approx 0.4714 \qquad q=r=\frac{2\sqrt{2}}{3}\approx 0.9428$$

(In practice it is taken that $p=0.5 \quad q=r=1$)

From (VIII)

$$\sin\alpha=\frac{\sqrt{(1-\frac{2}{9})(1-\frac{8}{9})}}{\frac{4}{9}}=\frac{\sqrt{7}}{4}\approx 0.6614 \qquad \alpha\approx 41^\circ\,25'$$

and from (IX)

$$\sin\beta=\frac{\sqrt{(1-\frac{8}{9})(1-\frac{8}{9})}}{\frac{8}{9}}=\frac{1}{8}=0.125 \qquad \beta\approx 7^\circ 10' \qquad \text{(Fig. 4)}$$

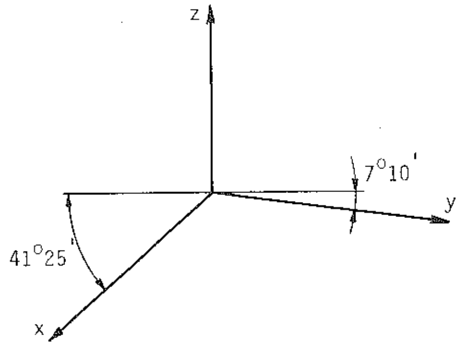


Figure 4

c) Dimetric projection with $p:q:r=1:\frac{1}{2}:1$

Calculations similar to the above result in:

$$p=\frac{2\sqrt{2}}{3}\approx 0.9428 \qquad q=\frac{\sqrt{2}}{3}\approx 0.4714$$

$$\sin\alpha=\frac{1}{8} \qquad \sin\beta=\frac{\sqrt{7}}{4} \qquad \alpha\approx 7^\circ\,10' \qquad \beta\approx 41^\circ\,25'$$

shown in Fig. 5.

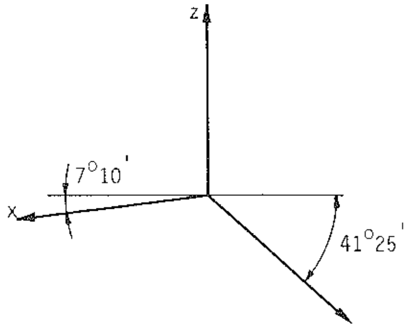


Figure 5

d) Trimetric projection with $p:q:r=5:9:10$

From (VII)

$$p^2+\frac{81}{25}p^2+4p^2=2 \qquad p=\frac{5}{\sqrt{103}}\approx 0.4926$$

$$q=\frac{9}{\sqrt{103}}\approx 0.8867 \qquad r=\frac{10}{\sqrt{103}}\approx 0.9853$$

(In practice it is taken that $p=0.5$ $q=0.9$ $r=1$)

Substituting the above values for p, q and r in (VIII) and (IX) we obtain:

$$\sin\alpha \approx 0.3060 \qquad \alpha \approx 17^\circ\ 49'$$

$$\sin\beta \approx 0.0903 \qquad \beta \approx 5^\circ\ 11' \qquad \text{(Fig. 6)}$$

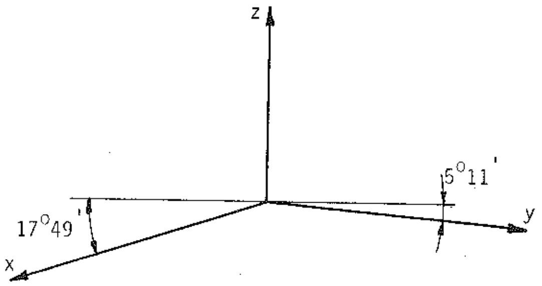


Figure 6

2) Oblique Projection with YZ-plane parallel to the picture plane P, i. e. $\lambda_1=0$, $\mu_1=\frac{\pi}{2}$, $\nu_1=\frac{\pi}{2}$, resulting in $q=r=1$.

Here it must be considered that with ϕ being known, the locus of the rays of projection will be a right circular cone. Therefore contrary to the orthographic projection, where p, q and r are sufficient to determine the directions of axes, we must also prescribe two of the three angles λ, μ and ν in addition to p, q and r.

a) Isometric projection with $p=q=r=1$

From (IV)

$$p^2+q^2+r^2=2+\cot^2\phi$$

or $\cot\phi=1 \qquad \phi=45^\circ \ \left(\lambda=\frac{\pi}{2}-\phi=45^\circ\right)$

If we choose $\mu=\nu=60^\circ$, then α and β are calculated as follows:

$$\sin\alpha=\frac{\cos^2\nu_1\frac{1-p^2}{1-r^2}+\cos^2\lambda_1}{\frac{2pr}{1-r^2}\cos\lambda_1\cos\nu_1}$$

$$=\frac{\cos\nu_1}{\cos\lambda_1}\cdot\frac{1-p^2}{2pr}+\frac{\cos\lambda_1}{\cos\nu_1}\cdot\frac{1-r^2}{2pr}$$

Considering that since $\cos\nu_1=0$, the first term vanishes, we have under consideration of (III)

$$\sin\alpha=\frac{\cos\lambda_1(1-r^2)}{2pr\cdot\cos\nu_1}=\frac{\cos\lambda_1\left(\frac{2\cos\nu\cos\nu_1}{\sin\phi}-\frac{\cos^2\nu_1}{\sin^2\phi}\right)}{2pr\cdot\cos\nu_1}$$

$$=\frac{\cos\lambda_1\left(\frac{2\cos\nu}{\sin\phi}-\frac{\cos\nu_1}{\sin^2\phi}\right)}{2pr}=\frac{\cos\lambda_1\cdot\cos\nu}{pr\cdot\sin\phi}$$

Substituting $\cos\lambda_1=1$ $\sin\phi=\frac{1}{\sqrt{2}}$ $\cos\nu=\frac{1}{2}$ in the above, we obtain:

$$\sin\alpha=\frac{\sqrt{2}}{2}, \qquad \alpha=45^\circ$$

and under consideration of (II) and (III):

$$\sin\beta=\frac{\cos^2\nu_1(1-q^2)+\cos^2\mu_1(1-r^2)}{2qr\cdot\cos\mu_1\cos\nu_1}$$

$$=\frac{\left[\begin{array}{l}\cos^2\nu_1\left(\frac{2\cos\mu\cos\mu_1}{\sin\phi}-\frac{\cos^2\mu_1}{\sin^2\phi}\right)\\ \quad+\cos^2\mu_1\left(\frac{2\cos\nu\cos\nu_1}{\sin\phi}-\frac{\cos^2\nu_1}{\sin^2\phi}\right)\end{array}\right]}{2qr\cdot\cos\mu_1\cos\nu_1}$$

$$=\frac{\cos\nu_1\left(\frac{2\cos\mu}{\sin\phi}-\frac{\cos\mu_1}{\sin^2\phi}\right)+\cos\mu_1\left(\frac{2\cos\nu}{\sin\phi}-\frac{\cos\nu_1}{\sin^2\phi}\right)}{2qr}$$

Substituting $\cos\mu_1=0$, $\cos\nu_1=0$ in the above, we obtain: $\sin\beta=0$ $\beta=0$ (Fig. 7)

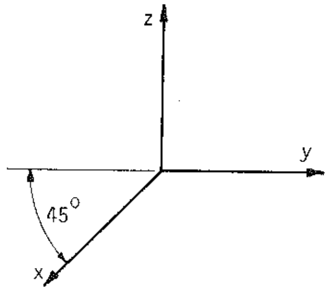


Figure 7

b) Dimetric projection with $q=r=1$ and $p=\frac{1}{2}$

From (IV):

$$p^2+q^2+r^2=2+\cot^2\phi$$

$$\cot^2\phi=\tfrac{1}{4} \qquad \cot\phi=\tfrac{1}{2} \qquad \phi=63^\circ\ 25'$$

We have again:

$$\sin\alpha=\frac{\cos\lambda_1\cdot\cos\nu}{pr\cdot\sin\phi}$$

If we choose $\mu=\nu=\operatorname{arc}\cos\frac{1}{\sqrt{10}}$ and substitute $\cos\lambda_1=1$, $\sin\phi=\frac{2}{\sqrt{5}}$, $\cos\nu=\frac{1}{\sqrt{10}}$ in the above, we obtain:

$$\sin\alpha=\frac{1}{\sqrt{2}} \qquad \alpha=45^\circ$$

and in exactly the same way, as in the isometric case, we obtain $\sin\beta=0$ $\beta=0^\circ$ (Fig. 7)

3) Oblique projection with XY-plane parallel to the picture plane P, i. e., $\lambda_1=\frac{\pi}{2}$, $\mu_1=\frac{\pi}{2}$, $\nu_1=0$, resulting in $p=q=1$.

concluded next page

Here we could also obtain an isometric and a dimetric projection with $r=1$ and $r=\frac{1}{2}$ respectively. The calculations, being similar to those under 2), are not shown here. The axes are shown in Fig. 8.

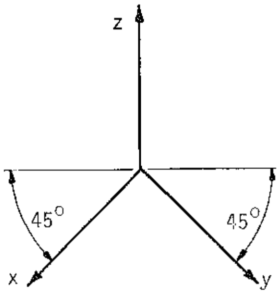


Figure 8

I trust that this elaboration will stimulate those engaged in teaching Engineering Graphics to consider the use of correct geometrical terms and the use of axes in pictorial graphics.

PRELIMINARY ANNOUNCEMENT

ASEE North Central Section

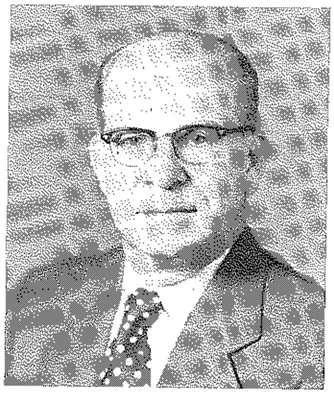
Workshop on Minority Programs in Engineering

The North Central Section of the American Society for Engineering Education will sponsor a two-day Workshop on Minority Programs in Engineering at the University of Pittsburgh in early May, 1977. This workshop is intended for engineers in education, industry, and government who are concerned about, and involved in, the education and employment of minorities in the engineering profession. This workshop will give interested engineers an opportunity to actively participate in discussions that will increase the scope and quality of their involvement in the education and employment of minorities in engineering.

Individual workshop sessions will address the following areas:
- How to start a minorities program in engineering.
- Pre-college programs
  - High school, pre-high school, summer workshops
- Retention
  - Counseling, tutoring
- Financial support
  - Financial aid, summer and co-op jobs
- Program implementation
  - University commitment, faculty in-service training

Participants will have the opportunity to attend all of these sessions.

Additional details may be obtained from: Dr. Karl H. Lewis, Civil Engineering, 740 Benedum Hall, University of Pittsburgh, Pittsburgh, Pa. 15261. (412) 624-5378.



Ralph S. Paffenbarger
Department of Engineering Graphics
The Ohio State University
Columbus, Ohio 43210

A History of the Engineering Design Graphics Division

CHAPTER 2 -- THE NINETEEN THIRTIES

The 1930 membership in S. P. E. E. - 2192

The Wickenden Report was a little ahead of its time in projecting and predicting the direction of engineering education and the need for technical institutes. The depression of the 30's delayed a few years the full implementation of the recommendations.

DRAWING MATERIALS AND INSTRUMENTS: Engineering Drawing Courses up to the early 30's included much inking both on paper and tracing cloth, and sets of instruments included two ruling pens and bow pens as well. Early tracing paper contained a vegetable or mineral oil, and became somewhat brittle with age. It was not until tracing papers improved in clearness and stability that inking became a thing of the past. Methods of reproduction were also slow in developing and had quite an impact on methods of preparing finished drawings. Tracing linen has been long gone, and vellum and mylar are used universally. With these changes, drawing instrument sets have been cut down.

WORK BOOKS AND PROBLEM LAYOUTS: Early laboratory courses took more time because many drawings were made on blank paper, and it was necessary to lay out borders, title strips, lettering, inking, etc. With reduction in time in many courses, methods of speeding instruction has been quite a factor.

DESCRIPTIVE GEOMETRY COURSES: From the early 1920's there were numerous texts on Descriptive Geometry written by various faculty members from all over the United States. Unlike the early Mongean text or texts used universally for many decades, several changes in methods were developed.

A variation from the earlier methods of descriptive geometry came when it was noticed that in many problems the ground line served no real purpose. Also, in the practice of commercial drafting rooms, the ground line is not used, and neither are traces of planes. The first American textbook advocating this method was that of Millar and Maclin (1913). They state that this method is new in American textbooks, but that it has been used to some extent by French authors. This method retains the general idea of projections in building up the theory of the subject.

Now and then, there were some teachers who questioned whether the planes of projection might not be taking more than their share of attention. In 1895, C.W. MacCord stated in the preface of his book, "..... in the treatment of projections the aim is to lead the student to draw these in a matter of fact way as they would appear from different points of view, the express design being to keep out of sight as far as possible the artificial and often useless stage machinery of descriptive geometry."

In 1920, Prof. George J. Hood of the University of Kansas began experimenting in teaching classes in descriptive geometry without ever mentioning planes of projection. The new method seemed to bring an increased interest on the part of the students, and gave promise of other advantages. In 1926 he incorporated these methods in a textbook. A new name, "Geometry of Engineering Drawing," was given to the subject and, for the purpose of library classification, a subtitle, "Descriptive Geometry by the Direct Method."

Along about the same time that Prof. Hood was developing his system, Prof. Frank M. Warner of the University of Washington, using similar methods, began teaching descriptive geometry simply as advanced orthographic drawing applied to more advanced engineering problems. This was prepared first in mimeographed form, and was later published as an available text in 1934 with the title of "Applied Descriptive Geometry." Thus, both of these authors (Hood and Warner) are credited with what is commonly known as "Direct Method."

AMERICAN STANDARD - DRAWINGS AND DRAFTING ROOM PRACTICE

Includes arrangement of views, line work,
dimensioning, sheet sizes, and lettering.

Sponsoring Organizations

Society for the Promotion of Engineering Education
The American Society of Mechanical Engineers

For many years there was a growing desire for a national standard for engineering drawings, and as far back as December 1914 the A.S.M.E. approved and published the report of its Committee on Standards for Cross-Sections.

Progressive manufacturing firms standardized their drawings and drafting room practice and published manuals to record these practices, but there was considerable variation in these practices which led to confusion for draftsmen, designers and instructors. Numerous questionnaires were issued with the idea of accomplishing unification and one of the first was sent out in 1922.

This subject was laid before the A.S.M.E. Standardization Committee in April 1925 and in May the A.S.M.E. Council voted to approve the recommendation of the Committee that the American Standards Association be requested to authorize the organization of a nationally representative committee under its procedure to develop standards for drawings and drafting room practice. This recommendation was considered favorably and a preliminary conference was called by the ASA for October 14, 1925, and a general conference for December 4, 1925.

At the meeting of the ASA Standards Council, December 1925, the project was finally approved, its scope was outlined, and the Society for the Promotion of Engineering Education and The American Society of Mechanical Engineers were designated as joint sponsors. The organization meeting of the sectional committee was held September 24, 1926, at which Dean Franklin deR. Furman was elected chairman. Subsequently six subcommittees were appointed and undertook the formulation of tentative drafts of the several sections of the final report which were distributed for criticism and comment.

During this early period of the Committee's work the S.P.E.E. Division on Engineering Drawing prepared and mailed to its membership a questionnaire dealing with the scope of this project and the subcommittees made thorough studies of the results of this inquiry and of the very large amount of material bearing on company and organization standards which had been gathered together. The standards approved by several of the national standardizing bodies of foreign countries were also carefully scrutinized.

In the spring of 1931 an Editing Committee, Dr. Thos. E. French, Chairman, combined and harmonized the final reports of the several subcommittees. Its report was reviewed by members of the sectional committee. The proposed standard was duplicated and approved by letter ballot vote of the sectional committee in December, 1934. It was subsequently approved by the sponsor societies and transmitted to the American Standards Association for approval and designation as an American Standard, a status which was granted in May, 1935.

There were 56 members of this Committee responsible for this Standard. Ten of them were members of college faculties that represented S.P.E.E. They were:

Roger G. Alexander, Prof. of Drawing, U.S. Military Academy, West Point, N.Y.

Clarence E. Coolidge, Prof. of Machine Design, Georgia School of Technology, Atlanta, Ga.

Thomas E. French, Prof. of Engineering Drawing, Ohio State University, Columbus, O.

Franklin deR. Furman, Dean of College, Prof. of Machine Design, Stevens Institute of Technology, Hoboken, N.J.

Frederic G. Higbee, Prof. of Descriptive Geometry, State University of Iowa, Iowa City, Iowa

Walter H. James, Prof. of Mechanical Engineering Drawing, Massachusetts Institute of Technology, Cambridge, Mass.

Harvey H. Jordan, Prof. of General Engineering Drawing, University of Illinois, Urbana, Illinois

Herbert B. Langille, Associate Prof. of Mechanical Engineering, University of California, Berkeley, Calif.

Harry M. McCully, Prof. of Drawing & Geometry, Carnegie Institute of Technology, Pittsburgh, Pa.

Clarence B. Townsend, Prof. of Engineering Drawing, Cornell University, Ithica, N.Y.

1930 SUMMER SCHOOL

The first summer school of the Division on Engineering Drawing and Descriptive Geometry at Carnegie Institute of Technology was held in Pittsburgh, Pennsylvania June 12-21, 1930. This was by far the largest of the five previous summer sessions held by the S. P.E. E. starting in 1927. The attendance was 103, with a staff of 20 teachers who presented the program, and 57 colleges represented. Prof. Harry M. McCully acted as Secretary, but was the Chairman of the Engineering Drawing Division of S. P. E. E. for the years 1930-1936. He was also Chairman of the Department of Drawing and Descriptive Geometry at Carnegie Tech and really arranged the excellent program.

Dean Harry P Hammond of Pennsylvania State University representing the Society acted as Director and opened the Session on the "Purposes of the Summer School and the Place of Engineering Drawing and Descriptive Geometry in the Curriculum." Quoting from part of this presentation:

"As I see it, the drawing teacher has both a great opportunity and a great responsibility. He is generally the first man in the engineering faculty who has any contact with the freshmen, unless the school happens to provide a separate orientation course. Whether it does or not, the work of the drawing department gives the student the first introduction to the realities of engineering studies, and whether there is or is not a separate orientation course, one of the major functions of drawing instruction, I believe, is orientation to engineering. It is possible, through the drawing work, either to do an excellent job of orientation or a wretched one; I have seen both done. Second, drawing work and, in particular, descriptive geometry, are among the best media through which to teach the concepts of space relations, which are important throughout almost all engineering. Therefore, and this point has been covered many times, drawing gives the opportunity of stimulating students' conceptual powers, a function of such importance that it can hardly be overestimated.

Again, drawing work offers the opportunity of a drill in standards of performance - the meeting of specified requirements and, together with mathematics, gives the student almost his first drill in quantitative, as well as in qualitative, standards. It combines mental and manual drill, the control of nerves and muscles, which always will be of importance to engineers. It offers the opportunity of providing acquaintance with the things that engineers deal with - machines, topography, structures, etc. It offers the opportunity of some drill in elementary design and can be used as a means of introducing the student to the methods through which designs are executed. Above all else, it comes early in the curriculum and, together with mathematics, may be used to set the standards to which the students must adhere in all their subsequent work. These brief statements are sufficient to indicate, as I have said, both the opportunities and the responsibilities of your work, as they appear to one not immediately within your group."

The afternoon session of the first day started with a presentation on "The Orientation of Freshmen to Engineering," by Dean Robert L. Sackett, School of Engineering, Pennsylvania State University. Quotation from the first two paragraphs of his talk:

"The investigation made by the S. P. E. E. emphasized the importance of selection, aptitude and orientation. When we recall that of the students entering engineering, 33% fail scholastically, that 9% change their courses voluntarily and that unknown causes account for another 6%, we are confronted with a problem which includes 48% of all engineering students.

Of the scholastic failures, over 50% are attributed to "lack of ability and lack of interest." Other causes of elimination and failure cannot be attributed entirely to faulty selection or defective guidance but it is a fair judgment that these two functions, if more effectively administered, would avoid an appreciable percentage of elimination and failures.

Our subject is, however, confined to orientation which I define as follows: Orientation of an engineering student consists, first, in informing him of the nature of the work which engineers do or what that particular branch of the profession does in which the student is interested; second, to describe the training required to prepare one for such fields of work; third, to present those aptitudes which are essential and those which are desirable for various lines of engineering endeavor; fourth, to give the student some idea of self-analysis and self-guidance; and fifth, to drill him in the right method of approach to an engineering problem."

OFFICERS OF ENGINEERING DRAWING DIVISION SPEE

Annual Meeting Year	U. of N.C. Chapel Hill 1928	Ohio State Columbus 1929	Ecole Poly Montreal 1930	Purdue W. Lafayette 1931	Oregon State Corvallis 1932	Stevens Hotel Chicago 1933
Chairman	T. E. French	T. E. French	H. M. McCully	H. M. McCully	H. M. McCully	H. M. McCully
Secretary	R.P.Hoelscher	R.P.Hoelscher	R.P.Hoelscher	Jud Rising	Jud Rising	Jud Rising
Executive Committee	H.H. Jordan W.G.Smith F.G. Higbee C.V. Mann H.M.McCully	H.H. Jordan W.G.Smith F. G. Higbee C.V. Mann H.M.McCully	H.H. Jordan W.G.Smith F. G. Higbee C. V. Mann W.E.Farnham T. E. French	C.L.Svensen W.G.Smith F. G. Higbee C. V. Mann W.E.Farnham T. E. French	C.L.Svensen F.M. Warner F. G. Higbee C. V. Mann W.E.Farnham T. E. French	C.L.Svensen F.M. Warner E. Tozer C. V. Mann W.E.Farnham T. E. French
Editor of T.Sq. Page				F.G.Higbee	F.G. Higbee	F. G. Higbee

Annual Meeting Year	Cornell Ithica, N.Y. 1934	Georgia Tech Atlanta 1935	U. of Wis. Madison 1936	MIT-Harvard Cambridge 1937	Texas A & M College Station 1938	Penn State State College 1939
Chairman	H.M.McCully	H.M.McCully	H.M.McCully	J.M. Russ	J. M. Russ	C.L. Svensen
Secretary	Jud Rising	Jud Rising	R.P.Hoelscher	H.D. Orth	H.D. Orth	H. D. Orth
Executive Committee	C.L.Svensen F.M.Warner E. Tozer F.W. Ming T.E.French W.E. Farnham	C.L.Svensen F.M.Warner E. Tozer F. W. Ming T. E. French	Jud Rising F.M.Warner E. Tozer F. W. Ming T. E. French	Jud Rising A.S. Levens E. Tozer F. W. Ming H.M.McCully	Jud Rising A.S. Levens H.C.Spencer F. W. Ming H.M.McCully	Jud Rising A.S. Levens H.C. Spencer F. W. Ming H.M.McCully
Editor T.Sq. Page	F. G. Higbee	F. G. Higbee	F. G. Higbee	F. A. Heacock	F. A. Heacock	F. W. Slantz
Publication Committee			Higbee Russ Mann	Higbee Russ Mann	Russ Mann Heacock	Russ Mann Heacock

Following each of the first two presentations, as in all succeeding talks, there was discussion conducted by selected individuals, with wide participation, which added much to the conduct of the school.

It is interesting to note that Dean Sackett served as president of S. P. E. E. in 1927-28, and Dean Hammond in 1936-37.

Other speakers at this session were Dean Franklin deR.Furman, Stevens Institute of Technology whose topic was "Relationship of Engineering Drawing Courses to Engineering Curriculum," and Thomas E. French, Ohio State University, who spoke on "Objectives of Courses in Drawing and Descriptive Geometry."

The program on the second day included:
Standards for Drawing and Drafting Room Practice. . . Franklin deR. Furman
The Content of an Engineering Drawing Course . . . Harry M. McCully - Discussion
The Content of a Descriptive Geometry Course . . . William G. Smith, Northwestern University - Discussion

The program on the third day included:
Sectioning Students on the Basis of Ability. . . . Henry W. Miller, Univ. of Michigan -- Discussion
Aptitude Tests and their Use in Sectioning Students. . . Clair V. Mann, Missouri School of Mines - Discussion

The program on the fourth day included:
The Use of the Recitation in Teaching Drawing . . . . Randolph P. Hoelscher, University of Illinois - Discussion
The Problem Question: Source, Presentation, Laboratory Methods. . . . Carl L. Svensen, Texas Tech - Discussion
Engineering College Preparation for the Industrial Drafting Room. . . . A. E. Lofbert, Westinghouse Co.

The program on the fifth day included:
A Survey of the Methods of Teaching Descriptive Geometry. . . . George J. Hood, Univ. of Kansas - Discussion
The Use of the Recitation Period in Descriptive Geometry. . . . Carl H. Schumann, Jr., Columbia University
The Use of the Laboratory Period in Descriptive Geometry. . . . William G. Smith, Northwestern Univ. - Discussion
Engineering College Preparation for the Industrial Drafting Room. . . . P. J. Reich, American Bridge Co. - Discussion

The program on the sixth day included:
Demonstration Teaching:

1. A Class in Engineering Drawing
   Thos. E. French
   Ohio State University
2. A Class in Freehand Lettering
   William D. Turnbull
   Ohio State University
3. A Class in Descriptive Geometry
   Harry M. McCully
   Carnegie Institute
4. A Class in Descriptive Geometry
   George J. Hood
   University of Kansas
5. A Class in Descriptive Geometry
   Frederic G. Higbee
   University of Iowa

The program on the seventh day included:
Organization and Administration of an Engineering Department. . . . Harvey H. Jordan University of Illinois - Discussion
The Responsibility of the Teacher. . . . Wm. E. Wickenden, Case School of Applied Science
The Development of a Course in Engineering . . . . Frank M. Warner, University of Washington - Discussion

The program on the eighth day included:
History of the Development of Graphical Representation. . . . Frederic G. Higbee, University of Iowa
Drafting Room Design: Equipment and Appliances. . . . H. W. Harrold, Architect
Reports of Committees:
No. 1 - Aims and Purposes of Engineering Drawing Courses.
No. 2 - Methods of Teaching Engineering Drawing.
No. 3 - Aims and Purposes of Descriptive Geometry Courses.
No. 4 - Methods of Teaching Descriptive Geometry.
Demonstrations: Manufacturing and Printing Processes used with Drawing Papers

The program on the ninth day included:
Reports of Committees:
No. 5 - Coordination of Drawing and Descriptive Geometry Courses with other Courses.
No. 6 - Examinations and Tests of Achievement.
No. 7 - Drafting Instruments and Appliances.
No. 8 - Pre-College Training in Engineering Drawing.
Examinations and Tests of Achievement. . Clair V. Mann
Subscription Dinner. Gardner L. Anthony, guest of honor

As part of the program, visits were scheduled to the Koppers Company, McClintic-Marshall Company, Alleghany Observatory, Westinghouse Electric & Manufacturing Company, and the Carnegie Museum.

This program for drawing teachers was an exceptional and very successful undertaking, and constitutes one of the important milestones in the Division history.

The Montreal meeting of the Society followed the Summer School so closely (within one week) that the Division decided to hold only one session in the three-day meeting. Two important steps were taken, however, in the onward progress of the Division. First, the T-square page in the Journal was authorized and the work of editing it placed in the competent hands of Professor F. G. Higbee. Secondly, the term of office of a member of the executive committee was fixed as five years and the expiration dates of those then serving on the committee were determined by lottery. It was decided that the retiring chairman should be a member of the committee ex officio for one year. The single paper presented by Professor Landrean described the work done in Drawing and Descriptive Geometry in the Ecole Polytechnique of Montreal and served admirable to contrast the systems of teaching these subjects in the United States and Canada.

The Division developed the theme type of program at Purdue in 1931 by focusing the contents of five excellent papers on a general topic, "Art in Engineering Drawing and Design." The program attracted wide attention and many favorable comments.

Steps were taken at the Purdue meeting to inaugurate a national competition in drawing. The subject was given further consideration at the Corvallis meeting in 1932, and a committee was appointed to investigate the possibilities of a more definitely organized competition than had been proposed up to that time.

Specifications for the first competition were approved by the executive committee in December, 1932. Thirteen institutions submitted drawings to be judged at the Chicago meeting in 1933. Twelve students in eight institutions received awards in four classes of drawings. In 1934, twelve students in nine institutions received awards. In 1935, there were ten students in eight institutions winning awards. Each class was composed of three subdivisions but the subject of the drawing and the size of paper to be used were not specified so that difficulty in judging the drawing arose through lack of uniformity and standards of comparison.

The competition was changed in character in 1936 to insure more standarized specifications for the problems and to give greater simplicity and ease in judging the entries. Nine classifications were established in place of twelve with a first and second award in each class. The problems to be executed were drawn up by the committee in charge and distributed to schools planning to enter the competition. Ninety-seven drawings were entered in 1936 at the Wisconsin meeting. Seventeen students from twelve institutions received awards. The beneficial results of the change in specifications were clearly evident in the work of judging these entries.

The 1937 competition, judged at Cambridge, resulted in seventeen students in nine institutions earning awards. There were one hundred and eighty entries in this competition.

(A glimpse into the future shows that the competition was changed in 1942 to become a display of student work in complete courses, so that the members of the Division might have an opportunity of seeing the complete laboratory work that was accomplished in each given course, and thus become better acquainted with the overall accomplishments throughout the Division.)

The Wisconsin meeting of the Society in 1936 was marked by a three-day preconvention conference of the Drawing Division. This was a sort of abbreviated summer school with six formal half-day sessions culminating in the annual dinner of the Division. The Division took an important step forward at this meeting by authorizing the publication of the Journal of Engineering Drawing as a medium of presentation and discussion of papers prepared by members of the Division. This major undertaking may be considered the infant child of the Division although he promises to develop into a very husky youngster in the publication field.

Space does not permit any adequate mention of the important part committee work has played in developing the scope of and the interest in the activities of the Division by members of the Society. We mention only a few without disparagement to the many others.

Professor Mann's committees on Research and Investigation, Objective Tests, and Visualization have given much to the Division. The committees on Historical Books, Instruments, and others have contributed very greatly to the prestige and interest in the Division. Individual papers have been many and of high rank in character.

Regardless how much stimulation and value may have come to its members out of the first ten years of the Division's existence, it was judged that its future success depended on the continuation of the ideals which had guided the Division, and an even greater effort by an even larger segment of the membership in conducting the affairs of the organization.

Robert M. Barnett
Associate Professor
Department of Civil Engineering and
Engineering Mechanics
The University of Arizona

Engineering Graphics at the University of Arizona

Engineering Graphics means different things to different people. To some it is basic drawing of mechanical parts, to others descriptive geometry, to others the designing of objects or devices, to others some combination of these and so on. Here at the University of Arizona, we have taken a look at the background of our students, the time (credit hours) allotted for graphics and the objectives of the departments in engineering for the students we teach in setting up our program. We also have considered the courses that the students are taking concurrently with graphics and the courses they will be taking subsequent to graphics, whether graphics is a prerequisite for the course or not. It is only in this manner that we can set up some goals and objectives for our courses.

Of our engineering students who take graphics, approximately 83% have had either no mechanical drawing background or less than one year. The balance of 17% have had one or more years of high school mechanical drawing. Those students with one year or more are channeled into C. E. 11, 3 units, an advanced Engineering Graphics class and those will less than one year are enrolled in C. E. 10, 3 units, the regular Engineering Graphics classes.

It is obvious that the majority of the students must start from scratch, so our course must start with the fundamentals of graphics, lettering, basic orthographic projection, pictorials, auxiliaries, sections and dimensioning. Here we stop and take a good look at our objectives -- do we want to make draftsman or do we want our students to learn the fundamentals of Graphics so they can be in a position to direct draftsmen, to visualize objects in space, to know how to read drawings and if necessary be able to make drawings. We believe the latter statements are true, but we also believe that they can best learn these things by doing them, so we put them on the board for freehand and instrument drawing.

In order to develop their ability to analyze, visualize and solve graphical problems, we take them on into descriptive geometry. Since only 3 units are allotted to graphics, we can only go into those topics that are the most important and most fundamental. These are the line and plane problems, Note that the solution of vector problems, intersections and developments are based on the principles learned in line and plane problems and, hopefully, the student can think through these problems when and if the need arises.

The students that are required to take graphics are those in Civil Engineering, Aerospace Engineering, Mechanical Engineering, Engineering Math, and Agricultural Engineering. These all take the common course in Engineering Graphics or Advanced Engineering Graphics. In our basic graphics we have one hour of lecture with visual aids and six hours of laboratory per week. We have the students draw mechanical parts to teach them orthographic projection and dimensioning. In the descriptive geometry part of the course, we give the students ditto sheets with practice problems which illustrate the theory for each principle, then we assign a variety of practical engineering type problems, spread over as many disciplines as possible so that each student can see that there is an application in his particular field.

In our Advanced Engineering Graphics course we also have one hour of lecture and six hours of laboratory per week. In this class we use a workbook plus some problems from the text. First we have the students make some freehand orthographic sketches with dimensions and some freehand pictorials to check on their background. Then we take them into descriptive geometry with mostly engineering application problems. Because we spend less time on basic orthographic projection we are able to go into vectors, intersections and developments, graphical calculus, charts and graphs, empirical equations, nomographs and linkages and cams. We do not go deeply into these, but enough so the student has a feel for and appreciation of the graphical methods and when they are appropriate for solving and/or visualizing and analyzing these problems.

In addition to the above, both of the Engineering Graphics classes have a design project to work out. The difference is that in C. E. 10 they are allotted six hours to make up working drawings of some object or device of their own choice so it necessarily is a simple device. In C. E. 11 the students are allotted about 20 hours spaced throughout the semester and in addition to the working drawings are required to write up a report on the design project which includes a letter of proposal, preliminary ideas and sketches, the working out of the final design, the pitfalls, areas in which their background is deficient, etc. We have found the design project a very effective motivating element in that the students (1) have a sense of accomplishment, (2) find that they need more knowledge about materials, forces, etc. and (3) start looking forward to the courses that will provide this information.

To bring what I have stated above all together, our objectives are to bring our students to the point where they can read drawings, visualize lines and objects in space, analyze data and put it in logical order to solve graphical problems (this helps also in their math and science problems), to put graphical methods in their proper perspective in the solution of engineering problems and to be able to apply these graphical principles in subsequent courses such as Surveying, Statics and Dynamics, Structures, Machine Design, etc. The proof of the pudding, of course, is in the eating.

How have our students fared in subsequent courses, in part time and summer jobs, in co-op programs, etc? In talking to instructors of subsequent courses (and I might say there are only one or two that require drawings) they have informed me that the students are well prepared and qualified. Students have reported back from part time, summer and co-op jobs to say that their on board experience was very useful and adequate for their jobs. One co-op student who had taken C. E. 11 came back stating that both his board experience and report writing had helped him tremendously, while other students without this background were at a disadvantage.

We have been under some pressure in recent years to include some computer graphics in our courses. We have been reluctant to do so for three reasons:

1. Students need to learn the fundamentals of Engineering Graphics. Our time is too much taken up with this to confuse them with computer programming in the same course.
2. Our students take a one unit course in computer programming but only about one-third of them take it concurrently with graphics. We do not have enough time in our course to teach programming.
3. Once the student has learned the principles of orthographic projection in our course and the use of the computer in his computer course, he will have very little difficulty in combining the two if and when the occassion arises in subsequent courses or on the job.

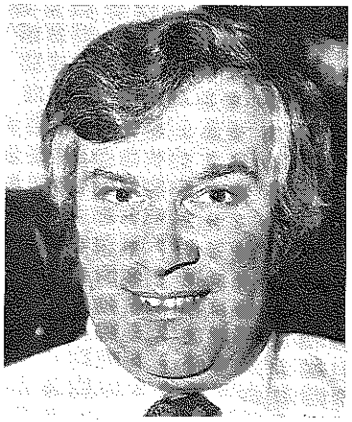
As a postscript, the local unit of the American Society of Structural Engineers recently made a survey and appraisal of our curriculum in Structural Engineering and found no fault with our graphics courses, except that they would like to have us give more structural problems and have one or two advanced structural courses where the students would design and draw up structures.

INTERACTIVE DESIGN SYSTEMS CONFERENCE

April 13-15, 1977 Stratford - upon - Avon

This conference will bring together an international group of experienced users of interactive graphics-based design and manufacturing systems. The goal is to produce a state-of-the-art report of value to users and suppliers alike, reflecting current experience and future requirements. The Program is to be in four parts: Suppliers' presentations, Detailed Users' case studies, Forum Discussion of Experience, and Research Sessions.
Attendance will be by invitation only and full proceedings will be published. Persons interested in participating as speakers, chairmen, or attendees, should indicate with B. Gott, Chief Consultant, The Computer Aided Design Centre, Madingley Road, Cambridge, England, CB3 OHB., indicating their topic of expertise.

Alan J. Brainard
Director
Freshman Engineering Program
University of Pittsburgh



Freshman Engineering Design Projects

Freshman students in engineering at the University of Pittsburgh have some choice in their engineering course selection. A series of mini-courses or modules of seven-week duration have been developed and in service for the past three years. More information concerning these modules has been given (1). This paper is concerned with student projects in one of these, the creative design module.

Students in the creative design module are divided into teams in the "workshop" (laboratory) sessions of the course and work as teams on several group projects. Teams usually number three or four students. With the present enrollment, this results in approximately thirty-five student teams in three workshop sessions. Two projects are assigned the students during the module.

The first project, a five-week assignment, places major emphasis on the construction and testing of a workable prototype. A number of projects have been used in this assignment. The following provides a brief description of three of these projects.

Project I Egg-Delivery

Problem Statement

A pine board 8" high and 8' in length is placed 8' from a starting line. A target having a bull's eye of 5" in diameter is then placed with the center of the target 8' from the board. The starting line, board and target are all in a smooth horizontal plane. Figure 1 is a schematic of the set-up. Each team of students is given a raw hen's egg and asked to construct a "vehicle" that will travel either over or around the barrier to deliver the egg unbroken to the target. An acceptable solution includes either depositing the egg on the target or having the "vehicle" stop with the egg above the bull's-eye. Constraints on the solution included.

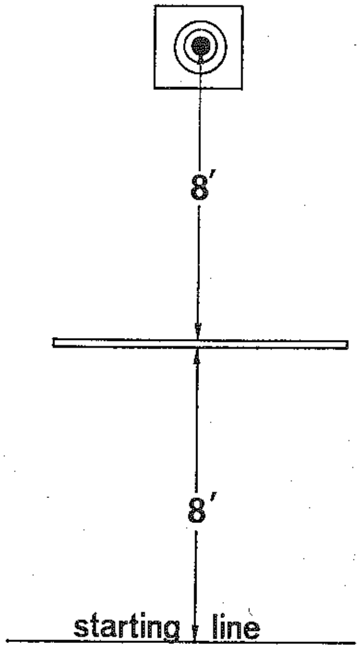


Figure 1. Egg delivery setup.

. . . . . No trained pets.
. . . . . Each group was allowed a single interaction with their "vehicle". (They could close a switch, plug the vehicle in, etc. This eliminated radio-control and other devices which provide continuous control.)

Description of Student Solutions

A great variety of solutions were attempted. Of the thirty-four student teams that participated only four teams were able to deliver the egg onto or directly above the bull's-eye. Two of the successful solutions will now be described.

Successful Solution No. 1

Two circular discs having a diameter of 8/ feet were cut from sheets of Masonite® and joined in their center by an 8" axle. A notch was cut out of each disc that would enable the disc to just slip over the board as it travelled to the target. The discs were placed behind the starting line and given a gentle push toward the target. One revolution would bring the discs to the board and a second revolution would bring them to the target. The egg is placed in a container which is attached to the axle by a cord which unwinds as the discs roll. After two revolutions the container reached the floor and very neatly served as an anchor for the folling discs. After a few trials the "vehicle" was nearly fool-proof. Figure 2 provides a schematic of this solution.

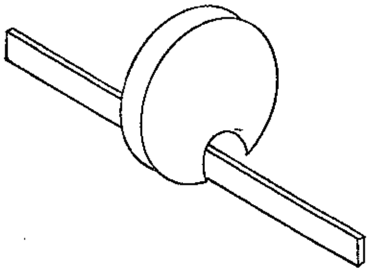


Figure 2. Solution no.1 – egg delivery problem.

Successful Solution No. 2

A "vehicle" having four sets of legs on wheels driven by a motor formerly used to drive a home barbecue spit was the second successful prototype. The "vehicle" travelled to the board until it made contact with it. The lead set of legsthen flexed back enabling the vehicle to progress until the second set made contact. These also flexed back, the motor activated a third set of legs which then provided stability while the first two pairs of legs, which by this time had cleared the board, returned to the floor. The fourth set then made contact with the board and they flexed back and loced in an upright position. Figure 3 provides a schematic for this solution. As the "vehicle" continued on, a treble fish-hook attached itself to the board. A length of string then played out until the "vehicle" reached the target. When the end of the string was reached, a switch stopped the motor and activated a trap-door release that delivered the egg to the bull's-eye.

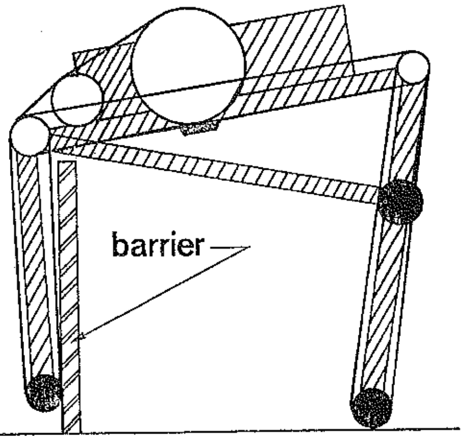


Figure 3. Solution no. 2 – egg delivery problem.

Other "vehicles" included ones that travelled on a circular arc around the barrier to stop on the target, a hydrogen balloon (not very successfull) and a solid-propellant powered device that literally "flew" across the floor and delivered the egg by having it slide down a ramp. Several of the student solutions including the two successful ones described above were demonstrated at an session at the ASEE annual conference in 1974.

Project 2 Get the Bone Away from the Watchdogs

Problem Statement

A rawhide dog bone is placed in the center of a circle 12' in diameter. Three watchdogs (plastic banks of the former TV character "Underdog") are placed in an equilateral pattern within the circle to surround the bone. The same target used in Project 1 is then placed adjacent to the perimeter of the circle. Figure 4 provides a schematic of this set-up. The object is to construct a "vehicle" that starts totally outside of the circle and the target area (outside of the infinite cylinder and rectangular parallelepiped that rise above them also), enters the circle, "grabs" the bone and delivers it either to the bull's-eye or within the infinite cylinder that rises above it.

Constraints included:

. . . . . No trained pets.
. . . . . A single interaction with the "vehicle".
. . . . . Loss of 25 points if one of the watchdogs were bumped.

Description of Student Solutions

Once again a great variety of solutions were developed. This problem proved to be easier as more than half of the student teams delivered the bone to the bull's-eye.

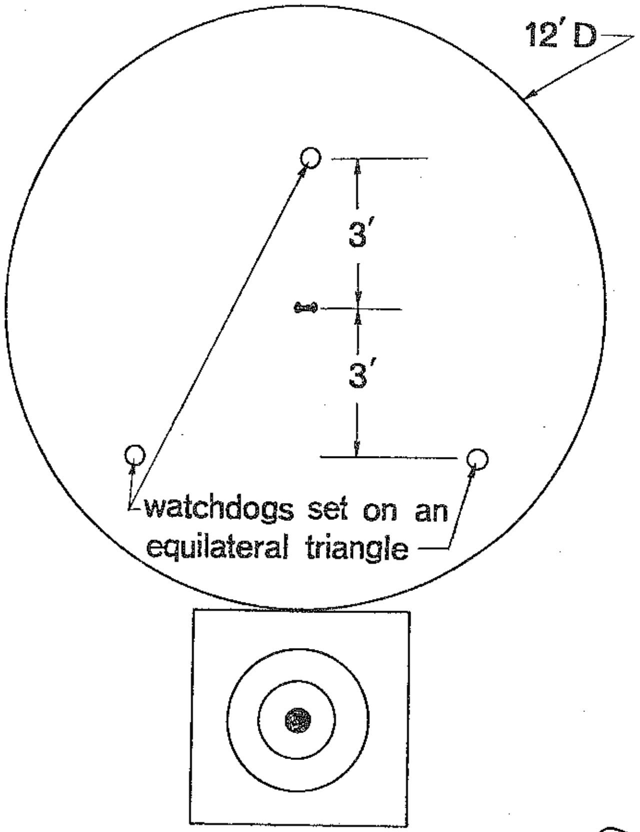


Figure 4. Bone – watchdogs setup.

Successful Solution No. 1

A rigid rod attached to the roof of a dog house which is placed outside the circle had a paper-mache dog (a la Snoopy) attached to the other end. A motor inside the dog house was turned on and Snoopy entered the circle, reached the bone, and then gently pushed the bone to the bull's-eye with the help of a small "cowcatcher" attached to the front of Snoopy. When the rod had travelled the correct distance it closed a switch which stopped Snoopy and the bone right on target. Figure 5 presents a schematic of this solution. This approach which I call a fixed-pivot approach was the most common one used.

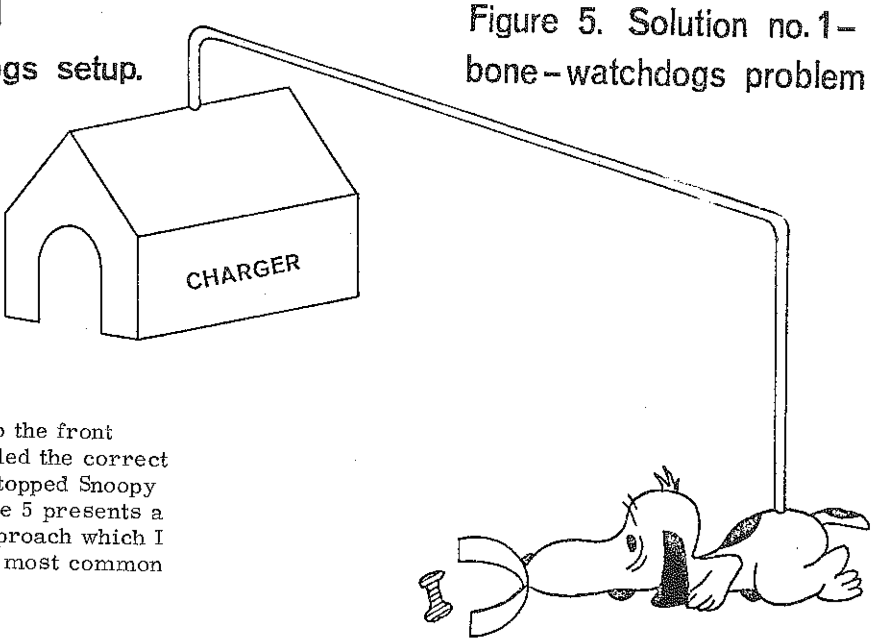


Figure 5. Solution no. 1 – bone – watchdogs problem

Successful Solution No. 2

A schematic of this solution is presented in Figure 6. Once the switch activating the drive motor is closed the "vehicle" travels across the target until the small plate at its front slips under the bone. A relay turns the drive motor off at this point. After a brief wait a second motor is automatically activated causing the plate to lift and drop the bone on a conveyor belt that then takes it to the end of the "vehicle" where it falls directly on the bull's-eye. This "vehicle" was almost precision made as it could travel over 10 feet without deviating as much as 1/8" from a plumb line.

Project 3 Marble Delivery

Problem Statement

Given a ramp 2' from a starting line rising at a 10° angle with the floor attached to a board which is in a plane parallel to the floor, each team is given 10 marbles at the mid-point of the starting line which they place in a "vehicle" of their design that delivers the marbles to a container located in the cut-out of the horizontal platform. Figure 7 provides a schematic of the set-up.

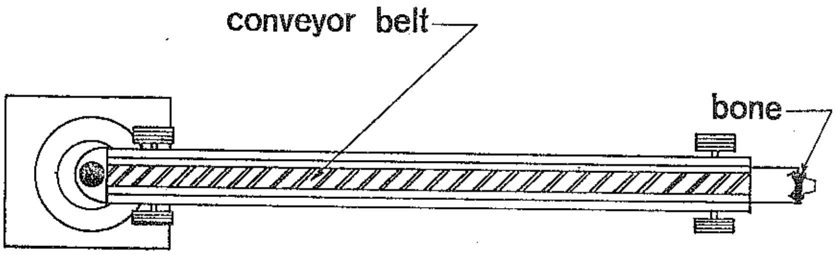


Figure 6. Solution no. 2 – bone – watchdogs problem.

Constraints included:

. . . . . No trained pets.

. . . . . A single interaction with each "vehicle"

. . . . . No cord that goes back to the starting line that controls the "vehicle" is allowed.

. . . . . Marbles may not be delivered in a bundle.

. . . . . The "vehicle" was penalized 25 points if it delivered the marbles in kamikaze fashion by falling into the container.

A special bonus was given to the student group whose "vehicle" was least massive that did deliver all ten marbles.

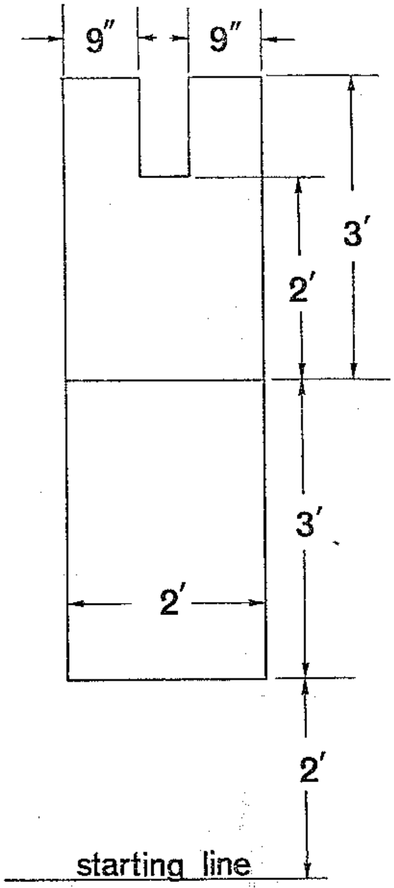


Figure 7. Marble delivery setup.

Description of Student Solutions

Most of the solutions attempted for this project involved "vehicles" that climbed the ramp and managed to stop short of the cut-out. Approximately fifty percent of the student teams were successful.

Successful Solution No. 1

This "vehicle" was a small car constructed of balsa wood powered by two "C" cell batteries with a self-contained switch that turned the power off at the front edge of the cut-out and then released the marbles to fall into the container by gravity.

Successful Solution No. 2

A "vehicle" having a long hollow plastic tubing was attached to a motor assembly as shown in Figure 8. When a switch activating the motor is closed, the tubing travels on an arc until the snout is over the container. The motor is turned off and the marbles are released to fall into the container by gravity.

The actual student demonstrations were covered by several of the local TV stations and were aired along with the news of the day. Further, one of the local TV talk shows has provided about 10 minutes of live coverage of the student demonstrations the past two years.

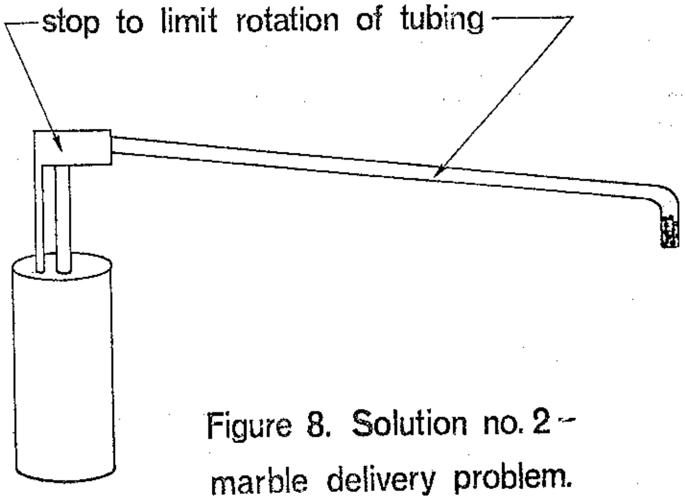


Figure 8. Solution no. 2 - marble delivery problem.

No funds were provided to support any of these projects. The students "begged, borrowed and bought" the necessary materials. Further, no university tools or personnel were available to assist the students in construction of their "vehicles".

The students enjoyed the construction of the working prototypes and were wildly enthusiastic when their "vehicles" were successful. As each of these projects allows an infinity of solutions, all student groups in theory could realize a grade of 100 for the assignment. The projects were designed so that all groups could "win" (solve the problem). The author has also employed projects which were "win-lose" (a race, for example) and has found that "win-win" is a better format for student competition. This point has been considered in more detail in (2).

The second design project was of two-week duration and addressed design areas that had been identified by the United States Consumer Product Safety Commission as serving as real potential health hazards for young children.

The following projects have been used:

1. Develop a design improvement that can be added to present day bicycles or form an integral part of the design of future bicycles that can contribute to their safety.
2. Design a child-resistant safety match (for a child less than seven years old).

Once again students were expected to develop working prototypes of their designs and communicated their solutions by means of both oral and written reports.

A number of interesting possibilities surfaced from the bicycle safety project. One team developed a braded clamp that was attached to the front fork and prevented the front wheel from falling off even when the two holding nuts had been completely removed. As young children have a great love of "popping a wheelie" this item could serve to reduce accidents resulting from this practice. A display of this item was exhibited at the Engineering Design Graphics Division display in 1974 where it won an honorable mention. One of the two young women who developed the idea is currently pursuing a patent on her idea.

Student proposals of an improved safety match design ranged from placing the matches in a container similar to those presently used for medicines to elaborate attempts to disguise the striking surface. Some even suggested a number of improvements that have been incorporated in the proposed matchbook standards. (3)

Student acceptance of the creative design module has been very favorable. A summary of one student's favorable experiences was presented at the ASEE Annual Conference at Colorado State. (4) They enjoy themselves while learning to work as a team and to meet deadlines. There has been no procrastination problem with over 150 teams as all teams have had their prototypes ready to test on competition day. There seems to be a definite advantage to assigning projects requiring a kinetic rather than static solutions. Perhaps the students view them as more of a challenge.

My experience with these projects has also been very satisfying. This approach does keep one busy thinking up new projects -- but that in itself is a source of satisfaction.

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2. Brainard, A. J., "Teaching Win-Win Better Prepares Students for Subsequent Experiences in Life", paper presented at session 1635 ASEE Annual Conference, June, 1975.

3. DeMarco, J., "Making a Safer Matchbook A Case Study in Standards Setting", New Engineer, 4, No. 7, 24 (July/August 1975).

4. Krejdovsky, K., "Experiences in a Freshman Engineering Design Course at the University of Pittsburgh", paper presented at a panel discussion "Spitball Review" at ASEE Annual Conference June, 1975.

Jobs

The University of Wisconsin - Milwaukee is seeking a Lecturer in engineering design and graphics. Areas of concentration: design techniques, graphics, and descriptive geometry. Secondary areas possible: computer graphics and/or manufacturing processes. Qualifications: M. S. in engineering or technology with industrial design experience. Send resume to Prof. Earl Ratledge, Systems Design, University of Wisconsin - Milwaukee, Milwaukee WI, 53012. UWM is an affirmative action/equal opportunity employer.

The Engineering Design Graphics Department of Texas A&M University is seeking applicants for an assistant or associate professorship. Duties will include the teaching of engineering graphics and descriptive geometry to freshman engineering students. Applicants should be competent in and able to teach specialty courses such as computer graphics, electronic drafting, pipe and vessel drafting, nomography, etc.

It is preferred that applicants have a doctor's degree with at least one degree in a field of engineering. Salary is open based upon the qualifications of the applicant. Texas A&M is an equal opportunity, affirmative action employer.

Graduate Assistantships and part-time teaching positions are also available in the Engineering Design Graphics Department.

Contact James H. Earle, Engineering Design Graphics Department, Texas A&M University, College Station, Texas. Phone (713) 845-1633.

Faculty position open in the area of engineering graphics for the Fall 1977 semester. Additional interest in computer graphics, industrial design, architectural drawing, and extension conferences and short courses are also desirable. For more information, contact the Chairman of the Mechanical Engineering and Aerospace Engineering Department, University of Missouri-Columbia, Columbia, Mo, 65201. The University is an equal opportunity/affirmative action employer.

Jack Arwas
Technion, Israel Institute of Technology

VISIBILITY of POINTS on the ISOMETRIC VIEW of a SPHERE

It is generally easy to determine the visibility of a given point on the isometric view of a sphere, especially if it could be related to some line on the sphere envelope.

In some cases, however, the answer is not quite obvious and it would be useful to establish a method to determine the visibility of any point on the isometric drawing of a sphere.

The Problem

To present the problem, we will assume the sphere as being projected on the horizontal and vertical planes shown in Fig. 1. The isometric direction is projected as two arrows, and the large circle perpendicular to this direction-which is the contour circle on the isometric drawing of the sphere - is projected as ellipses on the horizontal and vertical planes. The direction and length of the ellipses axis are obtained by the usual "shade" construction shown in Fig. 1.

As the contour circle in the isometric drawing divides the sphere into two parts, the nearer to the observer visible and the other hidden, it is therefore important to establish whether any point A on the sphere envelope is nearer to the observer or farther.

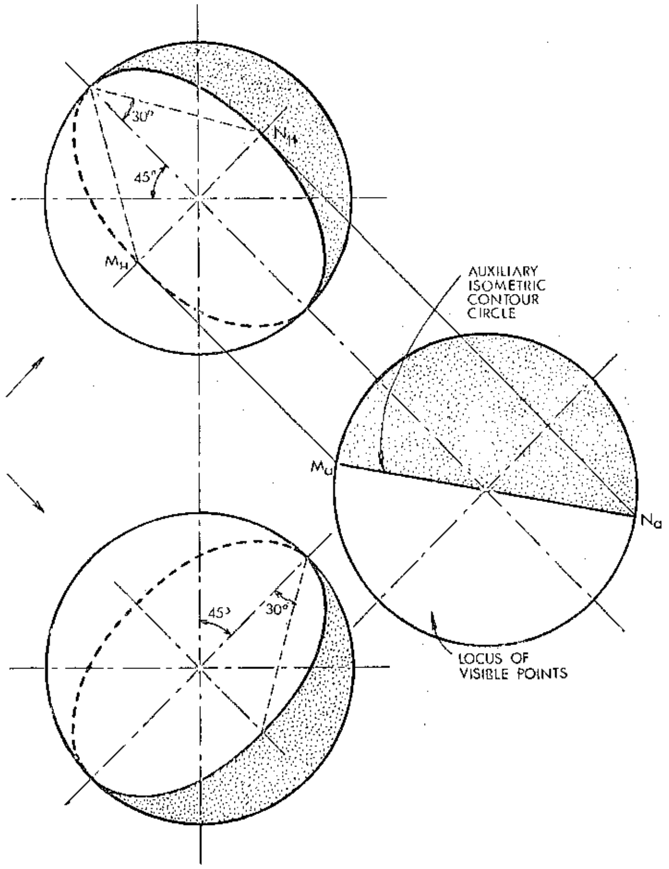


FIGURE 1

Jack Arwas is also the author of an earlier Journal article (V38, n2, Spring 1974, p11) concerning spheres in isometric.

Chairman Clarence Hall, in reviewing this article, correctly observed that both first- and third-angle projection are used in Figures 1 and 2. While this should probably be corrected for publication in this country, the Editor felt that it would be better to expedite publication of this article, which has already been delayed by the change of editors. Perhaps the exercise required to interpret these figures will prove valuable to our readers.

Auxiliary Projection

In order to get a conclusive answer, we may project the sphere on an auxiliary plane so that the isometric contour circle will be projected on it as a straight line MaNa as shown in Fig. 1. This plane is perpendicular to the isometric direction and the projected contour circle divides the sphere into two parts, the first being locus of all the visible points and the second of all the hidden points in the isometric view of the sphere.

Four Zones

By dividing the horizontal projection of the sphere into 4 zones as shown in Fig. 2, we can safely state that any point A located on the sphere envelope and projected as A_H and A_V on the horizontal and vertical planes, will be hidden as A_I in the isometric view of the sphere, if A_H is located in zone 1 and visible if A_H is located in zone 4, independently of the location of A_V in both cases.

We can further state that if A_H is located in zone 2: A_I will be hidden if A_V is below the zero level; and if A_H is located in zone 3: A_I will be visible if A_V is above the zero level.

The only cases where further checking will be required, is when:

a) A_H in zone 2 and A_V above zero level.
b) A_H in zone 3 and A_V below zero level.

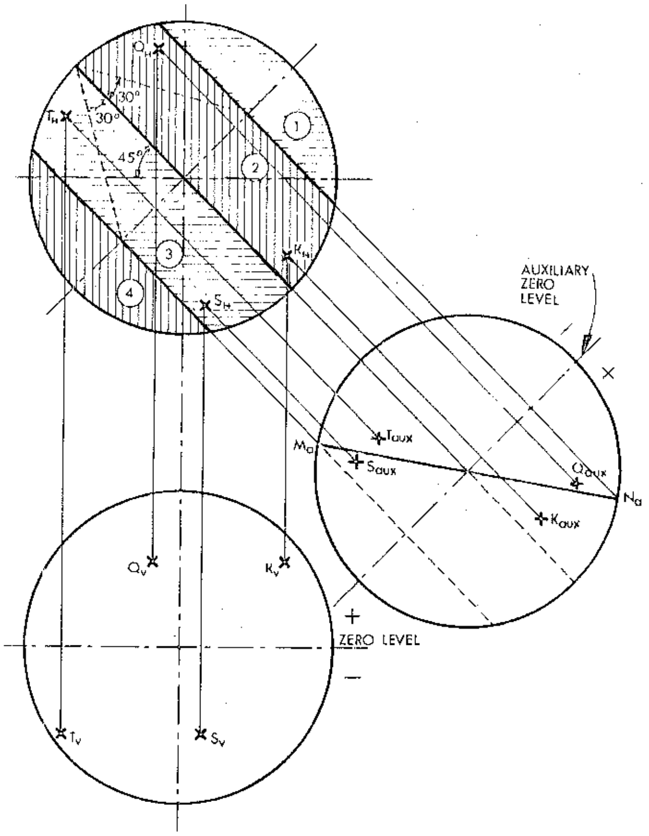


FIGURE 2

Thus, points K and Q located both in zone 2, will be declared "visible" in the case of K and "hidden" in the case of Q, after further checking on the auxiliary plane shown in Fig. 2.

Similarly, points S and T located both in zone 3 will be declared "visible" in the case of S and "hidden" in the case of point T.

Table

To summarize, we can draw the following table:

ZONE 1	ZONE 2	ZONE 3	ZONE 4	THE ISOMETRIC PROJECTION		
				VISIBLE	HIDDEN	TO BE CHECKED
A_H					X	
	A_H, $A_V$neg.				X	
	A_H, $A_V$pos.					X
		A_H, $A_V$neg.				X
		A_H, $A_V$pos.		X		
			A_H	X		

Application

Let us assume that on the sphere envelope projected in Fig. 3 we have the points A, B, C, D, E, F. These points are located on the isometric drawing of the sphere shown in Fig. 4 as A_I, B_I, C_I, D_I, E_I, and F_I. We have to determine which of these points will be visible and which will be hidden. To start with, we can draw the four zones previously mentioned. We may also have the auxiliary view coincide with the horizontal projection thus designating straight line MN as "auxiliary isometric contour circle".

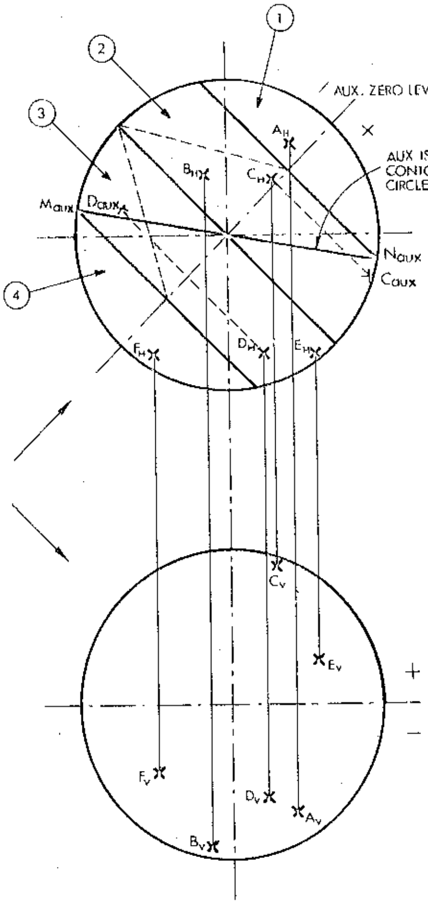


FIGURE 3

Now we can draw the following conclusions:

A. Since A_H is in zone 1, then A_I is hidden.

B. Since B_H is in zone 2, and B_V is below the zero level, then B_I is hidden.

C. Since C_H is in zone 2 and C_V is above the zero level, C_{aux} indicates that C_I is visible.

D. Since D_H is in zone 3 and D_V is below the zero level, D_{aux} indicates that D_I is hidden.

E. Since E_H is in zone 3 and E_V is above the zero level, then E_I is visible.

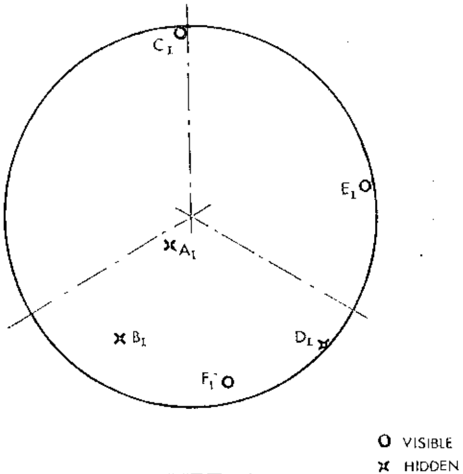
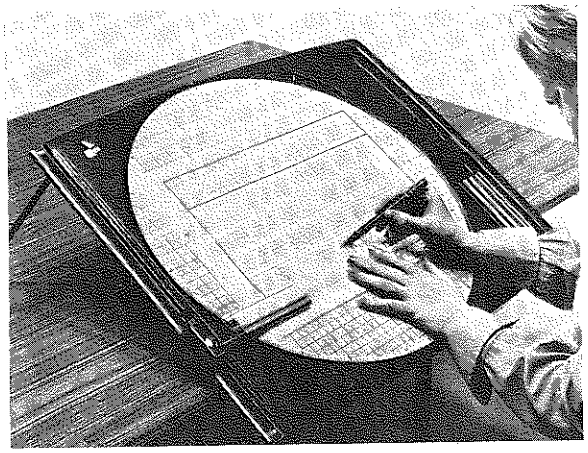


FIGURE 4

F. Since F_H is in zone 4, then F_I is visible.

NEW PRODUCT RELEASE

ROTOBORD



SUBEN & COMPANY introduces Rotobord, a new portable semi-automatic drawing board. The manufacturer claims that its rotary table with a unique spacer unit cuts scaling time in half. Its large protractor allows for smaller precision scaling sizes up to 18" x 18". Free spin with click stops at 0, 30, 45, and 60 degrees. Metric conversion chart included. Excellent application for technical drawing, form design; facilitates uniformity in cicuit and isometric diagrams.
15 W. 110 83rd St., Hinsdale, IL 60521.

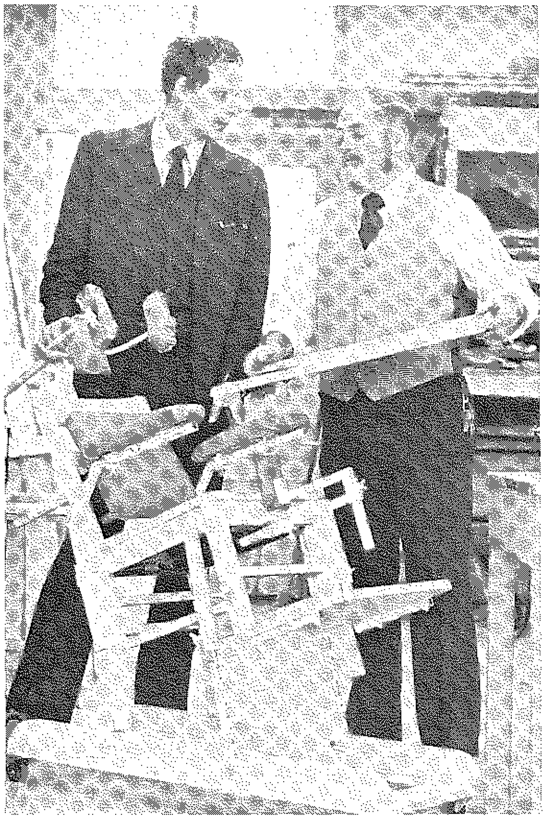
MSU Technician Designs
Orthopedic Chair for Children

Charles Thomas, senior engineering technician for Mississippi State University, has designed and built a special orthopedic chair for training handicapped children. It can also be used for adults.

The chair is presently in use at the Mental Health Regional Developmental Training Center in Starkville.

Because of his previous work in physiotherapy, Thomas became interested in a course offered by the Department of Special Education entitled, "Teaching the Severely Retarded Child."

The purpose of the course, according to Professor H. M. Blaine, is to analyze the development of the severely retarded child and prepare him through educational programs for a useful life in the home and community. To realize this goal, Dr. Blaine required his students to observe the children at the Regional Developmental Training Center and complete a project working with them.



NEW ORTHOPEDIC CHAIR - Dr. Marty Blaine (left) of the Department of Special Education at Mississippi State University examines the new orthopedic chair designed and built by Charles C. Thomas (right), technician in the Departments of Engineering Graphics and Industrial Engineering at Mississippi State University.

On his first visit, Thomas realized that the children needed a special training aid. Consequently, he promptly began his project; the design and construction of an orthopedic chair. Using an old straight-back chair and metal and wood scraps from various workshops, Thomas spent 50 hours constructing the training device.

Built originally to aid a child with cerebral palsy, the chair can also be used to train children with polio or other serious motor disorders. It holds the child comfortably erect while enabling the child to gain dexterity. Furthermore, the chair has no belts to strap the child in, thus increasing the user's confidence. The chair is also invaluable for holding the attention of hyperactive children.

All parts of the chair are adjustable, so that any size person from an infant to a 200-pound adult can use the design comfortably. The chair can be fully reclined for sleeping while a head brace can be used to keep the child's attention during training.

A tray can also be attached to facilitate eating, reading, and working. Rollers on the base of the chair make transportation easy. Built to optimize space utilization, the chair has made working with handicapped children much easier for the personnel at the Mental Health Complex.

* * *

Limerick Laureates

A COUPLE OF LIMERICKS FROM MISSISSIPPI

BY MARY JASPER

There once was a gal who said "Y'all"
When she knew that "you" was all
she needed to utter
but she remembered her "mutter"
Who'd said, "Girls from the south have a ball!"

I've heard of a writer of late,
Who tended to procrastinate.
No deadline she'd meet.
Editors thought her no treat.
I wonder what will be her fate.

Paul S. DeJong
Department of Freshman Engineering
Iowa State University

Improving Visualization: Fact or Fiction?

The work described in this paper is the outgrowth of several seemingly disconnected thoughts and observations, separated in both subject and time, and which must be outlined and properly related to explain the project. It is also appropriate to clarify that the visualization discussed here is simply that ability to construct and retain a strong, vivid mental image of a problem at hand.

The first observation came as a result of trying to motivate students in the freshmen graphics course. The writer suggested to his students that there are several reasons for learning orthographic projection and descriptive geometry, including the obvious need for an accurate method of description, analysis, and synthesis. It was also pointed out that a less-obvious side effect of the experience was the improvement of both analytical ability and visualization ability. A graphics course should, among other things, increase the students' ability to visualize the processes and physical significance of many diverse phenomena to be encountered, from spatial position to clearances and piercing points to heat or electron flow to molecular arrangements to Fermi surfaces. The overall goal should be the ability to synthesize and communicate with others as a result of clear visualization and basic graphic abilities.

Second: while many engineers would probably agree that visualization is a major goal of a graphics course, it appeared to the writer that visualization was not a defined objective of the typical graphics course content; it was not being taught but rather "taught at". This is incompatable with the increasingly more important requirement to use time more effectively. Therefore attempts were made to encourage active visualization involvement in lectures, class exercises, and quizzes. This tended to involve only the better students, though, and it was obvious that a more systematic approach was needed.

Third: It appears that the basic visualization abilities of an ever-increasing number of students have deteriorated badly as a result of a constant barrage of television images over the formative years. These images allow no significant exercise of any thought processes, and many students seem to be unable to conjure up anything more than the simplest mental images. Asking them to imagine a cutting plane passing through two intersecting planes is too great a load for their undersized visualization wiring.

Fourth: It is generally agreed that highly creative persons demonstrate outstanding visualization abilities. This has been observed in the work and writings of many famous people such as John Browning[1], Nicolai Tesla[2], and Charles Kettering[3]. Lewis Walkup[4] came to this conclusion in a study of his co-workers, as did Faste[5] in a study of student creativity. In recent years a great deal of effort by McKim[6], Vander Wall[7], Samuels[8], and others have produced a great deal of fine material on visualization training.

These admittedly subjective observations led the writer to believe that many students enter college with a poor ability to visualize, but need that ability not only to understand much of the material they will be required to master, but also to realize their full creative potential. Engineering graphics or some similar course is needed to improve visualization but is generally not doing so at present. Finally, to develop visualization, problems must be employed which require construction of a mental image, which cannot be done without that mental image, and which are of progressive difficulty.

THE EXPERIMENT

Pursuing an idea discussed by Nelson[9], an informal exercise was tried in which students were required to draw views of some unseen basic shapes - infant's toys - contained in paper bags. Students were enthusiastic about the problem and it was gradually seen to have potential on a more sophisticated scale as a learning device. Using this idea as a basis a more refined and systematic set of exercises, the subject of this paper, was planned and implemented to promote development of the student's visualization ability. Every exercise in the experiment requires the student to obtain information and use some kind of mental image of increasing complexity to determine a correct response. Five to fifteen minutes were devoted to the exercises at the beginning of most class periods. An educational grant from the ISU Alumni Achievement Fund financed the fabrication of twenty-four boxes and a large supply of two- and three-dimensional shapes for the experiment. The exercises were not used as grading criteria, but as developmental tools. An experimental section and parallel control section were established for two quarters of the 1975-76 academic year. The author taught both sections and tried to duplicate teaching methods as much as possible, except that the control section was not exposed to the visualization exercises. Answers to three questions were sought in conducting the experiment

1. Does the visualization ability of students improve during a basic graphics course?

2. Can visualization exercises be formulated which are beneficial and whose effects are detectable in problems requiring a different type of visualization?

3. Is improved visualization accompanied by an improved learning ability, as might be evidenced by the final examination for the course?

4. Can visualization exercises provide a motivating and interest-generating element to the basic graphics course?

There were approximately 29 class periods during each quarter. The exercises are described below. Every exercise involved some "coaching", and suggestions to assist and encourage better visualization.

Period 1: Image Construction and Retention. Students were asked to look up from their paper, listen to five-digit numbers stated once, then write the five numbers on command after a slight pause. The number sets were read as quickly as possible and students were encouraged to try to "see" them. The class was also shown a picture having a variety of objects for one minute and then asked to list as many as possible.

Period 2: Five- and six-place alphanumeric sets were read to the students to reproduce as before. Another picture of many objects was used for the students to recall and list; they were encouraged to try to visualize and categorize the objects.

Period 3: Image Construction, Retention, and Operation. Ten problems consisting of two two-digit numbers were read quickly and their sum or differences requested. The first four problems involved no carrying. No "doodles" or calculations were allowed; the students were encouraged to "see" and operate on the image, then write only the answer.

Period 4: Ten problems consisting of two three-digit numbers were read and their sum or difference requested.

Period 5: Ten problems consisting of three two-digit numbers were read and their sum requested. An effort was made to watch the time required to do the first problem and reduce the allowed time by a small amount for each succeeding problem, thereby encouraging concentration.

The remaining exercises utilized objects hidden in numbered boxes. Before their use, the purpose of the boxes, Fig. 1, was explained clearly as well as the importance of not looking in at the object. Four progressively more difficult and time-consuming identification exercises were used.

Period 6: Identification, by name only, of twenty-four generally familiar objects. Students moved from desk to desk listing the object contained opposite its box number. Results were checked against a prepared schedule.

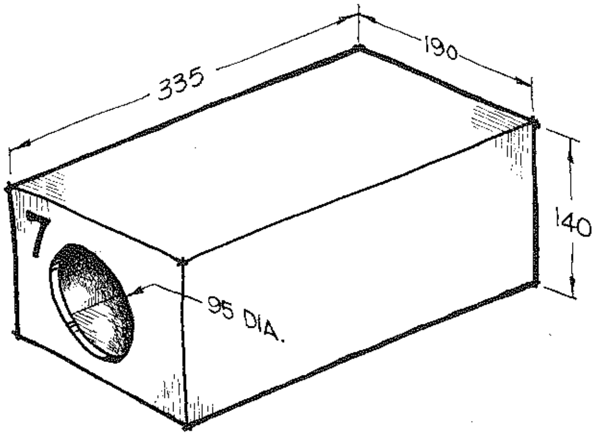


Fig. 1. Plywood box to contain objects for identification.

Period 7: Identification of the "count" on twenty-four dominoes, by feeling the depressions. Results were again checked against a prepared schedule.

Periods 8-11: Sketching of two-dimensional shapes, Fig. 2, as accurately as possible.

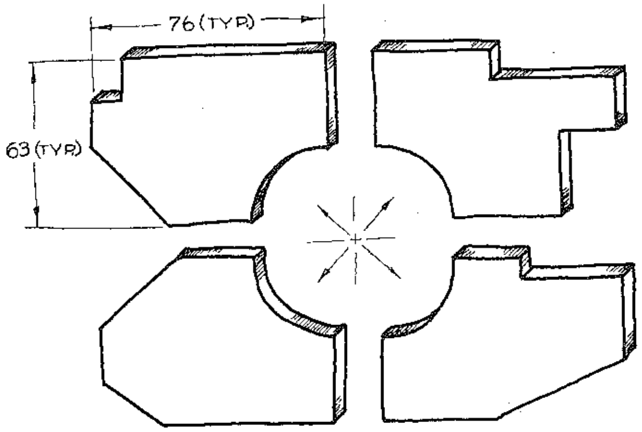


Fig. 2. Four two-dimensional shapes typical of thirteen variations cut from tempered masonite.

Periods 12-end: Sketching the orthographic views and pictorials of a variety of "mutilated" cubes, Fig. 3. Twenty different shapes were available and students were encouraged to work on drawing those shapes whenever time permitted. The short period-opening sessions were used whenever possible.

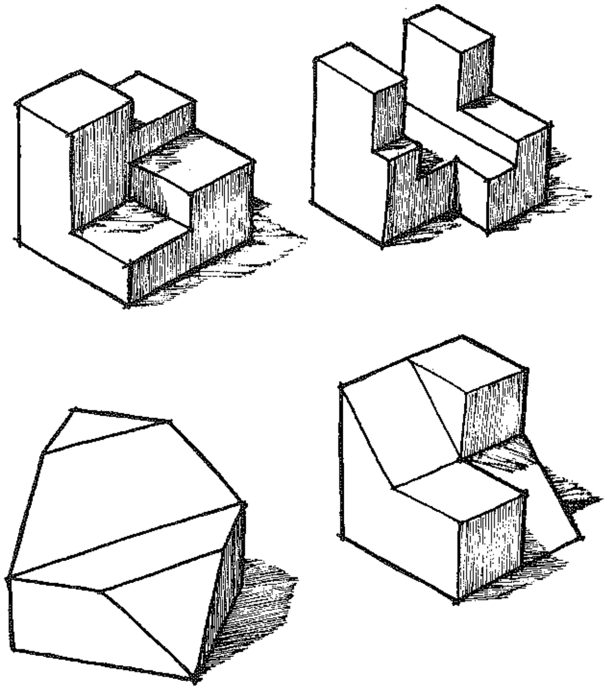


Fig. 3. Four three-dimensional shapes typical of twenty variations cut or fabricated from pine blocks measuring 50 x 50 x 50.

TESTING

Students in both the experimental and control groups were given a short timed fifteen-minute visualization test, part of which appears in Fig. 4. This test was patterned after the well-known Multiple Aptitude tests of Segal and Raskin[10], and consisted of two-and three-dimensional pattern recognition, rotation, and simple mechanical reasoning problems. There were a total of 156 evaluations required to complete the test. Students finishing early recorded their time of completion. None of the test problems resembled the class exercises. The test was administered on the first and last periods of the Fall and Winter quarters. Scoring produced three indices indicative of visualization ability.

1. Rate of evaluating alternative responses, symbolized ER, number per minute.

2. Accuracy of evaluation, symbolized ACC, equal to $\frac{\text{total evaluations - incorrect answers.}}{\text{Total Evaluations}}$

3. Rate of evaluating alternatives correctly, symbolized CER, equal to the product ER x ACC. This index should be a more accurate measure of visualization ability than speed or accuracy alone.

It should be emphasized in this pilot project, no attempt was made to statistically analyze the little data available. The groups are small and too few students involved to draw statistical conclusions. The initial and final visualizations tests are summarized in Table 1. From these entries, some general observations may be made about the experiment which may be helpful and informative.

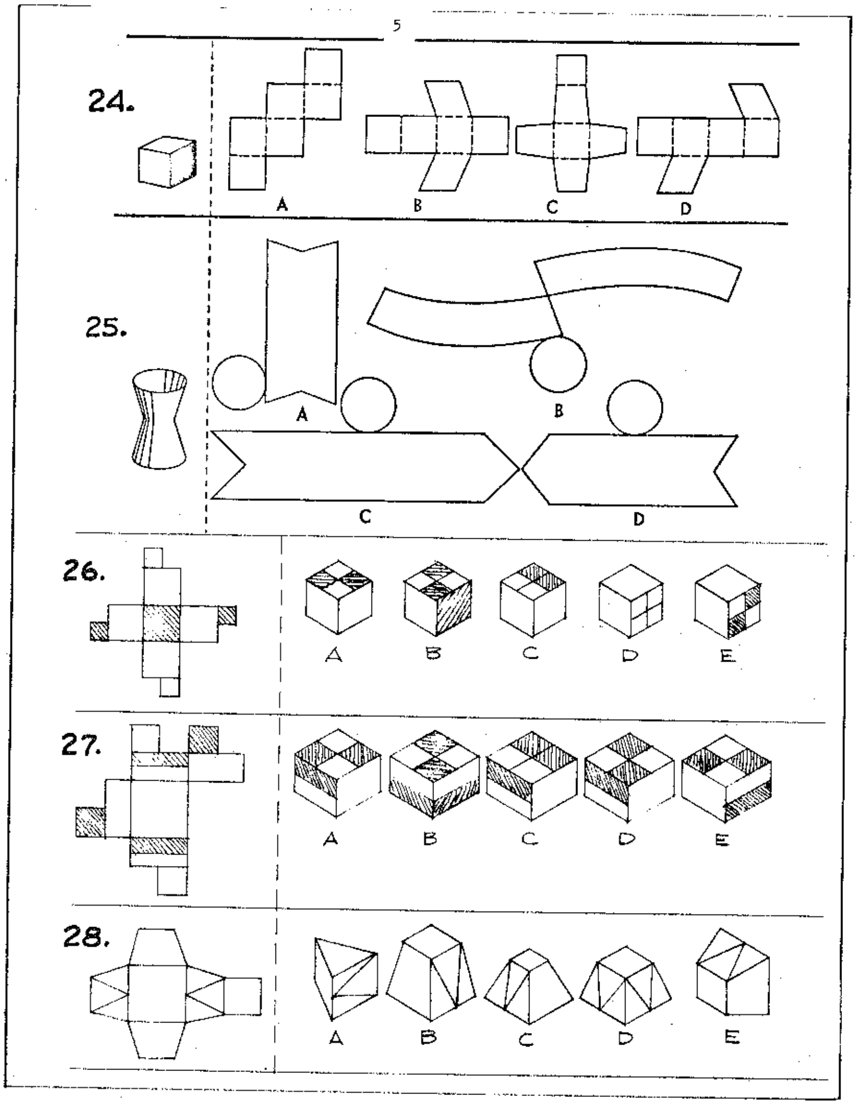


Fig. 4: Sample page from the visualization test administered to both experimental and control groups at the beginning and end of the course. On the page shown, twenty-three different configurations must be evaluated for correctness in taking the test.

	INITIAL VISUALIZATION TEST DATA			FINAL VISUALIZATION TEST DATA			R	PERCENT STUDENTS HAVING R > 100
	AVERAGES STANDARD DEVIATIONS			AVERAGES STANDARD DEVIATIONS			$= \frac{CER_f}{CER_i} \times 100$	
	Evaluation Rate, ER no / min	Accuracy ACC percent	Correct Evaluation Rate, CER_i no / min	Evaluation Rate, ER no/ min	Accuracy, ACC percent	Correct Evaluation Rate, CER_f no / min	Ave. Std. Dev.	
Experimental Section, Fall 17 Students	8.78 1.32	85.81 5.45	7.53 0.98	9.76 1.54	84.17 4.73	8.25 1.23	110 15.0	76.5
Control Section, Fall 16 Students	8.42 1.20	85.69 5.35	7.16 1.00	8.03 0.47	85.47 5.73	6.85 0.64	97 11.0	25.0
Experimental Section, Wtr. 14 Students	9.09 1.19	86.69 7.40	7.84 0.92	10.47 1.34	86.18 6.14	9.11 1.01	117 12.0	100
Control Section, Wtr. 13 Students	8.37 1.61	85.44 6.53	7.04 1.52	9.23 1.12	85.70 10.50	7.98 1.60	115 20.0	69.2

Table 1.

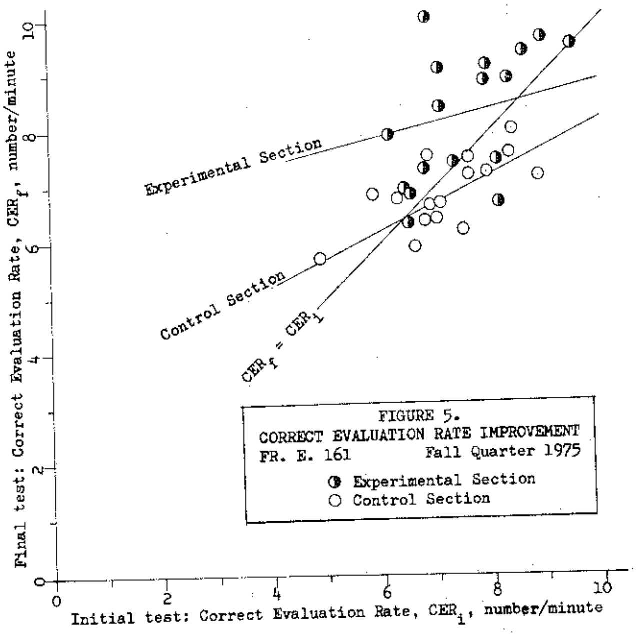


FIGURE 5.
CORRECT EVALUATION RATE IMPROVEMENT
FR. E. 161 Fall Quarter 1975

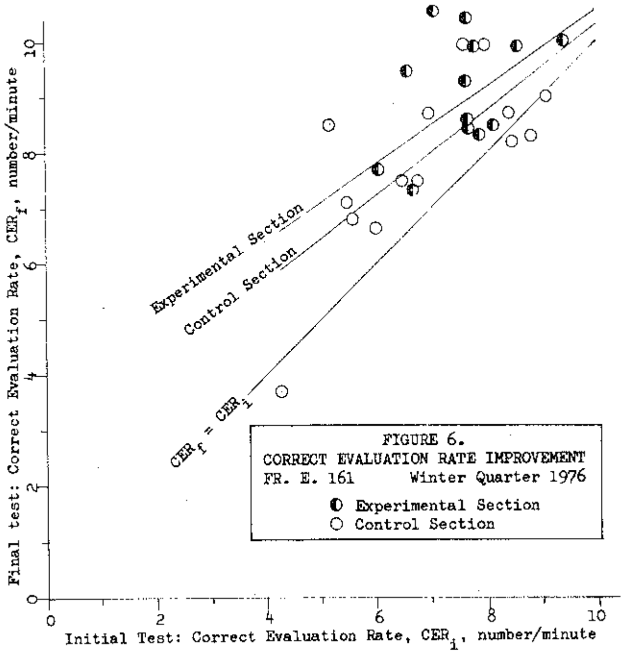


FIGURE 6.
CORRECT EVALUATION RATE IMPROVEMENT
FR. E. 161 Winter Quarter 1976

Table 1 contains average values and standard deviations for all the indices determined and averaged in studying the results of the experiment. It can be seen that the experimental and control groups entered with similar abilities. Their evaluation rates and accuracy during the initial visualization test were similar, although the control groups scored slightly lower than their parallel experimental groups. The final visualization test averages reveal that all groups tended to make more mistakes; their accuracy is lower in every case. However, the experimental groups scored noticeably higher than their control group counterparts on the final test as measured by the CER index, and the Fall quarter control group actually demonstrated a lower final CER than their initial visualization test CER. This would tend to confirm what some students claim; they became more confused and probably less confident as the course progressed. Columns 7 and 8 in Table 1 show the average improvement in CER for the class and the percentage of the class actually showing an improvement. More students demonstrated improved visualization ability in the experimental section, and in general that improvement was larger and more consistent than occurred in the control groups, as indicated by the smaller deviations for the experimental groups.

Fig. 5 and Fig. 6 show the distribution of the individual students in CER development during the Fall and Winter quarters respectively. The effects of the experiment are seen clearly here. During the Fall quarter, all but four of the students in the experimental group demonstrated an increase in CER, whereas all but four in the control group demonstrated a decrease in CER. Similar but less dramatic results occurred during the Winter quarter when all the experimental group members increased their CER, while only four of the control group did not. Least square lines are shown for the four data sets, but it must be realized that this is to determine trends only; no significance was established or is implied. The answer to the first question appears to be yes, at least some of the time. Many students in the two control groups did improve in CER during the Graphics course, but it should be remembered that as shown on Table 1 the average CER for the Fall quarter control group decreased. The answer to the second question is surely affirmative. Almost all of the students in the experimental groups increased in CER; it appears that these visualization exercises, however imperfect, do affect visualization development, as measured by the short test.

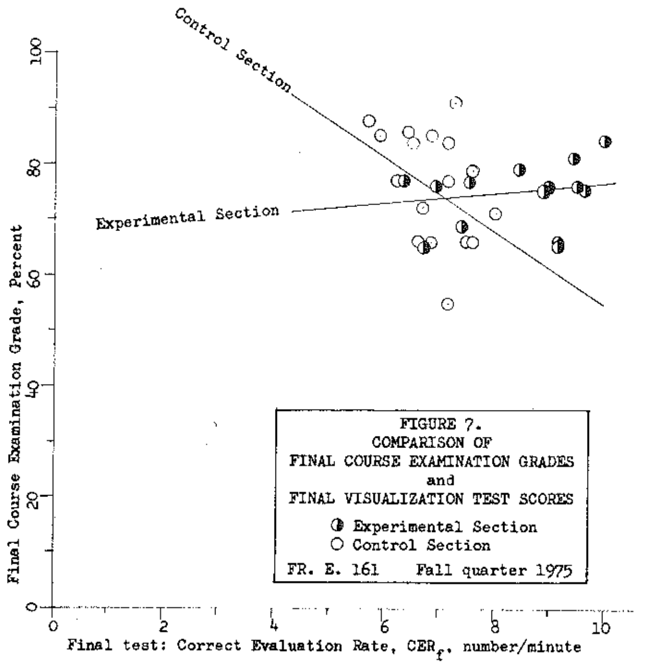


FIGURE 7.
COMPARISON OF
FINAL COURSE EXAMINATION GRADES
and
FINAL VISUALIZATION TEST SCORES

FR. E. 161 Fall quarter 1975

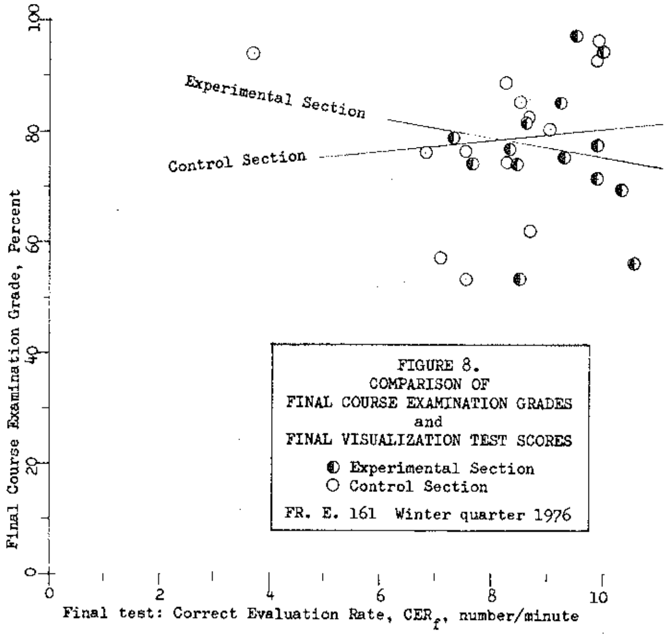


FIGURE 8.
COMPARISON OF
FINAL COURSE EXAMINATION GRADES
and
FINAL VISUALIZATION TEST SCORES

FR. E. 161 Winter quarter 1976

Question three is not answered, at least not by this small experiment. This can be seen in Fig. 7 and Fig. 8 where the final course examination grade is plotted against the final CER for each student. In the Fall quarter, Fig. 7, the final exam grade showed only slight improvement with CER increase for the experimental group, and actually decreased with increasing CER for the control group. However, these positions were reversed during the Winter quarter, Fig. 8. The experimental group students who demonstrated high CER at the end of the quarter did not do as well on the course final as their control group counterparts who scored lower in CER at the end of the quarter.

Question four was answered by asking for the opinions of the students in the experimental group. 87% of them indicated they enjoyed the exercises, and 93% felt that the exercises were helpful to them in developing their visualization ability. Some comments were particularly gratifying; several students indicated that they could not recall having been required to use a mental image analytically. Certainly this is not entirely true, but perhaps illustrates the dependence of our society on controlled visual images.

Several objective and subjective observations were made during the course of the experiment. First, the students seemed to enjoy the challenge of the exercises, and shared many laughs as they worked. This would be less noticeable, certainly, had it been a factor in the course grade. Second, their concentration on an "inner image" was very apparent and evidenced by a frequent glassy-eyed vacant look as they "studied" the more challenging shapes. Third, and least expected by the author, was that most students would detect angular relationships, relative sizes, and shapes much more accurately with their writing hand than with the other, which the author originally suggested that they use. This is logical and probably almost invariant; the hand used naturally to write is controlled by the dominant part of the brain, which is probably also more accurate in observation.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that there is serious doubt concerning the effectiveness of the present-day graphics courses in developing visualization, and that the series of exercises discussed here can have a positive effect on the enhancement of visualization ability. It is the opinion of the author that the results demonstrated here can and should be enhanced by improving the system.

A partial list of the areas which merit attention and development are:

1. Study and application of the psychology and mechanisms of visualization to making the exercises more objective.
2. Improvement and extension of the exercises described.
3. Formulation of more meaningful and comprehensive visualization tests that can be administered within a reasonable time.
4. Establishment of experimental groups large enough to assure good statistical comparisons and conclusions.
5. Design of class problems which incorporate use of more visualization ability as well as graphic ability.
6. Study of the contradictory behavior of the academic achievement and visualization development demonstrated in this paper.

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AFTERNOTE:

The key word in Professor DeJong's paper is "motivation". Freshmen engineering students have had little pre-matriculation experience in visualization. As noted by McKim,[1] these experiences are usually stifled by educators in the elementary and secondary school systems. Trying to teach graphics techniques to these students requires new methods. Orthographic projection, in particular, seems foreign to the student who has been taught by his/her preparatory teachers not to dream and not to imagine.

Most graphics teachers accept as a universal fact that teaching visualization is difficult at best, but is sometimes impossible. To motivate the student to transfer perception from one of the senses to the brain to a sheet of drawing paper becomes visualization in its truest form. When the sense involved is the sense of touch alone then the student himself realizes visualization and the powers of his mind which he didn't realize were there before.

Professor DeJong's paper was purchased by this instructor at the 1976 ASEE Summer Meeting in Knoxville, Tennessee, but not read until the first of September. Simultaneously, interest in improving teaching techniques in Graphic Communication (EG1112---the first graphics course for engineering freshmen at M. S. U.) had been developed. This course had always been boring personally and it was apparent teaching enthusiasm must be generated before learning enthusiasm would be evident.

To keep costs down and morale up, paper lunch sacks were used, and wooden models no larger than three inches (7.62 cm.) in the greatest dimension were placed in the sacks, one model per sack. The models had previously been used in the Department's "GOSS Box"[2], or by other instructors to explain individual textbook problems to the students.

After an introductory film and lecture on orthographic projection, the sacks were distributed to thirty students in each of two sections, and they were told to draw three freehand proportional orthographic views without looking at the object, but just from feeling it. When the drawings were completed and checked by the instructor (for projection, proportion, and proper selection of views), the students were allowed to remove the object from the sack and see with their eyes what they had "seen" with their fingers. The resulting drawings were surprisingly close to the actual model. Several students had estimated two of the three basic space dimensions accurately, and one student in each section had drawn an exact orthographic drawing of the model. The students were allowed to make an instrument drawing from the freehand sketch and eliminate any inaccurate dimensions by actual measurement. The whole exercise (known as "feelies" by that time) took less than 60 minutes.

This innovative exercise set the tone for the whole semester's activity. Both sections of this beginning engineering graphics course have been able to perform harder visualization exercises with little difficulty. The percentages of absences has dropped considerably compared to previous semesters, and enthusiasm remains at a high level in both sections.

Although "hard" data is not given to re-enforce the proposed theory that visualization can be taught, the intuitive evidence is sufficient to recommend to the EDGE membership the inclusion of this type of sensory perception exercise in Freshman Engineering graphics courses.

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AN EXERCISE IN COORDINATE PLOTTING

Coordinate plotting is the process of locating the position of contour points or the end points of boundary lines in a plane survey by means of X and Y coordinates. By using the intersection of the X and Y axes as the origin (0,0), points can be plotted by means of their coordinate distances from the origin.

Latitudes and Departures

The process of plotting topographic maps and surveying plats involves laying off distances measured parallel to the X and Y axes called latitudes and departures (see Figure 1). Latitudes are distances laid off in a north-south direction parallel to the Y axis. Points having northerly latitudes are positive, and points with southerly latitudes are negative. Departures, on the other hand, are distances measured parallel to the X axis and laid off in an easterly (+) or westerly (-) direction. The calculated latitude and departure of line 1-2 are shown in Figure 2. The latitude and departure of line 1-2, or of any line, can be found using the following formula:

Latitude of a Line = Cosine of the Bearing x Length of line

Latitude of Line 1-2 = Cos 30^0 x 100.00'
= 86.603'

Departure of a Line = Sine of the Bearing x Length of Line

Departure of Line 1-2 = Sin 30^0 x 100.00'
= 50.000'

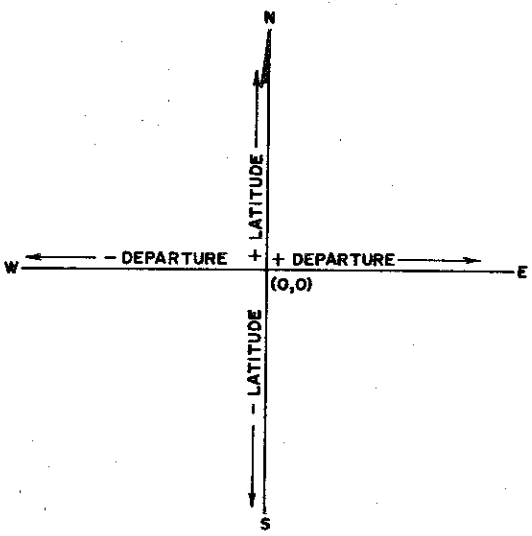


FIGURE 1

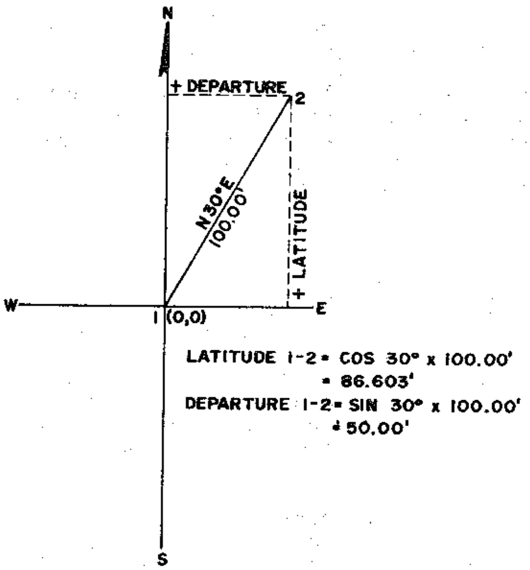


FIGURE 2

Since line 1-2 is located in the northeast quadrant, both its latitude and departure are positive.

The problem can be compounded by introducing a second traverse line 2-3 (Figure 3). Again, compute the latitude and departure of line 2-3 by using the previously mentioned formulas:

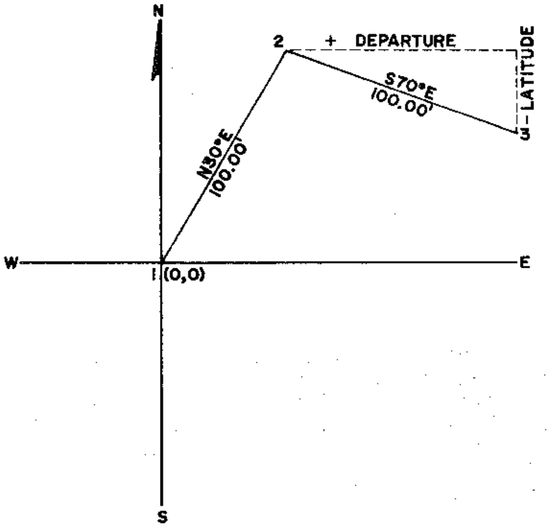


FIGURE 3

Latitude of Line 2-3 = Cosine of the Bearing x Length of line
= Cos 70^0 x 100.00'
= -34.202'

Departure of Line 2-3 = Sine of the Bearing x Length of Line
= Sin 70^0 x 100.00'
= 93.969'

Note that the bearing of line 2-3 lies in the southeast quadrant. Thus, the departure is easterly or positive, and the latitude is southerly or negative. Continue to calculate the latitude and departure of each line in the traverse being careful to note whether the latitudes and departures are positive or negative.

Coordinate Points

Latitudes and departures are used to locate the position of a point in relation to a previous point. The location of point 3 inFigure 3, for example, was located by its positive departure distance and negative latitude distance from point 2. Point 3 is 93.969 feet east of, and 34.202 feet south of point 2.

Coordinate points, on the other hand, are always located with respect to the origin (0,0) by algebraically summing the departures of line 1-2 and 2-3. The Y coordinates of point 3 are:

X Coordinate--Point 3= (Departure of Line 1-2) + (Departure of Line 2-3)
= (+50.000')+(93.969')
= 143.969'

Y Coordinate--Point 3= (Latitude of Line 1-2) + (Latitude of line 2-3)
= (+86.602')+(-34.202')
= 52.400'

Computer Program

The computer program[1] shown in Figure 4 was used by the author at LeTourneau College, Longview, Texas, in plane surveying classes to check the accuracy of student field problems. It was found that the program provided students with a practical introduction to many engineering principles and data processing, therefore a coordinate geometry unit was added to the freshman engineering graphics courses. Topics covered in the unit included: the use of civil engineer's scales, traverse adjustments, calculation of latitudes and departures, coordinate plotting, and computer data input and output.

Data read into the computer includes the length and azimuth of each traverse line in the survey. The program shown in Figure 4 computes the latitude and departure of each traverse line and the coordinate location of the end points of each line. In addition, the error of closure (closure), ratio of error (precision), area of the traverse, and corrected azimuth and length of the traverse line are computed. The program is limited in that it cannot handle traverse problems with curved or circular sides.

Error of Closure

In surveying a closed traverse, the point at which the traverse ends is theoretically the starting point or origin (0,0). Due to inaccuracies in linear and angular measurement, the traverse usually ends at a point near, but not exactly at, the point of beginning (see Figure 5). This distance between the actual end of the traverse (1') and the beginning point (0,0) is known as the error of closure. The error of closure is used to determine the accuracy of a survey. It is divided by the total perimeter distance around the traverse to determine the "ratio of error". The error of closure can be calculated as the square root of the algebraic sum of the latitudes squared plus the algebraic sum of the departures squared:

Error of Closure =

$$\sqrt{\Sigma \text{Latitudes}^2 + \Sigma \text{Departures}^2}$$

---

[1] This program is the product of a program published in the text, Russel C. Brinker, Elementary Surveying, 5th Edition (Scranton, Pa., International Text Book Co., 1969), p. 231; plus modifications that the author of this article made in the azimuth and length adjustment portions of the program.

FIGURE 4

```
      SUBROUTINE ARCTN (ANGLE,Y,X)
C THIS SUBROUTINE COMPUTES CORRECTED AZIMUTHS AND
C LENGTHS USING CORRECTED X AND Y COORDINATES
      ANGLE=0.
      IF (ABS(Y)-.001)2,9,9
    9 IF(Y)1,3,3
    3 IF (X)4,12,12
    4 ANGLE=6.2831852
      GO TO 12
    1 ANGLE=3.1415927
   12 ANGLE=ANGLE+ATAN(X/Y)
      RETURN
    2 IF (ABS(X)-.001) 8,11,11
   11 IF(X) 6,7,7
    6 ANGLE=4.7123889
      RETURN
    7 ANGLE=1.5707963
    8 RETURN
      END
C CLOSED TRAVERSE COMPUTATION--FORCES CLOSURE USING COMPASS RULE.
C CALCULATES ERROR OF CLOSURE, RATIO OF PRECISION,AND AREA IN ACRES.
C CALCULATES CORRECTED LENGTH OF TRAVERSE LINES AND CORRECTED AZIMUTHS
C PROCEDURE--1. INTERIOR ANGLES MUST TOTAL (N-2)180 DEGREES. USE ONE OF
C                THE METHODS OUTLINED IN TEXT TO MAKE NECESSARY CORRECT-
C                IONS.  DIRECTIONS OF LINES CALLED OUT MUST BE AS
C                AZIMUTHS.
C DATA CARD ARRANGEMENT--
C FIRST DATA CARD--NUMBER OF SIDES IN TRAVERSE (RIGHT JUSTIFIED--I5
C                   FORMAT--NO DECIMAL POINT)
C SECOND DATA CARD--1. LENGTH OF LINE 1-2 (F10.3 FORMAT--COLUMNS 1-10)
C                   2. AZIMUTH DEGREES (F5.0 FORMAT--COLUMNS 11-15)
C                   3. AZIMUTH MINUTES (F5.0 FORMAT--COLUMNS 16-20)
C                   3. AZIMUTH SECONDS (F10.2 FORMAT--COLUMNS 21-30)
C THIRD AND REMAINING DATA CARDS--USE SAME FORMAT AS SECOND DATA CARD
C EXAMPLE--
C123456789101112131415161718192021222324252627282930  (COLUMNS)
C    4  (RIGHT JUSTIFIED TO COL 5)
C285.145    26.       8.        54.   (LENGTH,AZIMUTH IN DEG,MIN,SEC)
      DIMENSION DIST(25),DEG(25),AMIN(25),SEC(25),RAD(25),X(25),Y(25)     003
      DIMENSION XC(25),YC(25),XCOR(25),YCOR(25),TSEC(25)                  004
      DIMENSION CORL(25), ANGLE(25), NSEC(25), NDEG(25), NMIN(25)
      READ(5,10)N
      WRITE(6,10)N
      DO 5 I=1,N                                                          006
      READ(5,15)DIST(I),DEG(I),AMIN(I),SEC(I)                             007
      WRITE(6,15)DIST(I),DEG(I),AMIN(I),SEC(I)
      RAD(I)=(DEG(I)+AMIN(I)/60.0+SEC(I)/3600.0)/57.295780                008
      X(I)=DIST(I)*SIN (RAD(I))                                           009
    5 Y(I)=DIST(I)*COS (RAD(I))                                           010
      DX=0.0                                                              011
      DY=0.0                                                              012
      PER=0.0                                                             013
      DO 20 I=1,N                                                         014
      DX=DX+X(I)                                                          015
      DY=DY+Y(I)                                                          016
   20 PER=PER+DIST(I)                                                     017
      CLOS=SQRT (DX**2+DY**2)                                             018
      PREC=PER/CLOS                                                       019
      IPREC=PREC                                                          020
      WRITE(6,27)
      WRITE(6,28)
      XCOR(1)=0.0                                                         023
      YCOR(1)=0.0                                                         024
      DO 30 I=1,N                                                         025
      J=I+1                                                               026
      XC(I)=X(I)-(DIST(I)*DX)/PER                                         027
      YC(I)=Y(I)-(DIST(I)*DY)/PER                                         028
```

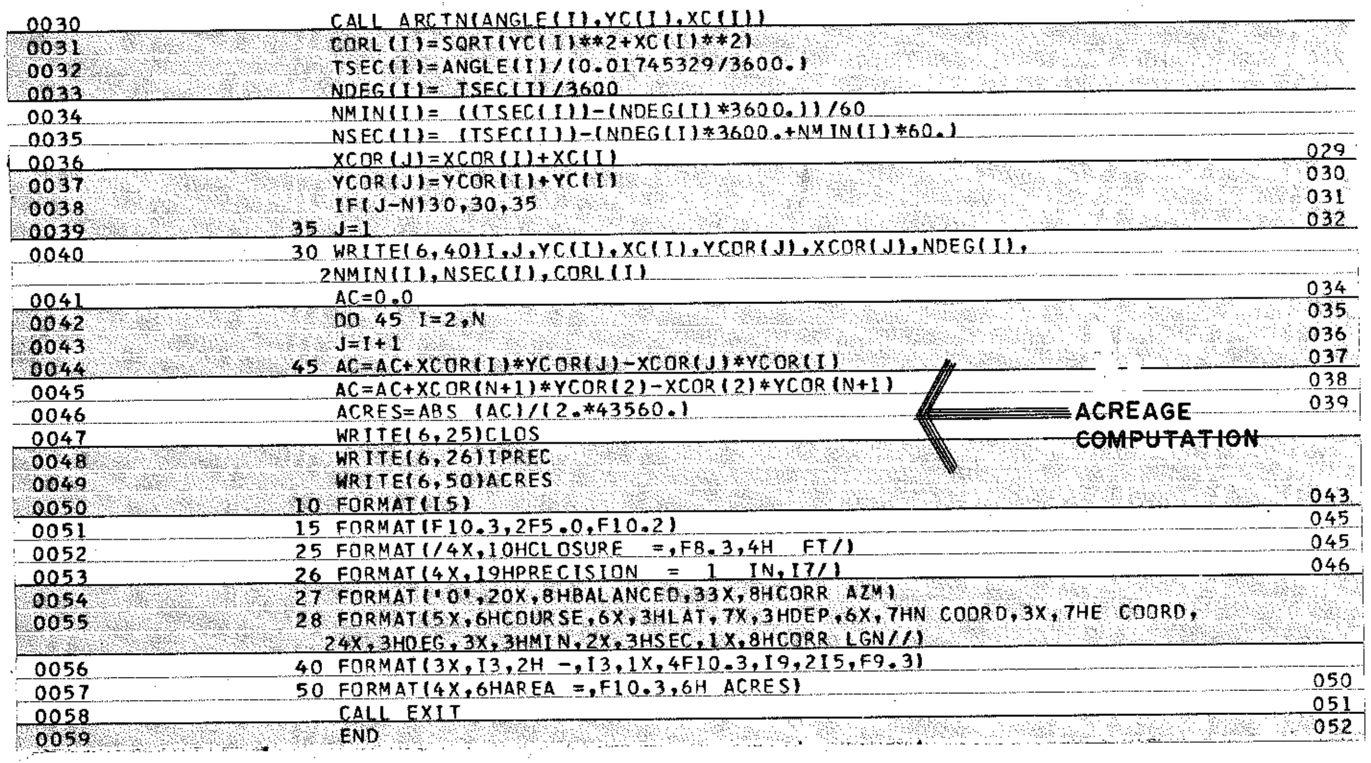
CONVERSION FROM COMPASS RULE CORRECTED X AND Y COORDINATES TO CORRECTED AZIMUTHS AND LENGTHS

DATA INPUT

ERROR OF CLOSURE AND RATIO OF ERROR COMPUTATIONS

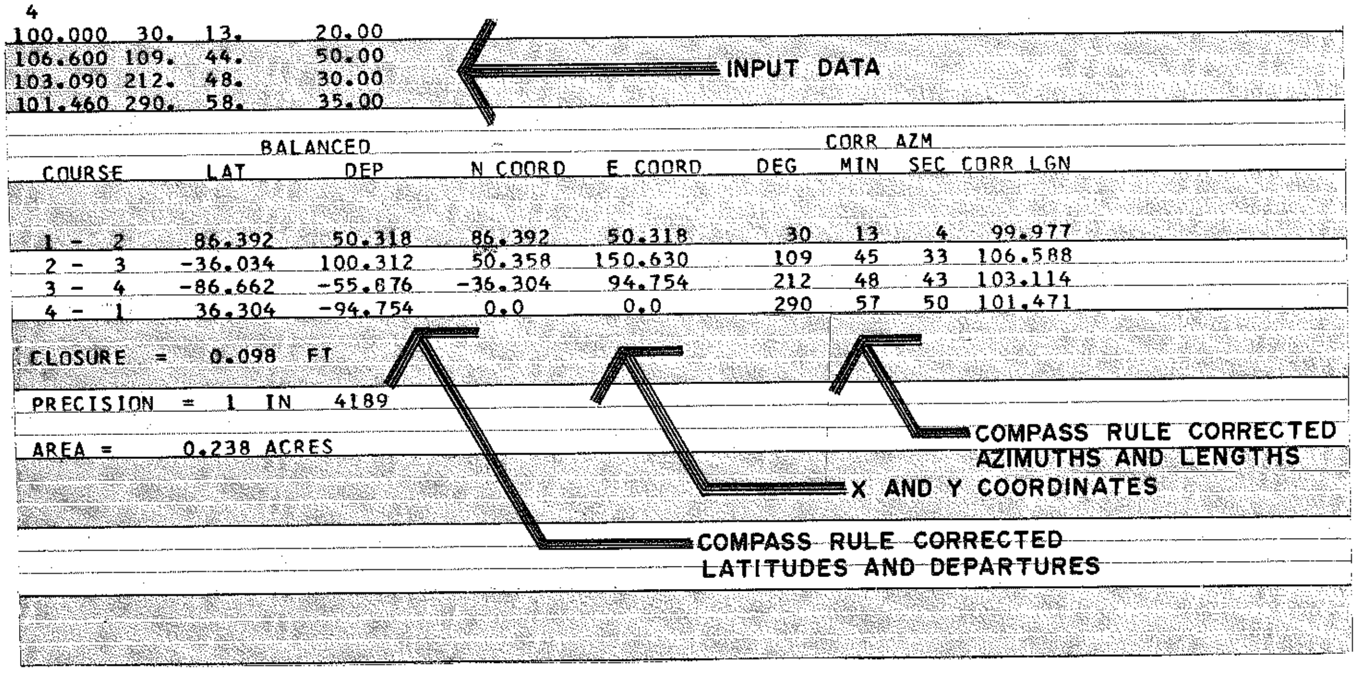
FIGURE 4 CONTINUED NEXT PAGE

FIGURE 4 CONTINUED



```
      CALL ARCTN(ANGLE(I),YC(I),XC(I))
      CORL(I)=SQRT(YC(I)**2+XC(I)**2)
      TSEC(I)=ANGLE(I)/(0.01745329/3600.)
      NDEG(I)= TSEC(I)/3600
      NMIN(I)= ((TSEC(I))-(NDEG(I)*3600.))/60
      NSEC(I)= (TSEC(I))-(NDEG(I)*3600.+NMIN(I)*60.)
      XCOR(J)=XCOR(I)+XC(I)
      YCOR(J)=YCOR(I)+YC(I)
      IF(J-N)30,30,35
   35 J=1
   30 WRITE(6,40)I,J,YC(I),XC(I),YCOR(J),XCOR(J),NDEG(I),
     2NMIN(I),NSEC(I),CORL(I)
      AC=0.0
      DO 45 I=2,N
      J=I+1
   45 AC=AC+XCOR(I)*YCOR(J)-XCOR(J)*YCOR(I)
      AC=AC+XCOR(N+1)*YCOR(2)-XCOR(2)*YCOR(N+1)
      ACRES=ABS (AC)/(2.*43560.)
      WRITE(6,25)CLOS
      WRITE(6,26)IPREC
      WRITE(6,50)ACRES
   10 FORMAT(I5)
   15 FORMAT(F10.3,2F5.0,F10.2)
   25 FORMAT(/4X,10HCLOSURE  =,F8.3,4H  FT/)
   26 FORMAT(4X,19HPRECISION  =  1  IN,I7/)
   27 FORMAT('0',20X,8HBALANCED,33X,8HCORR AZM)
   28 FORMAT(5X,6HCOURSE,6X,3HLAT,7X,3HDEP,6X,7HN COORD,3X,7HE COORD,
     24X,3HDEG,3X,3HMIN,2X,3HSEC,1X,8HCORR LGN//)
   40 FORMAT(3X,I3,2H -,I3,1X,4F10.3,I9,2I5,F9.3)
   50 FORMAT(4X,6HAREA =,F10.3,6H ACRES)
      CALL EXIT
      END
```

ACREAGE COMPUTATION



```
    4
100.000  30.  13.      20.00
106.600 109.  44.      50.00
103.090 212.  48.      30.00
101.460 290.  58.      35.00

                    BALANCED                                 CORR AZM
     COURSE      LAT       DEP      N COORD   E COORD    DEG   MIN  SEC CORR LGN


       1 -  2    86.392    50.318    86.392    50.318     30    13    4   99.977
       2 -  3   -36.034   100.312    50.358   150.630    109    45   33  106.588
       3 -  4   -86.662   -55.876   -36.304    94.754    212    48   43  103.114
       4 -  1    36.304   -94.754     0.0       0.0      290    57   50  101.471

    CLOSURE  =    0.098  FT

    PRECISION  =  1  IN    4189

    AREA =      0.238 ACRES
```

INPUT DATA

COMPASS RULE CORRECTED AZIMUTHS AND LENGTHS

X AND Y COORDINATES

COMPASS RULE CORRECTED LATITUDES AND DEPARTURES

FIGURE 4

Ratio of Error

The ratio of error of a traverse is the reciprocal of the error of closure divided by the total perimeter distance around the traverse:

$$\frac{\text{Error of Closure}}{\text{Perimeter Distance Around Traverse}} = \frac{1}{X}$$

Thus, the ratio is always expressed as 1/___. Ratios of error greater than 1/10,000 indicate an accurate survey, whereas ratios less than 1/2,000 indicate loosely controlled work.

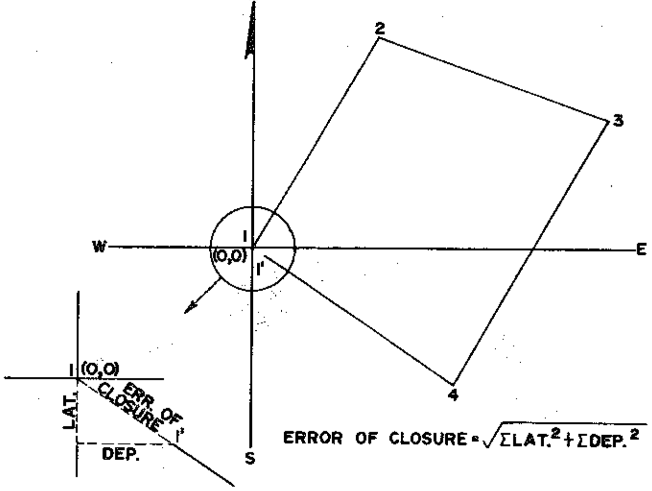


FIGURE 5

Forcing Closure

Before any remaining traverse computations can be made the traverse must be "forced" or adjusted to close at the origin. The procedure for forcing closure involves adjusting the bearings and/or lengths of the individual traverse lines. There are several accepted procedures used to make these adjustments of which the "compass method" is the most widely accepted. The compass method of adjustment is based on the assumption that the amount of error in a survey can be attributed equally to error in angular and error in linear measurements. Thus, when making adjustments using the compass method, modifications are made in both the bearings and lengths of the individual traverse lines. The procedure for making these adjustments will be discussed in greater detail later. It is important to remember that the error of closure and ratio of error calculations are computed before the traverse is forced to close. All of the remaining computations including the calculation of latitudes and departures, coordinates, corrected azimuths and lengths, and area are computed after the traverse has been forced to close.

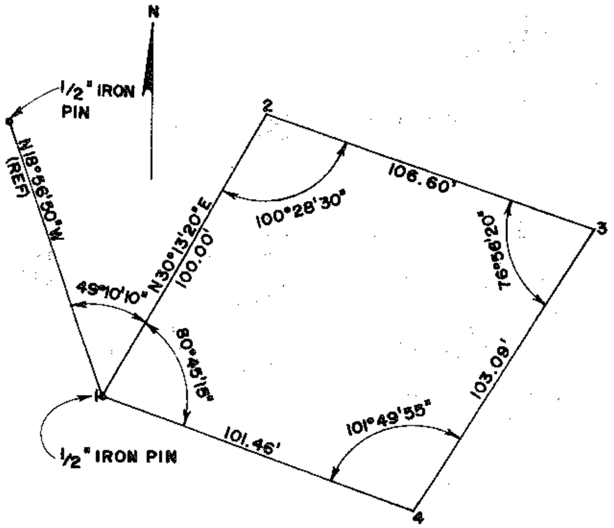
Corrected Azimuths and Lengths, and Area

Two final pieces of information generated by the computer program are the corrected azimuth and length of each traverse line, and the area of the traverse in acres (1 acre = 43,560 s.f.). The corrected azimuths and lengths are used in labeling the final layout drawing or plat.

Sample Problem #1

Sample Problem #1 will be used to outline the procedure for adjusting interior angles, converting the relationship between traverse lines from interior angles to bearings and then to azimuths, and finally entering the data into the computer.

The first check that should be made is to determine if the sum of the interior angles is equal to (N-2) 180°, where "N" is the number of sides in the closed traverse. To simplify the first problem, the interior angles do sum to (4-2) 180°, or 360°. If the sum of the interior angles does not total (N-2) 180°, adjustments in the sizes of the interior angles must be made. The procedure for making these adjustments will be covered in Sample Problem #2.



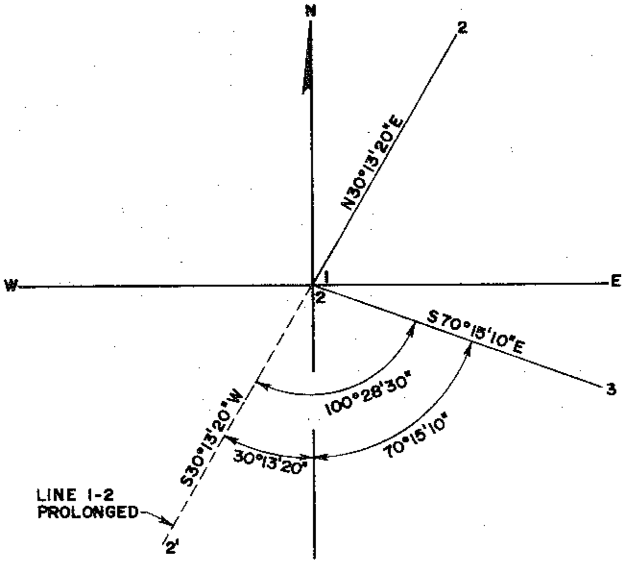
FIELD NOTE SKETCH FOR SAMPLE PROBLEM #1

FIGURE 6

Converting Interior Angles to Bearings

Assume that the line extending from point 1 to the one-half inch iron pin (Figure 6) is an established reference (Ref) line from which all of the other lines in the survey are referenced. Given the referenced bearing of N18°56'50"W and a measured interior angle of 49°10'10", the bearing of line 1-2 can be determined.

The bearing of line 1-2 (Figure 6) is N30°13'20"E, and the interior angle at point 2 is 100°28'30". Calculate the bearing of line 2-3. Remember that a line can be identified with one of two bearings depending upon its sense (see Figure 7). Line 1-2 lies in the N-E quadrant, but it can be prolonged into the S-E quadrant and wuld have a bearing of S30°13'20"W. Prolong line 1-2 into the S-W quadrant and lay out the 100°28'30" angle. The bearing of line 2-3 can now be determined. The key to this procedure is to always, (1) prolong the line with the known bearing into the opposite quadrant, (2) lay off the interior angle, and (3) calculate the unknown bearing.

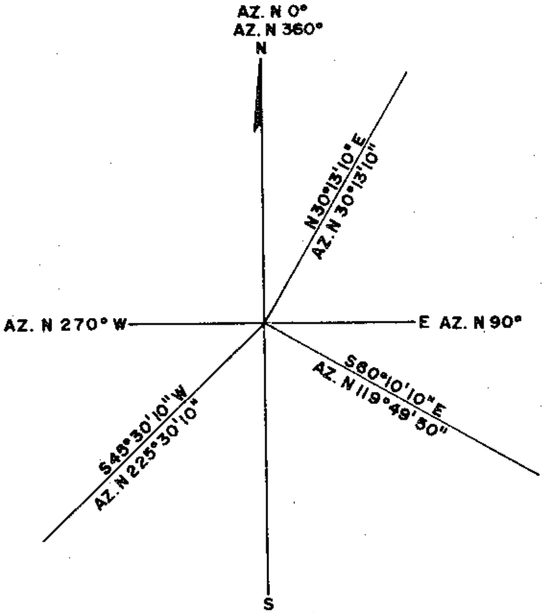


CONVERSION FROM INTERIOR ANGLES
TO BEARINGS

FIGURE 7

Converting Bearing to Azimuths

The direction of the traverse lines must be read into the computer program as azimuths. Thus, the calculated bearings must be converted to azimuths. For convenience, reference the azimuths to north as shown in Figure 8. The traverse shown in Figure 9 is ready to be keypunched and input into the computer.

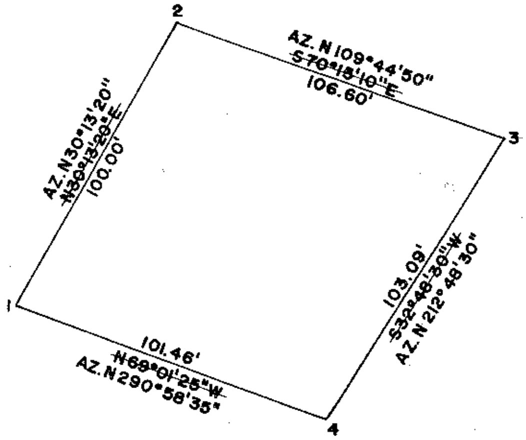


RELATIONSHIP OF BEARINGS
TO NORTH-REFERENCED AZIMUTHS

FIGURE 8

Data Input

The first data card lists the number of sides in the traverse, and is listed on the card using a right-justified I5 format (no decimal point) (see Figure 10). Each of the remaining data cards lists the lengths and azimuth of one traverse line (line 1-2, line 2-3, etc.). The formats for the length, azimuth degrees, azimuth minutes, and azimuth seconds are F10.3, 2F5.0, and F10.2 respectively (see Figure 10). Instructions for keypunching the data cards are also printed as comments in the program (see Figure 4). The program can handle a traverse with as many as 25 sides. In order to identify any keypunch mistakes, the input data are printed at the beginning of the output portion of the program (see Figure 4).



BEARINGS CONVERTED TO AZIMUTHS
SAMPLE PROBLEM #1

FIGURE 9

Data Output

Output data generated by the program are listed in the following manner. First, the data cards are listed--number of sides, length and bearing of each line (see Figure 4). Below this information is a listing of the balanced latitudes and departures (adjusted using the compass method), the adjusted north and east coordinates of each point, and the adjusted azimuth and length of each traverse line. The last three pieces of information include the error of closure (closure), ratio of precision (precision), and the area of the traverse in acres.

Manual Calculation of Coordinates

The manual calculations for Sample Problem #1 are shown in Figure 11. These data were manually calculated in order to more fully explain the procedure used to calculate the coordinate points.

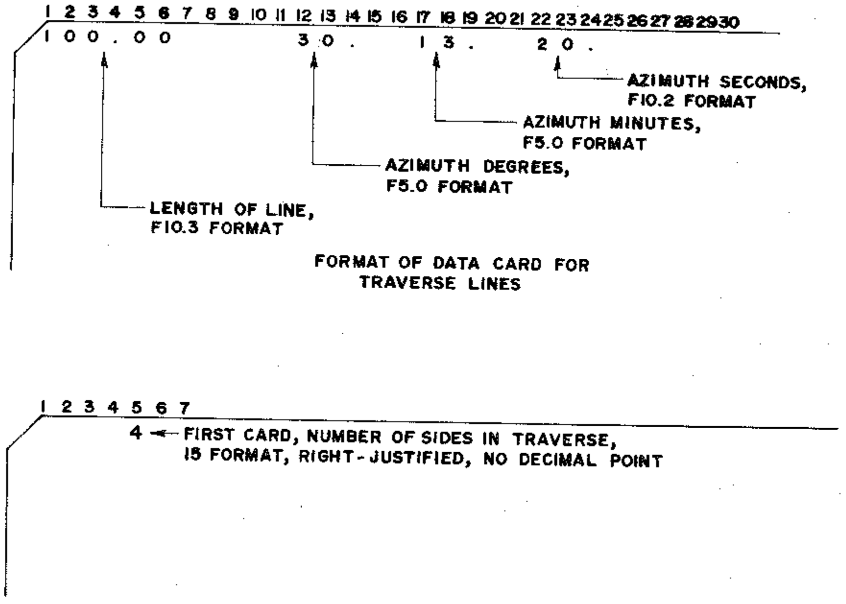


FIGURE 10

POINT	LENGTH	BEARING	(+) LATITUDE N	(-) S	(+) DEPARTURE E	(-) W	BALANCED LAT.	DEP.	TOTAL LAT.	DEP.
1										
	100.00	N30°13'20"E	-.016 86.408		-.018 50.336		N86.392	E50.318		
2									N86.392	E50.318
	106.60	S70°15'10"E		+.017 36.017	-.019 100.331		S36.034	E100.312		
3									N50.358	E150.630
	103.09	S32°48'30"W		+.017 86.646		+.019 55.857	S86.663	W55.876		
4									S36.305	E94.754
	101.46	N69°01'25"W	-.016 36.321			+.018 94.736	N36.305	W94.754		
1									0.000	00000
	411.15		122.729 -122.663 0.066	122.663	150.667 -150.593 0.074	150.593				

COMPASS RULE CORRECTIONS

Latitude Corrections:

Correction 1-2 = 100.00 x $\frac{0.066}{411.150}$ = 0.016

Correction 2-3 = 106.60 x $\frac{0.066}{411.150}$ = 0.017

Correction 3-4 = 103.09 x $\frac{0.066}{411.150}$ = 0.017

Correction 4-1 = 101.46 x $\frac{0.066}{411.150}$ = 0.016

Departure Corrections:

Correction 1-2 = 100.00 x $\frac{0.074}{411.150}$ = 0.018

Correction 2-3 = 106.60 x $\frac{0.074}{411.150}$ = 0.019

Correction 3-4 = 103.09 x $\frac{0.074}{411.150}$ = 0.019

Correction 4-1 = 101.46 x $\frac{0.074}{411.150}$ = 0.018

CLOSURE $= \sqrt{\Sigma Lat^2 + \Sigma Dep^2}$

$= \sqrt{0.066^2 + 0.074^2}$

$=$ 0.099

RATIO OF PRECISION

$\frac{\text{Closure}}{\text{Perimeter}} = \frac{1}{X}$

$\frac{0.099}{411.150} = \frac{1}{X}$; X = 4,153; Ratio of Rrecision = 1/4,153

MANUAL CALCULATIONS FOR SAMPLE PROBLEM #1

FIGURE 11

The points, distance between the points and bearings are listed first. The latitude and departure of each line are calculated using the trigonometric formulas previously mentioned. Most surveying texts have an appendix of natural sines and cosines for angles listed in degrees, minutes and seconds. The sine or cosine of the seconds portion of the angle will usually have to be determined by interpolation. The north and south latitude columns are summed, and the smaller sum is subtracted from the larger. This difference is the error of closure in the latitude direction of the traverse. This error is adjusted using the compass rule as follows: (1) find the perimeter distance around the traverse--411.15'; (2) make a compass method adjustment for each latitude using the following formula:

$$\frac{\text{Correction in Latitude for Given Line}}{\text{Closure in Latitude}} = \frac{\text{Length of Given Line}}{\text{Perimeter of Traverse}};$$

Therefore

Correction in Latitude for Given Line =

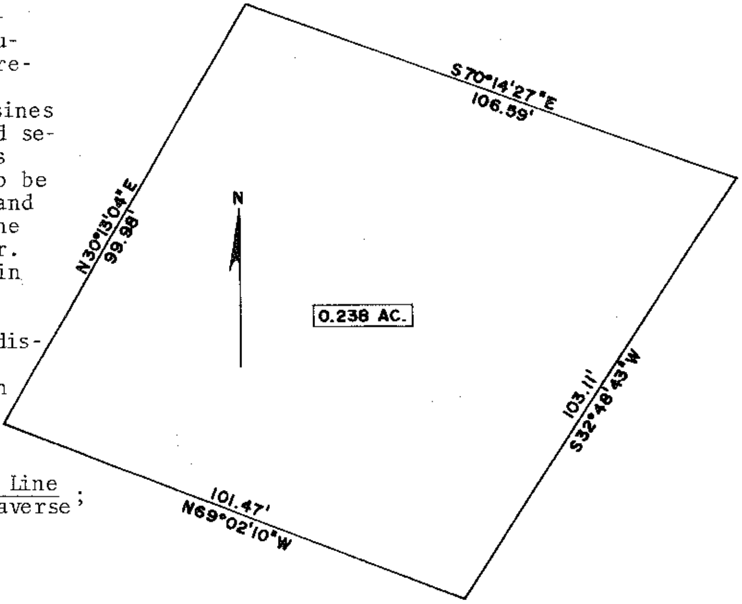
$$\text{Length of Given Line} \times \frac{\text{Closure in Latitude}}{\text{Perimeter of Traverse}}$$

Example:
$$\text{Correction 1-2} - 100.00 \times \frac{0.066}{411.150} = 0.016'$$

(3) subtract corrections from the side (north) having the larger total (122.729), and add corrections to the side (south) having the smaller total (122.663). Departure corrections are made following the same procedure as was used for the latitude corrections.

The balanced latitude and departure columns list the latitudes and departures with the compass corrections either added or subtracted.

The coordinate locations of the individual points are listed in the "Total Latitude and Departure" columns. These coordinate points are calculated by algebraically summing the latitude column (north (+), south (-)) and departure column (east (+), West (-)).



LAYOUT OF SAMPLE PROBLEM #1
SCALE 1" = 20.0'

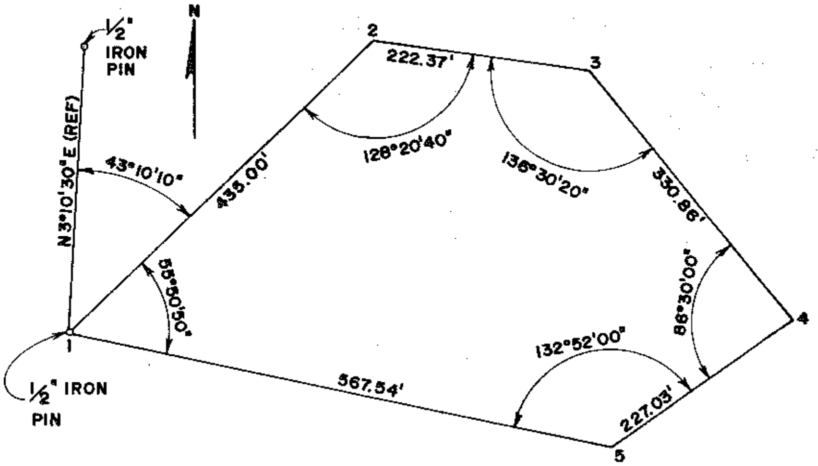
FIGURE 12

Plotting the Data

The data from Sample Problem #1 are plotted in Figure 12. The points were located using the corrected "N COORD" and "E COORD" data from the program (see Figure4). The corrected azimuth (or converted bearing) and length of each line are those taken from the "CORR AZM" and "CORR LGN" columns of the printout.

Sample Problem #2

Sample Problem #2 (see Figure 13) is similar to Sample Problem #1. Sample Problem #2 differs from Sample Problem #1 in that the sum of the interior angles does not total (N-2) 180°, or 540°, therefore



FIELD NOTE SKETCH FOR SAMPLE PROBLEM #2

FIGURE 13

Point	Interior Angle	Adjustment	Corrected Interior Angle
1	55°50'50"	-40"	55°50'10"
2	128°20'40"	-40"	128°20'00"
3	136°30'20"	-50"	136°29'30"
4	86°30'00"	-50"	86°29'10"
5	132°52'00"	-50"	132°51'10"
Total	540°03'50"	-3'50"	540°00'00"

INTERIOR ANGLE ADJUSTMENT
FOR SAMPLE PROBLEM #2

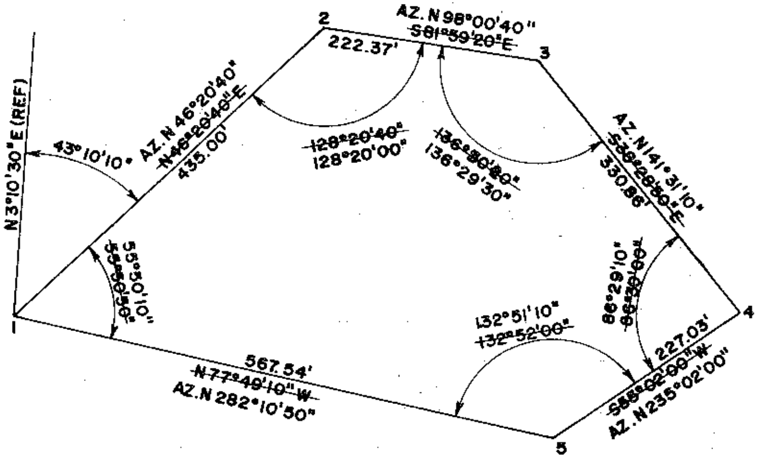
FIGURE 14

the interior angles must be adjusted. Figure 14 shows the procedure for adjusting the interior angles. Note that the sum of interior angles is 540°03'50". The adjustments in this problem were made randomly in multiples of 10". There are several other accepted methods for balancing interior angles. Since these methods of adjustment are beyond the scope of this article, reference can be made to one of the texts listed in the bibliography for further information. Usually the adjustments are made according to the smallest angle that the transit used in the survey is capable of measuring. This usually ranges from 20"-30" for a transit to 1" for a theotelite.

After subtracting the adjustments from the interior angles, the adjusted interior angles are placed on the field note sketch to determine bearings and azimuths (see Figure 15). Always begin a traverse computation by summing, and if necessary, adjusting the interior angles of the closed traverse. Also, remember that the output data will vary according to the method in which the interior angles were adjusted.

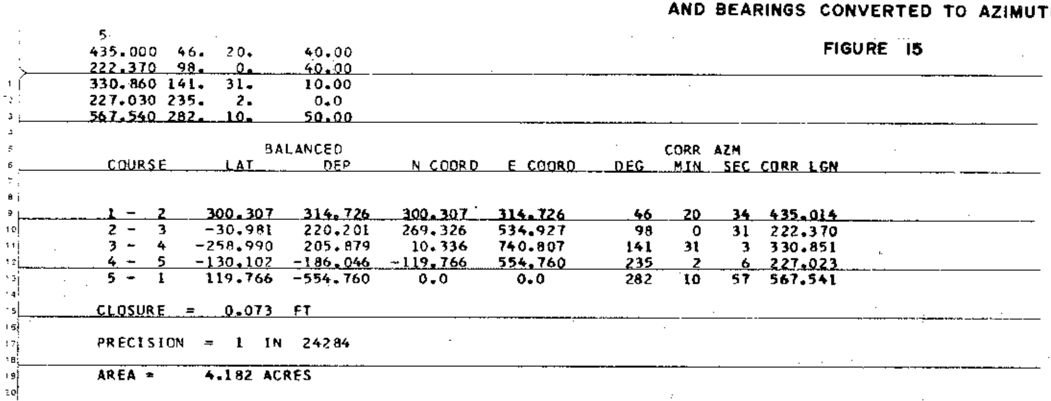
The remaining procedures for calculating the problem are identical to those used for Sample Problem #1. The printout for Sample Problem #2 is shown in Figure 16, the plot is shown in Figure 17, and the manual calculations are shown in Figure 18. Note that the bearings are always placed on the outside of the traverse and the distances on the inside.

It is interesting to compare the ratios of precision of the two sample problems. Sample Problem #1 had a ratio of 1/4,189, as compared to a ratio of precision of 1/24,284 for Sample Problem #2. A ratio of 1/4,189 indicates rather loosely controlled work. A 1/24,284 ratio, on the other hand, indicates a very accurate survey.



INTERIOR ANGLE ADJUSTMENT
AND BEARINGS CONVERTED TO AZIMUTHS

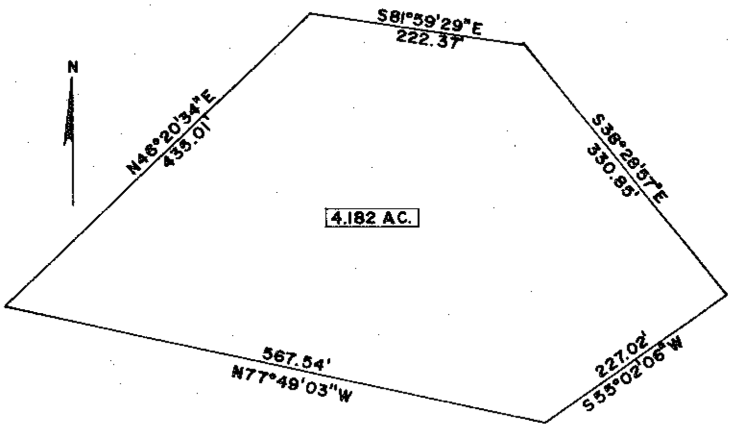
FIGURE 15



```
 5
435.000  46.  20.     40.00
222.370  98.   0.     40.00
330.860 141.  31.     10.00
227.030 235.   2.      0.0
567.540 282.  10.     50.00

                    BALANCED                                     CORR  AZM
   COURSE       LAT       DEP      N COORD   E COORD    DEG   MIN   SEC  CORR LGN


   1 -  2     300.307   314.726   300.307   314.726      46    20    34   435.014
   2 -  3     -30.981   220.201   269.326   534.927      98     0    31   222.370
   3 -  4    -258.990   205.879    10.336   740.807     141    31     3   330.851
   4 -  5    -130.102  -186.046  -119.766   554.760     235     2     6   227.023
   5 -  1     119.766  -554.760     0.0       0.0       282    10    57   567.541

  CLOSURE  =   0.073  FT

  PRECISION  =  1  IN  24284

  AREA =     4.182 ACRES
```

OUTPUT DATA FOR SAMPLE PROBLEM #2

FIGURE 16



LAYOUT OF SAMPLE PROBLEM #2
SCALE 1"=100.00'

FIGURE 17

Summary

The following list of steps will serve both as a summary for computing the coordinate points of a closed traverse and as a bibliography reference guide for additional information on the procedures covered:

1. Sum the interior angles of the closed traverse. The sum total should be equal to (N-2) 180°. Adjust the interior angles if necessary (Brinker, p. 222; Davis, Foote, Kelly, p. 459).
2. Determine the bearing of the traverse lines (Brinker, p. 151).
3. Convert bearing to azimuths (Brinker, p. 151; Davis, Foote, Kelly, p. 260).
4. Punch data cards.
5. Run program
6. Select a suitable graphic scale.
7. Plot data using the "N COORD" and "E CPPRD" data output values.
8. Annotate the drawing using the "CRR AZM" (or converted bearing) and "CORR LGN" output values.
9. List the acerage and scale on the drawing.

Bibliography

Brinker, Russell C. Elementary Surveying. 5th ed. Scranton, Pennsylvania: International Textbook Co., 1969.

Davis, Raymond E.; Foote, Francis S.; and Kelly, Joe W., Surveying Theory and Practice. 5th ed. New York: McGraw-Hill Book Co., 1966.

POINT	LENGTH	BEARING	(+) LATITUDE N	(-) S	(+) DEPARTURE E	(-) W	BALANCED LAT.	DEP.	TOTAL LAT.	DEP.
1										
	435.00	N46°20'40"E	+.017 300.290		+.002 314.724		N300.307	E314.726		
2									N300.307	E314.726
	222.37	S81°59'20"E		-.009 30,991	+.001 220.200		S30.982	E220.201		
3									N269.325	E534/927
	330.86	S38°28'50"E		-.013 259.004	+.002 205.877		S258.991	E205.879		
4									N10.334	E740.806
	227.03	S55°02'00"W		-.009 130.111		-.001 186.048	S130.102	W186.047		
5									S119.768	E554.759
	567.54	N77°49'10"W	+.022 119.747			-.003 554.763	N119.769	W554.760		
1									N0.001	W0.001
	1782.80		420.037	420.106 -420.037 0.069	740.801	740.811 -740.801 0.010				

COMPASS RULE CORRECTIONS

Latitude Corrections:

Correction 1-2 = 435.00 x $\frac{0.069}{1782.80}$ = 0.017

Correction 2-3 = 222.37 x $\frac{0.069}{1782.80}$ = 0.009

Correction 3-4 = 330.86 x $\frac{0.069}{1782.80}$ = 0.013

Correction 4-5 = 227.03 x $\frac{0.069}{1782.80}$ = 0.009

Correction 5-1 = 567.54 x $\frac{0.069}{1782.80}$ = 0.022

Departure Corrections:

Correction 1-2 = 435.00 x $\frac{0.010}{1782.80}$ = 0.002

Correction 2-3 = 222.37 x $\frac{0.010}{1782.80}$ = 0.001

Correction 3-4 = 330.86 x $\frac{0.010}{1782.80}$ = 0.002

Correction 4-5 = 227.03 x $\frac{0.010}{1782.80}$ = 0.001

Correction 5-1 = 567.54 x $\frac{0.010}{1782.80}$ = 0.003

CLOSURE $= \sqrt{\Sigma Lat^2 + \Sigma Dep^2}$

$= \sqrt{0.069^2 + 0.010^2}$

$= 0.070$

RATIO OF PRECISION

$\frac{\text{Closure}}{\text{Perimeter}} = \frac{1}{X}$

$\frac{0.070}{1782.80} = \frac{1}{X}$; X = 25,469; Ratio of Precision = 1/25,469

MANUAL CALCULATIONS FOR SAMPLE PROBLEM #2

FIGURE 18

letters

To the Editor:

Another reader of the JOURNAL has suggested that it might be helpful to many of us if the editor would occasionally print lists of appropriate reference materials regarding new metric standards. Some engineering standards have been reworked and published, while others are stil in the process of metrication.

Just as a starter, I would like to offer the following list of standards gleaned from the 1974 ANSI catalog, the latest edition I happen to have. All are available from the American National Standards Institute, 1430 Broadway, NY 10018.

ISO 9000-1973, SI Units and Recommendations for the Use of Their Multiples and of Certain Other Units, $1.50

B1 Report, ISO Metric Screw Threads, $4.25

ISO 17-1973, Guide to the Use of Preferred Numbers and of Series of Preferred Numbers, $3.70

ISO 68-1973, ISO General Purpose Screw Threads---Basic Profile, $3.70

ISO 965/I-1973, ISO General Purpose Metric Screw Threads--Tolerances--Principles and Basic Data (old B1.16), $7.35

ISO 965/II-1973, ISO General Purpose Metric Screw Threads--Tolerances--Limits of Sizes for Commercial Bolt and Nut Threads--Medium Quality (old B 1.16), $9.45

SR 11, ISO System of Limits and Fits--General Tolerances and Deviations, $6.50

SR 12, ISO System of Limits and Fits-- Inspection of Plain Workpieces, $5.00

Klaus Kroner
University of Massachusetts

Many thanks, Klaus, for your interest and contribution. This subject would probably merit an in-depth development of a formal bibliography for some interested division member. A couple of good manuals follow. -PSD

Metric Transition for Managers. Sellers, Robert C. Dunn-Donnelly Publications, NY, 1975

Reference Handbook for the Proper Usage of Metric-SI in Science and Engineering. Sellers, Robert C., ed. Robt. C. Sellers & Associates, Inc., Floral Park, NY 11002. 1974. $1.95.

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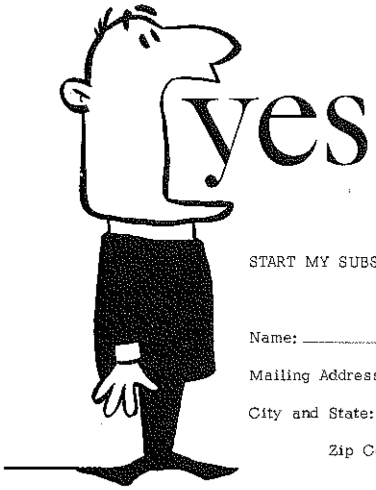

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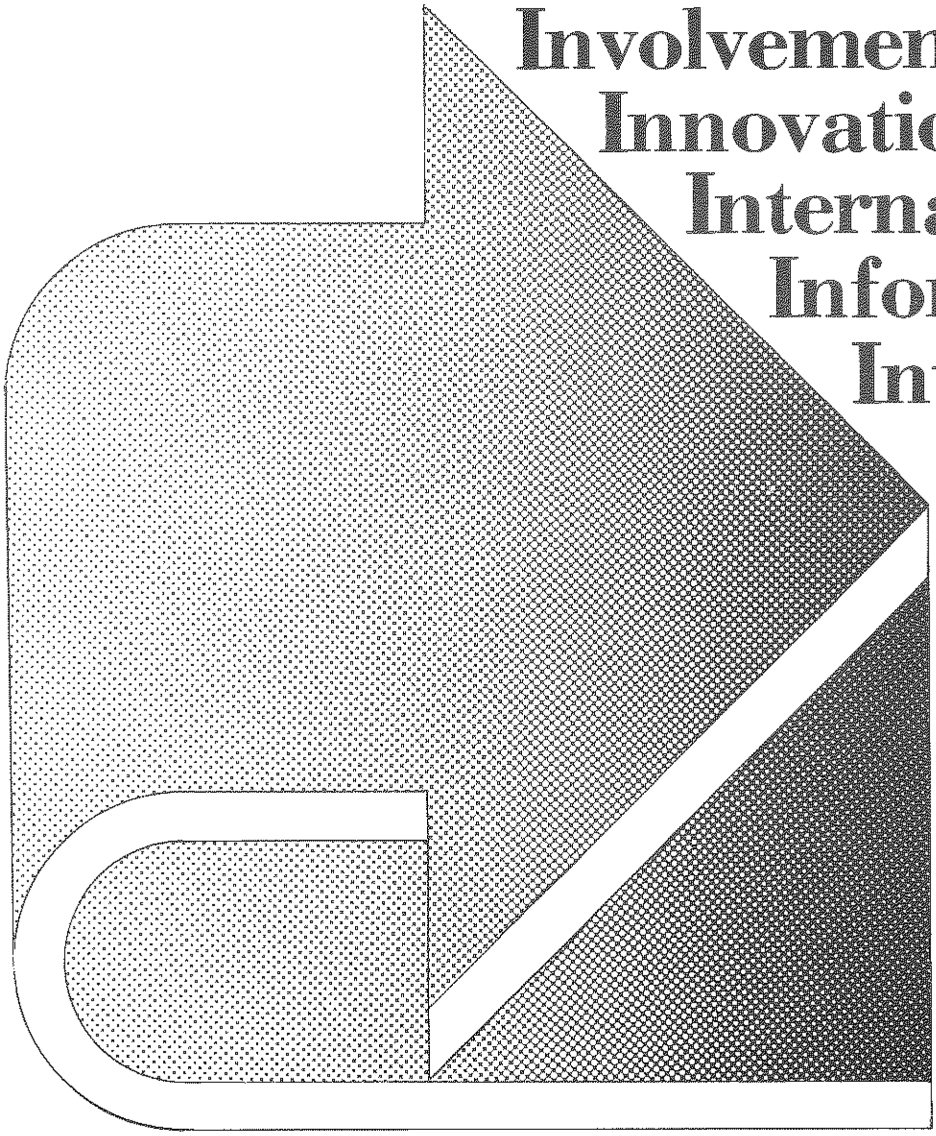

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