ENGINEERING DESIGN GRAPHICS JOURNAL

SPRING 1978 VOLUME 42 NUMBER 2

INTERNATIONAL

50

Conference on Descriptive Geometry

Vancouver, B.C., Canada
June 14-18, 1978

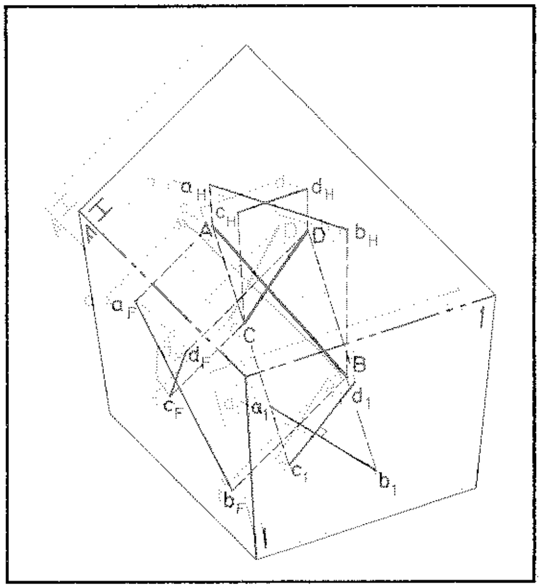
Sponsored by the
Engineering Design Graphics Division, ASEE

on its 50th anniversary

ENGINEERING GRAPHICS AND DESCRIPTIVE GEOMETRY IN 3-D

G. F. Pearce Professor, Faculty of Engineering, University of Waterloo, Canada

"Engineering Graphics and Descriptive Geometry in 3-D is an excellent piece of work." *Buckminster Fuller*



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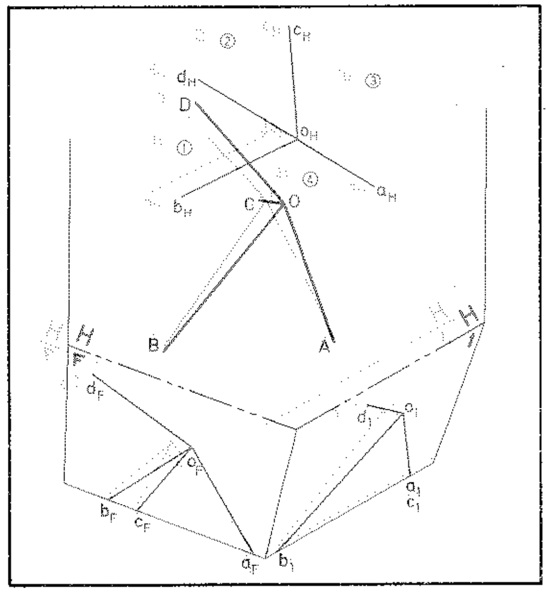

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CALENDAR

ASEE ANNUAL CONFERENCES

1978 - University of British Columbia, Vancouver. June 19 - 22.

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

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

1981 - University of Southern California

EDGD MIDYEAR CONFERENCES

1978-University of Alabama, January 1978

1979-Mississippi State

1980-Cogswell College

1981-North Carolina State

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

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

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

STYLE GUIDE FOR JOURNAL AUTHORS

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

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

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

3. Two copies of each manuscript are required.

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

Accordingly, be sure all lines are sharply drawn, all notations are legible, reproduction black is used throughout, and that everything is clean and unfolded. Do not submit illustrations larger than 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 spelling, structure, and clarity to avoid ambiguity and maximize continuity of thought. Proofreading will be done by the editorial staff. Galley proofs cannot be submitted to authors for review.

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

8. All articles shall be written using Metric-SI units. Common measurements are permissible only at the discretion of the editorial staff.

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

REVIEW OF ARTICLES

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

deadlines for author

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

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Engineering Design Graphics Journal

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EDITORIAL

Since writing the editorial for the Winter issue of the JOURNAL, your editor has done some research and found that the dimension change will cause little or no concern in library binding, so we are proceeding full steam ahead. With luck, the JOURNAL you are holding will be printed and cut to the 198 x 280 mm size described in that editorial. No doubt there will be some feedback by the time the Fall issue is printed and we will try to print your responses - pro and con.

A couple of thoughts:

Looking over the material while putting this issue together, it is apparent that many people have contributed a lot of hard work and time, creating programs, developing thoughts, and polishing presentations, all of which are vitally necessary to the life of both the JOURNAL and the Division. To all of these -- and particularly to Jack Brown and his team -- our sincere thanks.

It is also difficult to ignore how frequently some names tend to appear in the JOURNAL. These people have overcome the "activity hurdle" and are finding it difficult to become inactive. Why don't you join them? Budget some time to undertake that project you've been postponing and create a first-class article for the JOURNAL.

You'll find it more rewarding than you imagine!

Chairman's Page

Amogene F. DeVaney
Amarillo College

Since this will be my last message as chairman of the Division, I want to tell you what a rewarding experience it has been for me to serve as your chairman. The Division has had a good year, and one factor that has contributed greatly to this is the caliber of people who make up the leadership of this Division. Their dedication to the welfare of the Division and the fine work they do to carry out its objectives make me proud to be part of this effort.

An example of this leadership was evident at the Mid-Year Conference. Larry Goss had prepared a varied and interesting program, and the University of Alabama, with Jack Brown in charge, provided that warm southern hospitality and good food that made this an especially enjoyable conference.

Several members attended who have recently retired from teaching. Others who were in attendance are now close to retirement, and still others were in attendance who beagan their careers teaching graphics in 1946 and will retire in 7 or 8 years. Will these teachers be replaced? If they are replaced, what type of training should the new graphics teachers have?

I will not attempt to answer these questions in depth, but if we look at our present technology, we will see that more theoretical graphics will be required, that is to say more descriptive geometry. Drawing will be automated. The computer will do the drawing. It has been a long time getting here. I am sure some of you remember the Mid-Year meeting in Wichita, Kansas in the early 1960's, when we saw automated drafting at Boeing. I recently visited a large company that has just completed automation of all of its drafting. In this company the final drawings are made entirely by the computer from very rough sketches prepared by the engineers. Engineers were using interactive computer graphics to solve their design problems. It is exciting, but I asked myself if we are training our students to fit into this environment? A few schools are, but most are not. Future graphics teachers must have knowledge to use computers as tools as well as a strong background in theoretical graphics.

To go back to my first question, "Will these retiring teachers be replaced"? In some colleges they are being replaced by young, qualified graphics teachers, but there are some colleges, and I'm afraid far too many, who are making retirements an opportunity to cut costs by using more graduate assistants. When these colleges try to rebuild their graphics departments, they will probably have difficulty finding qualified teachers. The use of more graduate assistants in engineering colleges could reduce the membership of the Division. If, however, we interest community college graphics and drafting teachers in Division membership, we could reverse this possibilty.

While my year as chairman is almost over, the most important events are yet to come. I am referring to the Annual Conference and the International Conference on Descriptive Geometry which precedes it. By the time you read this page you will have received the program for the International Conference on Descriptive Geometry. I want to extend my special thanks to Clarence Hall who has done a superior job in getting the program together, printed and in your hands well in advance of the reservation date. I hope you have made plans to attend and join us in celebrating the Fiftieth Anniversary of the Engineering Design Graphics Division and to stay for the ASEE Annual Conference which follows.

I look forward to seeing each of you in Vancouver.

TECHNICAL — PROFESSIONAL COMMITTEE CORNER

Merwin L. Weed
Penn State University
Teaching Techniques Comm.

DESIGN PROJECTS--LARGE VS. SMALL, INDIVIDUAL VS. TEAM

In any design-oriented graphics course, design projects must be considered. Should a single project be assigned? Or should the students be expected to complete two, three, or maybe even more projects? Should the project be completed by one individual or a team? If a team, how many students should make up a team?

No set rule could ever satisfy every situation. Such variables such as class size, goals of the course, instructor's temperament, student background, and course credits (time available) will have to be weighed in making a final decision on the type and magnitude of any design project.

After trying many combinations of varying project sizes and team sizes, some observations have been made and are indicated below.

PROJECT SIZE

A small project requires the same design thought processes as does a large one and it allows time for several projects in widely diverse areas; this reduces the chance of boredom or student apathy towards his work. Several small projects provide a natural series of deadlines which are needed training for our structured society. This is not to say that a long-running project cannot have built-in deadlines; but, with a short project, the completed project is a natural end point.

If fundamental graphics material is being taught as an integrated part of a design course, then the shorter project is more easily tailored to the material just previously covered in the course. Then each project would be designed to make use of all material presented up to that point in the course.

DESIGN PROJECTS

It is interesting to note the effect of assigning a design project in advance of covering the material needed to complete the design or material needed to complete the presentation of the design. When a student sees a need for learning, learning takes on new meaning and appears to come earlier. Also, there is something to be said for the long term project. Again, in preparation for his place in society, the student should be prepared to take on a major effort and see it to completion. This type of project may lend itself to a more advanced design course rather than a beginning course that is taken by students with little background from which to draw.

TEAM SIZE

Design projects executed by an individual have the obvious advantage of guaranteeing that the individual has gone through the entire design process on his

Professor Weed's article was presented as a member of the Teaching Techniques Committee. As a new feature of the Journal, "Technical-Professional Committee Corner", seeks informative and interesting articles like Professor Weed's to feature as a spotlight on that particular committee. It is hoped that all Technical and Professional Committees will use this feature as a forum to express their ideas and activities.

Frank M. Croft--Associate Editor

own, and, for a beginning course, this may be best; but for a class of students which has already had this individual design experience, perhaps a team effort would be a new and exciting frontier. Some advantages of a team-effort design project are as follows:

1. A more complicated design can be developed in a given length of time.
2. Leadership is fostered.
3. The ability to work with others is developed.
4. One student will learn from the background of others on the team.
5. The design is generally more complete due to scrutiny from each member of the team.
6. Peer pressure tends to generate additional enthusiasm for the project.
7. Peer pressure tends to reduce "slacking off" by any individual team member.

The size of a team will to some extent be determined by the size of the class. For example, a class of 18 would conveniently form six teams of three members each. There is, however, a problem with large teams--the tendency is for an individual to get lost in the crowd if the team is allowed to become much larger than five members.

As noted above, peer pressure plays a major role in the success of the team effort. To enhance this pressure, each member of a team may be given an opportunity to grade (in confidence) his fellow teammates. This grade is in addition to the project grade which is shared equally with all team members. It has been observed that for the most part, the grade given an individual by his teammates is consistent with the instructor's opinion of that individuals performance.

It has been found that for at least one particular design course a combination of short individual design projects, followed by a moderate-length team project and finishing with a large-design team effort has been a good scheme.

Why not experiment? It makes the class more exciting for both the instructor and the students.

News of Promotion

Professor Mary Blade, longtime member of the Division of Engineering Design Graphics Division has been appointed Associate Dean of Engineering of the Cooper Union School of Engineering.

Professor Blade graduated from the University of Utah in Electrical Engineering and worked with the Southern Utah Power Company after graduation.

She has been teaching Machine Design and Engineering Graphics for many years at Cooper Union where she was the first woman faculty member. She also was a member of the Creative Service Program of New York University.

Her special interest has been an innovative course in Freshman Graphics and Problem Solving in which students learn by working on Engineering Design Projects. Dr. Ellis Blade, her husband and collaborator on many projects is an engineer-scientist. Professor Blade is a graphic artist and has exhibited her etchings and water colors. She is a member of the IEEE, ASEE, Pi Tau Sigma, and the New York Academy of Sciences. She was editor of the Journal for three years.

Congratulations, Mary!

COMMITTEE COMMUNICATIONS

FRESHMAN YEAR COMMITTEE

The Freshman Year Committee (FYC) was established by then Vice-Chairman Devaney and unanimously approved by the Executive Committee at its meeting in June 1977 at Grand Forks, North Dakota. The Committee reports to Professor Margaret Eller, Technical and Professional Committee Director. The general objective for the FYC is to represent interests of EDG members who work in areas involving engineering students at the freshman level outside the traditional graphics and design disciplines. Many possibilities have not yet been discussed but several seem to be of particular interest. These include orientation, advising, problem solving (analysis or computation) courses, and the so-called integrated freshman programs. Specific and detailed objectives will be considered when the Committee meets formally for the first time at the 1978 ASEE Annual Conference.

Through the efforts of FYC members and in cooperation with EDG Program Chairman, Arv Eide, FYC is sponsoring a session at Vancouver dealing with the "transition of high school graduates into first year engineering students". Five panelists will briefly describe programs which they have used in their respective schools. These programs which they have used in their respective schools. These programs range from pre-college counseling and entry level course placement techniques, to advising systems and orientation procedures. A portion of the session will be reserved for discussions among panelists and those in attendance. You are invited to attend the session and participate there or to direct suggestions and comments to FYC Chairman, Larry L. Northup, Department of Freshman Engineering, Iowa State University, 112 Marston Hall, Ames, Iowa 50010.

COMMITTEE FOR THEORETICAL GRAPHICS

Your committee chairman, Mary Blade, would like to meet all members of the Division who are interested in Theoretical graphics and space concepts at the Vancouver conference.

A most interesting book has been published, "Biological Mechanisms of Attachment" by Werner Nachtigall, Springer-Verlag N.Y., 1974.

Some years ago our distinguished Professor Hiram Grant published and illustrated design details. I am reminded of these when I recently was referred to this book on the design of attachments. These attachments are not machine-made, however, but are biological. The author has distilled an encyclopedic search for biological forms of mechanical attachments to a usable form, permitting to use these ideas in solving problems.

As all geometers know, the intersections of lines present no problem. However, as soon as the lines are embodied into three-dimensional structures, there are many problems in connecting these structures. Mr. Nachtigall, in his book, has assembled an extraordinary collection of attachments which illustrate the varied possibilities of structural connections which nature offers the designer. There are 721 illustrations to show comparative morphology and bioengineering or organs for linkage, suction and adhesion.

An example which only recently has been utilized for "soft" materials is the probabilistic fastener. This approach, which we find in barbed plants such as burrs, has been used in the new "Velcro" fasteners. But designers may use the probabilistic approach in many revolutionary ways, such as fastening machine parts or seals in this way.

Another possibility for inventors is extended use of sealants and molecular adhesion in novel ways.

Rigid, flexible, permanent and releasable attachments are all illustrated to enrich the designer's repertoire.

Mary Blade
Associate Dean of Engineering
Cooper Union School of Engineering

Charles W. Keith
Professor
School of Technology
Kent State University
OAEG President, 1977-78

THE OHIO ASSOCIATION FOR ENGINEERING GRAPHICS

Over a decade ago several engineering graphics professors in Ohio decided that there were items which might be of interest for all of the college level engineering graphics professors throughout the State, and therefore, after writing and calling a number of the professors, held their first meeting at the Faculty Club at The Ohio State University, Columbus, Ohio. Since that time the membership in the very loose knit organization has grown to approximately 100 members and includes teachers from two-year technical institutes and two-year community colleges, as well as professors of engineering graphics in all of the engineering and post secondary technical schools in the State.

Membership is open to anyone teaching technical drawing, engineering graphics, descriptive geometry, and/or other courses directly related to associate degrees or baccalaureate degrees in engineering technology, in engineering, and in other similar types of degree curricula. The main purpose of the organization is to alert those individuals involved with the subject area to the activity of their fellow teachers throughout the State. However, at each annual meeting part of the program is devoted to industrialists who use our product - the student graduate.

Meetings are held annually the first week of May and alternate between The Ohio State University, central within the State, and outlying colleges and universities. Last year's meeting, held at Kent State University, included the following topics:

"Design for the International Market" by Mark A. Miller, Design Engineer, The Timken Company.

"Continuous Metal Processing Lines - Their Design, Manufacture, and Installation" by Robert Messerly, Assistant Manager of Engineering, Wean United, Inc.

"Engineering Graphics Evaluation Procedures" by Dr. Lowell S. Zurbuch, Professor, Kent State University.

"Vector Geometry" a slide/tape presentation, by Mr. John Troche of Texas Instruments.

Last year a survey was made of all engineering design courses taught in the State at post-secondary level. This compilation which included: course title, credit hours, course description, text used and instructor responsible for instructing the course was provided to the membership. In addition a newsletter is being prepared whereby membership are alerted to current happenings in the discipline.

The association also provides an opportunity for the membership to exchange new techniques, ideas and simply have the opportunity to know fellow instructors and their programs.

The 1978 meeting will be held at the University of Cincinnati with Professor William Miller, vice president elect, being the host. Current officers of the Association include:

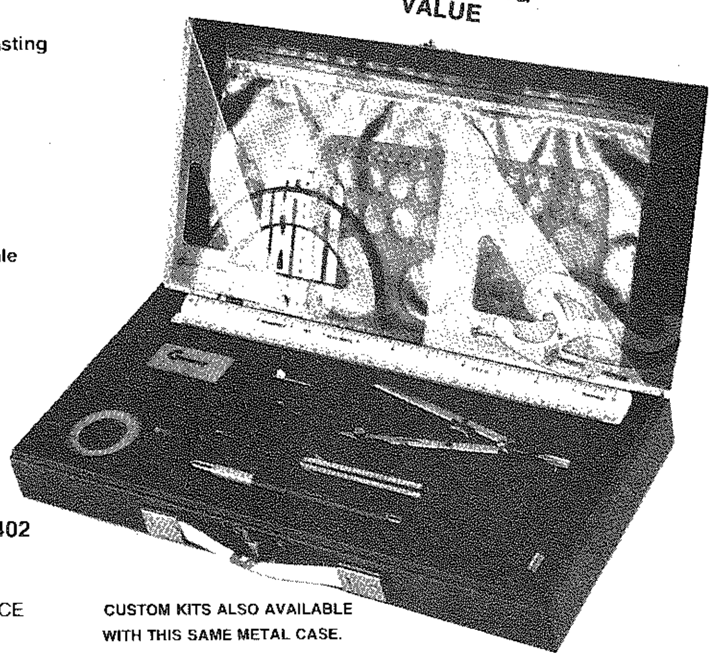
Mr. Ben Mandzuch, past president, Babcock and Wilcox Company.

Professor William Miller, vice president, Ohio College of Applied Science.

Professor George Pankratz, vice president elect, University of Toledo.

Professor Anthony O'Donnell, secretary-treasurer, Jefferson County Technical Institute.

Professor Robert LaRue, newsletter editor, The Ohio State University.



Mid-Year Conference

HIGHLIGHTS OF ALABAMA

The Mid-Year Conference of the EDG Division, ASEE has come and gone but is not forgotten. Our Host, Jack Brown and the University of Alabama provided the warm southern hospitality that promoted an atmosphere of fellowship that will remain with those in attendance for a long time.

The conference began with the Executive Committee Meeting Wednesday afternoon (January 4, 1978) with Amogene F. DeVaney, Chairman, EDG Division presiding. A tour of the Holt Lock and Dam was well attended by those conferees not required to attend the closed session of the Executive Committee Meeting.

The first formal session of the conference got underway early Thursday morning (January 5) with Larry D. Goss, the conference Program Chairman welcoming everyon to the conference. The first speaker of Session I was John Demel of Texas A&M University. He related his experiences in the instruction of a computer graphics course that enabled him to teach computer programming by using graphics. This presentation coupled with the presentation of Robert D. LaRue of Ohio State University offered many points of concern that instructors must face when teaching computer graphics.

After a brief coffee break, the spotlight turned from computer graphics to metrication. Frank M. Croft of the University of Louisville talked about his experiences with using SI units in Descriptive Geometry. Larry D. Goss of Indiana State University Evansville followed with a very interesting presentation concerned with product manufacturers not following the prescribed guidelines for metric measure on their products.

Following the luncheon business meeting the afternoon session began. Bobby G. Felder of the U.S. Army Corps of Engineers gave a slide presentation showing the planning, design, and construction phases of the Holt Lock and Dam Project. Joseph E. Parker, a Research Assistant at Louisiana State University followed with a presentation dealing with photogrammetric applications of descriptive geometry. Both presentations were well received.

The afternoon session ended with Robert H. Hammond leading an informal discussion concerning accreditation guidelines for the Freshman Year in Engineering.

On Friday morning (January 6) Lee Harrisburger of the University of Alabama presented his views on "Engineering Design-A Necessity for Engineering" which proved to be of major interest to all.

Following brunch, which was outstanding as were all the meals, Charles Mauro of New York City spoke on the subject of Human Factors in Engineering. Mr. Mauro, who is President of Charles Mauro Associates, related two of his company's projects through a slide presentation. Through his presentation, Mr. Mauro showed the results of design when the human element is considered as a parameter in the design.

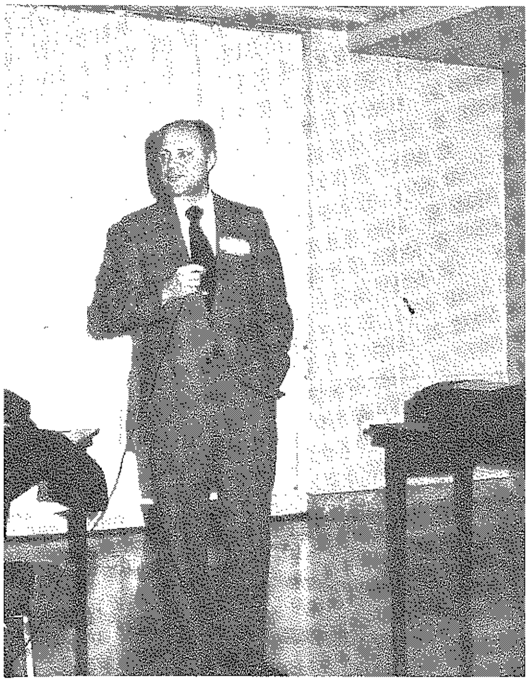
The last speaker on the program was Ray Hollub of the University of Alabama. His presentation dealt with the problems associated with the metric system and its implementation in this country. Even though Ray was the last speaker on the program, it could be said that the best was saved for last. His presentation won The Oppenheimer Award for the best paper presentation at the Mid-Year Conference.

In closing it can be said that the hospitality was warm, the food terrific, and a grand time was had by all. Thank-you University of Alabama for being such gracious Hosts!

Charles L. Mauro, Mauro Associates, New York, and a presentor at the 1978 Mid-Year Meeting of the EDG Division at the University of Alabama, is the recipient of the Alexander C. Williams, Jr. Award for 1977. The Award was presented to Mauro by The Human Factors Society for his "outstanding contributions" to the development of the Pfizer Medical Systems 0200FS Whole Body Radiological Scanner.

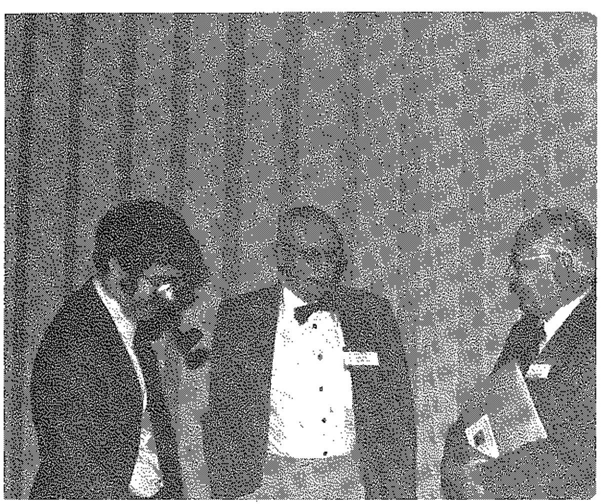
The scanning system, which includes a mobile patient handling system for radiography, was designed and developed under Mauro's guidance as industrial design consultant.

The case study of this system was a part of Mauro's presentation in Alabama. A part of his intent in speaking before the membership of the EDG Division of ASEE was to solicit input from the Division members of student designs which take Human Factors into account. Submit case studies or design projects of this nature to him at 135 West 41st Street, New York, N.Y.10036



Lee Harrisburger-University of Alabama
Speaking on Engineering Design.

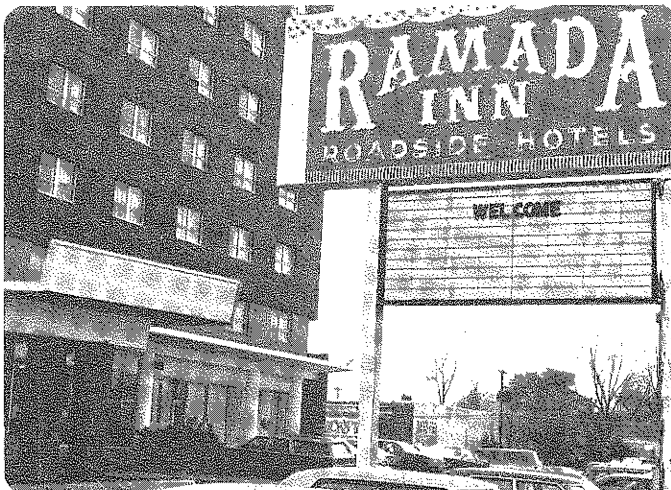
Ken Botkin (Purdue) and Jack Brown (Alabama)
examine the Descriptive Geometry Archives.



Casual conversation at coffee break.

Business of the Division being conducted
at The Executive Committee Meeting.

Here are more candid snaps from the conference. You'll find many familiar faces here, but not Margaret Eller. She was doing all the camera work! Many thanks, Margaret!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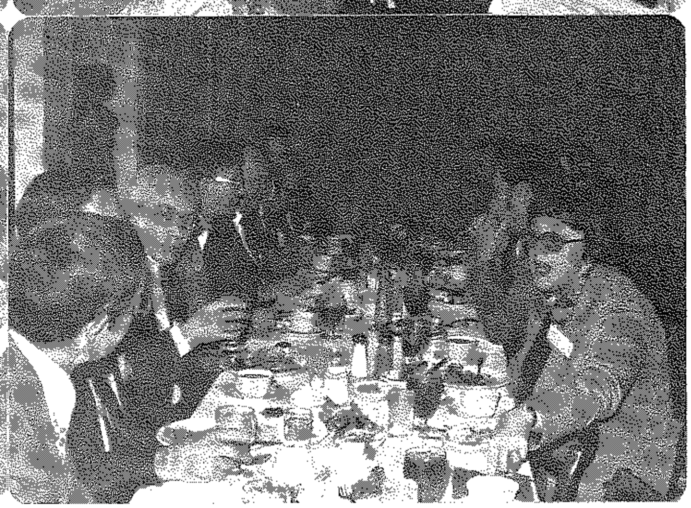
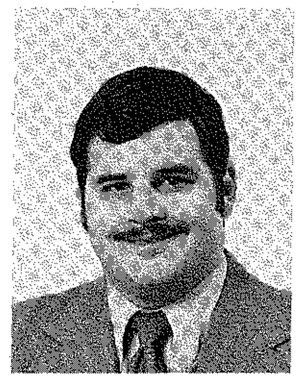


from the midyear conference ...

Frank M. Croft
Assistant Professor
Speed Scientific School
University of Louisville



THE USE OF SI UNITS IN DESCRIPTIVE GEOMETRY

INTRODUCTION

For SI units to become the standard system of units in this country, it is imperative that individuals be able to think in SI units. For example, in estimating a distance, one's first thought should be the number of meters or kilometers, not the number of feet or miles the distance represents.

To schieve this goal of thinking in SI units various philosophies in the instruction of SI units in the classroom have evolved. Some instructors favor the direct conversion approach which simply converts the English unit to the SI unit by a multiplying factor. Others support the idea of forgetting the English unit all together and using the SI unit directly without conversion. Simply from the very first day, begin with SI units and never mention the English system of units. This has been labeled the "cold turkey" approach. I feel very strongly that the cold turkey approach, if established properly and at the right time, can achieve the goal of thinking in SI units while direct conversion only adds to the confusion.

The cold turkey approach was used in the instruction of Descriptive Geometry at the Speed Scientific School, University of Louisville this past fall semester. This paper relates my experiences in teaching this course using the cold turkey approach in SI units.

COURSE BACKGROUND

The Descriptive Geometry course, as it exists at the Speed Scientific School, is strictly for Engineering Technology students. More specifically, the course is only required in the Mechanical Engineering Technology Program. Other Engineering Technology Programs use the course as a technical elective. The Engineering Program does not require the course in its curriculum.

The format for the instruction of the course is a one (1) hour lecture and a three (3) hour laboratory. This lecture-laboratory combination yields a total of two (2) semester credit hours. The lecture and laboratory are held back to back in a single session. This past fall the course was scheduled from 5:30 PM to 9:30 PM on Wednesday. The University operates a full evening program in Mechanical Engineering Technology. Therefore, the scheduling of the course in the evening was necessary to accomodate the many students working full time in local industry and pursuing a degree in the evening.

The course included the traditional elements of Descriptive Geometry and their application to relevant technical problems with the exception that SI was the only system of units used. A course outline is included in the Appendix.

STUDENT INPUT

The total enrollment in the course was 22 students. At the conclusion of the course the students completed a questionnaire which was designed to ascertain facts regarding their background in SI units. This questionnaire is included in the Appendix. Statistical methods were not employed in the design of this questionnaire. The object of this paper is to relate my experiences using the cold turkey approach in teaching Descriptive Geometry in SI units and not to state any statistical conclusions.

As mentioned earlier, many of the students worked full time in local industry. Of the 22 students enrolled in the course, 13 or 59% worked full time. Most of these students are employed in a technical capacity with large corporations such as General Electric, Brown & Williamson Tobacco, and Ford Motor Company. It is interesting to note that all 13 students reported that to the best of their knowledge their employer did not have a plant-wide educational program in SI units. This is not to say such programs do not exist in these companies, but simply the students were not aware of them.

The students by and large had little or no exposure to SI units either through other courses they had taken or through their own experiences.

COMMENT

In his presentation Professor Croft described the problems that he and his students encountered when he taught Descriptive Geometry using only SI units. He had several barriers to overcome: (1) most of his students were working more than 20 hours a week in industrial drafting and design jobs using the familiar English scales, (2) the class met only once a week for four hours, (3) the class met in the evening when the students were tired, and (4) Descriptive Geometry traditionally has been somewhat difficult to learn. A questionaire given at the end of the course showed that, in spite of the barriers, the students had begun to think in SI units. A closer focus upon and better description of the methods used and time spent introducing the SI units would have been helpful to other graphics teachers as they approach similar problems.

John T. Demel
Assistant Professor
Engineering Design Graphics
Texas A&M University

PITFALLS AND PROBLEMS ENCOUNTERED

Perhaps the single most important problem encountered was the students learning to use the metric scale properly. Some students never did learn the proper use of the metric scale despite numerous class sessions designed to promote the use of it. Other students discovered early the versatility of the metric scale and preferred it to the traditional architect's scale and engineer's scale which are in English units. One student who was having difficulty with the metric scale commented very seriously that he felt there should be an entire course devoted strictly to using the metric scale since most students in graphics were more familiar with the English unit scales used in the basic graphics course they had enrolled in the semester before. This Descriptive Geometry course was the first graphics course in which these students had been exposed to SI units and the metric scale.

Another problem encountered was that of using coordinates in problem layout. When three (3) coordinates are given to define a point in space from some reference, the coordinates are <u>always</u> given in millimeters and are <u>always</u> full size. Some students would forget the full size constraint and lay the drawing out using the coordinates with the given scale. When a layout is done in this manner the drawing often becomes too small to be workable, especially when large scales are encountered. Some students recognized that their drawings were too small to work with and they expanded the scale to meet their needs, thus introducing immense error into the problem. Once the students had cleared this obstacle, another method of layout using directions and elevations where scaling is necessary might have been introduced. With the difficulties that were encountered with the coordinate system of layout and the very good possibility that the students would confuse the two systems, the idea was quickly abandoned.

The students had the problem of not knowing the size of a meter, centimeter, or millimeter. It is very easy for them to estimate the length of a pencil in English units for they have been using English units all of their lives. To estimate that same pencil's length in SI units is a different matter. In order to do this the students must think in SI units. To aid them in this problem identity models were used. Physically measuring some common items in SI units gave them a "feel" for the size of a meter, centimeter, and millimeter.

Various other problems which were minor in nature emerged but nothing of any major consequence. By the conclusion of the course those students who received passing grades no longer were subject to the previously mentioned problems and pitfalls.

CONCLUSIONS AND RECOMMENDATIONS

Descriptive Geometry is accepted by most students and professors as being one of the most difficult graphics courses in any engineering or engineering technology curriculum. Many of my colleagues have stated that for them, Descriptive Geometry was one of the most difficult courses they were confronted with in their undergraduate education. I tend to agree with them since I have seen the difficulties students have had with the course as they confront the problems with visualization, intersections, developments, and all the other elements that make up Descriptive Geometry.

Introduction of SI units into a course when the students have had nothing but English units in the preceding graphics courses can also be difficult to comprehend. The students are familiar with inches and feet as being the basic unit and then suddenly millimeters and meters become the basic unit. It takes time to make the adjustment.

When the difficulties of the course material in Descriptive Geometry and the introduction of SI units using the cold turkey approach are esperienced by the students simultaneously, unnecessary confusion may result. In concentrating on the mastery of SI units, the students may not comprehend the vital elements of Descriptive Geometry and vice-versa.

I conclude that the time to start using the cold turkey approach in the instruction of SI units in graphics is immediately in the first graphics course taught in the freshman year. In this manner, the number of students having been exposed to English units in graphics is lower than it would be in a later course, such as Descriptive Geometry. Since in the basic graphics course a section dealing with the scale is always present, the students can be taught the use of the metric scale rather than the traditional English units scale. This would eliminate many problems down the line when the student encounters Descriptive Geometry and it is taught using SI units. They will already have had the necessary background in SI units so one difficult learning obstacle will have been eliminated.

Appendix I

Course Outline

24.110 DESCRIPTIVE GEOMETRY
Prof. F.M. Croft
Rm. 2 W.S. Speed Bldg.
588-6276 or 588-6277

DATE	LECTURE TOPIC
SEPT. 7	INTRODUCTION TO SI UNITS, REVIEW ORTHOGRAPHIC PROJECTION, AUXILIARY VIEWS
SEPT. 14	FUNDAMENTAL VIEWS OF POINT, LINE AND PLANE
SEPT. 21	FUNDAMENTAL VIEWS CONTINUED
SEPT. 28	PARALLELISM AND PERPENDICULARITY
OCT. 5	PARALLELISM AND PERPENDICULARITY
OCT. 12	SKEW LINES
OCT. 19	SKEW LINES
OCT. 26	MIDTERM EXAMINATION
NOV. 2	PIERCING POINTS OF LINES AND PLANES ANGLE BETWEEN LINE AND PLANE
NOV. 9	INTERSECTION OF PLANES, ANGLE BETWEEN PLANES (DIHEDRAL)
NOV. 16	INTERSECTIONS OF PLANES WITH SOLIDS
NOV. 23	INTERSECTIONS OF SURFACES(PLANAR,WARPED)
NOV. 30	DEVELOPMENTS (PLANE SURFACE)
DEC. 7	DEVELOPMENTS (WARPED SURFACE)
DEC 14	FINAL EXAMINATION

QUESTIONNAIRE ON SI UNITS IN DESCRIPTIVE GEOMETRY

In questions 4-10 circle the number which best describes your reaction to the statement. The scale reads from left to right meaning 1 is low and 5 is high.

1. If employed, does your employer have an educational program in SI units?

2. Your level (year) 1 2 3 4 5

3. How many hours a week do you work?

0	10	20	30	40	More than 40	
4	0	3	2	11	2	Full time= 13

4. Prior to this course my exposure to SI units from any source was

1 Low	2	3	4	5 High	
9	4	5	4	0	Average Response 2.18

5. My exposure to SI units from other courses is

1 Low	2	3	4	5 High	
10	4	6	1	1	Average Response 2.05

6. I feel the "cold turkey" approach to teaching courses with SI units is

1 Low	2	3	4	5 High	
1	2	5	10	4	Average Response 3.64

7. I think in SI units.

1 Low	2	3	4	5 High	
4	10	4	4	0	Average Response 2.36

8. The textbook in relation to SI units was

1 Poor	2	3	4	5 Very Good	
2	11	6	1	2	Average Response 2.59

9. SI units in other graphics courses would have been

1 No Help	2	3	4	5 Very Helpful	
1	2	8	3	8	Average Response 3.73

10. Additional comments about the course and SI units.

Appendix II -- Questionnaire & Response Averages.

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J. Tim Coppinger, P.E.
Associate Professor
Department of Engineering Design Graphics
Texas A & M University

IMPROVING CLASSROOM EFFICIENCY

In order to keep pace with modern technology, instructors are continuing to increase their course content. Since the number of hours a student is in class has not increased the instructor must improve his productivity. This has led to the use of various prepared materials in the classroom. Slide projectors, overhead projectors, movie projectors as well as closed circuit TV monitors have already improved the instructor's output. Some instructors have used the above media both singularly and in concert to the extent they deserve applause for their directorship, dexterity, and choreography. If the lecture material cannot be condensed and the students cannot be enticed to work faster, what can be done?

A close examination of an instructor's activities shows that a substantial part of the instructor's time is used to listen to the student's "reasons" for missing class or for not having their assignments completed on time. It appears that these "reasons" could be codified. This would allow a student to convey his "reason" by number thus, eliminating the time consuming explanations and therefore saving valuable class time. This concept has the advantage of simplifying record keeping, since the numbers are easily recorded. A partial list of coded reasons, that may be supplemented by the reader, follows.

> Comment: LW-14. LW-11.
>
> \- Paul S. DeJong

Reasons For Being Late or Missing A Class

EX-1 I forgot I was taking the course.

EX-2 I over slept.

EX-3 The other professor kept us late.

EX-4 I had a conference with my dean.

EX-5 I was in court.

EX-6 I was detained by county officals.

EX-7 It was a long walk from P.E.

EX-8 My grandmother died.

EX-9 My car broke down.

EX-10 My girlfriend's or roommate's car broke down.

EX-11 My car pool drowned.

EX-12 I was trying to get my laundry.

EX-13 My girlfriend's father had a shotgun.

EX-14 My grandmother died again.

EX-15 I had a flat tire on the way home from the football game.

EX-16 My roommate was holding me for ransom until my folks sent me some more money.

EX-17 I have been in the health center (quack shack).

EX-18 My roommate was sick.

Reasons For Not Having Completed

The Assignment On Time

LW-1 Was that assignment due today?

LW-2 I didn't think that it was that important.

LW-3 I dropped my pencil.

LW-4 My drafting machine was dirty.

LW-5 I helped Jane do hers.

LW-6 That's the way I've always done it.

LW-7 We were having so much fun I didn't get around to it.

LW-8 I left it at home.

LW-9 I had the assignment completed and on the way over someone threw an egg and it broke on my work.

LW-10 I strained my hand lifting a pop top.

LW-11 How was I to know that this one was different?

LW-12 Is today Monday?

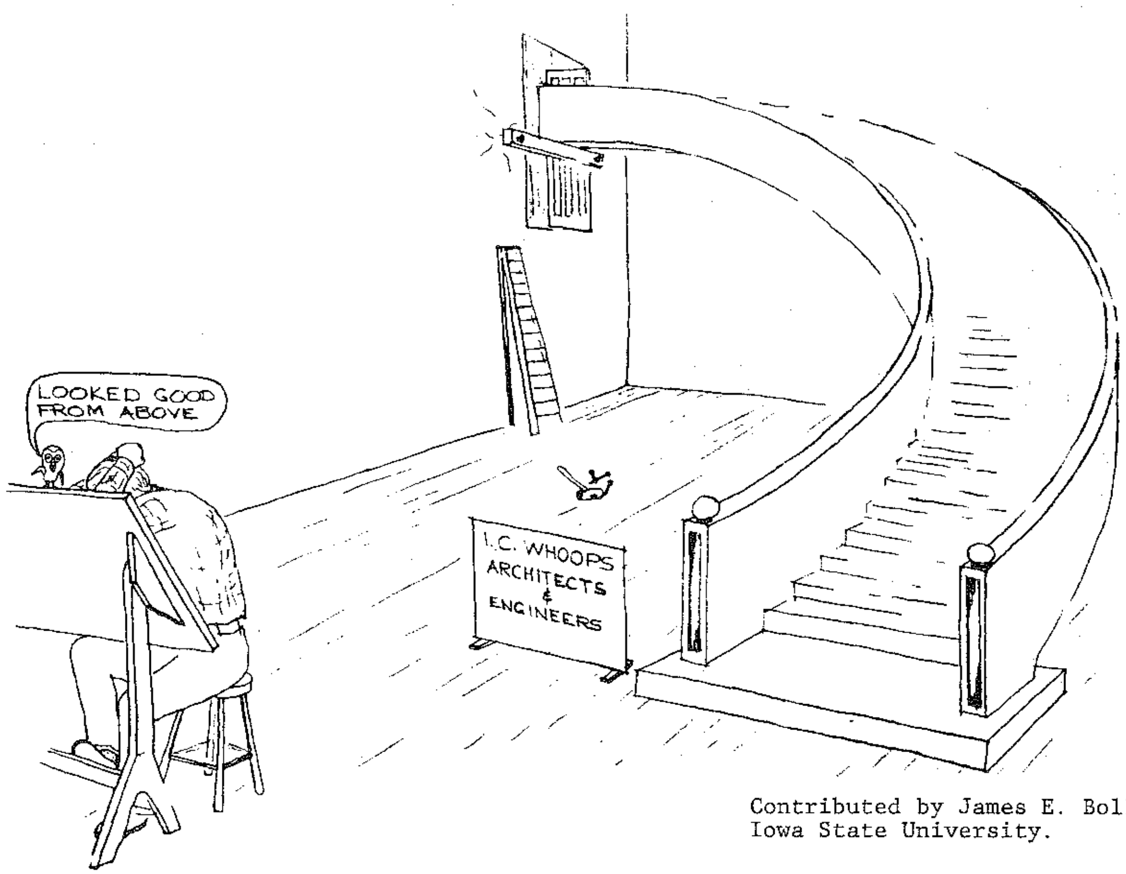
LW-13 My heart is willing but my pencil is dull.

LW-14 I have it completed in my mind.

LW-15 Charlie's Angels were on TV.

Even more time could be saved if the instructor would codify his answer. For example, he might say A-6, meaning "accepted" or NT-3 for "nice try but rejected". The concept could even be extended to the instructor's lectures. GM-22 could mean "Good Morning Class.. ..as you remember......", and Q-1 could mean "are their any questions?" If this technique catches on, an entire course or several courses in Abbreviated Communications could be taught. Perhaps after 2 years of instruction, a student could complete his entire four-year curriculum in an additional 3½ years.

Implementation of this timesaving technique is readily accepted by both the faculty and students alike. They strive to have their own reasons added to the official list. References would have been added to this paper but LW-7 and LW-2.



Contributed by James E. Bolluyt, Iowa State University.

Carl J. Sayre
Assistant Professor
Freshman Engineering
Iowa State University

A TRANSPARENCY FOR LESS THAN TWO CENTS? IT'S POSSIBLE!

Are transparencies, handout materials, etc. contributing to the high cost of teaching your courses? I may have an answer to one of these problems, that is, the 40¢ to 60¢ you have to pay for a single transparency. This high cost has been a concern of mine and have been looking for a way to make transparencies that might be just as effective but cheaper. As a result, I've found that clear polyethlyene can be used in much the same way you would use a regular transparency with excellent results.

Polyethylene plastic sheeting, the kind used for window covers, moisture barriers, paint drop cloths, etc., is available in various size rolls at hardware and department stores or nearly any source of building supplies. The roll I purchased was 3 feet wide, 50 feet long, and 4 mils thick. With some planning, and using a slow stroke on a large paper cutter, I was able to cut 240, 8½ x 10" sheets. At less than $3.00 per roll, that figures about 1.27¢ per sheet. This material has a somewhat milky appearance but is clear enough to give excellent results. In fact, overlays 6 sheets thick have been made with this plastic without loss of resolution on the screen.

There are two ways to make a transparency using this polyethylene:

1. You can draw right on the plastic. A ball point pen or some other relatively sharp object can be used to trace a picture or to write a formula, etc. This only indents the plastic but the indenture will diffuse the light to create good black lines on the screen. You can also use marking pens with permanent or watersoluble inks for color purposes.

2. Surprisingly, you can also use this material in the same manner as commercially available transparency materials. It can be run through the Thermofax® copier; the endless belt, heat generating type. Place a sheet of the plastic on a good black and white copy as you would with commercial transparency material and run it through the copier.

It seems to take a little more time in the copier to get a good transparency for this material, so the speed should be set somewhat slower than for Thermofax® material. You'll need to experiment to determine the right exposure time for your copies. The copy will have white lines burned onto the plastic, but will produce black lines on the viewing screen.

The resulting copy can be used like any other transparency. It can be colored, drawn upon, overlays made, etc. The finished copy can be filed for future use or thrown away, if that is appropriate. After all, you've only spent a couple of pennies and a bit of your time.

Happy transparency production!

Comment:

Carl Sayre describes here an interesting discovery he has made which may have far-reaching effects. It also demonstrates that if you're going to do something new, you've got to try some different and maybe extreme adjustments. In 1973 I tried this and concluded that polyethylene wouldn't react to the machine; apparently I gave up before trying the hotter settings. Pretty slick, Carl!

Paul S. DeJong

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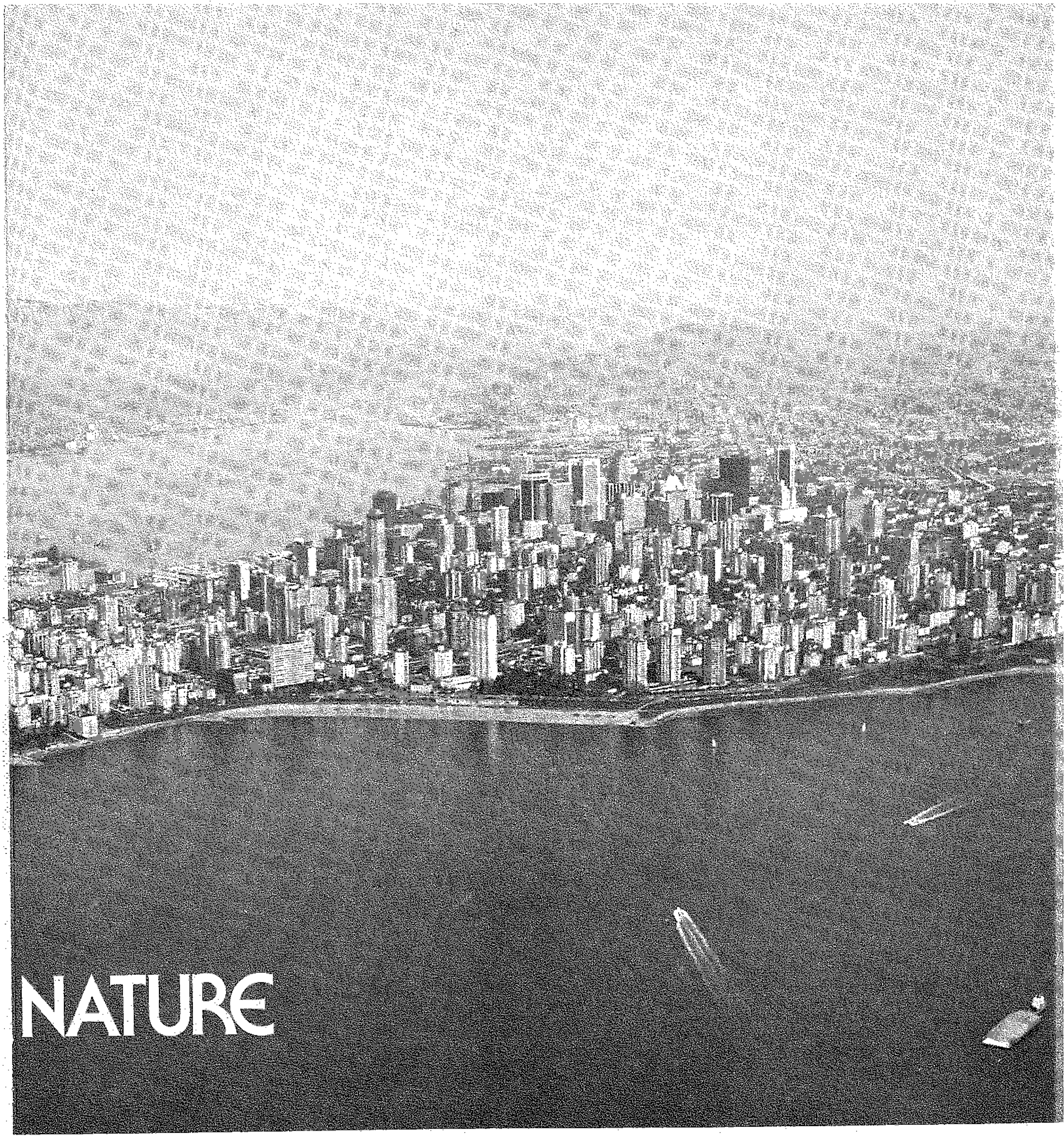

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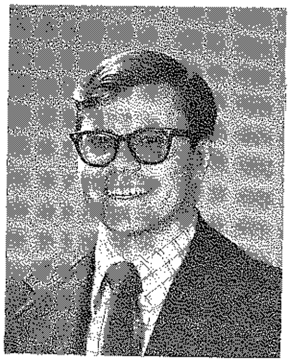
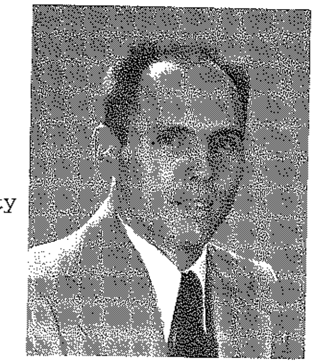


John T. Demel
EDG Department
Texas A&M University

Tim Coppinger
EDG Department
Texas A&M University



from the midyear conference ...

USING GRAPHICS TO TEACH COMPUTER PROGRAMMING

ABSTRACT

Today's students must know how to program computers. Learning to program has been difficult because present teaching methods many times use abstract problems. A set of practical problems with a continuous theme can speed the learning process and stimulate the students' interest. This paper will show how a carefully chosen set of graphics problems requires the students to learn programming statements in a step-by-step approach.

INTRODUCTION

The advances in computer hardware have put computer graphic systems prices within range of many engineering and technical firms. Students in these fields must be prepared to go into industry and use these tools effectively. This means that they must be able to understand and use the programs that come with the systems and be able to write programs as the need arises. The language used in the technical fields to communicate is graphics and this is an excellent basis for students to learn programming and computer graphics simultaneously. This is also a good approach for the graphics instructor who has not yet learned to write programs. This paper will describe a systematic approach to computer programming using graphical problems.

```
C  THIS IS A SET OF CALL PLOT STATEMENTS
C  THAT WILL DRAW THE LETTER 'A'.
      CALL PLOT (0.0,0.0,3)
      CALL PLOT (1.5,3.0,2)
      CALL PLOT (3.0,0.0,2)
      CALL PLOT (2.67,1.0,3)
      CALL PLOT (0.33,1.0,2)
      CALL PLOT (0.0,0.0,3)
```

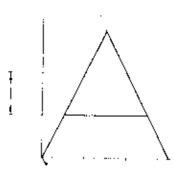


Figure 1: A simple two-dimensional figure.

BACKGROUND

Computer graphics at Texas A&M began in the early 1970's. It was soon found that the major difficulty in obtaining a drawing from a machine was not the graphics but the programming. Thus basic programming techniques were introduced into the course. Teaching only the programming statements necessary to solve one graphics problem at a time allowed the students to "see" how each statement manipulated the machine.

THE COURSE

After a short review of real and integer variables, arithematic statements, and the print statement, the concept of subroutines is introduced. Using the Calcomp software subroutine PLOT (X,Y,IPEN) draws a line. X and Y are coordinates of the new location to where the pen will move. If IPEN is 2, a line is drawn from the old location to the new location. If IPEN is 3, the pen moves to the new location but a line is not drawn. Some simple two dimensional figures (Figure 1) are drawn on graph paper and the students write the necessary CALL PLOT statements with the appropriate X,Y and IPEN values to draw the figures.

To introduce the manipulation of variables in a subroutine, the student is then asked to write a subroutine that will draw a rectangle of variable dimensions at a given location on the page. Figure 2 is typical of how this may be accomplished.

The next collection of statements to be introduced are the looping statements (DO loop). A subroutine that draws a hexagon is an excellent way to do this. This introduces the trigonometric functions of

```
(CONTROL CARDS)

C  THIS IS THE MAIN PROGRAM THAT WILL CALL
C  SUBROUTINE RECTAN
      X = 3.0
      Y = 6.0
      W = 5.0
      H = 8.0
      CALL RECTAN(X,Y,W,H)
      STOP
      END

      SUBROUTINE RECTAN (X,Y,W,H)
C  THIS IS A SUBROUTINE THAT WILL PLOT
C  A RECTANGLE OF HEIGHT, H, WIDTH, W,
C  WITH THE LOWER LEFT HAND CORNER
C  AT X,Y.
      XX = X + W
      YY = Y + H
      CALL PLOT (X,Y,3)
      CALL PLOT (XX,Y,2)
      CALL PLOT (XX,YY,2)
      CALL PLOT (X,YY,2)
      CALL PLOT (X,Y,2)
      CALL PLOT (X,Y,3)
      RETURN
      END
```

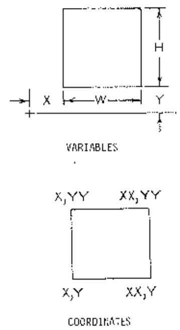
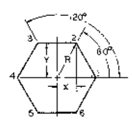


Figure 2: Program to draw rectangles.

```
      SUBROUTINE POLYGN (XTR,YTR,R,N)
C  THIS SUBROUTINE WILL DRAW A POLYGON OF
C  RADIUS, R, AND N SIDES LOCATED AT XTR,YTR.
      X = XTR + R
      CALL PLOT (X,YTR,3)
      A = 0.0
      DA = (360./N)/57.3
      DO 3 J = 1,N
      A = A + DA
      XPLOT = R*COS(A) + XTR
      YPLOT = R*SIN(A) + YTR
      CALL PLOT (XPLOT,YPLOT,2)
    3 CONTINUE
      RETURN
      END
```

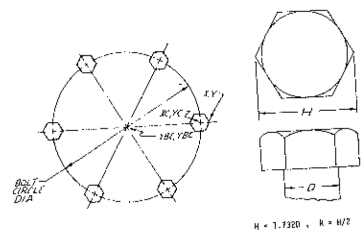
Figure 4: This subroutine will draw N-sided polygons.

```
ALGEBRAIC STATEMENTS AND COMMENTS TO DRAW
A PARTIAL HEXAGON

  R = 2.0
GO TO POINT 1
  CALL PLOT (R,0.0,3)
GO TO POINT 2
  X = R COS 60°
  Y = R SIN 60°
  CALL PLOT (X,Y,2)
GO TO POINT 3
  X = R COS 120°
  Y = R SIN 120°
  CALL PLOT (X,Y,2)
```




```
C  THIS IS A MAIN PROGRAM THAT CALLS SUBROUTINE
C  HEXAGON
      R = 2.0
      CALL HEX(R)
      STOP
      END

      SUBROUTINE HEX(R)
C  THIS SUBROUTINE DRAWS A HEXAGON
C  OF RADIUS 'R' AT LOCATION 0.0,0.0
C  FIRST GO TO POINT 1 WITH THE PEN UP
      CALL PLOT (R,0.0,3)
C  INDEX THE ANGLE
      A = 60.0
C  PLOT THE SIDES
      DO 20 J = 1,6
      X = COS(R*COS(A*.01745)
      Y = SIN(R*SIN(A*.01745)
      CALL PLOT(X,Y,2)
C  INCREASE THE ANGLE
      A = A + 60.0
   20 CONTINUE
      RETURN
      END
```

Figure 3: Program to draw hexagons.




```
      SUBROUTINE BOLTCL (XBC,YBC,DBC,NBLTS,D,N)
C THIS SUBROUTINE WILL DRAW NBLTS THAT ARE N
C SIDED AND OF DIA, D, ON A BOLT CIRCLE OF DIA,
C DBC, CENTERED AT XBC,YBC. H = 1.732D WHERE H
C IS THE BOLT HEAD SPAN.
      B = (360./NBLTS)/57.3
      Z = 0.0
      H = 1.732*D
      RB = H/2.
      DO 33 K = 1,NBLTS
      XC = (DBC/2.)*COS(Z) + XBC
      YC = (DBC/2.)*SIN(Z) + YBC
      CALL POLYGN (XC,YC,RB,N)
      Z = Z + B
   33 CONTINUE
      RETURN
      END
```

Figure 5: This subroutine to draw bolt circles requires the subroutine to draw polygons.

sine and cosine. This also is the first time the student uses the power of the computer to calculate the coordinates for the end points of the lines. In Figure 3 a partial list of algebraic statements show the need for the DO loop.

After the hexagon has been mastered the next step is to extend subroutine hexagon to a more general polygon routine such that it can be placed at coordinate XTR and YTR with N sides. The polygon subroutine, Figure 4, can also be used to approximate circles. Subroutine polygon introduces no new programming techniques but is a logical extension of subroutine hexagon.

Nested DO loops are best illustrated by having students write a program that constructs a bolt circle. This also reinforces the concept of having one subroutine call another. See Figure 5.

To introduce the READ statement a bar graph can be used. The students are asked to write a subroutine that will read one card at a time, calculate the bar height and then call the rectangle subroutine to draw the bar. See Figure 6. Data storage and subscripted variables using the dimension statement can be introduced using the broken line graph as shown in Figure 7.

Orthographic views of an object are an excellent way to introduce formatted data input and the common statement. See Figure 8.

Obliques, Figure 9, and isometrics, Figure 10, are a logical extension of the of the three dimensional data deck.

```
      SUBROUTINE BRGRAF (TOPSC,BARS,BGW,BGH)
C  TOPSC   IS THE TOP SCALE VALUE ON THE Y AXIS
C  BARS    IS THE NUMBER OF BARS IN THE GRAPH
C  NOBARS  IS EQUAL TO BARS
C  BGW,BGH ARE THE BAR GRAPH HEIGHT AND WIDTH
C  S       IS THE SPACING BETWEEN BARS
C  BW      IS THE BAR WIDTH = 2S
C  XINC    IS 3S, THE DISTANCE THAT THE PLOTTER
C          MOVES AFTER PLOTTING EACH BAR
C  DATA    IS THE DATA WHICH GIVES THE BAR HEIGHT
      CALL RECTAN (0.0,0.0,BGW,BGH)
      S = BGW/(3.0*BARS + 1)
      BW = 2.0*S
      SF = BGH/TOPSC
      NOBARS = BARS
      XINC = S
      DO 50 I = 1,NOBARS
      READ, DATA
      PRINT, DATA
      BH = DATA*SF
      CALL RECTAN (XINC,0.0,BW,BH)
      XINC = XINC + 3.0*S
   50 CONTINUE
      RETURN
      END
```

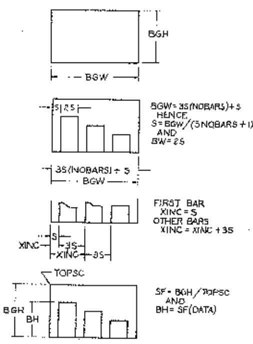


Figure 6: This subroutine will draw a bar graph any size and with any number of bars.

```
C  THIS PROGRAM WILL PLOT A BROKEN-LINE
C  GRAPH. IT WILL READ AND STORE THE
C  DATA POINTS USING THE DIMENSION
C  STATEMENT  AND THEN RECALL THE
C  DATA AND PLOT THE BROKEN-LINE.
      DIMENSION X(8),Y(8)
C  NPTS IS THE NUMBER OF POINTS
      NPTS = 5
C  THIS DO LOOP  READS AND STORES DATA
      DO 30 I = 1,NPTS
      READ (5,101) X(I),Y(I)
  101 FORMAT (2F10.3)
   30 CONTINUE
C  THESE CALL PLOT STATEMENTS DRAW THE
C  X AND Y AXES.
      CALL PLOT (0.0,0.0,3)
      CALL PLOT (10.0,0.0,2)
      CALL PLOT (0.0,6.0,3)
      CALL PLOT (0.0,0.0,2)
C  THIS DO LOOP PLOTS THE BROKEN LINE.
      DO 40 I = 1,NPTS
      XPLT = X(I)
      YPLT = Y(I)
      CALL PLOT (XPLT,YPLT,2)
   40 CONTINUE
      CALL PLOT (0.0,0.0,3)
      STOP
      END
//$DATA
2.0         4.0
4.0         3.0
6.0         6.0
8.0         4.0
10.0        3.0
/*END
```

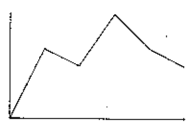
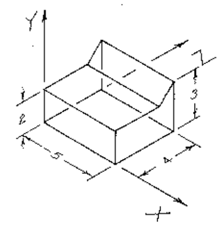


Figure 7: This program will read data and draw a broken-line graph.

```
C   THIS IS A MAIN PROGRAM THAT WILL CALL READIN AND
C   FRONT AND RSIDE IN ORDER TO PLOT THE FRONT AND
C   RIGHT SIDE VIEWS OF THE DESIRED OBJECT
      COMMON X(100),Y(100),Z(100),IPEN(100),NDATA
      CALL READIN
      CALL FRONT
      CALL RSIDE
      STOP
      END
```



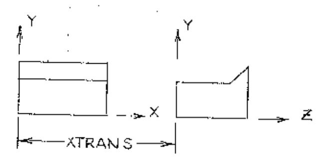
OBJECT TO BE DRAWN

```
      SUBROUTINE FRONT
C THIS SUBROUTINE PLOTS THE FRONT VIEW FOR
C A 3-D FIGURE.
      COMMON X(100),Y(100),Z(100),IPEN(100),NDATA
      DO 20 J = 1,NDATA
      XPLOT = X(J)
      YPLOT = Y(J)
      IP = IPEN(J)
      CALL PLOT (XPLOT,YPLOT,IP)
   20 CONTINUE
      RETURN
      END

      SUBROUTINE RSIDE
C THIS SUBROUTINE PLOTS THE RIGHT SIDE
C VIEW FOR A 3-D FIGURE.
      COMMON X(100),Y(100),Z(100),IPEN(100),NDATA
      XTRANS = 4.0
      YTRANS = 3.0
      DO 30 J = 1,NDATA
      XPLOT = Z(J) + XTRANS
      YPLOT = Y(J)
      IP = IPEN(J)
      CALL PLOT (XPLOT,YPLOT,IP)
   30 CONTINUE
      RETURN
      END
```

X	Y	Z	IPEN
0	0	0	3
5	0	0	2
5	2	0	2
0	2	0	2
0	0	0	2
0	0	4	2
0	3	4	2
0	2	3	2
0	2	0	2
5	2	0	3
5	2	3	2
5	3	4	2
5	0	4	2
5	0	0	2
5	2	3	3
0	2	3	2
0	3	4	3
5	3	4	2

DATA NECESSARY TO DRAW THE OBJECT

```
      SUBROUTINE READIN
C THIS SUBROUTINE READS IN AND STORES THE
C DATA FOR 3-D FIGURES.
      COMMON X(100),Y(100),Z(100),IPEN(100),NDATA
      NDATA = 0
      DO 90 J = 1,100
      READ (5,101,END=95)X(J),Y(J),Z(J),IPEN(J)
101   FORMAT (3F10.3,I3)
      NDATA = NDATA + 1
 90   CONTINUE
 95   WRITE (6,102) NDATA
102   FORMAT (' ',10X,'NDATA =',I3
      RETURN
      END
```



FRONT AND RIGHT SIDE VIEWS OF THE OBJECT

Figure 8: This program will read and store data for three-dimensional figures and plot orthographic views.

```
      SUBROUTINE OBLQUE
C  THIS SUBROUTINE WILL PLOT OBLIQUE
C  DRAWINGS OF 3-D FIGURES.
      COMMON X(100),Y(100),Z(100),IPEN(100),NDATA
      XTRANS = 4.0
      YTRANS = 3.5
      SF = 0.5
      THETA = 45.
      SNT = SIN(THETA*.0175)
      CST = COS(THETA*.0175)
      DO 50 J = 1,NDATA
      XPLOT = X(J) + Z(J)*SF*CST
      YPLOT = Y(J) + Z(J)*SF*SNT
      IP = IPEN(J)
      CALL PLOT (XPLOT,YPLOT,IP)
   50 CONTINUE
      RETURN
      END
```

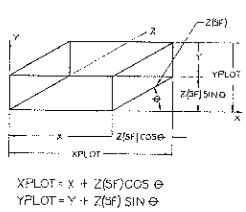


Figure 9: This subroutine will take three-dimensional data and plot an oblique drawing.

```
      SUBROUTINE ISOMET
C  THIS SUBROUTINE WILL PLOT ISOMETRIC
C  DRAWINGS OF 3-D FIGURES.
      COMMON X(100),Y(100),Z(100),IPEN(100),NDATA
      XTRANS = 4.0
      YTRANS = 6.0
      CST = COS(30*.0175)
      SNT = SIN(30*.0175)
      DO 60 J = 1,NDATA
      XPLOT = X(J)*CST + Z(J)*CST + XTRANS
      YPLOT = -X(J)*SNT + Y(J) + Z(J)*SNT + YTRANS
      IP = IPEN(J)
      CALL PLOT (XPLOT,YPLOT,IP)
   60 CONTINUE
      RETURN
      END
```

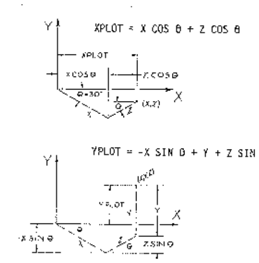


Figure 10: This subroutine constructs isometric drawings.

The "IF" and absolute value statements are used in the axonometric subroutine to separate the axonometric portion of the program from the perspective modifier, Figure 11.

CONCLUSION

Some students will not be required to write computer graphics programs during their careers. The will, however, be using the power of the computer graphic machinery either in computer-aided design or analysis. The authors believe that the above approach when coupled with discussions of new computer equipment, current design applications and field trips will be an excellent foundation on which the students can build for the future.

```
      SUBROUTINE AXOMET
C  THIS SUBROUTINE WILL PLOT AXONOMETRIC DRAWINGS
C  OF 3-D FIGURES. THETA IS THE ROTATION ABOUT THE
C  Y AXIS, PHI IS THE ROTATION ABOUT THE X AXIS,
C  PRJDIS IS THE PROJECTION DISTANCE (IF PRJDIS =
C  ANYTHING GREATER THAN .0001 A PERSPECTIVE WILL
C  BE PLOTTED), SF IS THE SCALE FACTOR
      COMMON X(100),Y(100),Z(100),IPEN(100),NDATA
      XTR = 4.0
      YTR = 6.5
      SF = 0.6
      THETA = 45.
      PHI = -30.
      PRJDIS = 15.
      CT = COS(THETA/57.296)
      CP = COS(PHI/57.296)
      ST = SIN(THETA/57.296)
      SP = SIN(PHI/57.296)
      DO 70 J = 1,NDATA
      XREV = X(J)*CT + Y(J)*0.0 + Z(J)*ST
      YREV = X(J)*ST*SP + Y(J)*CP + Z(J)*(-CT*SP)
      ZREV = X(J)*(-ST*CP) + Y(J)*SP + Z(J)*CP*CT
      IF (ABS(PRJDIS).LT..0001) GO TO 65
      XREV = XREV * PRJDIS/(ZREV + PRJDIS)
      YREV = YREV * PRJDIS/(ZREV - PRJDIS)
   65 CONTINUE
      XPLOT = XREV*SF + XTR
      YPLOT = YREV*SF + YTR
      IP = IPEN(J)
      CALL PLOT (XPLOT,YPLOT,IP)
   70 CONTINUE
      RETURN
      END
```

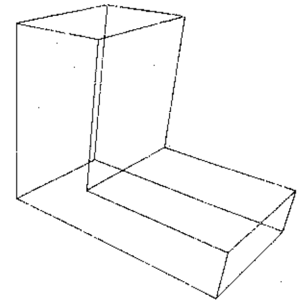


Figure 11: SUBROUTINE AXOMET constructs axonometric and perspective drawings.

AN OPINION

Dr. John T. Demel and Dr. J. Tim Coppinger presented a paper, "Using Graphics to Teach Computer Programming" at the mid-year meeting of the Engineering Design Graphics Division of ASEE at Tuscaloosa, Alabama, January 5, 1978. This paper was a most informative one for those of us who are in the process of learning computer programming and how it can be used in the engineering design graphics field. The speakers emphasized the fact that they had been "uneducated" in the use of computers and computer language. The course was developed based upon research done by Dr. Jack C. Brown in his dissertation as well as work which Dr. Brown had done in the development of a computer graphics course and was modified for the computer hardware available. Assuming that students in the course and prior to the introduction of the computer programming had certain foundation knowledge of graphics, the program was developed using an analysis study first for the development of sub-routine programs needed for each design. This then was followed by the application of these sub-routines to each design problem as needed and injected into the complete program of each problem. This technique has several values. First, it does not require great indepth study and prior knowledge on the part of the instructor. Second, it provides for a logical analysis of each design problem and forces the designer to apply principles of logic and step by step sequence in the design process. Third, it teaches the student how to apply the use of computers and computer language to design early in the student's degree study. Finally, by use of a printer plot simulation program, the student learns quickly the accuracy of his work. As one who is in the process of learning the application of computer language to engineering design graphics the method used by Dr. Demel and Dr. Coppinger seems valid indeed.

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School of Technology
Kent State University

from the midyear conference . . .

Larry D. Goss
Associate Professor
Division of Engineering Technology
Indiana State University, Evansville

METRICS IN THE MARKETPLACE

The United States adopted the metric system as an acceptable system of measurment in 1866. In 1893, the official yard and pound were defined from the standard meter and kilogram. In 1975, President Gerald Ford signed the Metric Conversion act (P.L. 92-186) urging phasing in of SI units over a "reasonable period" (which has been construed to be ten years). We are now in the midst of that conversion period. Some industries now claim to be "90" or some other percent converted to SI units, but the industries that make those claims are ones which can make the conversion without involving the public (their consumers) in learning a measurement system which is different from the one to which they are accustomed. The medical profession, for instance, normally does not involve its patients in the details of treatment. The system of measurement used for medication or for describing an operation makes no difference to the patient. It is relatively easy, therefore, for such an industry or any industry which does not have to involve the public in its measurement system to convert to SI. Automobile manufacturers represent another industry of this nature. The system of measurement used in manufacturing a car is not a fundamental factor in the sales appeal of the vehicle. Therefore, it has been reasonably easy in terms of public resistance for this segment of the economy to convert to SI units.

But what about those industries who merchandise their products by weight (or mass), length, or volume, and who must rely on the general public to make a decision at the point of purchase to select their product instead of the competition's; such items as foodstuffs, hardware, and sundries. These industries also are converting to SI units, and they have the monumental task of simultaneously educating the public in the measurement system itself. Compounding the problem of educating the public on SI units is the apparent confusion many manufacturers have concerning the system. In particular, many manufacturers are currently exhibiting a lack of understanding concerning the use of symbols for unit names and the form the names themselves should take. The word or symbol for grams can be found written as "g.", "G.", "Gms.", "gms.", "GR.", "GM.", "GMS.", "GRS.", "Gr.", "Gm.", and "GRAMS" on currently stocked items in any supermarket -- all of which are incorrect. The standard on Metric Practice (ASTM E380-76) is very explicit on the form that symbols and written unit names can take in SI and it appears to this observer that a great public service could be performed if manufacturers of all consumer items would voluntarily abide by those guidelines in the labelling of their products. As it stands now, there appears to be no regulation on the form of SI unit names

Professor Goss made his interesting and well-researched highly visual presentation with very little formal comment. A great deal of discussion took place and comments volunteered as the slides were presented.

It was an enjoyable presentation, and unfortunately probably loses something in translation to the printed page.

Note how few "hard" conversions are found in these many illustrations. I hope Larry takes his paper to the National Association of Manufacturers or some similar body.

Paul S. DeJong
Iowa State University

and symbols being printed on consumer products. The resulting confusion by the general public in trying to interpret what the manufacturer intended to say can only lead to added public resistance to the forthcoming SI conversion.

The following examples are indicative of the types of errors in SI labelling which currently can be seen on the shelves of any supermarket or hardware store in the United States. The number of errors in each example, plus additional comments, are listed at the end of this article. Look through the examples. If you have trouble picking out the errors, maybe you too need to brush up on the guidelines for unit names and symbols in SI.

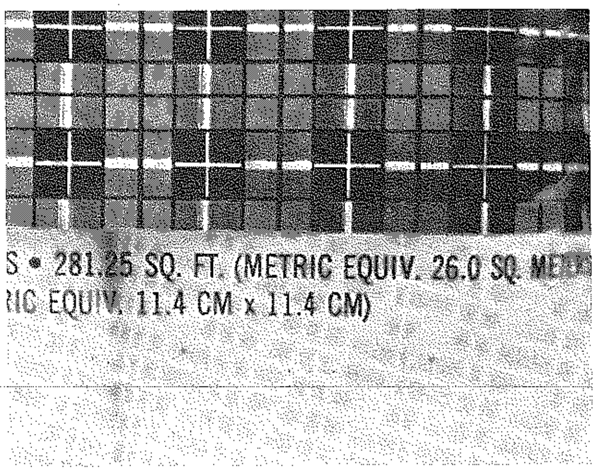


Fig. 1. Two errors.

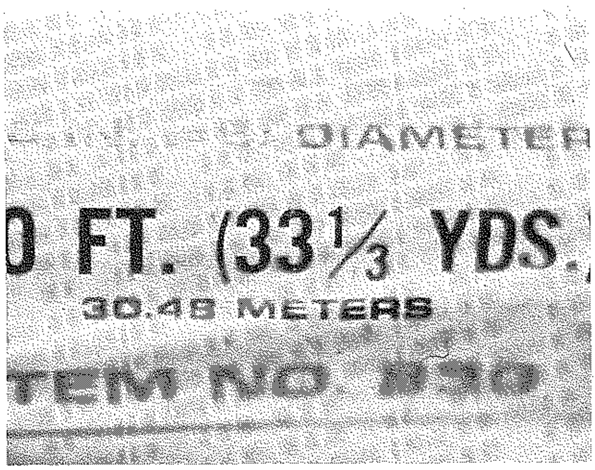


Fig. 2. One error.

Fig. 5. Two errors - Why couldn't this company have listed the volume simply as 1.892 L?

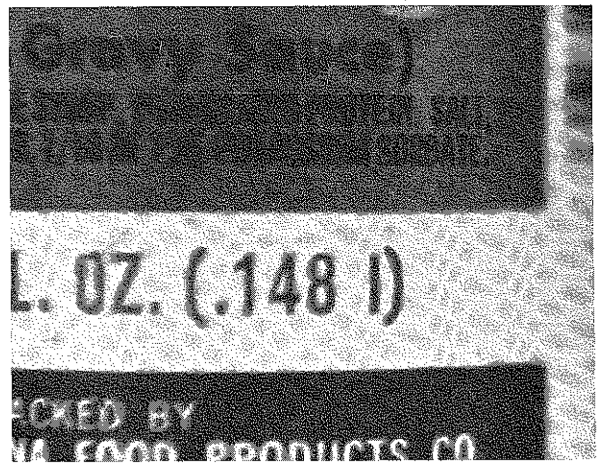


Fig. 3. One error - This is an excellent example of the confusion which can result from using the lower case "L" as the symbol for "liter", but the error lies elsewhere.

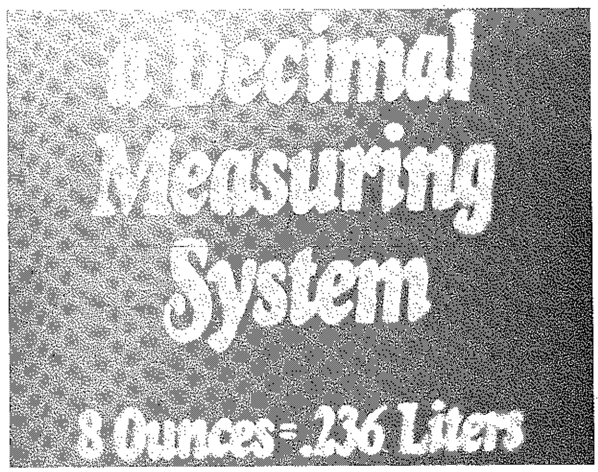
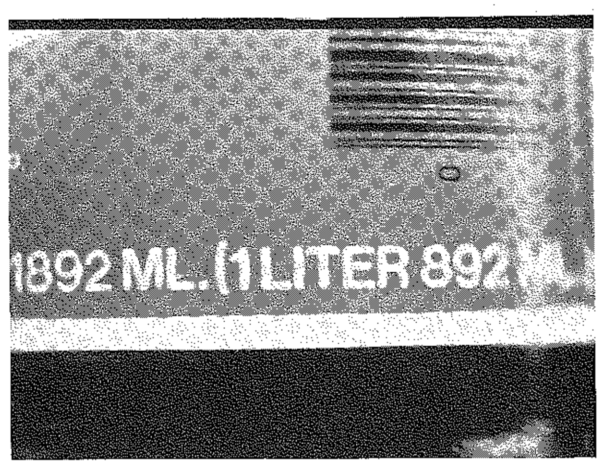


Fig. 4. Two errors - The guidelines indicate that a unit name can be capitalized when it is used in a headline. This surely doesn't qualify.



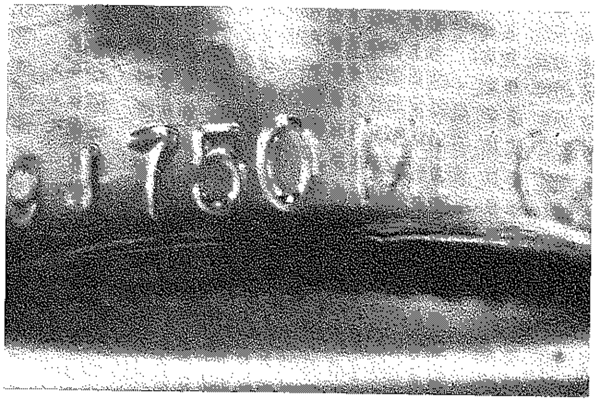


Fig. 6. One error - The wine industry as a group has made this error in the molded information in all of its bottles.

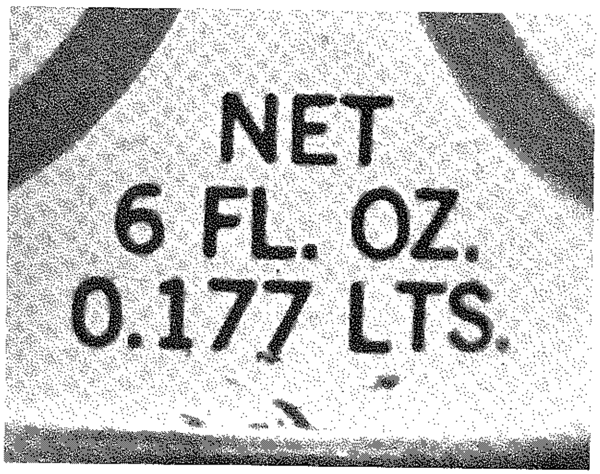


Fig. 7. Two errors - Besides the errors of form, there is the error of a completely wrong unit symbol being used here. Another one, similar to this, showed "MISKG" as the unit symbol for torque on a wrench. Look for it in your local K-Mart.

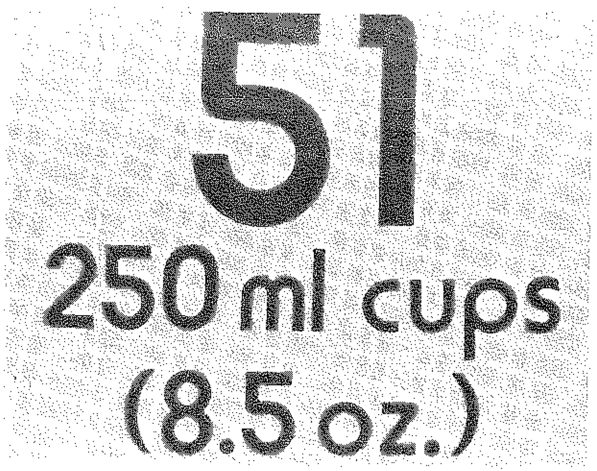


Fig. 8. No errors - It is indeed a joyful occasion to find the occasional manufacturer who handles SI correctly.

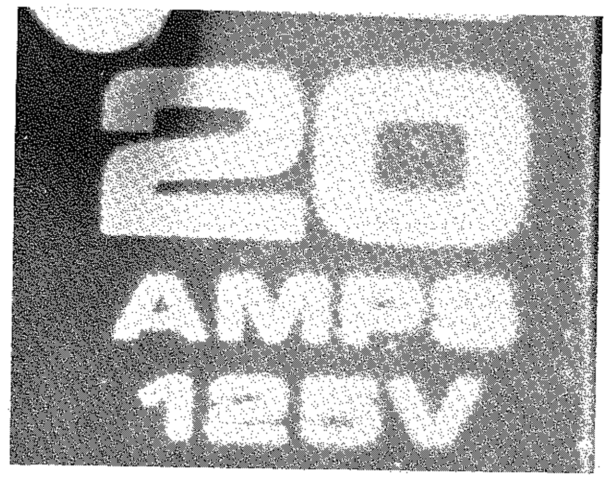


Fig. 9. Two errors - The electrical industry has adopted a smug attitude in some quarters because they always have been "metric", but that doesn't keep them from making mistakes.

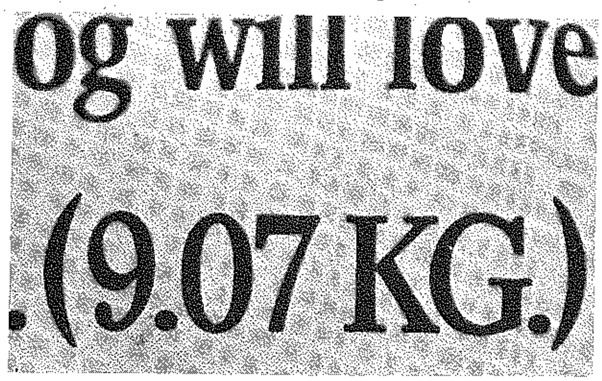


Fig. 10. Two errors.

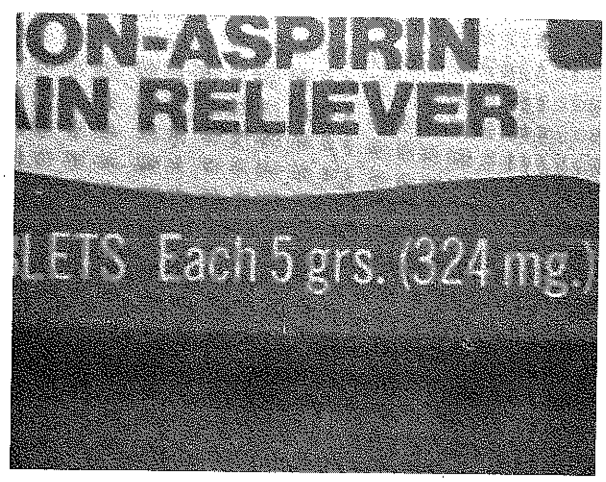


Fig. 11. One error - "grs." is the abbreviation for "grains" in apothecary measure and as such is not in error, but the same combination of letters is also used to indicate "grams" and that can lead to all sorts of confusion. (See Fig. 16.)

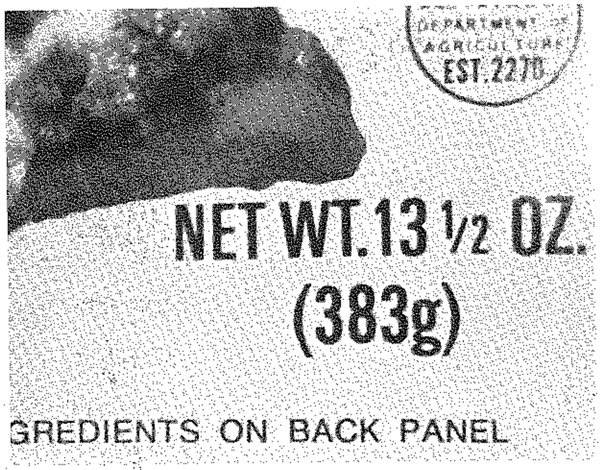


Fig. 12. One error.

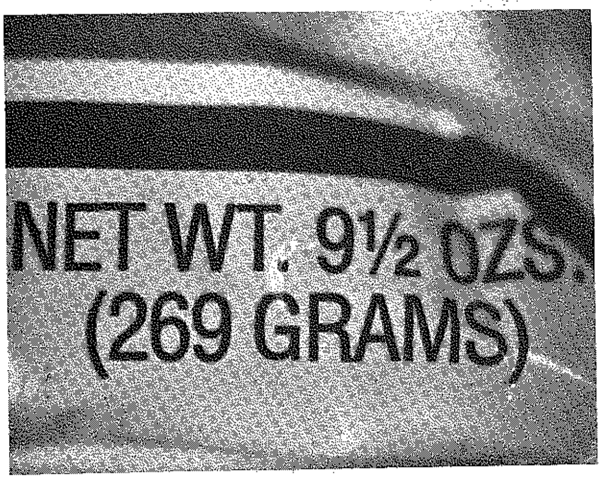


Fig. 13. One error.

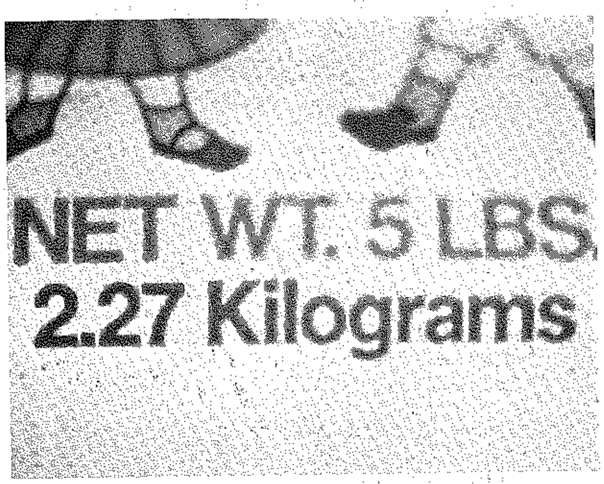


Fig. 14. One error.

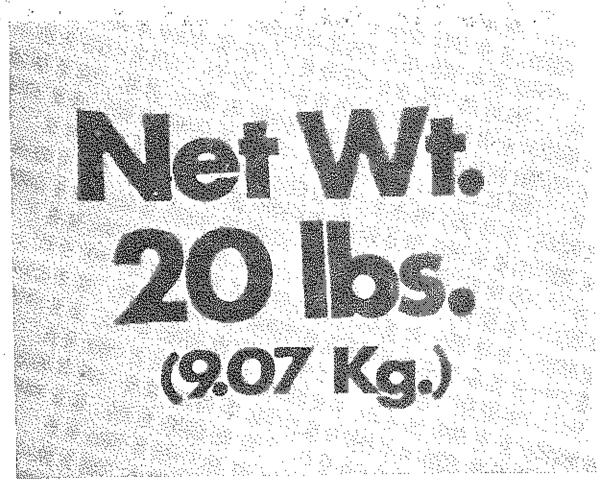


Fig. 15. Two errors.

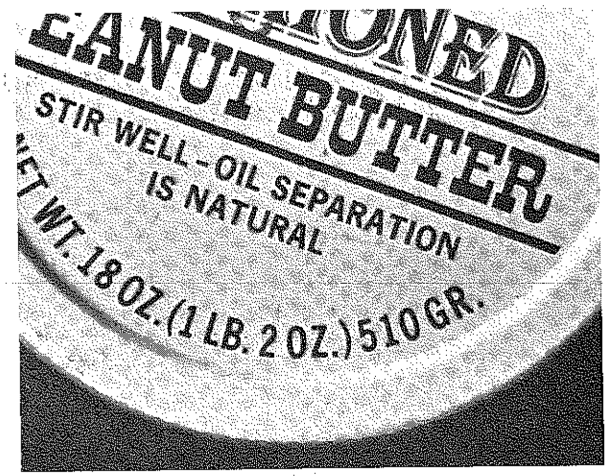


Fig. 16. Two errors - Plus an erroneous symbol.

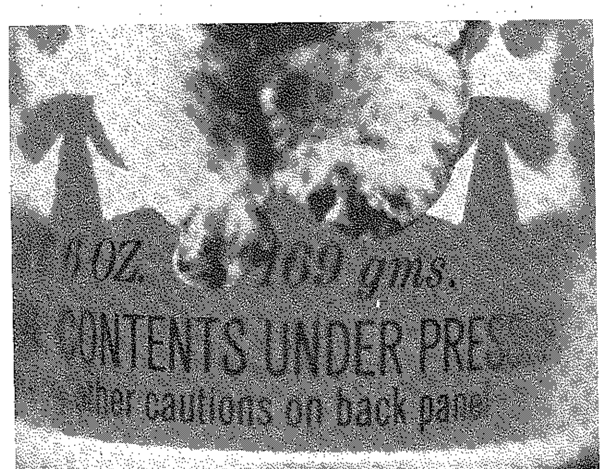


Fig. 17. Three errors.

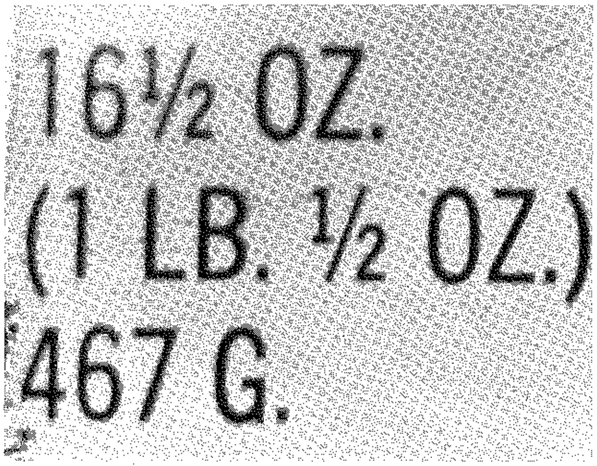


Fig. 18. Two errors.

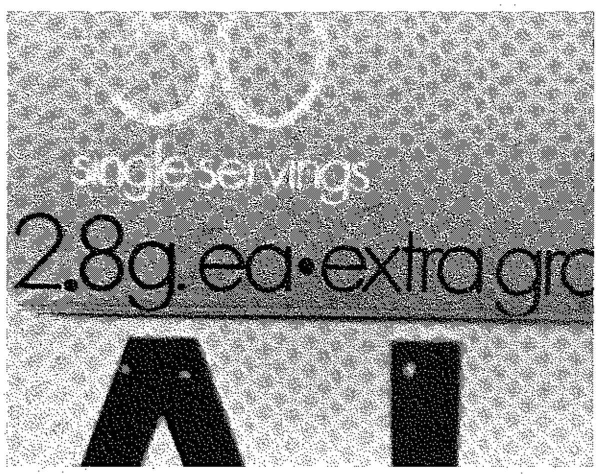


Fig. 19. Two errors - notice the difference in size of the decimal marker and the period. One has the feeling that the manufacturer wasn't sure whether there should be one or not so he put in a little one to be on the safe side.

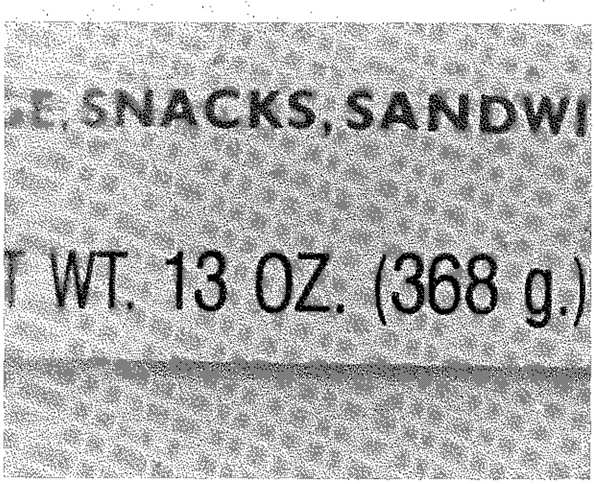


Fig. 20. One error.

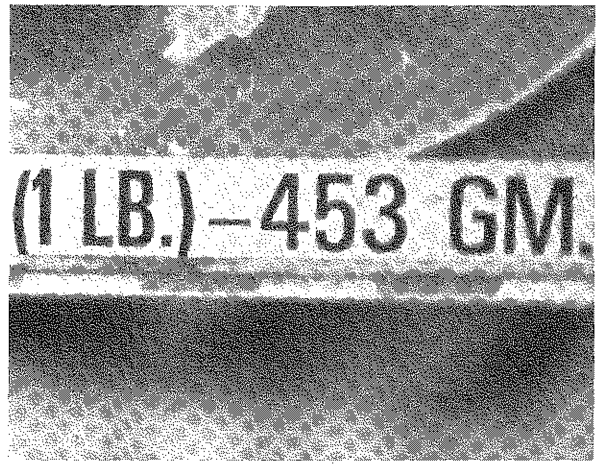


Fig. 21. Three errors.

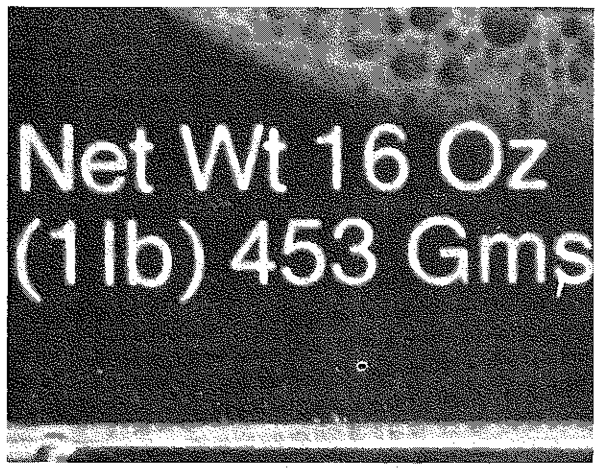


Fig. 22. Two errors.

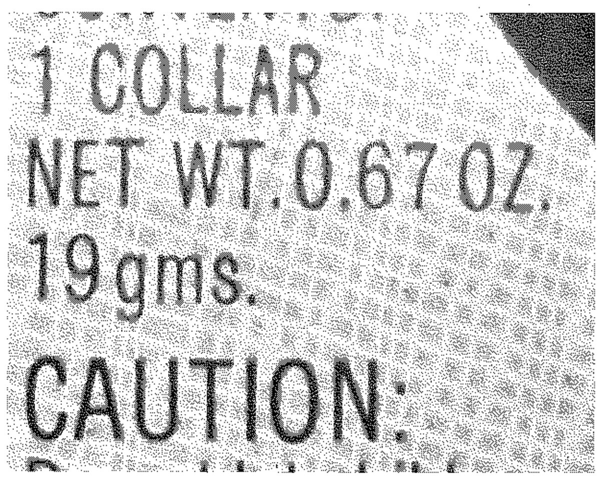


Fig. 23. Two errors.

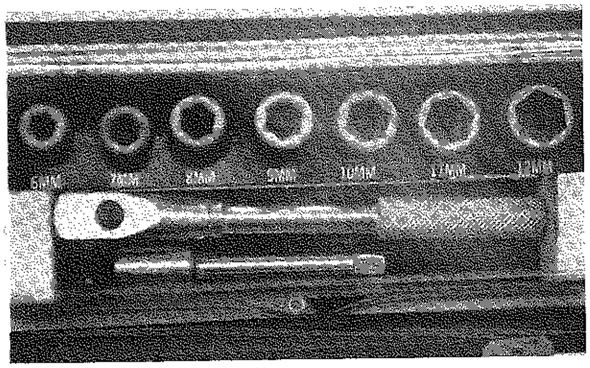


Fig. 24. Two errors.

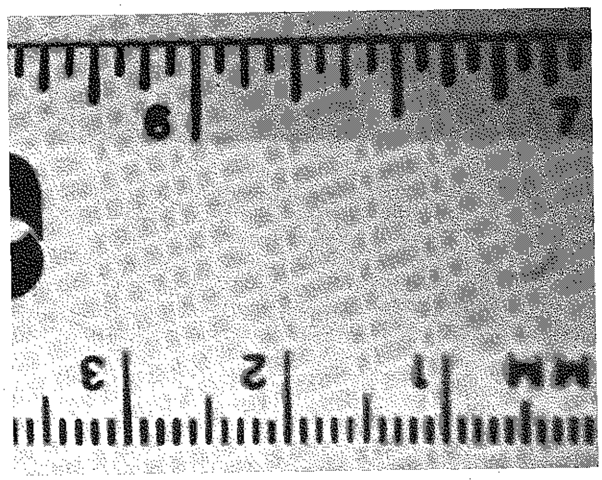


Fig. 25. One error - A good many measuring devices make the additional mistake (as this one has done) of not only committing an error of form, but of indicating the wrong units as well. The unit designation on this should really be "cm".

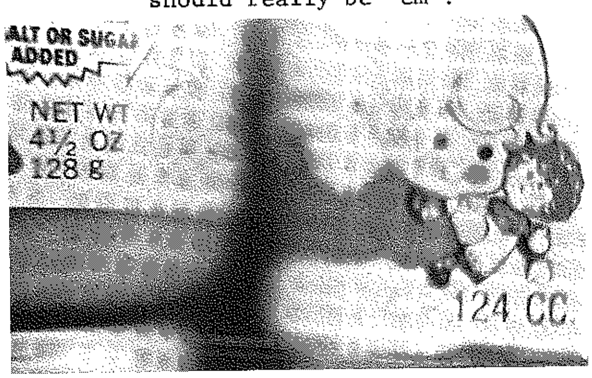


Fig. 26. Two errors - Both of these baby food containers contain 4 ½ ounces. But one is labelled in avourdupois ounces and the other in fluid ounces. Now one is labelled in mass and the other in volume, which may be acceptable, but it would be less confusing to have all products of a similar nature marketed by the same units. Unfortunately, the company which is marketing by volume has made additional errors by using the abbreviation "cc" instead of "cm^3" , and the really appropriate symbol should be "ml".

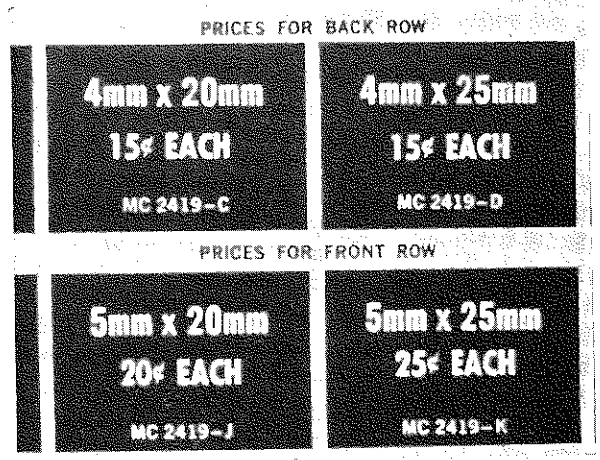


Fig. 27. One error - Actually this example looks reasonably correct until one realizes that what is being priced are metric cap screws. Then it's apparent that everything about the entire specification is wrong.

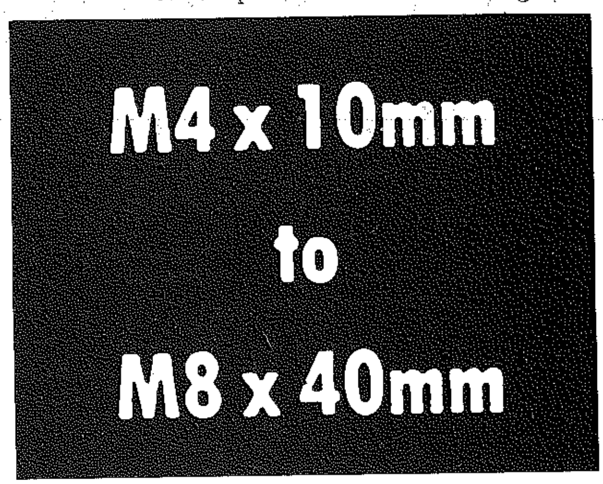


Fig. 28. One error - Similar to Fig. 27, this example looks deceptively close to being correct; but once again it is being used to specify cap screws and at best can be described as drastically incomplete.

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Department of Mathematics
Haifa, Israel

Arwas

Banai

A QUICK APPROXIMATION of the DEVELOPMENT ANGLE of an OBLIQUE CONE

In many cases it is convenient to establish the value of the development angle of a cone if, for instance, material is to be prepared for the actual construction of a conical envelope.

The development angle α of a right circular cone is that of a sector given by

$$\alpha^\circ = 360 \frac{R}{L}$$

where R is the radius of the circular base and L, the true length of the generating element. However, it is generally considered quite difficult, if not impossible, to establish in advance the development angle of an oblique cone.

Mathematically, this angle is given by an integral of the elliptic type which could not be solved by the usual methods.

However, application of the Computer to this problem permits this angle to be calculated very accurately. Further, a Computer plotter can be used to prepare an alignment chart, through which, given the particulars of the cone, a quick approximation of its development angle can be made accurately.

Development of an Oblique Cone:

Given the cone as shown in Figure 1 in a first-angle projection, the usual graphical method consists of dividing the base circumference into a number (n) of equal parts, then developing the cone envelope as one would an inclined pyramid of the same number of faces, placing one triangular face next to the other, using the true length of the elements.

Using this method on a computer, the division of the circumference could be greatly increased to, say, 100 to 200.

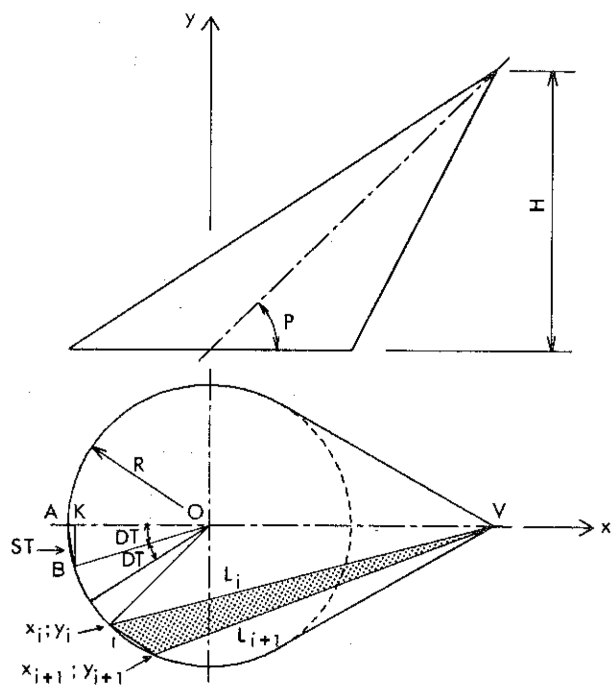

Figure 1

Assuming Angle $DT = \frac{2\pi}{n}$

H = height of the cone

P = its angle of inclination

R = radius of the base circle

we have OV = H/tan P

It is possible to compute the true length of the cone elements in a single loop, as follows:

$L_1 = \sqrt{(OV-OA)^2+H^2} = \sqrt{(OV+R)^2+H^2}$

$L_2 = \sqrt{(OV-OK)^2+(R\sin DT)^2+H^2}$

$= \sqrt{(OV+R\cos DT)^2+(R\sin DT)^2+H^2}$

$L_3 = \sqrt{(OV+R\cos 2DT)^2+(R\sin 2DT)^2+H^2}$

.
.
.

$L_n = \sqrt{\{OV+R\cos(n-1)DT\}^2+\{R\sin(n-1)DT\}^2+H^2}$

$L_{n+1} = L_1 = \sqrt{(OV+R\cos nDT)^2+(R\sin nDT)^2+H^2}$

The development itself is shown in Figure 2. The previously mentioned faces can be plotted as triangles of sides L_1, L_2, $L_3 \ldots L_n$ and of a constant base ST given by:

$$ST = \sqrt{2R^2(1-\cos DT)}$$

The vertex angle DA of the first triangle can be computed using the law of cosines:

$$\cos DA = (L_1^2 + L_2^2 - ST^2)/2L_1 \cdot L_2$$

and so on for the remaining triangles.

The development plotted in Figure 2 was based on the dimensions assumed for the cone shown in Figure 1, i.e.:

H=2"; P=45°; R=1"; n=60.

In this case the total of the development angle DA=A, was computed as 108°.

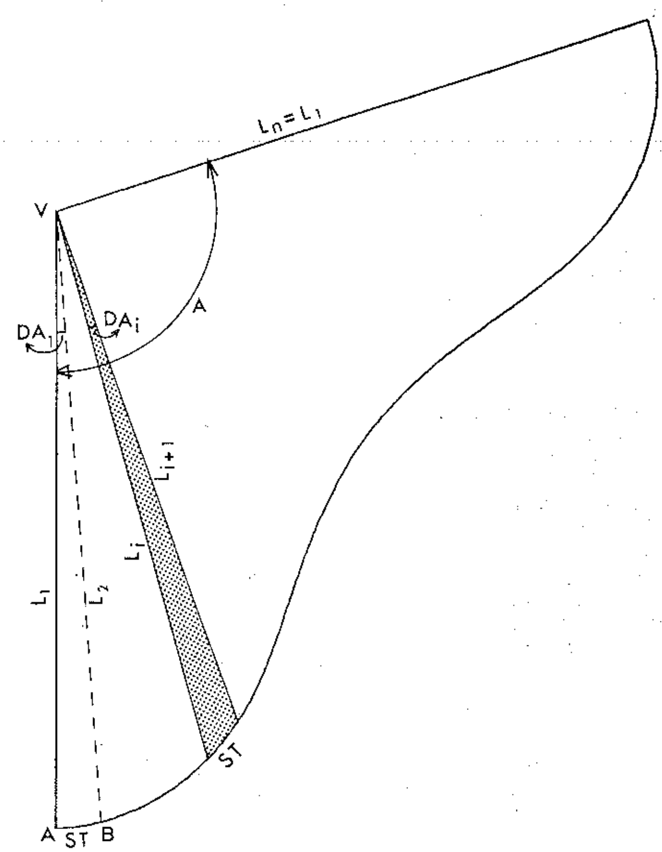

Figure 2

Alignment Chart:

By converting this program into a subroutine, computing the angle of development for different ratios of H/R, starting from 0.1 up to 10, and angles of inclination P from 5° to 90° we have plotted several curves for every 5 degrees.

The resulting series of curves shown in Figure 3 could be also interpreted as being the representative curves of the function H/R=f(A), where "A" is the development angle of the oblique cone, and each curve is the locus of the cones of inclination P.

The various curves, thus plotted, form a convenient alignment chart which could be put to use in most practical cases.

Application:

Assuming we want to find out what would be the angle of development of the envelope of an oblique cone whose height is 7"; its base radius R=2" and its angle of inclination P=40°.

Using the alignment chart shown in Figure 3, determine first the ratio H/R which in this case is equal to 3.5; then starting from that point on the H/R scale and moving parallel to the axis A, draw a line up to the curve P=40° on the chart--otherwise stop at a point estimated by interpolation.

From that point move down to read on scale A: 54° which is a good approximation of the angle of development.

Notes:

1. The alignment chart employs the ratio H/R and not separate scales of H and R. Such separate scales could have been represented in a sub-nomogram using the scale H/R as a reference scale, but this would have limited use of the alignment chart to specific dimensions of the cone height and its base radius, while the ratio H/R covers a much larger range of practical cases.

However, the nomogram shown in Figure 4 has been provided for a quick reference which could prove useful in many cases.

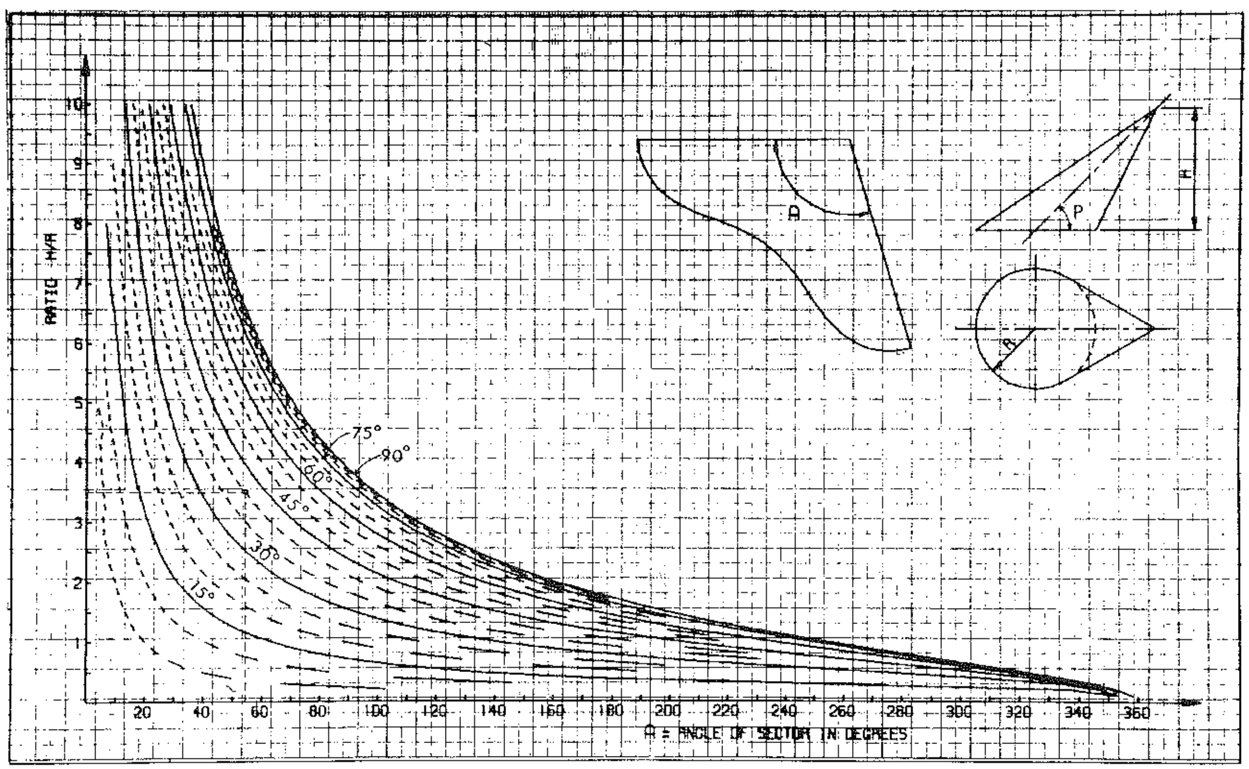

Figure 3

2. The function curves, shown in Figure 3, being similar to the $y=x^m$ $(m<o)$ type, could have been plotted as practically straight lines, but this would have in turn reduced the accuracy for small values of the ratios H/R and required the use of logarithmic scales instead of the simpler linear scales illustrated.

General References:

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3. Arwas, J. 'Graphical Mathematics' Michiol (Technion) 1974.

4. McCracken, D.D. "A Guide to Fortran IV Program' John Wiley & Sons.

5. IBM Manual, 'IBM System/370 Fortran IV Language'.

6. Computer Center, 'Plotter Guide' Technion Press 1971.

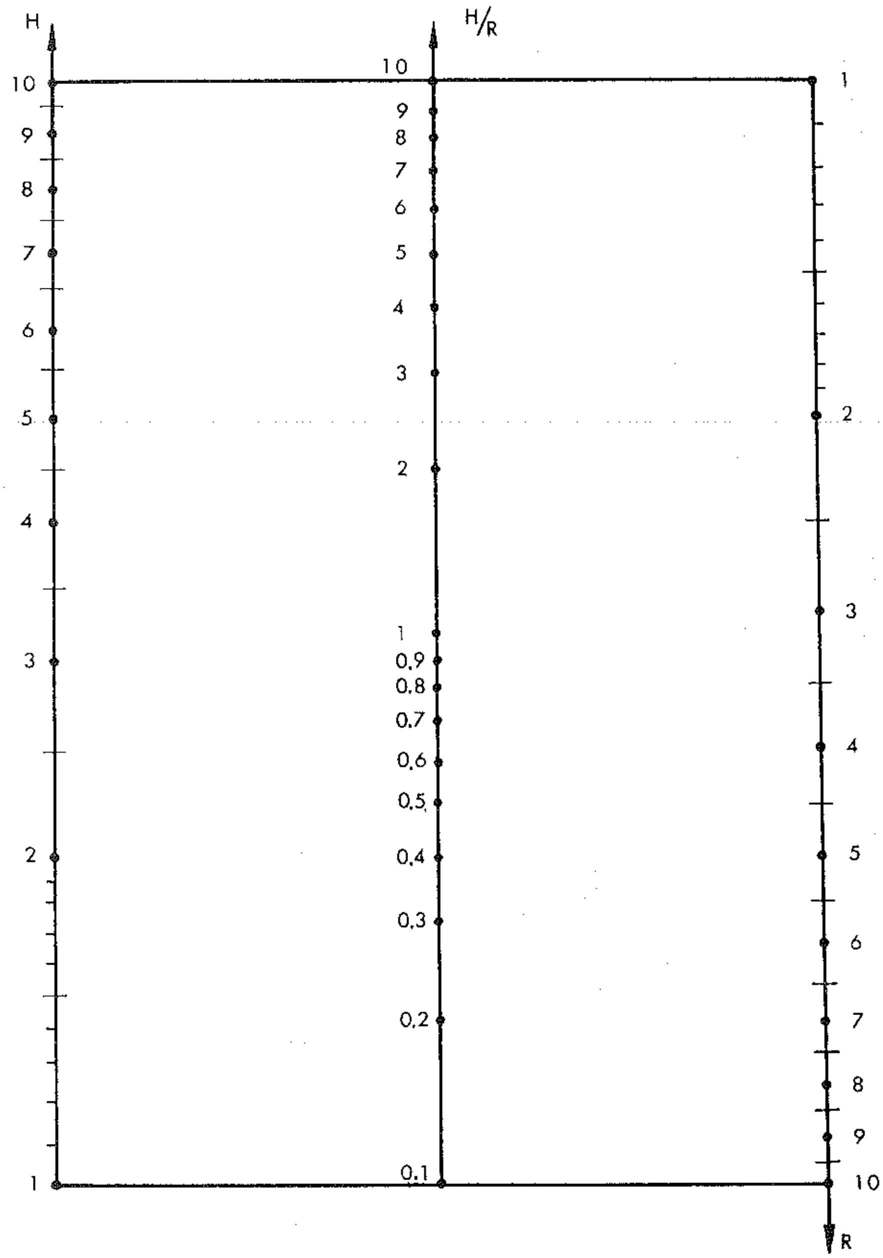
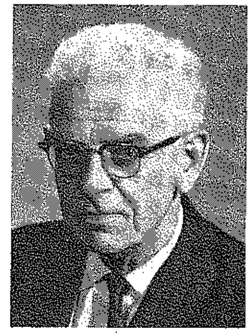


Figure 4

Q: What is as scarce as hen's teeth?

A: A cross word from Almfeldt!

ALMFELDT'S CROSSWORD



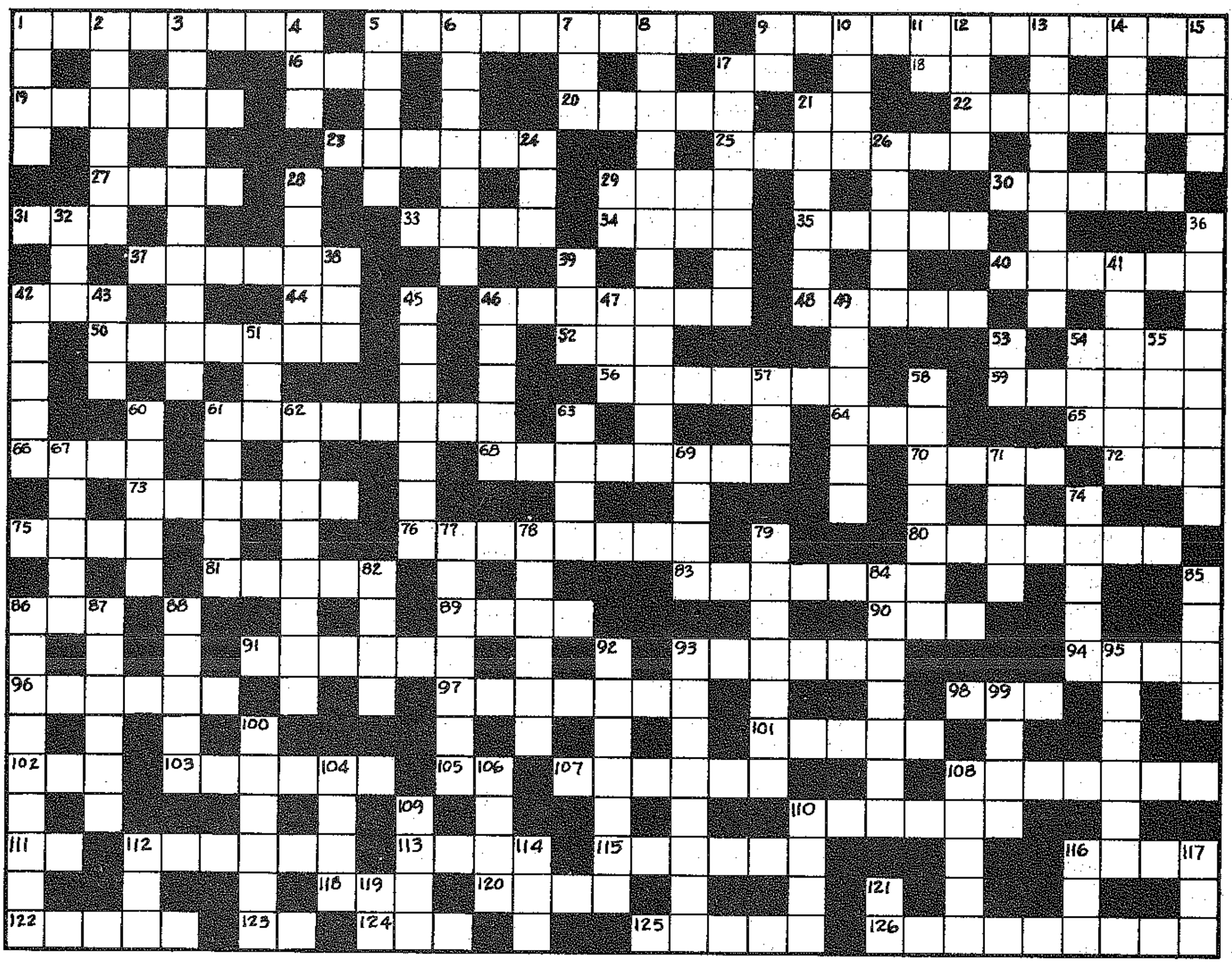
M.W. Almfeldt
Professor Emeritus
Iowa State University

Maurice W. Almfeldt, better known as "Al" to most of us, composed this crossword puzzle a long time ago and recently plopped it on my desk, commenting with his dry New England humor that HE didn't know what it was good for, and that I could throw it away better than HE.

I was amazed, to put it mildly. How people construct these things has always been a mystery to me, and here was one of the Gifted, right in our midst, in the person of Al Almfeldt.

So, here it is. Wayne C. Dowling looked it over and noted that there were a few undefined two-letter combinations, but no doubt you can get past those. Have fun. The treat's on Al.

We'll have the solution in the Fall issue. That should give you plenty of time to figure out 101 Across and 17 Down.



Across

1 Position
5 Size description
9 Actual sizes
16 Unified (Abbr.)
17 Dip direction
18 Professional Engineer (Abbr.)
19 Measured size of an object
20 The act of entering
21 Compass direction
22 A sub-division of a chapter in text
23 Dry Diazo print
25 Multiplied by itself
27 Compass direction
29 Important factor in any design

30 Eradicate
31 Non-arrow side in welding
33 A common type of gage
34 An S-shaped curve
35 A sloping edge
37 A type of elbow
40 To tie together
42 Ratio of side opp. to adj. (Abbr.)
44 Branch of engineering
46 Helical ridges
48 Quotient
50 Side view
52 A common type of screw
54 An example of an annular torus
56 Isometric picture of a square
59 A machine whose cutting tool travels
61 Freehand drawings
64 A thin flat plate connecting 2 more solid parts
65 A horizontal view
66 A form of welding
68 A device for fastening a collar to a shaft
70 Determined by two points
72 A period of time
73 Mate
75 A measuring device
76 Machines used to produce smooth surfaces
80 Method of copying an original drawing
81 Ratios of the side opp. to the hypotenuse
83 To separate
86 Used with ink
89 Aeronautics (Abbr.)
90 Designation for time in the Eastern time zone
91 Orthographic specifications for single part.
93 Self evident principles
94 Keyway
96 A common material for piping
97 A style or type used to emphasize importance
98 Rotational speed (Abbr.)
101 Inner circle of a Hyperboloid of Revolution
102 Friction reducer
103 Slot for a key
105 Federal Commission responsible for reactor monitoring (Abbr.)
107 Pincers for holding small objects
108 Spacers
110 Hidden
111 Inside diameter
112 Twice original size
113 Egg shaped
115 Tabulated values
116 Used to close a pipe
118 Horizontal portion of the slope ratio
120 Shows locations of cities, rivers, etc.
122 Constant elevation
123 Opp. of right hand
124 Unit of time (Abbr.)
125 Lettered, on an office machine
126 Threaded, removable or permanent devices

Down

1 Lateral distance traveled in 1 revolution of a helix
2 A common type of pin
3 Connector between 2 different shaped openings
4 Important part for a bolt
5 Commonly called ozalid print
6 Operation performed on a milling machine
7 Soc. of Automotive Engineers (Abbr.)
8 An important method of projection
9 Branch of engineering
10 Measure of surface
11 Opposite of down
12 To interpret and understand
13 Substance
14 Thread reliefs
15 Non-parallel, non-intersecting
17 Functional assemblies of components
21 Quantity required
24 Direction & slope angle of steepest downhill line on a plane
26 A permanent fastener
28 Malleable alloy of iron & carbon
29 Company (Abbr.)
32 American Standards Assoc. (Abbr.)
36 On the inside
38 Three outlet pipe connector
39 Electric welding
41 Three times original size
42 Surface formed by revolving a conic section
43 Straight thread specification
45 Used as a reducer in piping
46 A framework for supporting a roof
47 Used for listening
49 The ultimate goal of any problem
51 Liquid used in pens
53 Master of Science (Abbr.)
54 To thread a hole
55 Opposite of front view
57 Small compass
58 Spheroids
60 A common material used by industry
61 Mathematical symbols
62 You are studying to be one
63 A fastener, threaded on both ends
67 Surface defined by 2 intersecting lines
69 Vertical portion of the slope ratio
71 Arrow side of weld symbol
74 Measured value or distance
77 Readjust a drawing
78 Perpendicular to a plane
79 Circular, helical fasteners
82 A form of welding
84 Plans and sketches a new object, etc.
85 A high pressure valve
86 A view showing 3 principal planes
87 A short pipe
88 Examine carefully
92 Stress relievers at the intersection of 2 unfinished surfaces
93 All parts put together
95 Composed of lines
99 Top or map view
100 Graphical representation
104 American (Abbr.)
106 To enlarge a hole
108 Permanent fastening
109 A fine whetstone
110 Employed
112 Sometimes used in expressing a bearing
114 Latitude (Abbr.)
116 A round fastener, usually tapered
117 A form of welding
119 United States (Abbr.)
121 Symbol for Wide flange

Robert D. LaRue, PE
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The Ohio State University

HOW WOULD YOU DRAW IT?

ABSTRACT

Those with no previous experience in computer programming who are interested in computer graphics may be overwhelmed by what they perceive to be complicated hardware and computing languages as well as the probability of using higher mathematics.

This paper points out that user and programmer aspects of hardware are easily understood and that a computer language can be learned without much difficulty. Furthermore, a great deal can be done in computer graphics using mathematics at a level no higher than simple analytical geometry and trigonometry. In fact, a strong background in engineering graphics may be more useful than an equivalent mathematical background.

"Almost any set of numbers may be presented in the form of a picture that will describe their relationship far better than any tabular listing."

R.A. Holekamp

"I always say that when you can express something about which you are talking in numbers then you know something about it."

Lord Kelvin

INTRODUCTION

The quotations given above may appear to be contradictory. However, the first is another version of one of Confucius sayings - "A picture is worth a thousand words" - with which most will agree. When one considers that a digital computer is only a device for high speed manipulation of numbers (even though drawings are the final output), the significance of both statements relative to computer graphics can be seen.

One experience common to most of us is that of making a picture by drawing straight lines to connect a series of sequentially numbered points. In some cases, the instructions might indicate that no line was to be drawn between certain points in the sequence.

Essentially, the processes followed in producing computer generated drawings are the same as those described above. Some type of graphical output device under computer control causes lines to be (or not to be) drawn as the "pen" of the device is moved (in straight lines) from point to point.

In some cases, there are four numerical values associated with each point involved in the drawing.

1. A number identifying the sequence in which the point is to be used;

2. The x, y coordinates of the point;

3. A number indicating whether or not a line is to be drawn between the previously located point and this point.

As far as this paper is concerned, we will classify those interested in computer graphics as <u>users</u> or <u>programmers</u>. The user wants to be able to go to a graphics terminal and produce

This paper by Bob LaRue was presented at a joint Illinois-Indiana-North Central Section meeting in April, 1977. The two other papers given at the same session appeared in the last issue (EDG Journal, v. 42 n 1, pp 12 & 22.)

graphical output with a minimum of effort. This means little or no language capability. On the other hand, the programmer is interested in producing graphical software for use in a computing system. We will consider the minimum language and hardware knowledge required for this type of individual and will examine how a good knowledge of engineering graphics can be extremely useful.

HARDWARE

While there are many types of graphical devices which can be used to input information into the computer, they will not be discussed in this paper. As far as output devices are concerned, x-y plotters and cathode ray tubes (CRT) will be briefly examined.

Plotters are relatively slow operating devices in which the computer controls the relative motion between a pen and the plotting surface (paper, film, etc.). On a flatbed printer the pen is mounted on a carriage which permits movement in both x and y directions. The paper on a drum plotter moves in the x-direction, while the pen moves in the y-direction.

Depending upon the transmission linkage between computer and CRT, the speed at which a graphic display can be completed will vary between slow (although faster than the plotter) and extremely fast. In general, CRTs can be classified as storage or refresh types. Both work because the surface of the tube is coated with a phosphor which will give off light when struck by an electron beam. Storage CRTs have high persistance phosphors on which a line may remain for an hour after it has been generated. Refresh CRTs utilize low persistance phosphors. A line may need to be "redrawn" 60 times per second if the viewer is going to have a picture to look at.

Let us assume that the terminal used in conjunction with the programming discussed in the remainder of the paper will have a storage type CRT for displaying graphics and/or messages from the computer and keyboard (similar to a typewriter) which will be used by either programmer or user to send messages to the computer. Thus we have a simple interactive graphics system.

Minimum knowledge of this hardware is what happens when certain special keys on the keyboard are pushed. It also might be well to know where the on-off switch is located!

LANGUAGE

A computer language is a means of communicating with the computer so that certain desired results can be accomplished. There are many languages which can be used to do computer graphics. Most hardware manufacturers will furnish (for a price) programs which will produce various types of graphical output. Minimum requirements are for enough "software" to permit programming the various functions which the hardware is able to perform. In most cases, this software will be compatible with the language used on the computing system.

The programmer must learn the language in which the graphical programs will be written. In general these languages (BASIC, FORTRAN, APL, etc.) are easy to learn. Meticulous care must be used when writing a program. What may appear to be a relatively insignificant error (ie., omission of a parentheses) may produce total disaster when the program is run.

Perhaps the most important thing to be learned (and this applies to <u>any</u> language) is the logic involved. A program is a logically arranged sequence of step-by-step instructions which describe a process to the computer. Another characteristic of programming is that a relatively short, properly written program can produce an enormous amount of useful information. This is possible because the computer can repeat a short sequence of commands very rapidly. By changing the values of numbers used for each repeated computation (and these changes can also be programmed) new results are obtained on each successive run through a program sequence.

INTERACTIVE COMPUTER GRAPHICS

Once the user has established communication with the computer (through interactive use of keyboard and CRT), the computer might ask - "What do you want drawn?" Assume that a program to draw various geometric shapes is being used. The user might respond by typing in the word CIRCLE. At this point the computer would probably request the location of the center and radius or diameter of the circle. After this information was received, the requested shape would be "drawn" on the CRT.

How would you draw it? Probably by locating the center on the drawing surface, setting the radius on a compass, and drawing the circle. If a circle template with the proper diameter was available it might be used instead of the compass. Notice the similarity between the operations here.

What was involved in developing the program for the user? We will omit the conversational part of the program and consider requirements after the shape, size, and location have been made available to the computer.

A general equation for a circle is

$$(x - x_c)^2 + (y - y_c)^2 = r^2 \qquad (1)$$

where x and y are points on the circle; x_c and y_c are coordinates of the center of the circle; and r is the radius of the circle.

A program could be written using this equation but there are a few disadvantages as far as graphical output is concerned.

The following set of equations is much easier to use and produces as good (if not better) results than equation (1)

$$x = r \cos\theta + x_c \qquad (2a)$$

and

$$y = r \sin\theta + y_c \qquad (2b)$$

Definitions are the same as for equation (1). However, θ is an angle measured from the center and x-axis of the circle.

The program required to produce the circle would include the following sequence of steps:

1. Choose an increment, $d\theta$;
2. Set $\theta = 0$;
3. Compute x, y and MOVE* to this location;
4. Increment θ;
5. Compute x, y and DRAW* to this location;
6. Repeat steps 4 and 5 until the circle has been completed.

If an appropriate value was selected for the resulting graphical output would look like a circle. However, it would actually be a regular polygon with a large number of very short sides. Consider what the resulting output might have been had equation (1) been used with equal x-increments.

A LINEAR GEOMETRIC PATTERN

The particular geometric pattern (see Figure 1) to be discussed in this section is to demonstrate that the programmer may have several options as he develops a program for a particular geometric shape. In all probability, the user would request PATTERN and be asked for information including location, size and orientation.

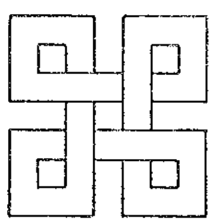


Fig. 1 Geometric Pattern

How would you draw it? Figures 2a and 2b show one way in which the pattern might be manually produced. A light 7 x 7 coordinate grid could be drawn; the end points of all horizontal lines located and those lines drawn; and, finally, a similar procedure could be followed to produce the vertical lines. Even though there are some repeated patterns in both horizontal and vertical line sets, this approach does not seem to be amenable to easy programming.

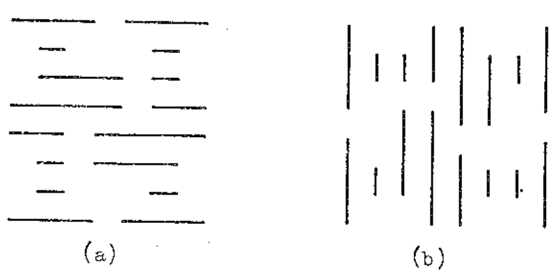


Fig. 2 Horizontal and Vertical Line Components of Pattern

* MOVE means that the electron beam is to move from its current to new location without "drawing" a line while DRAW indicates that a line is needed.

Figures 3a, 3b, and 3c show that the pattern can be constructed using squares. This approach might appeal to the draftsman who has a square template. Once the size of the small squares have been established only the location needs changing to permit all five small squares to be produced by one program segment.

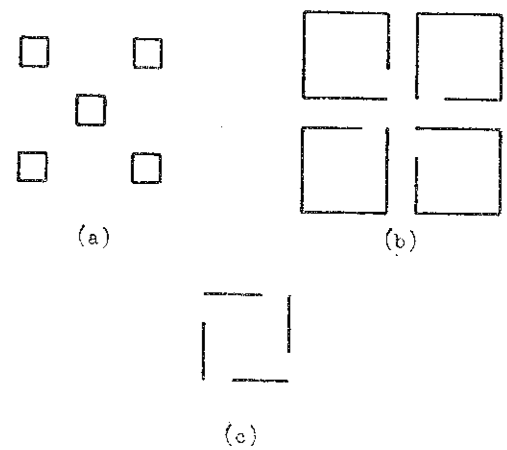


Fig. 3 Square Components of Pattern

If the program segment is expanded slightly to permit constructing squares having sides which are incomplete, the same segment could be used to construct the large squares.

Still another approach is illustrated in Figures 4a and 4b where geometric elements in the shape of the letter P are used to construct the total pattern.

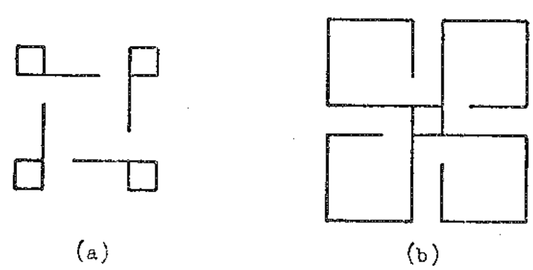


Fig. 4 Letter 'P' Components of Pattern

It has previously been mentioned that plotters are quite slow. If plotting efficiency is defined as the ratio of the total length of line drawn to the total travel (including movement where no lines are drawn) it is suspected that plotting efficiency would be different for each of the three approaches shown. This is a consideration that should be evaluated when developing programs for use on a plotter.

GASKET

The pattern shown in Figure 5 would normally have one large and two small circles within the outer boundary. Since the requirements for producing circles has already been discussed, the boundary shown will be used to illustrate another aspect of programming for graphic output.

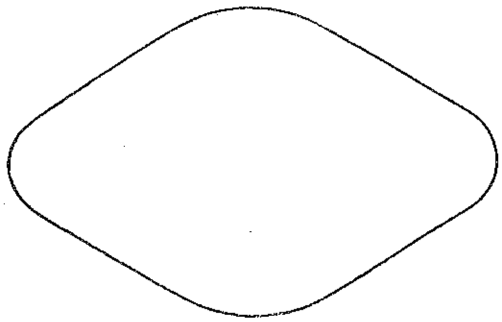


Fig. 5 Gasket Border

The information supplied by our user (after he has requested GASKET) would include the circle information as well as the center-line distance to the center of the small arc and the radii of both arcs.

How would you draw it? Probably, using the information as input by the user, the tangent would be constructed between the two arcs in one quadrant of the total pattern. Then utilizing the symmetry (around both axes), the location of the remaining tangent points could be easily established by transferring measurements between quadrants.

Computing the coordinates of the tangent points as well as the angular relationships needed to construct the arcs can be done using a simple right triangle relationship. The programmer should sketch the tangent construction and see that the hypotenuse of the triangle is equal to the distance from the center of the large arc to the center of the small arc and that one side of the triangle is equal to the difference between the radii of the arcs.

Again, a short program segment is all that is needed to compute these relationships. Furthermore, a repeating pattern exists around the border. Arc, line, arc describes the geometric components in each quadrant of the figure. This relationship can be used in establishing the repetative portion of the program.

RIGHT CIRCULAR CYLINDER

The last geometric shape was chosen to demonstrate that looking at a three-dimensional geometric shape from the viewpoint of its graphical representation may be of great help to the programmer in his development of graphical programs.

The user call to the computer for this program might possibly be BEER CAN. Hopefully the computer would request diameter, length, axis location and orientation rather than what kind and how many.

Figure 6 shows the general orthographic view of a right circular cylinder with axis inclined to the viewer's line of sight. Notice that one end is represented by a complete ellipse, the other end by a half-ellipse and that these two components are connected by a pair of straight lines.

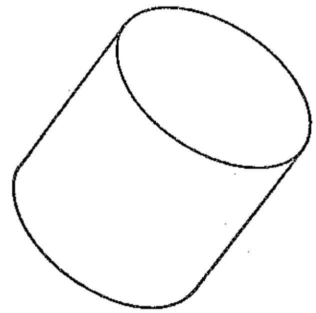


Fig. 6 Right Circular Cylinder

Just as a circle could be produced by a small program which was provided with location a diameter information, an ellipse program can be developed. For the cylinder representation the ellipse segment would require location of center, major and minor diameters and orientation of major axis.

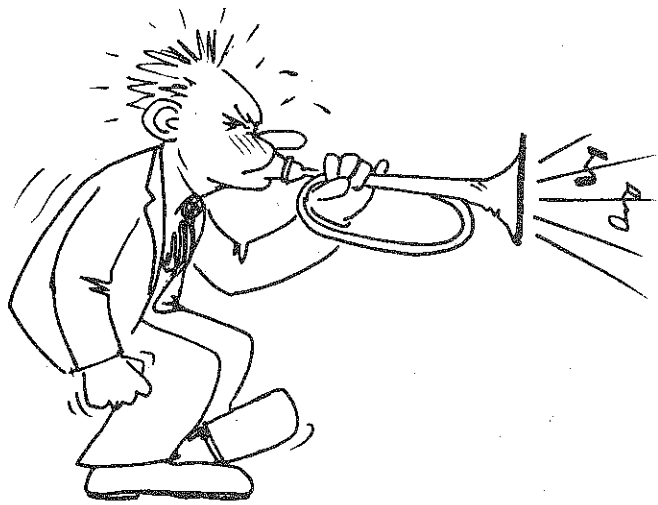
In the orthographic representation of a right circular cylinder, the centers of the two ellipses are at the ends of the axis of the cylinder. Furthermore, the length of the major diameters is ALWAYS equal to the diameter of the cylinder and the orientation of the major diameters is ALWAYS perpendicular to the cylinder axis. (It should be emphasized that the relationships that have just been described are for those lines as they would appear on a drawing). One other factor is that the minor diameter is parallel to the cylinder axis and, therefore, perpendicular to the major diameter of the ellipse.

The length of the minor diameter can be related to the view length of the cylinder axis. The equations necessary for this relationship and also for determining the locations of the ends of the axis can be established by the programmer from a set of axonometric views constructed to show these relationships.

Finally, it should be noted that the two straight lines that complete the view extend between the ends of the major diameters of the two ellipses.

CONCLUSION

Since computer graphics is finally coming into general use in industry, there need to be programs for developing users and programmers. For both types an understanding of engineering graphics can be very useful. For the programmer, knowledge of languages and some mathematics is essential.

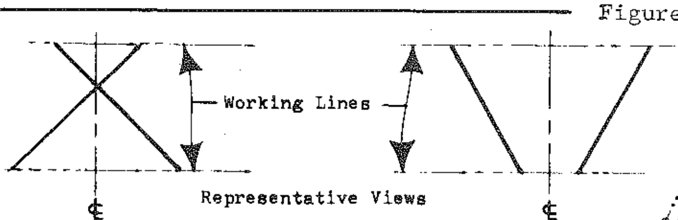


PUZZLE CORNER

With that fanfare we are elated to announce the appointment of Robert P. (Pat) Kelso to the position of Editor of the Puzzle Corner, (or whatever he chooses to call it) and thank him in advance, but not for the last time, for his contribution. Pat will serve for an indefinite period, probably limited only by his endurance. In this position, he will select puzzles and compose whatever material seems appropriate for the column. It appears that it may be quite a task, but Pat is certainly up to the challenge.

The problem last posed in the Puzzle Corner (EDGJ Vol. 41 Number 3 p 62) was to find the view in which two skew lines would appear equal in length but not parallel. The problem was originally suggested by Professor Abe Rotenberg from the University of Melbourne, and at this point I must apologize for misquoting Professor Rotenberg who actually said "Perhaps, the statement 'There are at least three ways to solve this problem' applies to any solvable problem of Descriptive Geometry." In any event, it still seems to be an accurate and appropriate observation.

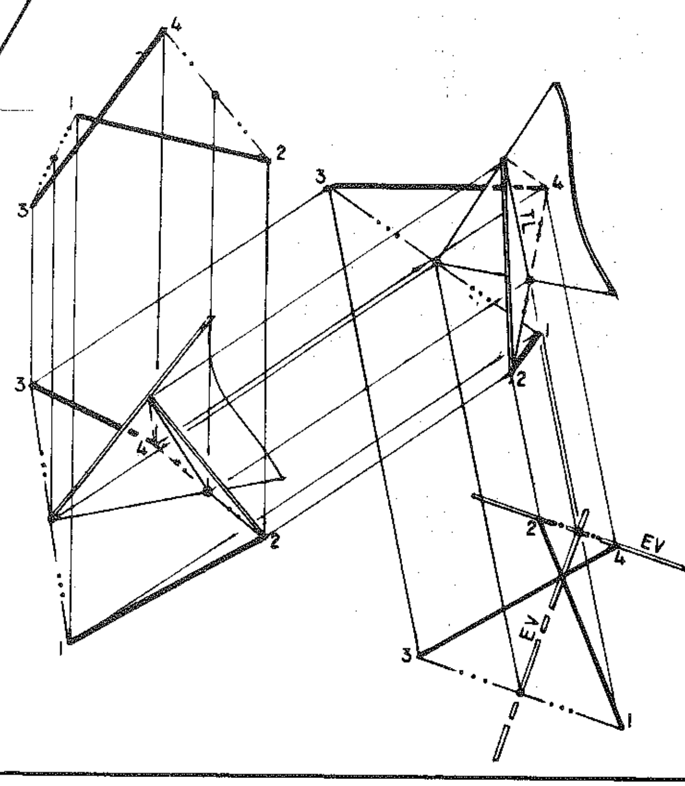
Figure 1



General Approach:

Achieve a single orthographic view in which the given lines appear symmetrical and in which the "working lines" connecting their end-points appear parallel.

This is accomplished by (A) constructing a plane containing-one-of-the-working-lines-and-parallel-to-the-other-working-line and (B) constructing another plane perpendicular to the plane-containing-the-working-line and which also passes through the mid-points of both owrking lines. The edge view of this latter plane will define the line of symmetry, therefore, the projection which shows the edge views of both planes (by projecting the end-view of their line of intersection) will show the given lines to appear symmetrical and the working lines to appear parallel -- which is a solution.



In addition to the original problem and solution submitted by Professor Rotenberg, a solution was received from the new Puzzle Corner editor, Pat Kelso, who has joined Louisiana Tech University at Ruston since his last submission and whose solution to this problem appears in Figure 1. Professor Walter N. Brown of Santa Rosa Junior College also responded again with a solution to the new problem. The method used by Professor Brown was also used by Professor William P. Harrison of VPI & SU, whose solution appears in Figure 2 with a description.

Professor John Boyden of the State University of New York at Canton submitted a solution appearing in Figure 3. The method is essentially the same as that used by Professors Brown and Harrison.

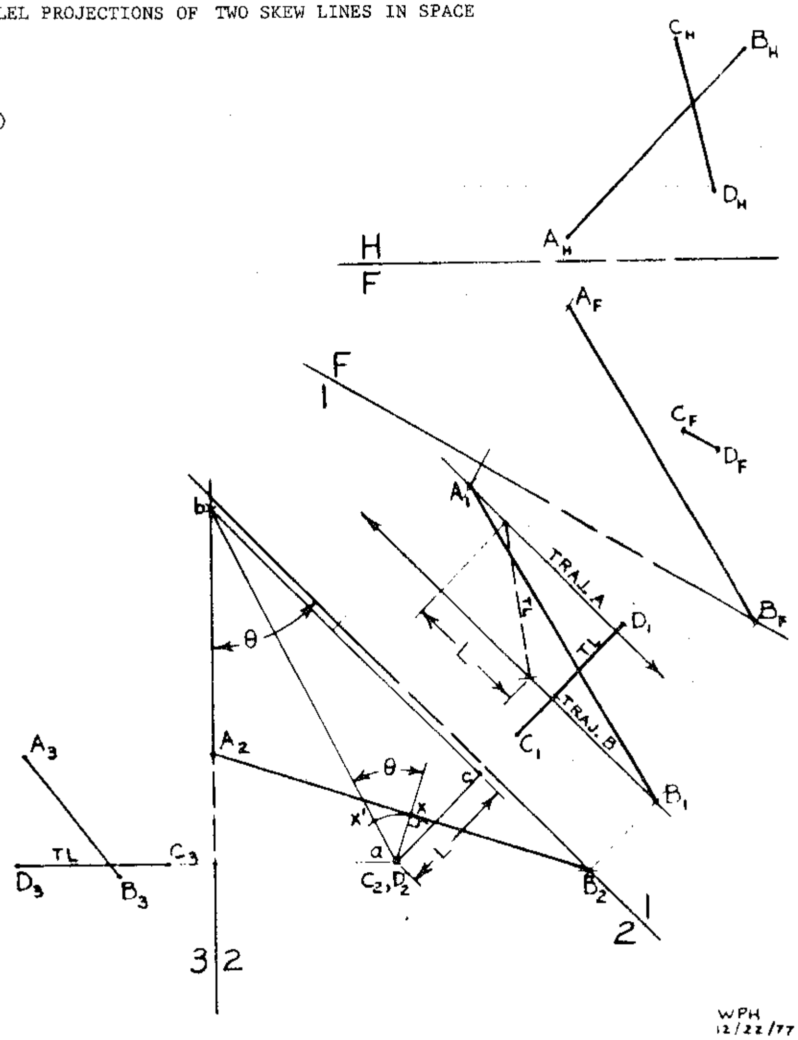
Several of the solutions received in the Puzzle Corner have been accompanied by problem suggestions, and I am sure the editor will want to consider them for future problems. The new Puzzle Corner problem was among several submitted by Professor Boyden with his latest solution. It looks like a real challenge.

Figure 2

THE PROBLEM OF FINDING EQUAL-BUT-NON-PARALLEL PROJECTIONS OF TWO SKEW LINES IN SPACE

A general approach to the solution of this problem is to obtain a point view (PV) of the shorter of the two given skew lines and then to rotate in that view until the projection of the longer line shortens to the shorter length already found in the adjacent view. By this approach, then, the problem reduces to that of finding what angle of rotation will produce the desired projection length. Once that angle is found the desired view in which the projected images of the two lines appear equal (but not parallel) can then be constructed. The specific steps performed in the attached drawing are as follows:

1. Obtain a PV (Plane 2) of the shorter line ($\overline{CD}$).
2. In Plane 1, obtain $\overline{CD}$ projection length L by transferring $\overline{CD}$'s TL to any convenient location between (and touching) the trajectory trace lines through pts. A and B. (This transferred TL is the length and is located in a parallel position to which $\overline{A_1B_1}$ would be shortened by a ccw rotation through θ degrees about the PV.)
3. To find θ: in Plane 2 lay off L from the PV, perpendicular to Plane 1, forming one leg of rt. triangle abc; then, length $\overline{A_2B_2}$ as hypotenuse through the PV (at a) gives the required angle θ between perpendicular $\overline{ax}$ and its rotated position $\overline{ax'}$
4. At angle θ from Plane 1, project the final orthographic view into Plane 3 where the projected image of $\overline{AB}$ and line $\overline{CD}$ will have equal measure.

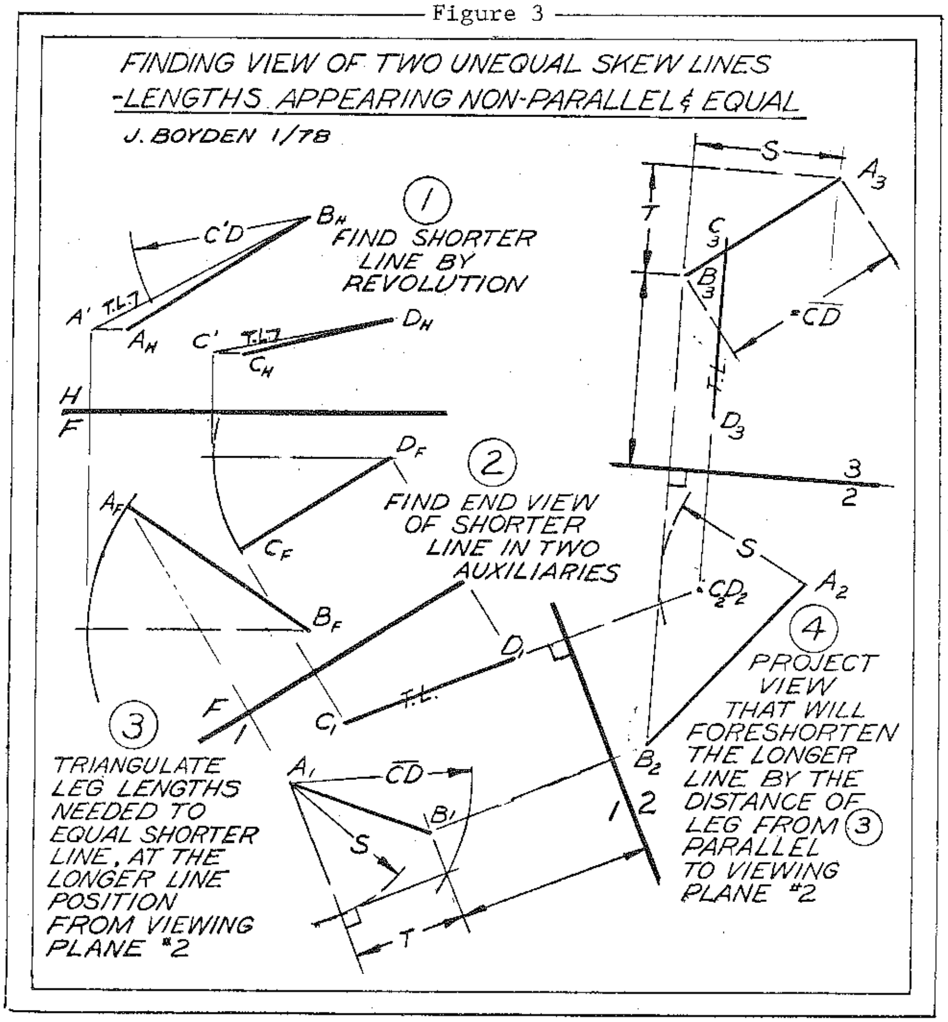


Given: an oblique triangular limited plane, and point not in plane, in any two successive orthographic views.

Find: two orthographic views that would define the diameter and center location of the sphere whose surface passes through each plane vertex and also passes through the non-planar point.

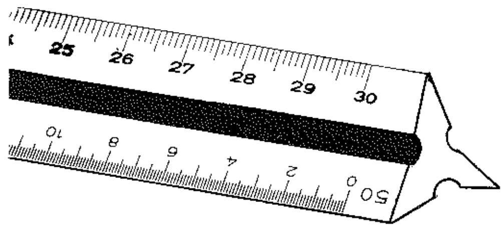
Send your solutions to the Official Journal Puzzle Corner Editor: Professor Robert P. Kelso, Head, Engineering Graphics, School of Engineering, Louisiana Tech University, P.O. Box 4875, Tech Station, Ruston, Louisiana 71272.

Figure 3



SCALES ◦ CONVERTORS ◦ PROPORTIONAL SCALES

TRIANGULAR SCALES



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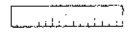
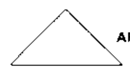
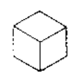
FOR CONVERSION AND METRICATION


LENGTH

IN. ↔ CM. YD. ↔ M.
FT. ↔ M. MI. ↔ KM.


AREA

IN.² ↔ CM.² YD.² ↔ M.²
FT.² ↔ M.² MI.² ↔ KM.²


VOLUME

IN.³ ↔ CM.³ YD.³ ↔ M.³
FT.³ ↔ M.³ MI.³ ↔ KM.³

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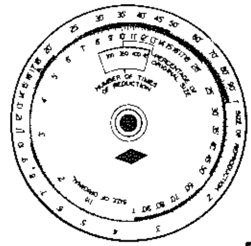

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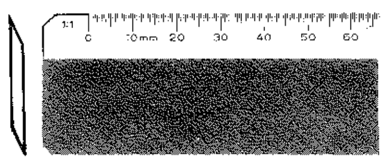

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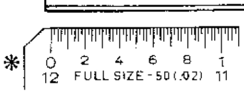
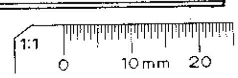
No. 573M — Divided: 1:2, mm, 50ths Full Size (.02).



● **Enlarged View of First Inch**



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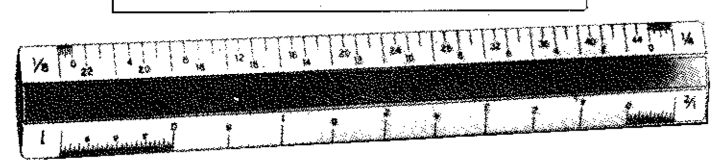

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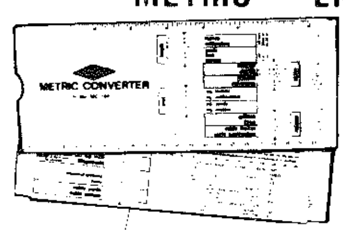

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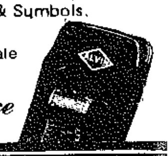

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