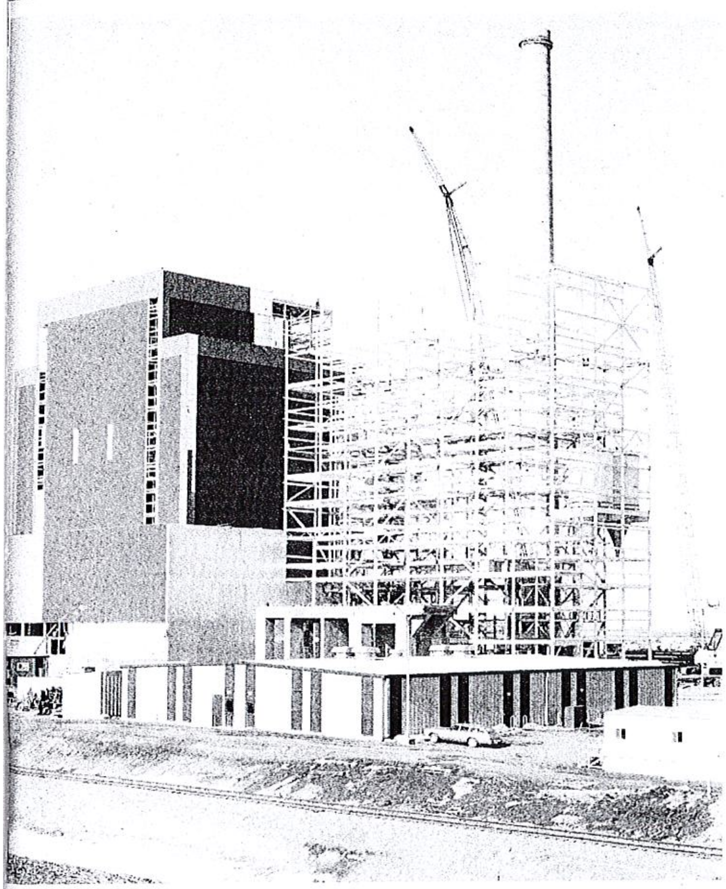
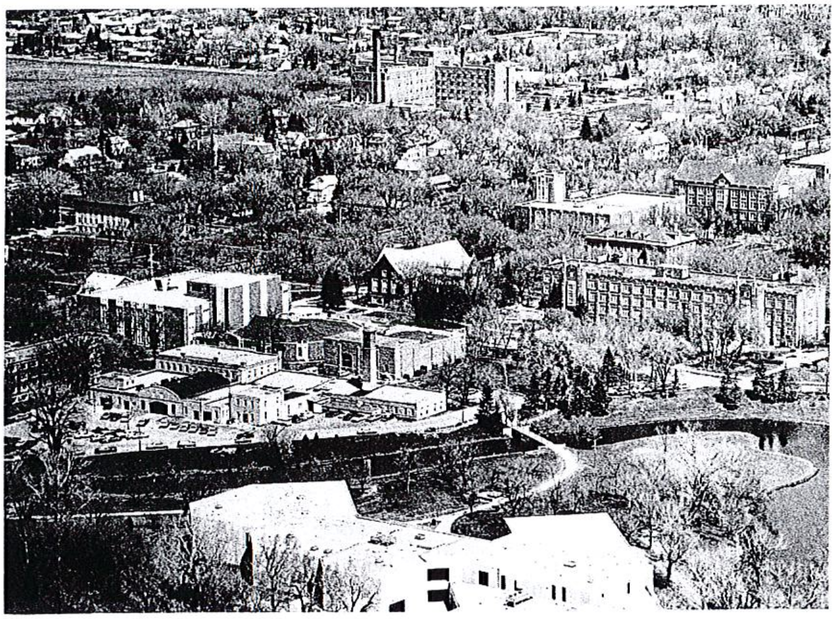
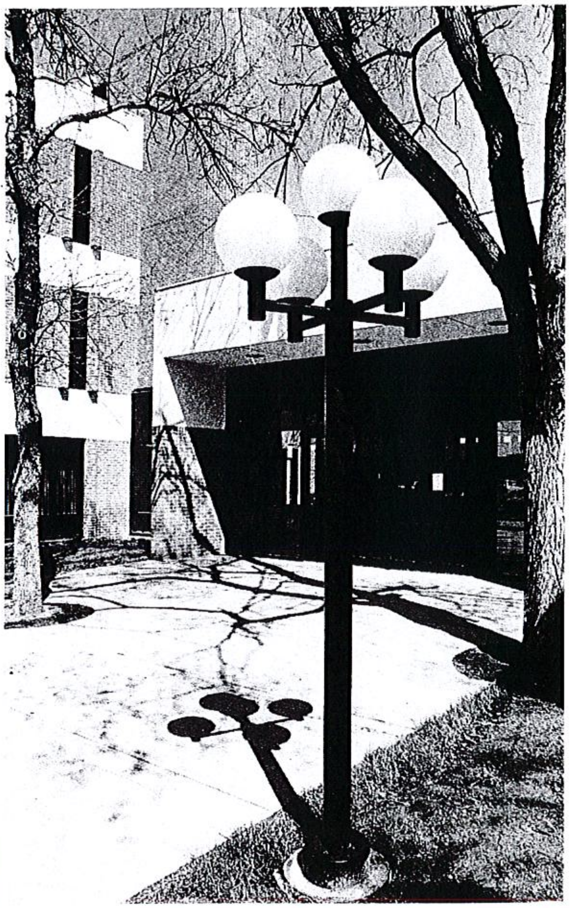
ENGINEERING DESIGN GRAPHICS JOURNAL

SPRING 1977 VOLUME 41 NUMBER 2 SERIES 123







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THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Engineering Design Graphics Journal

SPRING 1977 VOLUME 41 NUMBER 2 SERIES 123

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ENGINEERING DESIGN GRAPHICS JOURNAL

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

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

Yearly subscription rates: U.S., Mexico, Canada

	1 yr.	2 yr.	5 yr.
ASEE members	$3.00	$5.00	$10.00
Non-members	5.00	10.00	25.00
Other subscribers	10.00	20.00	50.00

Single copy rates:
In U.S., Mexico, and Canada:
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Back issues are available at single copy rates prepaid and are limited in general to numbers published with the past six years.

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ENGINEERING DESIGN GRAPHICS JOURNAL OBJECTIVES:

The objectives of the JOURNAL are:

1. To publish articles of interest to teachers and practioners of Engineering Graphics, Computer Graphics and allied subjects.
2. To stimulate the preparation of articles and papers on topics of interest to its membership.
3. To encourage teachers of Graphics to innovate on, experiment with, and test appropriate techniques and topics to further improve quality of and modernize instruction and courses.
4. To encourage research, development, and refinement of theory and applications of engineering graphics for understanding and practice.

REVIEW OF ARTICLES

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

DEADLINES FOR AUTHORS, COORDINATORS, AND ADVERTISERS

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

STYLE GUIDE FOR JOURNAL AUTHORS

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

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

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

3. Two copies of each manuscript are required.

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 8-1/2 x 11. If necessary, make 8-1/2 x 11 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.

6. Please make all changes in your manuscript prior to submitting it. Check carefully to avoid ambiguity, to achieve maximum clarity of expression, and to verify correct spelling throughout. Proofreading will be done by the editorial staff. Galley proofs cannot be submitted to authors for review.

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

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

CALENDAR

ASEE ANNUAL CONFERENCES

1977-University of North Dakota
June 27-30, 1977
1978-Vancouver, British Columbia

EDGD MIDYEAR CONFERENCES

1977-78--University of Alabama
January, 1978

EDITOR'S PAGE

Your editorial staff and this member in particular may be a bit shopworn, but the JOURNAL has been an enjoyable task for us all and a particularly gratifying experience for me.

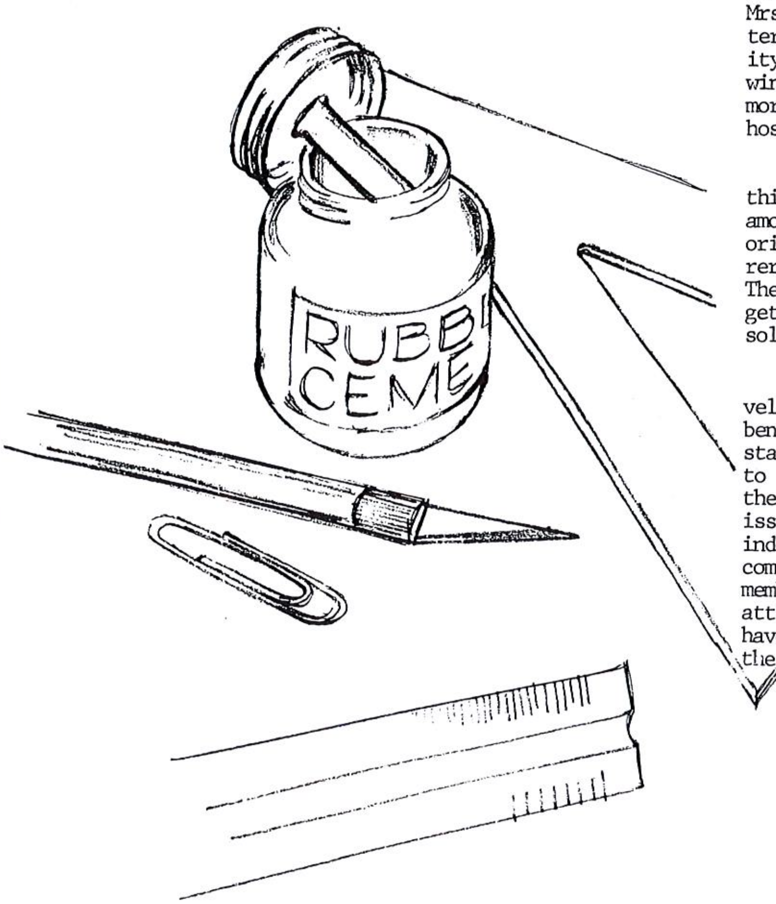
For one thing, it has been a great experience to work with so many fine people; authors, reviewers, JOURNAL staff, and Ed O'Neill and his staff at W.C. Brown, who provide so much professional assistance in producing the JOURNAL.

Clyde Kearns finishes two terms of service as Circulation manager with this issue. Clyde is an exceptional guy who has done a great job in a tough area and it has been a real honor to work with him this year. I hope I'll have the honor again somehow.

Among many other pleasant things, we are pleased to have what may be the first bilingual issue of the JOURNAL with the timely French-English summary of the Montreal Conference by Claude DeGuise (p14).

On the subject of the Midyear conference, our friends at Ecole Polytechnique had several tough acts to follow, with the many recent outstanding midyear conferences, but they were more than equal to the challenge. Claude is at a disadvantage; he can't express the feelings of their guests. We do want to extend our warmest thanks and friendship to Dean and Mrs. Langlois, Roland and Mrs.Dore, and Claude and Mrs. DeGuise and all their staff for a memorable winter visit. The meeting was excellent, the hospitality warm, the ladies program great fun, the food and wine without equal, and the Laurentian mountains even more beautiful than promised. To all our hosts and hostesses, our sincere thanks.

We hope you have read and enjoyed the JOURNAL this year and will continue to do so. If you are among those who can't find anything exciting to do in original academic work in graphics, may I suggest you reread the past five or six issues more closely. There are a lot of ideas to be found there if you just get involved. For a small start, you might try to solve the problem posed on page 26.



Besides the excellent technical sessions, two developments took place that at Montreal which should benefit the division considerably. First, the Journal staff scheduled and held a productive business meeting to coordinate our efforts, and decided then to change the Journal deadlines to better distribute the three issues over the academic year. Second, Amogene DeVaney indicated her intention to schedule afternoon executive committee meetings whenever possible so that the board members can spend more time with other conference attendees. In the past, these sessions, by necessity, have lasted far into the night, practically isolating the board from important member contact.

Chairman's Page

Clarence E. Hall
Louisiana State University

And Moses said to the people of Israel, "See the Lord has called by name Bez'alel the son of Uri . . . and he has filled him with the Spirit of God, with ability, with intelligence, with knowledge, and with all craftsmanship, to devise artistic designs, to work in gold and silver and bronze, in cutting stones for setting, and in carving wood, for work in every skilled craft. And he has inspired him to teach . . . . He has filled them with ability to do every sort of work done by a craftsman or by a designer or by an embroiderer in blue and purple and scarlet stuff and fine twined linen, or by a weaver -- by any sort of workman or skilled designer."

Exodus: 35:30-35

The significance of engineering design graphics to the practicing engineer is unsurpassed by any other fundamental engineering subject. One of the principal attributes of the engineer that serves to distinguish him or her from the scientist is the ability to accurately commit the results of one's efforts into some practical commutable form. The final packet of an engineering project usually consists of at least one or more drawings accompanied by specifications and other data.

History is silent as to the earliest time when drawings were first used to supplement or improve man's art of oral communication, but it seems safe to surmise that the historical development and use of drawings closely parallels the history of his quest for adequate supplies of food, clothing and shelter. Whatever degree of progress he may acclaim relative to achieving these goals can be attributed to a combination of inspiration and perspiration.

The history of drawing is so closely interwoven with the development of mathematics and architecture that it is rather difficult to know which one preceded the other. While drawings may be employed at times to direct the thoughts of the mathematician, mathematical principles are frequently used to prove the validity of graphic designs. Both of these disciplines were combined to give impetus to architectural designs. As early as 550 B.C. drawings were used in the construction of buildings. The earliest record of any theoretical work being done toward the development of architectural drawings indicates that certain geometrical principles were applied to the construction of perspective drawings about 470 B.C. The theoretical development of perspective drawings plagued philosophers, mathematicians and artists for the next 2200 years. Despite the excellent works of art as rendered by such great artists as da Vinci and Michaelangelo in the 15th century, a full mathematical treatment of perspective drawings was not achieved until the 18th century. The advent of computer graphics within recent years has stimulated a renewed interest in the mathematical development of perspective drawings.

Mathematical and scientific advances of the 17th and 18th centuries gave rise to several significant cultural developments on which much of our present technology is based. It was during the latter half of the 18th century that the Frenchman, Gaspard Mongé, synthesized the art of drawing and mathematics into one discipline which he designated as "descriptive geometry." The development of the technique of projecting three orthographic views of an object onto three mutually perpendicular planes by Mongé, coupled with the standardization of manufacturing processes by Eli Whitney, exercised a very significant and positive influence in the development of modern technology. This positive influence is just as much present today in industry as it has ever been in the past. For without the mathematical rigor of design graphics, there would be no computer graphics; and without the standardization of manufacturing processes, there would be no automatic manufacturing systems such as we now have with numerically controlled machinery. As engineering educators, we must continually stress the technical and cultural values of descriptive geometry and its present role in engineering design.

Some of the more astute engineering educators and practicing engineers who have a keener appreciation of the significance of design graphics are advocating strengthening this portion of the undergraduate engineering curriculum. In response to these suggestions, several colleges and universities are either putting graphics back in the engineering curriculum or strengthening the present program.

Institutions attempting to improve their graphics programs are encountering some difficulty in locating personnel who have an in-depth knowledge of this discipline or who have an interest in teaching the material. The Engineering Design Graphics Division, in recognition of the shortage of graphics teachers, is sponsoring an International Conference on Descriptive Geometry in conjunction with the annual ASEE conference in 1978. Additional information pertaining to the Conference may be found elsewhere in this publication.

The Relevance of Descriptive Geometry

Amogene F. DeVaney, Vice-Chairman
Engineering Design Graphics Division
Chairman, International Conference on
Descriptive Geometry

At a recent meeting a professor of electrical engineering asked me to tell him in what way descriptive geometry is relevant to the work of an engineer. I am not happy with the answer I gave him. At the time, the answer to the question seemed so obvious that it did not deserve a serious answer. However, the engineer seemed sincere as he continued, "I don't think it should be a required course for engineers. In many colleges it is no longer taught." You have heard this statement voiced many times, and you probably felt as I did. In the time since this meeting, however, I have given his question some thought, and I have tried to formulate in my mind a good answer to this question: Is descriptive geometry relevant, and if it is, to what?

This is a difficult question to answer—not because it contains exotic or technical terms that are out of the realm of our experience, but rather that it contains two ordinary terms, "descriptive geometry" and "relevance" that are familiar to all of us in engineering education. The difficulty lies in their use and meaning to each individual. To get a meaningful answer to the question, we must first clarify the meaning of these two terms.

Let us begin with the word "relevant." In Webster's dictionary—"relevant implies a traceable and significant connection." In the past years it has been customary to use the term relevant to refer to a relationship between some mode of action and a body of values or purposes. An action is relevant to a purpose if the action supports or helps achieve the purpose. For an individual some action is relevant if by doing it, his purpose is achieved.

The meaning of "descriptive geometry," I believe and propose to show, can best be clarified by showing that there are four meanings and these meanings depend on usage. The user in each case determines its relevance.

The first usage is found in advanced industrial societies of which the U.S. is the leading example. Descriptive geometry is so pervasive that we hardly notice its many uses. It is used in maps, hobby kits and patterns, in the everyday life of plumbers, carpenters, and automobile mechanics. In its higher reaches it includes such users as engineers and architects. It would be difficult to imagine how our technology, which has spread to the remote corners of the world, could have done so without descriptive geometry. The criterion of relevance or value with respect to descriptive geometry in terms of this basic usage is social utility. The usage of descriptive geometry in this area is relatively standardized, and the techniques not especially interesting from an intellectual point of view.

The second usage refers to the techniques and concepts of descriptive geometry which are used to formulate and solve problems in various branches of engineering and science. In terms of day-to-day practice, this is the primary function of descriptive geometry. The intellectual difficulties which must be resolved and the ingenuity which must be applied are often of a high order of magnitude. The standard of relevance within the framework of these applications is the usefulness of the result for the area of engineering or science to which it is applied rather than the intrinsic interest and fruitfulness of the processes by which that result is reached. Since the relevance of the descriptive geometry activity is its fruitfulness for the solution of the intellectual problems of the engineer or scientist, its value is thereby limited to the relevance of the problems to which it is applied.

The third usage refers to the investigation of the concepts, methods and problems of the discipline of descriptive geometry. This is what is usually called research or theoretical descriptive geometry. The criterion of relevance for this usage is the effectiveness of the research in resolving unsolved problems, in extending concepts and methodological tools, and in clarifying the logical structure of constructions and proofs. Practice of this discipline takes the form of a creative art which works on given problems and concepts by means of intuition.

The fourth usage is not a full-time activity of any one user, but is some of all. It is the vision of descriptive geometry as the intellectual ordering of space, as the science of space pattern and structure. It is a powerful technique for the understanding of spatial pattern and for the analysis of the relations of these patterns. It is a way of thinking and a way of viewing reality. The criterion of relevance for this usage is the degree to which a mode of thinking and seeing has been achieved.

What can we say about the relevance of descriptive geometry to contemporary engineering education? The complete answer is not obtainable because of the lack of objectivity caused by our closeness to the issue. On the one hand, we see the tremendous intellectual vitality of descriptive geometry in the past several decades, and its successes in the solution of both theoretical and practical problems. While on the other hand, as engineering education leaps ahead, descriptive geometry in its primary usage is alien to many engineers.

It is my suspicion that the discrepancy in the intellectual use of descriptive geometry by engineers may be attributed in no small part to a defect in our fundamental concept of descriptive geometry and the education of the engineer. To put the matter differently, the defect lies in viewing the teaching of descriptive geometry in practical terms exclusively, that is, in terms of the first usage. We fail in large measure to find ways to convey the spirit and the transcendent ideal of descriptive geometry as a way of thinking and viewing the world. This failure is in turn due to the failure or refusal of many of our engineering colleagues to recognize the validity or even the meaningfulness of such an ideal.

It is my hope that this failure represents a challenge that will be overcome in this era in which we play a part, and through the International Conference on Descriptive Geometry we may be provided an opportunity to assess the relevance of descriptive geometry as well as the means by which its spirit and vitality might be taught.

Public Relations Committee

Invitation for Ideas!

We need your help! We wish to make our Engineering Design Graphics Division more visible and more attractive to join. The Public Relations Committee had a preliminary meeting on developing policy and setting goals. YOUR IDEAS ARE URGENTLY NEEDED TO MAKE OUR DIVISION MORE SUCCESSFUL!! Here are some proposals on which your comments are invited.

1. The establishment of an ASEE Engineering Design Graphics Division speakers bureau with members making themselves available to speak at national, regional and state engineering conventions and to high school audiences at career guidance affairs.

2. Promoting more interest for becoming involved with JETS among division members.

3. Establishing a list of members available for judging at science fairs.

4. Establishing a list of qualified speakers for giving presentations at national, regional and state conventions of the Association of Community College Trustees (ACCT). These meetings are attended by board members and administrators of community colleges, junior colleges and technical institutes. These institutions are a fertile ground for membership recruitment. They can certainly use our guidance and expertise for establishing transferable two-year programs.

5. Provide speakers for national, regional and state conventions of high school mathematics, science and industrial arts teachers.

6. Get more closely involved with ECPD accreditation with regard to contents of engineering graphics design courses at universities and colleges offering engineering and/or engineering technology programs. This would include accreditable two-year associate degree programs in engineering technology.

Any ideas or comments? Please send them to me as soon as possible. Also: We hope to see you at our divisional public relations meeting at this summer's ASEE national convention.

Henry Kroeze, Chairman
Public Relations Committee
Engineering Design Graphics Division
University of Wisconsin - Waukesha
County Center
Waukesha, WI 53186

ASEE Annual Conference

University of North Dakota

June 27-30, 1977

Margaret Eller
Program Chairman
Louisiana State University

The 85th Annual Conference of ASEE will be held June 27-30, 1977, at the University of North Dakota, at Grand Forks. UND is situated on 500 scenic acres in one of the richest agricultural areas in the world, and the theme of the conference, "Food, Resources, Energy and Environment: the Critical Interfaces" (FREE), is particularly appropriate to the area. Trips have been planned to various sites to inspect environmental projects, and food and energy operations.

The City of Grand Forks is situated at the junction of the Red River and the Red Lake River. Its first inhabitants were French fur traders and Indian hunters and trappers, and the region was known as the Dakota Territory. Today the principal industry is agriculture, and the population is approximately 42,000.

The Grand Forks Air Force Base is about 15 miles west of the city and is a vital link in the northern chain of Strategic Air Command Bases. Approximately 13,000 reside on the base, 6,624 military, 6,090 dependents, and 500 civilian employed. The Base is a major economic factor in the local area.

The University of North Dakota, located on the western edge of the city, is the oldest and largest institution of higher learning in North Dakota. Established by the Legislative Assembly of the Dakota territory in 1883, with a faculty of four, it now boasts a faculty of more than 700, and an enrollment of more than 8,600 students. The University offers courses through the doctoral level, and is ranked "Class A" with the Commissioner of Education. The state's only graduate professional schools of law and medicine are located at UND.

Conference attendees who wish to extend their vacation to explore North Dakota and/or surrounding states of Minnesota, Montana, South Dakota, and Wyoming, will find striking scenery and many historical points of interest.

Among the attractions in North Dakota are Medora and the Badlands, the "Roughrider Country" of Teddy Roosevelt; the two-mile-long Garrison Dam and Lake Sakakawea; the International Peace Garden, symbolic of eternal friendship between Canada and the United States; scenic Lake Metigoshe; and the state capital and museum in Bismarck. Rodeos and other events occur throughout the summer.

In Minnesota, the state of 10,000 lakes, will be found the metropolitan center of Minneapolis-St. Paul; the Pipestone National Monument, where Indians still quarry redstone for sacred ceremonial pipes; and the "Iron Range" of Duluth and northern Minnesota.

Points of interest in South Dakota include the gigantic Oahe Dam near the capital of Pierre; the Black Hills, Mt. Rushmore, Crazy Horse and Badlands monuments, and Custer, Jewel Cave and Wind Cave parks.

In Wyoming there is Yellowstone Park, and the Buffalo Bill center at Cody; and the striking Devils Tower National Monument.

In Montana, the Custer battlefield near Hardin is of historical interest.

The Women's Program (but not for women only) promises to be most interesting and varied, and will carry out the theme of the Conference.

Four full-day trips are planned to include visits to Winnipeg, Manitoba; Bonanzaville (a frontier town); Itasca State Park; and an Indian reservation.

Also planned are half-day trips to working farms in the Red River Valley, the United Hospital, the Grand Forks Air Force Base, and through the country near Grand Forks to locate, identify, and discuss uses of edible wild plants.

For those who do not care to wander, there are local visits to the Human Nutrition Laboratory, Mini-conventions of AAUW (American Association of University Women) and League of Women Voters, and Chamber Orchestra workshops.

Craft workshops will include Spinning and Weaving, Batik, Macrame, Pottery, Sketching and Drawing, Stitchery, Pysanky, Rosemaling, and Thai flowers.

A tea at the home of UND President and Mrs. Thomas Clifford will welcome attendees and provide an opportunity to meet old friends and make new ones. A Swedish smorgasbord and an Irish brunch, both with appropriate entertainment, are also on the program.

Hockey, basketball, swimming, and gymnastic camps will be held for younger members of the family.

PROGRAM

ENGINEERING DESIGN GRAPHICS DIVISION

The Engineering Design Graphics Division program was planned to include a variety of topics so as to interest a majority of Division members. Whenever possible, co-sponsorship of events with other Divisions or Constituent Committees was sought in order to minimize conflicts and to provide more varied viewpoints.

MONDAY, JUNE 27

8:00 - 9:45 a.m.
CREATIVE DESIGN DISPLAY - COMMITTEE MEETING (closed)

Menno DiLiberto, Chairman
Ohio University

3:45 - 5:30 p.m.
THEORETICAL GRAPHICS APPLICATIONS

Mary F. Blade, Moderator
Cooper Union

New Advances in Theoretical Graphics Applied to Design and Problem Solving in Engineering

Mary F. Blade
Cooper Union

Geometry, Symmetry, and Materials Science

Kalinath Mukherjee, Head
Dept. of Metallurgy
Polytechnic Institute of New York

The Golden Section Revisited

Matt Abbitt
General Motors Institute

Game Problems for Graphics

Robert Rights
New Jersey Institute of Technology

Pictorial Representation by Affinity and Homology

Manuel De Medeiros
SUNY, Morrisville

6:00 p.m.
EXECUTIVE DINNER (by invitation)

C. E. Hall, Chairman

8:30 p.m.
DESIGN RAP SESSION - SO YOU THINK YOU TEACH WELL?

Co-sponsored with Engineering Design Committee

Former students will act as panel of experts to respond to ideas about good teaching.

TUESDAY, JUNE 28

8:00 - 9:45 a.m.
THE FIRST YEAR - Freshman Programs

Under the guidance of Robert LaRue, this event was planned as a direct result of "The Rap Session" at Knoxville. There is a growing trend to involve educators in a total freshman curriculum, which includes teaching, advising, and orientation activities. This is a departure from the teaching of engineering graphics and specialty courses only--when class periods provide the only time for teacher-student contacts, and advising may be done on an informal basis. Some who have participated in the newer direction are enthusiastic about the results, and will share their experiences with attendees.

1:45 - 3:30 p.m.
COMPUTER GRAPHICS "FRESHMEN"

Byard Houck, Jr., Moderator
North Carolina State University

The "Freshmen" referred to in the title are those teachers who may be experienced in teaching, but are just beginners in teaching computer graphics. This session is based on results of a survey conducted by Francis Mosillo and his Computer Graphics Committee.

Computer Graphics - A Small Scale Application

Carl H. Gausewitz, Architect and Engineer
University of Wisconsin - Platteville

Three-Dimensional Computer Graphics Program - On a Large Scale

Francis Mosillo
University of Illinois at Chicago Circle

One Year With a Computer Graphics System - An Educational Experience

Robert J. Beil
Vanderbilt University

3:45 - 5:30 p.m.
HUMAN AND COST FACTORS IN DESIGN

Co-sponsors

Engineering Design Committee
Industrial Engineering Division

F. J. Jankowski, Moderator
Wright State University

PROGRAM

ENGINEERING DESIGN GRAPHICS DIVISION

The Importance of Life Cycle Costs and Human Resource Factors in Engineering Design

Robert J. Patton
Vought Corporation

Implications of Product Liability for Engineering Design and Engineering Education

J. M. Christensen
Wayne State University

Practice and Problems of Incorporating Human Resource Factors/Data in the Engineering Design Process

E. L. Thomas
Clemson University

The Incompatibility of Human Factors With Traditional Engineering: The Importance of Life-Cycle-Costs

M. L. Ritchie
Wright State University

Status and Prerequisites for Human Resources Factors in Engineering Design Education

F. J. Jankowski
Wright State University

6:30 p.m.
ANNUAL AWARDS BANQUET

Creative Design Awards
Recognition and Awards for outstanding Division members
Change of leadership ceremony

WEDNESDAY, JUNE 29

8:00 - 9:45 a.m.
METRICS IN TECHNOLOGY AND DESIGN GRAPHICS

Co-sponsored with Metrication Coordinating Committee

Moderator
K. E. Kroner
University of Massachusetts

Speakers
J. L. Meriam
California Polytechnic State University

L. D. Goss
Indiana State University

12:00 - 1:30 p.m.
EDG DIVISION BUSINESS LUNCHEON

1:45 - 3:30 p.m.
CREATIVE TEACHING

Co-sponsors

Educational Research and Methods Division
Engineering Technology Division

3:45 - 5:30
HUMAN FACTORS IN ENGINEERING DESIGN

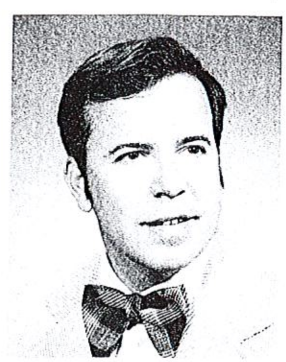
John G. Kreifeldt, Moderator
Tufts University

Engineering Design and Technology Transfer, Past, Present, and Future

Charles C. Kubokawa, Chief
Technology Utilization Office
NASA

Mary F. Blade

Kalinath Mukherjee



Matt Abbitt

Byard Houck, Jr.

PROGRAM

ENGINEERING DESIGN GRAPHICS DIVISION

Problems and Opportunities in Developing New Product Concepts

Thomas G. Cannon, President
Design Factors

Humans and Seats: Recent Design Research

Stefan Habsburg
General Motors Design Staff

THURSDAY, JUNE 30

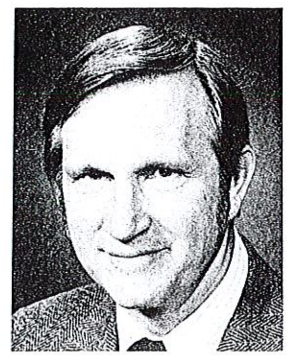
8:00 - 9:45
RAP SESSION - Freshman Engineering

A continuation of the Tuesday morning event. Time to react to the speakers, or offer comments, ask questions, agree or disagree.

Thomas G. Cannon

Stefan Habsburg

Charles C. Kubokawa



Malcolm L. Ritchie

Creative Engineering Design Display

Dr. Menno DiLiberto, chairman of the Engineering Design Graphics Division Creative Design Display Committee, announces that the annual creative design competition and display will be held at the 1977 Annual Meeting of the ASEE at the University of North Dakota, Grand Forks, North Dakota, June 27 through 30, 1977.

"This year's competition promises to be bigger and better than ever," DiLiberto said, "and we encourage those schools who have not participated before to do so this year." Participating colleges and universities are allowed to enter in the following categories:

Freshman Division	-	2 entries
Sophomore Division	-	1 entry
Junior Division	-	1 entry
Senior Division	-	1 entry
Graduate Division	-	1 entry

For more information concerning competition rules and guidelines, write to:

Dr. Menno DiLiberto, Chairman
Engineering Graphics Department
Industrial Technology Building
Ohio University
Athens, Ohio 45701

Highlights

Mid-Year Conference In Montreal

Claude De Guise
General Chairman
Mid-Year Conference

FRENCH

Comme nous l'avions promis à Williamsburg, lorsque nous avons accepté la responsabilité d'organiser le congrès à Montréal en 1977, la température s'est montrée des plus clémente du 5 au 7 janvier avec une moyenne de 15° à 20°F. Afin de ne pas décevoir nos amis du Sud, nous avions aussi prévu la neige qui était au rendez-vous pour le souper Laurentien et un aperçu plus impressionnant le vendredi pour atteindre Dorval. Malheureusement, notre responsabilité cessait à la frontière; c'est pourquoi quelques uns ont éprouvé certaines difficultés à différents points de correspondance. Le Québec s'était montré hospitalier pour ses visiteurs afin de les inciter à revenir nous voir et leur montrer qu'il peut exister moins de problèmes à Montréal qu'à certains endroits des Etats-Unis.

Pour la première fois depuis 1933, Montréal avait l'honneur de recevoir le congrès. Profitant de cette occasion, l'Ecole Polytechnique inaugurait ses nouveaux amphithéâtre dans la tour centrale nouvellement construite au centre de l'Ecole.

Afin de palier aux inconvénients de la distance des hôtels au campus, un service d'autobus spéciaux a permis aux congressistes d'atteindre sans encombres le lieu des activités.

Débutant le mercredi soir par une soirée sociale et une réunion du conseil à l'Hôtel Méridien qui s'est prolongée fort tard. Tout le monde était en pleine forme le jeudi pour assister aux conférences et à toutes les activités qui semblent avoir grandement intéressé tous les membres tout autant que leurs épouses.

Le dîner de bonne entente au Chantecler de Ste-Adèle dans les Laurentides et le trajet de plus d'une heure vers les pentes enneigées fut sans contredit le clou des évènements sociaux. La bonne chère et le bon vin semblent avoir endormi les uns et réveillé les autres car, si le retour fut silencieux dans le premier auto-

ENGLISH

As promised in Williamsburg when we assumed the responsibility to organize the Engineering Design Graphics Mid-Year Convention in Montreal in 1977, the weather was very mild from the 5th to the 7th of January, between 15°F to 20°F. For our friends of the South we wanted to show them how nice the snow was in Quebec and the snow was there for the Laurentian friendship dinner in the Laurentian mountains. To give a better idea of the snowfall in Montreal, Friday showed another view of the city but everybody reached Dorval airport. But we were not responsible for what was going on on the other side of the border, and it seems that some people had some problems with the storms in the United States. This goes to show that, after all, it might sometimes be as easy to live in Quebec as South of the border!

For the first time since 1933, Montreal had the honor to host the convention and Ecole Polytechnique took this opportunity to inaugurate her new amphitheaters in the central tower recently built in the middle of the school.

In order to reduce the inconvenience of distances between the hotels and the campus, a shuttle bus service assured the participants an easy access to the activities.

The Conference started on Wednesday night with a social party and a meeting of the Executive Committee at the Hotel Meridien. Everyone appeared to be in good shape to attend the conferences and all the activities which seemed to have greatly interested all the members and their wives.

The Laurentian friendship dinner at the Chantecler in Ste-Adèle and the one-hour drive to reach the snow hills was certainly the hit of the social events. The good meals and the good wines seemed to rejoice all the participants. The return was very quiet in one bus but it seems that our friend Raymond Gauvin with his

FRENCH

bus, les chansons françaises de notre ami Raymond Gauvin ont réveillé l'enthousiasme de tous.

Tous les conférenciers du jeudi et du vendredi furent à la hauteur de la situation et ont grandement intéressé leur auditoire. Comme il fallait faire un choix, les membres du comité de sélection ont choisi Monsieur Fernand Dugal comme récipiendaire du Prix Oppenheimer pour son magnifique exposé sur l'application du système international aux universités et à l'industrie.

Malgré une neige qui n'était pas au programme la visite de Montréal en autobus, quelque peu modifiée, a tout de même permis de voir une partie de la métropole et a même procuré quelques moments d'hilarité.

Nous tenons à remercier tous ceux qui ont bravé les intempéries pour venir participer à cette rencontre. Ils se sont rendus compte que Montréal n'est pas le pôle Nord! Après avoir vu Montréal sous la neige, nous espérons vous revoir sous le soleil radieux de l'été.

Tous les membres du comité d'organisation et les autorités de l'Ecole Polytechnique espèrent que tous ceux qui ont participé au "Mid Year Convention 1977" à Montréal garderont un bon souvenir de leur séjour dans la métropole du Canada. Nous les remercions de leur participation et nous espérons les revoir bientôt.

Comme nous le disions, si la température a été un peu plus froide que celle de l'Arizona, nous espérons que la chaleur de l'hospitalité aura été des plus bénéfique.

ENGLISH

French songs kept the other bus quite awake.

All the speakers on Thursday and Friday were really interesting. The question periods seemed to be too short. The selection committee had a big problem choosing the recipient of the Oppenheimer Award for the best presentation. They finally decided to give the Oppenheimer Award to Mr. Fernand Dugal for his presentation on Metrication applications in Industry and University.

Even with the snowfall which was not on the program, the visit of Montreal by bus showed part of the city, but as we were delayed we could not see all that we wanted.

We want to thank all those who came to visit us, even if some were afraid of our Quebec weather. They realized that Montreal was not the North Pole! After seeing Montreal under the snow, we hope that you will come again during the beautiful summer.

All the members of the Committee and the authorities of the School want to thank everyone who came to the 1977 Mid-Year Conference and hope that they will keep a good souvenir of their stay in the metropolis of Canada.

As we said, if the weather was colder than in Arizona, we hope that the warmth of the hospitality here made up for it.

Editor's Note: The Journal, on behalf of all the Engineering Design Graphics Division members, wishes to express its deep appreciation to Claude, the faculty and staff of Ecole Polytechnique and their wives for a most unusual, exciting, hospitable and warm Mid-Year Conference in Montreal.

Oppenheimer Award

The Oppenheimer Award was presented to Mr. Fernand Dugal of the Canadian Metric Commission at the Mid-Year Conference of the Engineering Design Graphics Division. Mr. Dugal's paper, "Metrication Application in Industry and University," was judged to be the best of eight excellent papers presented at the conference. Arnold Cammarata of the Gramercy Corporation presented the award and one hundred dollars in cash to Mr. Dugal.

The Oppenheimer Award is presented once each year at the Mid-Year Conference. It was established and funded by Frank Oppenheimer of the Gramercy Corporation to encourage and reward excellence in the presentation of papers at Division meetings.

from the midyear conference...

METRICATION in INDUSTRY & UNIVERSITY

SUMMARY

Klaus E. Kroner
University of Massachusetts

Mr. Dugal's dynamic presentation left no doubt that Canada is well on its way to becoming a metric nation. Indeed, evidence of this can be noticed on the major highway approaches to Montreal in that mile posts have been replaced by kilometer markers and the distance to destinations is given by that same measurement unit. All highway signs will be converted by the end of this September.

The Canadian Metric Commission has established a large group of special interest committees, each charged with developing a conversion timetable for its respective industrial, educational, governmental, business, etc. sector. These committees are at various stages of progress, several having met numerous times and their work virtually being completed.

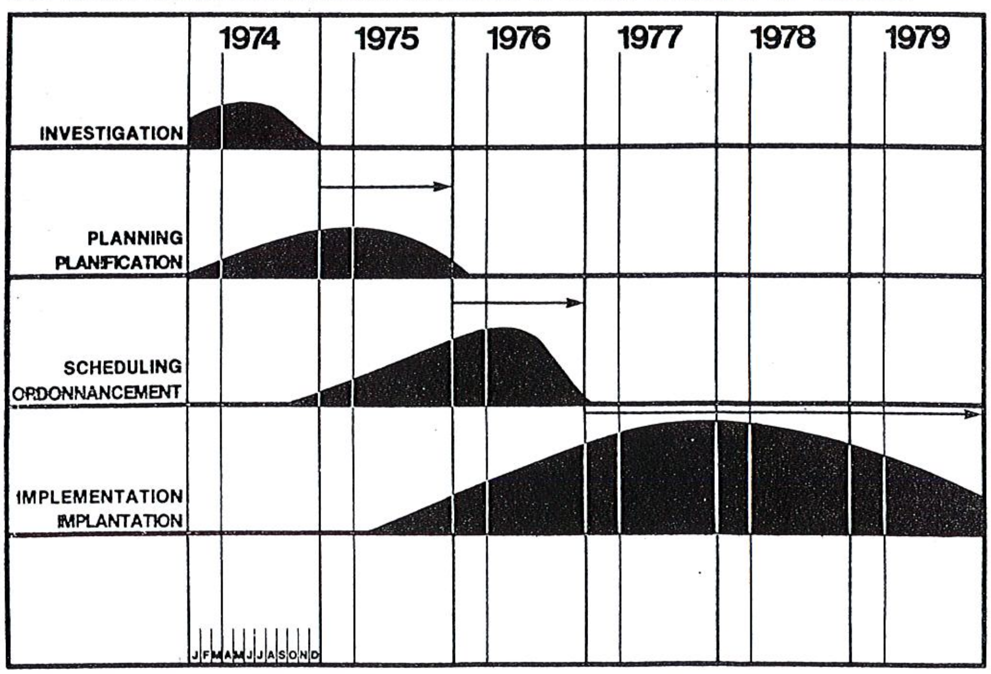
In comparison to the metrication activities in the U.S., Canada seems to have taken a more aggressive approach. Once Parliament made the decision early in 1970 for Canada to adopt the metric system, it made steady progress towards planning a well-coordinated changeover. The implementation effort of the the conversion plan is scheduled to peak early in 1978 with completion in sight by 1980.

Channels for appeals and arbitration in cases of conflicts or disagreements have been set up to have problems resolved in a speedy manner. One of the early resolves concerned the spelling of the SI base units - namely that the spelling for m is metre.

It seems that when the U.S. Metric Board is finally appointed and operating, it can learn a great deal from its equivalent in Canada - the Canadian Metric Commission. Even though the task will be a larger one here, much of their work is applicable to our situation. Mr.Dugal spoke of previous cooperation with ANMC, and his Commission has offered to extend this cooperation to the U.S. Metric Board.

Mr. Dugal's talk was lively and effective, illustrated with well-designed slides. This outstanding presentation earned him the Frank Oppenheimer award which he received at the conclusion of the Conference.

THE FOUR PHASES OF METRIC CONVERSION IN CANADA
LES QUATRE PHASES DE LA CONVERSION AU SYSTÈME MÉTRIQUE AU CANADA



from the midyear conference...

3-D SIMPLIFIED

An interesting and possibly historically significant paper was delivered at the Montreal conference by a familiar EDG member, Marc Sauvageau of the Ecole Polytechnique. However, since his paper dealt with the operation of a device designed to make pictorial drawings, both Professor Sauvageau and the Journal staff felt it would be appropriate to describe it in a summary to avoid any possible commercialism.

Historically, his paper had its beginnings in the 1960's during his study of axonometric projections. In January, 1970, at the midyear conference at San Luis Obispo, Professor Sauvageau described the result of those studies in a paper (1) based on his earlier book (2). It was also described in a two-part article in Engineering Graphics (3).

Professor Sauvageau continued his work in this area and in the Montreal paper he described a new device of his own invention called the Axograph(T). The Axograph permits the user to create a wide variety of formal, accurate axonometric drawings directly from the orthographic views of an object without any intermediate calculations or projections.

Without going into the operational aspects, which were described well by Professor Sauvageau, the principal features of the Axograph can be seen in Fig. 1. It consists of a round graduated table with three adjustable heads, one for each axis of the pictorial. Each head carries two adjustable blades. With the heads and blades properly set using the instructions provided, the Axograph will orient the pictorial axes correctly and permit the user to locate any feature of the object in pictorial, thus foreshortening all axes by the correct factors.

We were impressed and pleased to see this fine example of basic research in graphics brought to fruition in a workable and promising product. Professor Sauvageau further demonstrated well many of the principles we advocate in the design process. We wish him good luck with his new venture.

Those interested in obtaining more information about the Axograph should write directly to Professor Sauvageau, at the following address:

AXO-GRAPH Ltd/Ltée
665, chemin du Lac, local 2,
Boucherville, (Quebec) Canada, J4B 5E4

(1) Sauvageau, M. A New System for Exact Axonometric Projection Directly From Multiview Projection ASEE/EDGD midyear conference, Jan. 21-24, 1970.

(2) Sauvageau, M. Projections Axonometriques Exactes Directement des Projections Orthogonales. 1968.

(3) Sauvageau, M. A New System for Exact...
Part I: Engineering Graphics, Dec. 1970, p7.
Part II: Engineering Graphics, Jan. 1971, p12.

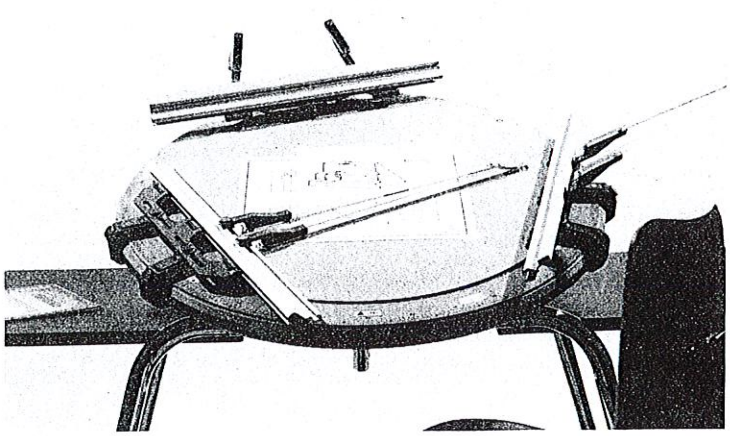


Fig. 1. The Axograph (T)

from the midyear conference...

DESIGN GRAPHICS AND APPROPRIATE TECHNOLOGY

Summary of Presentation

"Design Graphics and Appropriate Technology, their impact on Development in Third World Countries"

by Steve Slaby

A major theme of this paper by Professor Steve Slaby was that individuals with interests and expertise in Design Graphics can make contributions to technology transfer efforts of groups working in or for the Third World countries.

Professor Slaby set out to define the problem by:

1. defining "Third World People". in a broad sense that includes "any people who historically have been exploited, disenfranchised, politically and technologically powerless, economically poor , prejudiced against and relegated to the lower social and economic levels of society."

2. describing examples of resource use (consumption), education, and other measures of imbalance of technological development between the "rich" and "poor".

A specific example was then used to illustrate the types of inputs that design graphics experts can contribute in the Technology Transfer process.

Sets of technical drawings, produced by the 'Intermediate Technology Group', of equipment designs for third world people were examined. It was pointed out that while the technology represented by these designs had been scaled to levels appropriate for third world users and craft skills, the drawings and instructions themselves introduced new problems. These problems included: inappropriate language; incorrect or misuse of drafting standards; mismatch of dimensions and specifications with third world production processes; and uses of multi-view drawings when pictorial forms would be superior. In general, the example delineated clearly cross-cultural communication problems associated with technical projects.

Individuals interested in exploring the possibilities of using projects of this type within design courses and programs can obtain information from several sources:

1. Intermediate Technology Publications, 9 King Street, London WC2.
2. Peter N. Gillingham, Intermediate Technology, 556 Santa Cruz Ave. Menlo Park, CA 94025.
3. VITA (Volunteers in Technical Assistance), 3706 Rhode Island Ave., Mount Rainier, MD 20822.

A variety of other information sources can be found by reviewing current literature on intermediate technology.

-E. W. Knoblock

from the midyear conference...

A NEW APPROACH TO DESIGN

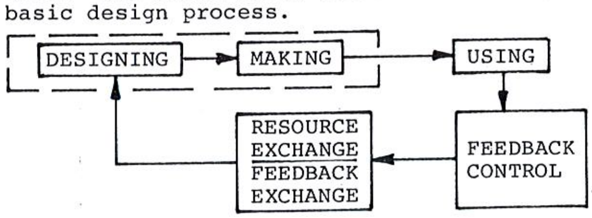
SUMMARY OF

"A NEW APPROACH TO DESIGN"

by S. F. Love

Designectic International, Inc.

In this presentation Mr. Love indicated that a trend in design methodology is to (and should be to) move toward the inclusion of the user in the decision process. The model below describes the basic design process.



Within this (or any) design system a feedback time constant exists for each environment. The time constant is relatively short/small for the free market (industrial) environment, and relatively long/large for the governmental environment.

Three generations of design methods were briefly described.

First generation - the designer, as expert, has all responsibilities in making the design.

Second generation - the designer uses methods to allow for user feedback on the array of alternates being proposed. The designer then completes the design with the user inputs.

Third Generation - the designer provides for full participation of the user in the complete design process.

Many examples of second generation design can be identified in current practice. A few examples of third generation design methods can be sited as experiments and trend indicators.

If these trends in design are true, the implications for design educators are clear. Design courses must teach students how to:

1. work with people in the design process.

2. provide for user participation in the decision-making structure.

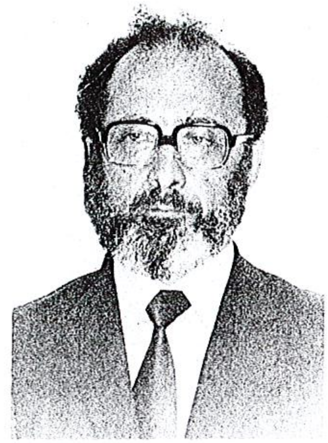
3. enable users to participate in the creative and decision-making processes.

Considerable discussion by the audience for this presentation centered on the feasibility of having a high degree of user participation in major projects that have serious long range implementations.

-E. W. Knoblock

from the midyear conference...

A. Rotenberg
Mechanical Engineering
University of Melbourne



Representation of Curved Surfaces by Computer Graphics

I DEFINITIONS

An edge on a surface Σ is a locus of points on Σ at which no single tangent plane to Σ exists.

A silhouette Λ (Figure 1) of a surface Σ is the locus of points M_i of tangency of all rays SM_i tangent to Σ at points M_i.

An outline λ of a curved surface Σ on a projection plane Π is the projection on Π of the silhouette Λ of Σ.

An outline of a polyhedron on a projection plane Π is a projection on Π of an edge on the surface of the polyhedron.

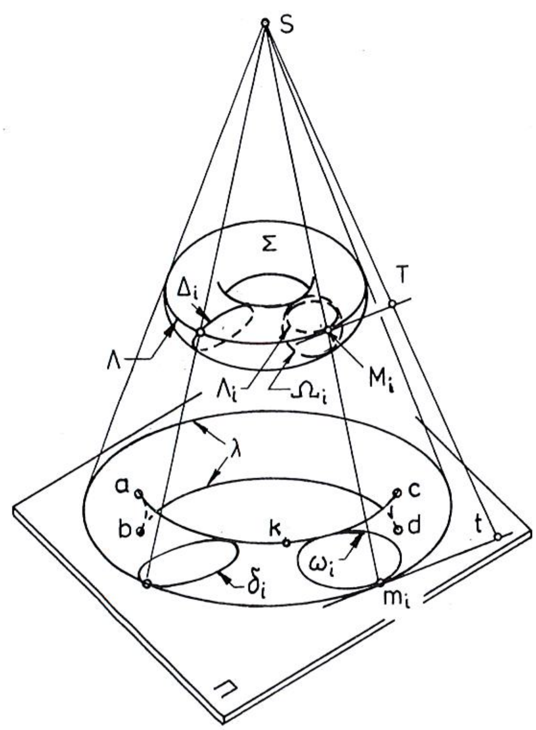


Figure 1

II INTRODUCTION

The problem of computer drafting of outlines of curved surfaces is quite distinct from that of polyhedra since

an edge on a surface of a polyhedron is a property independent of the projection apparatus; a silhouette of a curved surface is a line whose shape depends on the position of the centre of projection with respect to the surface.

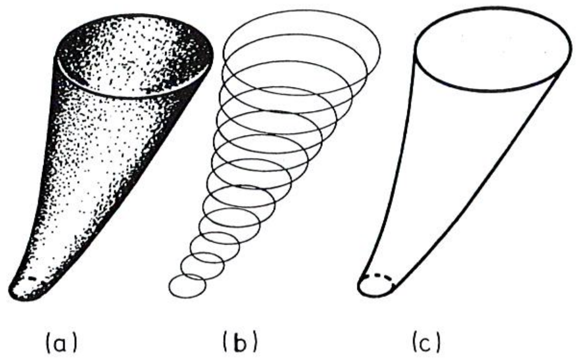


Figure 2

Existing computer methods for graphical representation of curved surfaces are usually based on 'lofting' or 'three-dimensional molding'. In these methods, an imaginary line-grid, or a set of planar sections, is drawn on the surface to be represented and the resulting drawing is a projection (orthographic, axonometric or perspective) of this grid (Fig. 2). To complete the drawing in accordance with engineering conventions, the outline needs yet to be drawn and, in many cases, the grid itself erased.

This paper describes a computer method for constructing outlines of curved surfaces without the use of an intermediate 'line-grid'. The general case of perspective projections is discussed and the examples illustrate the common engineering particular case of orthogonal axonometry.

III THE 'DIRECT' METHOD

The general method in descriptive geometry for construction of an arbitrary point m_i (Fig. 3) of an outline λ of a curved surface Σ consists of the following steps:

(i) Draw an arbitrary plane P through the centre of projection S;
(ii) Draw the line Λ of intersection of P with Σ;
(iii) Draw the line (s) SM_i tangent to Λ;
(iv) Find the point (s) m_i of intersection of SM_i with the plane Π.

For the purpose of computer programming, it seemed quite natural to calculate the co-ordinates of the points m_i using a similar analytical approach. In most cases, however, attempts to implement this procedure analytically lead to an enormous amount of calculation and, therefore, this approach was abandoned.

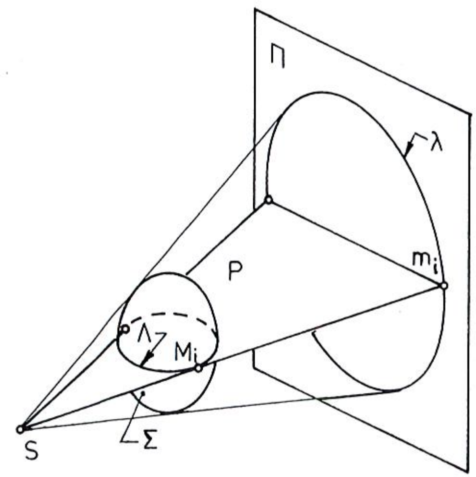


Figure 3

IV THE ENVELOPE METHOD

The surface to be represented on the drawing is regarded as either

(a) a locus of a family of generating curves, or
(b) an envelope of a family of generating surfaces.

For example, in Fig. 1, Δ_i is a curve of the family Δ and Ω_i - a surface of the family Ω. The surface Σ may be regarded as either the locus of all the curves Δ or as the envelope of all the surfaces Ω. The following two theorems relate the outline λ of the surface Σ to the projections of Δ and outlines of Ω.

Theorem 1. All points of the outline λ (Fig. 1) of a three-dimensional surface Σ are points of the envelope of the projections δ of a family of curves Δ generating Σ.

This theorem is a restatement of the 'rule 1' formulated and proven in reference [2]:

'The projection of a silhouette of a surface is an envelope of the projection of its generating curves' (p. 149).

Theorem 2. All points of the outline λ (Fig. 1) of a three-dimensional surface Σ are points of the envelope of the outlines ω of a family of surfaces Ω generating Σ.

Proof

Let Ω be a family of generating surfaces Ω_i

Σ -a surface enveloping Ω

S -the centre of projection

Π -a projection plane not containing S

Λ -the silhouette of Σ

Λ_i-the silhouette of Ω_i

λ -the outline of Σ on Π

ω_i-the outline of Ω_i on Π

An envelope of a family of coplanar curves may be defined as a curve that is tangent at each of its points to some curve of the family [1, p.40]. Thus, to prove the theorem, we need to show that, at each point m_i of λ (which is also a point of ω_i), ω_i and λ have a common tangent.

'Rule 3' [2] states:

'The silhouette of an enveloping surface is an envelope of the silhouettes of the enveloped surfaces' (p. 150).

Let M_i be the point of tangency of Λ and Λ_i and M_iT their common tangent. Then, from 'assertion 19' [2]:

'The projection of a point of tangency of a line to a curve is the point of tangency of the projection of the line to the projection of the curve' (p. 115),

follows that the projection m_it of M_iT is a common tangent to ω and λ.

q.e.d.

By theorems 1 and 2 respectively, all points of the outline of Σ may be regarded as points of either

(a) an envelope of the projections of the generating curves, or

(b) an envelope of the outlines of each of the surfaces in the family of the generating surfaces.

It is assumed that the equations of the family of generating curves Δ or the generating surfaces Ω are known. The method based on the two theorems includes the following steps:

(i) Derivation of the equations of the families of curves δ or ω (i.e., the family of projections of Δ or the family of outlines of Ω).
In general, this equation is of the form
$f(X,Y,\alpha) = 0$,
where α is a parameter such that each numerical value of α corresponds to one curve of the family.

(ii) Derivation of the equation of the envelope λ of the families δ or ω. Ignoring singular points, this equation may be expressed (e.g. [2]) parametrically as

$$\left.\begin{aligned} f(X,Y,\alpha) &= 0 \\ \frac{\partial f(X,Y,\alpha)}{\partial \alpha} &= 0 \end{aligned}\right\} \qquad (1)$$

(iii) Solving equations (1) for X and Y.

(iv) Elimination of all points of the envelope which are not points of the outline. (See Section V of this paper).

(v) Setting of a computer program for plotting the locus of points (X,Y).

V THE DISTINCTION BETWEEN OUTLINE AND ENVELOPE

Although all points of the outline λ (Fig. 1) of the surface Σ are points of the envelope of the families δ or ω, some points of the envelope may not belong to the outline, e.g., the arcs ab and cd (shown in broken lines) belong to the envelope but not to the outline λ. A general method for identifying arcs of the envelope which do not belong to the outline is not known to the author; however, it is conjectured that

> if a continuous branch of the envelope of the families of curves δ or ω contains arcs not belonging to the outline λ, these arcs are bounded by singular points.

Hence, if an arbitrary point k of the envelope is found to belong (or not to belong) to the outline λ, the arc ac passing through k and bounded by singular points a and c also belongs (or does not belong) to λ. This conjecture was verified in the examples considered.

Subject to certain conditions, the coordinates of the singular points may be calculated as values of X and Y for which the parameter α satisfies the equations:

$$\frac{\partial X}{\partial \alpha} = \frac{\partial Y}{\partial \alpha} = 0 \qquad (1a)$$

In some cases, equations (1a) are difficult to solve with respect to the parameter α, and the following alternative test may be preferred.

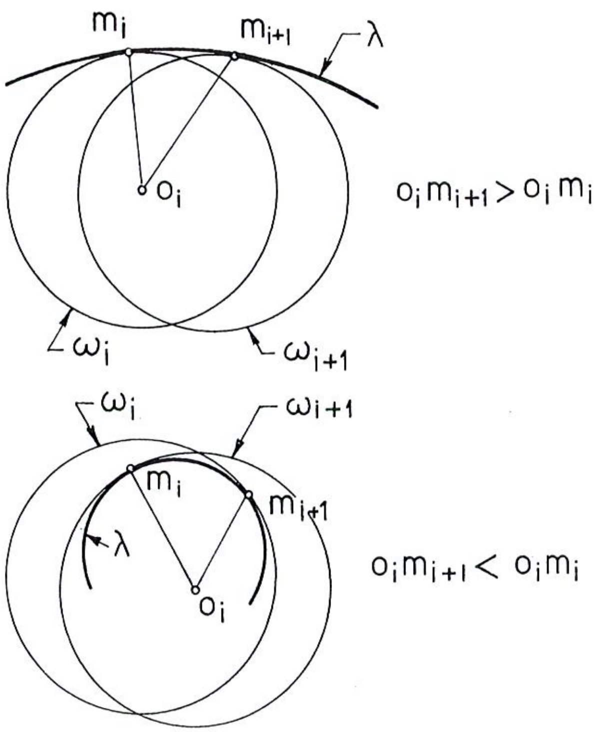


Figure 4

In Figure 4, let

ω_i and ω_{i+1} be the projections of two adjacent curves (or the outlines of two adjacent surfaces) generating

λ - the envelope of the family of curves ω

m_i and m_{i+1} - points of tangency of ω_i and ω_{i+1} respectively with λ

o_i - the centre of curvature of ω_i at the point m_i.

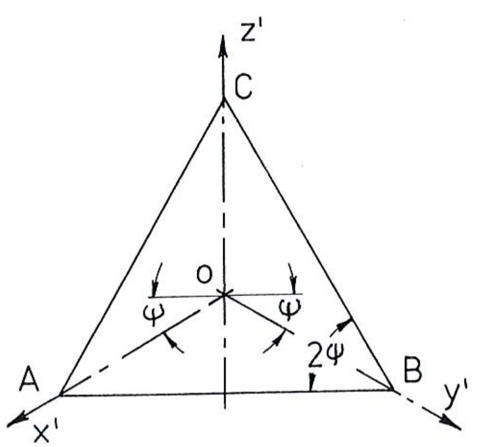


Figure 5

For each consecutive point of the envelope, the distance

$$d = o_i m_{i+1} - o_i m_i$$

is calculated and any point at which d changes its sign is (or is in the vicinity of) a singular point. This test is based on the assumption that the families of curves δ or ω will all lie on one side of each continuous branch of the outline λ.

The test is particularly easy to apply in cases when ω is a family of circles.

VI THE ORTHOGONAL AXONOMETRIC TRANSFORMATION

In axonometric projection, a Cartesian system of axes xyz in space is represented as three concurrent lines ox', oy', oz' with the respective foreshortenings along them $p = \frac{ox'}{ox}$, $q = \frac{oy'}{oy}$, $s = \frac{oz'}{oz}$. Since trimetric projection ($p \neq q \neq s$) is rarely used in engineering drawings, we consider here the more common particular case of dimetric projection with $\angle x'oz' = \angle y'oz' = \frac{\pi}{2} + \psi$ and $p=q=1$ (Fig. 6).

For an arbitrarily selected value of s, the angle ψ may be found using Weissbach's theorem:

> 'Axonometric axes are bisectors of the angles of a triangle whose sides are proportional to the squares of the foreshortenings' [1].

Let, in Fig. 5, $AB:AC:BC = s^2:1:1$. Then from Δ ABC, $\cos\angle ABC = \cos 2\psi = \frac{AB}{2BC} = \frac{s^2}{2}$,

$$\psi = 0.5 \arccos\frac{s^2}{2} \qquad (2)$$

From Fig. 6, the co-ordinates X and Y of the dimetric projection m of a point M(x,y,z) in space are

$$\left.\begin{aligned} X &= (y-x)\cos\psi \\ Y &= sz-(y+x)\sin\psi \end{aligned}\right\} \qquad (3)$$

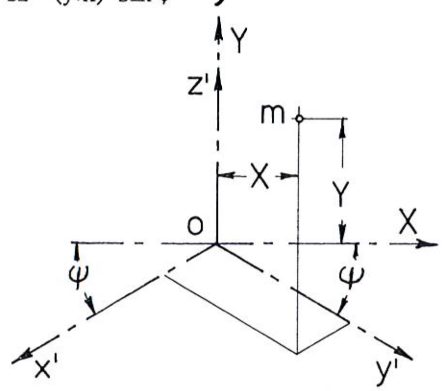


Figure 6

VII EXAMPLES

1. Dimetric Outlines of a Helical Spring

The surface of a helical spring may be generated by a family of spheres of a constant radius r (Fig. 7) whose centres are points of a helix with radius R and pitch t. The parametric equations of the helix are:

$$\left.\begin{aligned} x &= R\cos\alpha \\ y &= R\sin\alpha \\ z &= \frac{t\,\alpha}{2\,\pi} \end{aligned}\right\} \qquad (4)$$

Using equations (3) and (4), the parametric equations of the dimetric projection of the helix are:

$$\left.\begin{aligned} X_c &= R(\sin\alpha - \cos\alpha)\cos\psi \\ Y_c &= \frac{st\,\alpha}{2\,\pi} - R(\sin\alpha + \cos\alpha)\sin\psi \end{aligned}\right\} \quad (5)$$

The dimetric outline of the surface of the spring belongs to an envelope of a family of circles.

$$f(X,Y,\alpha) = (X-X_c)^2 + (Y-Y_c)^2 - r_a{}^2 = 0\ ,$$

where $r_a = r\sqrt{\frac{s+2}{2}}$ is the radius of the circles; the enlargement factor $\sqrt{\frac{s+2}{2}}$ results from the assumption p=q=1.

Solving equations (1) for X and Y, we have

$$\left.\begin{aligned} X &= X_c \pm Ar\,\frac{\partial Y_c}{\partial\alpha} \\ Y &= Y_c \mp Ar\,\frac{\partial X_c}{\partial\alpha} \end{aligned}\right\} \qquad (6)$$

where

$$\frac{\partial X_c}{\partial\alpha} = R(\cos\alpha + \sin\alpha)\cos\psi$$

$$\frac{\partial Y_c}{\partial\alpha} = \frac{st}{2} + R(\sin\alpha - \cos\alpha)\sin\psi$$

$$A = \sqrt{\frac{s+2}{2\left[\left(\frac{\partial X_c}{\partial\alpha}\right)^2 + \left(\frac{\partial Y_c}{\partial\alpha}\right)^2\right]}}$$

A necessary condition for a point m_i of the envelope to be also a point of the outline of the helical surface is:

$$(X_{i+1} - X_c)^2 + (Y_{i+1} - Y_c)^2 \geq r_a$$

where X_i, Y_i and X_{i+1}, Y_{i+1} are co-ordinates of two adjacent points m_i and m_{i+1} respectively calculated from equations (6).

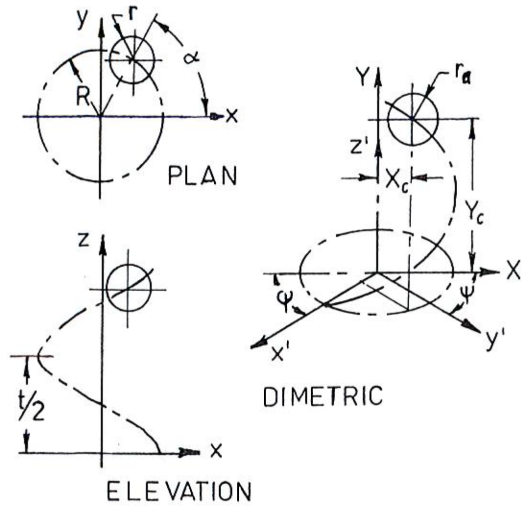


Figure 7

2. Dimetric Outline of a Torus:

To illustrate the use of Theorem 1, the surface of the torus is regarded here as generated by a family of circles of variable radius (Figure 8).

$$\left.\begin{aligned} x^2 + y^2 &= (R + r\cos\alpha)^2 \\ z &= r\sin\alpha \end{aligned}\right\} \qquad (7)$$

From equations (1), (3) and (8), the equation of the dimetric projection of the family of the circles is:

$$f(x,Y,\alpha) = (s\cdot r\cdot\sin\alpha - Y)^2 + X^2\tan^2\psi - 2(R + r\cos\alpha)\sin^2\psi = 0$$

and the dimetric outline of the torus belongs to the envelope

$$\left.\begin{aligned} X &= \pm (R + r\cos\alpha)\cos\psi\sqrt{2\left(1 - \frac{2}{s^2}\sin^2\alpha\tan^2\alpha\right)} \\ Y &= r\cdot s\cdot\sin\alpha + \frac{2}{s}\sin^2\psi\tan\alpha\,(r\cdot\cos\alpha + R) \end{aligned}\right\} \quad (8)$$

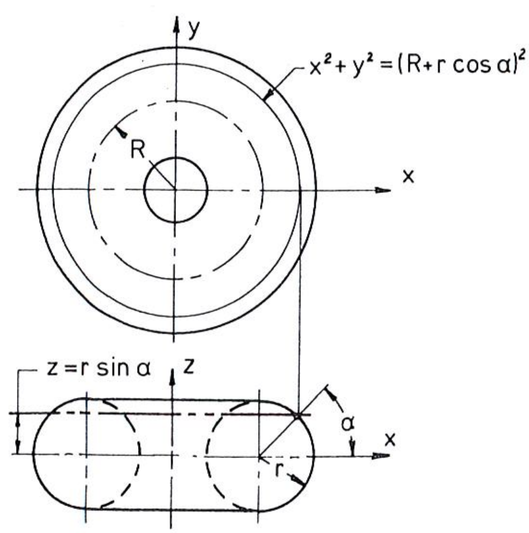


Figure 8

To find the singular points of the envelope, we differentiate equations (8) with respect to and equate the result to zero:

$$\frac{\partial X}{\partial \alpha} = \frac{\partial Y}{\partial \alpha} = 0$$

This leads to

$$\alpha_s = \arccos \sqrt[3]{\frac{-R(2-s)^2}{r(2+s)^2}}$$

where α_s is the value of the parameter for which equations (8) yield the coordinates of the singular points. Inspection (visual or mental) of the envelope is needed to decide which arcs between the singular points should be erased.

FORTRAN programs were set for plotting the equations (6) and (8) and the outputs obtained on an IBM 1627 plotter are shown in Figures 9 and 10. The programs were then corrected to erase the hidden outlines and arcs of the envelopes which do not belong to the outlines (Figures 11 and 12).

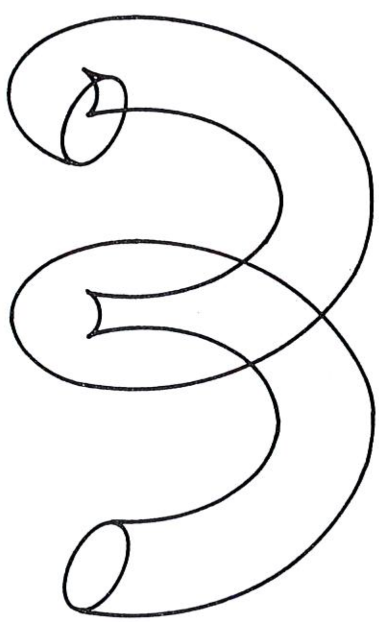


Figure 9

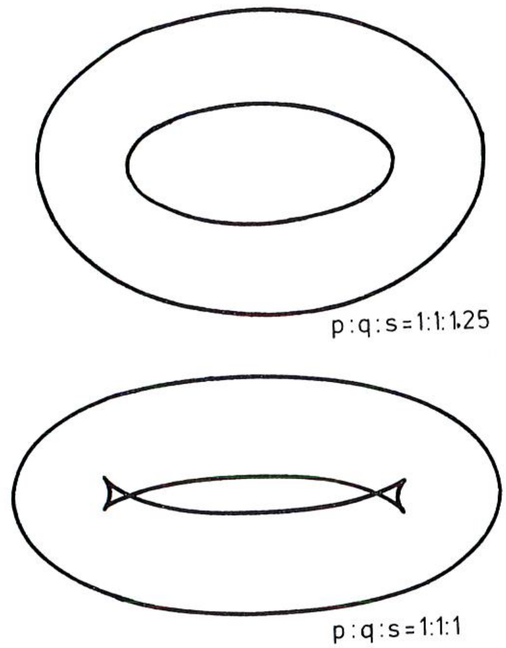


Figure 10

VIII CONCLUSIONS

The envelope method described in this paper may be used to obtain computer drawn outlines of curved surfaces if the equations of the family of generating curves (or the equations of the outlines of generating surfaces) are known. The method is illustrated

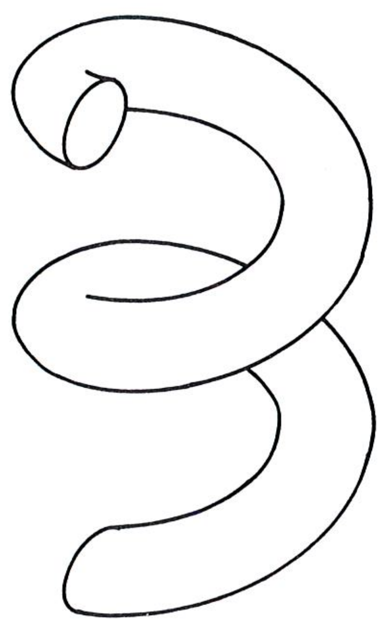


Figure 11

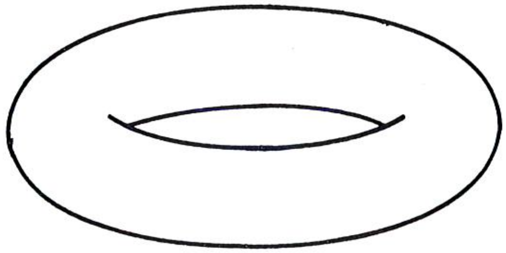


Figure 12

by orthogonal axonometric constructions only, though, it may also be used in other systems of projection. The method permits 'rotation' of surfaces, i.e., the same computer program may be used for drawing views of the surface in different directions. Theorem 2 (Section IV) is particularly useful for construction of outlines of surfaces that may be generated by a family of spheres ('canal surfaces'). In orthogonal axonometry, outlines of such surfaces may be obtained as envelopes of families of circles. Though a general method for identifying points of the envelope which do not belong to the outline, is not known to the author, some useful hints are given in Section V.

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[2] A.I. Dobryakov, Kurs nachertatelnoi geometrii, State Publishing House for Building and Architectural Literature, Moscow, 1952 (in Russian).

[3] N.A. Popov, Kurs nachertatelnoi geometrii, OGIZ, Moscow, 1947 (in Russian).

ACKNOWLEDGEMENT

The author expresses his deepest gratitude to Dr.C. J. Pengilley for the valuable assistance in preparation of this paper.

LETTERS

To the Editor:

Dr. M. Boleslavski made some recommendations in the Fall 1976 issue of the Journal that would do engineering education much good. Many of us feel that the theoretical has replaced too much of the practical.

May I ask, though, that Item 4 (topography, perspective, shades and shadows) be considered more affirmatively for engineers? Instead of saying that parts of it are intended for architects, why not say it is useful to Civil Engineers? Items 5 and 7 are also important to C.E.'s, even if they do lay out their curves in the field instead of in a machine shop.

-W.G.G. (Bill) Blakney
Technical Services
Auburn University
Auburn, Alabama

PUZZLE CORNER

Given the H & F views of two oblique, skew lines of nonsymmetric orientation and different lengths.

Develop a method for finding the orthographic view in which the projected images of the two lines will be equal in length. There are at least three ways to solve this problem.

Send your formal solution to the editor for the fall issue. The published solution will be selected by a panel on the basis of neatness, date received, and clarity of explanation.

Do you have a thought-provoking problem or puzzle? Would you like to chair a "puzzle corner" committee? If so, write to the editor expressing your interest.

WLADAVER*

INTERNATIONAL CONFERENCE ON DESCRIPTIVE GEOMETRY

A Dissent and A Suggestion

Irwin Wladaver
Associate Professor Emeritus
New York University

Well, not really a dissent; let's say my prejudice is showing and always does when four-dimensional descriptive geometry rears its ghostly head, although how you can rear a head is a tale yet to be told.

I was lucky enough to be invited by Professor Steve Slaby to attend a seminar on 4-D (let's call it) given by Dr. Louisa Buonfiglioli at Princeton University in 1965. And I was lucky enough to get my wife to come along to pay the tolls on the George Washington Bridge and on the New Jersey Turnpike (the total amount exceeding my regular allowance).

The tremendous stature of the speaker of the afternoon--she was less than five feet tall, about 1.524 meters -- impressed me beyond description. But as she talked and sketched her way on the blackboard, I slunk lower and lower in my seat. Sneakily I looked around the room; everybody else seemed transfixed and intensely involved. Me, I was only fixed. Then finally, at the end of the presentation, I spoke to the lady in my impeccable Italian, her native language, and to my dismay she didn't understand a word I said. That evened the score. Bewildered as I was, I started to drive home until my wife stopped me and explained, "New York is THAT way, not THIS way."

Some time later I got another invitation from Steve to sit in on another 4-D session to be given by C. Ernesto Lindgren, who eventually became a good friend. At the end of Lindgren's presentation, Steve turned toward me and asked, "Well, Vlad, do you believe now?" Still stunned by Ernie Lindgren's brilliance and shamed by the exposure of my ignorance, all I could manage to reply was that "once you accept a person's assumptions you must accept his conclusions if he has developed his topic in unassailable logic". But since I do not accept Lindgren's assumptions, I cannot accept his conclusions. I do not believe that a person living in three dimensions can possible visualize four dimensions. Lindgren took me off the hook by generously saying, "Of course the gentleman cannot agree with the results if he does not accept the postulates". A few years later, when Lindgren knew me better, he questioned in an article in the JOURNAL whether I knew the color of Napoleon's white horse. I think he was just horsing around. I rather hope so.

Descriptive geometry is an engineering subject. Engineering is an art, not a science. What we say or hear about 4-D is worthless to us for any purpose that I can conjure up in our study or our teaching in respect to our work. If we were pure (or even impure) scientists, we could study anything that we could afford without worrying about practical uses. But I say again that it is utter nonsense to try to visualize four-dimensional space. Ask a fish, a smart fish, to think what it would be like for him, having swum up, down, and around, to try swimming at a higher level, namely, above the water in what would be for him a fourth dimension. Unthinkable.

On the other hand, teaching calculus often requires teaching some solid analytic (3-D) geometry, which is the symbolic equivalent of the graphical descriptive (3-D) geometry. I taught solid analytics and calculus for many years and always took time to make the easy extension to four, five, and so on to "n" dimensions. You must realize that these "dimensions" are, however, variables rather than anything resembling space measurements. But descriptive geometry is, by definition, three-dimensional; any attempt to go beyond three is futile.

What, then, should we be doing in descriptive geometry conferences or in the solitude of our own studies? We are about to sponsor an international conference. I suggest two items for consideration:

First, why not show how descriptive geometry is dealt with in other countries, especially in those countries that are our neighbors, Mexico and Canada? South Vietnam, not exactly a neighbor, used the system at least partially used in Mexico and Canada. How many of us have ever heard of géométrie cotée? Who of us knows the "classical," Mongean system? It was in practice at my School until 1949. Anyway, how can a conference be considered "international" if no consideration is given to practices in other nations, especially Canada? The Canadians know our system; why don't we know theirs? There must be some light at the end of the Vietnamese tunnel.

Second, why not show the dependence of descriptive geometry on another subject? All of descriptive geometry is a single, special case of projective geometry. Take the "station point" of projective geometry back to infinity and, voilá!, you have descriptive geometry. Surprised? I was.

How can we avoid some illustration of the three best known systems, including the modern, "direct" method, géométrie cotée, and the Mongean system? I think we should have some of the elements of projective geometry; the simpler the better. Have your 4-D if you want it, but don't neglect the essentials.

* Special treatment accorded special long-time distinguished members on a completely arbitrary and capricious basis, vaguely associated with the recipient being a wonderful character possessing great character. Everyone who knows Wlad will agree: he qualifies with honors.

One Career in Engineering Graphics

Boris W. Boguslavsky

Who says a career in engineering design graphics cannot be exciting? One man I know about studied engineering and graphics in the Polytechnic School in Paris, France, applied their principles in Napoleon's campaign against Russia, was captured—through no fault of engineering graphics—by the Russians and—thanks to engineering graphics—was treated by them as an honored guest, then went to the United States and became a professor of engineering in the United States Military Academy, after which he was the chief engineer of the State of Virginia, the president of Jefferson College, one of the founders of the Virginia Military Institute, and the principal of the Richmond Academy.

The man I have briefly described is none other than Claude Crozet. Recently attention has been called to Crozet by an article in the August, 1976, issue of Civil Engineering. This article is reproduced, with permission, on the opposite page.

Claude Crozet was born in 1789 in France, in a village near Lyons, and died in 1864 in the United States, near Richmond. He was what we would call now a civil engineer, but his work combined the sciences which form the basis of work of every engineer: mathematics, mechanics, and graphics. These three are inseparably intertwined in every engineering document. Has anybody seen an engineering report, and engineering textbook, or an engineering design without numbers, equations, pictures, and diagrams?

When Crozet arrived at West Point at the age of 28 he discovered that his students at the Military Academy had no notion of descriptive geometry, that their mathematical background for it was grossly inadequate, and that, to compound his teaching woes, a textbook in descriptive geometry in English did not exist. It may be added parenthetically that descriptive geometry is a science of the graphical use of geometry to solve mathematical problems.

Crozet took the bull by the horns. He first taught his cadets pure mathematics, then followed it with descriptive geometry, and then made the boys combine the two to solve their engineering problems. In his instruction he was one of the first to popularize the use of the blackboard and chalk. And in 1821, scarcely five years out of France, Crozet published the first book on descriptive geometry in the English language.

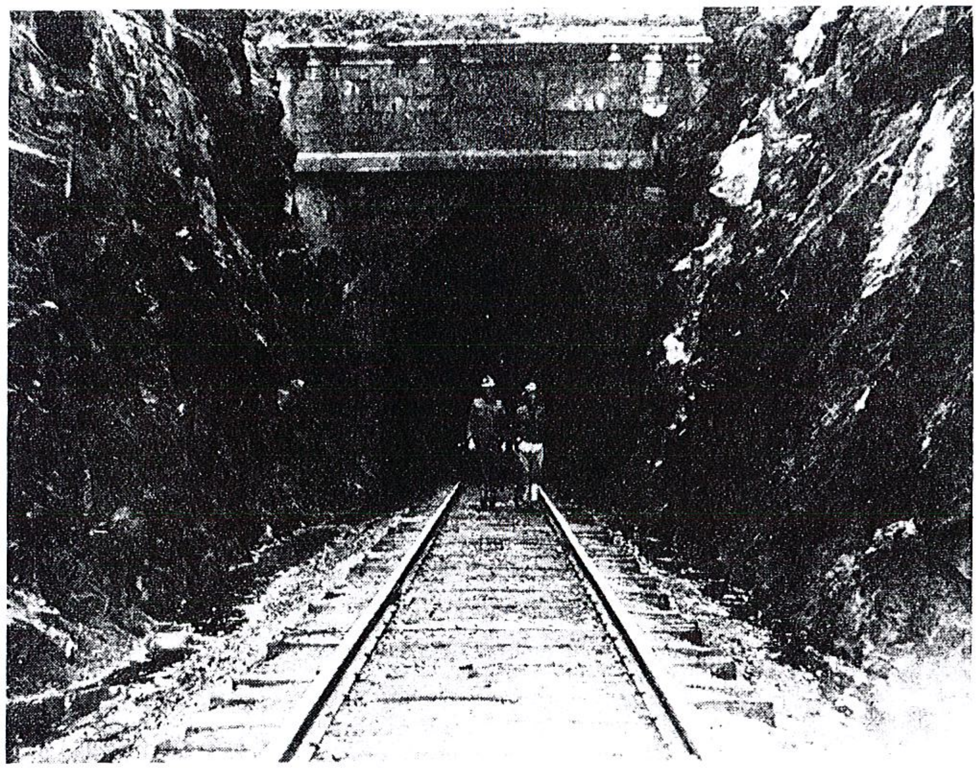
In his lifetime Crozet satisfied his two desires and ambitions: to teach and to do. After West Point, between 1821 and 1859, he was alternately the principal engineer of the State of Virginia, the president of the Jefferson College, and the principal of the Richmond Academy. It is in his capacity as the engineer of Virginia that he developed the state waterways and built its first railroad, including the tunnel described in the reprinted article.

For the details of Claude Crozet's life I am indebted to Dr. Clarence E. Hall, chairman of the Engineering Graphics Department, Louisiana State University. These details—and many more—may be found in Dr. Hall's thesis for the degree of Master of Science (University of Tennessee), "The Historical Development of Multi-View Drawing and Its Role in Engineering Education."

Landmarks attest CE contribution to progress

In this Bicentennial year, it seems particularly appropriate to single out for attention some of the still existing testaments to American technological progress that were the work of civil engineers. Surely numbered among these are the seven recently designated national historic civil engineering landmarks, announced in April by the Society's Board of Direction (see CE, May 1976, page 98).

Following are brief descriptions and photos of some of them. Special ceremonies are being planned at each of the landmarks by those ASCE Sections located in the landmark areas. The latest seven bring to 57 the number of ASCE historic landmarks designated since the program began 10 years ago. In addition, many Sections conduct similar ongoing local programs of their own.



The Crozet Tunnel in Virginia, completed in 1858, was the longest railroad tunnel of its time.

Almost a miracle

Virginia's **Crozet Tunnel,** completed in 1858, represented at that time the culmination of civil engineering technology based on manual drilling methods. At 4,273 ft (1,439 m), this tunnel, sometimes referred to as the Blue Ridge Tunnel, was then the longest railroad tunnel in the U.S. Located at Rockfish Gap, it was designed and built by Claude (Claudius) Crozet, a French-born civil engineer. Through its linkage with the Ohio River Basin and southern ports, it greatly facilitated the development of ocean-borne commerce in the south.

That the Crozet Tunnel ever came into being at all is considered to be something of a miracle. The decade during its construction was one of ridicule and insult for Crozet; people betting large amounts of money that the workmen digging from east to west portals, almost a mile apart on a curved path, would not meet in the middle; newspaper editors declaring that the tunnel was too small to permit the passage of an engine; and would-be engineers predicting the tunnel's imminent collapse.

Crozet, however, forged ahead toward the vision he had promoted 30 years earlier before most people were awakened to the railroad's potential. During a period when tunnelbuilding was no routine matter, Crozet's engineers and workmen steadily and laboriously bored ahead. It was almost a handwork job; Crozet had no high-speed rock drills nor mucking equipment essential to modern tunnel building, and dynamite was yet to be discovered. Added to the problems of tunneling—without benefit of compressed air, mechanical shovels or pumps, dump cars or adequate explosives—were rising costs, unsettled land damages, the financial crisis of 1855, political pressure, construction difficulties (such as excessively hard rock, rock slides), deficiencies of all sorts of materials (including lime, timber and building stone), and the eruption of successive veins of water. Not only did Crozet meet these difficulties with characteristic patience and ingenuity, but also with precision—for when the workers holed through 120 years ago, the two shafts met squarely.

Early in his career, Crozet was a professor at the fledgling U.S. Military Academy at West Point; later, he helped organize the Virginia Military Institute at Lexington. At West Point he initiated the country's first military science course. (To Crozet also goes credit for introducing to America the use of chalk and blackboards.) Later, he worked as principal engineer for the Virginia Board of Public Works. It was in that position that he came to bore the tunnel which bears his name. A bronze plaque will be installed on October 29, 1976 near the tunnel at Natural Bridge, Va.

Ralph S. Paffenbarger
Professor
Engineering Graphics
Ohio State University

A History of the Engineering Design Graphics Division

CHAPTER 3 - THE 1940's

MEMBERSHIP IN SPEE, FEBRUARY 1940 - 3,086

The early 30's being depression years, we noted some enrollment decline, but with the 40's we noticed a markedly increased interest in our Journal of Engineering Drawing and what it stood for. The volume of material increased, content was exceedingly well selected, and it gave the subscribers a chance to keep up with the National picture and how things were progressing even when they could not get to the annual meetings. The war years still had an effect on enrollment, but the day came when students were supplemented by the Engineering Science and Management Training students (ESMT) - in Defense and War effort, to provide personnel for increased production. The shortage of draftsmen was alarming and many departments about the country were taxed to capacity in preparing people for the increased demand. Special courses had to be set up with extra effort on shape and size description, going further into dimensioning and tolerancing than with our engineering day-students. Lack of background in many cases made it very hard to get qualified results. Those who did have the experience in industry were very well qualified, and it was remarkable what percentage of these people actually worked into successful jobs.

For the aircraft industries, many production illustrators were developed. Production illustration courses were not only taught in many schools but in the plants themselves. An engineer with artistic skills made a good production illustrator and teacher. Manuals, completely illustrated, were prepared which enabled workmen to comprehend and direct the intricacies of assembly and repair. Mechanics were able to work from charts, diagrams, and perspective drawings which thoroughly clarified the details of each type of airplane and engine. Whatever their professional and educational background, students of these classes broadened their aspect of a new and exciting industry. They had glimpsed the rapidly shaping future of a new type of engineering drawing born of war necessity, and conditioned by the unceasing demands for mass production of aircraft.

SLIDE RULE :

Many schools taught the use of all scales of the slide rule in connection with their drawing courses where no other related instruction was available during the mid 30's and 40's. This was usually integrated in courses where working drawings were in the outline of instruction. Very little, if any, previous instruction had been received by the student in his secondary education when this was done.

NOMOGRAPHY:

Among the courses in advanced graphics during this period, those in Nomography seemed to be receiving more consideration than others. Early proponents of these courses were: J. Norman Arnold of Purdue University; A. S. Levens of the University of California, Berkeley; and John Rule and Douglas P. Adams of Massachusetts Institute of Technology.

OFFICERS ENGINEERING DRAWING DIVISION
SPEE 1940 - 1946
ASEE 1946 - 1949

	SPEE	SPEE	SPEE
Meeting	U. of California	U. of Michigan	All New York Univ.
Place	Berkeley	Ann Arbor	New York City
Year	1940, June 24-28	1941, June 27-30	1942, June 29-July 2
Chairman	C. V. Mann	R. P. Hoelscher	R. P. Hoelscher
Secretary	H. C. Spencer	W. H. Seegrist	F. H. Heacock
Journal Editor	F. W. Slantz	F. W. Slantz	R. R. Worsencroft

	SPEE	SPEE	SPEE - ASEE
Meeting	Ill. Inst. Tech. & Northwestern	U. of Cincinnati	Washington Univ.
Place	Chicago	Cincinnati	St. Louis
Year	1943, June 18-20	1944, June 25-28	*1945/1946, June 18-28
Chairman	W. E. Farnham	W. E. Farnham	Justus Rising
Secretary	E. F. Tozer	J. Lawrence Hill	R. W. Bockhorst
Journal Editor	R. R. Worsencroft	W. E. Street	W. E. Street

*1945 meeting cancelled by War Comm. on Conventions, Office of Defense Transportation

	ASEE	ASEE	ASEE
Meeting	U. of Minnesota	U. of Texas	Rennselaer P. I.
Place	Minneapolis	Austin	Troy, N. Y.
Year	1947	1948	1949
Chairman	John Rule	F. A. Heacock	H. C. Spencer
Secretary	O. W. Potter	O. W. Potter	O. W. Potter
Journal Editor	T. T. Aakhus	T. T. Aakhus	T. T. Aakhus

NATIONAL SURVEY OF ENGINEERING DRAWING

At the meeting of the Drawing Division at Berkeley, California in June, 1940, Dr. C. V. Mann, Chairman of the Division, proposed that a national survey of engineering drawing be made to determine the facts (a) about the practice of our engineering colleges in regard to the treatment of high school drawing credits; and, (b) about the general quality and method of conducting drawing courses in the colleges themselves, dealing mainly with teachers. This project was carried on during the two years that Randolph P. Hoelscher was Chairman of the Division, and questionnaires went to all ECPD schools, junior colleges, state-supported private and parochial colleges throughout the United States and Canada. These questionnaires covered the following five sections.

1) Origin and purpose
2) Treatment of high school drawing credit by colleges
3) Preparation and experience of drawing teachers
4) Course administration
5) Course content.

The results of the survey were published in full in the November 1942 issue of the Journal of Engineering Drawing.

Briefly, the ECPD schools showed the majority of credit for high school drawing was established through proficiency examinations, as well as for some professional experience.

It was likewise recommended that departments should be well administered, and teachers should have degrees, preferably beyond the bachelor's level, and, in addition, some professional background and experience.

ACCELERATED PROGRAMS

Due to the large and increasing demand for engineering and technical graduates to fill the needs of the war emergency, engineering schools and colleges were encouraged to begin continuous, all-year operation, thus enabling students to finish their normal four-year course in about three years. This was established in many universities, which were either on the quarter or semester plan, in early 1942 and continued many places through 1946. This brought about many irregularities in student participation, as well as programming for repeated course scheduling. About 75% of the students favored this arrangement, but most of the faculty were glad that in most areas it did not go beyond two years. The 1946 increase in enrollment due to the returning veterans imposed more severe difficulties in scheduling and finding suitable staff to handle the overload. Many departments had to double, or even triple the number of their staff to properly handle the additional influx.

AMERICAN STANDARD
DRAWINGS AND DRAFTING ROOM PRACTICE-ASA-Z14-1946

Includes Arrangement of Views, Lines and Line Work, Sectional Views, Screw Thread Representation, Dimensioning, Notes, Trimmed Sizes of Drawing Paper and Cloth Titles and Lettering

PREFACE - 1946 EDITION

This revision of Drawings and Drafting Room Practice has been requested by the many in industry, government, and education who have found the first edition (ASA Z14.1-1935) helpful in standardizing drafting room procedures. A need for this revision has also become evident because of the enormous expansion in the use of the graphic language as a result of war industry, and the development of new techniques which have come into common use.

Accordingly, this revision was authorized in December, 1940, and the problem was studied for over three years. Then a tentative draft was distributed to a large number of interested persons who have generously cooperated with comments and suggestions for betterments. It is believed by the committee in charge, that it now represents a substantial agreement among a representative group of industrialists, government engineers, and teachers.

Acknowledgment should be made to Prof. R.P Hoelscher, and his colleagues, Mr. J.G. Perrin and Capt. C.A. Trexel, for the careful and thorough survey and report they made which formed the basis of the present revision.

The standard as presented herewith was submitted to a representative and diversified group for review and criticism. The editorial revisions, incorporated as a result of these comments, are the work of Prof. F.G. Higbee. The committee responsible for the approval of the standard is listed herewith and was under the chairmanship of Dr. Thos. E. French until his sudden death on November 2, 1944.

It is eminently appropriate to record here that the successful development and completion of this project is due in no small measure to the inspiration and wise leadership of Dean Franklin deR. Furman and Dr. Thos. E. French who served successively as the chairman of Sectional Committee, Z14.

Throughout this standard, reference is frequently made to American standards on machine elements, related matters such as screw threads, pipe threads, tapers, etc. These American standards which represent in each case general agreement on the part of maker, seller, and user groups as to the best current practice, are available. The recommendations contained in this standard also represent general agreement and it is urged, therefore, for the purpose of making the reading and writing of the graphic language approach the ideal of standardization that they be accepted toward the end.

PERSONNEL OF THE SUBCOMMITTEE ON REVISION

F.G. Higbee, Chairman, Prof., Dept. of Engineering Drawing, State University of Iowa
R.P. Hoelscher, Prof. of General Engineering Drawing, University of Illinois
L.W. Hance, Asst. Chief Engr., The Baldwin Locomotive Works, Philadelphia, Pa.
A.S. Levens, Asst. Prof., of Drawing and Descriptive Geometry, University of Minnesota
A.E. Lofberg, Advisory Engr., Westinghouse Electric Corp., East Pittsburgh, Pa.
H.M. McCully, Prof. of Drawing and Geometry, Carnegie Institute of Technology
W.C. Mueller, Manufacturing Engr., Western Electric Company, Chicago, Ill.
J.G. Perrin, Standards Engr., Pratt and Whitney Company, Hartford, Conn.
W.F. Pioch, Head, Tool Designing Dept., Ford Motor Company, Dearborn, Mich.
L.W. Schrader, Head, Design Division, General Engineering Dept., Standard Oil Development Co., Elizabeth, N.J
E.F. Tozer, Prof, and Head of Dept. of Drawing, Northeastern University
C.A. Trexel, Rear Admiral, U.S.N., Alaska Div., Bureau of Yards and Docks, U.S. Navy Dept., Seattle, Wash.

CHANGE IN NAME OF THE SOCIETY: At the annual meeting held at Washington University, St. Louis, Missouri, June 20-23, 1946, the name of the Society for the Promotion of Engineering Education was changed to the American Society for Engineering Education, ASEE.

The third Summer School of the Engineering Drawing Division was held at the time of this meeting. The proceedings of this school was printed in book form, and a copy was distributed to each of the 135 persons attending. It is known as the Proceedings of the Summer School for Drawing Teachers, and was made available by the McGraw-Hill Book Company. A copy may be found in many departments and libraries across the country. The Preface to this 639-page volume, as well as its table of contents, follows.

PREFACE

The Summer School for engineering drawing teachers was organized under the auspices of the Drawing Division of the American Society for Engineering Education. Professor Justus Rising, Chairman of the Division, initiated the program with the approval of the Division and the Council of A.S.E.E. at its annual meeting in June 1944 at Cincinnati, Ohio. The school was originally scheduled for June 1945, but was postponed until June, 1946 because of the war time ban on conventions.

A committee of twenty-two present and past officers of the Drawing Division planned the summer school; Dean A.A. Potter, who secured appropriations from the Society for about one-third of the operating budget; Dean Langsdorf, who made available the facilities of Washington University; Professor Hoelscher of the University of Illinois, Chairman of the Summer School faculty; Professor Bockhorst of Washington University, Secretary for the summer school; the late Professor McCully of Carnegie Institute of Technology, Publicity Director and Editor of the Proceedings.

The school was held concurrently with the annual meeting. The preconvention sessions on Tuesday, June 18, and Wednesday, June 19, were devoted to organizing the school and the presentation of the first major theme, namely- the relationship between engineering drawing as taught in our colleges and its use in industry. The convention sessions were devoted to interdepartmental relationships between the drawing departments and the degree granting departments. The post-convention sessions from Monday, June 24, through Friday, June 28, were devoted to a study of teaching methods, techniques, equipment, etc.

The Chairman of the Faculty was responsible for selecting the speakers and organizing the pre-convention and post-convention sessions while the Chairman of the Drawing Division was responsible for the Convention sessions. Both men are indebted to many members of the Drawing Division for suggestions concerning available speakers.

The program of the Summer School was supplemented by four exhibits: (1) Foreign drawings from twenty countries; (2) Student work from forty-nine schools; (3) Course outlines for one hundred seventy-nine courses; and (4) Visual aids by ten different schools. None of this material can be presented in these proceedings.

The proceedings published herein represent only the papers and discussion and are presented in substantially the same order as given except Section I which consists of Professor Rising's opening paper and addresses made at dinner and luncheon meetings. Section II represents the pre-convention program; Section III the convention papers and Sections IV through XI the post-convention sessions. The appendices consist of committee reports, roster of attendance, and other items of interest.

The publication of these proceedings has been made possible through the generosity of the McGraw-Hill Book Company who assumed all costs of publication without guarantee of sales by the Drawing Division. We hereby acknowledge our indebtedness to them.

In the plan originally set up, the late Prof. Harry M. McCully was designated to edit the manuscript for this publication. This he did in very excellent fashion. Then in the process of manufacturing, somewhere along the line the entire manuscript was lost. Unfortunately, duplicate copies were not available and Professor McCully undertook to reassemble the material and had almost completed the task when he was overtaken by illness which resulted in his death on November 29, 1947. The illustrations, which the publisher had returned to him, could not be located.

At the request of the McGraw-Hill Book Company Professors Justus Rising and R.P. Hoelscher were asked to complete the task.

In finishing this work it was not possible to replace some of the illustrations since originals were used with the first manuscript and they could not be replaced. Professor McCully had also secured many additional photographs which would have added to the inter3st of the present volume. Because of the lack of time no attempt has been made to replace these. Our apologies go to those who supplied personal photographs. In re-editing this work, no attempt has been made to unify the style of the various authors except in minor details. The discussion of the various papers was abbreviated where the remarks were not pertinent to the subject as sometimes happened in long continued discussion of an impromptu character.

The Drawing Division of A.S.E.E. is deeply indebted to Dean A.S. Langsdorf of Washington University who made the school possible by underwriting the expense involved and to Professor R.W. Bockhorst of Washington University who was the secretary of the school and handled the many details necessary for housing the members of the school and providing other facilities for their use.

R.P. Hoelscher
Justus Rising
June, 1949

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The summer school was a huge success. The program thoroughly covered all matters of interest to a teacher of Engineering Drawing and and Descriptive Geometry - from administrative organization and physical equipment to course content and methods of teaching.

Emphasis was given to the necessity of enlarging, beyond the freshman level, the services offered by the Departments of Engineering Drawing. Professor Al Levens gave a technical review of the work done at the University of California, where descriptive geometry proved valuable in the solution of certain problems arising in the design of prosthetic devices. Professor Frank Warner of University of Washington stressed the value of further training in graphics through its application to advanced engineering problems. Professors Douglas Adams and John Rule of Massachusetts Institute of Technology reviewed the application of the graphic medium to nomography and gave a tentative outline of a course of study in graphics covering four years.

VISUAL AIDS.

Teaching Aids have always been very valuable in the presentation of graphics courses. The object in their use is for the student to learn more, remember longer, increase interest, and save time by reducing chalkboard work. Starting with the old lantern slides 3 1/4" x 4", then 2" x 2" and film strips, and more recently, movies, all are known as text film and have been very helpful. Exhibit material when properly used can be extremely helpful. When models are used they are sometimes presented to large classes by projection methods.

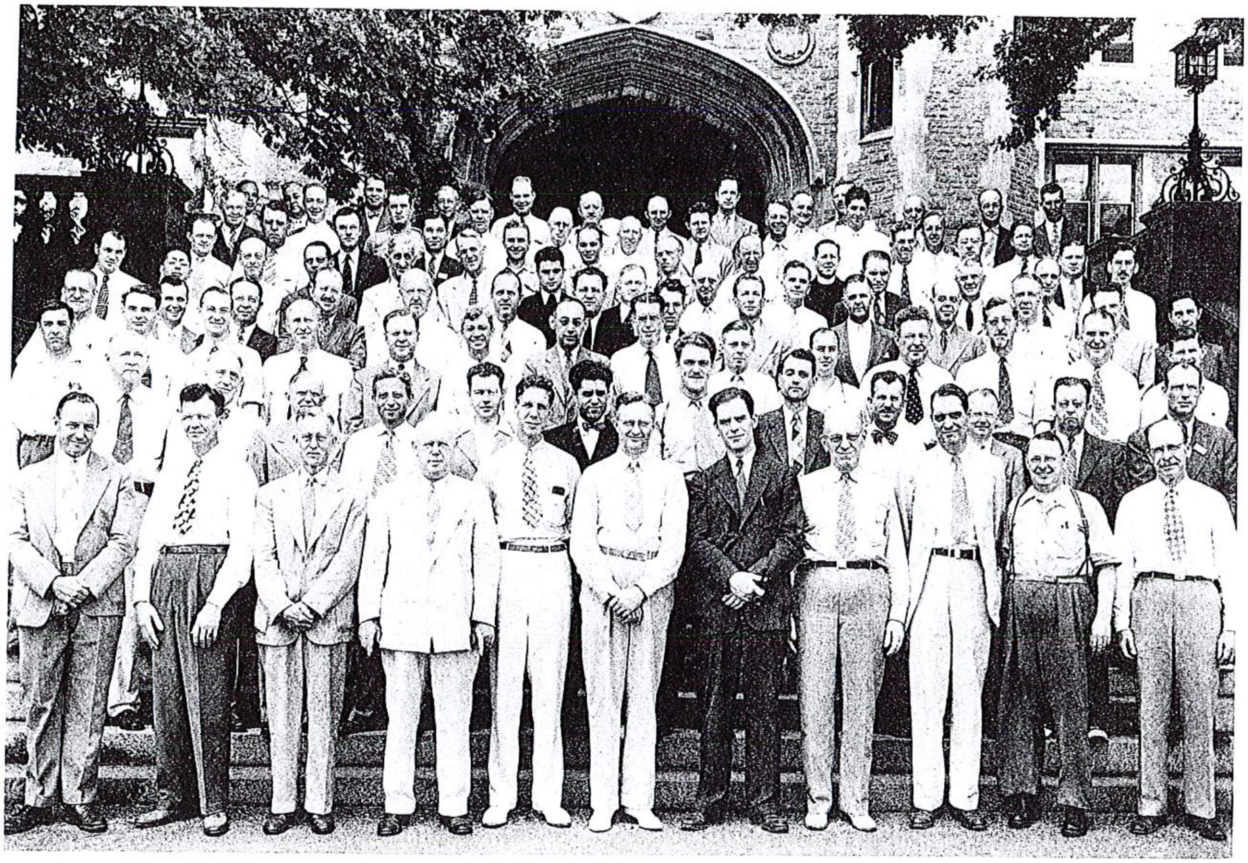
One of the finest collections of models was owned by Professor C. E. Rowe of the University of Texas. Professor Rowe made a hobby of model building, and the results of his efforts were published in a bulletin by the University.

The modern and speedy way of presenting visual material, particularly in step-by-step solutions, is with the overhead projector-using transparent overlays.

MID-WINTER MEETINGS.

The 1940's saw the development of our midwinter meetings. Sectional meetings of the ASEE started earlier, but following our 1946 Summer School we began holding our own Drawing Division gatherings.

The first midwinter meeting of record of the Drawing Division of ASEE was held at the Brooklyn Polytechnic Institute, Brooklyn, New York on Saturday, February 1, 1947. There were



DRAWING DIVISION SUMMER SCHOOL
AMERICAN SOCIETY FOR ENGINEERING EDUCATION
WASHINGTON UNIVERSITY - ST. LOUIS, MO. JUNE 1946

(READ FROM LEFT TO RIGHT)

ROW 1. RUSS, AAKHUS, HIGBEE, McCULLY, HILL, HOELSCHER, BOCKHORST, J. RISING, RULE, NORTHRUP, PAFFENBARGER.

ROW 2. MANN, WARNER, ROWE, GERARDI, LARSON, HRACHOVSKY, MAGNUSON, LOVING, CAMBRE, ADAMS, HOWES, STREET.

ROW 3. BULLEN, PRESTON, VIDETO, RADFORD, STONE, JENKINS, J. S. RISING, N. THOMAS, WORSENCROFT, EUVRARD, LEE, ALLEN, BOERLIN, CHRISTMAN.

ROW 4. WILLEY, OWEN, T. C. BROWN, SPENCER, KENT, JOHNSON, BECKER, LEX, BROCK, HEACOCK, HOWE, WHENMAN, SHOOK, MACHOVINA.

ROW 5. IRWIN, BETTENCOURT, ROBERTSON, VIERCK, HUGHES, A. L. THOMAS, FREDERICK, FENWICK, ORTH, OLSON, DAINES, TURNER, WEBB, BUCK.

ROW 6. RIEBETH, RANSDELL, DEVINE, VOJTA, HEINKE, ENBURG, KNEBLE, GORMAN, VRANA, DIXON, THOMPSON, HALES.

ROW 7. BRATTIN, HEBRANK, SISSON, PALMERLEE, RUSSELL, GRISWOLD, SHIGLEY, BRUNO, SWANNER, H. HARRIS, McGUIRE.

ROW 8. WOOD, POTTER, HOPPE, FULLER, CHAPP, CLEARY, CLEMENT, M. HARRIS, B. L. BROWN, BRAGG, FARNHAM, STEWART, McTYRE.

close to 50 in attendance and Chairman John Rule presided.

The morning session featured a talk by Dr. Otto Klitgord of the Institute of Applied Arts and Sciences in Brooklyn on "The Technical Institute Movement". It was followed by committee reports and a discussion of Engineering Science and Management Defense Training Courses (ESMDT).

The afternoon session featured a paper by Steven A. Coons of the Chance Vought Aircraft Corporation, titled "The Application of Graphical Methods to Aircraft Design".

The theme for the annual meeting at the University of Minnesota in June was chosen as "Emphasis on Graphical Methods and Graphical Research".

ADVANCED CREDITS COMMITTEE.

At the St. Louis meeting a committee was appointed to prepare unit examinations on subjects treated in basic drawing courses. The tests were primarily seen as a means to establish credits in drawing for transfer students or use in testing on a specific subject.

The committee consisted of the following members:

W. M. Christman, University of Wisconsin
Maurice Graney, Purdue University
Randolph Hoelscher, University of Illinois
John M. Russ, University of Iowa
Ralph S. Paffenbarger, Ohio State University

The committee decided on objective tests of multiple choice type. With financial aid from the Measurement and Guidance Project in Engineering Education New York, New York, tests were set up covering the following subjects.

1. Use of Instruments and Applied Geometry
2. Three-View Drawing
3. Reading views (Missing Lines)
4. Sections and Conventions
5. Auxiliary Views
6. Elementary Dimensioning
7. Screw Threads and Threaded Fastenings
8. Advanced Dimensioning
9. Working Drawings
10. Isometric Drawing
11. Oblique Drawing
12. Perspective Drawing
13. Charts, Graphs and Diagrams
14. Intersections
15. Developments

After the validation of these tests they were made available through The Educational Testing Service, Princeton University, Princeton, New Jersey. These were available through the years 1947, 1948 and 1949.

ANNUAL MEETING OF ASEE
MINNEAPOLIS, MINNESOTA - June 17-21, 1947

The Engineering Drawing Division had four very excellent papers presented at their sessions at this meeting. They were:

1. "Analytical Procedure in Aircraft Design" - R. W. Holmes, Curtis-Wright Corp., Columbus, Ohio.

2. "Descriptive Geometry of Crystallography" - H. T. Evans, M. I. T.

3. "Method of Presenting Dimensioning" - Paul Machovina, Ohio State University.

4. "Decimal System-Its use in Aeronautical Industries" - P. J. Hayes Jr., American Air Lines.

Professor Frank Heacock of Princeton University was elected to serve as chairman of the Engineering Drawing Division at this meeting and presided over the mid-winter meeting held during the Holiday season December 27, 1947 in the Horace H. Rackham Foundation Building, Detroit, Michigan.

ASEE ANNUAL MEETING
AUSTIN, TEXAS, June 14-18, 1948

At the annual meeting of ASEE at the University of Texas, the Engineering Drawing Division had a most interesting program with Frank Heacock presiding.

First Session: Joint with Machine Design of Mechanical Engineering Division.

Papers presented:

1. Some Relations between Descriptive Geometry, Mechanics and Mathematics- W. H. Taylor, Univ. of Alabama.

2. Preparing the Beginning Engineering Drawing Student in Drawing for His Later Work in Machine Design - H. N. Tyson, Calif. Inst. of Technology.

3. Standard Parts and Practices - A. W. Luce, Pratt, Institute.

4. Modern Dimensioning Practices - S. B. Elrod, Purdue University.

Second Session: Teaching Clinic on Engineering Drawing and Descriptive Geometry - W. H. McNeill, University of Texas, presiding.

1. Blackboard demonstration of teaching engineering drawing - H. C. Spencer, Ill. Inst. of Technology.

2. Objectives of an Engineering Drawing Course - R. P. Hoelscher, Univ. of Ill.

3. Methods of Stimulating Students Interest in Engineering Drawing and Descriptive Geometry - F. G. Higbee, State Univ. of Iowa.

4. Development of the Students Ability to Think and Analyze in Space - F. M. Warner, University of Washington.

5. Importance and Place of Pictorial Methods in a Course in Engineering Drawing- John Rule, M. I. T.

6. Grading Students Drawing - J. Gerardi, Univ. of Detroit.

7. Preparation of Quizzes and Examinations - R.S. Paffenbarger, Ohio State University.

Third Session:

1. Visual Aids and Models for Engineering Drawing and Descriptive Geometry - C. E. Rowe, University of Texas.

2. An Adaptable Teaching Model for Orthographic Views - P. M. Mason, Texas A&M.

3. A rating Scale for Grading Engineering Drawings - E. G. Kirkpatrick, Purdue Univ.

H. C. Spencer of Illinois Institute of Technology was elected chairman of the Drawing Division for the year 1949.

REVISION OF ASA Z14 STANDARDS FOR DRAWINGS & DRAFTING PRACTICE.

Active work on the reorganization of Sectional Committee ASA Z14, sponsored jointly by the ASME and ASEE got under way at a meeting of the Sectional Committee with forty-four (44) representatives of colleges and industries on March 30, 1948.

It was decided to form an Executive Committee and the following persons were named as well as the officers to direct the activities. They were:

R. F. V. Stanton, American Machine & Foundry Co., Chairman (ASME).

R. P. Hoelscher, Univ. of Ill., Vice Chairman (ASEE).

R. S. Paffenbarger, Ohio State Univ., Secretary (ASEE).

J. M. Barnes, Drafting Division Philadelphia Electric Co. (member at large).

W. A. Bischoff, Standards Engr., Bell Telephone Lab (ASA Telephone Group).

W. A. Siler, Delco-Remy Div., General Motors Corp. (SAE).

H. L. Keller, Mer. Com'l Eng., Ohio Crank Shaft Co. (ASME).

C. A. Ward, Senior Naval Architect, Gibs & Cox, Inc. (Soc. Naval Arch.).

This committee was authorized to extend to industries and National Societies not presently represented. They met monthly and when Mr. Stanton, the chairman, resigned from the committee he was replaced by Clifford Springer of the University of Illinois (ASEE). Randolph Hoelscher was made Chairman, Springer-Vice Chairman, and Paffenbarger - Secretary.

The ASME and ASA changed the designation of the committee to ASA Y14 instead of Z14.

It was decided to publish the eventual revision in separate sections. Upon completion of a section that the individual committee had agreed upon, it was submitted for Sectional Committee approval and then sent to sponsors and ASA. Completed sections were published and sold by the ASME 29 W. 39th St., New York, New York.

In a year's time, or on March 10, 1949, the Executive Committee had set up the following sub-committees.

1. Size and Format
2. Line Conventions, Lettering, and Sectioning.
3. Projections
4. Pictorial Presentation
5. Dimensioning & Placing Tolerances on Drawings
6. Screw Threads
7. Gears, Splines, and Serrations
8. Castings
9. Forgings
10. Metal Stampings
11. Plastics
12. Die Casting
13. Springs - Round and Flat
14. Structural Drafting
15. Air Frames Standard
16. Tool and Gage Drawing
17. Notes

Many of these sub-committees went right to work and in the years time many had their standard submitted for approval. Effort was being made to include unification of the standard to be developed with the British, Canadian, and others.

1949 MEETINGS.

The mid-year meeting of the Division of Engineering Drawing was held at Ohio State University in Columbus, Ohio, January 28-29, 1949. It was held in conjunction with the 75th anniversary celebration of the University.

Professor Fred Higbee of the State University of Iowa gave this lecture on "The History of Drawing" in University Hall auditorium to all freshman engineering students as well as those of our own group the day before our sessions started.

Henry C. Spencer, Chairman of the Division, presided over the meetings which included a business luncheon and banquet with Professor Samuel Renshaw, the speaker on "The Visual Third Dimension".

Others on the program were Col. L. E. Schick, U. S. Military Academy on "Military Graphics"; Harry W. Stertzbach, Engr. Consultant, Buckeye Steel Castings Co. on "Development of Railroad Rolling Stock Specialities"; James A. Flint, Research & Development, Jeffrey Co., on "Development of Conveying and Mining Machinery"; and, Glenn R. Logue, Chief Engr. Bridges, Ohio Highway Dept. on "Trends in the Design of Highway Bridges".

ANNUAL MEETING OF ASEE

RENSSLAER POLYTECHNIC INSTITUTE., TROY,

NEW YORK - JUNE 20-24, 1949.

In addition to the business luncheon and annual banquet, papers presented in various sessions were:

First Session:

1. Ellipse Guides - J. G. McGuire, Texas A&M.

2. Foreign Drafting Practices - T. C. Brown, North Carolina State College.

3. S. A. E. Drafting Standards - J. H. Hunt, General Motors Corp.

4. Y14 Progress Report - R. P. Hoelscher, University of Illinois.

5. General Discussion

Second Session:

1. Visualization - Mary Blade, The Cooper Union.

2. Welding Symbols - Allen C. Craig, General Electric Co.

3. Logic of Multiview Approach in Descriptive Geometry - B. L. Wellman, Wooster Polytechnic Institute.

4. General Discussion

New officers elected at this meeting are as follows:

Chairman - O. W. Potter, University of Minnesota.

Secretary - C. H. Springer, University of Illinois.

Member Exec. Comm. - 5 yrs. - Cerowe University of Texas.

T Square Page - W. J. Luzadder, Purdue University.

Editor of Journal - T. T. Aakhus, University of Nebraska.

Jobs

FACULTY ASSOCIATE OR INSTRUCTOR IN ENGINEERING, 1977-78. Teach courses in engineering drawing and graphics, descriptive geometry, introduction to engineering, and elementary engineering design. Preference given to those admitted to a graduate engineering degree program at ASU. First application deadline May 16, 1977; second deadline July 15, 1977.

Application, three letters of professional reference, resume and transcripts to Dr. George C. Beakley, Director, Engineering Core, Arizona State University, Tempe, AZ (85281). (602)965-3421. Equal Opportunity/Affirmative Action Employer who complies with Title IX of the Educational Amendment of 1972.

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

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

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.

William G. Stinson
Department of Engineering Drawing
Queen's University
Kingston, Canada

USE of the STEREOGRAPHIC NET in structural geology problems involving rotation

As I pointed out in an earlier introductory article on the use of stereographic nets (see pages 20-25, E.D.G. Journal, Winter 1976), such nets when used in structural geology are the stereographic projection of the lower half of a sphere having N-S axes and E-W line lying in the horizontal plane of projection. The spherical surface is represented by its great circle intersection with the plane of projection and by the projections of the lower half of a family of meridian circles established every two degrees and by the projection of the lower half of small circles located every two degrees and lying in planes perpendicular to the N-S axis (like parallels of latitude). See Fig. 1: A Stereographic Net.

Rotation About Horizontal Axes

If we imagine the hemispherical bowl represented by such a stereo-net to be filled with a mating solid hemisphere of clear plastic that is made to rotate about the N-S axis of the 'bowl', every point on the surface of the solid hemisphere will move along or parallel to one of the vertical small circles all of which have their centres on the N-S axis. These small circles project on the stereographic net as circular arcs which divide and are divided by the meridian circles into 2-degree segments.

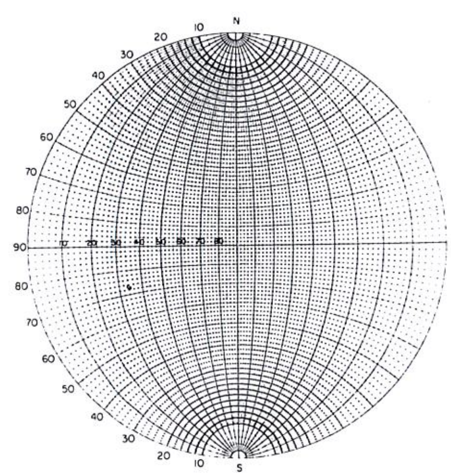


Figure 1: A stereographic net

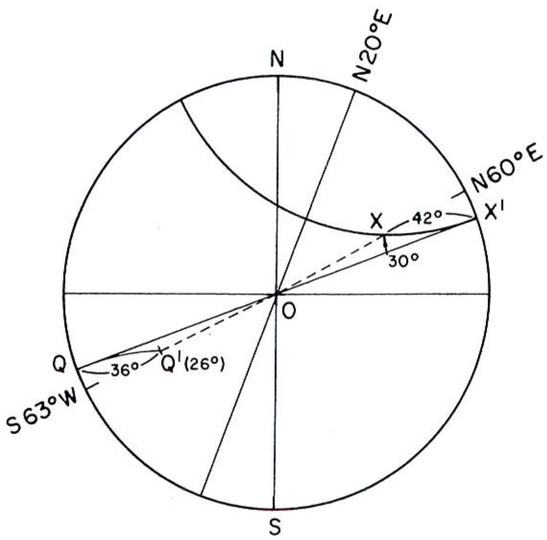


Figure 4: Rotation of a line to a position about the horizontal

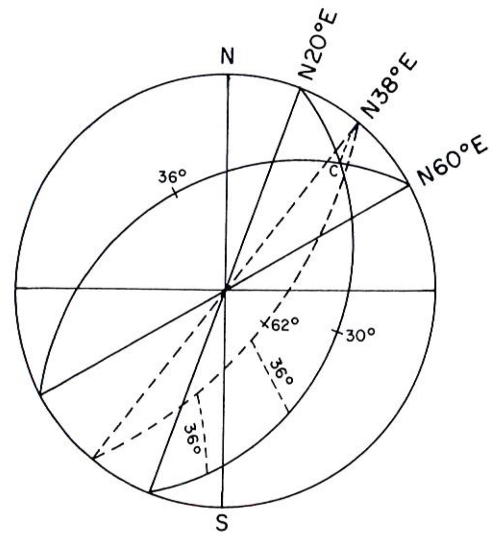


Figure 5: Solution of a 2-tilt problem

Solution

Refer to Fig. 5. On a tracing paper overlay mark the stereonet N-point, and the strike lines and great-circles of intersection of planes having the same strike and dip as the 2 sets of beds. Both sets of beds must be rotated until the younger set are horizontal. This means that the axis for this rotation must be horizontal and bearing N60°E and that the rotation must be 36° clockwise looking N60°E (this reverses the process that tilted the younger beds). This 'reverse tilting' as applied to the older beds would carry every point of the great circle representing them through a similar 36° rotation. This is simplified by performing this rotation for two representative points, finding their new positions, and then establishing the common great circle on which they lie. This immediately gives the strike and dip of the older beds before the second tilting. The operation may be somewhat simplified by taking the intersection point, C , as an additional point. The new position of C automatically establishes one end of the strike line for the previous position of the older beds, and the strike can be determined (N38°E). The great circle may now be readily drawn through the other 2 points and the dip of 62° south-easterly read directly from stereonet.

Rotation About An Inclined Axis

Because of the nature of the stereonet, i. e. the projected small circles are all circles on the surface of the sphere that have their centres on the horizontal N-S axis, it is convenient to arrange the steps in a problem-solution so that rotations are always performed about a horizontal axis. In order to achieve this the solution requiring rotation about an inclined axis will normally involve several rotations and reverse rotations.

In the case of rotations involving planes, a process that would be fairly complicated can be greatly simplified by changing the way a plane is represented. Up to this point we have confined ourselves to defining the attitude or direction of a plane on the stereonet by its great circle intersection with the hemisphere and by its strike (horizontal) lines passing through the centre of the sphere. While this representation is particularly useful for intersection determinations and angular measurements it is cumbersome for solutions involving multiple rotations. The direction of applane may be equally well-defined by the direction of a line perpendicular to it or, more specifically, by the point where the normal to the plane through the centre of the sphere intersects the surface of the sphere. This point, called the pole of the plane adequately defines the direction of the plane and provides a greatly simplified problem-solution, especially when rotation is involved, even though it contributes little to the visualization of the problem details. Normally the position of the pole of the plane is described by the plunge and bearing of the line perpendicular to the plane. See Fig. 6, in which orthographic views of a hemisphere illustrate the relation between the strike and dip of the plane and the location of the pole.

Example 2 may now be solved using polar representations for the planes. We need only to recall that for rotation of an inclined plane to a horizontal position the axis of rotation must be parallel to the horizontal or strike lines of the plane and to realize that when a plane is horizontal the line to its pole is vertical.

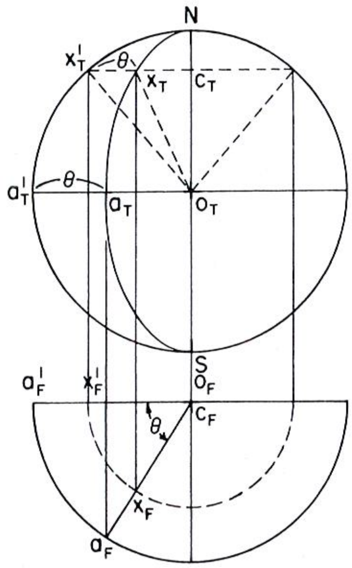


Figure 2: Rotation about N-S axis

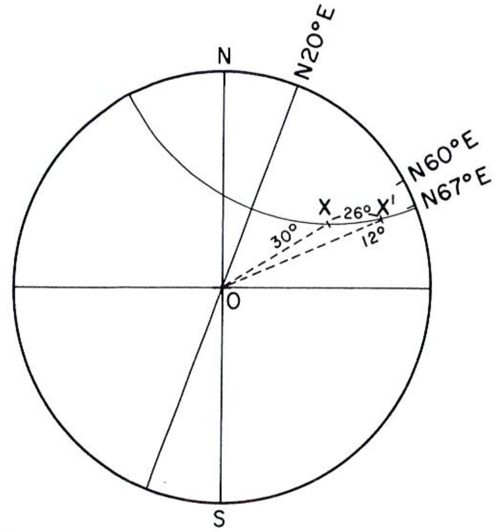


Figure 3: Rotation of a line about a horizontal axis

For example, as shown in the orthographic projections of Fig. 2, a line OX in the solid hemisphere of plastic would be carried about with its end-point X travelling about the vertical small circle having centre C and with the line itself sweeping out the surface of a cone. Note that a plane containing OX and having a N-S strike (i. e. N-S horizontal lines) would be carried about with each point of its great circle intersection with the hemisphere moving along its own small circle arc through an angle equal to the angle of rotation. On the stereonet this angle could be counted out in degrees along any small circle. Fig. 2 illustrates line OX and plane NAS being rotated through θ degrees to positions OX' and NA'S respectively.

If it is required to rotate any configuration about a horizontal axis other than the N-S axis, the north point and the direction of the required axis are marked on an overlay of tracing paper which is then rotated about the vertical axis of the hemisphere until the required axis coincides with the N-S axis of the stereonet. The required rotation is then performed for all components of the configuration, using the small circles of the stereonet. The overlay is then rotated back about the vertical axis to return the North point and specified horizontal axis back to their proper locations and the new positions of the various points, lines, etc. would be clearly established.

Example 1

(a) A line plunging at 30° in a direction N 60°E is rotated about a horizontal axis bearing N 20°E through 26° clockwise (looking N 20°E). What will the new plunge and bearing of the line be?

(b) What will the new plunge and bearing be if the clockwise rotation is 78°?

Solution

(a) Refer to Fig. 3. On a tracing paper overlay mark the N-point of the stereonet, the N 20°E axis, and the line OX plunging at 30° in a direction N 60°E. Then rotate the overlay until the N 20°E axis on the overlay coincides with the N-S axis of the stereonet. The small circle of rotation of X about this axis can now be identified, and the clockwise angle of 26° can be counted out along it to locate the new position of X, X' as shown in Fig. 3. By rotating the overlay until X' lies in the plane of the E-W vertical circle the plunge of OX' can be determined as 12°. By rotating the N-point of the overlay back to the N-point of the stereonet the bearing of OX' can be read off.

(b) Refer to Fig. 4. If the clockwise rotation of OX were increased to a total of 78° then after a 42° rotation OX would be horizontal. In rotating OX the remaining 36° OX would move up out of the hemisphere and beyond the limits of our stereographic net. This remaining rotation can only be handled by using the reverse extension of OX' which I will call OQ and Q must move down into the hemisphere 36° to give position Q', with a plunge of 26° and a bearing of S 63°E.

Example 2

A geological map indicates two sets of dipping sedimentary beds, a younger set dipping at 36° north-westerly and having a strike of N 60°E.

Determine the strike and dip of the older set of beds before the tilting of the younger set occurred.

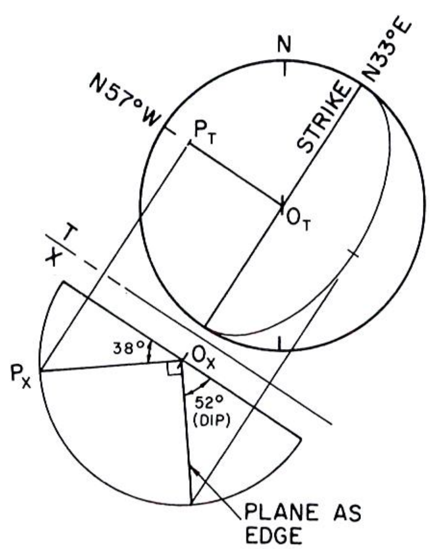


Figure 6: Pole of plane is P

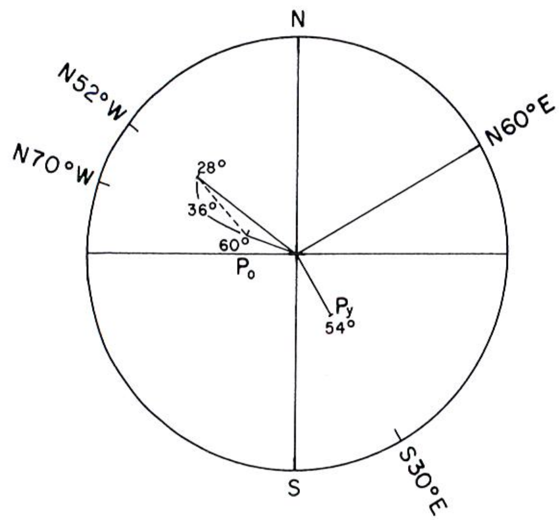


Figure 7: Solution of 2-tilt problem using poles

Refer to Fig. 7. Using an overlay mark on P_y for the younger set of beds using a plunge of 54° and a bearing of S30° and P_o for the older set of beds using a plunge of 60° and a bearing N70°W. To reverse the tilting of the younger beds requires a clockwise (looking N60°E) rotation of 36°. Such a rotation moves P_y directly below the centre and P_o 36° along its small circle to give a new plunge and bearing of 28° N52°W. Converting this polar direction to strike and dip yields a strike of N38°E and a dip of 62° south-easterly, as before.

Example 3

Using an axis of rotation OA which plunges at 24° in a direction S47°W, rotate point P, located at a plunge of 35° in a direction S9°W, through an angle of 40° counterclockwise (looking down along OA).

Solution

Refer to Fig. 8. Mark on a tracing paper overlay the stereonet North point, the bearing of OA (S47°W) and the bearing of OP (S9°W). Rotate the overlay until the S47°W bearing lies above the E-W great circle of the stereonet and locate A at a plunge of 24°. Similarly locate P at a plunge of 36°. Now rotate the overlay until the horizontal axis OB, perpendicular to OA, corresponds with the N-S axis of the stereonet and OA once again lies in the plane of the E-W great circle. Rotate OA up through 24° until it is horizontal and A occupies A' on the rim of the hemisphere. At the same time P must be rotated in the same direction through 24° along its small circle to position P'. Now the overlay must be rotated about the vertical axis of the hemisphere until A' corresponds with N of the stereonet. OP' may now be rotated counter-clockwise about OA' through 40° to position OP'' along the appropriate small circle. All that remains now is to rotate the overlay to make OB coincide with the N-S axis of the stereonet and to place A' in the plane of the vertical E-W great circle and return A' to its original position A at the same time rotating P'' 24° in the same direction to position P'''.

The bearing of OP''' and its plunge may now be read off to give the new position of **P** at a plunge of 55° and a bearing of S26°W.

Rotational Fault Problem

The technique of the previous example may be applied to a problem involving a rotational or picotal fault, i.e. a fault where the rotational or 'scissor' component of the motion is appreciable. In such a case the attitude or orientation of the beds in the displaced block will be changed, or in other words the strike and dip of the beds interrupted by a pivotal fault will be different on the two sides of the fault plane. In addition when two masses or bodies separated by a common plane undergo a relative motion that is rotational the axis of rotation must be perpendicular to the plane of the separation, in this case the fault plane. Refer to Fig. 9.

Example 4

A rotational fault that strikes N10°E and dips 50° easterly cuts through a series of beds having a N83°E strike and a 32° north westerly dip. It is estimated that the hanging wall (upper block) has tilted downward toward the north through 26°. Find the strike and dip of the beds in this block.

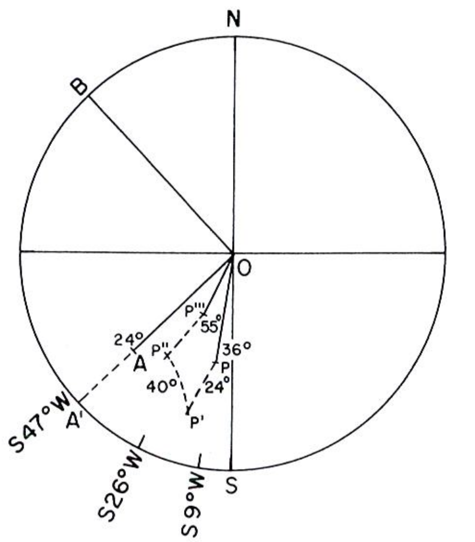


Figure 8: Rotation of a line about an inclined axis

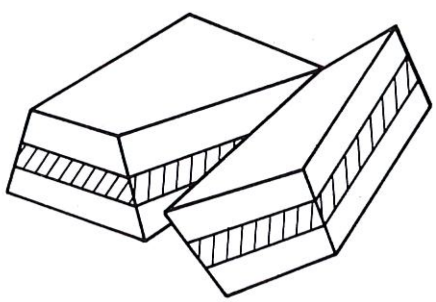


Figure 9: A pivotal fault

<u>Solution</u>

Refer to Fig. 10. The pole of the fault plane P_F is located at a plunge of 40^o in a direction $N80^oW$. The pole of the series of beds is located at a plunge of 58^o in a direction $S7^oE$. When looking down toward the pole of the fault plane and tilting of the upper block could be described as a clockwise rotation.

On a tracing paper overlay mark the N-point of the stereonet, P_F, the pole of the fault plane, and P_B, the pole of the beds. Since the tilting motion is actually a rotation about an axis perpendicular to the fault plane, the line OP_F may be used as the axis of rotation. This inclined line must first be rotated about a horizontal axis, bearing $N10^oE$, through 40^o to the horizontal position OP'_F. Of course pole P_B must be rotated about the same axis through 40^o in the same direction to P'_B so that the relative position of P_F and P_B is not changed.

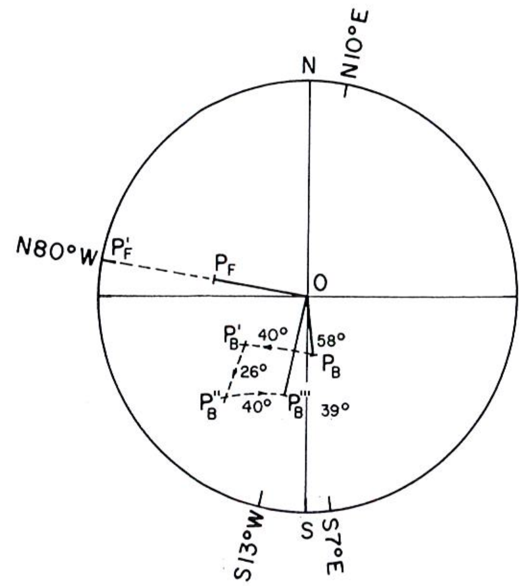


Figure 10: Pivotal fault problem

Then line OP'_F is rotated to coincide with the N-S axis of the stereonet and P'_B, the pole of beds in the upper block may be tilted or rotated clockwise through 26^o to position P''_B. Now all that remains to complete the solution is rotate OP'_F back into the plane of the vertical E-W great circle and reverse the original 40^o rotation to return P_F to its proper position and P_B to its tilted position at P'''_B. The position of the pole of the beds may now be located at a plunge of 39^o in a direction $S13^oW$, and the altitude of the beds described by a strike of $N77^oW$ and a dip of 61^o northerly.

J. Charit
Department of Mathematics
Technion - Israel Institute of Technology
Haifa, Israel

COMPUTER-AIDED DETERMINATION of INTERSECTION LINES for surfaces of revolution having parallel axes

This article presents material which should be of considerable educational value to the readership of the EDG JOURNAL. It describes, through a well-developed example, how the computer can do things normally requiring tedious graphical constructions. The computer handles these details efficiently and accurately.

Wayne C. Dowling
Department of Freshman Engineering
Iowa State University

Machine-part design frequently involves intersecting surfaces of revolution with parallel axes. A method is presented below for computer-aided construction of an intersection line of the latter type, including the determination of visibility.

The basic assumption is that the surface contours are irregular curves, continuous or discontinuous, with or without rectilinear segments.

The procedure consists of three stages:
(1) Scanning of the drawing.
(2) Determination of the intersection line.
(3) Plotting of its projections.

The scanning operation consists of translating the graphical data in the drawing into information suitable for discretized processing with the aid of any digital computer. The so-called "Silhouette" unit used in the present experiments (an optical-electronic device manufactured in the Lithuanian SSR), scans the ordinates of a pair of plotted curves at short intervals and produces perforated-tape information fed directly to the computer.

The procedure is illustrated in Fig. 1. The necessary graphical information is shown in Fig. 2 and is seen to be confined to the pair of contours; the axes are omitted, and only their location and spacing are indicated in the margin. The drawing, on standard-size computer paper is rolled on a drum and presented sidewise to the scanning head, as shown in the magnified section, Fig. 3. Extra-large drawings may be photographed to scale on standard film and scanned with the aid of a special attachment.

The device scans the curves with respect to the lower axis at equal intervals $\underline{u}$, which may range from 0.1 to 1.5 mm. Denoting the readings (ordinates) at abscissa $h_j(=j\cdot u)$ by r_j and Y_j respectively, and the spacing of the axes by G, it is seen from Fig. 3 that the ordinate of a point of the upper curve with respect to the upper axis is $R_j=Y_j-G$.

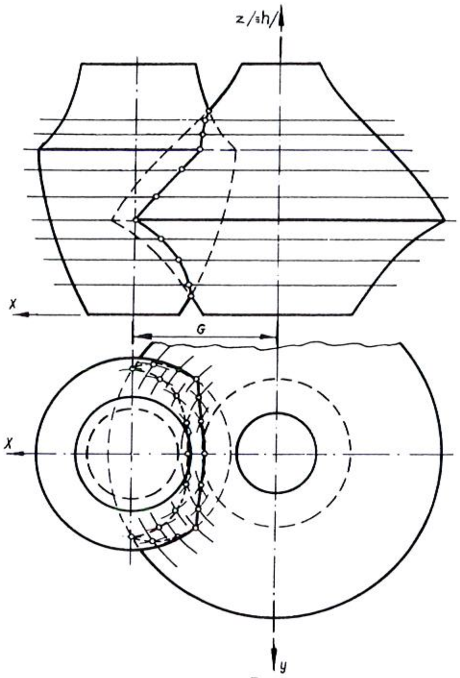


Figure 1

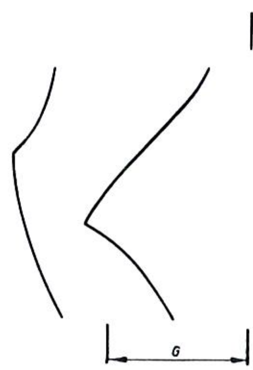


Figure 2

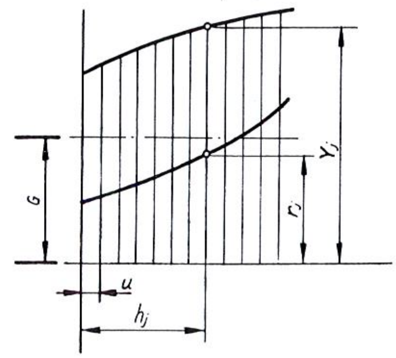


Figure 3

In our example, the intersection line is normally constructed with the aid of auxiliary planes (perpendicular to the axes of revolution), which are chosen on visual considerations in accordance with the configuration involved, and which intersect the surfaces in circles having radii R_j and r_j, determined by the device. The steps are programmed with the aid of an approximation algorithm A_{app}, described in an earlier paper [1] (see Appendix). This algorithm permits judicious subdivision of a curve into a finite number of segments whose deflections relative to their chords lie within a given limit, and also detects discontinuities, if any.

In the problem in question, both surfaces have to be approximated simultaneously, beginning with h_o and concluding with h_m, as follows ($R_o + r_o = R_m + r_m = G$):

(1) Take the first step on curve 1 and determine a possible subdivision point.

(2) Ditto for curve 2.

(3) Compare the abscissae of the resulting points, and take the lesser of the two.

(4) Determine the corresponding R_j and r_j.

(5) Store the three values, which are the initial data for the next step.

The extended algorithm as above is denoted by A'_{app}.

---

[1] J. Charit, "Computer-Aided Construction of the Line of Intersection of Surfaces of Revolution with Arbitrary Generating Contours", Litovskii Mekhanicheskii Sbornik, Vilnius 1968, vol. 2(3). (In Russian).

The points thus found are logical locations for the auxiliary planes. The radii of the corresponding circles of intersection are known, and their common points, determining the desired intersection in Fig. 4, are given by:

$$x = \frac{G^2 + r^2 - R^2}{2G}$$

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

in turn yielding the angles

$$\varphi = \text{arc cos}\,\frac{G-x}{R}$$

$$\partial = -\,\text{arc cos}\,\frac{x}{r}$$

the minus sign indicating that the angles are laid off in opposite directions.

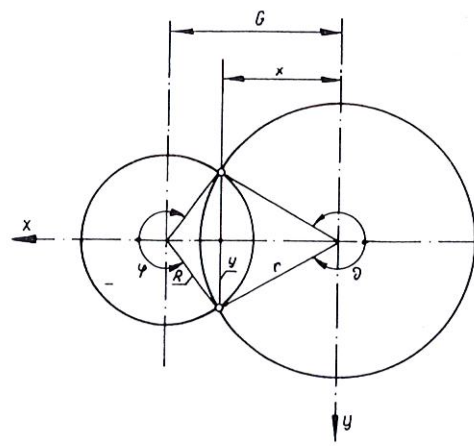


Figure 4

The sequence of steps for determining and ordering the intersection-line data is denoted by A_{int}.

The set of data stored in the memory - three dimensional Cartesian, and cylindrical, coordinates of the sought points with respect to the axes of revolution - may be printed out as follows, the subscripts denoting the serial numbers of the auxiliary planes:

Auxiliary plane No.	Altitude h	H	x	y	R	φ	r	∂

where $H_j = \sum_{j=o}^{j} h_j$

The points are sufficiently close together to be joined in rectilinear segments; where necessary, smoothness can be ensured by means of appropriate subprograms.

The data may be fed directly from the memory to a programmed plotter, thereby achieving complete automatization of the process.

Projective presentation may be effected on the basis of one of the surfaces. The elevation is conveniently plotted as $x=f(H)$, with the two branches coincident and the projection visible. The plan is plotted as $x=f(y)$. Since it is obviously symmetrical, one half of the view suffices.

Visibility in the plan is determined in a reverse sequence (i.e. from h_m to h_0), with each interval between two consecutive auxiliary planes examined as illustrated below.

In our problem, the first interval $(h_m - h_{m-1})$ is visible. The radii are then compared as follows:

(1) If $R_{j-1} > R_j$ and $r_{j-1} \geq r_j$, or $R_{j-1} \geq R_j$ and $r_{j-1} > r_j$, the segment in question is visible.

(2) If $R_{j-1} = R_j$ and $r_{j-1} = r_j$, visibility remains as before (the segment reduces to a point in the projection).

(3) If $R_{j-1} < R_j$ and/or $r_{j-1} < r_j$, the section is hidden.

R_j and/or r_j are characterized as local maxima (R'_{max}, r'_{max}) and all subsequent radii (R_{j-i}, r_{j-i}) are compared with them. So long as at least one of the compared radii is less than its local maximal counterpart, the segments remain hidden. When $R_{j-i} > R_{max}$ or $r_{j-i} > r_{max}$, these radii become the new maxima for comparison (R''_{max}, r''_{max}) and the procedure is continued.

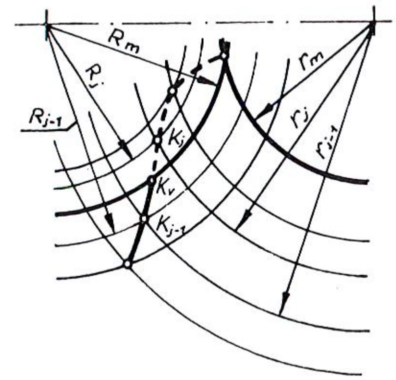


Figure 5

The point of transition from concealment to visibility, K_V, generally falls between two consecutive points (Fig. 5) and is to be included in the set of the intersection line. It is obtainable with sufficient accuracy on the assumption that the three points (K_j, K_v, K_{j-1}) are interrelated as the coorresponding differences of R_j, R^i_{max}, R_{j-1}, or their r-counterparts, as the case may be. Where both radii are operative, the solution is ambiguous (K_v and K'_v), and the sought point is the one nearest the visible end of the segment ($x_{j-1} - x^1_v \to$ min, y^1_v = min). The sequence of steps for determining the visibility is denoted A_v.

In conclusion, the main operations may be summarized in the accompanying block diagram:

SCANNING	$A'_{app} \cdot A_{int}$	$A_v \cdot$ PLOTTING

Appendix

APPROXIMATION OF SURFACE

The given contour or profile of the surface, plotted on a strip of drawing paper or photographed by cinecamera, is scanned by a "Silhouette" unit, with the scanning speed adjusted in accordance with the sought degree of accuracy. An example of an initial contour is shown in Fig. 6 (horizontal straight line - axis of revolution of surface). The output of the "Silhouette", obtained in punched tape for direct feeding to a computer, comprises the ordinates y in intervals u(u=0.1, 0.2, 0.8, 1.4mm, etc.). These ordinates are the radii of revolution of discrete points on the surface, R_i.

The next step is the approximation proper. The contour is subdivided, inaccordance with the desired degree of accuracy, into a finite number of segments, which are replaced by their chords. By this means the surface is approximated by an aggregation of coaxial

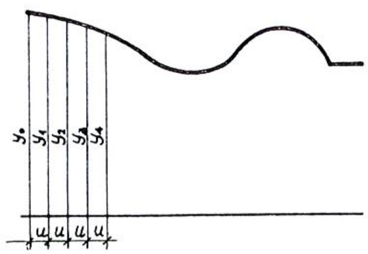


Figure 6

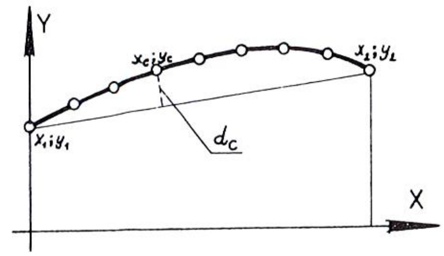


Figure 7

circular cones, cylinders and planar rings. The term "desired degree of accuracy" means the maximum permissible deflection (ξ) of the segment relative to its chord. According to Fig. 7, the equation of the chord is:

$$kx - y + y_1 = 0$$

where

$$k = \frac{y_2 - y_1}{x_2}$$

Denoting

$$\mu = -\frac{1}{\sqrt{k^2+1}}$$

we have for the controlled point (x_c, y_c):

$$d_c = \left| \mu (kx_c - y_c + y_1) \right|$$

On basis of this expression, we construct the approximation algorithm using a variable frame of reference (Fig. 8) in which the x-axis is coincident with or parallel to the axis of revolution and the y-axis slides parallel to itself, passing successively through the endpoints of the chords.

Given n points (1, 2, 3, ... , i-1, i, i+1, . . . , n) on the contour, we consider the section beginning with point i (ordinate R_{j-1}). The procedure is as follows:

(1) Connect point i with point i+t (t=2, 3, . . . n-1).
(2) Calculate the deflections of all intermediate points i+s (s=1, 2, . . . t-1),

$$d_{i+s} = \left| \frac{1}{\sqrt{k_i^2+1}} (k_i\ s \cdot u - y_{i-s} + y_i) \right|$$

where

$$k_i = \frac{y_{i-t} - y_i}{t \cdot u},$$

and compare them with the permissible deflection:

(a) If for all the intermediate points $d_{i+s} < \xi$, then try a longer chord by advancing t by one, thus moving the chord terminal point to the next point along the curve. Repeat steps (1) and (2) for this new chord.

(b) If for at least one of the intermediate points $d_{i+s-} \geq \xi$, then the attempted chord is too long. Proceed to Step 3.

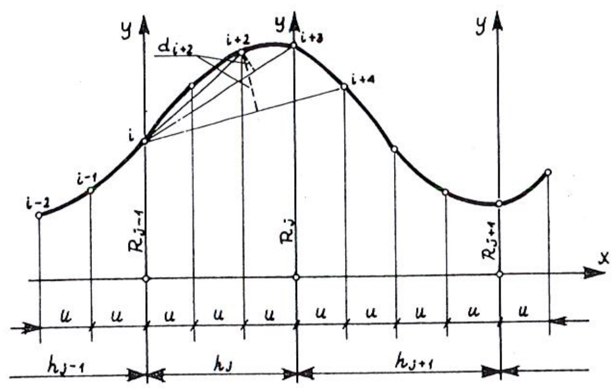


Figure 8

(3) The longest acceptable chord is one increment shorter than the last one attempted. Therefore, replace the section between i and i+t-1 by its chord. The corresponding zone of the surface is thus approximated by a circular cone or cylinder j with altitude $h_j = (t-1) \cdot u$, and base radius $R_j = y_{i+t-1}$.

(4) With i+t-1 as initial point for the next approximated section j+1, repeat the procedure beginning with Step 1.

Thus, m zones are obtained with corresponding h_j and R_j, which are stored in the memory.

ANALYSIS OF PERSPECTIVES

* This is a translation of Chapter IX in F. Hohenberg's Konstruktive Geometric in der Technik ,Springer-Verlag, New York, 1966. The preface of this book was presented in the Spring 1976 issue of the Journal. The present chapter was translated by Mr. Tim Brown, a PhD candidate in the German Dept. at the University of Massachusetts who has a science background. This project was under the supervision of Prof. Klaus E. Kroner of UMass and is being funded by the Journal in the interest of acquainting its readers with some of the theoretical work being done in the graphics area in other countries.

FOREWORD

Hohenberg's book, from which the following was translated, approaches the solutions to descriptive geometry problems from a more theoretical point of view than one is accustomed to in American literature. His explanations of spatial relationships make challenging reading material and are most likely too advanced for the average undergraduate student.

In deciding which portion of the book should be translated, the chapter on perspectives was chosen as probably meeting the broadest interest among the readers of the Journal.

Klaus E. Kroner

Inspection of perspective illustrations.

If one views a perspective picture with one eye from a point O, used as the visual center, then one can gain a correct geometrical impression of the depicted object. Usually, however, one will view the figure with both eyes and , in general , neither eye will be located exactly at O since geometrical divergences result from the natural visual impression. If one considers a line AB in space and its projection A^cB^c from O, then the visual angle $\sphericalangle AOB = \sphericalangle A^cOB^c$ is immediately apparent; its size is dependent on the length and position of AB. In a ladder parallel to the picture plane (Π), the rungs follow in even intervals also in the picture, while the eye perceives the more distant rungs at a smaller angle than the close ones. Even so, it is in proportion to the rungs of a lattice parallel to Π . A facade appears in the front perspective in true shape, whereas the eye perceives window-widths and heights as becoming smaller the further the ray of vision deviates from the main line of sight. A sphere generally does not appear in a perspective figure as a circle, but the visual rays which touch the sphere form a cone of rotation, and artists represent a sphere as a circle. Spheres which are equidistant from Π appear in the perspective figure as larger and more distorted the further they are located from the main line of sight. In the graphic representation of a frontal row of columns, the more distant columns appear as wider parallel bands than the closer ones.

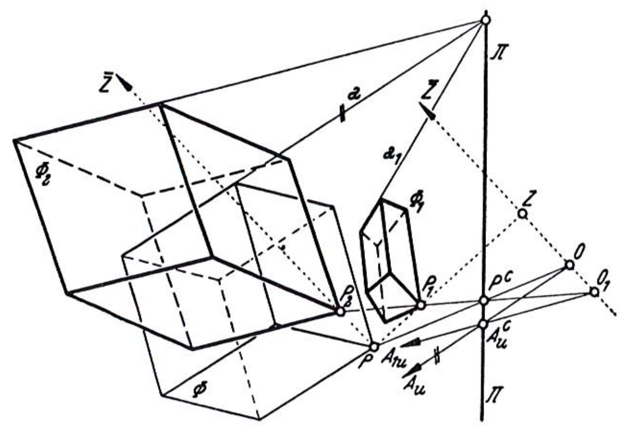


Fig. 1. View from O_1

Photographs are usually viewed from too great a distance; pictures usually hang too high on the wall. What does it mean geometrically, when a perspective figure located in the picture plane is not viewed from the visual center O but from a point O_1 ? Fig. 1 shows a side view. The eye at point O_1 interprets a point P^c in Π as the image of some point P_1 on O_1P^c . What kind of connection exists between the solid figure Φ of the point P and the solid figure Φ of the point P_1 ? In Fig. 1, Φ is assumed to be a cube. In architectural drawings it is justifiable that the drawing a^c of a straight line a from Φ looking from O_1 is interpreted as a figure of a straight line. This line a_1 lies in the plane O_1 a^c . Any line a from Φ corresponds to a line a_1 from Φ_1; it follows then that a spatial collineation exists between Φ and Φ_1. The points of the visual ray O_1P^c correspond to those of the visual ray OP^c, that is to say that each visual ray from O_1 corresponds to one from O. If one assigns the point O to Φ and the point O_1 to Φ_1, then O and O_1 conform to one another in the collineation.

If this is to be a perspective collineation then the center Z must lie on OO_1. The plane of collineation can only be Π since the corresponding visual-rays cut across Π. If one assumes that Z is on OO_1, then the cube depicted in Fig. 1 becomes a hexahedron Φ_1. If one gives Z all possible positions on OO_1 and if one then generates all possible perspective collineations (especially lengthening) on the developing views Φ_1 from the center O_1, then a group of solid views Φ_1 is produced. It can be shown that no other solid figures Φ_1 are imaginable. This ambiguity is reduced if one recognizes the vanishing point in perspective figures, which will always be possible with architectural drawings. If A^c_u is the vanishing point of all lines a parallel to OA^c_u then all a^c, when viewed from O_1, are to be interpreted as images of line a_1 with the direction O_1 A^c_u. If one recognizes in the drawing at least three vanishing points, X^c_u, Y^c_u, Z^c_u, (which do not lie on a single line), then these vanishing points are interpreted, even in the view from O_1, as distant points, namely the distant points of $O_1X^c_u$, $O_1Y^c_u$, $O_1Z^c_u$. The relationship between Φ_1 and Φ becomes an affinity. The center of this affinity (distant point of the affine rays) can only be the distant point $\overline{Z}$ on OO_1. The perspective affine solid figure Φ_2 (Fig. 1) yields to Φ which can still be exposed to all extensions with the center O_1.

Whoever impartially views a picture from too great a distance and recognizes a vanishing point in it, gets the impression of an affinely transformed solid figure. In reality, the original visual impression is quickly corrected because our previous experiences help us to properly interpret the visual impression and to assess the spatial position and size of objects. One can recognize how far such influences permeate for if one continually wears "reverse glasses" which exchange up and down on the retina, everything looks "normal" again after a few days.

Curved Perspectives.

If one views a larger facade from the front, then the horizontal lines both left and right seem to lean towards the horizon. The vertical lines seem to run together from above and below. That follows, as we have seen, from the reduction in size of the visual angle. In the attempt to express this graphically many different methods have been suggested which are supposed to replace the perspective with a better representation. One can imagine that the visual rays which come out from O are intersected by a "Visual sphere", χ, whose center lies at O and further that in some way this sphere is projected on the picture plane Π. We call the generated figure a curved perspective since solid lines were generally represented by curves in the suggested methods and these turn their concave sides towards the main point in Π. By means of the points of a line in space the lines of sight cut χ so as to form the locus of a great circle whose length is proportional to the sight angle under which the line from O appears. If one then wants to reproduce the sight angle as realistically as possible in Π, then the task arises to reproduce χ as exactly as possible on Π.[1] Distortions in it are unavoidable since a sphere cannot be congruently developed on a plane.

The same problem, that is to say the projection of the spheroid globe or a part of the globe on to a flat map, is to be found in every attempt at map making---with a difference: the map depicts the globe as seen from without but the curved projection depicts the visual sphere as seen from inside, like a stellar map. If one holds onto the usual perspective of mapmaking where all spatial points to include the points of χ, are projected from O onto Π, one attains a gnomic projection. While O and the perspective picture lie on the same side of Π, the gnomic map lies on the other side.

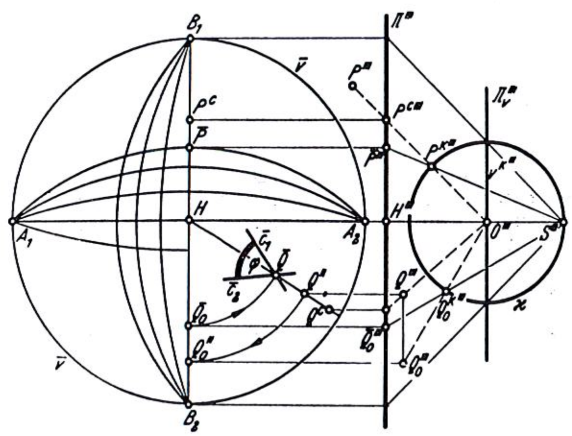


Fig. 2. Stereographic Perspective

One example of a curved perspective is the "stereographic perspective". S would be that point on χ which is most distant from Π (Fig. 2, right side elevation). A point in space P is projected from O towards χ at point P^k, then P^k is projected from S towards Π at point $\overline{P}$. $\overline{P}$ is called the "picture point" of P. In Fig. 2, P lies in the profile plane. Another point in space Q, given through the vertical projection Q'' on Π and profile Q, is first turned in the profile plane towards Q_o. From Q_o comes $\overline{Q}_o$ and through reverse rotation it determines $\overline{Q}$. For every point R on the vanishing plane Π_v, $\overline{R}$ lies on the intersecting circle v^k of χ with Π_v. $\overline{R}$ lies on the circle $\overline{v}$ = (H; HS). Within this circle lie the "picture points" of all points in space which lie in the profile left of Π_v. In contrast, the usual perspective pictures of these points fill the entire plane Π. The projection of χ from S to Π is a stereographic projection.[2] It possesses interesting characteristics (Fig. 3). A circle c_1^k on χ which goes through S appears as an intersecting line c_1 of its plane with Π. If a point P^k moves along c_1^k towards S, then $\overline{P}$ moves along $\overline{c}_1$ towards infinity and the tangent of S to c_1^k is parallel to $\overline{c}_1$. Two circles c_1^k and c_2^k on χ, which intersect in S and a further point of χ, appear therefore as two lines $\overline{c}_1$ and $\overline{c}_2$ through $\overline{Q}$ which enclose the same angle as the tangents in S on c_1^k and c_2^k. However, c_1^k and c_2^k intersect Q^k with the same angle as in S and therefore the angle of intersection φ of c_1^k and c_2^k with Q^k appears in true size as the angle ϕ of $\overline{c}_1$ and $\overline{c}_2$ with Q. Any two curves s_1^k and s_2^k on χ which intersect in Q^k and there touch c_1^k and c_2^k respectively appear subsequently as two curves $\overline{s}_1$ and $\overline{s}_2$ in Π which are touched in $\overline{Q}$ by $\overline{c}_1$ and $\overline{c}_2$ respectively and which intersect in the same angle. If s_1^k and s_2^k are major arcs of χ, then they are projected from O by visual planes and it follows that: In stereographic projections the angle formed by two intersecting visual planes appears in true size.

Let c^k be a circle on χ which does not go through S. χ will be touched by a cone of rotation, the vertex of which is C, along the length of c^k; SC intersects Π in C. In a projection from S on Π the cone-generating elements appear as straight lines through $\overline{C}$. The right angle which is formed by the intersection of c^k and the cone-generating elements appears as a right angle in Π. Therefore, the circle $\overline{c}$ on the picture plane projected from c^k must be intersected at right angles by all lines going through $\overline{C}$, it is then a circle with a center at C. If, for example, a sphere γ can be represented in a stereographic perspective then χ would be intersected by a tangent cone from O on γ like a circle c^k and this appears as circle $\overline{c}$. Therefore, the outline of a sphere in stereographic perspective is a circle.

A great circle g^k on χ is related to a line in space g and appears as circle $\overline{g}$ in stereographic perspective. g^k intersects Π_v in the end points of a diameter of v^k, hence $\overline{g}$ and $\overline{v}$ intersect in the end points of a diameter of $\overline{v}$. χ is touched along the length g^k by a cylinder of rotation. The perpendicular in S directed to O_g intersects Π at the midpoint of $\overline{g}$.

A kind of curved perspective can be seen in every attempt at map making. Artists have often depicted lines as curved (for example,

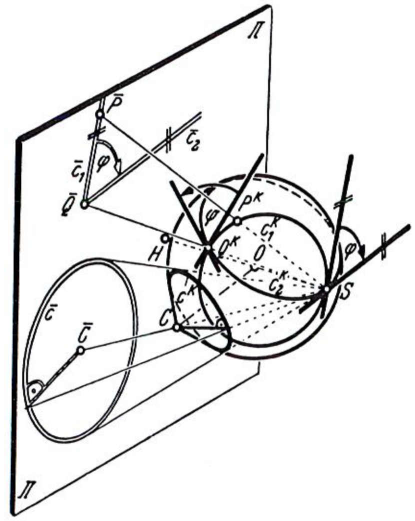


Fig. 3. Stereographic Perspective

A. Dürer, Scheldetor in Antwerp, Albertina in Vienna). One also finds such curves in architecture itself (for example, Parthenon, Athens). However, the need for a change in a perspective drawing is seldom perceived because our eye is just as used to viewing paintings, drawings, and photographs in perspective as East Asians are used to their slanting lines.

Other Graphic Means of Representation.

a) Panorama: The unidirectional view does not suffice for a panoramic view from a single viewing point, but the eye at O must turn from side to side. Then one can intersect the visual rays with a vertical cylinder of rotation whose axis goes through O. Fig. 4 depicts a portion of the cylindrical plane Π. The axis of Π is vertical, and on it lie O and the outline O^1 of O on the horizontal ground-plane Γ. A line OP intersects Π in two points but only that point of intersection which lies on the same side of O as P will be considered as the projection point P^z of P. The ellipse g^x is the figure of a line g in the general case since the plane O_g intersects Π in an ellipse. The panorama can be developed into a long rectangle. One views it segmentally on the cylinder or on the development. Sometimes one also puts together several photographs taken from O at regularly spaced intervals. If these photos are lined up one after another, then the edges must be hidden by hanging tree branches or other irregular forms. If the panorama is taken by means of an "all-round-camera" which turns about a vertical axis, then no edges will appear. In such a picture non-vertical lines appear curved.

b) Planetarium: If the side to side movement of the eye does not suffice to survey the object, then one can transfer it to the inside of a visual sphere around O and view it segmentally from O. For example, the starry sky in a planetarium is depicted in this manner.

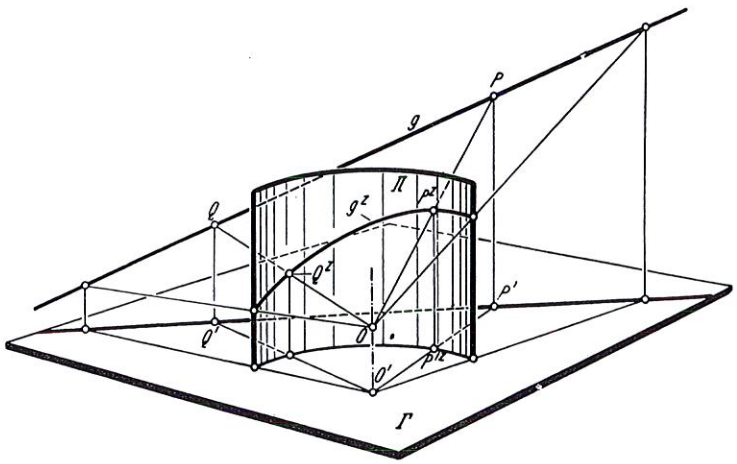


Fig. 4. Panorama

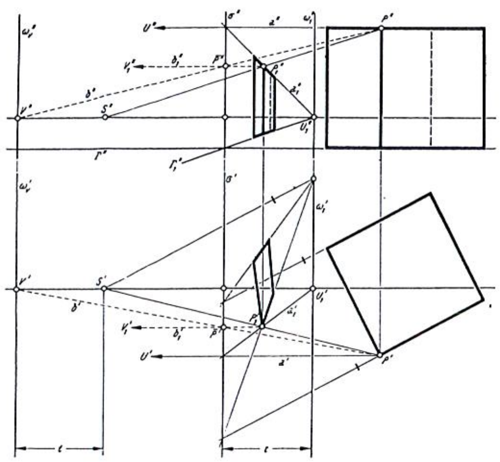


Fig. 5. Relief Perspective

c) Arch and dome painting, scene projection: Here the visual rays are intersected by the surface of a dome or arch. The drawing surface is frequently a cylinder of rotation, elliptical cylinder, or a sphere. The eye is not on the axis of the cylinder or the center of the sphere but rather at the place where it is assumed that the viewer will stand. Painters, especially in the art of the Baroque, have artistically extended columns and other architectural structures into the dome with amazing skill and attained startling effects. On many modern stages, slides are projected by means of one or two projectors, which simulate the background of the stage set on a "curved horizon". Usually the "curved horizon" is a standing elliptical cylinder; sometimes a half-dome is set up for it. The slides must be drawn in such a way that the projected background appears free of distortion when viewed from a central point in the audience. [3]

d) Relief, Theaterperspective: If an object is subjected to a spatial perspective affinity or collineation, then one can conceive of the affinely or collinearly transformed object as a spatial picture of the original object. In Fig. 5 the horizontal and vertical projections are pulled apart so that S' does not coincide with S", likewise V' and V", U' and U" do not coincide. By means of the perspective spatial collineation the horizontal plane Γ is transformed into the plane Γ_1. For each point P_1, which is not on the same side of σ as S, there is a corresponding point P, which lies between the plane of collination σ and the base plane. The width t of the layer between σ and ω_1 is called the depth of relief. Fig. 5 shows the construction of a "Relief"; that is to say the collinear drawing of a cube.

Point $\overline{P}$ is the normal view of the relief point P_1 on the plane σ and at the same time $\overline{P}$ is the orthographic view of the spatial point P from V onto σ. One sees that: The orthographic projection of an object from V onto σ is also the normal view of the relief on σ. Such a relief often has the function of depicting an object of great depth in a space of more limited depth. One finds reliefs on coins and also as decoration on walls, doors, columns, and so forth. One gets the proper impression if one views the relief from the turned center of collineation or respectively from the direction of the affine rays. The distortions of the relief become apparent when viewed from another point and especially when viewed with both eyes. Therefore, free standing human figures in reliefs should not result in full collinear or affine distortion. Sharply illuminated reliefs behave unnaturally (trees throw shadows on mountains) and therefore reliefs are best begun in places without sunlight.

Similar questions arise with stage perspectives. There an effect of great depth is attempted on a stage with limited depth. The side walls converge at the rear and the ceiling is not horizontal but slants down toward the rear.

e) Stereoscropes, Anaglyphs, and Plastic Film: Stereoscopic reproduction was explained earlier. In the stereoscope each eye is presented with its own picture while the other picture is separated by a dividing screen. Anaglyphs attain the same effect by coloring the left picture red and the right picture green. Then a pair of glasses is placed in front of the eyes, and left lens of which is green and the right red. Red light rays come from the red picture, which cannot pass through the green lens and therefore the left eye perceives the left picture as black, similarly the right eye perceives the right picture as black. In a short time the object will be clearly perceived as plastic. [5] Complicated technical and medical objects are presented plastically through stereoscopic photography and anaglyphic pictures. In addition, stereoscopic x-ray photographs as well as stereoscopic photographs taken with electron and optical microscopes are being produced. One can plastically clarify the inner structure of an organism, the assembly of complicated machines, the excavation blue print of a mine survey or etc., by making several stereoscopic photographs with very short exposure times on the same photographic plate and taking away an outer layer of the object after each photograph. The result is a spatial view in which one can see into the inside of the object whose outer parts act as if they were transparent. Such binocular microscope photographs help in the inspection of surfaces and illumination of the minute characteristics of raw materials.

The stereo-comparer and other important geodetic instruments have also developed from the stereoscope.

Plastic film is a similar case. Each eye is offered its own picture and by use of colored glasses each eye only perceives one picture. Another method makes use of polarized light.

As explained earlier, the spatially perceived object experiences a spatial affinity if the eyes are shifted in a parallel manner. If at the same time the viewing distance is changed, but the direction of OO_1 kept constant, then the spatially-viewed object undergoes a spatial collineation. Practically speaking it is important that the spatial impression also remains preserved when the line OO_1 changes its direction (within certain limitations). Since visual rays viewed at related picture points are in general skew, then the spatial impression is no longer to be explained geometrically but is in the physiological and psychological realm. Above all, the old notion that depth perception is solely dependent on biocular vision is not valid. Not only do momentary perceptions function in each visual scene, but also all earlier experiences. The toddler reaches for the moon even though he sees it with both eyes. On the other hand, one-eyed people also need to spatially orient themselves. The same is true for herbivorous animals and for fish, whose eyes are placed on the side of the head and receive from their right and left eyes two completely different optical images.

f) Scaled-down Models: One cannot force the "real" impression which an object causes to appear in a picture, but one can approximate it. A scaled-down model, like one put together by architects to assess the aesthetic effect of a planned structure, has the advantage that the viewer is able to look at the model from different angles. Of course one should also be able to reduce the distance between the viewer's eyes according to the scale of the model. Since this is not possible, then it is suggested to view the scaled-down model from different sides with only one eye which should be brought as close as possible to the model. Models of larger building projects work the best, since for the most part they are viewed from above under similar conditions as with the actual building. The architectural effect of interior spaces cannot be satisfactorily reproduced.

g) Movies of Models: Scaled-down models can be filmed, and through photographic tricks, which make the vision of the proportionately reduced person possible, the film makes the structure appear like the normal size building in which it seems that the viewer can wander around. Excellent pictorial effects can be obtained if the model of the structure and its surroundings is advantageously lighted, and is exact in both form and color; if during filming the camera is handled in such a way that the film reproduces the viewers movements well with respect to space and time; and finally if the film is viewed during its showing from approximately a point in the viewing room which coincides with the optical mid-point of the camera. If one of these conditions is not met, then the impression is just as displeasing as that of an inexpertly drawn perspective. Model films succeed best with meaningful interior spaces, for instance in churches. The field of applications for movies is severely limited by the high cost of model construction and movie production. Model-films have been used for a long time in the presentation of feature films in film studios. Film-photographs of models made in Hollywood are very skillfully blended into feature scenes from all parts of the earth and ages of man.

h) Life-size models (Prototypes) placed at the future location of a monument or building, which are supposed to give the final impression of the aesthetic effect of a project, are only erected in special cases because of high cost.

1. "Analytical Treatment in U. Graf", Jahresbericht der Deutschen Mathematikervereinigun, 50 (1940), 35-53.

2. This was already known to Hipparch as a mapmaking technique. A transverse map is formed in Figure 2 only when the figure is drawn on the backside of Π .

3. cf. U. Graf, Z. angew. Math. Mechan. 18 (1938), 237 and 20 (1940), 50, as well as Z VDI 82 (1938) , 1429.

4. Concerning the construction of reliefs according to Staugil and de la Gournerie cf. E. Müller and E. Kruppa, Lehrbuch der Darstellenden Geometrie, 5th Edition, pp371-76. Viena: Springer, 1948.

5. There are machines which can produce stereoscopic pictures from paired normal outlines. Cf. T. Hildebrandt, Stereobilder zeichende Geräte. Baden-Baden: Verlag für Angewandte Wissenschaften, 1959.

Public Law 94-168
94th Congress, H. R. 8674
December 23, 1975

An Act

To declare a national policy of coordinating the increasing use of the metric system in the United States, and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That this Act may be cited as the "Metric Conversion Act of 1975".

Metric Conversion Act of 1975. 15 USC 205a note.

SEC. 2. The Congress finds as follows:

15 USC 205a.

(1) The United States was an original signatory party to the 1875 Treaty of the Meter (20 Stat. 709), which established the General Conference of Weights and Measures, the International Committee of Weights and Measures and the International Bureau of Weights and Measures.

(2) Although the use of metric measurement standards in the United States has been authorized by law since 1866 (Act of July 28, 1866; 14 Stat. 339), this Nation today is the only industrially developed nation which has not established a national policy of committing itself and taking steps to facilitate conversion to the metric system.

SEC. 3. It is therefore declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States and to establish a United States Metric Board to coordinate the voluntary conversion to the metric system.

15 USC 205b.

SEC. 4. As used in this Act, the term—

Definitions. 15 USC 205c.

(1) "Board" means the United States Metric Board, established under section 5 of this Act;

(2) "engineering standard" means a standard which prescribes (A) a concise set of conditions and requirements that must be satisfied by a material, product, process, procedure, convention, or test method; and (B) the physical, functional, performance and/or conformance characteristics thereof;

(3) "international standard or recommendation" means an engineering standard or recommendation which is (A) formulated and promulgated by an international organization and (B) recommended for adoption by individual nations as a national standard; and

(4) "metric system of measurement" means the International System of Units as established by the General Conference of Weights and Measures in 1960 and as interpreted or modified for the United States by the Secretary of Commerce.

SEC. 5. (a) There is established, in accordance with this section, an independent instrumentality to be known as a United States Metric Board.

United States Metric Board. Establishment. 15 USC 205d.

(b) The Board shall consist of 17 individuals, as follows:

Membership.

(1) the Chairman, a qualified individual who shall be appointed by the President, by and with the advice and consent of the Senate;

(2) sixteen members who shall be appointed by the President, by and with the advice and consent of the Senate, on the following basis—

(A) one to be selected from lists of qualified individuals recommended by engineers and organizations representative of engineering interests;

(B) one to be selected from lists of qualified individuals recommended by scientists, the scientific and technical community, and organizations representative of scientists and technicians;

(C) one to be selected from a list of qualified individuals recommended by the National Association of Manufacturers or its successor;

(D) one to be selected from lists of qualified individuals recommended by the United States Chamber of Commerce, or its successor, retailers, and other commercial organizations;

(E) two to be selected from lists of qualified individuals recommended by the American Federation of Labor and Congress of Industrial organizations or its successor, who are representative of workers directly affected by metric conversion, and by other organizations representing labor;

(F) one to be selected from a list of qualified individuals recommended by the National Governors Conference, the National Council of State Legislatures, and organizations representative of State and local government;

(G) two to be selected from lists of qualified individuals recommended by organizations representative of small business;

(H) one to be selected from lists of qualified individuals representative of the construction industry;

(I) one to be selected from a list of qualified individuals recommended by the National Conference on Weights and Measures and standards making organizations;

(J) one to be selected from lists of qualified individuals recommended by educators, the educational community, and organizations representative of educational interests; and

(K) four at-large members to represent consumers and other interests deemed suitable by the President and who shall be qualified individuals.

Term of office.

As used in this subsection, each "list" shall include the names of at least three individuals for each applicable vacancy. The terms of office of the members of the Board first taking office shall expire as designated by the President at the time of nomination; five at the end of the 2d year; five at the end of the 4th year; and six at the end of the 6th year. The term of office of the Chairman of such Board shall be 6 years. Members, including the Chairman, may be appointed to an additional term of 6 years, in the same manner as the original appointment. Successors to members of such Board shall be appointed in the same manner as the original members and shall have terms of office expiring 6 years from the date of expiration of the terms for which their predecessors were appointed. Any individual appointed to fill a vacancy occurring prior to the expiration of any term of office shall be appointed for the remainder of that term.

Quorum.

Beginning 45 days after the date of incorporation of the Board, six members of such Board shall constitute a quorum for the transaction of any function of the Board.

(c) Unless otherwise provided by the Congress, the Board shall have no compulsory powers.

(d) The Board shall cease to exist when the Congress, by law, determines that its mission has been accomplished.

Policy implementation. 15 USC 205e.

SEC. 6. It shall be the function of the Board to devise and carry out a broad program of planning, coordination, and public education, consistent with other national policy and interests, with the aim of implementing the policy set forth in this Act. In carrying out this program, the Board shall—

(1) consult with and take into account the interests, views, and conversion costs of United States commerce and industry, including small business; science; engineering; labor; education; consumers; government agencies at the Federal, State, and local level; nationally recognized standards developing and coordinating organizations; metric conversion planning and coordinating groups; and such other individuals or groups as are considered appropriate by the Board to the carrying out of the purposes of this Act. The Board shall take into account activities underway in the private and public sectors, so as not to duplicate unnecessarily such activities;

(2) provide for appropriate procedures whereby various groups, under the auspices of the Board, may formulate, and recommend or suggest, to the Board specific programs for coordinating conversion in each industry and segment thereof and specific dimensions and configurations in the metric system and in other measurements for general use. Such programs, dimensions, and configurations shall be consistent with (A) the needs, interests, and capabilities of manufacturers (large and small), suppliers, labor, consumers, educators, and other interested groups, and (B) the national interest;

Comments and hearings.

(3) publicize, in an appropriate manner, proposed programs and provide an opportunity for interested groups or individuals to submit comments on such programs. At the request of interested parties, the Board, in its discretion, may hold hearings with regard to such programs. Such comments and hearings may be considered by the Board;

(4) encourage activities of standardization organizations to develop or revise, as rapidly as practicable, engineering standards on a metric measurement basis, and to take advantage of opportunities to promote (A) rationalization or simplification of relationships, (B) improvements of design, (C) reduction of size

variations, (D) increases in economy, and (E) where feasible, the efficient use of energy and the conservation of natural resources;

(5) encourage the retention, in new metric language standards, of those United States engineering designs, practices, and conventions that are internationally accepted or that embody superior technology;

(6) consult and cooperate with foreign governments, and intergovernmental organizations, in collaboration with the Department of State, and, through appropriate member bodies, with private international organizations, which are or become concerned with the encouragement and coordination of increased use of metric measurement units or engineering standards based on such units, or both. Such consultation shall include efforts, where appropriate, to gain international recognition for metric standards proposed by the United States, and, during the United States conversion, to encourage retention of equivalent customary units, usually by way of dual dimensions, in international standards or recommendations;

Consultation and cooperation.

(7) assist the public through information and education programs, to become familiar with the meaning and applicability of metric terms and measures in daily life. Such programs shall include—

Public information and education programs.

(A) public information programs conducted by the Board, through the use of newspapers, magazines, radio, television, and other media, and through talks before appropriate citizens' groups, and trade and public organizations;

(B) counseling and consultation by the Secretary of Health, Education, and Welfare; the Secretary of Labor; the Administrator of the Small Business Administration; and the Director of the National Science Foundation, with educational associations, State and local educational agencies, labor education committees, apprentice training committees, and other interested groups, in order to assure (i) that the metric system of measurement is included in the curriculum of the Nation's educational institutions, and (ii) that teachers and other appropriate personnel are properly trained to teach the metric system of measurement;

(C) consultation by the Secretary of Commerce with the National Conference of Weights and Measures in order to assure that State and local weights and measures officials are (i) appropriately involved in metric conversion activities and (ii) assisted in their efforts to bring about timely amendments to weights and measures laws; and

(D) such other public information activities, by any Federal agency in support of this Act, as relate to the mission of such agency;

(8) collect, analyze, and publish information about the extent of usage of metric measurements; evaluate the costs and benefits of metric usage; and make efforts to minimize any adverse effects resulting from increasing metric usage;

(9) conduct research, including appropriate surveys; publish the results of such research; and recommend to the Congress and to the President such action as may be appropriate to deal with any unresolved problems, issues, and questions associated with metric conversion, or usage, such problems, issues, and questions may include, but are not limited to, the impact on workers (such as costs of tools and training) and on different occupations and industries, possible increased costs to consumers, the impact on society and the economy, effects on small business, the impact on the international trade position of the United States, the appropriateness of and methods for using procurement by the Federal Government as a means to effect conversion to the metric system, the proper conversion or transition period in particular sectors of society, and consequences for national defense;

Surveys. Recommendations to Congress and President.

(10) submit annually to the Congress and to the President a report on its activities. Each such report shall include a status report on the conversion process as well as projections for the conversion process. Such report may include recommendations covering any legislation or executive action needed to implement the the programs of conversion accepted by the Board. The Board may also submit such other reports and recommendations as it deems necessary; and

Report to Congress and President.

Report to Congress and President.

(11) submit to the Congress and to the President, not later than 1 year after the date of enactment of the Act making appropriations for carrying out this Act, a report on the need to provide an effective structural mechanism for converting customary units to metric units in statutes, regulations, and other laws at all levels of government, on a coordinated and timely basis, in response to voluntary conversion programs adopted and implemented by various sectors of society under the auspices and with the approval of the Board. If the Board determines that such a need exists, such report shall include recommendations as to appropriate and effective means for establishing and implementing such a mechanism.

SEC. 7. In carrying out its duties under this Act, the Board may—

Committees, establishment. 15 USC 205f.

(1) establish an Executive Committee, and such other committees as it deems desirable;

(2) establish such committees and advisory panels as it deems necessary to work with the various sectors of the Nation's economy and with Federal and State governmental agencies in the development and implementation of detailed conversion plans for those sectors. The Board may reimburse, to the extent authorized by law, the members of such committees;

Hearings.

(3) conduct hearings at such times and places as it deems appropriate;

Contracts.

(4) enter into contracts, in accordance with the Federal Property and Administrative Services Act of 1949, as amended (40 U.S.C. 471 et seq.), with Federal or State agencies, private firms, institutions, and individuals for the conduct of research or surveys, the preparation of reports, and other activities necessary to the discharge of its duties;

(5) delegate to the Executive Director such authority as it deems advisable; and

(6) perform such other acts as may be necessary to carry out the duties prescribed by this Act.

Gifts and bequests. 15 USC 205g.

SEC. 8. (a) The Board may accept, hold, administer, and utilize gifts, donations, and bequests of property, both real and personal, and personal services, for the purpose of aiding or facilitating the work of the Board. Gifts and bequests of money, and the proceeds from the sale of any other property received as gifts or bequests, shall be deposited in the Treasury in a separate fund and shall be disbursed upon order of the Board.

(b) For purpose of Federal income, estate, and gift taxation, property accepted under subsection (a) of this section shall be considered as a gift or bequest to or for the use of the United States.

(c) Upon the request of the Board, the Secretary of the Treasury may invest and reinvest, in securities of the United States, any moneys contained in the fund authorized in subsection (a) of this section. Income accruing from such securities, and from any other property accepted to the credit of such fund, shall be disbursed upon the order of the Board.

Unexpended funds.

(d) Funds not expended by the Board as of the date when it ceases to exist, in accordance with section 5(d) of this Act, shall revert to the Treasury of the United States as of such date.

Compensation. 15 USC 205h.

SEC. 9. Members of the Board who are not in the regular full-time employ of the United States shall, while attending meetings or conferences of the Board or while otherwise engaged in the business of the Board, be entitled to receive compensation at a rate not to exceed the daily rate currently being paid grade 18 of the General Schedule (under section 5332 of title 5, United States Code), including traveltime. While so serving, on the business of the Board away from their homes or regular places of business, members of the Board may be allowed travel expenses, including per diem in lieu of subsistence, as authorized by section 5703 of title 5, United States Code, for persons employed intermittently in the Government service. Payments under this section shall not render members of the Board employees or officials of the United States for any purpose. Members of the Board who are in the employ of the United States shall be entitled to travel expenses when traveling on the business of the Board.

5 USC 5332 note. Travel expenses.

Executive Director, appointment. 15 USC 205i.

SEC. 10. (a) The Board shall appoint a qualified individual to serve as the Executive Director of the Board at the pleasure of the Board. The Executive Director, subject to the direction of the Board, shall be responsible to the Board and shall carry out the metric conversion program, pursuant to the provisions of this Act and the policies established by the Board.

(b) The Executive Director of the Board shall serve full time and be subject to the provisions of chapter 51 and subchapter III of chapter 53 of title 5, United States Code. The annual salary of the Executive Director shall not exceed level III of the Executive Schedule under section 5314 of such title.

5 USC 5101 et seq.
5 USC 5331.

(c) The Board may appoint and fix the compensation of such staff personnel as may be necessary to carry out the provisions of this Act in accordance with the provisions of chapter 51 and subchapter III of chapter 53 of title 5, United States Code.

Experts and consultants.

(d) The Board may (1) employ experts and consultants or organizations thereof, as authorized by section 3109 of title 5, United States Code; (2) compensate individuals so employed at rates not in excess of the rate currently being paid grade 18 of the General Schedule under section 5332 of such title, including traveltime; and (3) may allow such individuals, while away from their homes or regular places of business, travel expenses (including per diem in lieu of subsistence) as authorized by section 5703 of such title 5 for persons in the Government service employed intermittently: *Provided, however*, That contracts for such temporary employment may be renewed annually.

Financial and administrative services.
15 USC 205j.

SEC. 11. Financial and administrative services, including those related to budgeting, accounting, financial reporting, personnel, and procurement, and such other staff services as may be needed by the Board, may be obtained by the Board from the Secretary of Commerce or other appropriate sources in the Federal Government. Payment for such services shall be made by the Board, in advance or by reimbursement, from funds of the Board in such amounts as may be agreed upon by the Chairman of the Board and by the source of the services being rendered.

Appropriation authorization.
15 USC 205k.

SEC. 12. There are authorized to be appropriated such sums as may be necessary to carry out the provisions of this Act. Appropriations to carry out the provisions of this Act may remain available for obligation and expenditure for such period or periods as may be specified in the Acts making such appropriations.

Approved December 23, 1975.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 94-369 (Comm. on Science and Technology).
SENATE REPORT No. 94-500 (Comm. on Commerce).
CONGRESSIONAL RECORD, Vol. 121 (1975):
Sept. 5, considered and passed House.
Dec. 8, considered and passed Senate, amended, in lieu of S. 100.
Dec. 11, House concurred in Senate amendment.
WEEKLY COMPILATION OF PRESIDENTIAL DOCUMENTS, Vol. 11, No. 52:
Dec. 23, Presidential statement.

Clair M. Hulley
Engineering Analysis Department
University of Cincinnati

CONTOURING

For years the accumulation of data followed by time consuming interpolating and plotting the data for a contour plot has required many man hours.

With the advent of the computer and digital plotter the effort and time have been reduced drastically. It must still be remembered that sufficient accurate data must be collected before a plot is made. Also no plotter can "eyeball" a contour line based on the general trend of the surrounding surface. As the sophistication of the algorithm increases so does the plotting time. Frequently the highest contour line becomes an n-sided polygon because of the lack of data and the plot is in question. The draftsman frequently would omit the line or sketch a nice ellipse and no question would be raised.

Commerical packages are not only expensive, but also run very slowly and frequently are written in assembly language. For these reasons a subroutine in Fortran language featuring linear interpolation was written to allow students to have first hand experience in contouring using not only a familiar language but also reasonably small amounts of expensive computer time.

The logic was written for a Zip mode 718 Flatbed Calcomp plotter on line with an 1130 IBM 16K computer. Any computer with an ASA Fortran compiler and at least 16K should be sufficient.

A four pen option allows pens of different colors or widths to be used. Contour lines may be periodically annotated. Border scales are optional.

The flow of logic has been written so as to cause the computations to be performed while the plotter is moving thus saving much time.

Most of the arguments are fed through the CALL list. However, the large altitude array is placed in the COMMON area to save linking time.

The Example in Fig. I was chosen to show how the logic functions using a VERY difficult mathematical surface. Too often an example is selected to make the program look more effective than it really is. In Fig. 1, values of Z, contours, are plotted for the equation

$$Z = \sin(X) + 0.5*\sin(X*Y) + \sin(X/2.) + 0.5*\cos(Y/1.5)$$

Note that in the creation of the Z array from the X and Y vectors only the Z array is fed to the package. The Z (I,J)th value is related to the Ith value of X and the Jth value of Y. The separate SCLES subroutine may be used to relate X and Y.

Where a grid square is intersected by a contour line on all four sides, all possible lines connecting the points are drawn. It is easier to cover the unwanted line with correction fluid using an erasing shield than to add a line as is necessary in other packages.

For CONTOUR only Calcomp PLOT is needed. For SCLES routine the AXIS and associated Calcomp routines are needed. When using a single-pen plotter, the calls to and the logic for NUMPN should be omitted.

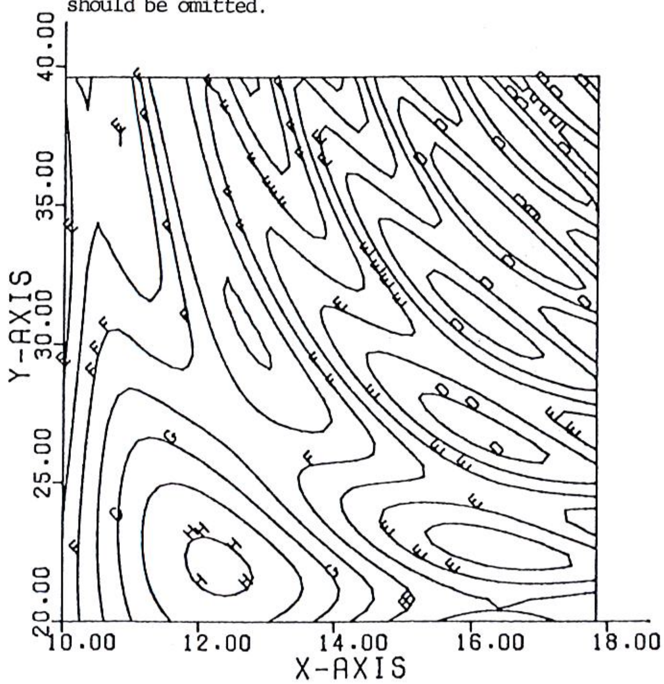


Figure 1

Figure 2

```
PAGE   1

// JOB

LOG DRIVE   CART SPEC   CART AVAIL  PHY DRIVE
  0000        0009        0009        0000

V2 M07   ACTUAL 16K  CONFIG 16K

// FOR
*ONEWORDINTEGERS
*LISTALL
      SUBROUTINE CONTR(TMIN,TMAX,TDEL,IZ,JZ,SCALI,SCALJ,KK,FREQ,IACC,SIZ
     *E,ANG,N,BORDR)
      DIMENSION BRDR(2)
      COMMONT(50,50)
      DATA BRDR/'YES','NO'/
C KK=0 WILL NOT TEST FOR A NEAR PLATEAU,KK=1 WILL TEST BUT RUNS SLOWER...
C IF IZ IS NEGATIVE WILL GIVE A THREE COLOR PLOT...
C JZ NEGATIVE  GIVES SYMBOLS, PLUS NO SYMBOLS.
C FREQ=FREQUENCY OF SYMBOLS...
      I=IABS(IZ)
      J= IABS(JZ)
      IM1=I-1
      JM1=J-1
      DO 100 II=1,IM1
      DO 100JJ=1,JM1
      ICONT=0
      TT=TMIN
400   CALLREVRS(JM1,JJ,II,K)
      IF(KK)900,3000,900
900   IF((ABS(T(II,K)-T(II+1,K))+ABS(T(II,K)-T(II,K+1))+ABS(T(II+1,K)-T(
     $II+1,K+1))+ABS  (T(II,K+1)-T(II+1,K+1)))-.002*ABS(T(II,K)+T(II+1,K
     $)+
     $T(II+1,K)+T(II,K+1)+T(II,K+1))/4.)1,3,3
3000  IF(TT-T(II,K))700,700,601
601   IF(TT-T(II+1,K))700,700,602
602   IF(TT-T(II+1,K+1))700,700,603
603   IF(TT-T(II,K+1))700,700,100
700   IF(TT-T(II+1,K))701,300,300
701   IF(TT-T(II+1,K+1))702,300,300
702   IF(TT-T      (II,K+1))703,300,300
703   IF(TT-T(II,K))9,300,300
300   CALLENTRY(TT,T(II,K),T(II,K+1),T(II+1,K+1),T(II+1,K),R1,R2,R3,R4)
C DRAWS LOGIC...
      ICNT=0
      X=(II-1)*SC ALI
      Y=(K-1)*SCALJ
      X1=II*SCALI
      Y1=K*SCALJ
      IPN=3
      IF(R1-.1E20)1,2,1
1     IF(IZ)31,200,200
31    CALLNUMPN(TT,TMIN,TMAX,TDEL)
200   CALL PLOT(X,Y+R1*SCALJ,IPN)
      IF(JZ)21,20,20
21    CALL SYMBL(ICONT,FREQ,0,IACC,SIZE,ANG,N)
20    ICNT=ICNT+1

PAGE   2

      IPN=2
2     IF(R2-.1E20)3,4,3
3     IF(IZ)32,500,500
32    CALLNUMPN(TT,TMIN,TMAX,TDEL)
500   CALLPLOT(X+R2*SCALI,Y1,IPN)
      IF(JZ)36,  30,30
36    CALL SYMBL(ICONT,FREQ,1,IACC,SIZE,ANG,N)
30    IPN=2
      ICNT=ICNT+1
4     IF(R3-.1E20)6,5,6
6     IF(IZ)33,40,40
33    CALLNUMPN(TT,TMIN,TMAX,TDEL)
40    CALLPLOT(X1,Y+R3*SCALJ,IPN)
      IPN=2
      ICNT=ICNT+1
5     IF(R4-.1E20)8,9,8
8     IF(IZ)34,41,41
34    CALLNUMPN(TT,TMIN,TMAX,TDEL)
41    CALL PLOT(X+R4*SCALI,Y,IPN)
      ICNT=ICNT+1
      IF(ICNT-4)9,10,9
10    IF(IZ)35,42,42
35    CALLNUMPN(TT,TMIN,TMAX,TDEL)
42    IF(T(II,K)-T(II,K+1))9,44,9
44    IF(T(II,K+1)-T(II+1,K+1))9,45,9
45    IF(T(II+1,K+1)-T(II+1,K))9,43,9
43    CALLPLOT(X1,Y1,2)
9     CONTINUE
      TT=TT+TDEL
      ICONT=ICONT+1
      IF(TT-TMAX)400,400,100
100   CONTINUE
      IF(BORDR-BRDR(1))50,51,50
51    CALLPLOT(IM1*SCALI,0.,3)
      CALL NUPEN(1)
      CALLPLOT(IM1*SCALI,JM1*SCALJ,2)
      CALLPLOT(0.,JM1*SCALJ,2)
      CALLPLOT(0.,0.,2)
      CALLPLOT(IM1*SCALI,0.,2)
50    CALLPLOT(IM1*SCALI+1.,0.,3)
      RETURN
      END
VARIABLE ALLOCATIONS
    T(RC)=7FFE-6C78  BRDR(R )=0002-0000     TT(R )=0004        R1(R )=0006        R2(R )=0008        R3(R )=000A
   R4(R )=000C          X(R )=000E           Y(R )=0010        X1(R )=0012        Y1(R )=0014         I(I )=0028
    J(I )=0029        IM1(I )=002A         JM1(I )=002B        II(I )=002C        JJ(I )=002D     ICONT(I )=002E
    K(I )=002F       ICNT(I )=0030         IPN(I )=0031

STATEMENT ALLOCATIONS
 400  =00B8  900  =00C5  3000 =0180  601  =018E  602  =019C  603  =01AA  700  =01B8  701  =01C6  702  =01D4  703  =01E2
 300  =01F0  1    =0262  31   =0266  200  =026C  21   =027D  20   =0286  2    =0290  3    =0297  32   =029B  500  =02A1
 36   =02B2  30   =02BB  4    =02C5  6    =02CC  33   =02D0  40   =02D6  5    =02ED  8    =02F4  34   =02F8  41   =02FE
 10   =0317  35   =031B  42   =0321  44   =033A  45   =0353  43   =036C  9    =0371  100  =0384  51   =039F  50   =03DE

FEATURES SUPPORTED
 ONE WORD INTEGERS
```

Guide to Subroutine CONTR., shown in Fig. 2.

CALL CONTRO (TMIN, TMAX, TDEL, IZ, JZ, SCALI, SCALJ, KK, FREQ, IACC, SIZE, ANG, N, BORDR)

TMIN: Real value of smallest expected contour value.

TMAX: Real value of largest expected contour value.

TDEL: Real value of contours interval.

IZ and JZ: Integer value of the size of the array to be plotted.

T(50,50) maximum on a 16K unit.

SCALI and SCALIJ: Real value in inches along the x and y axis representing a unit change in subscripts IZ and JZ.

KK: Integer value; Zero usually.

FREQ: Real value which controls how often contour is labeled. (FREQ = 1. is most frequent)

IACC: Integer value; Zero suggested.

SIZE: Real value for height (inches) for alphabetic contour label.

ANG: Real value for angle (degrees) from +X measured counterclockwise for alphabetic label.

N: Integer value; zero suggested.

BORDR: Real value alphabetic YES or NO to print or suppress border.

Special features: If IZ is negative plot will be in four colors. Lower 25% of contour lines for Pen 1 and etc.

If JZ is negative the plot will be annotated using letter A for TMIN, B for TMIN +2*TDEL and etc.

IACC and N are included here and in SYMBL, so if numeric labels are desired the logic can be added easily.

In certain problems a large plateau area may have small undulations giving rise to unwanted loops in this area. Under these conditions selects a value for KK other than zero. Running time increases substantially as a result however.

Subroutine REVRS scans the area left to right and reverses the Y direction every other time to speed the plot.

Subroutine ENTRY and AOVRB calculate the entry points for the contour lines with each grid square.

Subroutine NUMPN calculates proper pen to be used to draw the contour line. (And annotation)

Subroutine SYMBL calculates proper integer equivalents for alphabetic label. The border if requested is drawn last and the pen moves to the right off the plot.

```
      SUBROUTINE SCLES(I,J,SCALI,SCALJ,NUMB,AX,NXX,XMIN,XDEL,AY,NYY,YMIN
     *,YDEL)
C NUMB IS THE NUMBER OF SCALES 2 OR 4
C AX AND AY ARE THE ALPHAMERIC ARRAYS CONTAINING THE AXIS TITLES
C  NX AND NY ARE THE NUMBER OF ALPHABETIC CHARACTERS IN EACH TITLE.
C   XMIN XDEL ARE THE FIRST VALUE ALONG THE SCALE AND THE INCREMENT PER INCH.
      IM1=I-1
      JM1=J-1
      NX=NXX
      NY=NYY
      K=0
      A=0
      B=0
5     CALL AXIS (0.,A,AX,-NX,IM1*SCALI*1.1,0.,XMIN,XDEL)
      CALL AXIS(B,0.,AY,NY,JM1*SCALJ*1.1,90.,YMIN,YDEL)
      IF(K)4,3,4
3     IF(NUMB-2)1,4,1
1     A=JM1*SCALJ
      B=IM1*SCALI
      NX=-NX
      NY=-NY
      K=K+1
      GOTO5
4     RETURN
      END
      SUBROUTINE SYMBL(ICONT,FREQ,CODE,IACC,SIZE,ANG,N)
      INTEGER CODE
      DATA IVERT,IHORZ/2*1/
      IF(CODE)3,4,3
4     IF(IVERT-IFIX(FREQ))6,11,6
11    IVERT=1
      GOTO10
6     IVERT=IVERT+1
      RETURN
3     IF(IHORZ-IFIX(FREQ))60,110,60
110   IHORZ=1
      GOTO10
60    IHORZ=IHORZ+1
      RETURN
10    SMB=ICONT/2.
      IF(ABS(SMB)-IFIX(SMB))2,2,1
2     CALLWHERE(X,Y,Z)
      IF(SMB-9)20,21,21
20    ISMB=SMB+18
      GOTO30
21    IF(SMB-18)22,23,23
22    ISMB=SMB+25
      GOTO30
23    ISMB=SMB+33
30    CALLSYMB(X,Y,SIZE/2,ISMB,ANG,-1)
      CALLPLOT(X,Y,3)
1     RETURN
      END
      SUBROUTINE NUMPN(T,TMIN,TMAX,TDEL)
      DATA FIRST,NUPN/0.,1/
      IF(FIRST)3,4,3
4     SLOPE=4./(TMAX-TDEL-TMIN)
      B=1.-SLOPE*TMIN
3     FIRST=1
      NOPN=NUPN
      NUPN=T*SLOPE+B
      IF(NUPN-5)8,7,8
7     NUPN=4
8     CONTINUE
      IF(NUPN-NOPN)5,6,5
5     CALLNUPEN(NUPN)
6     RETURN
      END
      SUBROUTINE AOVRB(T2,T1,T,RATIO)
      DEN=T2-T1
      IF(ABS(T2-T1)-.1E-3)1,2,2
1     DEN=SIGN(.1E-3,T2-T1)
2     RATIO=(T-T1)/DEN
      IF(RATIO)4,3,3
4     RATIO=.1E20
3     IF(RATIO-1.)5,5,6
6     RATIO=.1E20
5     RETURN
      END
      SUBROUTINE REVRS(JM1,JJ,II,K)
      IF(II/2-FLOAT(II)/2.)1,2,1
1     K=JJ
      GOTO3
2     K=JM1-JJ+1
3     RETURN
      END
```

Figure 3

Guide to Subroutine SCLES, Figure 3.

CALL SCLES (IZ, JZ, SCALI, SCALJ, NUMB, AX, NX, XMIN, XDEL, AY, NY, YMIN, YDEL)

NUMB: Integer value; If NUMB = 2 scales are drawn on left and bottom. If NUMB = 4 scales are on all sides.

AX(AY): Real alphabetic label on X(Y) axis.

NX(NY): Number of characters in AX(AY).

XMIN(YMIN): Starting value on X(Y) axis.

XDEL(YDEL): Increment between labels on X(Y) axis. Other values same as in CONTR.

```
      SUBROUTINE ENTRY(T,T1,T2,T3,T4,R1,R2,R3,R4)
      CALL AOVRB(T2,T1,T,R1)
      CALLAOVRB(T3,T2,T,R2)
      CALLAOVRB(T3,T4,T,R3)
      CALLAOVRB(T4,T1,T,R4)
      RETURN
      END
```

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ENGINEERING DESIGN GRAPHICS JOURNAL

SPRING 1977 VOLUME 41 NUMBER 2 SERIES 123

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