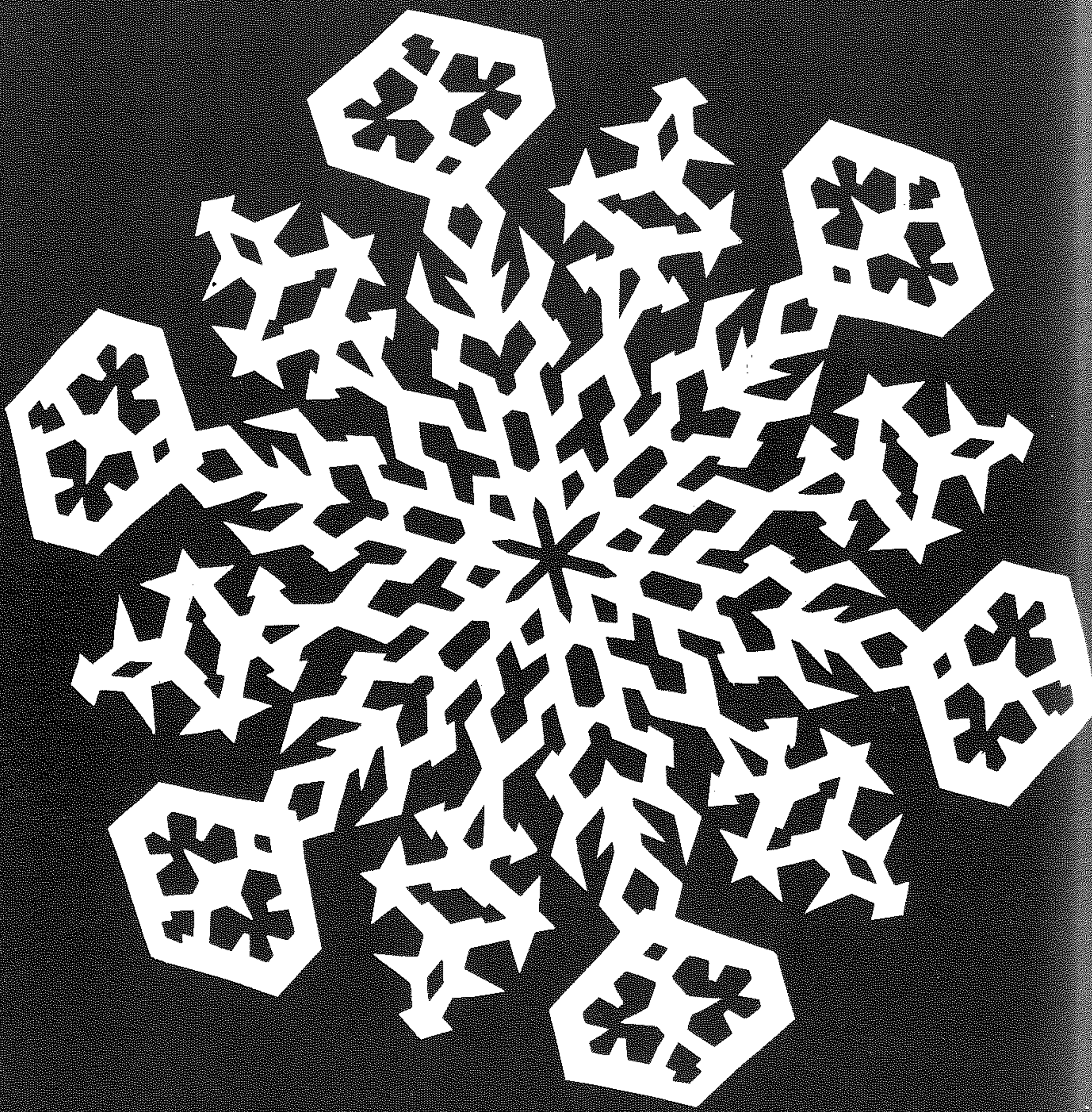
METRIC

ENGINEERING DESIGN GRAPHICS JOURNAL

WINTER 1979 VOLUME 43 NUMBER 1



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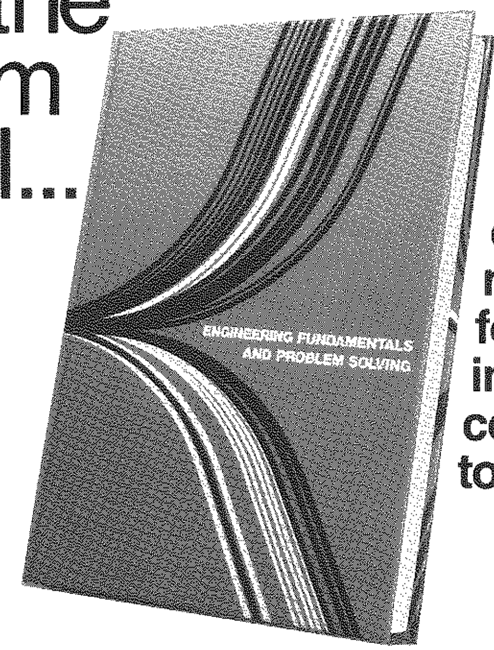

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ENGINEERING FUNDAMENTALS AND PROBLEM SOLVING

Arvid R. Eide, Roland D. Jenison, Lane H. Mashaw, and **Larry L. Northup,**
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1979, 416 pages (tent.), $16.95 (tent.) Solutions Manual

Engineering Fundamentals and Problem Solving provides a logically organized and clearly written general introduction to engineering. Yet at the same time, its treatment of the subject is sophisticated enough to give students a solid foundation in three major areas of interest: orientation, computation, and design.

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No mathematical expertise beyond algebra and trigonometry is required, and review material for these subjects is contained in appendixes. The text touches upon graphics for review or reference purposes, and includes an appendix that outlines the fundamentals of graphical techniques. The authors have carefully described rules for proper use of SI units, and the problems and examples in the text employ both SI and English units.

Contents/Preface. PART A: AN INTRODUCTION TO ENGINEERING. The Engineering Profession. Engineering Solutions. Presentation of Technical Information. Engineering Estimations and Approximations. PART B: METRIC (SI) UNITS IN ENGINEERING. Dimensions, SI Units, and Conversions. PART C: COMPUTERS AND CALCULATORS IN ENGINEERING. Introduction to Computing Systems. Programming. PART D: APPLIED ENGINEERING CONCEPTS. Mechanics. Chemistry. Material Balance. Electrical Theory. Energy. Engineering Economy. Statistics. PART E: FOUNDATIONS OF DESIGN. Design Process. APPENDIXES. Selected Topics from Algebra. Trigonometry. Graphics. General.

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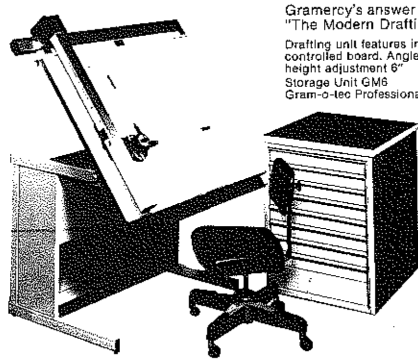

ENGINEERING DESIGN GRAPHICS JOURNAL

CALENDAR

ASEE ANNUAL CONFERENCES

1979 - Louisiana State University, Baton Rouge. June 25 - 28

1980 - University of Massachusetts, Amherst. June 22 - 27

1981 - University of Southern California

EDGD MIDYEAR CONFERENCES

1980-Cogswell College

1981-North Carolina State

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 opinions and technical accuracy rests entirely upon the author.

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ENGINEERING DESIGN GRAPHICS JOURNAL OBJECTIVES:

The objectives of the JOURNAL are:
1. To publish articles of interest to teachers and practioners of Engineering Graphics, Computer Graphics and subjects allied to fundamentals of engineering.
2. To stimulate the preparation of articles and papers on topics of interest to its membership.
3. To encourage teachers of Graphics to innovate on, experiment with, and test appropriate techniques and topics to further improve 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.

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

3. Two copies of each manuscript are required.

4. Refer to all graphs, diagrams, photographs, or illustrations in your text as Figure 1, Figure 2, etc. Be sure to identify all such material accordingly, either on the front or back of each.
Illustrations cannot be redrawn; they are reproduced directly from submitted material and will be reduced to fit the columnar page.

Accordingly, be sure all lines are sharply drawn, all notations are legible, reproduction black is used throughout, and that everything is clean and unfolded. Do not submit illustrations larger than 198 x 280 mm. If necessary, make 198 x 280 or smaller photo copies for submission.

5. Submit a recent photograph (head to chest) showing your natural pose. Make sure your name and address is on the reverse side.

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

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9. Send all material, in one mailing to:
Paul S. DeJong, Editor
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Iowa State University
Ames, Iowa 50011

REVIEW OF ARTICLES

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

DEADLINES FOR AUTHORS AND ADVERTISERS

The following deadlines for the submission of articles, announcements, or advertising for the three issues of the JOURNAL:
Fall--September 15
Winter--December 1
Spring--February 15

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Engineering Design Graphics Journal

WINTER 1979 VOLUME 43 NUMBER 1

EDITORIAL

Those of you who missed the Mid-Year conference at Mississippi State really missed a good one! Just to make things interesting Mother Nature fixed the Ramada Inn with "cold" and "colder" running water and spotty electricity. Claude Westfall kept warm and out of the dark with a candle, while Bud Devens and Bill Rogers unsuccessfully pursued an uninvited cat who was staying warm in their room. In spite of those problems, Hunter and Juanita Eubanks, Mary Jasper, Grover Taylor, Frank Cade, Dean Stewart, and gang really put on a fine meeting and we all found that Mississippi is truly the "hospitality state". We also had some interesting controversy about Graphics and its directions....well, you can read all about that in the Spring issue of the JOURNAL. We will have a thorough review of the conference there, and don't miss it.

One of the subjects raised at the meeting was precipitated by the schizophrenic behavior of the Washington Bureaucracy. Many readers will recall the Metric Act of 1975, and even the controversy about the spelling of metre which the Department of Commerce incorrectly "solved" by edict in a Federal Register Notice dated Dec. 10, 1976. It fortunately appears that their dictum is being largely ignored.

While the Metric Advisory Committee is promoting metrication, the National Weather Service threatens to "go English" because it wasn't given a position on the committee.

More recently, the General Accounting Office got into the act, much to the horror of those of us who noticed the newspaper accounts. Klaus Kroner was among us, and obtained a copy of their report. Generally, it sounds as if it were the result of an effort to create summer employment, and its plot runs something like this: while some industries are going metric, there doesn't seem to be any reason for it, (the law doesn't require it, there isn't a government policy regarding metrication,) it will cost a lot of money, and no one we talked to liked it much anyway, so why don't we forget it.

continued on p.6...

CONTENTS

Cover: The winter of 1979 as seen by the editor...among others.

COMMITTEE COMMUNICATIONS

METRICATION COMMITTEE

The Metrication Committee met on Tuesday, June 20, at Vancouver, B.C. with five members present. The Committee helped plan several events at the Vancouver Conference. A session on Metrication is on the program at the Mississippi State Conference and the EDG Division is co-sponsoring an event with the ASEE Metric Coordinating Committee at L.S.U. in June. All recent issues of the EDG Journal have had at least one article on metrication.

The Metrication Committee will hold a short meeting at Mississippi State University. The members are:

Henry Kroeze
University of Wisconsin, Waukesha
Klaus Kroner
University of Massachusetts
Ken Meek
St. Lawrence College
Claude de Guise
Ecole Polytechnic

Howard Hedinger
Lester Johnson
Savannah State College
Kenneth Howard
Henry Ford Community College
William VanderWall
North Carolina State

The members are broken down into two groups, the first group of four are participating. The second group are names of people I never met but indicated an interest in metrication.

Ed Mochel
University of Virginia

COMPUTER GRAPHICS COMMITTEE

Committee Chairman Francis Mosillo reports the committee has been restructured into various subcommittees. The organization of these subcommittees is reflected in the committee roster shown below.

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Freshman Engineering Graphics

Update Editor

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Subcommittee I:

Directory of computer graphics movies, text materials, syllabi, etc.

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Directory of available computer graphics software as utilized in engineering graphics courses.

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Nashville, Tennessee
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(615) 322-4730

James Burnett
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Michigan State University
East Lansing, Mich. 48824
(517) 355-5123

CALL FOR PAPERS

The Engineering Design Graphics Division of the American Society of Engineering Education is inviting the submission of papers for its 1979 mid-year meeting. November 14-16 are the dates for the conference to be held in San Francisco, California with Cogswell College serving as the host institution.

Papers should be of a topic relevant to developments within the area of Graphics or some related field, with its content limited to a twenty-minute presentation. Any proposals for topics and contributors for these sessions will be welcomed by the conference organizers.

Please address all inquiries to:

Professor Peter W. Miller
Engineering Graphics Dept., MGL
Purdue University
West Lafayette, IN 47907
(317) 494-8020

OR

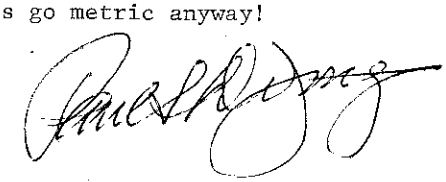
Professor Arvid R. Eide
Freshman Engineering
Iowa State University
Ames, IA 50011
(515) 294-8355

Editorial: continued from p.3...

Why the report was ever written (Who asked them?!?) and how it could be taken seriously staggers the imagination. It will probably reach its rightful place, - oblivion, - in time, but in a way, it ought to stand as some kind of a monument to the uncoordinated effort it exemplifies so well.

Maybe the "District" should be rechristened with a more "native-American-sounding" name. A modest suggestion would be "Runamuck". It seems so appropriate, and it has endless potential. I suppose it would get tied up in committee, though, or the Department of Commerce would insist on a different spelling.

Let's go metric anyway!

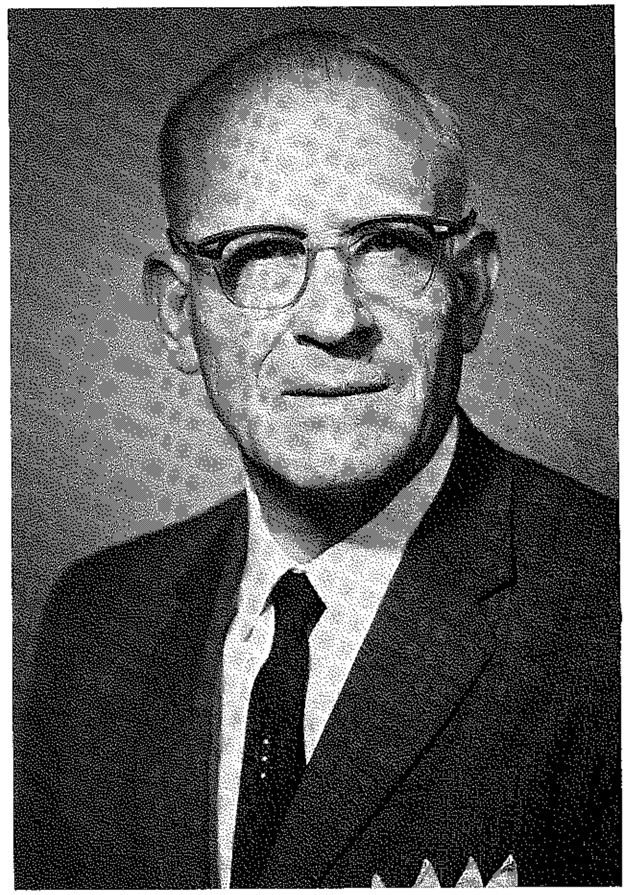


CREATIVE DESIGN WORKSHOP

A three-day Creative Design Workshop was held Jan. 10-12 at the University of Massachusetts. A wide spectrum of subjects was discussed, including What is Design, How to Teach Design to Freshman, Teaching Upperclass Students, Product Liability, Human Factors, Generation of Projects at the various levels, and Computer-Aided Design. Workshop sessions were included to assure participation of the attendees, and reports reaching the JOURNAL indicate the conference was oversubscribed and a huge success.

The speakers were without doubt responsible in some measure for that success, and included many distinguished persons whose names are familiar to EDGD members as well as authorities from the industrial sector.

Proceedings of the Workshop are available for $1.00 from:
Joseph Marcus, Associate Dean
School of Engineering
University of Massachusetts
Amherst, MA. 01003



WILLIAM EZRA STREET
1901-1978

William E. Street, one of the most prominent members of the EDG Division, died on November 6, 1978, at his home in Nashville, Arkansas. He was buried at Dickens, Texas, on November 10th. He is survived by his wife, Clara, and daughter, Mrs. Louise Beagle.

Professor Street was the recipient of the EDG Division's Distinguished Service Award in 1961 which climaxed his many years of service to the Division. He had held practically all elected positions from editor of the JOURNAL to the chairmanship in 1956. Few members, if any, have matched his record for attendance at ASEE meetings and his active participation in and contributions to the Society over the years.

Professor Street retired as head of Louisiana State University's Engineering Graphics Department in 1971. He had previously been the head of Texas A&M Engineering Graphics Department from 1941 through 1965, after leaving Texas Tech's Engineering Graphics Department.

He was a well-known author of several text books and laboratory manuals. His last book, Engineering Graphics, was published by Van Nostrand Publishing Company in 1963. He is listed in Who's Who in Engineering Education.

Dr. Street was the 1961 recipient of the General Dynamics Award as the outstanding teacher in the College of Engineering at Texas A&M.

In addition to his academic duties, Professor Street was an active Rotarian and served as a district governor. He was an elder in the Church of Christ for over 40 years.

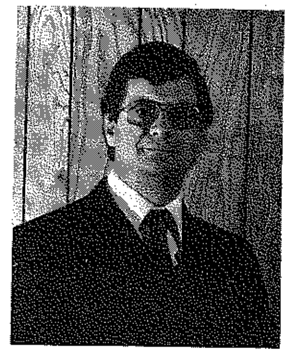
Throughout his career Dr. Street spent his off hours as a part-time rancher; and after retirement he devoted full time to this pursuit until his unexpected death.

Bill Street will never be forgotten by those of us who knew him and worked with him. His career touched and influenced the lives of many students, associates and friends. He was a good man and a good friend. We will miss him.

James H. Earle
EDG Department
Texas A&M University

TECHNICAL - PROFESSIONAL COMMITTEE CORNER

TEACHING TECHNIQUES



Merwin L. Weed
Penn State University
McKeesport Campus

STUDENT-DESIGNED PLEXIGLASS MODELS

Generally speaking, a student will find learning a happy and exciting experience if he can achieve a sense of accomplishment and/or fulfillment. This notion was supported in a descriptive geometry class in which the students were asked to design plexiglass models that would illustrate some truth or construction found in their study of descriptive geometry. Before such a design could be accomplished, the student had to gain a thorough understanding of the theories involved in the point he wished to illustrate.

The enthusiasm mounted as plans were made to have the models constructed for use in future classes. Without being aware of it, the students of that class were eagerly going through the design process as well as acquiring a broad knowledge of descriptive geometry.

Each project was to be presented in the form of a working drawing complete with an assembly drawing, a bill of materials, and details.

There was a limitation placed on the materials to be used on the models since only a small variety of plexiglass stock shapes and a quantity of 3/4" plywood were available. At first, this was viewed as a negative limitation; but, in retrospect, this narrow availability of materials forced the students to work under only one more design parameter - an early view of real life.

Photo No. 1 pictures four plexiglass models designed by individuals of the class and built by a gifted work-study student of that class. It has worked well to have these and others available in the classroom to be used during lecture or for a student who might just want to look at one to reinforce his thinking.

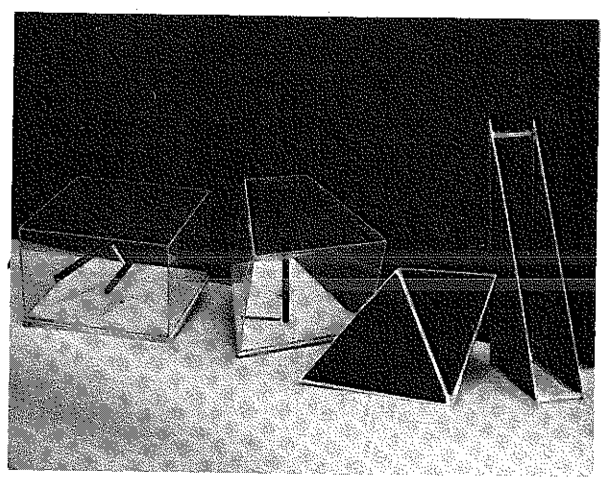


Photo No. 1
Four Plexiglass Models Designed and Built by the Students in the Class.

Photo No. 2 shows a simple model of two intersecting planes. This is a handy model to use when describing to a class the necessity of sighting down the line of intersection in order to view the true angle between two planes. The student himself had to view down the line of intersection of two planes in order to prescribe the angle of cut to be made on each plane of his model.

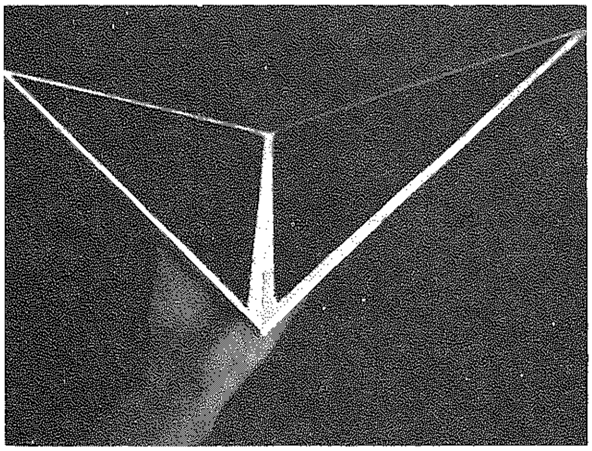


Photo No. 2
A Simple Model of Two Intersecting Planes.

Photo No. 3 is of a model of two parallel planes. This model as well as the intersecting planes model are of a size that is convenient to hand hold while lecturing and is large enough for all in the room to see. Both are made of a bright red plexiglass with the edges painted white to better define the perimeters of the planes.

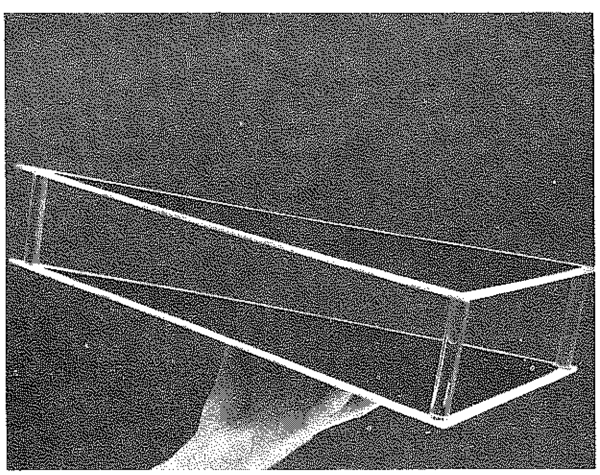


Photo No. 3
A Model of Two Parallel Planes.

Photos No. 4 and 5 are two views of the same model. This model was designed to exhibit skew lines and demonstrate the necessity of sighting down one of the lines in order to see the true length of the shortest connector.

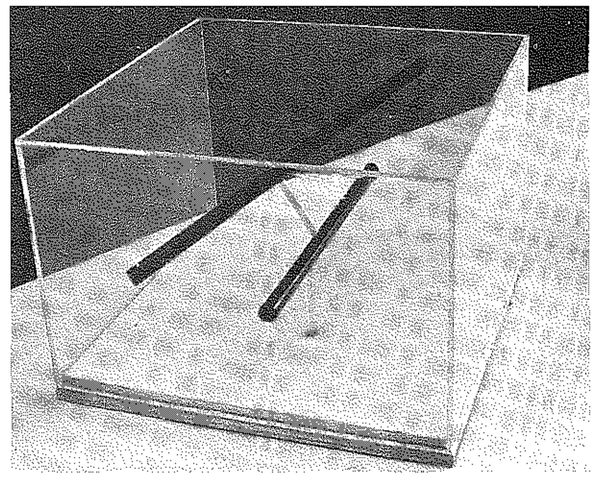


Photo No. 4
A Model to Exhibit Skew Line Relationships.

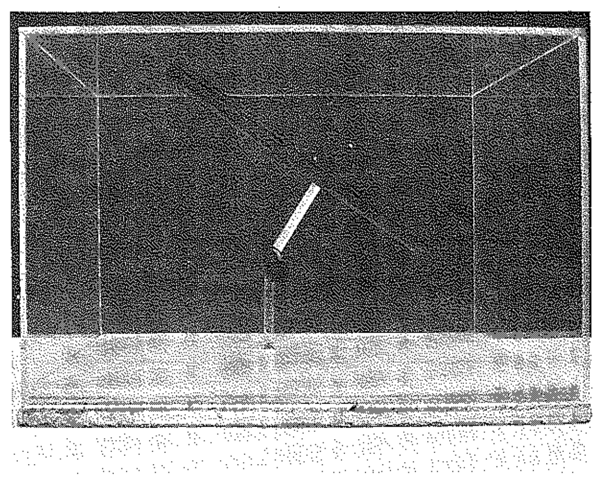


Photo No. 5
Another View of the Skew Line Model.

Finding the true length of a line by projecting that line onto a plane of projection parallel to the line is portrayed in the model pictured in Photo No. 6. The construction of this model was the most difficult of the four models illustrated here because of the various angles between the faces of the plexiglass box. The plexiglass box was deemed necessary, however, to represent planes of projection.

The design and construction of these plexiglass models seem to have had a positive effect on both the instructor and his students. As a teaching technique, this project proved to be most satisfactory.

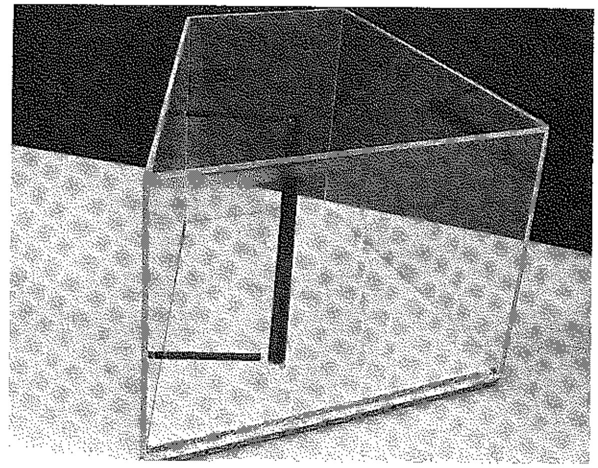
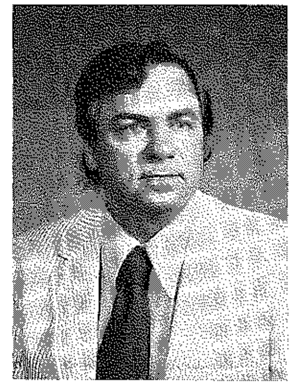


Photo No. 6
A Model That Demostrates the Proper Method For Determining the True Length of an Oblique Line.

Merwin L. Weed is currently serving as Chairman of the Teaching Techniques Committee of the EDG Division. This paper is a fine example of a technique that needs to be shared with the readership of the JOURNAL. The editorial staff of the JOURNAL would be most happy to consider for publication under this format any and all papers describing innovative techniques in teaching. Papers from other Technical-Professional Committees are welcome also and are encouraged. It is our earnest desire to keep our readers abreast of current trends in engineering graphics. With your help we can achieve this simple goal.

Frank Croft
Associate Editor

Robert P. Kelso
Louisiana Tech University



A SMALL 'FLAW' IN THE OINTMENT

(Sorry about that!)

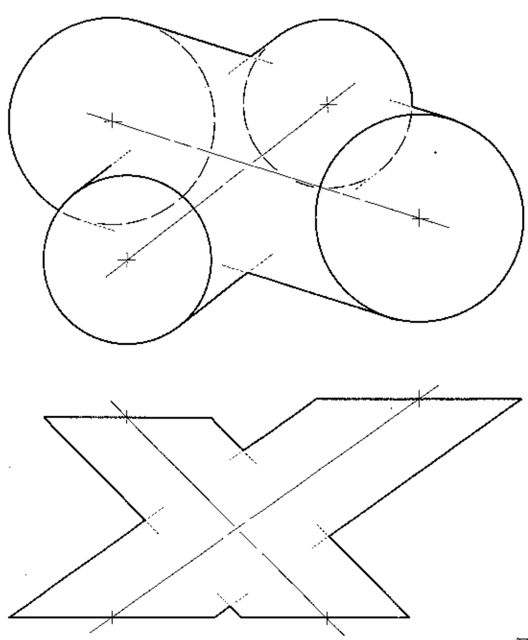
In all texts which I am familiar the subjects of INTERSECTIONS and TANGENCIES seem slightly flawed in one respect: illustrative drawings are used which show principal views of the cylinder and the cone in skew positions, the bases of which, having been formed by principal planes, appear as circles. (Figure 1)

This is visually unintelligible until it is realized these illustrated geometric figures are elliptical. Texts don't always make this obvious. The elliptical natures of the figures become apparent when the diameters length are compared in two views.

Discovering this, one is posed with the visualization question: "How is it possible that an elliptical cylinder or cone, in a skew position, when cut by a principal plane, will yield a circular-line-of-intersection in a principal view?"

The answer is, of course, that the figures must be placed in propitious positions. Since mention is seldom made of this in texts, this special situation may be mistaken for a general condition. I suspect there are alert students who harbor the notion that any elliptical cylinder or cone, in any skew position, and whose bases are formed by principal planes, will show their bases as circles in principal views.

An alternative I suggest is that, in the illustrative drawings to be used, the elliptical cylinder and the cone be retained but they be of undefined length and that the circular-base appearance, as seen in principal views, be developed.



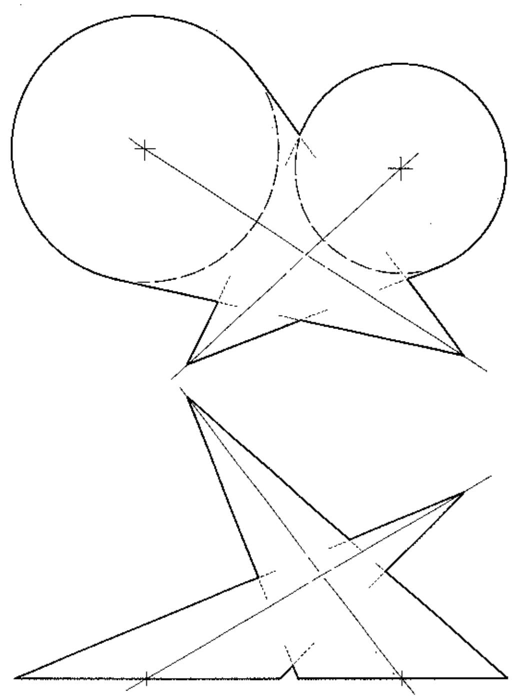


Figure 1

A typical development is given below for each of the cylinder and cone. (Fig. 2 and 3).

GIVEN:
(1) Top and Front Views of Elliptical cylinder A-B.
(2) Point C in the Top View.

CONSTRUCT:
A cutting plane through Pt. C such that its line-of-intersection with the cylinder will be seen as a circle in the Front View.

STEPS IN THE CONSTRUCTION:
(1) In the Front View, draw a "trial" circular base at any location of convenience on the cylinder.
(2) Project to the Top View the EV of the cutting plane which defines the trial circular base (two possible).
(3) Construct, in the Top View, the EV of a "final" cutting plane through - Pt. C-and-parallel-to-the-trial-cutting -plane.
(4) Project the line-of-intersection-of-the-final-cutting-plane-with-the-cylinder to the Front View. This line-of-intersection will be seen as a circle.

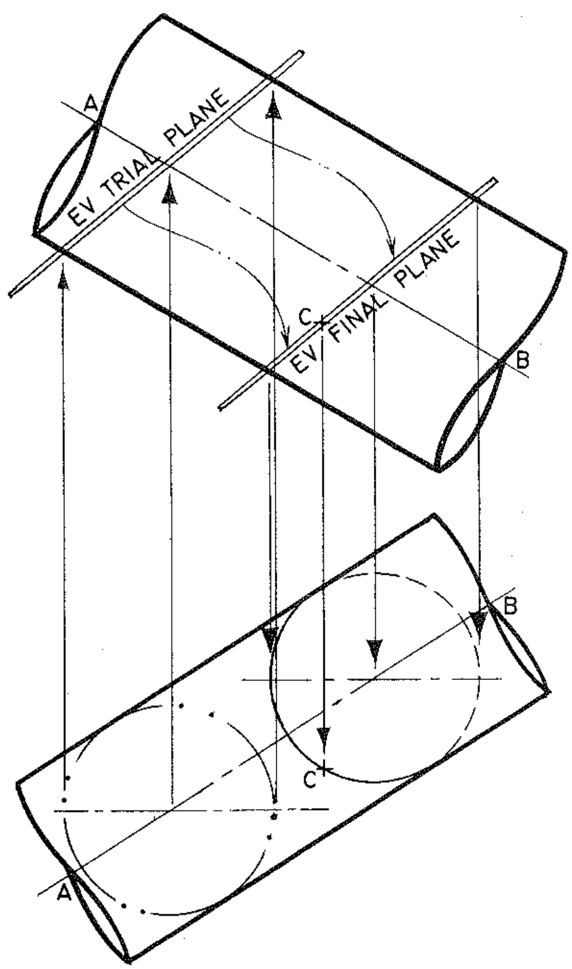


Figure 2

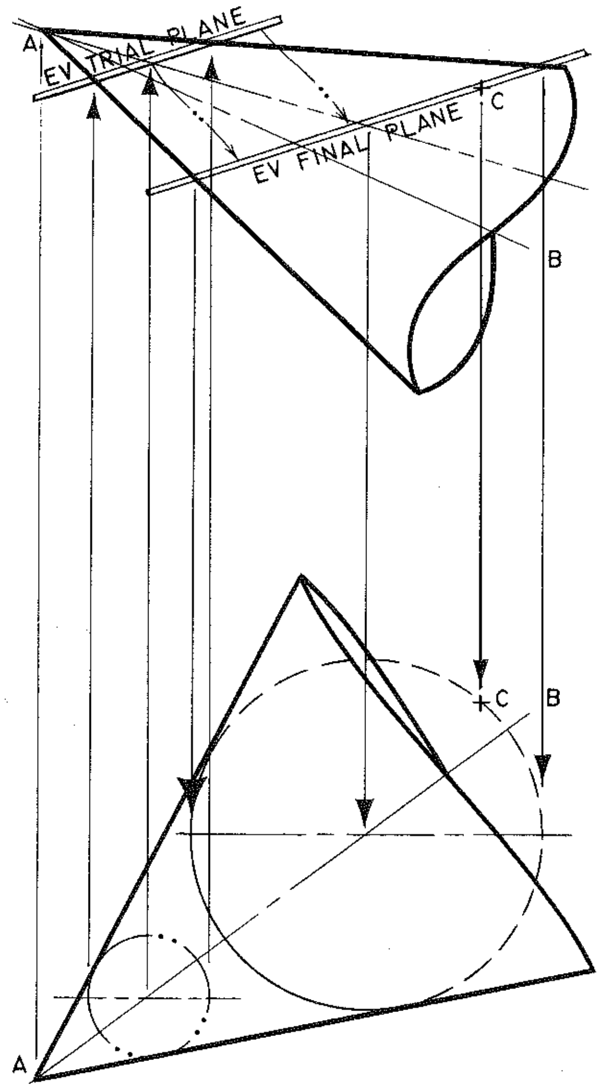


Figure 3

GIVEN:
(1) Top and Front Views of elliptical cone A-B.
(2) Point C in the Top View.

REQUIRED:
To construct a cutting plane through Pt. C such that its line-of-intersection with the cone will be seen as a circle in the Front View.

STEPS IN THE CONSTRUCTION:
The approach is the same as with the cylinder.

Robert N. McDougal
University of Nebraska-Lincoln

THE INEVITABILITY OF COMPUTER GRAPHICS

ABSTRACT

This paper offers comments on Engineering Graphics as taught traditionally. References are made to the comments of several educators and industrial representatives. The beneficial results of curriculum changes in Engineering Graphics at the University of Nebraska at Lincoln are discussed. Suggestions are offered relevant to the benefit of using visual aids, group participation, and particularly Computer Graphics as teaching and motivating tools. Included in the Appendix is a listing of visual aids sources, textbooks, etc. used by those Universities who responded to a survey made by the author.

INTRODUCTION

Recently Engineering Graphics has experienced a change which is for the betterment of the engineering profession. Several educators have expressed their reasons concerning this change.

Professor Phillip C. Sell, Professor of Civil Engineering at Highline Community College published an article in the November 1977 issue of Engineering Education entitled "Graphics: A subject for all Engineers". In his paper he made this statement, "A survey from recent catalogues from 25 colleges selected at random, showed an average graphics requirement of less than three semester credits; nine schools required zero." "In comparing this finding," states Prof. Sell, "With the average requirement of six to nine credits common ten to fifteen years ago, reveals a trend which to those professors involved in the teaching of graphics might consider to be challenging." Prof. Sell suggests several possible reasons for this drop in Engineering Graphics requirements. Some of those cited were: The credit hour squeeze. As science and technology grow and expand, so do the demands of additional courses in the engineering curriculum. Usually as a result of these demands there are pressures to eliminate some of the courses which the engineering faculty feel are less important to the engineering graduate. Another possible reason for the lack of hours in the graphics area is respectability. Again quoting Prof. Sell, "Many engineering educators believe graphics is not rigorous enough to be included in the college curriculum" A third possible reason is relevance. Some question the relevance of graphics to the modern engineers work. Modern mathematical methods and computers have replaced graphical methods in many areas, especially as problem-solving tools. There is a decided shift from the practical to the theoretical in many schools and graphics has very little of the theoretical. Prof. Sell goes on to state that in his review of 33 general graphics texts it was determined that only 88 of the 534 total chapters were devoted to topics in graphical analysis, construction drawing, systems drawing, and concept drawing. The main emphasis in present day graphics is on mechanical drawing or drawing of objects for manufacture. He therefore, feels that graphics taught as mechanical drawing is relevant to only a minority of practicing engineers.

Professor Amogene F. DeVaney, then chairman of the Engineering Graphics Division proposed these questions in the Spring, 1978 issue of Engineering Design Graphics Journal: "As those professors who are now involved in teaching engineering graphics retire will they be replaced or will it provide an opportunity for the administrators to reduce or eliminate courses in drafting from the curriculum? Secondly, if graphics is continued in the curriculum, what if these teachers are replaced, what type of training should the new graphics teacher have?" Prof. DeVaney does not propose to answer these questions but does suggest that in our present technology we will see that more theoretical graphics will be required. Drawing will be automated, the computer will do the drawing. She then cites a visit that was made in the early 1960's to a Boeing facility in Wichita, Kansas where drawing was done by automation, and goes on to say that recently she had visited a large company that was just completing automation of all of its drafting. The final drawings in this company were made entirely by the computer from very rough sketches prepared by the engineers.

An article by D.A. Curtiss in a July 1965 issue of Graphic Science entitled "Automated Drafting - Where Are We Now?" states that automated drafting was definitely a necessary part of the engineering equipment at Rocketdyne Corporation. He continues, in the article, to describe the different pieces of equipment that were being utilized and the benefits received in terms of engineer time and economics, which was advantageous to the corporation.

This brief review of the statements of the contributors mentioned would suggest that there definitely must be a change in our presentation of engineering graphics to the modern day engineering student. The advent of the computer and its accessability to the engineer has provided a tremendous opportunity for the engineer to use computer graphics facilities in the design of machines and structures.

PRESENT DAY COMPUTER GRAPHICS

Several articles have been written relevant to computer graphics as a part of the present day engineering curriculum. An article entitled "Computer Graphics in Chemical Engineering Gaming and Simulation" authored by H. Scott Fogler of the University of Michigan observed in the 1978 Winter issue of ERM indicates that the computer-base simulation gaming system used at the University of Michigan has proven a valuable educational and motivational aid. In that same periodical in an article entitled, "Computer Graphics in Undergraduate Education" by M. Firebaugh, N. Marron and D. Piele from the University of Wisconsin at Kanoshia, Wisconsin, this statement is made: "Recognizing the need for improved data analysis techniques for undergraduate students in science and mathematics, the University of Wisconsin-Parkside has developed computer graphic softwear. The softwear is used in the classroom in a variety of instructional modes." In 1977 Professors R.J. Beil & Phil Sherrod of Vanderbilt University published a paper entitled "Computer graphics; a modular approach." Excerpts from the paper state the following: "While some, but not all, students enter Vanderbilt University with a background in Computer programming, all freshman engineering students are required to complete 10 two-hour modules in BASIC. This language, when transferred to Fortran, gives students the programming background necessary for the graphics module, Introduction to Computer Graphics, that follows the BASIC module." They state that this language gives the student a sense of accomplishment.

Professors John T. Demel and Tim Coppinger of Texas A&M University published an article in the Engineering Design Graphics Journal entitled "Using Graphics to Teach Computer Programming." In that article they

The computer age is truly upon us, and Professor McDougal's article, condensed from a paper given at Vancouver, presents a rather impressive collection of facts about trends and developments in this field which may escape those of us who may not be "keeping score". Even the most aloof, however, have seen computer programming fundamentals move down from the graduate level to freshman and sophomore courses, thus largely eliminating "programming ignorance" as an argument against computer graphics. There are some perplexing questions still to be answered, even so. First, exactly what does computer graphics teach or provide to the student that good sketching techniques do not? Second, will the student be able to use that specialized ability after graduation? Third, what subject material is removed from the curriculum to provide time for computer graphics? Fourth, where does the money come from to obtain the equipment to provide "extensive hands-on" experience for 1000 freshmen?

These questions are troublesome, especially to the larger universities, who find themselves logistically and financially unable to provide uniform and meaningful computer graphics experience.

Those who are developing computer graphics courses may wish to contact Prof. McDougal for a copy of his original paper which contains data on the texts used by the various universities in their computer graphics courses.

Paul S. DeJong
Iowa State University

state: "Computer Graphics at Texas A&M began in the 1970's. It was soon found that the major difficulty in obtaining a drawing from a machine was not the graphics but the programming, thus basic programming techniques were introduced into the course, teaching only the programming statements necessary to solve one graphics problem at a time, allowing the students to see how each statement manipulated the machine." In the 1974 Winter issue of the Engineer Design Graphics Journal an article written by Prof. F.A. Mosillo of the University of Illinois of Chicago Circle states that the softwear program TRIDEM which was developed at North Carolina State University at Raleigh was introduced to the students of Chicago Circle, thus utilizing the concept of Computer Graphics in the Engineering Graphics curriculum.

Professors Robert J. Beil and Phillip H. Sherrod have also collaborated on a paper entitled "One Year With the Graphic System, an Educational Experience" (EDGJ). In this article they explained the computer graphics system as it was bieng taught at Vanderbilt University. Engineering undergraduate students make use of CRT terminals, hard copy and graphics tablet at Vanderbilt.

Others have written articles on computer graphics. Some are: "Three Dimensional Computer Graphics Program On a Large Scale" by Francis Mosillo; "Computer Aided Engineering Design Graphics" by Juricic and Skubic; and "Teaching Professional Use of The Computer While Teaching the Major" by James L. Lubkin.

At present, industry uses computer graphics in designing machines and structures. An article in the October 1977 issue of Engineering Graphics, entitled "Computer-Aided Design Develops Radar Systems" explains how computer graphics is used in designing at the ITEK Corp. To quote an excerpt from the paper, "Applied Technology, a division of ITEK, uses computer-aided design extensively to solve problems associated with the development and manufacture of radar warning systems for the United States and other governments." In that same issue an article entitled "Micro Graphics Builds a Future At Parsons" explains how the Ralph M. Parsons Company at Pasadena, California utilizes the concept of modern engineering technology such as computer graphics and microprocessing to more economically design structures and machines. An article entitled, "An Application of Computer Graphics in the Packaging Technology of Electronic Devices" authored by Mohammad H. Asghar with Western Electric Company at Columbus, Ohio explains how computer graphics is used in that industry. In the 1978 Winter issue of the Engineering Design Graphics Journal is an article entitled "Use of Computer Graphics in Product Engineering." This was written by Mr. Ned. L. Brown, manager of the Systems Analysis, Product Engineering Department, Saginaw, Michigan. Mr. Brown explains the use of computer graphics in the design of their products and how it is beneficial to the design concept.

Other articles such as "Computer Aided Design, Computer Aided Manufacturing And Its Applications in the Eastman Kodak Company"; "Airforce Moves Toward Computer Aided Manufacturing for Aircraft Parts"; "Solar Softwear"; "Computer Design Programs for Residential Solar Heating and Cooling" utilize the concept of computer graphics.

These references cited suggest that there is indeed a need for Engineering Graphics in the engineering student's curriculum. It is not acceptable to eliminate engineering graphics from the curriculum; it definitely is a necessary means of communication for the engineer, but it is on the other hand necessary to up grade or revise the methods of teaching Engineering Graphics. Computer graphics is one method of upgrading

These references cited suggest that there is indeed a need for Engineering Graphics in the engineering student's curriculum. It is not acceptable to eliminate engineering graphics from the curriculum; it definitely is a necessary means of communication for the engineer, but it is on the other hand necessary to upgrade or revise the methods of teaching Engineering Graphics. Computer graphics is one method of upgrading the curricula. Since industry is utilizing the concept of computer graphics, it seems necessary that these concepts be introduced to the students during their college educational experience. In the author's opinion, computer graphics in association with introduction to Design is a necessary part of the engineering freshman's education and should be experienced by engineering students of all disciplines.

ENGINEERING GRAPHICS TEACHING AIDS AT UN-L

The success of teaching a course, particularly at the freshman level, is usually enhanced by the use of teaching aides. Motion picture films, slides, transparencies, group participation, etc. can be a great asset in teaching a course such as Engineering Graphics.

At the University of Nebraska at Lincoln, it was evident in the late 1960's, that Engineering Graphics as it had been taught over the years was no longer respected by several departments within the engineering college. Mechanical drafting did not satisfy the criteria for the modern day engineering student. As a consequence, a study was initiated which resulted in the development of an entirely new concept for the presentation of engineering graphics at the University of Nebraska. In the early 1970's two entirely new courses were proposed and taught as pilot courses to the engineering students. The first course entitled "Methods of Communication in Engineering I", had the following description. "Communications of technical information through the exclusive use of freehand sketching. The exercise of basic principles of descriptive geometry to compliment fundamentals of shape and size description. The student design project: a complete design project from initial design problem statement through idea conception and evaluation, including cost analysis and progress reports to termination of design by means of complete drawings and oral reports." A second pilot course entitled "Methods of Communication in Engineering II" has the following course description. "Communications of technical information through the application of the Fortran-IV digital computer language. The expansion of mathematical and physical relationships in engineering problems through proper programming and the ability to use the digital X-Y plotter. Graphical representation of engineering data through freehand sketching and computer graphics."

As is noted in the course description, these courses differ greatly from the original basic engineering graphics course. Although some mechanical drafting is required in the course, a greater emphasis is placed on freehand sketching and the basic concepts and understanding of graphics and its interpretation. The design aspect of the course contributes greatly to students interests and gives them an opportunity to learn to work together as a group. Generally, a group consists of from 4 to 6 students, one of which is the project engineer. The project engineer acts as a laison between the group and the instructor or the visiting engineers. Visiting Engineers consist of Professional Engineers in the area who attend twice during the semester, the first time to visit with each group about their engineering project and then again at the end of the semester to act as judges when the students make their oral presentation. This design project is considered to be a tremendous teaching aid in the first graphics course. The second course, as indicated, involves the use of the computer and its application to digital plotting.

Plotting programs are written by the student and apply to several areas: Graphic, lettering, dimensioning and views of objects. The "hands-on" experience the students receive is a motivational and teaching tool.

Supplementing both courses are films and slides which relate to the subject matter. In the first course motion pictures related to design concepts are shown: one in particular entitled "The Engineering Workbook" leads the viewer through the processes related to engineering design. Slide presentations related to threads and fasteners, dimensioning, sectioning, and orthographic projection are utilized when applicable. A shop visit is included to acquaint the student with manufacturing equipment and machines. These also are advantageous as teaching aids. Texts used are: Engineering Graphics by Geisecke, et al, for Engineering Communications I, and FORTRAN IV Programming for Engineers and Scientists by Murrill and Smith, and Calcomp Programming for Digital Plotters by DeLorm and Kersten, for Engineering Communications II. The plotting text lists several of the Calcomp subroutines which are used with FORTRAN IV for plotting procedures. Several softwear programs have been written by students and members of the faculty, some of which are included in Appendix B of the original paper.

RESULTS OF A SURVEY

In an attempt to ascertain the general trend of engineering graphics at engineering colleges today, approximately two hundred colleges were contacted within the United States and Canada asking several questions concerning Engineering Graphics. The questions asked were: 1. Is Computer Graphics being taught to students in your college? 2. What texts, if any, are used in teaching the course? 3. At what level of instruction is the course being offered? 4. What does the course consist of? 5. What supplemental teaching aids (movies, slides, handouts, etc.) are used?

Of the two hundred Universities conteacted, fifty-eight responded. Twenty of those who reponded indicated that Computer Graphics was not included in their engineering curriculum. The remaining colleges were offering one or more courses in computer graphics. Table No. 1 and the Appendixes indicate the results of those Universities responding.

TABLE NO. 1

Class level at which Computer Graphics is taught at the responding Universities listed.

Brown University
Grad.
University of California-Davis
Fr., Grad.
University of California-Los Angeles
Jr. or Sr.
Carleton University (Canada)
Unknown
Case Western Reserve
Sr. or Grad
Clemson University
Fr., Jr., Sr.
Colorado School of Mines
Soph.
University of Colorado
Soph.
Columbia University
Jr., Sr., Grad.
Connecticut University
Jr.
Cornell University
Jr., Sr.
Georgia Institute of Technology
Sr., Grad.
University of Idaho
Soph. or above
University of Illinois at Chicago Circle
Fr.
Louisiana State University
Soph., Sr., Grad.
Mississippi State University
Fr.
University of Missouri-Columbia
Jr., Sr., Grad.
University of Missouri-Rolla
Fr., Soph.
Montana State University
Sr.

Naval Academy
Jr. and Sr.
Naval Postgraduate School
Grad.
New Mexico State University
Fr.
Ohio State University
Soph.
Pennsylvania State University
Fr.
Princeton University
Fr.
Purdue University
Jr., Sr., Grad
University of Rochester
Jr., Sr.
Southern Methodist University
Grad.
Syracuse University
Grad.
Texas A & M University
Sr.
University of Toledo
Fr., Soph.
University of Tulsa
Jr.
Vanderbilt University
Fr.
University of Virginia
Jr.
University of Waterloo (Canada)
Grad.
Wayne State University
Jr.
Worchester Polytechnic Institute
Sr.
Yale University
Sr., Grad.

Responding Universities Whose Curriculum

Did Not Include Computer Graphics

At The Time of the Survey

Stanford University
University of Kansas
Oregon State University
Marquette University
California State University-Long Beach
Northwestern University
West Virginia University
University of Wyoming
Thayer School of Engineering
University of Southern Florida
University of Dayton
University of Detroit
John Hopkins University
University of Western Ontario
University of Maine at Orono
Washington State University-Pullman
University of Notre Dame
Kansas State University
Virginia Military Institute
University of Illinois at Urbana

APPENDIX A-I
American Society for Engineering Education
Engineering Design Graphics Division
Computer Graphics Committee
Sub-committee Ib - Textbooks, Manuals
Franklyn K. Brown and Thomas C. Smith
June 1978

Part I

Textbooks, Workbooks, Handouts used at Schools (Numbers in circles refer to Part II)

University of California (Davis)
Handout, TDGRAPH (3D Pictures)
University of California (Los Angeles)
(2)
Case Western Reserve University
(2)
Clemson University
Computer Graphics for Engineers, Marcel Dekker publ, 270 Madison Ave, New York.
University of Colorado (Boulder)
Handouts
Columbia University
Columbia University Graphic Manuals & IBM Manual PLOT10
Also (2) & (4)
University of Connecticut
(2)
Georgia Institute of Technology
(3)
University of Idaho
(5)
University of Illinois (at Chicago Circle)
Engineering Drawing and Computer Applications, Mosillo & Pancner, (Workbook-Text)
Louisiana State University
Elements for Computer Graphics, Rogers & Odaues
Also (2) & (6)
University of Missouri (Columbia)
(2)
University of Missouri (Rolla)
Plotter Package Handout (CALCØMP)
Computer Center, U. Of Missouri-Rolla
Montana State
(2)
Naval Postgraduate School
(2)
University of Nebraska (Lincoln)
Introduction to Digital Computer Plotting - for Users of CALCØMP and CØMPLØT Plotters, T.C. Smith and Y.C. Pao, Gordon and Breach Science Publ. 1973 (Reference)
University of Nebraska (Omaha)
(7)
New Mexico State University
Introduction to FØRTRAN IV, Hammond, Rogers & Houck.
Also (4)
Northeastern University
Digital Computer Plotting, 2nd ed., Northeastern University, 1971
Ohio University
IBM 1627 Plotter Manual
IBM 1130 College prepared users manual
Pennsylvania State University
Handouts
Purdue University
IMGRAF - The Imlac Graphics Programming System User's Manual, Purdue
University of Rochester
Users' Guide to GPAK, W.A. Hunt & H.B. Voelcker: (Fortran programs for Geometry and Graphics) 1976 (CROM-9)
Programmed Graphics, Wm. Schneerer, (with exercise book) McGraw-Hill
Projective Geometry, Rosenbaum, Addison Wesley
Introduction to Topology & Modern Analysis. McGraw-Hill
Users' Manual for FLECS, A Fortran Pre-processor Ver 22 (Rev 1975)
U. of Oregon Computing Center
Survey of Computer Graphics, Appendix A of Discrete Part Manufacturing Theory & Practice (TR-1-A: Production Automation Project, University of Rochester
EE 208 Notes, 1978
PAR - University of Rochester
Geometric Modelling of Mechanical Parts and Processes. (Production Automation Project October 1977)
Southern Methodist University
Handout: "Status Report of the Graphic Standards Planning Committee of ACMISIGGRAPH," Computer Graphics Vol. 11, No. 3, 1977
Also (2)
Syracuse University
Rosebush & Judson, APL Visions Documentation & Users Manual
Also (2) & (4)
Texas A & M University
(1), (2) & (4)
University of Tulsa
Chemical Engineering INS Subroutines
Also (4)
U.S. Naval Academy
Engineering Applications of Digital Computers, Bashkow
Pertinent Concepts in Computer Graphics, Fauman & Nieuvergelt
Computer-Aided Integrated Circuit Design, Herskowitz.
Also (1), (3), & (4)
Vanderbilt University
Handouts (ES 120C-Module L)
University of Virginia
(2)
University of Waterloo
(2)
Wayne State University
(2), (3) & (4)
Worcester Polytechnic Institute
(2)
Yale University
Incremental Curve Generation, Cohen, Harvard Tech. Report.
B-spline Bezier Curves, Riesenfeld, Utah Tech Report.
Hidden Line Algorithms, Sutherland & Sproull, Tech Report
Also (2)

American Society of Engineering Education
Engineering Design Graphics Division
Computer Graphics Committee
Subcommittee Ib - Textbooks, Manuals
Franklyn K. Brown and Thomas C. Smith
June 1978

Part II

Textbooks, Workbooks used at more than one school listed alphabetically.

1. Mischke, An Introduction to Computer-Aided Design, Prentice-Hall, 1968
2. Newman, William & Robert Sproull, Principles of Interactive Computer Graphics, McGraw-Hill, 1973
3. Prince, M. David, Interactive Graphics for Computer-Aided Design, Addison-Wesley, 1971
4. Rogers, David F. & J. Alan Adams, Mathematical Elements for Computer Graphics, McGraw-Hill, 1976
5. Programming CALCØMP Pen Plotters. 1969. California Computer Products Inc.
6. GRAFIC User's Manual, Purdue.
7. CALCØMP Programming for Digital Plotters, DeLorm, R.T. & L. Kersten, University of Nebraska Press, 1976.

Jobs

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.

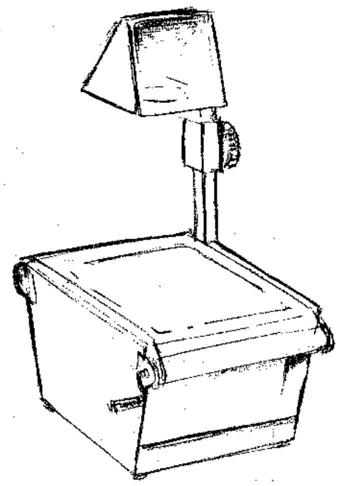
Graduate Assistantships and part-time teaching positions are also available in the Engineering Design Graphics Department.

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

LECTURE NOTES

AN EFFECTIVE METHOD TO PRESENT STUDENT WORKSHEETS

Edward Holland, Jr.
Federal City College



Problem worksheets are usually presented to students using one of two methods: (1) the problems are sketched out on the chalkboard, or (2) the problems are sketched out on the acetate roll of an overhead projector. Both of these methods are time-consuming and frequently students lose interest in the presentation during the periods of time when the problem sketches are being constructed. Another inherent weakness of this method of presentation is that after a problem has been sketched out on the chalkboard, discussed, and then erased, it is inevitable that a student will raise a question about the problem that can only be answered by reconstructing the problem on the chalkboard or overhead projector. One advantage of using the overhead projector and acetate roll is that the problem can be retrieved by rolling back the acetate roll.

The faculty members in the Engineering Design Graphics Department at Texas A & M University use a procedure to present student worksheets that is much more efficient and effective than either of the two procedures mentioned above.

At the beginning of the semester, an inexpensive thermofax transparency is made from each problem sheet. These transparencies, along with the problem sheets, can be punched and filed in a three-ring notebook with the problem transparency being placed directly in front of the problem in sequential order (transparency of sheet 1, sheet 1, transparency of sheet 2, sheet 2, etc.).

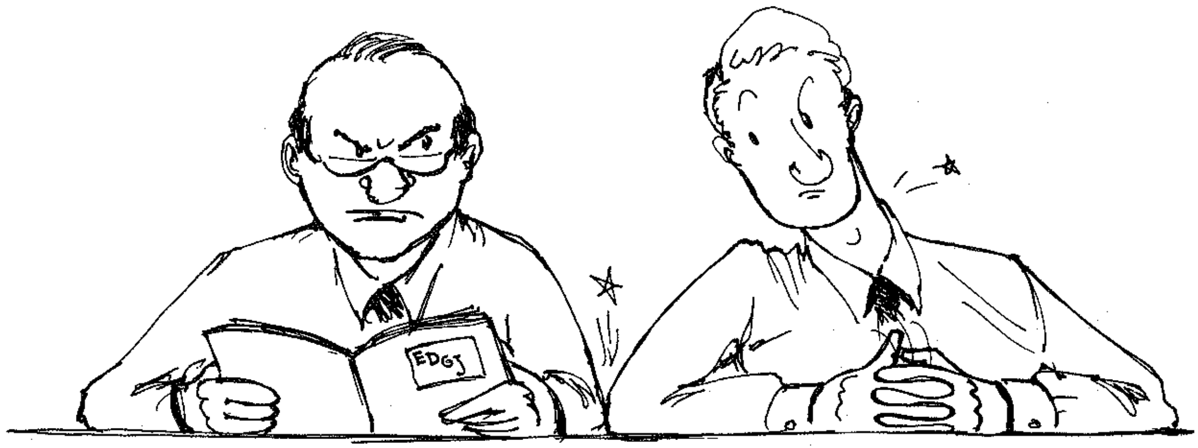
The thermofax copies of the problems can be presented using an overhead projector equipped with an acetate roll. The transparency problem sheets are placed <u>under</u> the acetate surface. Instructions can be labeled and problem solutions can be sketched on the acetate film with a grease pencil or other similar acetate marker. The problem of cleaning the problem sheets is eliminated by placing the thermofax transparency beneath the acetate roll film. The acetate roll can be cleaned with a damp cloth when it becomes filled.

If a student has a question about a problem that has already been covered, the thermofax copy can be retrieved and slid under the acetate roll surface for review. The instructions and sketches on the acetate film can also be rolled back and used as an "instant replay".

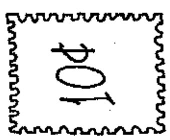
Probably the greatest advantage to this procedure is the time saved in not having to sketch out the individual problems. Greater rapport will also be enhanced between the instructor and students through more accurate communication. The student can follow along on his worksheet as the instructor reads, sketches, and points to various parts of the problem on the overhead projector.

I have personally found this technique to be one of my most useful aids in teaching any graphic-related subject.

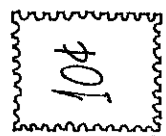
ARE YOU READING SOMEONE ELSE'S JOURNAL?



Well, don't! You needn't be left out! Remember that under the new Division membership policy, described on page 6 of the Fall 1978 issue, you should automatically receive the JOURNAL for only $1.50 a year -- less than the $2.00 subscription rate previously charged. But -- you had to check off the Division membership and pay the buck-and-a-half with your ASEE dues or your name won't show up on our mailing list -- and we do need your support and participation! So, if you're not presently getting the JOURNAL -- for whatever reason -- ask your source if you can cut out one of the cards below. Send it to Garland Hilliard for information or troubleshooting. We'll try to get things straightened out if something is amiss.



PROF. GARLAND K. HILLIARD
CIRCULATION MANAGER, EDGJ
239 RIDDICK HALL
NORTH CAROLINA STATE UNIVERSITY
RALEIGH, N.C. 27607



PROF. GARLAND K. HILLIARD
CIRCULATION MANAGER, EDGJ
239 RIDDICK HALL
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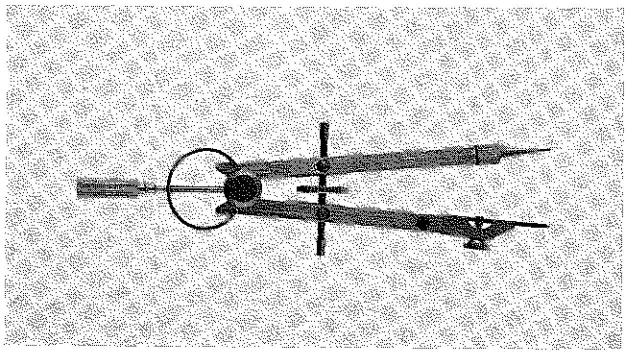
NEW PRODUCTS



NEW "Microsharp" compass cuts down drafting time. This new compass uses fine 0.5 mm lead to speed drafting jobs and produces sharp, clean arcs and circles every time without messy time-wasting lead sharpening. The long-lasting lead is easy to change and adjusts up or down simply by rotating the shaft-roller. Well-made and finished, these instruments are of a special alloy brass with a rich matte chrome finish. There are two styles and four sizes ranging from 55 mm to 190 mm radii. A rotationally advancing .5 mm drafting pencil is also available. Dealer inquiries are invited.

For full information and prices, contact: B. Carter Lykins - Importer, Dept. MS, P.O. Box 578, Nitro, West Virginia 25143.

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- ☐ I am not sure I paid the $1.50 Division dues.
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- ☐ I am not a member of ASEE but would like to subscribe to the JOURNAL.
- ☐ Other: __________

Please sign and give your mailing address:

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CALLIGRAPHY

Gretchen Weber, Iowa State University, again contributed a piece of her calligraphy to the JOURNAL. The staff decided to put it in the centerfold; the layout permits easy removal and posting without disturbing other JOURNAL articles. We hope you enjoy and use it. For those who may not be familiar with it, the block stamp in the lower right is the artist's "signature" in Chinese, an ancient custom serendipitously adopted by the Irish Ms. Weber.

CRITIQUE OF PURE REASON I. KANT

THE LIGHT DOVE

cleaving the air
in her freeflight
and feeling its resistance
might imagine that
its flight
would be easier
still
in empty space.

W. D. Teter
University of Delaware

A METHOD FOR DETERMINING THE LIMITS OF CUT OR FILL FOR A CIRCULAR HIGHWAY CURVE ON A GRADE

In the topic of highway design it is necessary to assure that cut and fill areas fit within the acquired right-of-way before design approval. Hilly terrain increases the depth of cut and fill areas and similarly the lateral limits (area) required for a cut or fill of specified slope. The problem of defining the lateral limits of cut and fill areas readily lends itself to a graphic solution.

Typically known are (1) a representation of the terrain with contours shown, (2) the width, route, elevation and grade, if any, of the roadway, and (3) the slope of the cut and fill banks. For the case of a level roadway all that is needed to determine the limits of the cut and fill areas is an elevation view showing the plane of the roadway surface as an edge.

Lines representing the inclination of the cut and fill slopes can be added and by projection the lateral location of their intersection with the ground contour can be determined at any specified elevation (Fig. 1).

Note that the location of the lines AB, CD, EF, etc. could be accomplished without the use of the elevation view. This can be seen by observing that all of these lines lie in the plane of the cut (or fill) bank which is of constant slope. Thus the lateral (horizontal) distance locating any of these lines relative to the edge of the roadway is a function of the slope of the cut (or fill) slope. i.e., for a 1:1 slope each 1 ft. of elevation change results in a 1 ft. departure from the edge of the roadway. This principle is documented by several authors (1, 2, 3).

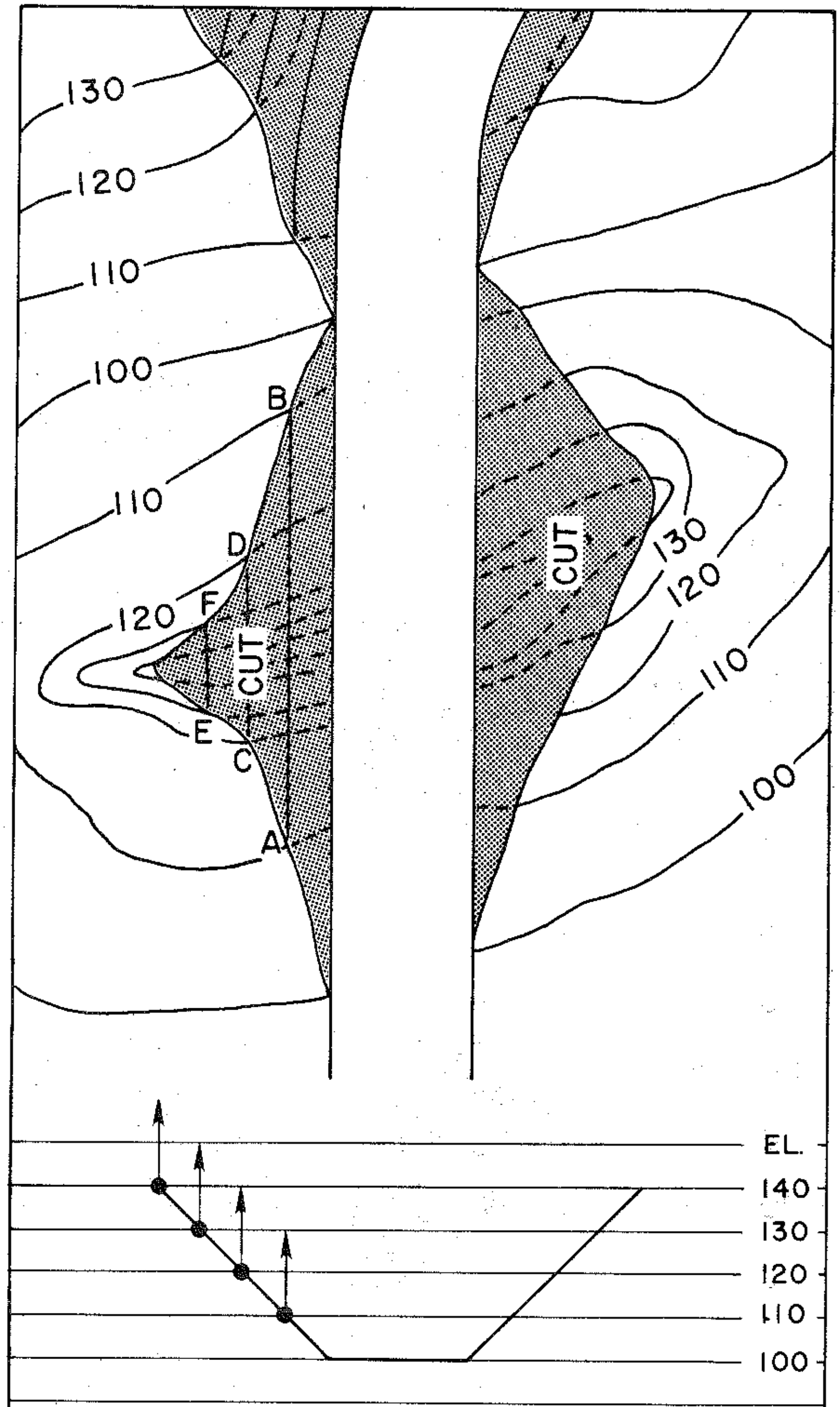


FIG. 1

Note in the example presented (Fig.1) that the lines of constant elevation (110, 120, 130, etc.) shown in the areas of cut in the plan view are regularly spaced. In addition, they are parallel to the straight-line portions and concentric with the circular portions of the roadway center-line. This is always the case when the roadway is level. If, however, the roadway lies on a grade, a different approach is necessary. An example of a non-level roadway is shown in Fig. 2.

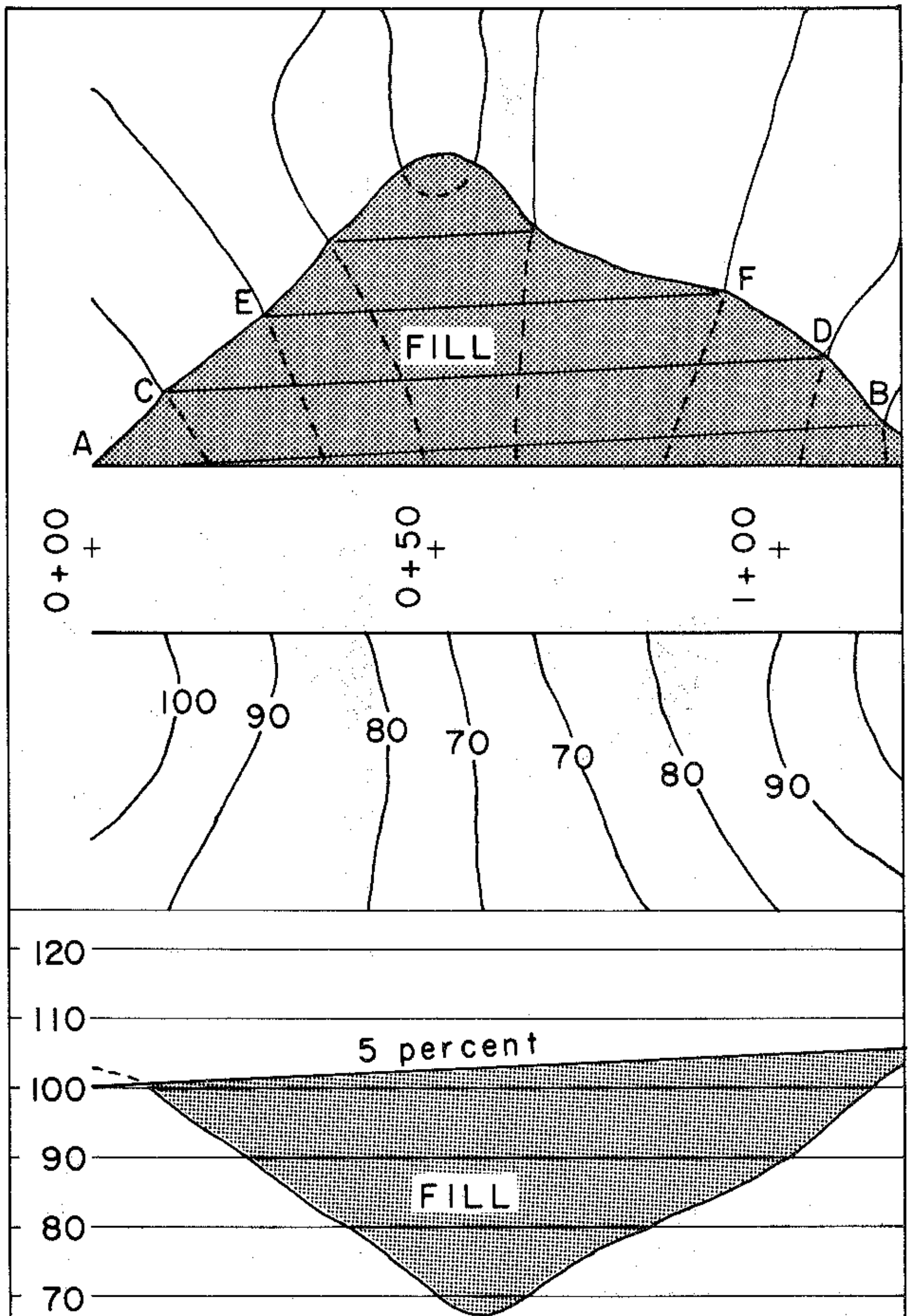


FIG. 2

Note in Fig. 2 that the lines of constant (level) elevation diverge relative to the edge of the non-level roadway with the divergence increasing with distance along the roadway in the direction of positive roadway slope. These lines (AB, CD, etc.) would become convergent if the area under consideration were one where a cut was required. The rate of divergence is dependent upon the grade of the roadway (5%) and the slope of the fill bank (which is taken to be 1:1 in Fig. 2). The level contour lines (AB, CD, etc.) are established by noting that the elevation of the roadway is 5 ft. higher at 1 + 00 than at 0 + 00; consequently, the line AB of constant elevation must be drawn to pass through a point located 5 ft. horizontally (5 ft. divergence) from the edge of the roadway at 1 + 00. If the slope of the fill bank were 1.5:1 and with the same roadway slope the divergence between the two stations would be 7.5 ft.

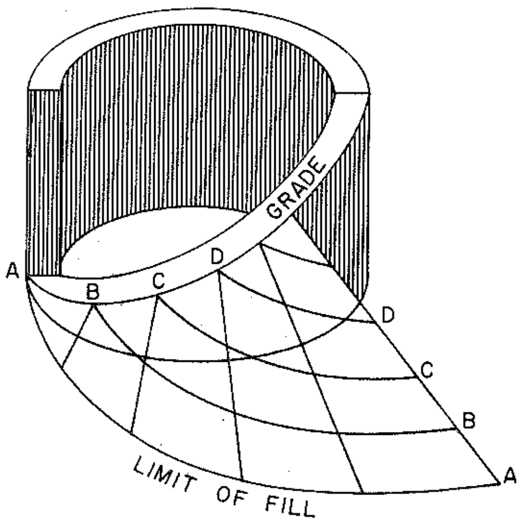


FIG. 3

The line AB represents the intersection of the plane of the fill bank with a horizontal plane at 100 ft. elevation. The successive lines CD (90 ft. elevation), EF (80 ft. elevation, etc.) may be determined at locations 10 ft. horizontally from the previously determined line. (Fig. 2) Upon establishment of these lines of constant elevation their intersection with the terrain contour lines of matching elevation is easily found. These points (A, B, C, etc.) shown in Fig. 2 define the limits of the fill area.

Several authors (2, 3) present this latter method for both the level and inclined roadway along a straight-line path. Hoelscher, Springer, et al. (3), indicate that for the case of a curving roadway the divergence of the contour lines on the fill slope must be determined by plotting points at individual stations corresponding to a series of fill-cross-sections taken along the curve.

It is the purpose of this article to extend the concept of divergence to the case of a circular curved roadway with a defined grade; the tedious process of constructing the numberous cross-sections can thereby be eliminated. A representation of a circular curve on a grade and its relationship to a sloping fill bank is depicted in Fig. 3. Note that the lines of constant elevation (AA, BB, etc.) on the surface of the fill bank follow a curving path that is divergent from the circular edge of the roadway. More specifically, the path of these level lines is that of a spiraling (involute) curve having its center at the center of curvature of the circular roadway.

The concept shown in Fig. 3 is amplified further by Fig. 4 where it is seen that the curving lines of constant elevation are merely an extension of the diverging straight lines preceding the curved path. The rate of divergence of the curved grade lines is, however, constant since the radius of curvature of the roadway is also constant.

In order to construct these lines of constant divergence, any method of involute construction is appropriate. Trials have been performed using as the basis of construction the involute of a triangle, square and circle. All prove to be equally accurate but the involute of a square has been chosen for the explanation that follows and which is illustrated in Fig. 5.

First a square is constructed with its center located at the center of curvature of the circular highway curve (point 0). The square must be oriented such that its central axis lies perpendicular to the straight-line grade lines from A, B, C, D, etc. which precede the curve. This results in two distinct orientations of the square dependent upon whether grade lines are to be constructed on the outside or inside of the circular highway curve. Fig. 5 shows the square in both orientations with the solid-lined square being the proper one for construction of the divergent involutes on the outside of the circular highway curve.

The corners (R, S, T, U) of the square will ultimately be used as centers for drawing the involute arcs. The correct arc radius and consequently the proper divergence of the involute of the square is dependent upon the dimension (s)

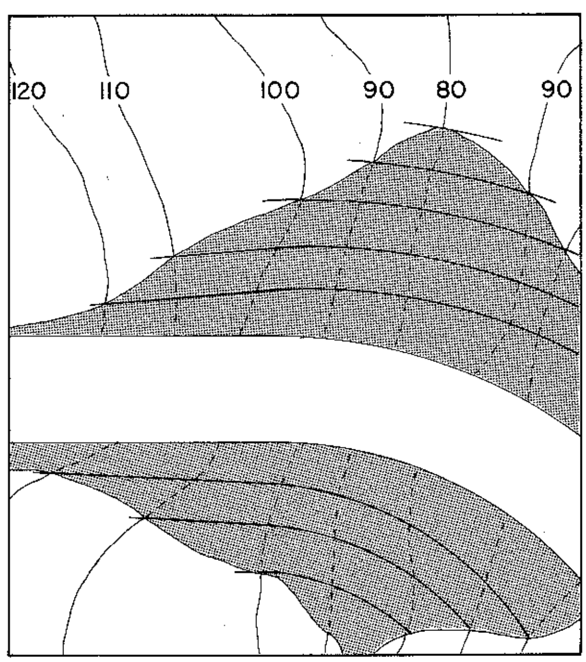


FIG. 4

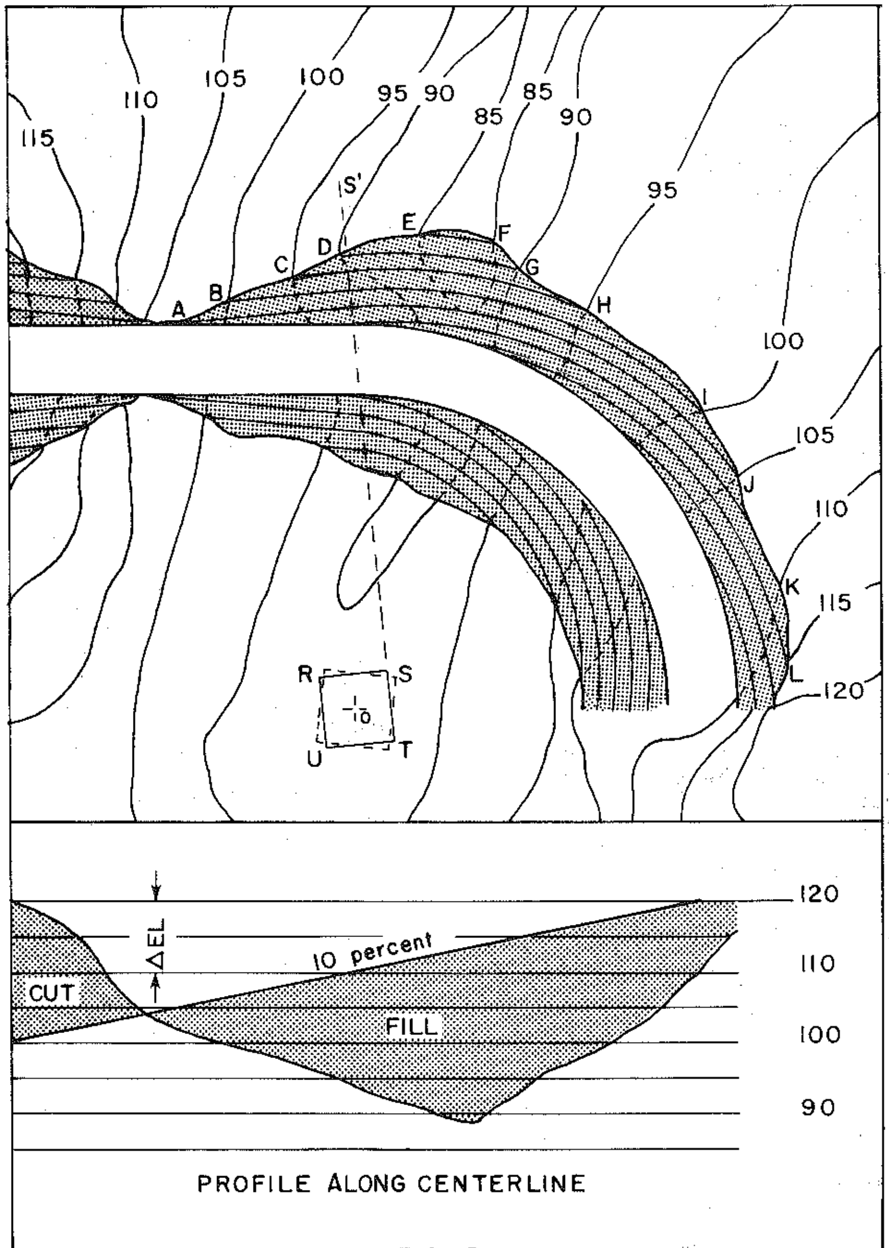


FIG. 5

of the square. Specifically, this dimension is equal to the elevation change exhibited by the highway within a full 90° of curvature. The elevation view in Fig. 5 depicts this change of elevation as $\triangle$EL.

Next the appropriate corner of the square is selected as the center of curvature for the several required involutes. In Fig. 5 the corner of the square at T provides the center for the desired diverging involutes on the outside of the highway curve. The successive involutes begin at points along reference line S-S' where the straight contour lines from A, B, C, etc. would become curved. The involutes then terminate at their intersection with a contour line of equal elevation (F, G, H, etc.). If the circular highway curve extends through more than 90° of curvature the center for the involutes must be shifted to point U in the order that the involute arcs may be continued with proper divergence.

Once the involute arcs are established it becomes a simple matter to plot their intersection with the topographic contour lines of matching elevation. In Fig. 5 these points which establish the limits of fill are shown at E, F, G, H, etc. The diverging involute arcs along the inside of the circular curve are established in a manner similar to that described previously. The corner, R, of the dash-lined square is used to produce the correct divergence for the inside involutes. If it should be necessary to extend these involutes beyond 90° of highway curvature, the center would be shifted from corner R to corner S of the dash-lined square.

Fig. 5 illustrates an area of fill where the lines of constant elevation diverge from the circular highway curve. When dealing with an area of cut the constant elevation lines would converge toward the circular highway curve. In order to produce convergent involute arcs different centers at the corners of the square must be used. For convergent involutes on the outside of the highway curve the corner of the dash-lined square at R would be used. Similarly, for convergent involutes on the inside of the highway curve the corner of the solid-lined square at T would be used. In any case a few simply trails with the compass, using the various corners of the squares, will quickly show the proper choice. Obvious divergence or convergence of the involute arcs cannot be produced with an incorrect arc center.

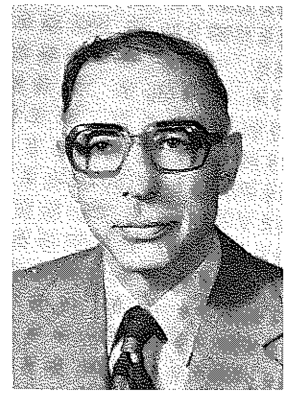
In summary, the method of extending the straight, diverging grade lines through (around) a circular curve requires only the simply construction of a few arcs based upon the involute of a square. Once the technique is mastered the determination of limits of cut or fill becomes quite simple. Of particular importance is the orientation of the square and selection of proper arc centers in order to produce correct divergency or convergency on either the inside or the outside of the highway curve.

Other methods of determination of limits of cut/fill involve the construction of a series of cross-sections extending around the curve. The value of the involute method in terms of time and effort saved is apparent. Also, the accuracy is dependent upon the number of cross-sections that are constructed along with the requirement for interpolation to points of elevation between contour lines on the topographic map.

[1]Earle, James H., Engineering Design Graphics, Addison-Wesley, 1969.

[2]Levens, A.S., Graphics Analysis and Conceptual Design (2nd Ed.), John Wiley, 1968.

[3]Hoelscher, R.P., Springer, C.H., Dobrovolny, J.S., Graphics for Engineers, John Wiley, 1968.



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GRAPHICAL CONSTRUCTION OF CLOTHOIDAL HIGHWAY CURVES

In modern highway engineering, the clothoid or spiral Cornu* long ago replaced the arc of a circle which necessitates heavy braking if entered into at high speeds. In this replacement, due to the continuous change in curvature of the clothoid, entry into the curve is smooth, brakes might be applied only moderately and sometimes it will even be sufficient to leave the gas pedal free.

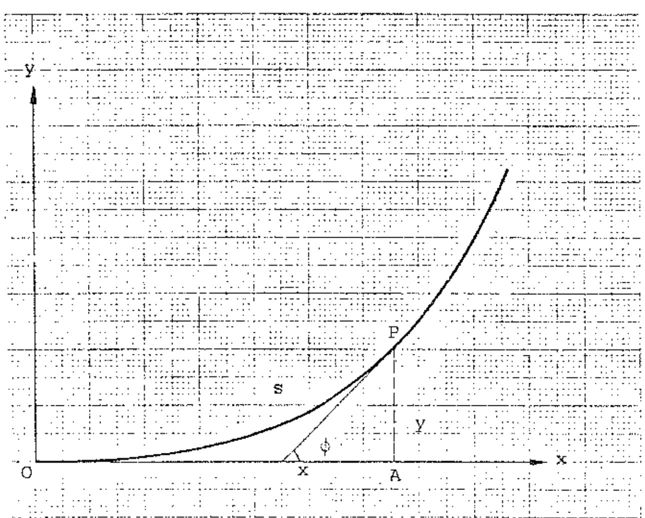

Fig.1

* M.A. Cornu, French physicist (1841-1902)

The above fact can be traced back to the geometrical definition of the clothoid: The clothoid is a curve whose arc length s, measured from an inital point to any point P on the curve, is proportional to the curvature k at the latter point. Thus the initial point, with S=0, has a zero curvature and the curvature continues to increase with further movement of the point along the curve.

For a point P on any curve (Fig. 1) it is known from analytic geometry that

with $\widehat{OP}=S$ the curvature $k=\frac{d\phi}{ds}$ and

$\cos\phi = \frac{dx}{ds}$, $\sin\phi = \frac{dy}{ds}$

From the above definition of the clothoid, it follows:

$s=a^2k$ (a^2 is the proportionality factor).

Consequently:

$$s=a^2\frac{d\phi}{ds} \qquad sds=a^2d\phi$$

$$\int_0^s sds=a^2\int_0^\phi d\phi \qquad \frac{s^2}{2}=a^2\phi \qquad \phi=\frac{s^2}{2a^2}$$

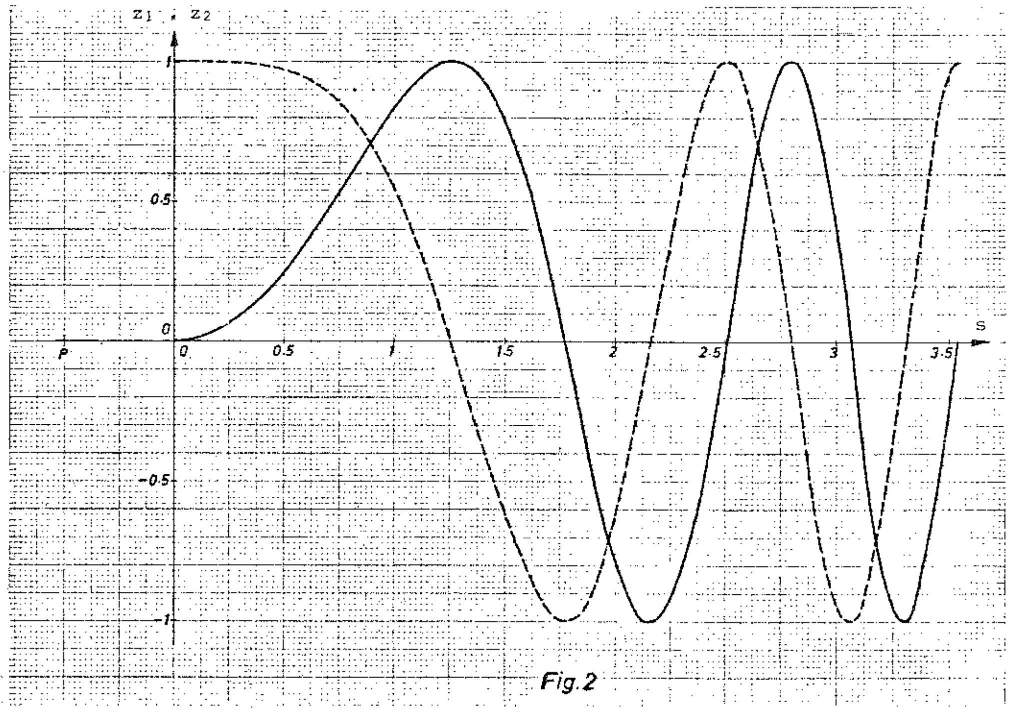

Fig.2

$$dx=\cos\phi\, ds \qquad x=\int_0^s \cos\phi\, ds = \int_0^s \cos\frac{s^2}{2a^2}\, ds \qquad dy = \sin\phi\, ds \qquad y=\int_0^s \sin\phi\, ds = \int_0^s \sin\frac{s^2}{2a^2}\, ds$$

The above two definite integrals, called the Fresnel* integrals, cannot be evaluated by elementary functions and might only be calculated by series ex-

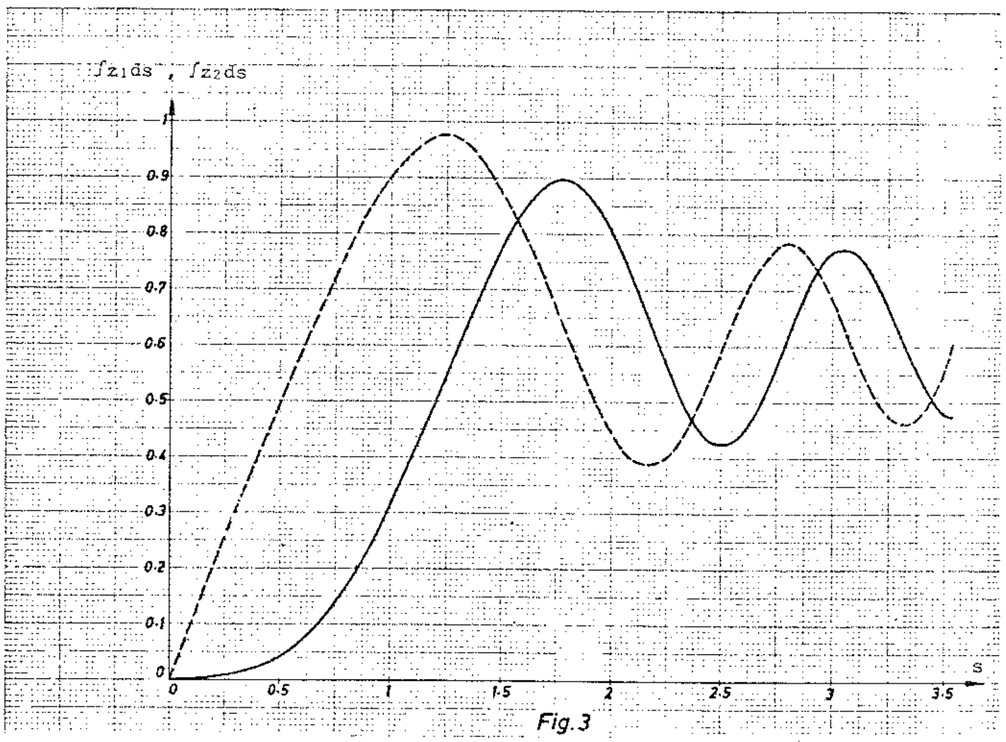

Fig.3

*A.J. Fresnel, French Engineer (1788-1827) pansions and successive integrations. However we might easily perform the integrations by graphical means of drawing the integral curves of the functions

$Z_1 = \cos\frac{s^2}{2a^2}$ and $Z_2 = \sin\frac{s^2}{2a^2}$. The two curves for $a=\frac{1}{\sqrt{2}}$ appear in Fig. 2 and the integral curves in Fig. 3. The pole distance has been chosen as OP=0.5 units of the s scale = 20 millimetres and the width for the narrow strips under the curves (not shown) from 2 to 5 millimetres

From the above two integral curves, we might obtain x and y values for any common value of s and thus draw the curve y = f(x) which is nothing but the clothoid, as shown in Fig. 4.

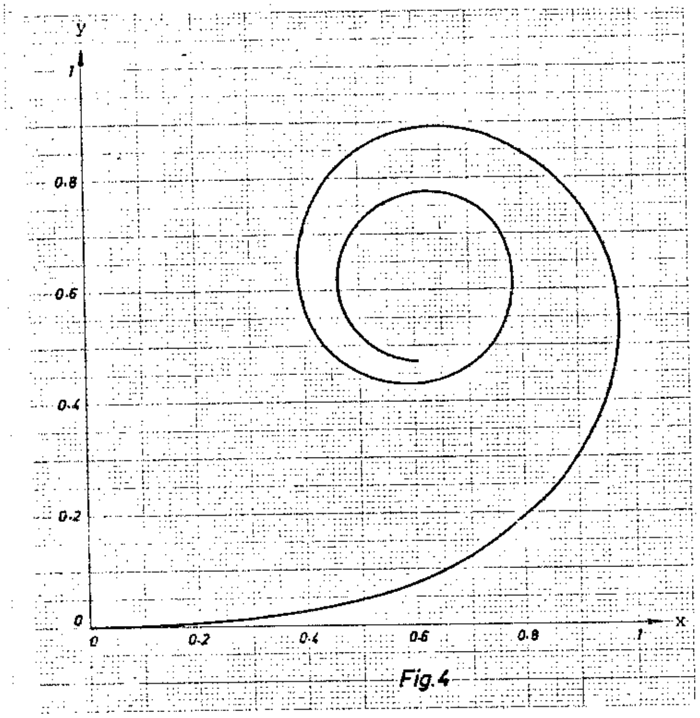

Fig.4

In order that the highway curve might have the same property in both directions of entry, it must consist of two identical clothoid arcs with axes x_1, y_1 and x_2, y_2 as shown in Fig. 5. Points O_1 and O_2 are chosen in such a way that the two arcs O_1P and O_2P have a common tangent in point P.

When entering the curve direction x_1, the speed is decreased along O_1P from v to v_1 and increased again along PO_2 from v_1 to v. The same applies to the entry in direction x_2.

In conclusion, I feel obliged to express my thanks to Mr. A. Mottaghipoor of the Engineering Graphics Centre who performed all accurate graphical work of this paper.

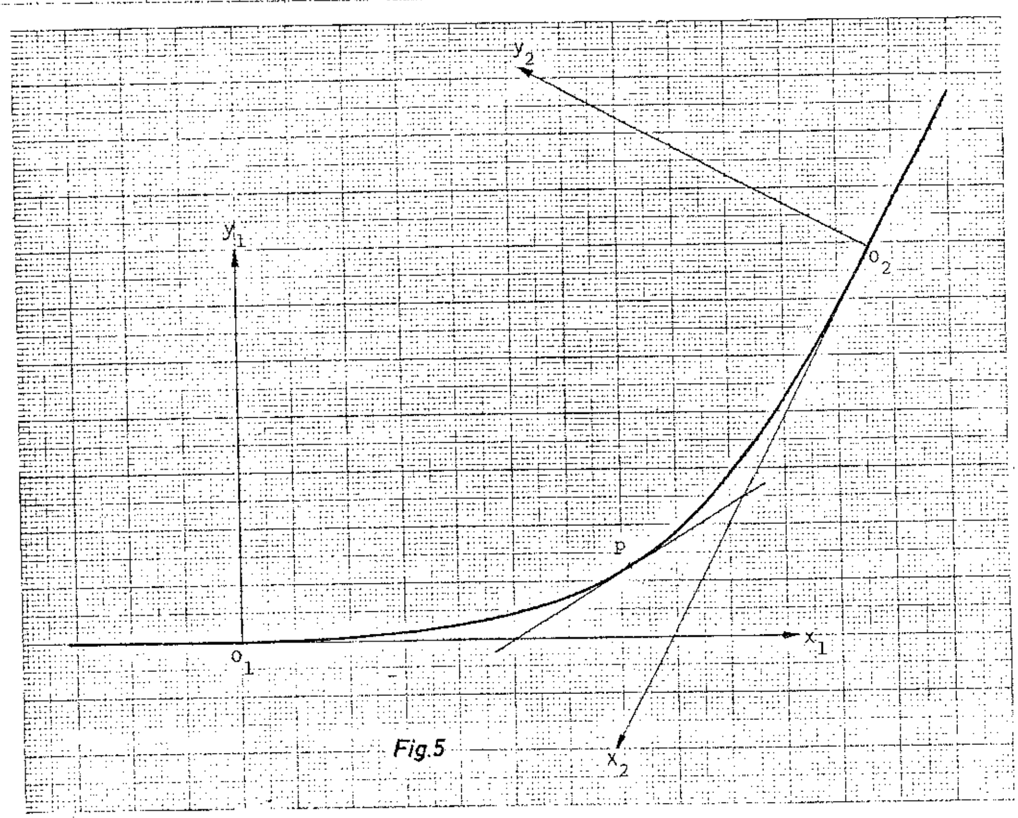

Fig.5

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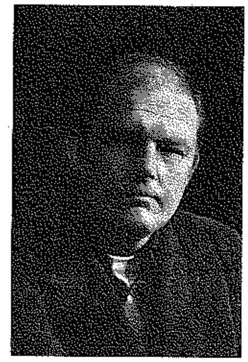
Rhode Island School of Design



A REASSESSMENT OF THE MATHEMATICAL CONCEPT OF THE POINT AT INFINITY

A very great problem arises in Projective Geometry with respect to the concept of lines of infinite length, for the algebraic principle of duality seems to imply that any two parallel lines must meet at a point at infinity. Such a conception defies sensible meaning and any reasonable capability of visualization. It is the purpose of this paper to show that the conception is based on a misuse of the concept of measurement. It will be shown that when comparing lines of finite length to lines of infinite length, the finite lines must be considered isotropic (i.e. any point of the finite line is zero distance from any other point on the line) and thus the coefficients of the Plücker coordinates of the linear equations defining a set of parallel lines are the same for any two such lines. As a result, any one of a set of infinitely long parallel lines is expressed by exactly the same coefficients such that a pencil of infinitely long lines in terms of Plücker coordinates is algebraically indistinguishable from a single line of the pencil. Simply Stated, a line of infinite length is an identity with a plane.

In An Introduction to Projective Geometry R.M. Winger[1] describes the basic argument of the algebraic proof of the duality of the point and the line in the Cartesian plane:

In the equation ux + vy + 1 = 0 "...where x and y are either rectangular or oblique point coordinates, the numbers u and v are called the Plucker line coordinates. Geometrically these numbers represent the negative reciprocals of the intercepts of the line as may be verified by setting x and y successively equal to zero."[2]

(a) If u and v are fixed constants
and x and y are variables
ux + vy + 1 = 0
in the equation of the line
(u,v)

(b) If u and v are parameters
the equation gives a doubly infinite
system of lines, viz., all lines
in the plane.

(a') If x and y are fixed constants
and u and v are variables
ux + vy + 1 = 0
in the equation of the point
(x,y)

(b') If x and y are parameters
the equation gives a doubly infinite
system of points, viz., all points
in the plane. ..."[3]

If it can be shown that the coordinates of the Cartesian plane are isotropic when compared to lines that are infinite in length, it follows that the above expression of the principle of duality only applies to a finite region of the Cartesian plane. The following argument is presented as such a demonstration:

A common perpendicular of finite length connecting two parallel lines of finite length has a proportionate length with respect to that of the parallels that may be expressed as a ratio. Suppose, for example, the two parallels are each ten feet in length while the common perpendicular, i.e., the perpendicular distance between them, is a distance of one foot. The ratio is then 1:10 or 1/10. If the length of the parallels is increased to 100 feet then the ratio becomes 1:100 or 1/100. As the length of the parallels increases, the ratio becomes a smaller and smaller number until finally at 1/00 it equals 0. This is to say that in a ratio a/x, where a is a finite number, as x increases the ratio becomes a smaller and smaller number with a limit of 0. But what does this mean concerning the distance a?

Starting with a distance $a=2$, letting $a/x = y$, then for some value n of x we have $2/n = y$. If $n = 5$ for example, then $y = 2/5$ and $a = x \cdot y$ or 2. If $n = 9$, the $a = 9 \times 2/9$ or 2. BUT, if $x = \infty$ then $a/x = 0$ and $a = \underline{x \cdot y} = 0$. In other words, as long as the ratio involves finite lengths the value of a remains any given constant, but when the ratio involves an infinite value, then the common perpendicular, i.e., the distance a, becomes isotropic. Consequently, when measuring the distance between parallel lines, if the parallel lines are considered infinite in length, then the finite distance between them is always zero. It follows that the Plücker coordinates only have meaning when considering lines of finite length.

In this manner the concept of the isotropic line becomes tangible as well in that the concept of magnitude engenders a unit of measure that is specifically related to the system being measured. For example, if one considers a line segment and tries to measure its length in terms of the number of points making it up one encounters the clear problem that the line segment cannot be considered the sum of its points as any meaningful measure of its length, for length is simply not a property of a point.

Any line segment must contain an infinite number of points, consequently there is no relation between the number of points in any finite line and its length, unless we consider some arbitrary unit as a measure of the length of the line and then express it as a ratio to the number of points in the line which would then by $x/\infty = 0$, the identical relation that we have already encountered.

It is not difficult to thus observe that an infinite number compared to a finite number is a comparison of different dimensions in the most literal sense: a finite number is to an infinite number as a point is to a line segment. Peano's famous curve is the clearest example that the limit of a line, i.e., a line of infinite length, is a surface. Of course, Peano's line is not a straight line, and intuitively one has difficulty conceiving of a line "at its limit" suddenly "becoming" a plane. However, since we have shown that a pencil of infinitely long lines is algebraically indistinguishable from a single line, it follows that a straight line of infinite length is an identity with the plane. It is not as though one simply extended the line with an increasingly large number of units, although by doing this one gets the sense of the meaning of the decreasing ratio, for the infinite number of units is not simply a very large number. One does not achieve the infinitely long line by the process of adding units. There is simply no reason to assume that this limit is in itself a "line" in the common sense of a line. On the contrary, everything points to its meaning as a plane which in this case is isotropic along one coordinate at the very least.

It follows that the concepts of the point at infinity, the line at infinity and the plane at infinity, etc., are in very serious need of re-evaluation as mathematical concepts.

Footnotes

1. Winger, R.M., An Introduction to Projective Geometry, Dover Press., N.Y., 1962 First pub. D.C. Heath and Co. 1923

2. Ibid, p. 16

3. Ibid, p. 17

COORDINATOGRAPHS FOR AUTOMATION OF DRAFTING AND DESIGN

Dan Ryan
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This article deals with an attempt to modernize and update drafting course content through the design and construction of a micro-graphics unit known as a coordinatograph. A coordinatograph is a highly accurate plotting, scribing, cutting or marking device for the production of graphic materials that require close size tolerances. For example, a photo-negative type mask can be made from "cut and peel" material for use as a printed wiring master or chemical milling master.

BEATING THE COST OF AUTOMATED EQUIPMENT

Most graphics and drafting instructors are placed in a very difficult position when they are asked to update an existing course or program with automated drafting techniques. The situation is usually one where very limited funds are available for computer-related equipment. Most machines, without the cost of the computer, begin at $5,200 and go upwards to $40,000. The low end is out of sight for most programs on a limited budget. This situation offered a challange and design problem for an engineering graphics research project at Clemson University.

The project, simply stated, called for the design and construction of a coordinatograph for under $1000.00. This highly precise drafting machine would be used in the automated graphics laboratory at Clemson. Students would digitize flat maps and drawings for storage in the IBM 370 and produce electro-mechanical masks which could be used in chemical milling processes.

A direct result of the research project was a set of working drawings and materials list so that other institutions could reproduce the instrumentation at a low cost. (Plans can be obtained by writing the coordinator of Engineering Graphics, Clemson University). As the project neared completion, the assembly of the piece parts into a working instrument took place. Care must be taken during the initial set-up to make sure that the table, desk, or stand used to hold the parts is completely level. The desk used in the photgraph was fitted with precision leveling screws and adjusted for zero runout after it was placed in the laboratory.

DESIGN OF THE COORDINATOGRAPH

Commercially available instruments are much larger than the Clemson experimental unit. They may be several feet larger. The Clemson unit is not intended for commercial operation; the largest drafting sheet used by most educational institutions is "D". It was found that the smaller size had advantages in that tolerances were easier to maintain. Pre-ground flat stock could be used for the axis arms and the precison bearings ordered could track on a totally flat surface. Wherever possible, standard tool-makers parts were specified. Cold rolled bar and round stock were used for the carriage assemblies. These parts were intended to be painted "instrument" green, but upon completion of the project, the surface finish was so good that a brush coat of STP was used as an oxidation shield and left to match the other parts of the machine.

FIELD TRIAL OF THE UNIT

After final assembly of the piece parts, a check of the X-axis movement over 36 inches showed a runout of only .0005 inch. This meant that any location in the Y direction could be positioned to within a half a thousandth. The Y-axis movement over 33 inches showed zero runout. This was totally unexpected and future construction of other units could be expected to vary a half-thousandth also.

A mask was cut with the unit and checked with a jeweler's loop for land thickness and pad locations. The operation was smooth and shorter in time than similar operations on commercial units like the one pictured. The mass of the experimental unit had been reduced so that the tool holder and Y-assembly moved with little effort on the part of the operator. Future tests and measurements of wear over several months of operation are needed for comparison against data gathered during a 1972 operational test conducted at the University of Nebraska's Technical Institute. The larger commercial coordinatograph located there has been in operation since 1969.

USE OF A COORDINATOGRAPH

When using a coordinatograph the objective is to draw the desired graphics as quickly and as easily as possible. The operator should be free of all data calculation while he is plotting in order to be able to fully concentrate on the settings of his micro-graphics unit and on the qualtity of his work. It would be incorrect to try to work from a sketch such as shown in Figure 1. Here engineering dimensions have been specified. Such dimensions are not in the "cartesian" form and cannot, without further reinterpretation, be entered on the dials and strips.

It is therefore recommended that design drawings be done in the "coordinate measure form" as shown in Figure 2. This pattern of graphics has been selected because it contains angles, straight lines and circles. It also can be considered as a repetition of values about the central axis of symmetry. For the purpose of automatic plotting, only basic values of one quadrant need be recorded. These are then automatically redrawn in the other three quadrants by simply switching from positive to negative values of "x" and "y" as required. Unless a figure consists of a large series of polar coordinate values, such as a cam profile, it is recommended that the procedure shown in Figure 2 be used.

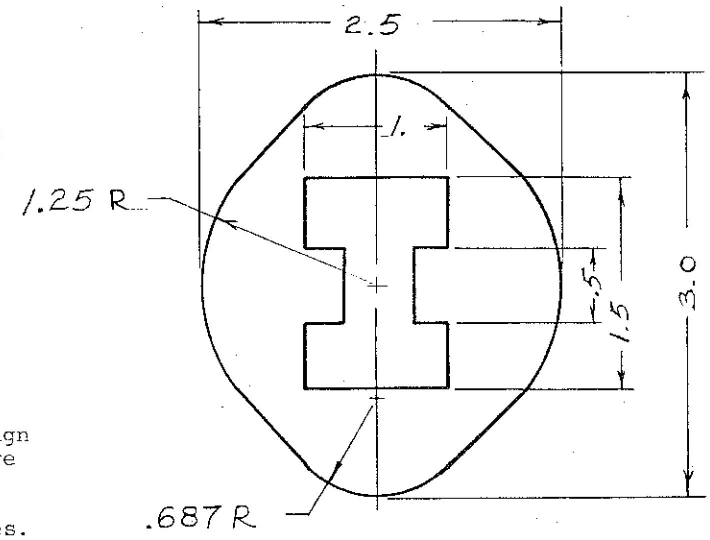


Figure 1. Engineering Dimensioning.

THE DRAFTING METHOD

The graphics pattern outlined above shall be performed as follows:

1. Place a piece of cut and peel foil on the table. Fasten it with drafting tape along the edges.
2. Be sure the X and Y dials are tightly held on the dial carrier assemblies and set the measuring strips to coincide with the dial zero at any convenient value.
3. Place the tool post firmly into the Y carriage.
4. Insert a cut and strip knife in the tool holder and orient the edge in line with the locating slots in the rosette at the top of the holder.
5. Near the edge of the foil check to see if the knife is properly centered by drawing to a point from four directions.
6. Begin the sequence of operations shown on the coordinate work sheet.

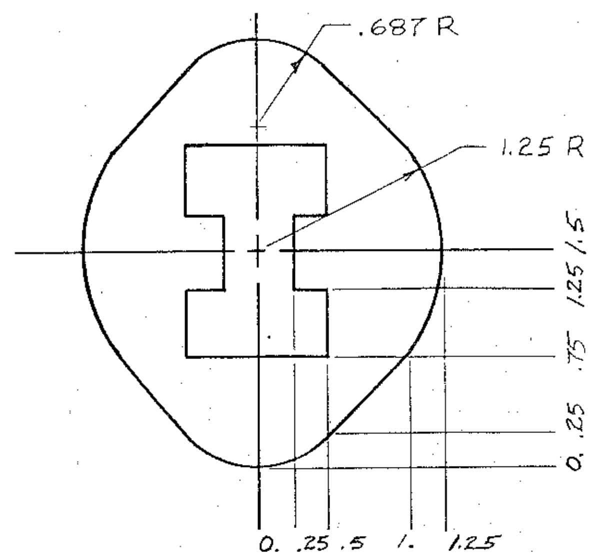


Figure 2. Coordinate Dimensioning.

ITEM: TEST PATTERN

TABLE: 30 X 40

OPERATOR: D. RYAN

DATE: 8/20/77

DEPARTMENT: EG 310

MATERIAL: CUT & PEEL

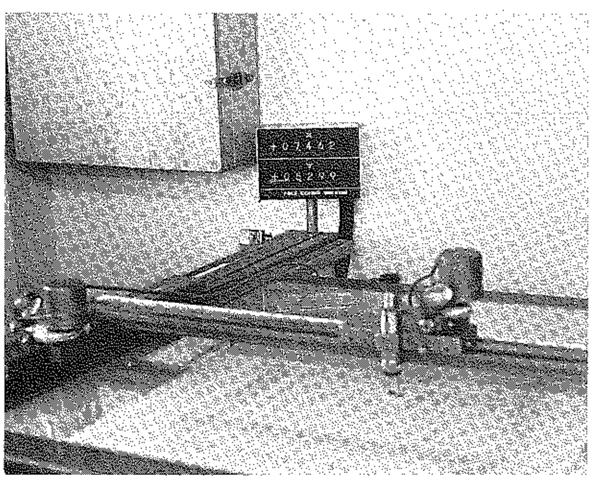
SCALE: FULL / METRIC

DRAWING METHOD: RECTANGULAR

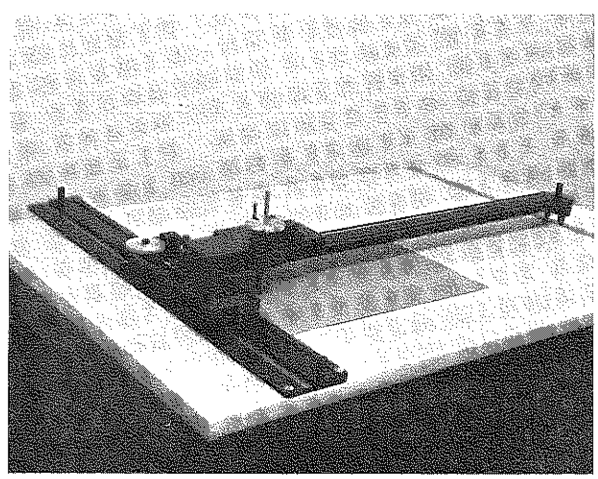
JOB NO:	T015
DATE RQD:	8/28/77
DATE ISSUED:	8/19/77
DESTINATION:	TTM

QUADRANTS: ✓Q1, ✓Q2, ✓Q3, ✓Q4

SEQUENCE		CUT KIND	LOCATION & DIMENSION	LIMITS From To	NOTES
1	3	MOVE	X 9.5, Y 2.5	±.001	POSITION AXIS
2	3	MOVE	Y.75	±.0008	INSERT KNIFE
3	2	XCUT	X.5	"	INDEX KNIFE
4	2	YCUT	Y.5	"	INDEX KNIFE
5	2	XCUT	X-.25	"	"
6	2	YCUT	Y.5	"	"
7	2	XCUT	X.25	"	"
8	2	YCUT	Y.5	"	"
9	2	XCUT	X-1.	±.001	RETURN ROSETTE
10	2	YCUT	Y-.5	±.0008	INDEX KNIFE
11	2	XCUT	X.25	"	"
12	2	YCUT	Y-.5	"	"
13	2	XCUT	X-.25	"	"
14	2	YCUT	Y-.5	"	"
15	2	XCUT	X.5	±.001	RETURN ROSETTE
16	3	Y MOVE	Y 1.5	±.002	1.25 R COMPASS
17	2	ARC	60° of ARC	± AXIS	RESET ARC DIAL



A Large Commercial Coordinatograph



The Clemson Experimental Unit

J. Charit
Technion City
Haifa, Israel

AUTOMATION IN SOLVING POSITION PROBLEMS WITH THE AID OF AUXILIARY SPHERES

Automated design and drawing involves computer-aided solution of certain geometrical problems of surface intersection. This paper describes the solution procedure based on use of auxiliary spheres.

As is known, auxiliary spheres are used in constructing intersection lines of cyclic surfaces. Specifically, concentric spheres are used in the case of a pair of surfaces of revolution with arbitrary profiles and intersecting axes.

An example is shown in Figure 1, where a sphere with radius ρ intersects the surfaces in circles with radii R and r, and the common points of these circles belong to the desired intersection line. Choices of the radii of the auxiliary spheres is generally based on visual considerations, in accordance with the profiles involved. In Figure 2 the surfaces are projected on plane zOy. The circles are obtainable as intersections of the sphere

$$x^2 + y^2 + z^2 = \rho^2 \qquad (1)$$

and the planes

$$Z = H \qquad (2)$$

$$z = \frac{H' - y \sin \gamma}{\cos \gamma} \qquad (3)^*$$

* Obtained from the general expression: $x \cos \alpha + y \cos \beta + z \cos \gamma - p = 0$ by substituting $\alpha = 90^\circ$; $\beta = 90^\circ - \gamma$; $p = H'$.

Solved together, the equations yield the coordinates of a pair of intersection points:

$$z = H$$

$$y = \frac{H' - H \cos \gamma}{\sin \gamma}$$

$$x = \pm\sqrt{\rho^2 - H^2 - y^2}$$

Using a separate cylindric coordinate system for each surface (axes z and z', see Figure 1), we have:

Surface I	Surface II
$z = H$	$z' = H'$
R	r
$\phi = \arc \sin \frac{x}{R}$	$\partial = \arc \sin \frac{x}{r}$

The automated construction follows the procedure outlined in (2), except for modifications in preparing the original drawing and in the algorithm, as explained on the following pages.

When the ordinates of any pair of curves are scanned at high frequence with respect to a single axis, these data are readily transformed for each curve to its own axis, provided the axes are parallel (2). This feature is utilized in preparing the original drawing.

Figure 3 shows segments of the given surface profiles with axes of revolution z and z'; two concentric auxiliary spheres are also shown as an example. From this figure, the original drawing (Figure 4) is obtained as follows:

The axes of both surfaces are drawn horizontal and parallel, spaced at G, and the profiles are plotted accordingly. The points of the axes corresponding to their intersection in Figure 3, lie in Figure 4 on a single vertical which serves as a line of departure for the scanner.

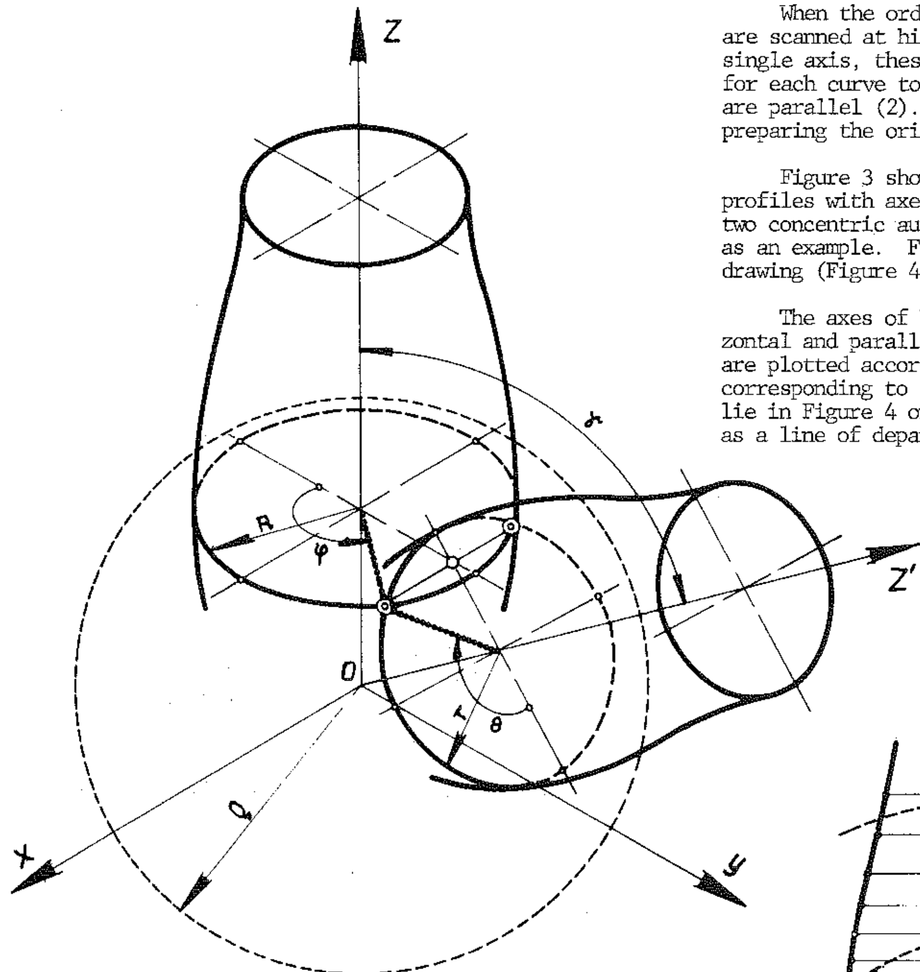


FIGURE 1

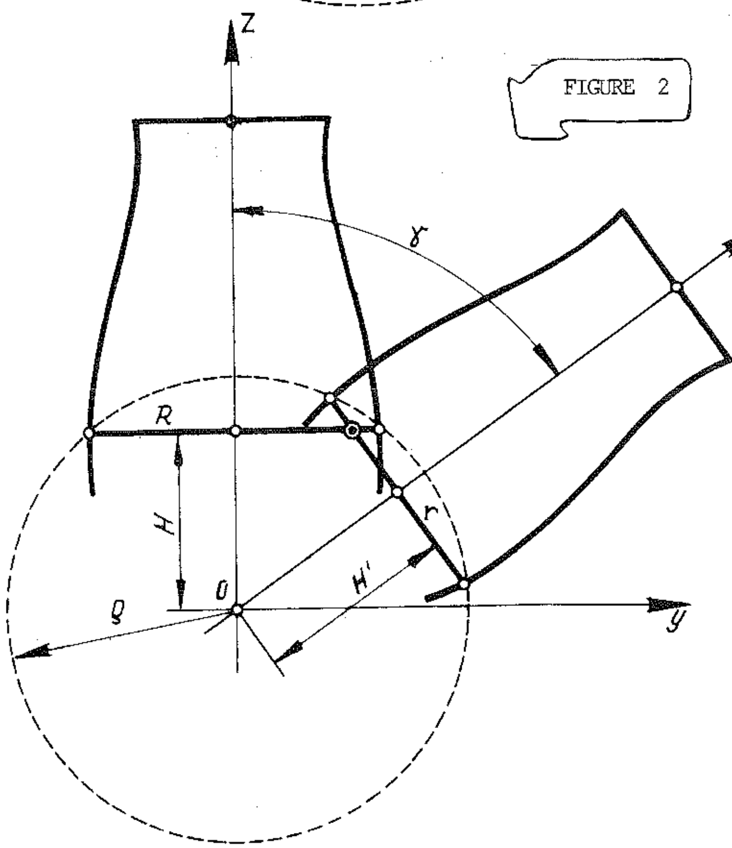


FIGURE 2

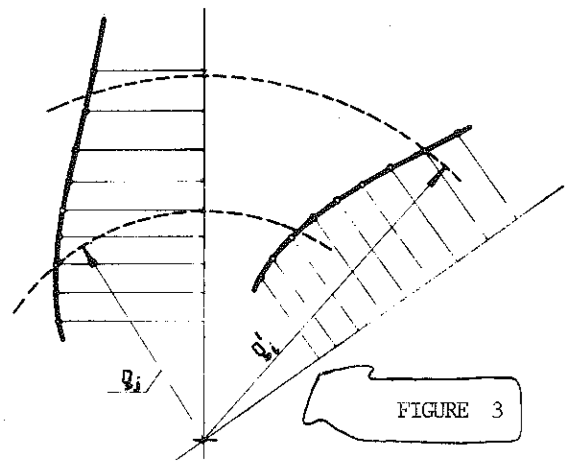


FIGURE 3

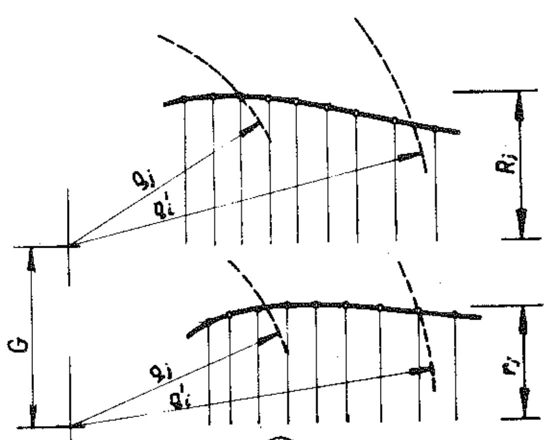


FIGURE 4

The next step is approximation of the surfaces with the aid of the algorithm A_{app} described in (1). In the process, the profiles are subdivided into a finite number of segments, with corresponding abscissae and ordinates of the subdivision points. We thus obtain the points, on each surface, through which the auxiliary spheres (radii ρ) are to be drawn. For instance (Figure 3 and 4) the sphere with radius ρ_j intersects with the first surface in a circle with radius R_j, and the sphere with radius ρ'_i intersects the second surface in a circle with radius r_i. The obtained data are:

Surface I				Surface II			
Points	z	R	ρ	Points	z'	r	ρ'
0	0	R_o	ρ_o	0	0	0_r	ρ'_o
1	H_1	R_1	ρ_1	1	H'_1	r_1	ρ'_1
j	H_j	R_j	ρ_j	i	H'_i	r_i	ρ'_i
m	H_m	R_m	ρ_m	n	H'_n	r_n	ρ'_n

where $H_j = \sum_{j=1}^{j} h_j$ $\qquad H'_i = \sum_{i=1}^{i} h'_i$

$$_j = \sqrt{H_j^2 + R_j^2} \qquad '_i = \sqrt{H_i'^2 + r_i^2}$$

We are concerned with the cases when $\rho = \rho'$, i.e. when the circles radii R and r are located on a common sphere. The procedure is as follows.

Compare each ρ_j with all ρ'.

(1) Find $\rho_j - \rho'_i$.

(a) If the difference is zero, note ρ'_i and go to next ρ (here ρ_{j+1}); then go back to the beginning.

(b) If the difference is not zero, note the sign of the difference.

(c) Compare with the next ρ'.

(2) Find $\rho_j - \rho'_{i+1}$.

(a) As under 1 (a).

(b) As under 1 (b).

(c) If the sign of the difference remains the same as in 1(b), compare with the next ρ' (here ρ'_{i+2}).

(d) If the sign of the difference changes, find an intermediate point i' between i and i+1, such that (i, i', i+1) are interrelated as the three corresponding differences of ρ'_i, ρ_j, ρ'_{i+1} (here, $\rho'_i = \rho_j$)*. Denoting

$$\frac{\rho_j - \rho'_i}{\rho'_{i+1} - \rho'_i} = \rho_i$$

we have $H'_{i'} = Q_{i'} (H'_{i+1} - H'_i) + H'_i$

and $r_{i'} = Q_{i'} (r_{i+1} - r_i) + r_i$

(3) Under "Surface II" in the table, add a row i' between i and i+1; go to the next ρ and then back to the beginning.

Having found all ρ' equal to the corresponding ρ, we compare each ρ'_i with all ρ as above. We now have all date for constructing the intersection line, the coordinates of whose points are given by Eqs (4) and (5).

The results are entered as follows in increasing order of z:

Point	$\rho=\rho'$	z (H)	R	z' (H')	r	x	y	ϕ	∂

The projections of the intersection line are plotted with Surface I (axis z) as base, as described in (2). In the front view the two branches of the intersection line coincide; this projection should be drawn through the points y = f(z). The horizontal view passes through the points x = f(y); being symmetric, only one half need be plotted.

* If higher accuracy is desired, i' can be found as intersection of a circle with radius ρ_j and a line through i and i+1.

Bibliography

(1) J. Charit, "Computer-Aided Construction of Line of Equilibrium on Surface of Revolution with Arbitrary Generating Contour", Litovskii Mekhanicheskii Sbornik, Vilnius 1968, vol. 2(3). (In Russian).

(2) J. Charit, "Computer-Aided Determination of Intersection Line for Surfaces of Revolution with Parallel Axes", Engineering Design Graphics Journal, Spring 1977 vol. 41. No.2, Series 123.

PUZZLE CORNER

R.P. Kelso
Assistant Editor

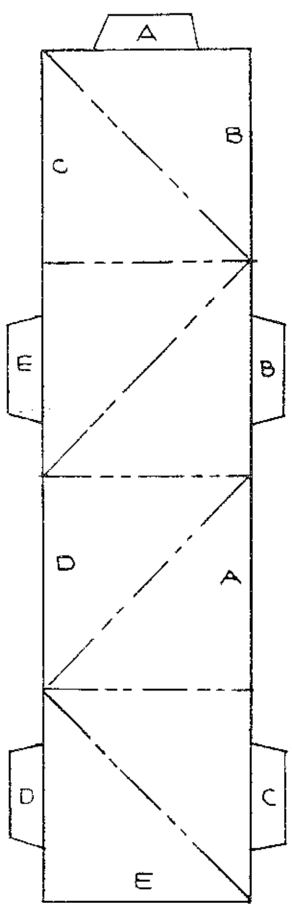
We have R.J. CHRISTENSON of the General Motors Institute at Flint, Michigan to thank for the new Corner Puzzle. He aptly calls it a PERPLEXAHEDRON but sadistically did not include the solution.

Figure 1 is the solution to the Fall '78 puzzle. Figure 2 is the pictorial. It is from ABE ROTENBERG of the University of Melborne.

In the first projection b_1-c_1 and d_1-e_1 are given lines. He begins by drawing b_1-a_1 parallel and equal to d_1-e_1 and operating from there. For simplicity he does not project d-e into the auxiliaries but, if projected, it would, of course, always appear parallel and equal to a-b -- including the sixth projection in which the final solution would be demonstrated. In the fourth projection a circle is drawn with line a_4, c_4-b_4 (m_4 is omitted for clarity) as the diameter. This represents the 'circular view' of a cone with-apex-at-b_4-and-base-perpendicular-to a-c at-midpoint-M (and seen as being perpendicular in the third and fifth projections). The shaded areas are the 'triangular' views of the cone and were edited in for visualization purposes. l_4 and l_3 are then located and are arbitrary points on the circle (cone base); therefore, b-l is any arbitrary element of the cone and represents any-one-of-the-set-of-lines-of-sight, each of which will yield the given lines as appearing EQUAL. (Not PARALLEL as stated in the note to the original problem.)

Note that the limiting elements of the cone, as seen in the triangular views, do not appear TL. Also note that a projection from arbitrary point l_4 perpendicular to b_4-l_4 will always pass through M_4.

Our compliments to ABE for a sweetheart of a problem and solution.



Winter '79 Puzzle

PERPLEXAHEDRON

1. CONSTRUCT A PATTERN USING FOUR SQUARES AND DIAGONALS AS SHOWN.
2. ADD THE ASSEMBLY TABS AND LABELS.
3. CUT OUT THE PATTERN
4. FOLD ALL SURFACE LINES, KEEPING THE LINES AND LABELS ON THE OUTER SURFACE.
5. ATTACH THE TABS TO THE SURFACES, AT THE PLACES INDICATED, TO CREATE A CLOSED BOX.
6. YOU HAVE A STRANGE BOX WITH EIGHT IDENTICAL SURFACES AND SOME ANGLES THAT LOOK INTERESTING.

PROBLEM

USING CONVENTIONAL DRAWING METHODS AND TECHNIQUES (NO CALCULATIONS) CONSTRUCT TWO PRINCIPAL VIEWS OF THIS PERPLEXAHEDRON

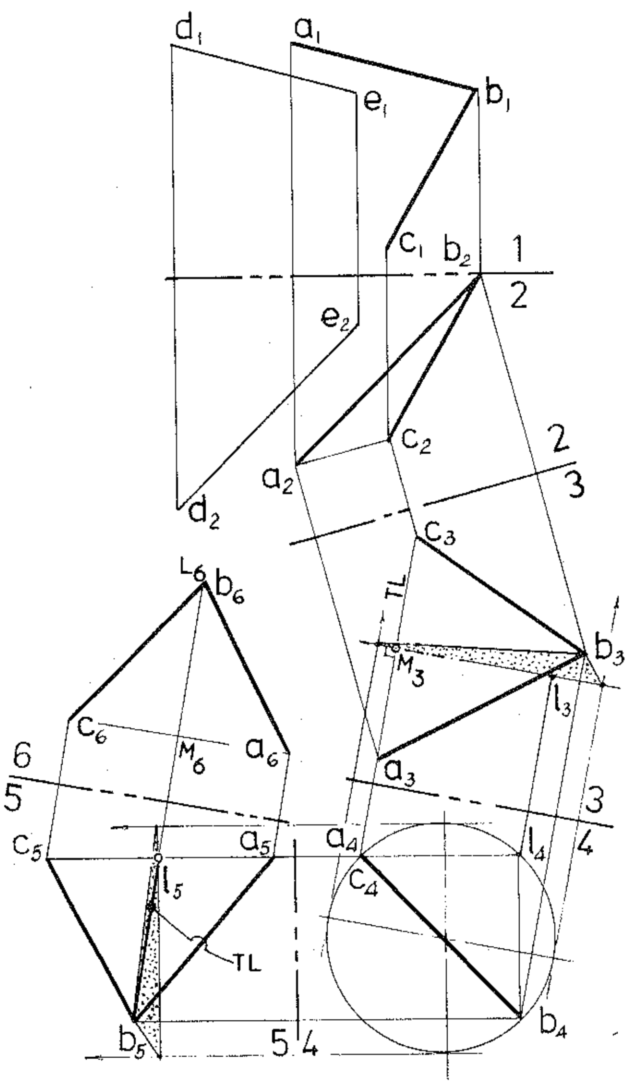


Figure 1

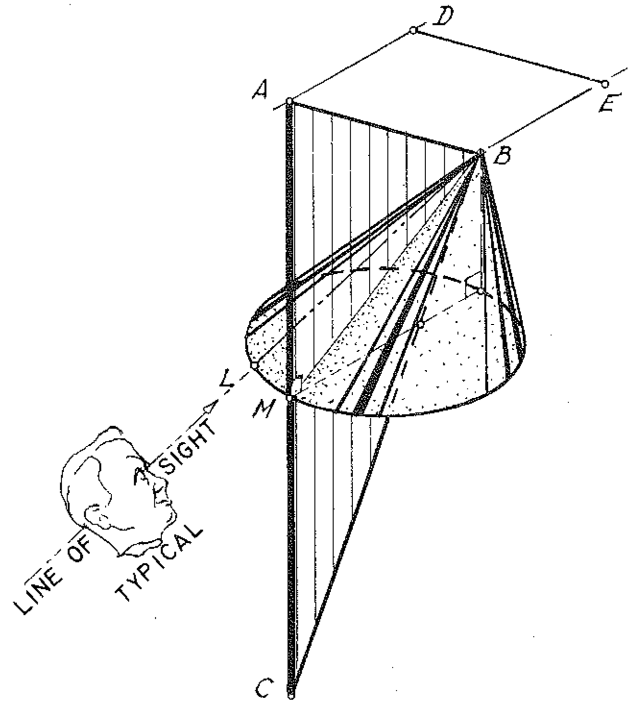


Figure 2

Continue to send in your ideas for future puzzles and fillers.

See 'ya in Baton Rouge.

Robert P. Kelso
Assistant Professor
Engineering Graphics
Louisiana Tech University
Ruston, LA 71272

Answers to the Fall "filler": (1) F; (2) F; (3) T; (4) F; (5) T; (6) F. Figure 3 is the new "filler" and is an old chestnut but a good one.

Draw the top view:

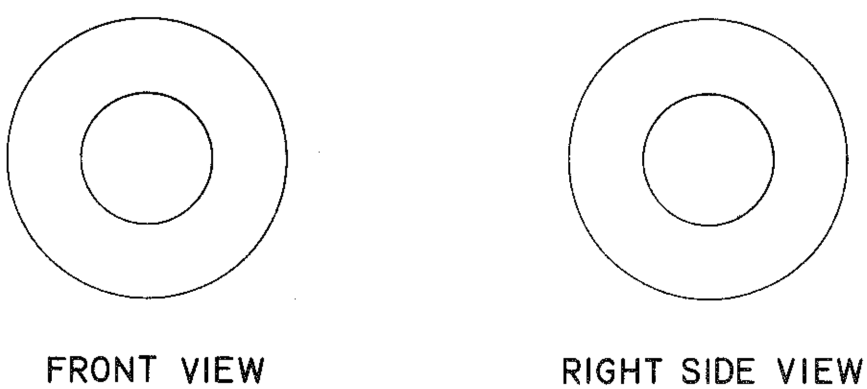


Figure 3

NEW PRODUCTS

DRAFTING MACHINE ADAPTORS FOR TRUE-POSITION PICTORIAL DRAFTING

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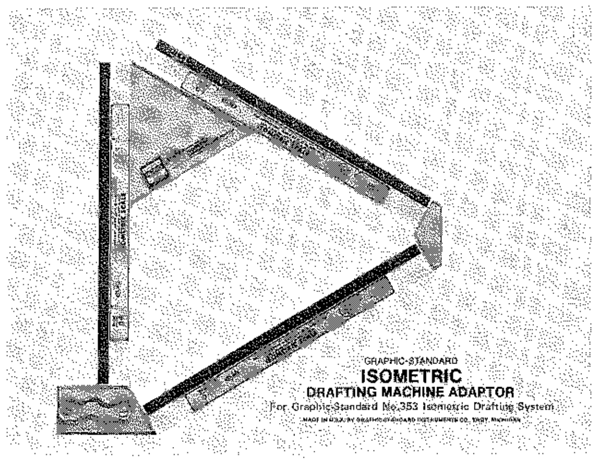
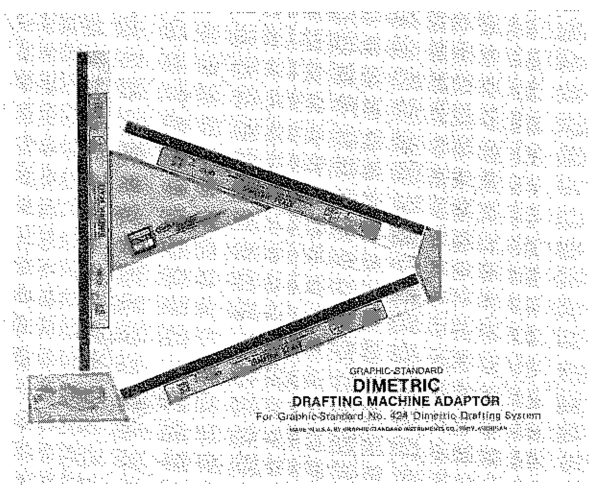
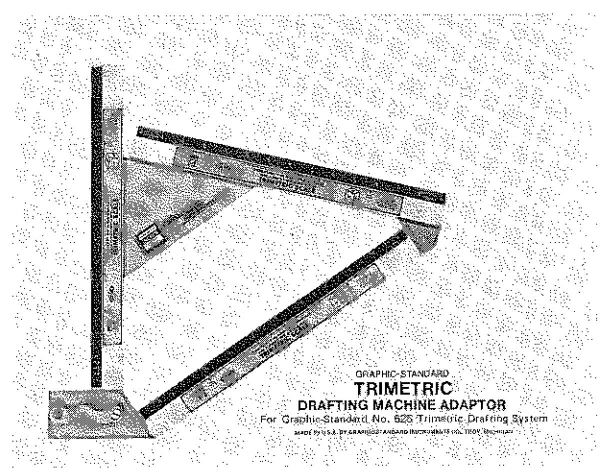


Based on the Graphic-Standard 353, 424 and 525 standardized axonometric drafting systems, the new adaptors produce drawings that are compatible with drawings made by use of the basic isometric, dimetric and trimetric manual drawing sets which have been marketed by Graphic-Standard since 1968. The manufacturer claims they can also be interfaced with computer graphics systems.



The manufacturer also claims that there pictorials are as accurate, dimensionable and scaleable as conventional orthographic drawings, and are therefore easily read without special training.



Each adaptor can be supplied with any one of six measuring systems - inches in fractions and decimals, metric in centimeters and millimeters, and four dual-graduated architectural scale series. These adaptors combine in a single drafting-machine mounted tool all functions of the company's Roc-N-Edge, Triangle and Axonometric Scales, thus eliminating as many as five separate tools on the drawing surface. They assure correct use and positioning of each scale every time, and maintain proper orientation of all axis-parallel lines. Both right-hand and left-hand models are offered. Advantages are substantially reduced board time, and enhanced communication value in technical drawings for both design engineering and technical illustration purposes. Graphic-Standard Instruments Co., 1101 Allen Dr., Troy, Mich. 48084.

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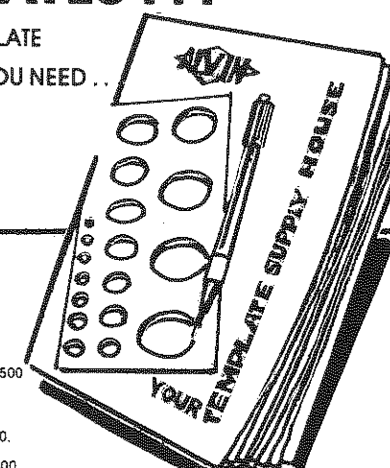

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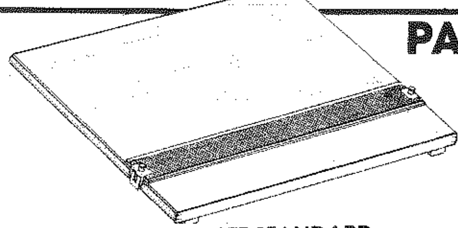

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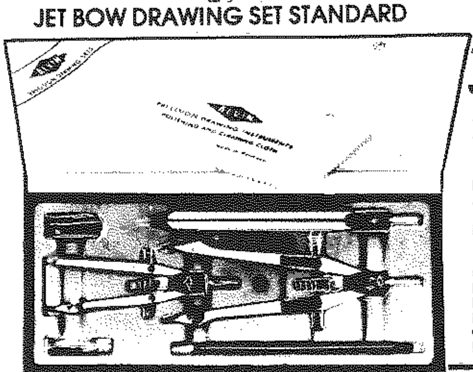

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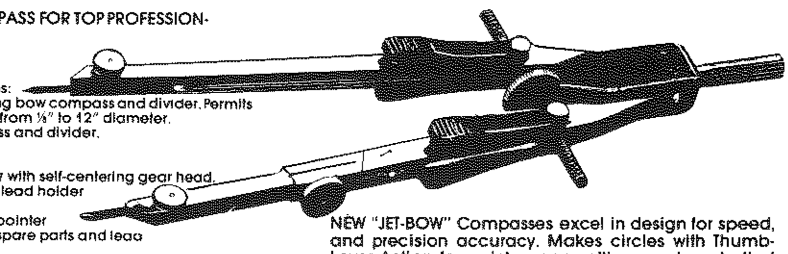

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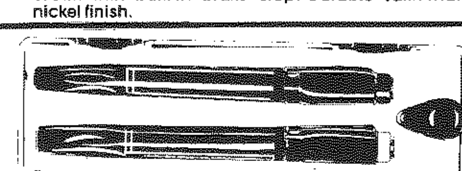

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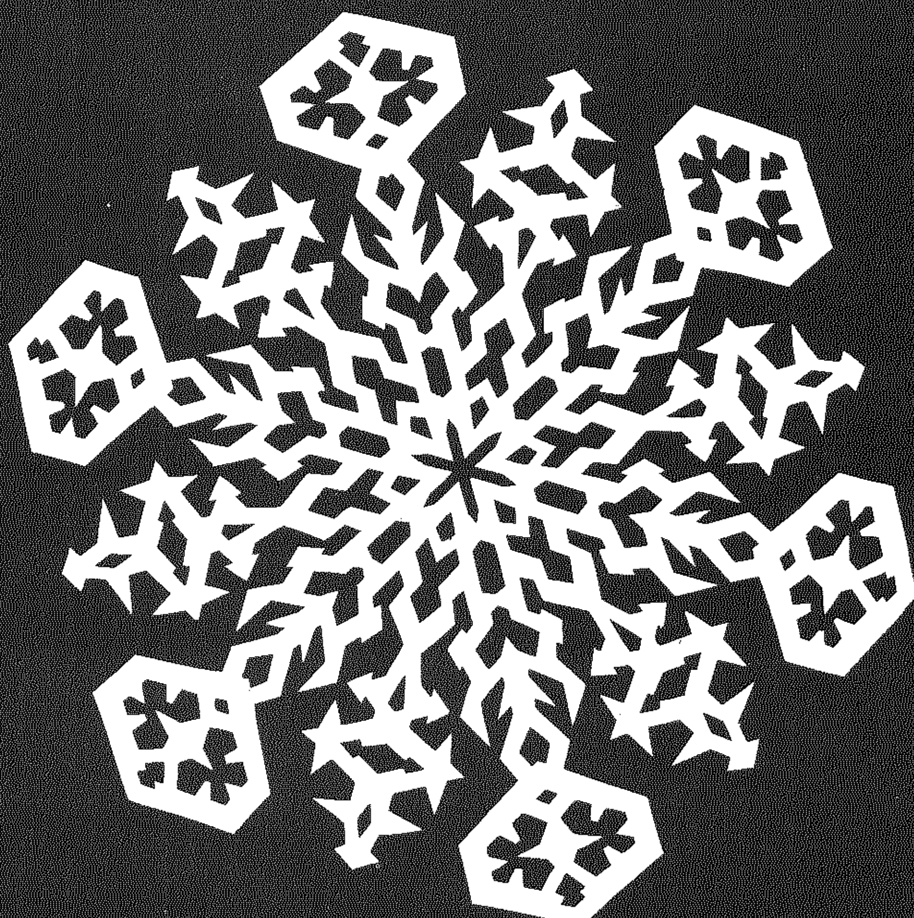

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