ENGINEERING DESIGN GRAPHICS JOURNAL

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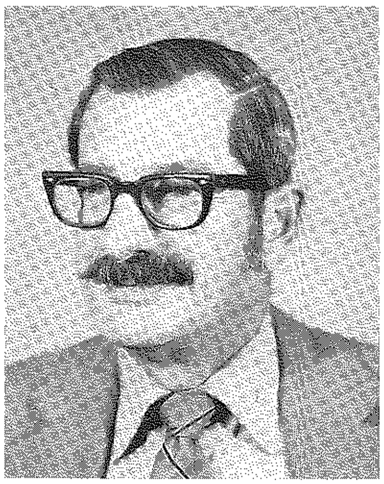
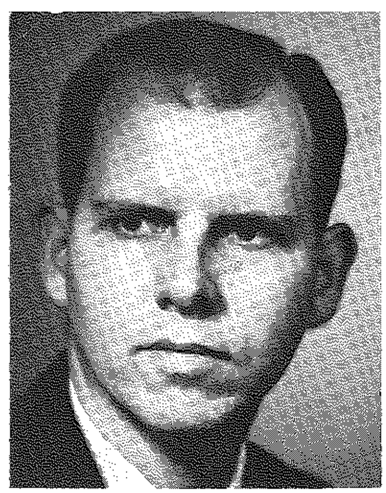


Bill Leach

Burt Fraser

A. P. McDonald



Jim Earle

MID-YEAR MEETING HOSTS

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CONTENTS

Editors' Board

EDITORIAL—ANOTHER MID-YEAR MEETING

During the past few years this section carried many words criticizing programs at the mid-year, as well as, the annual meetings of the Engineering Design Graphics Division of the American Society for Engineering Education. This past November the Division held another mid-year meeting and it seems necessary to comment on this latest of programs.

One of the complaints that has often been expressed in these pages was that too many speakers were crowded into a small period of time. At Houston, in November, this complaint would be somewhat inappropriate. Some of the attendees may have felt that the program had, perhaps, one too many speakers since little time was left, after each talk, for a question and answer period. However, these talks were interesting and easy to follow; there were not too many to listen to so as to become overbearing; the sound of the same human voices did not become tiring. Hence, one could concentrate on most of what was being said.

Another complaint was that the individual member had little, if any, chance to "put his two-cents worth" into the meeting. One found no time during which he -- or she -- could impart bits of information nor to pursue a particular line of questioning to receive desirable information. At Houston, this complaint was entirely invalid. A session was held (listed as a "rap session") during which all in attendance participated. It may have been a "wild session" but it certainly was also a very "wonderful session". Much was said in favor of, and against, areas of our discipline. Many, who have been kept quiet in the past took this opportunity to "open up". The results (notice the plural) of all this were 1) a better understanding of individuals, 2) a recognition of "unrecognized" individuals and their work, 3) vast amount of information was imparted which had been otherwise stifled and 4) a feeling, on the part of those in attendance, of being a vital part of a very important activity --- engineering education. Those who were there could, very likely, add personal results in addition to those listed, adding to value of the sessions. All of which helped to instill a sense of well-being and satisfaction in attending the meeting as well as of being a part of our profession.

Not only were we treated to an outstanding set of sessions, as has been mentioned, but our hosts had the audacity to continue the learning process while offering personal enjoyment at the same time. Although visits to industry have been made in the past, during previous conventions and meetings, it is seldom that these places would interest the delegates as well as their non-professional guests. This time, those of us who were accompanied to Houston by our wives and/or other guests were privileged to have their company while visiting the world famous Astrodome and, later, NASA. At each of these interesting places, arrangements had been made for guided tours through the facilities with well-informed and pleasant guides.

This section seldom mentions names of people. However, exception must be made now since we sincerely believe that those who were responsible for such a pleasant and informative meeting must receive proper recognition. Upon arriving at the registration table we met Burt Frazer and Bill Leach, both from the University of Houston. They were asked who did most of the work for the meeting and neither claimed credit. They recognized each other along with Jim Earle from Texas A&M University and A. P. McDonald from Rice University. In fact, both Jim Earle and A. P. McDonald also minimized their own efforts in the preparation for this memorable meeting. Who do we believe? I feel that they are all to blame: It takes more than one individual to plan such an activity with all of its important facets to satisfy "characters" like us. There were so few complaints concerning this meeting that we are sure that all of these colleagues had their "two cents worth" in it. Surely, Burt Frazer, Bill Leach, A. P. McDonald and Jim Earle all did their parts to make the 1971 Mid-Year Meeting of the Engineering Design Graphics Division, ASEE, a success. Those who missed it certainly have something to think about.

Closing on a personal note, my THANKS to all those who were responsible for the 1971 Mid-Year Meeting --- whether they admit to it or not.

Borah L. Kreimer
Editor

Perspective

Paul M. Reinhard

The Division of Engineering Design Graphics of the American Society for Engineering Education, engineering education as a whole and education in general, lost a unique individual in the person of Paul M. Reinhard. Paul died on September 5, 1971 after a lengthy illness.

Paul M. Reinhard was born in Eau Claire, Wisconsin on September 28, 1913. He attended the Eau Claire State University and the Stout State University in Menomonie, Wisconsin from which he received the Bachelor of Science degree. He received his Master of Arts degree from the University of Michigan and taught in schools in Greensborough and Charlotte, North Carolina before assuming the position of Civilian Training Supervisor at the 334th Sub-Depot located in Morris Field, Charlotte, North Carolina. He served two years with the United States Navy as a Lieutenant in the Pacific area. He participated in the invasion of Iwo Jima.

Prior to coming to the University of Detroit, Paul taught for several years at the Adrin High School in Adrin, Michigan. He completed 18 years of service at the University of Detroit where his work resulted in one of the most outstanding engineering graphics departments in the country. His department pioneered instruction in computers, computer programs as well as engineering design. Through his leadership and through his department the University of Detroit had one of the first programs for teaching freshmen the language of the computer and introducing them to the creative world of design.

He served our Division exceptionally well in various capacities. He was the Chairman of the Computer Graphics Committee of our Division as well as other committees over the years. His largest impact was in the extraordinary job he did in organizing the ENGINEERING GRAPHICS COURSE CONTENT DEVELOPMENT STUDY which was supported by the National Science Foundation. Quoting from the study. . . "A major goal of the study is to develop new concepts from which engineering educators could choose information on which to build and strengthen courses." This study resulted in a number of recommendations dealing with the "Conceptual Aspects of Design", "Graphic Analysis and Computation", and "Computer-Related Graphics". The formulation of the study by Paul M. Reinhard was a creative endeavor of the highest order and quality. His organizational and creative capabilities resulted in ideas and actions that had great foresight. The guiding force that Paul presented to our Division and our discipline deserves our deepest expression of thanks and appreciation. He shall not be forgotten and his impact on us, on our field, and engineering education will continue to be felt for many years to come.

The surviving members of Paul's family include Mrs. Paul M. Reinhard of Detroit, Michigan, Paul Richard of Washington, D. C. Carol Taylor of Springfield, Illinois, Mary McGeogh of Detroit, Michigan and Robert of Detroit, Michigan and two grandsons.

Design Instruction for Freshman Engineers

Paul S. DeJong
Associate Professor
Engineering Graphics
Iowa State University

I believe that we at Iowa State have greatly improved our understanding of how to teach design at the freshman level and hope that the ideas presented here can be of some assistance to others. Historically, design problems are not new to the Graphics Department at Iowa State. We have employed open-ended problems in teaching graphics since Jim Rising took the department reins in 1951, and their use has expanded under Gordon Sanders' leadership. Originally, the problems required the student to arrive at an original design and describe it completely. Now, like many others, we are requiring in addition that the student follow a logical process of analysis, synthesis, and evaluation in selecting his final design. However, it is not enough to simply incorporate the subject material of design into the curriculum. How it is taught is what really matters.

During our early attempts to teach a design process, it became apparent that there were several areas in which more instruction was needed. At our weekly staff seminars, lengthy and occasionally heated discussion developed, and still does, regarding such things as definitions and good illustrations for class use. As a result our Creative Design Committee undertook to prepare a series of "Instructors' Notes" which, at least in the committee's thinking, constituted a reasonable framework for lectures on the seven steps of creative design which we employ. The instructors would lecture briefly on each step at the beginning of the appropriate period, make suggestions as necessary, and have the design teams spend the remainder of the period, about an hour and a half, on that particular phase of the project. In our initial experiment, a project was undertaken during each course of our two-quarter sequence. It was assumed that the second association would improve abilities and reinforce learning, and indeed this proved true to some degree.

Creative Design at Iowa State

This year, instead of becoming involved in two design problems, the students spend one quarter on fundamentals of graphics and one quarter on fundamentals of design. This second quarter includes material more specifically related to the design function, including production dimensioning, data presentation, design process and a project. As shown in Figure 1, the first phase consists of four class periods spent, not lecturing, but discussing the design process in some depth. During the second phase, which is not discussed in this paper, teams of from 3 to 5 students are organized to complete a project. About eleven two-hour sessions and eleven hours of outside time are devoted to this team effort.

Beyond expecting the student to demonstrate good command of graphics, there are many important factors which must be considered in teaching design at the freshman level; a few of the more important categories are as follows:

- Involvement
- Responsibility
- Appreciation
- Guidance
- Feedback
- Salesmanship

I would like to discuss each of these factors and their relationship to our teaching at Iowa State.

Involvement: It is imperative that both the students and their instructor become involved in the design process. We have found that you can lecture to a student effectively for only about 20 minutes, sometimes less; from that point on you are probably lecturing at him. This is understandable; the student wants to participate, not simply listen, so to use a two-hour

COURSE TIME SCHEDULE

ENGINEERING GRAPHICS 162

IOWA STATE UNIVERSITY

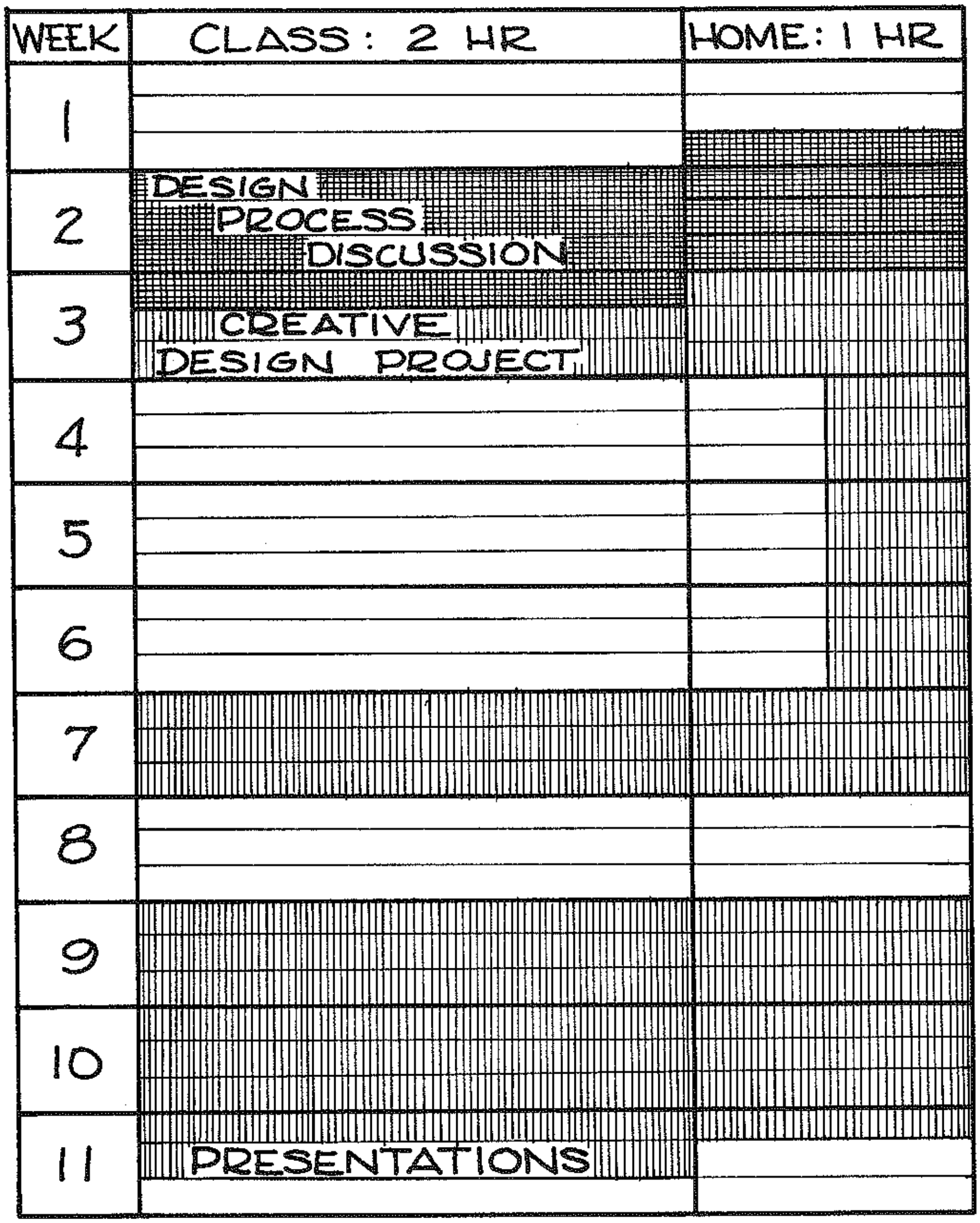


Figure 1

period, you must involve him. I believe that this is what we ought to do, since the concepts of the design process are best taught by discovery. By this I mean that the students are often best guided in group discussion to conclude or demonstrate certain facts. Apprehension about facing the class in a nose-to-nose situation like this probably presents a real barrier to many instructors. However, this problem can be overcome, just as in lecturing, by having a plan and being prepared to fulfill it.

This involvement of the instructor is not limited to simply being prepared for class. Many of us are trying to teach design with very little actual design experience. Although no one will ever have enough, we must try to bring more design experience to the classroom. This is difficult in areas that are not heavily industrialized. So, our staff is encouraged to obtain more industrial experience during summer months, and we have developed a program of departmental field trips to nearby industries which have been extremely "relevant" and enlightening. For example, we found that one of the firms we visited employs sophisticated computer-aided design techniques while another literally pirates its designs from successful competitors. The student will generally not find this kind of information in textbooks.

In promoting involvement, it should be remembered that the students have relatively little technical background as a group, and can be "turned off" by involved procedures or difficult technical problems. We must remember that it is the process we are trying to emphasize not the advanced design technology. We should avoid any tendency to make full-fledged designers out of freshmen. Class discussions must be held to realistic levels and limited subjects or goals that a freshman team can complete. One might require complete description of the solution to a simple problem like a tricycle wagon hitch, but only a conceptual description for a means of improving private aircraft safety.

Responsibility: The students should be given the opportunity to develop a responsible attitude; both in completing their assignments and in recognizing professional responsibility. They should understand that innovation is nothing if it is not responsible innovation, and that engineers must assume more responsibility to society.

The instructor also has responsibilities; not only in being prepared as mentioned before, but also in requiring periodic progress reports, in clearly establishing goals for outside or class assignments, and in defining what form reports should take and when they should be completed. If these are not made very clear to the class, much can be lost to confusion and wasted effort.

Appreciation: I believe we tend to overemphasize the importance of reducing attrition; the major concern should be to reduce attrition among potentially good engineers. Therefore, design experience as a freshman should make the student either appreciate the structure of his curriculum and a practical need for that knowledge, or realize that he is not "cut out" for creative problem solving, and perhaps should re-evaluate his educational goals.

Guidance: The average freshman is quite eager to undertake a design project but needs guidance and suggestions, even as a member of a team, to help him complete a project meaningfully. Whereas we previously tried to let each team progress with a minimum of assistance or advice, we have developed a policy that the instructor must spend the entire time in class moving from group to group, contributing whatever is needed, acting as a catalyst without leading the group.

Feedback: It is extremely important to evaluate the students' work and return it immediately for his reconsideration or confirmation. In fact, we are encouraging our staff to avoid collecting outside project work and instead sit down and discuss it with the team when it is due. It is rather easy to examine their work and decide its value in a very few minutes if specific assignments have been made for the team and its members and the instructor is aware of them. Here again, the instructor must be as involved as the students; he must be aware of the problems and be able to direct the team to their answers. Working within the team, he will have the opportunity to straighten out any misunderstandings which may arise.

Salesmanship: The student should learn the importance of salesmanship as a part of the design process. This can be discussed in class and practiced in presentations, but more important, must be exemplified in the behavior of the instructor. He must come to class well-groomed and well prepared with information, good illustrations, and with visual aids to support his discussions. Above all, he must show enthusiasm! In these important areas the instructor has more opportunities to get his A+ for teaching involvement.

Teaching the Design Process

It should be stated here that instructors are capable of conducting their own classes, and no attempt has been made to regiment instruction at Iowa State. Instead, the ideas presented here are the outgrowth of discussions and recommendations from our creative design committee and methods I have personally found helpful.

In preparation for each of the four periods devoted to the design process, the students should study and outline some specific material. This material may be taken from the text, from one of several references held on reserve in our University library, or it may be a specific article from a periodical such as Product Engineering or Machine Design. Since there are generally only one or two copies of these available, special methods must be employed if periodicals are used as resource material.

The period following each assignment is spent discussing that material. Here, the instructor's knowledge of the text material and his preparation are put to the test. He must ask questions which will lead to group discovery, and be able to quickly seize upon some student's statement to develop or pursue a specific thought.

Exactly how the instructor goes about obtaining student participation in a profitable discussion is usually omitted in articles in spite of its importance. Consider, for example, the first period devoted to the design process and problem analysis. One means would be to simply ask for definitions and statements from the reading material. This would cause some regurgitation of facts but very little real involvement. A more interesting introduction to the design process might be to discuss, for example, salesmanship and how it relates to the design process and presentation. A plan for such a discussion has been outlined in Figure 2.

It is hoped that during the discussion, points like the following can be brought out. Salesmanship is nothing more than convincing the customer that a product is better than its competition. In design, salesmanship is convincing a source of development money that a proposed design is better than any of its alternatives. This definition leads to the idea that any design must be carefully and logically selected from a large field of possible solutions, a conclusion which any group of people--freshmen or otherwise--can arrive at in guided group discussions.

The design process is predicated on this concept of the logical selection of the best

Figure 2

Class Discussion Plan
SALESMANSHIP AND DESIGN

Q: Principal Question
A: Eventual Goal through Discussion

Q: What is salesmanship?
A: Getting a customer to buy (pay for) your product.

Q: How is this accomplished?
A: Convince him he NEEDS the product.

Q: How do you convince him he needs it?
A: Know where and show him where he can improve his conditions.

Q: How do you know where?
A: By studying his business and analyzing his problems.

Q: Why not buy another product?
A: Ours is Best.

Q: How do we know it's the best?
A: By studying our competition and its strong and weak points.

Q: Suppose we are trying to "sell" management an idea and want $50,000 prototype financing. What must we do?
A: Convince management to support our effort.

Q: How?
A: Show how investment will be returned - demonstrate knowledge of market. Show where void exists in product line.

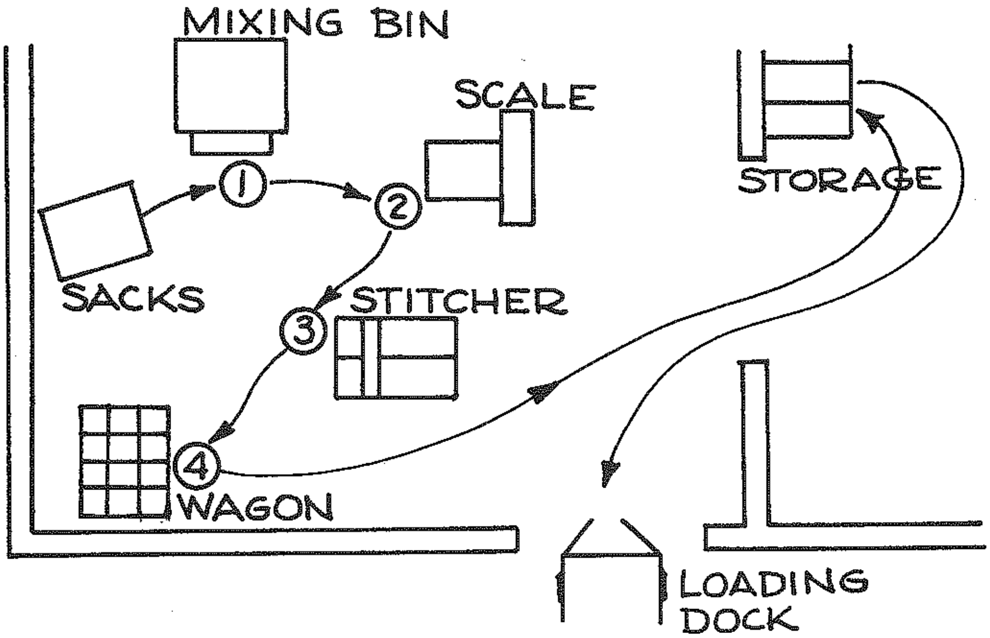
Q: What if he has an idea himself?
A: Be prepared to demonstrate why your idea is better.

Q: Can we "play it by ear"?
A: Probably not--either you will be ready or you won't.

Q: How can you possibly prepare for that?
A: By having considered all the alternatives you can possibly imagine (competition) and evaluated them.

Q: All the alternatives?
A: Only true involvement and logical thought will produce this knowledge.

Q: Can we synthesize a pattern of thinking here?
A:
1. Define a void in market; need to be satisfied profitably.
2. Consider all possible solutions.
3. Select best possible solution.
4. Demonstrate its possibilities.



The management of a large organization producing and distributing livestock feeds is concerned about the relatively high cost of handling and storing its products. You, as an engineer, have been assigned to the problem to seek a significant cost reduction. At the present the materials are bagged and stored by the method shown in the diagram.

POSSIBLE SOLUTIONS

1. To find the most economical means of filling, weighing, stitching, and stacking sacks of feed.
2. To find the most economical method of transferring feed from mixer (state A) to stockpiled sacks in the warehouse (state B).
3. To find the most economical method of transferring feed from mixer to sacks in the delivery truck.
4. To find the most economical method of transferring feed from mixer to delivery truck.
5. To find the most economical method of transferring feed from mixer to delivery medium.
6. To find the most economical method of transferring feed from mixer to the consumer's storage bins.
7. To find the most economical method of transferring feed from storage bins of the feed ingredients to the consumer's storage bins.
8. To find the most economical method of transferring feed from producer to consumer.

Adapted from "An Introduction to Engineering and Engineering Design," E. V. Krick.

Figure 3

solution. If the students understand it, we can alter their instinctive behavior of seizing upon their first solution and make them realize the need for a more logical approach to a final design. If they are really convinced of this need, study of the individual steps becomes relatively easy, since little evangelism will be required.

After this discussion on salesmanship, the class might be asked to build a series of steps leading up to the time of sale, which, with some guidance, ought to produce a series of steps for a design process.

Now, having a reasonable basis for the design process, a sample problem should be discussed wherein the class has the opportunity to analyze the problem and establish needs and goals. One such problem is illustrated in Figure 3. Here, several possible problem statements are given and are evaluated by the class.

The words "problem analysis" may be perplexing to the students. How does one analyze a problem? One good method is to follow a legal type of thinking. Pick out key words or sentences and clarify their meaning. For example: What is meant by "unsafe"? When is it unsafe? Why? How do we know? The more clearly the subproblems and causes are understood, the more fundamental and, therefore, universally applicable a design ought to be.

Figure 4 illustrates a case study of a battery powered lawn mower, which can be completely analyzed and a conclusion drawn by a class of freshmen. While no product design is involved, a real problem analysis is required. Moreover, the process can be illustrated "in action" if the instructor records the progression of knowledge on the board for review.

In case studies, it seems to be considered good form to leave the solution somewhat hazy, therefore, no exact answers are given. However, it should be pointed out that the mower was purchased and repaired by simply replacing the battery and charging unit.

An assignment is made at the close of each discussion period which requires the student to apply what he has learned and prepare for the next period's discussion. For example, the instructor might briefly describe a few of the many accidents associated with rotary lawn mowers. Then, given only the fact that something must be done about rotary lawn mower safety, the student is asked to write an analysis of the problem and statements of the needs and goals. These are then collected by the instructor for evaluation at the beginning of the following period and discussed by the class from memory. As mentioned before, we like to avoid collecting team work but frequently collect individual home assignments as "participation insurance."

The second period may be devoted to a review of the home assignment and discussion of research and specifications. We attempt to convince the student that the goal of research in design is to better understand requirements of the problem as well as the function of the design, but not its form or shape. It follows that the specifications determine the exact functional requirements of the solution.

As in Figure 5, one might try to obtain from the students a good definition of research and a discussion of different types of research and their purposes. The instructor should be prepared with specific examples of how research has affected designs. Some of the frequently cited examples such as the Edsel are becoming rather trite and would better be replaced periodically with fresh ones from the instructor's own experience.

It is desirable to familiarize the class with the literature search facilities and references such as indexing and abstracting journals that are available locally. The discussion might ultimately be dovetailed into the rotary lawn mower safety problem, which could be assigned for outside research.

The discussion of ideation, conceptualization, and evaluation held on the third period is probably the most difficult to manage. The class must have time to both discuss the material and participate in a practice session which causes some press for time. Nonetheless, I have them grouped together because they are so closely related.

One possible discussion plan is shown in Figure 6. The goal of the discussion is to determine methods for obtaining good solution ideas and selecting the best idea or design. Since designs must be compared, it follows that each must be clearly conceived and described. Further, since no model generally exists, the description must be a good graphical likeness. Obviously, the instructor should be prepared with good illustrations of ideas, concept sketches, and a decision matrix.

Some problem should be taken up in class to practice the three phases, particularly ideation. One plan would be to form four or five teams and present them with a common problem. The teams would then be given a specific time limit to prepare a list of say, 15 solution ideas, discuss them, and select their best solution. Each team would also select a spokesman to present their solution to the entire class. Competitive spirit produces a surprising number and variety of solutions and does an admirable job of demonstrating to the students their own ability to generate ideas, and that no single solution will be considered "best" by everyone.

For the problem, one might ask the teams to solve the problem of litter in national parks, to propose a single significant improvement in auto safety, how to transport tankcars of toxic

Figure 4

CASE STUDY
BATTERY POWERED LAWNMOWER I

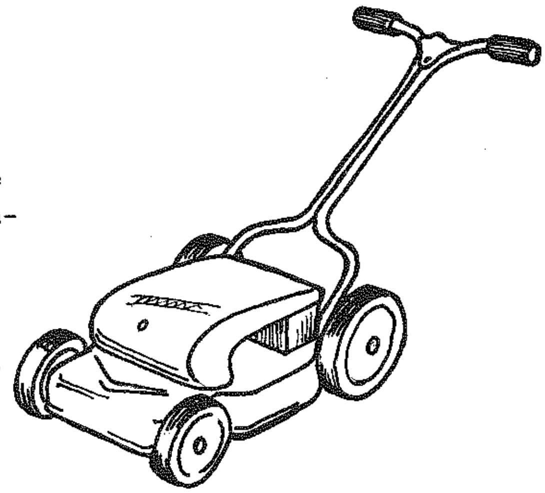


Figure a

Mr. Harold Smith was looking through the contents of a garage sale when he discovered the lawnmower illustrated in Figure a. He had seen only one mower like it previously, but knew it was a battery-powered electric push-type rotary mower. He recalled that it had seemed to be very effective, quiet, and expensive - about $150.

Although he was rather excited about this discovery, Mr. Smith tried to appear casual when he inquired about the mower. The owner said it had mowed very well its first season (two years previous) but had refused to run the following spring. The ignition switch key had been lost, but the owner's manual was still with the mower.

Removing the cover, Figure b, Mr. Smith could see through its translucent polyethylene case that the battery water was very low, half-exposing the plates. The paint on a small metal box under the cover appeared heat blistered. The vertically-mounted motor was an open type unit, and the windings were bright copper-colored.

Mr. Smith thought the mower would be desirable from the standpoints of noise abatement, environment, safety, and personal satisfaction.

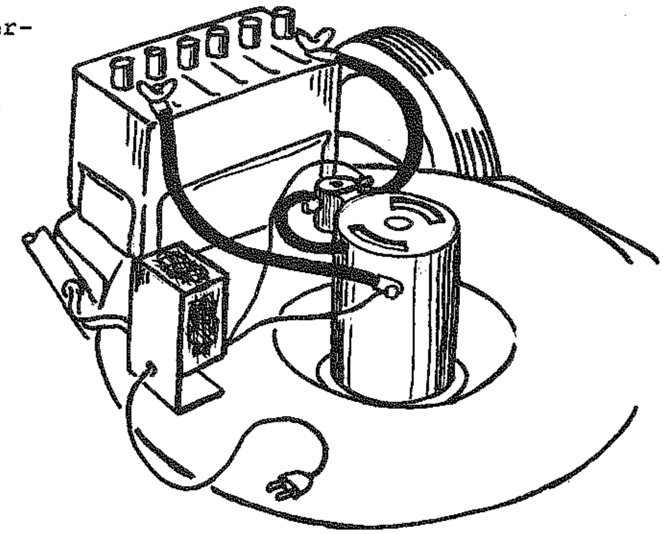


Figure b

Figure 4a

CASE STUDY
BATTERY POWERED LAWNMOWER I

Instructor's Guide

The students should, through discussion, recognize and analyze the problem, decide what is needed, and what action should be taken.

Possible results - Mr. Smith must decide (with risk) whether the mower can be made operable again, whether or not to buy, and how much he should pay if he does.

Students should recognize some "areas of ignorance" in analyzing the problem. Discussion of these areas in class will expose students having experience in areas needed, thus creating a synthetic equivalent to researching the field.

- How does the mower work?
- What do elements cost?
- How are they related, mechanically and electrically?
- How can elements be checked out or analyzed?
- What is wrong with the mower, in terms of possible and probable modes of failure?
- Can probable failures be corrected easily and/or inexpensively?

Possible Need - an understanding of the mower's operation and failure

Possible Goals - to estimate cost of repair and arrive at a decision of whether or not to buy.

Possible Decision - Risk purchase since battery and charger are probably only faulty components.

Figure 5

Class Discussion Plan

RESEARCH AND SPECIFICATIONS

Q: What is research?

A: See Webster
VonKarmann: "Scientists study what is; engineers create what has never been before."

Q: What kinds of research can we list? (what areas)

A: Phenomena
Properties
Applied
Market
Human Factors
Literature

Q: What purpose does each area serve? What role does it play?

A:

Q: What kinds of research is a design group interested in?

A: Market and applied research and data or laws obtained from pure research.

Q: Why are these areas of interest?

A: Need facts on technology
Need information about potential buyers and existing competition
Need information about areas of use, field performance requirements.

Q: What ought to be obtained from these efforts?

A: Knowledge about theory of operation and market requirements: Specifications.

Q: What are Specifications?

A: Exact description of qualities a successful design must possess. Possibly relate to construction specifications.

Discuss research and give examples of specifications in development of products like Edison's light bulb, Edsel, Xerox.

fluids across country for disposal, or to propose solutions to the rotary lawn mower problem described earlier. Regardless which problem is used, overhead projection transparencies of the instructor's proposed solutions could be easily prepared for class comparison and discussion.

The fourth period is devoted to finalization and presentation. Since design drawings are to be discussed at length later in the course, I have concentrated on the written report, its purpose, form, and presentation fundamentals. The object is to get the students involved in presentations of their own.

In preparation for this period, students should study some material such as Chapter 8 on Presentation in H. R. Buhl's text. Pairs of students are also assigned subjects from the list of Figure 7 on which to prepare a 5-minute presentation. This broadens the scope of study and familiarizes them with technical journals while providing presentation practice. In addition to the references given in the bibliography, teams are encouraged to interview major department faculty members and obtain other articles for resource material in preparing their presentations.

It should be announced that in class, strong and weak aspects of each presentation will be discussed and questions asked about areas which have or have not been considered. If

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Figure 6

Class Discussion Plan
IDEATION, CONCEPTUALIZATION AND EVALUATION

Q: What is Creativity?
A: ! ! ? ?
Ability to combine things into an interesting or useful product.
Ability to generate many ideas.

Q: How do you obtain ideas or promote creativity? Previous discussion implies we have a large list.
A: Get each person to submit ideas--different experience and personality patterns cause problem to be seen differently by different people.

Q: How do we promote individual contribution?
A: Create positive atmosphere. Don't criticize. Be open-minded.

Q: Name and describe some methods suggested for creating this atmosphere.
A: Brainstorming
Synectics
Imagineering
Idea Diagram
Incubation

Discuss qualities of a creative person:
Independent, self-reliant, open-minded thoughtful, persevering, involved, dedicated, resourceful. Try to get students to identify themselves with good qualities, therefore motivating him to display creativity.

Q: How do you select the "best" design once you have a large list of ideas?
A: Compare them.

Q: How do you compare peaches and apples? Designs probably differ as much.
A: Compare qualities: texture, taste, color, etc. Compare qualities of designs: appearance, functional correctness, simplicity, cost, etc.

Q: Does your idea list contain this information?
A: No. These ideas have little definite form. They represent possible principles of operation.

Q: What is required then, to compare ideas?
A: They must be refined into more definite form.

Q: How are they given definite form?
A: It is probably easiest and most economical to develop good graphical likenesses--concept sketches--using pictorials, sections, and brief notes.

Q: Do you have to develop complete likeness of all potential designs?
A: Only what we think are better ones.

Q: It was established earlier we had to compare qualities of our designs. Where do you obtain these qualities?
A: Look back to goals and research findings to determine what was found important. Build up decision matrix and describe its use here. Explain that it is not magic but simply a device to promote objective evaluation.

this is done in a friendly, constructive, even a kidding atmostphere, it will help the students immensely and they generally will not be offended by on-the-spot analysis.

Conclusion

Statistics are generally dull, inconclusive, and frequently questioned. None will be cited, but a few observations made about our results.

We believe that this re-orientation of our approach to teaching the design process has produced more enthusiasm among our students and faculty. Our presentations have improved noticeably and the students seem more interested in both the design process and their project. This is reflected in a more enthusiastic reception on the part of our major department judges. Much of this can be attributed to our efforts to develop:

Involvement
Responsibility
Appreciation
Guidance
Feedback
Salesmanship

Figure 7

POSSIBLE SUBJECT AREAS FOR TWO-MAN DISCUSSION TEAMS

5-Minute Presentations of Facts & Opinions

1. Need and Goal Statements
2. Problem Analysis
3. Methods of Obtaining Ideas
4. Responsible Innovation
5. Effectiveness of Ideation
6. Planned Obsolescence
7. Overcoming Personal Barriers
8. Overcoming Organizational Barriers
9. Solution Synthesis
10. Optimization
11. Role of Consumption in Design
12. Fundamentals of Presentation
13. Ethics in Engineering Design
14. Role of Computers in the Design Process

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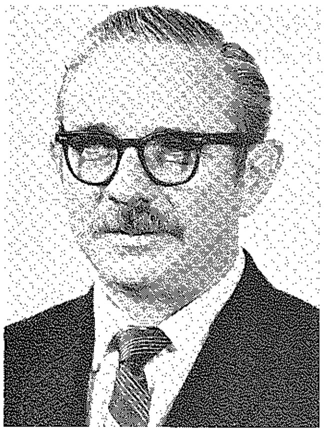


A Visit With Friends-
Technion
(Israeli Institute of Technology)

Borah L. Kreimer
Northeastern University

(EDITOR'S PREFACE)

Much has been written with respect to the politics, the history and the beauty of the countries of the world. Most of them also have fine educational institutions including those specializing in scientific and technical studies. Very little is known about these citadels of higher learning. It has been suggested that the ENGINEERING DESIGN GRAPHICS JOURNAL try to carry articles about our colleagues in various parts of the world, as often as is possible. Of course, we would be remiss if the emphasis is not centered about the interests of the Engineering Design Graphics Division of ASEE.

The first of these articles is about Technion - the Israel Institute of Technology. The editorial staff of the Journal hopes that articles about other schools, outside of the United States and Canada, prepared by knowledgeable people, will be sent to the editor. These articles will, presumably, bring about a better understanding and, perhaps, greater communication with others.

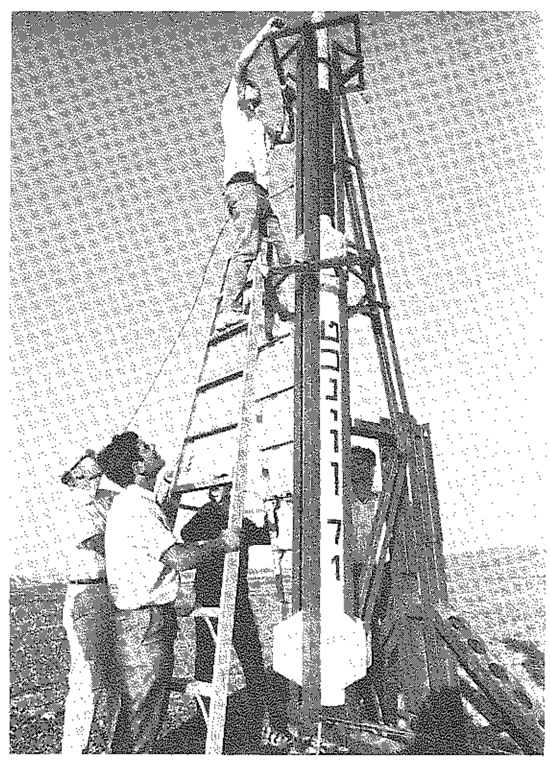
TECHNION
ISRAEL INSTITUTE OF TECHNOLOGY

Technion is located in the port city of Haifa -- in the northern part of Israel, a short distance from the Lebanese border. The city is built on three levels of Mount Carmel with a subway, in the mountain, connecting the top to the bottom. Of course, there are other forms of transportation, such as street buses and taxis which are more flexible, but will take longer to cover the same distance. Perhaps some taxis will not take as long since many of the drivers seem to be anxious to compete with their New York or Chicago counterparts.

The lower level, obviously, contains the port. Hence it is understandable that much of the industry of Haifa is located in that area. Since the city is considered to be the largest industrial center in Israel, the port area, with its industrial plants, covers most of the lower level.

On the middle level one will find most of the activities for the native population as well as for the visitors. Here, one sees most of the shops, theatres, restaurants and hotels. Although Israelis seldom go out to eat, they do enjoy buying sprees and seem to become ecstatic when the theatre is discussed or visited. In the shops and restaurants, it is not uncommon to hear English (American style) spoken by the shopkeepers and restaurateurs.

On the upper level one may find the more expensive shops and a few outdoor eating places. Here, a visitor may spend the night in one of Israel's finest hotels and eat in its restaurant



"Technion 71" with five of its ten designers in the Negev Desert.

overlooking the city. At night this presents a breathtaking view. In this general area there are two fine universities --- Haifa University and Technion.

Technion --- the Israel Institute of Technology was founded in 1912 and its first building completed in 1913. However, the program of studies did not begin until 1924 because of World War I as well as several other problems. Since then, the school has grown so that during the 1970-1971 school year it boasted an academic staff of 1300 persons drawn from universities in many countries including those from their own ranks; there are 4950 students studying for their Bachelor of Science degree in twenty areas of science and engineering; the graduate levels list 2200 students attending courses and conducting research projects to qualify for the Master of Science or the Doctor of Science degree. Although most of the students are Israeli -- Jews, Arabs, Druze and Christian --- there are approximately 1000 students from about 50 other countries including the United States.

It is interesting to note that a "department" as it is referred to in the United States is known as a "faculty". Their "department" is a subdivision of the "faculty". Yet areas of specialization toward a degree may be pursued in either of these. There are approximately twenty areas in which a student may earn degrees -- 10 in engineering, 7 in science, 1 in architecture and town planning and 1 in teacher education.

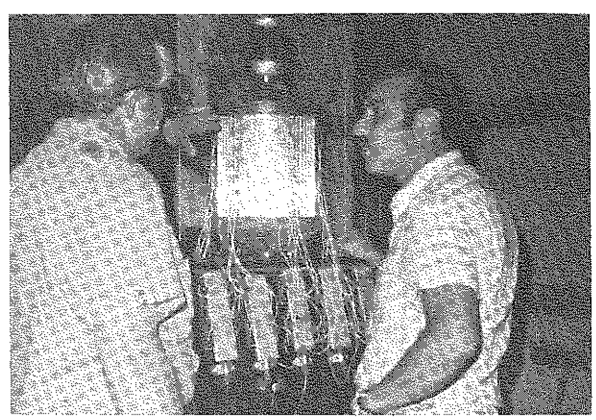
When the first landing was made on the moon in July of 1969, the event overshadowed the war news, in Israel. Although there is a political connotation here, a visit to Technion reveals a feeling of pride. It was in the laboratories of Technion that much research was done to find the best material to be used for the shell of the United States space vehicles.

In early summer of 1971 a two-stage meteorological sounding rocket was successfully launched from a military test range in the Negev desert. The rocket was designed by 10 fourth-year students as a project in the Aeronautical Engineering Department under the supervision of Professor Harry Wolff, formerly with the United Technology Corporation in Sunnyvale, California.

Technion's graduates --- engineers, scientists and industrial managers --- are the core of Israel's technological manpower. They are a vital part of the growing industry and instrumental in the progress of their modern agricultural production. Many key positions in important defense organizations are held by Technion alumni. Its facilities are used by developing countries for research as well as for other consultation services. It is not uncommon to find new countries sending young people to Technion to be trained for, both, upper and middle level technological positions.

The general concept of engineering education, at Technion, seems to be what it was in the United States several years ago. For the most part, the faculty believes that the student should have a strong pure science background preparatory for a professional occupation in engineering research and/or analysis. There are a few, as in the United States, who are more interested in the creative aspect of engineering and are looking for ways and means by which they could develop, as well as "sell" it. Most of these people are involved in the teaching of Descriptive Geometry -- a part of the Mathematics Faculty -- such as Dr. Luisa Bonfiglioli who has spent some time at Princeton University and who has been a contributor to the ENGINEERING DESIGN GRAPHICS JOURNAL, Moshe Boleslavski who has made a collection of engineering problems in industry that were actually solved with Descriptive Geometry, Ruth Shapira who is now on leave and living in New York City and Uzi Zamonski who is now a practicing engineer in Israeli industry. The latter two were co-authors of an article that received the Kreidler Award. Since Descriptive Geometry is steadily losing ground, those who identify with it must find an identity which is not necessarily new, but one which is, both, necessary and appealing. Creative Engineering Design seems to fit their situation very nicely.

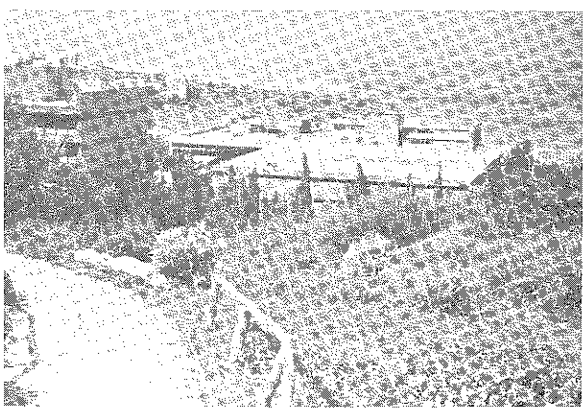
At present, most first year students are required to take two hours of Descriptive Geometry and three "class exercise" hours in



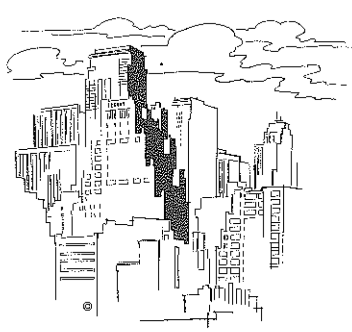
Shimon Nachman, Chief, materials laboratory, explaining tests that were conducted for the Apollo flights.

Technical Drawing. Except for Civil Engineering, the Technical Drawing is given by the Mechanical Engineering Department. Although there are many "design" courses, they all seem to be of an analytical nature with little, if any, creativeness required of the students. It was, perhaps most typically expressed by Professor Wolff, after the launching of the meteorological sounding rocket, when he said that "the students had to design, build, assemble and launch the rocket according to a set of specifications provided them---".

It seems that engineering education in Israel parallels that of the United States. There are those who feel that the knowledge of science and mathematics is all that an engineer needs, there are those who want to minimize the science and increase the creative aspect of engineering, and there are those who would like to see both areas represented in a broad curriculum. The arguments in Israel --- as in the United States --- are all based around the question "What is best for the student?"



A view of the Haifa harbor from the campus of Technion.



DISTINGUISHED SERVICE AWARD

The Distinguished Service Award Committee is soliciting nominations for the 1972 award to be presented at the Annual Conference in June. Division members wishing to nominate a recipient are requested to write to Professor Steve M. Slaby (Chairman of the Awards Committee), Princeton University, Princeton, New Jersey 08540. Please include in addition to the individual's name, a brief biographical sketch and the reason why you feel the award should be bestowed.

"THE COMMITTEE SHALL CONSIDER AS POSSIBLE RECIPIENTS OF THE DISTINGUISHED SERVICE AWARD THOSE NOMINEES THOUGHT TO BE WORTHY OF THE AWARD BECAUSE OF DISTINGUISHED SERVICE TO THE ENGINEERING PROFESSION, THE DIVISION, AND TO EDUCATION. SINCE THIS AWARD IS RECOGNIZED ALSO AS ONE OF THE OUTSTANDING AWARDS OF THE PARENT SOCIETY AND THE PERSON RECEIVING IT IS HONORED AT THE ANNUAL DINNER OF THE SOCIETY AS A PERSON OF CONSIDERABLE PROFESSIONAL STATURE, THE COMMITTEE NEED NOT SELECT A RECIPIENT IN ANY YEAR THAT NONE OF THE NOMINEES FULLY MEET THE REQUIREMENTS SET FORTH HEREIN BY THE DIVISION". *

* From Article VII, section 2d of the Bylaws.

PREVIOUS RECIPIENTS OF THE AWARD

1950 - Frederick G. Higbee
1951 - Frederick E. Giesecke
1952 - George J. Hood
1953 - Carl L. Svensen
1954 - Rudolph P. Hoelscher
1955 - Justus Rising
1956 - Ralph S. Paffenbarger
1957 - Frank A. Heacock
1958 - Henry C. Spencer
1959 - Charles E. Rowe
1960 - Clifford H. Springer
1961 - William E. Street
1962 - Jasper Gerardi
1963 - Theodore T. Aakhus
1964 - Warren J. Luzadder
1965 - Ralph T. Northrup
1966 - James S. Rising
1967 - Ivan L. Hill
1968 - B. Leighton Wellman
1969 - Edward M. Griswold
1970 - John H. Porsch
1971 - Mathew McNeary

IN THE DIVISION

DIVISION MEETS IN TEXAS

The Division of Engineering Design Graphics was greeted with a big Howdy! at the Mid-Year Conference of the Division in Houston, Texas, November 4-5, 1971. For the first time in several years, a commercial site instead of a campus facility was selected for the Conference. Headquarters for living and meetings was the new Houston Oaks Hotel situated in a sprawling ten-million dollar complex that offered numerous commercial stores and recreational facilities. The Conference was jointly sponsored and hosted by Texas A & M University, James H. Earle; the University of Houston, Burt Fraser and William J. Leach; and Rice University, A. P. McDonald.

Division Chairman Percy H. Hill of Tufts University welcomed some 75 members to the Mid-Year Conference and started the first day's session by introducing Clarence E. Hall, Louisiana State University, who spoke on "Computer Graphics--Its Role in Engineering Graphics and Design Courses for Freshmen." John R. Harrell, District Manager, IRD Mechanalysis, Inc. discussed "Industrial Applications of Graphics." Sessions followed on "Automatic Drafting with Interactive Computer Graphics," Carl Machover, Vice-President, IDI Information Displays, Inc. and "Communication and Graphics," Jerry Corbin, Vice-President, CRD, Architects Planners Engineers.

A major self-study report of the Division dealing with finances, meetings, organization, etc. was circulated and presented by William B. Rogers, Virginia Polytechnic Institute and Robert LaRue, The Ohio State University. The full report appeared in the Fall issue of the Journal. A committee will be appointed to implement this report after approval of the study at the Annual Conference in June at Texas Tech.

Two unique engineering installations were especially enjoyed by the attendees in Houston. Dale S. Cooper, a consulting engineer, presented a number of interesting features and problems encountered in the construction of the Astrodome. A tour of the domed Stadium and NASA Manned Spacecraft Center followed.

A Division brochure has been prepared for use in stimulating individuals engaged in teaching engineering design graphics to join ASEE and to affiliate with the Division. Questions about the Division are summarized, and copies for individual member use may be obtained by writing. . .Claude Z. Westfall, Department of General Engineering, 202 East Annex, University of Maine, Orono, 04473.

The Annual Conference at Texas Tech in June is one that all members will want to attend. The program will include creative design teaching techniques (including the creative design displays), human factors in design, a combined session with other design groups of ASEE, (A. S. M. E. Design Group and the Engineering Design Committee) and a session with the Technical Education Division. A summer school in Computer Graphics will be held on Thursday and Friday of the ASEE Conference. This will be an opportunity for individuals to broaden their outlook in another area of Engineering Design Graphics. Clarence E. Hall, Louisiana State University, and Edward V. Mochel, University of Virginia, are making plans for this event and a preliminary announcement is contained in this issue.

Division members will be asked to consider two Bylaw changes at Texas Tech in June.

1. Change Article III, Section 1 as follows:

   Secretary 1 year to Secretary 3 years.

   This change will benefit both the division and the Secretary by allowing adequate time to assume duties and to do them well.

2. Delete Article III, Section 2C (2). Section now reads:

   "He shall keep an up-to-date membership list. He shall prepare the membership list in a printed form and shall send copies to the Circulation Manager of the Journal, the Vice-Chairman, and the person in charge of the mid-year meeting."

   ASEE is now in a position to provide a computerized listing of all members to any officer or other member that has need for this information. Direct access to this data eliminates the need for the Secretary to prepare a membe rship list.

The Journal Advertising Manager, Klaus E. Kroner, University of Massachusetts, will be circulating a post-card questionnaire shortly. In soliciting potential advertisers which has been declining, information is needed relating to the readership about which clients ask questions. The results of this survey will be published in the Journal.

Claude Z. Westfall, Secretary

THE 1972 SUMMER SCHOOL

The 1972 Summer School on Computer Graphics will be held at Texas Tech University Lubbock, Texas. This Summer School, sponsored by the Engineering Design Graphics Division, will be held on June 22 and 23, 1972, the Thursday and Friday immediately following the Annual Meeting of ASEE.

The primary purpose of this Summer School is to get more Division members involved in the field of computer graphics. No previous experience in this area is assumed, and even no previous computer programming is necessary. However, a little previous experience in FORTRAN programming would be useful. The School will have two groups of participants, those with some previous FORTRAN programming and those without any previous programming experience.

The first day of the program will consist mainly in writing some short simple programs for using a plotter for two-dimensional problems. The second day will be spent using a program for three-dimensional space problems. A short discussion of equipment will conclude the program. The program used as a vehicle for teaching the course will be available for the participants to take home with them.

ALL AIRLINES LEAD TO LUBBOCK—

PROGRAM...

WHAT ARE YOU DOING?

Although it may seem like a long time the Division is already considering its program for the Mid-Year Conference at Denver, Colorado in 1972 and the Annual Conference at Iowa State in 1973. The Division exists to provide its some 1,000 members an opportunity to discuss and contribute to its educational activities. YOUR ideas are solicited in planning the conference program. Think back to the last convention you attended.

- What gripes did you have about the way it was run?
- What features did you particularly like?
- Are you engaged in any new techniques or programs and what would you like to see discussed?
- Would you be willing or do you know of others who would be willing to share their experiences with the Division?

Help us give you a great Conference by sending your program suggestions to Percy H. Hill, Department of Engineering Design and Graphics, Tufts University, Medford, Massachusetts, 02155. We will all benefit!

Claude Z. Westfall, Secretary

CREATIVE ENGINEERING DESIGN DISPLAY ADVISORY

Texas Tech University will be the site of the 1972 ASEE Annual Conference and the Fifth Creative Engineering Design Display. We hope to uphold the Texas claim of having the biggest of everything in the world with the biggest Design Display in history. This is an invitation for representatives from your school to participate in the 1972 Display.

If you have not seen previous Design Displays, you should know that entries have ranged from sets of design and working drawings to a complete design report. In many cases, models or prototypes have been included with the reports. This year, as indicated on the attached evaluation sheet, points for a model may be substituted for points on one of eight other areas in the judging criteria.

Judges for the 1971 Display included representatives from industry, chairmen of ASEE divisions, and at least one Past President of ASEE. Many of these individuals have indicated that they would like to continue participating in the Display activities. It appears that there will be support from industry for this year's Display.

Each school may enter a total of six projects, two freshmen and one each from sophomore, junior, senior and graduate levels. Space limitations are such that each project can occupy no more than 2 1/2 x 4 ft. of horizontal area. Additional details will be forthcoming.

To help with preliminary planning, it would be appreciated if you will write or call R. D. LaRue. This does not commit you to display but will provide information needed to estimate space requirements.

Additional information is available at the address or phone listed below.

Robert D. LaRue, PE
Coordinator
Creative Engineering Design Display
Engineering Graphics Department
2070 Neil Avenue
Columbus, Ohio 43210
Phone: (614) 422-2493

THE ASEE MEMBERSHIP CAMPAIGN

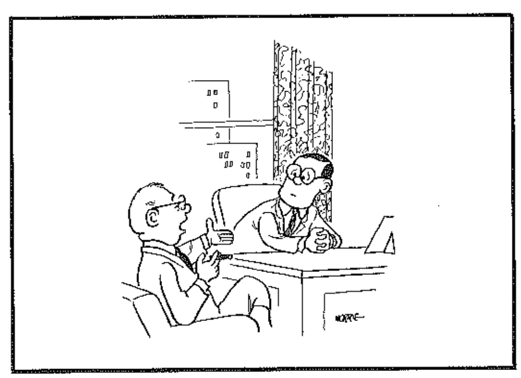
ASEE President Bolz has touched off the Society's first really large-scale membership campaign by asking each member to bring in a new member and asking each ASEE official to organize grass-roots support for the campaign.

Firm in the belief that every engineering educator should belong to ASEE and that ASEE has a great deal more to offer than most associations, President Bolz has directed that the campaign stress the vital role which the Society is playing today in the education of engineers and technicians. Potential members will learn of many ways in which they can become personally involved in this role, and the large number of benefits available to ASEE members.

The campaign will seek quantum increases in all categories of ASEE membership with special emphasis given to the recruitment of Individual, Industrial, and Affiliate Members.

Exciting incentives are being offered to everyone who obtains a new member. Details appeared in the December issue of Engineering Education. Attractive leaflets, posters, and other materials have been designed around the theme of Personal Involvement (π) and are available at ASEE Headquarters upon request. An intensive public relations effort will project the image of the Society into campuses, industries, and government agencies throughout the country.

ASEE MEMBERSHIP. . . . . BECOME
PERSONALLY INVOLVED



"I'm against the merger. Have you seen their stenographic pool?"

CONFERENCE PROGRAM SUMMARY

ENGINEERING DESIGN GRAPHICS DIVISION - 1972 ASEE ANNUAL MEETING

Day	Time	Theme
Monday	3:45 p. m.	Techniques of Creative Problem Solving The Role of Visualization in Creative Behavior R. A. Faste, Syracuse University Laboratory in Consumer Product Evaluation A. H. Clemow, Tufts University Programmed Invention S. W. Miller, Van Dyck Corp.
	7:30 p. m.	Executive Committee Meeting (closed) Percy H. Hill, Tufts University
Tuesday	12 noon	Division Luncheon and Business Meeting (open) William B. Rogers, V. P. I.
	6:00 p. m.	Division Annual Banquet Percy H. Hill, Tufts University
	7:30 p. m.	Engineering Design Rap Session (Joint session w/ M. E. Division Design Comm.)
Wednesday	10:00 a. m.	Human Factors Engineering Human Factors and Design Engineering J. G. Kreifeldt, Tufts University Teaching Human Factors W. R. Ferrell, University of Arizona Human Factors - Present and Future Needs W. G. Matheny, Life Science, Inc.
	1:45 p. m.	Computer Graphics Summer School Registration Fortran Programming E. V. Mochel
Thursday	9:00 a. m.	Computer Graphics Summer School Two-Dimensional Computer Graphics (Elementary program for a Plotter) Jack Brown, Texas A & M Programming Workshop Clarence Hall & Staff
	2:00 p. m.	Computer Graphics Summer School Plotting Applications Clarence Hall, Louisiana State Univ. Programming Workshop E. V. Mochel & Staff
Friday	9:00 a. m.	Computer Graphics Summer School Three-Dimensional Programs Byard Houck, North Carolina State Univ. Programming Workshop E. V. Mochel & Staff
	2:00 p. m.	Computer Graphics Summer School Space Geometry E. V. Mochel, Univ. of Virginia Choosing Equipment for Computer Graphics M. H. Pleck, University of Illinois

CREATIVE ENGINEERING DESIGN DISPLAY AWARDS

RALPH S. BLANCHARD, Chairman
Judging & Award

Plans for this year's Creative Engineering Design Display are rapidly finalizing and promise another display the Division can be proud of. Notices to the schools are being prepared and will be sent out in early February. It is hoped that the number of schools entering will again increase.

Thanks to the generosity of Colgate-Palmolive Company, DuPont, Monsanto, Union Carbide Corporation (Lindo Division) and Zenith Radio, there will be more substantial awards to the winners this year. In addition to the certificates, the first place winners in each category will receive a bronze plaque to present to their schools. This type of recognition, it is hoped, will encourage more students towards creative design, both in the classroom and in their professional careers. Industrial support is very encouraging and hopefully in future years may even lead to student winners being rewarded with a trip to a future meeting.

The judging this year will again be done by a group of judges from industry, divisional chairman of other divisions in A. S. E. E., and educators from the various disciplines. Some of our judges from previous years will again be with us. This balance of judges from widely different educational disciplines as well as different companies brings a breadth of backgrounds to judge displays which themselves vary over a wide range of fields.

This year there is an optional category for models in the judging sheet which has been completely revised. Practicality and Creativity have been added as areas to be judged. These changes all came as a result of comments from last year's judges and visitors to the displays.

On behalf of the committee, I know that all members of the Division will make an effort to stop by the Display and also submit student projects to be judged.

McGraw-Hill for a prolific selection of books in your field.

DESCRIPTIVE GEOMETRY

Grant: Practical Descriptive Geometry, Second Edition, $7.50
Grant: Practical Descriptive Geometry Problems, Second Edition, $5.95
Hood-Palmerlee-Baer: Geometry of Engineering Drawing, Fifth Edition, $10.95
Warner-Douglas: Applied Descriptive Geometry Problem Book, Fifth Edition, $5.95
Weidhaas: Applied Descriptive Geometry Problems, $6.50
Wellman: Alternate Problem Layouts for Technical Descriptive Geometry, Second Edition, $5.95
Wellman: Problem Layouts for Technical Descriptive Geometry, Second Edition, $5.95

ENGINEERING DRAWING

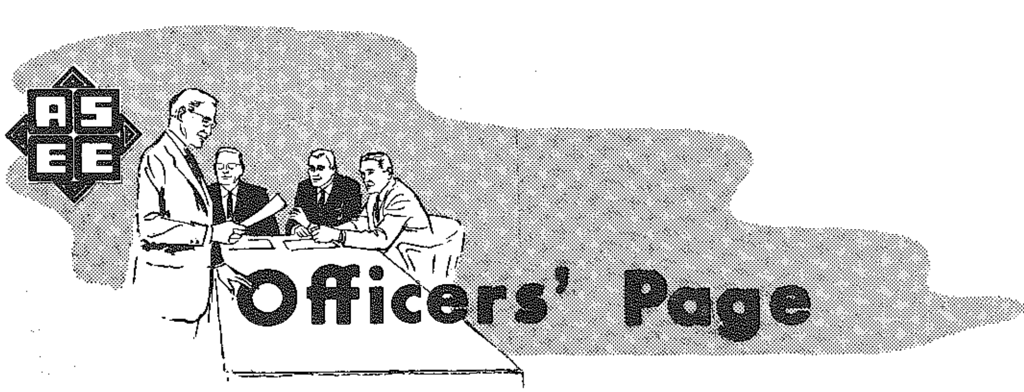
Grant: Engineering Drawing with Creative Design, Second Edition, $8.95
Grant: Engineering Drawing with Creative Design, Second Edition: Combined Text and Workbook, $12.95
Grant: Engineering Drawing Problems, Series One, Second Edition, $7.50
Vierck-Hang: Engineering Drawing Problems, Second Edition, $6.95
Vierck-Hang: Fundamental Engineering Drawing Problems, Second Edition, $5.50
Zozzora: Engineering Drawing Problems, Second Edition, $7.50

ENGINEERING GRAPHICS

Johnson-Wladaver: Engineering Graphics Problems, $6.50
Levens-Edstrom: Problems in Engineering Graphics, Series VI, $7.95
Schneerer: Programmed Graphics, $11.95
Vierck-Hang: Graphic Science Problems, Second Edition, $6.95
Weidhaas: Creative Problems in Engineering Graphics, $6.95
Weidhaas: Creative Problems in Engineering Graphics, Alternate Edition, $6.95
Wellman: Problems in Graphical Analysis and Design, $9.95

Prices are subject to change without notice.

McGraw-Hill



Time For A Change ---

OR WILL A T-SQUARE BY ANY OTHER NAME RULE AS STRAIGHT ?

To paraphrase an old standby, "There have been a lot of changes in this outfit since I joined twenty-five years ago, and I have been against every one of them!" To arbitrarily oppose all change is to join the ostrich with its head in the sand and ignore reality. On the other hand, to advocate change simply for the sake of change is equally foolish. Change is essential for the survival and healthy progress of an organization. One often wonders, in retrospect, why it took so long to effect some obviously needed improvement. The young are impatient with the resistance of their elders to change. Familiarity with the organizational philosophy and other factors existing at the time of a proposed change may make the opposition more understandable. Strong emotions are frequently involved and changes may be stubbornly opposed by some without basis in reasoned thought. Others are quick to approve a change simply because anything looks better than what we are doing now. In some instances there may be personal or selfish reasons for or against changing which have nothing to do with the needs of the organization. In every organization there are those so proud of past accomplishments that they would rather see the organization die stagnant in its old nest rather than seek rejuvenation through a radical change in direction. To be most effective and accomplish the most with the least damage, change should be gradual, evolutionary rather than revolutionary. But change is inevitable; if it is not anticipated and planned for, it will strike with rude suddenness, and is likely to leave one standing scorched amid the smoldering ruins of a dead past.

At the time this ASEE division was organized (as the Engineering Drawing Division, Society for the Promotion of Engineering Education), engineering drawing was generally recognized as a foundation course for an engineering education. A young engineer's most salable attribute was his skill on the drawing board. As engineering courses became less "practical" and more "theoretical", sophisticated sounding terms more attractive to the "academic image" were employed in catalog descriptions. Engineering drawing became engineering graphics. Few would admit that skill in the mechanical rendition of engineering designs was a part of their course. The division name was changed to Division of Engineering Graphics to more accurately reflect the philosophy and activities of its membership. The latest attempt to move with the trend of the times and keep our subject matter relative to today's needs added "design" to some course designations. After much discussion a plurality of our membership approved another name change and we became the Division of Engineering Design Graphics. Some critics, particularly those outside the immediate fraternity of graphics teachers, looked upon this move as a last gasp survival effort of a dying organization. Are we still advocating teaching our students to "kill the sabre-tooth tiger" long after the beast is extinct?

Today our members march to the cadence of several different drums and listen in vain for a clarion call to rally toward a well defined objective. Our division, in recent years, has been blowing an "uncertain trumpet", attempting by a futile exercise in semantics and half-truths to logically relate a variety of engineering subject areas to "graphics". The present understanding of the term graphics has become so broad that its original application by engineering educators to an integrated study of engineering drawing, descriptive geometry, and graphical calculations has no real meaning. Our name, the Division of Engineering Design Graphics, has become so general and undefined in its connotations that it is, paradoxically, restrictive. In an attempt to become all things to all men, we have lost a positive direction and are floundering in a sea of uncertainty.

Under a variety of catalog descriptions, our members are still involved in teaching and administering courses in basic engineering drawing, the spatial relationships of points, lines and planes (elementary descriptive geometry, if you will), and graphical calculations. In addition, we are teaching and administering courses which include the slide rule, computer programming, engineering problem solving techniques, principles of design, etc. These courses may be designated in the catalog as general engineering, introduction to engineering, engineering fundamentals, or even engineering graphics. The subject matter is organized in a variety of course sequences, but all are general. These constitute the first year engineering course, introduce the freshman student to the engineering profession, and provide a foundation in basic subject matter essential to further engineering study not included elsewhere in the curriculum. These course sequences, whatever they may be called, have two things in common: They are fundamental engineering courses required of all engineering students, and the students are freshmen. In many institutions the faculty teaching these courses also serve as faculty advisors to the freshman engineering students. At this level, the course material is common to all engineering fields, and the student is interested in an engineering career but not irrevocably committed either to engineering or any of its principal fields. We are common to and an important part of the four-year undergraduate program in engineering, the engineering technology program, the technical institute, and the junior college feeding transfer students into the four-year institution.

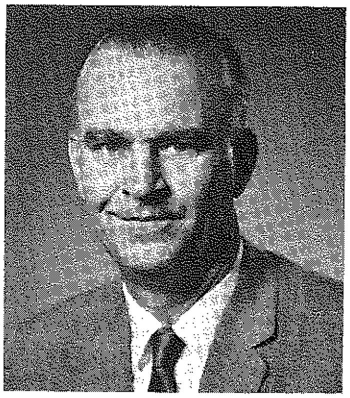
Engineering drawing (or graphics, or design, or whatever) can no longer stand alone as a cornerstone in engineering education. However, as one of the indispensable building blocks in a viable freshman program in engineering fundamentals, engineering drawing is alive and well. Now appears to be the time for this division to broaden its horizons, liberate itself from the narrow restrictive connotations of the drawing board and T-square and declare what we really are. I am suggesting that we state our philosophy and purpose in terms of engineering fundamentals and move full speed ahead as the Division of Engineering Fundamentals. Under this banner and with a broader purpose, we can attract new members, re-kindle the interest of old members who are no longer directly associated with graphics, per se, and greatly diversify our conference programs, and perhaps, talk and be listened to by a few other than ourselves.

As stated earlier, change should be evolutionary, not revolutionary. At first, this suggestion may appear revolutionary, but the change has, in fact, already taken place. All we need to do is recognize and acknowledge it. Many of our division members belong to this division only because they always have (this is where their friends are), or because our division, by default, comes closest to catering to their interests. A new name and philosophy could provide new inspiration and challenge which has long been needed.

It is appreciated that the wheels of institutional progress turn slowly, and it is not anticipated that such a change could, or should, be effected overnight or without a great deal of soul-searching, and impassioned discussion. As a result of the recent work of the Self-Study Committee, internal changes in division organization are under consideration. A questionnaire is being circulated by our Journal advertising manager to determine the spectrum of professional subject matter interest of our membership. Perhaps then, a formal proposal to change our name and orientation might be appropriate.

In the meantime, what do you think? How does the Division of Engineering Fundamentals sound to you? Let me hear from you.

William B. Rogers
Vice-Chairman



Engineering Graphics Passe ? No!

Robert H. Hammond
North Carolina State University

As I attend the various regional and national meetings of the Engineering Design Graphics Division, I often hear stories of how Graphics courses at various schools are being reduced. Many of our members reminisce of the "good old days." An air of pessimism pervades the air, and the few young instructors that occasionally attend probably soon begin planning on how soon they can change to teaching another subject. Some are leaving for Junior Colleges and technical institutes.

My experience here at North Carolina State University makes me believe that this attitude is wrong. We are not attending the wake of a fallen giant! Instead, we are present at the rebirth of a vital and growing fundamental of engineering education!

To understand this regeneration, the teachers of Engineering Graphics must realize a basic truth. The graphics courses can no longer be considered as a means to an end. We use to say (and believe) that if a student failed out of engineering he had learned, via our courses, a skill (draftsman) that he could use for a job. It was just that attitude that caused many of us to miss the whole point of the place of Graphics in an engineering education.

What is engineering education? To put it simply, it is an amalgamation of courses that are necessary to prepare the student for a career in engineering. How many individual courses in a curriculum are sufficient unto themselves? How many do not either build upon previous knowledge or prepare for future knowledge? The Engineering Graphics courses must fit into this jigsaw puzzle pattern of education. If the courses are not of value in the total development of the future engineer, they have no real place in the curriculum. Hence, the old concept that the graphics courses taught a skill that was an end unto itself is no longer valid. Instead, only the graphics courses that teach material that is of immediate use in future engineering courses and of use in the engineer's future career is valid in today's engineering curriculum.

Perhaps I might digress a moment here. We have been talking for years about Engineering Graphics. Recognizing the resurgence of the design emphasis, we have changed our Division's name to Engineering Design Graphics. Yet we are teaching many other things other than Engineering Design Graphics. What we are teaching are subjects fundamental to any engineering career. I ask the question: Has the emphasis on the word "Graphics" outlived its purpose?

Now to discuss the situation here. When I came to the University in 1966, the courses offered by the Freshman Engineering Division were:

E100 Introduction to Engineering - 0 Credits
E101 Engineering Graphics I - 2 Credits
E102 Engineering Graphics II - 1 Credit
E207 Engineering Graphics III - 2 Credits

E100 consisted of one one-hour lecture per week in which the various diciplines of engineering were discussed and the prospects and work in each field were discussed. It had become a recruiting opportunity for the various degree-granting departments and, as such, was really defeating its purpose. E101 was a course introducing the concepts of pictorial and multiview drawings, dimensioning, and working drawings. E102 introduced the concepts of Descriptive Geometry, but, with the Credit limitation, it could only be a broad introduction with no time to really dig in and really understand the fundamentals. E207 covered detailed shop and assembly drawings, and was a required course for only those students selecting the Engineering Operations curriculum (elective for others).

The first change was to revise the E101 course to include a four-week open-ended design problem. This necessarily caused some loss in fundamental graphics coverage, but it was felt that the loss was more than repaid by the increase in interest by the students. Simultaneously, discussions with the various degree-granting departments were initiated as to what they wanted in a graphics course. Then as a result of recognizing the failure of the E100 course to excite and motivate the new engineering students, a committee made up of members of all departments was appointed in 1968 to study the situation and make recommendations as to how to correct it. The result of this rather lengthy and complete study was a creative design project with the students formed into small companies attempting to design a solution to some recognized need. To fit this course into the curriculum, the E100 and E102 courses were eliminated. During this same time, the staff of the Furniture Manufacturing and Management Curriculum had requested the creation of a new course teaching the principles of graphics as used by the furniture industries. So starting with the Fall Semester of 1970, the courses offered were:

E101 Engineering Graphics I - 2 Credits
E120 Engineering Concepts - 3 Credits
E207 Engineering Graphics II - 2 Credits
E240 Furniture Graphics - 3 Credits

It should be pointed out that, with the initiation of E120, the need for a design problem in E101 disappeared and, therefore, the course was again revised to more completely cover its assigned objectives.

The discussions with the department heads continued and proposed courses were suggested and revised in keeping with their comments. When a consensus of agreement was reached, three new courses were proposed to the School and the University and, happily, all were accepted. This was no small achievement when it is realized that the School and the University is today concerned about the proliferation of courses in all areas. The course offerings for the Fall Semester, 1972, will be:

E101 Engineering Graphics I - 2 Credits
E120 Engineering Concepts - 3 Credits
E201 Spatial Relations - 3 Credits
E207 Engineering Graphics II - 2 Credits
E240 Furniture Graphics - 3 Credits
E301 Graphic Solutions - 3 Credits
E321 Computer Graphics - 3 Credits

It must be recognized that only E101 and E120 are required of all engineering students. E207 and E240 are each required by a specific engineering curriculum and are elective to others. E201, E301, and E321 are purely elective courses that will fulfill the needs and interests of differing students.

E201 is an in-depth study of Descriptive Geometry ending in a rather comprehensive presentation of vectors as an application of the principles previously taught. E301 teaches the graphical presentation and manipulation of data from graphs to empirical equations, graphical calculus, and special purpose slide rules. E321 presents the power of the computer in analyzing and manipulating two and three dimensional data and concepts using the CRT as an intermediate solution display and an x-y plotter as the final display. A powerful computer program has been created for this course and it has interested the Computer Science Department to the point where they are cross-listing it as one of their elective courses. It has already been experimentally taught generating much interest and enthusiasm on the part of both students and staff.

So our total graphics program has not diminished with time. Instead, it has grown stronger and larger. But the main point of this rather long discourse is that it has grown only as the degree-granting department heads become convinced that this Division was interested, not in perpetuating graphics for the sake of graphics, but in giving them the service that their students might need.

So this is the story of what is happening here at North Carolina State University. It can happen to you once it is realized that graphics is a service to engineering and all efforts must be aimed to that objective. It's time to forget the idea of making our students into draftsmen. The technical institutes have the time to do a much better job of that than we are able to do.

LETTERS TO THE EDITOR

Dear Sir:

Your editorial in the Fall issue of the Journal has prompted me to submit the commentary I received with a recent Creative Design Project report. Perhaps unsolicited comments such as these will console us occasionally when we feel frustrated - that not always are all the results of our teaching efforts reflected in the work submitted by our students.

If you think the enclosed commentary has some value to the readers of the Journal, feel free to print it.

Cletus R. Mercier
Assistant Professor
Engineering Graphics
Iowa State University

FORWARDLY SPEAKING . . .

It seems true to nature that man seeks reason for time spent and finds the plausibility of his efforts. It is felt, therefore, that a portion of a project such as this should be devoted to a perspective of its educational value.

The project was begun with some individual enthusiasm which decreased as we found the group not in agreement with many of our pet ideas and plans. The jumble of ideas lead to a lack of interest until finally we decided that we should function as a group. Headway was then made. Yet, something was still lacking, and continued to lack. That was strong leadership.

Time became a factor as we each were holding the group back somewhat. When the pressure came for the completion we took on the challenge as a functioning group and began sharing what amounts of creativity we could muster. Now, as the product is readied to turn in, we can look on the project as a true learning experience.

The learning experience, however, was not so much about the steering system of a motor vehicle--the subject of our adventure--but rather about group organization. We had little! But we did learn the value of it, and, after all, is that not the importance of education? We feel that it is.

Our time had reason and our efforts proved plausible.

---Group A12-1

Dear Sir:

In view of the two recent comments on my article on the Winter 1970 issue of the Engineering Design Graphics Journal, perhaps it would be appropriate to publish this note:

I have read with interest and appreciation the comments on my article, "Solution to a Class of Problems Involving Dihedral Angles", in the Winter 1970 issue. As pointed out by A. Romeo (1) and H. Niayesh (2) the solution can be found by the simpler cone method. The cone method is described in some texts on descriptive geometry, for example in the monograph by Wellman (3). I regret not being aware of this standard method at the time the article was written.

Nevertheless, perhaps the method can be adapted to the solution of other classes of problems than the one suggested by me?

References

(1) A. Romeo, "Another Geometric Solution for Problems Involving Specified Angles", Engineering Design Graphics Journal, Fall, 1970, Vol. 34, No. 3, Series 103.

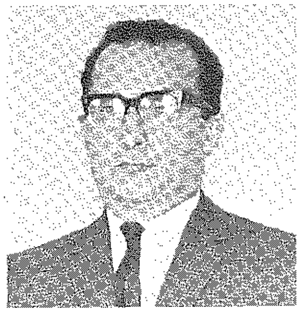
(2) H. Niayesh, "Another Method to Solve Dihedral Angle Problems", Ibid., Spring 1971, Vol. 35, No. 2, Series 104.

(3) B. L. Wellman, "Technical Descriptive Geometry", McGraw-Hill, New York, 1957, (2nd Ed.), p. 204.

Any comments you may have on this note will be appreciated.

Sincerely,

Thomas Thorsen
Assoc. Prof. of Engr.
El Camino College



Visual Illusion or Ambiguous Drawing ?

by A. ROTENBERG,
Lecturer in mechanical engineering,
University of Melbourne

A number of articles has been published in recent years on "impossible" or "undecidable" figures, some of which are (with minor modifications) reproduced here (Figs. 1 to 5). However, an important question - what are the necessary and/or sufficient conditions for any two-dimensional figure to represent a real three dimensional object? - still remains unanswered. This state of affairs has often resulted in a confusion between ambiguous drawings and "impossible" figures. When confronted with such figures, we tend to forget the simple fact that a single-view graphical representation alone is always ambiguous. Instead of analyzing the information provided by the drawing, we rely on the illusion it creates in our minds.

Unjustifiably, one tends to regard visual illusions as the result of some brain anomaly. However, in the communication of ideas by pictorial representation man's ability for illusory perception may be regarded as an important gift of nature. For these pictorial representations basically consist of a number of lines on a plane arranged in such a way as to make the viewer believe that he sees a three-dimensional object. e. g. three concurrent lines on a plane are often perceived as a set of Cartesian axes in space. Again, nine lines on a plane (Fig. 6) may be arranged so as to create the illusion of a cube.

A rough explanation of this illusory effect is that a "good" pictorial representation of an object simulates the image of the object produced by the human eye on its retina. Therefore, stimuli supplied to the human brain from looking at such representations may produce an effect similar to that supplied from looking at the very object itself. Although line density, shadowing, colouring etc. are often used to improve this illusory effect, we shall be concerned here only with black-and white drawings made with continuous lines and without shadowing.

Figs. 2, 3 and 4 show some of the "impossible objects" designed by L. S. and R. Penrose [2]. Fig. 2 is referred to by these authors as a "Perspective drawing of impossible structure," while Fig. 3 is defined as a "Diagram of structure with multiple impossibilities." Although these drawings do in fact produce an illusion of "impossible" structures, they may be regarded as ambiguous representations of an infinite number of real objects. (This fact has been acknowledged by the authors).

Figs. 7 to 10 show some (though not the only) real objects, of which Figs. 1, 2 and 3 are parallel projections onto a plane. In Fig. 8, the "impossible structure" (Fig. 2) has been modified slightly, but only to simplify the axonometric drawing. In Fig. 9 the same "impossible structure" has been regarded as an orthogonal projection (plan view) of an object in space, and the elevation has been added to more fully reveal the shape of this object. Fig. 10 is an "exploded" axonometric drawing of Penrose's "structure with multiple impossibilities." It shows that the figure may be regarded as a parallel projection onto the YZ-plane of nine separate solids arranged in a certain way. The nine solids may also be combined to form a single object which, when projected along the X-axis onto the YZ-plane, produces Fig. 3.

Martin Gardner [3] defines "undecidable figures" as "drawings of objects that cannot exist" and quotes the "notorious three-pronged blivet" (Fig. 11) as the best known figure of that kind. It is rather unfortunate that Figs. 2, 3 and 4 are also classified by Gardner as "undedicable" or "impossible." For, of all the figures listed above, the "three-pronged blivet" is the only one which cannot represent any real three-dimensional object. The others are in fact ambiguous representations designed to produce the illusion that the objects they represent cannot exist.

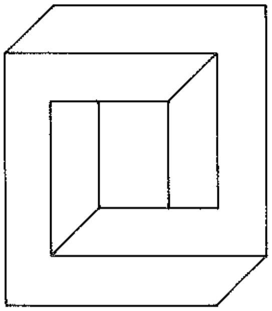


Figure 1

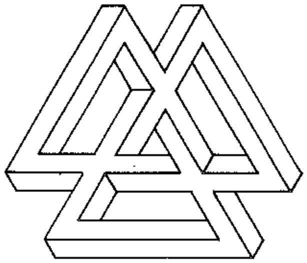


Figure 3

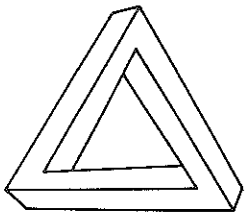


Figure 2

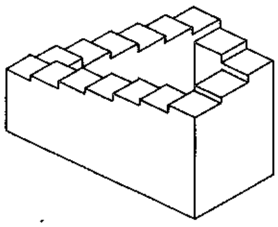


Figure 4

It is rather surprising to note that none of the many textbooks on technical drawing or descriptive geometry the author is familiar with clearly specify the necessary and sufficient conditions for a single-view drawing to be a correct representation of a three-dimensional object. Thus, an engineering student, or even a graduate with experience, may find himself unprepared to answer either of the notorious questions: - "is this figure correct?" or "what does this figure represent?" Perhaps, almost every mechanical (and not only mechanical) engineer has been or is likely to be confronted with these questions at least once in his engineering career. The relevant criterion which may help to answer these questions may be formulated as follows:

> The necessary condition for a two-dimensional line diagram to represent a real three-dimensional object is that it include and be wholly contained within a simple closed curve. This is also a sufficient condition.

Although this criterion may seem intuitively obvious to an engineer (after statement), nevertheless the author found it necessary to introduce some notions from topology in order to obtain a satisfactory proof.

A proof for the necessary part of the above criterion and the definition of some of the terms used is given in the appendix at the end of this paper. The author's proof of the sufficiency condition is rather lengthy, relies on three-dimensional visualization and, therefore, will not be produced here.

The reader interested in an answer to the "mystery" of the "three-pronged blivet" may convince himself that the blivet does not satisfy the necessary condition of the criterion stated and, hence cannot represent any real three-dimensional object.

ACKNOWLEDGEMENTS:

My thanks are due to Dr. C. J. Pengilley, Professor C. E. Moorhouse and Mr. L. J. Jones for assistance in preparation of this paper.

REFERENCES:

1. M. H. A. Newman, Elements of the Topology of Plane Sets of Points, Cambridge University Press, 1969.

2. L. S. Penrose and R. Penrose, Impossible

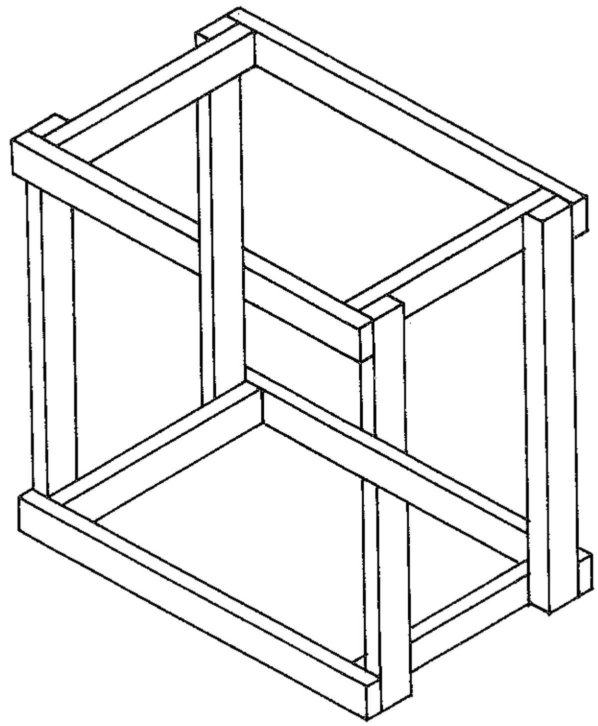


Figure 5

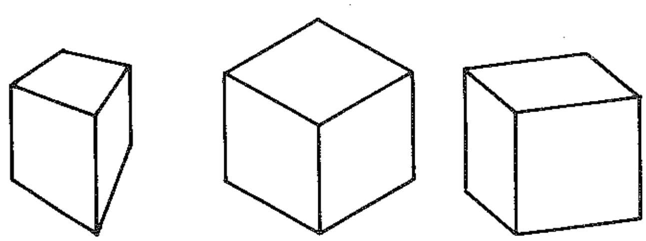


Figure 6

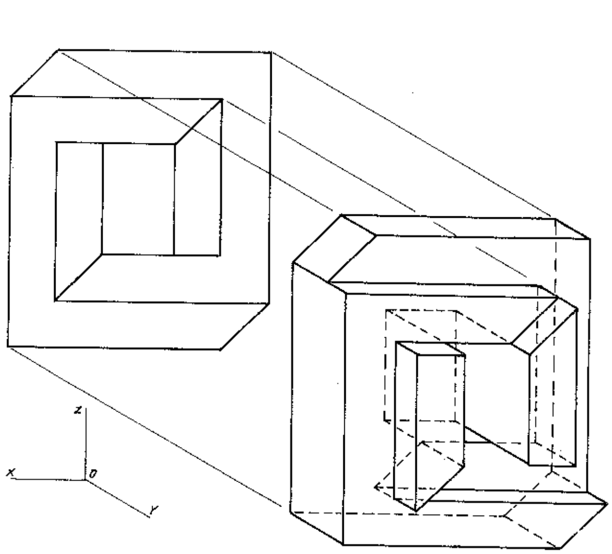


Figure 7

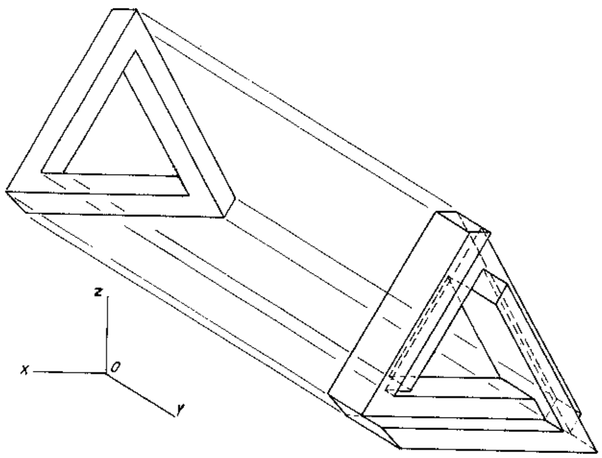


Figure 8

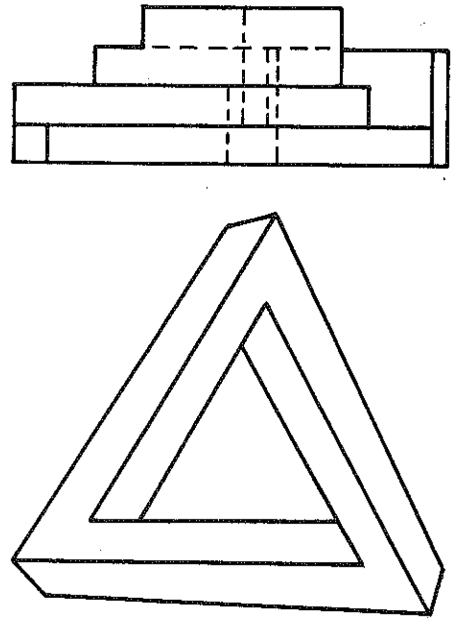


Figure 9

objects: A Special Type of Visual Illusion, British Journal of Psychology, General Section, Vol. 49, 1958, pp. 31-33.

3. Martin Gardner, Of optical illusions from figures that are undecidable to hot dogs that float, Scientific American, May, 1970, pp. 124-128.

4. J. T. Whyburn, Analytic Topology, American Mathematical Society Colloquium Publications, Vol. XXVIII, N. York, 1942.

FOOTNOTE:

For definitions of basic concepts in topology the reader is referred to [1] and [4].

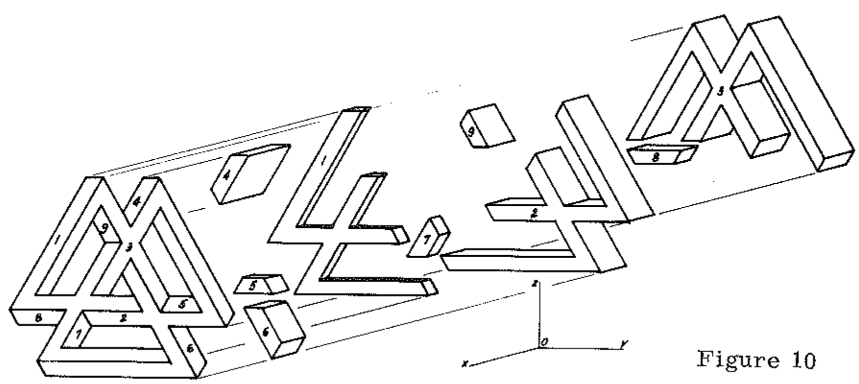


Figure 10

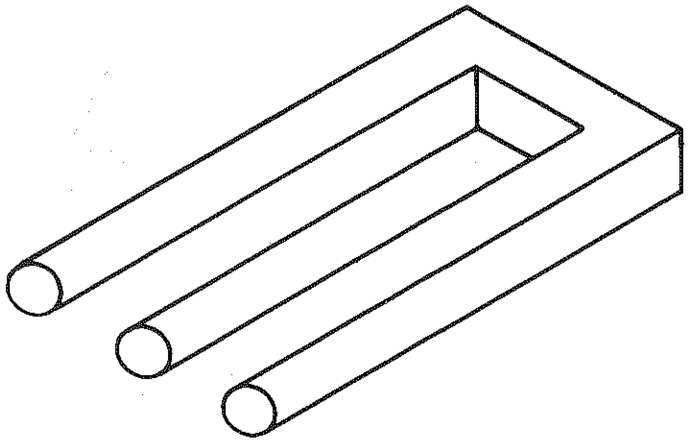


Figure 11

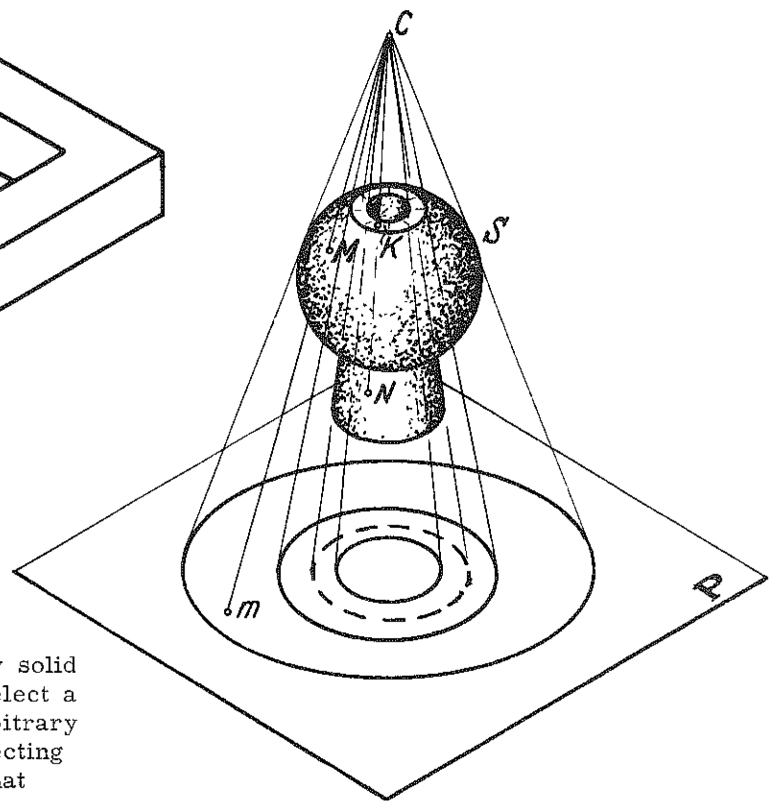


Figure 12

APPENDIX

Let S (Fig. 12) be an arbitrary solid and M an arbitrary point of it. We select a projecting apparatus consisting of an arbitrary plane P ("projection plane") not intersecting the solid S and a point C ("pole") such that

(i) C is not a point of S;
(ii) C is not a point of P;
(iii) No line CM is parallel to P;
(iv) If m is the point of intersection of the straight line CM with P, C is not between M and m.

Consider the conical surfaces formed by all those and only those straight lines which pass through the pole C and are either tangent to the surface of the solid S or contain at least one point of an edge of this surface.

A diagram consisting of all lines of intersection of such conical surfaces with the projection plane P will be referred to as a <u>correct graphical representation</u> (or shortly, a <u>representation</u>) of the solid S on the plane P, provided the projections of all "hidden" lines are shown by some convention distinguishing them from projections of "visible" lines.

A point K of the solid S is regarded as <u>visible</u> if it is the only point of the solid which is also on the line-segment CK. A point N of the solid S is regarded as <u>hidden</u> if the line segment CN contains at least one point of the solid S other than the point N. A line on the surface of the solid S is visible or hidden if all points of this line are visible or hidden respectively.

An <u>edge</u> of the solid S is a locus of points of the surface of S at which no tangent plane to the surface exists.

A <u>real three-dimensional object</u> (or a <u>solid</u>) S is a bounded, closed, connected and locally connected set of points in the three-dimensional Euclidean space. Furthermore, S has the property that no set of a finite number of straight lines K_i is a cutting of it, i. e. the set $S - \Sigma K_i$ is connected.

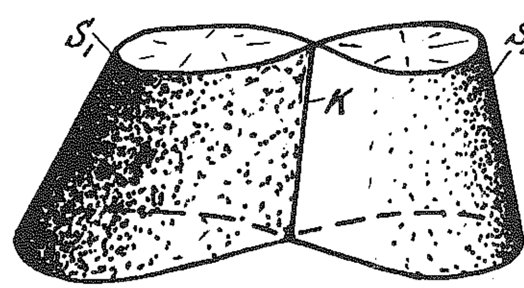


Figure 13

An example illustrating the above statement is shown in Fig. 13:- S_1 and S_2 are regarded as <u>two</u> solids joined along the line K.

Let $\bar{\xi}$ (Fig. 12) be the locus of all points of all the line-segment Cm;

ξ_s - the conical surface of $\bar{\xi}$;

L - the line of intersection of ξ_s with the plane P;

$\bar{X}$ - the set of all points m;

X - the open set $X = \bar{X} - L$

Since the solid S is a bounded and closed set of points, S is compact ([1] Chap. II, Theorem 14.3). The set $\bar{X}$ may be regarded as the image of the compact, connected and locally connected set S under a continuous mapping. It follows ([1] Chap. IV, Theorem 8.2) that $\bar{X}$ is compact and locally connected. $\bar{X}$ is also connected since connectedness is an invariant property of any continuous mapping ([1] Chap. IV, p. 71).

Further, the set $\bar{X}$ cannot have any cut points. For, if a point $m \in \bar{X}$ is a cut point of $\bar{X}$ then the line Cm is a cutting of the set S which contradicts the definition of the solid. It follows ([4] Chap. IV, Theorem 9.3) that $\bar{X}$ is cyclicly connected.

Thus, the set $\bar{X}$ may be described as a cyclicly connected locally connected continuum. Therefore ([4] Chap. VI, Theorem 2.5) the boundary of any bounded complementary domain of $\bar{X}$ is a simple closed curve.

It follows ([4] Chap. VI, Theorem 2.6 and Corollary 2.61) that the boundary L of $\bar{X}$ contains a simple closed curve which encloses all points $m \in \bar{X}$. An assumption to the contrary of above leads to a contradictory conclusion that $\bar{X}$ is either disjoint or unbounded.

Throughout the above argument, a central projecting apparatus has been used. However the result derived also applies to the case of parallel projections. The latter should then be regarded as a particular case of central projections with the pole C removed to a point at infinity along some line which defines the direction of projection.

LEVENS HONORED FOR TEACHING EXCELLENCE

Professor Emeritus Alexander S. Levens has received the Western Electric Fund Award for 1971 from the Pacific Southwest Section of the American Society for Engineering Education (ASEE).

The citation was presented at the Pacific Southwest Section's Annual Meeting. It reads:

"Professor of Mechanical Engineering at the University of California, Berkeley, the author of several well-known textbooks, 90 articles on the various branches of graphics including computer aided design, outstanding teacher, highly regarded by both undergraduates and advanced professionals for his lucid explanations of the subjects at hand. He has to an unusual degree the ability to transmit to students the skill of mental visualization so necessary to the engineer. In addition to this high ability both in his field and as a teacher, he has a remarkably warm and sympathetic, yet firm, personality."

The Western Electric Fund Awards for excellence in the instruction of engineering students have been awarded since 1964-1965 to outstanding teachers of engineering to honor the recipient and to serve as an incentive for him to make further significant contributions in teaching.

The awards consist of $1000 and a certificate. One award is presented in each ASEE Section with less than 1000 members, and two awards are made in Sections with over 1000 members.

The Role of Graphics in Industry

by John R. Harrell
District Manager
IRD MECHANALYSIS, INC.
Houston, Texas 77034

The purpose of this paper is to discuss how graphics and graphical techniques are being used by industry in a program to protect all types of rotating machinery and to reduce costly downtime. In this program, graphical solutions to various machinery problems are used because these techniques are simple, fast and accurate.

This program is based on three facts:

1. All machines vibrate and make noise.

2. An increase in vibration or noise indicates that trouble is developing.

3. Each machine will vibrate in a unique way, depending on the trouble, whether it is unbalance, misalignment, bad bearings, etc.

By using vibration and noise as the key to a machine's condition, a systematic program can be developed. This program is divided into three phases: DETECTION, ANALYSIS and CORRECTION. Charts and graphs are used to identify the cause and severity of vibration and graphical techniques are used in the correction phase to dynamically balance rotating parts.

DETECTION

Detection of the increase in vibration is accomplished by using small portable instruments to periodically check and record the vibration on critical machines throughout a plant. In this manner, the history of the machine's mechanical condition is obtained. Any increase in vibration levels serves as a warning of impending trouble. For high-performance machines, a weekly or monthly check may be inadequate, and continuous vibration monitors are being used to provide warning of an increase in vibration.

Although absolute vibration limits for a particular machine are not easy to define, realistic guidelines, as shown on the Vibration Severity Chart (Figure 1), are being used by industry to select acceptable vibration levels.

ANALYSIS

Where periodic checks indicate trouble, vibration analysis of the machine quickly and positively pinpoints the source. During the analysis phase, three parameters are observed. 1) Amplitude measurements tell how severe the vibration is. The vibration is measured in terms of displacement (mils, peak-to-peak: 1 mil = .001 inch), maximum velocity (inches per second) or acceleration (G's). 2) The frequency of vibration indicates the number of times per minute the part vibrates. By comparing the frequency of vibration with rotating speeds or multiples of the rotating speeds, the particular part responsible for the vibration as well as the cause of the vibration can be identified. 3) Ph-

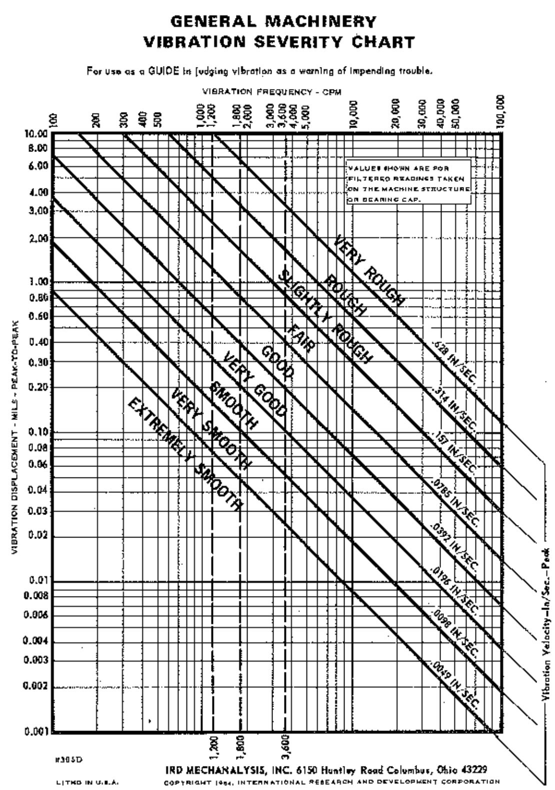


Figure 1

ase measurements are used to compare the motion of one component of a machine with another. A stroboscopic light, which is triggered by the vibration signal, is used to study the motion of the different parts of the machine. Phase measurements are also used during balancing and form the basis for the graphical solution to the balancing problem.

The Vibration Identification Chart (Figure 2) is used to identify the cause of vibration by noting amplitude, frequency and phase. For example, if the vibration occurs at 1 times rotating speed and is measured in the radial direction, then unbalance is the probable cause. An axial vibration at 1 times rotating speed indicates misalignment or a bent shaft. By observing how the machine vibrates, the trouble is quickly pinpointed.

CORRECTION

If the part causing the trouble is identified and the cause of the vibration is known, then the necessary manpower, replacement parts and equipment can be conveniently scheduled to correct the trouble. If unbalance is the cause, balancing can normally be done in-place, using the graphical techniques described below.

BALANCING

Because the amplitude of vibration is proportional to the unbalance, and since relative phase can be observed with a strob light, balancing in a single plane is accomplished using the following steps.

Step 1 - The rotating part to be balanced is run at normal operating speed and the amplitude and phase are measured. For this example, the initial readings were 3 mils at an angle of 3 o'clock or 90°.

Step 2 - A vector "O" is drawn on polar graph paper at an angle equal to the phase angle observed, 90° (see Figure 3). The magnitude of the vector "O" is equal to the observed amplitude of vibration in mils or inches per second. Any convenient scale is used, such as 1 inch = 1 mil.

VIBRATION IDENTIFICATION

CAUSE	AMPLITUDE	FREQUENCY	PHASE	REMARKS
Unbalance	Proportional to unbalance. Largest in radial direction.	1 x RPM	Single reference mark.	Most common cause of vibration.
Misalignment couplings or bearings and bent shaft	Large in axial direction 50% or more of radial vibration	1 x RPM usual 2 & 3 x RPM sometimes	Single double or triple	Best found by appearance of large axial vibration. Use dial indicators or other method for positive diagnosis. If sleeve bearing machine and no coupling misalignment balance the rotor.
Bad bearings anti-friction type	Unsteady - use velocity measurement if possible	Very high several times RPM	Erratic	Bearing responsible most likely the one nearest point of largest high-frequency vibration.
Eccentric journals	Usually not large	1 x RPM	Single mark	If on gears largest vibration in line with gear centers. If on motor or generator vibration disappears when power is turned off. If on pump or blower attempt to balance.
Bad gears or gear noise	Low - use velocity measure if possible	Very high gear teeth times RPM	Erratic	
Mechanical looseness		2 x RPM	Two reference marks. Slightly erratic.	Usually accompanied by unbalance and/or misalignment.
Bad drive belts	Erratic or pulsing	1, 2, 3 & 4 x RPM of belts	One or two depending on frequency. Usually unsteady.	Strob light best tool to freeze faulty belt.
Electrical	Disappears when power is turned off.	1 x RPM or 1 or 2 x synchronous frequency.	Single or rotating double mark.	If vibration amplitude drops off instantly when power is turned off cause is electrical.
Aerodynamic hydraulic forces		1 x RPM or number of blades on fan or impeller x RPM		Rare as a cause of trouble except in cases of resonance.
Reciprocating forces		1, 2 & higher orders x RPM		Inherent in reciprocating machines can only be reduced by design changes or isolation.

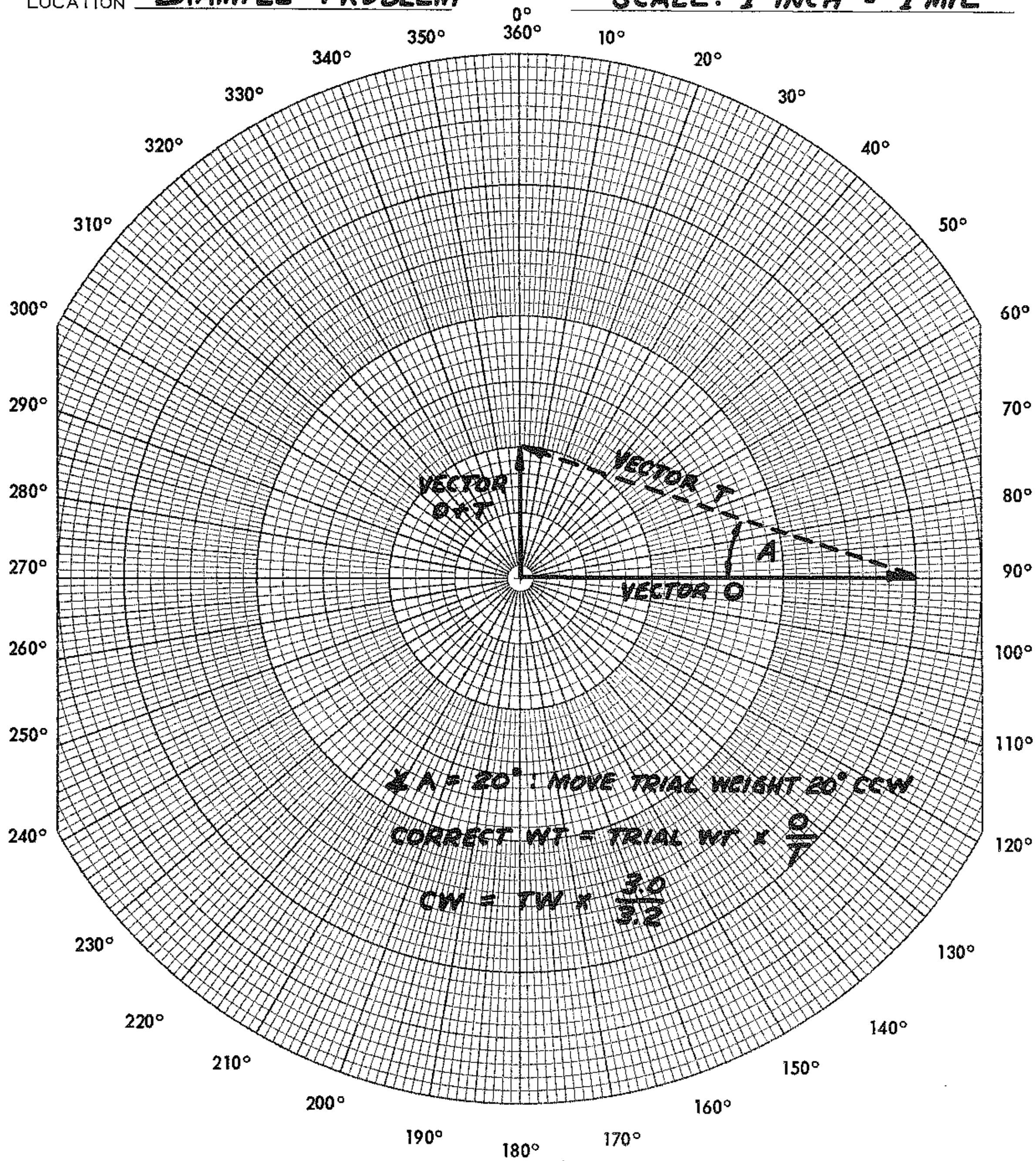
Figure 2

VECTOR DIAGRAM

DATE *NOV 4, 1971* MACHINE *MOTOR DEMONSTRATOR*

OPERATOR *J. HARRELL* PLANE(S) *SINGLE PLANE*

LOCATION *EXAMPLE PROBLEM* *SCALE: 1 INCH = 1 MIL*



RESULTS *UNBALANCE REDUCED TO .4 MILS*

Figure 3

Step 3 - The machine is stopped and a trial weight is added at some convenient location on the rotor.

Step 4 - The part is again brought to operating speed and the new amplitude and phase are observed. For this example, 1 mil at 12 o'clock or 0°.

Step 5 - The vector "O + T," which is the resultant of the original unbalance and the trial weight, is drawn to scale on the polar graph paper.

Step 6 - Vectors "O" and "O+ T" are connected by the vector "T". It should be noted that vector "O" plus vector "T", when added together graphically, produce the resultant "O + T." Also, since phase is a relative measurement, the vector diagram will be the same regardless of its orientation in space.

Step 7 - The angle between "O" and "T" is measured and the trial weight is moved on the rotor by this amount. For this example, the angle is equal to 20°.

Step 8 - The correct weight is computed by using the formula: Correct weight equals trial weight times "O" over "T". For this example problem, if the trial weight is equal to 10 ounces, then the correct weight is equal to 10 times the fraction 3.0 divided by 3.2 equals 9.4 ounces. The trial weight is then adjusted accordingly.

Step 9 - This balancing technique is repeated until a satisfactory vibration level is achieved.

If it is not possible to add the computed weight at the desired angle, as in the case of rotors with blades or impellers, then the weight must be divided between adjacent blades to achieve the desired result. A graphical technique as shown in Figure 4 is used to determine how the weight should be distributed on the blades. Example: Step 1 - Correct weight of 10 ounces is to be added 20° clockwise from blade 3 at a radius of 1 foot. Step 2 - Construct parallelogram ABCD. Step 3 - Correct weight to be added: Blade 3: 3.5 ounces at a radius of 1 foot. Blade 4: 6.7 ounces at a radius of 1 foot.

If the balancing is to be done in two planes, then the single plane technique is used

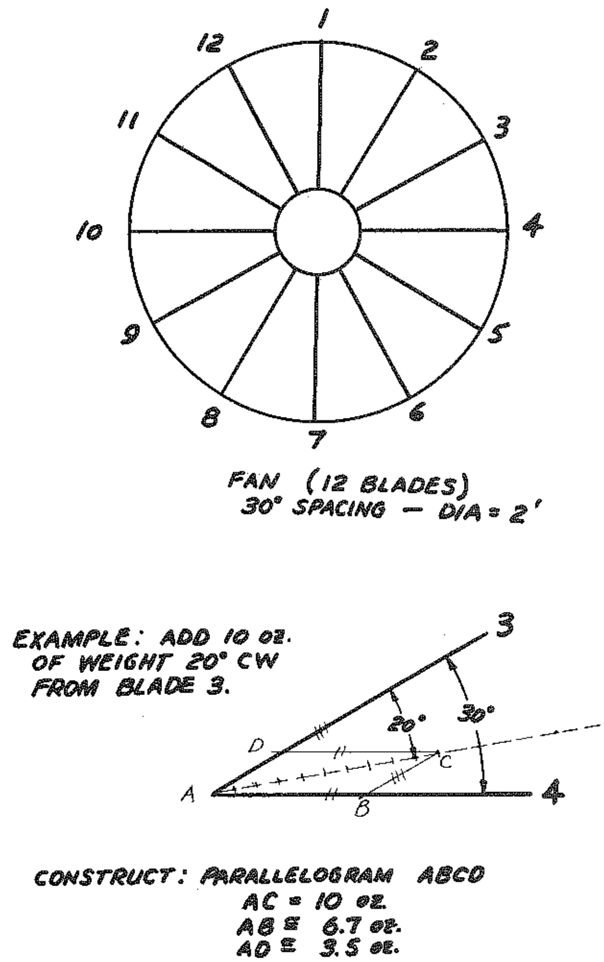


Figure 4

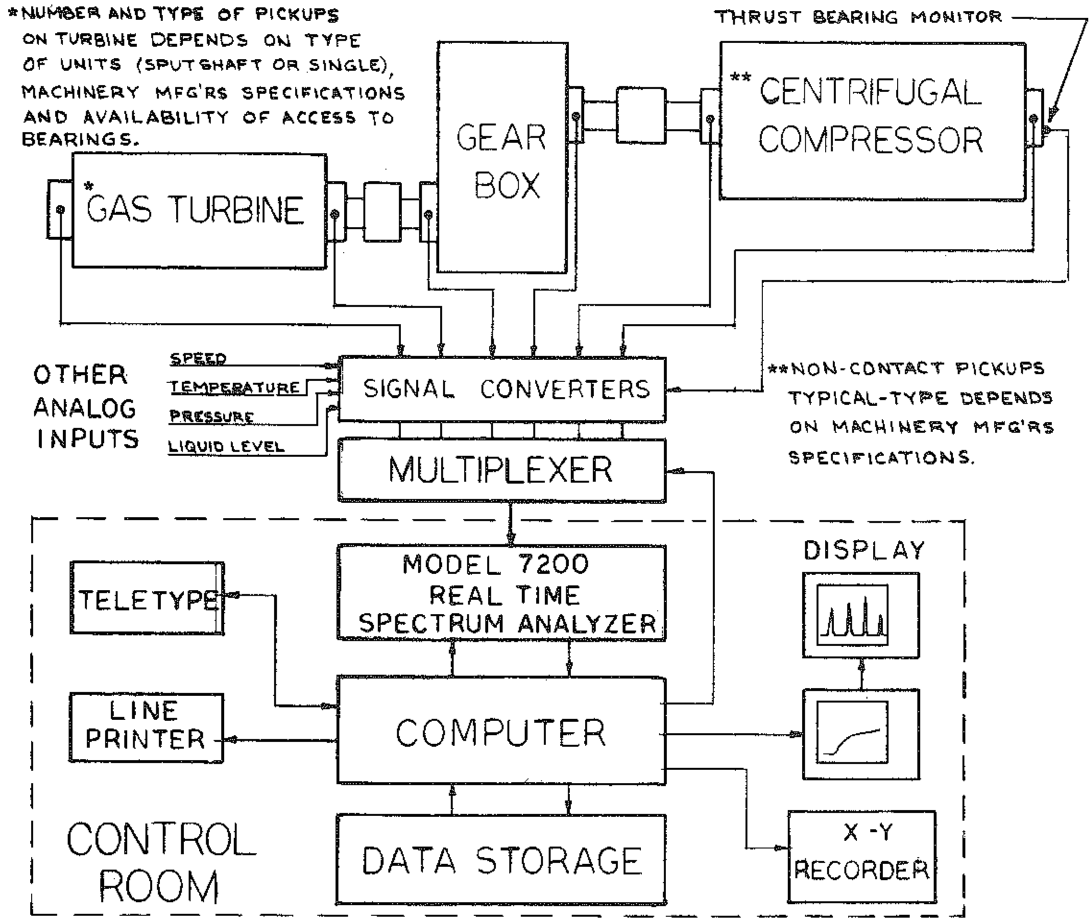
in first one plane and then the other. When severe cross effect is observed, a two plane vector calculation is used (see Appendix 1). Since this graphical solution and graphical check requires approximately 45 minutes, computer programs are now being used to quickly solve the two plane calculation.

COMPUTER APPLICATIONS

One of the newest techniques, still in the development stage, is the use of a computer in an automatic diagnostic system that detects the increase in vibration, analyzes the problem and then prescribes the necessary correction (Figure 5). Vibration information is fed to the computer, and this information is compared with the machine's normal vibration "signature." When vibrations from the normal signature are noted, the computer would print the probable cause. This automatic approach not only provides protection for the machine, but also yields immediate information concerning the problem causing the vibration.

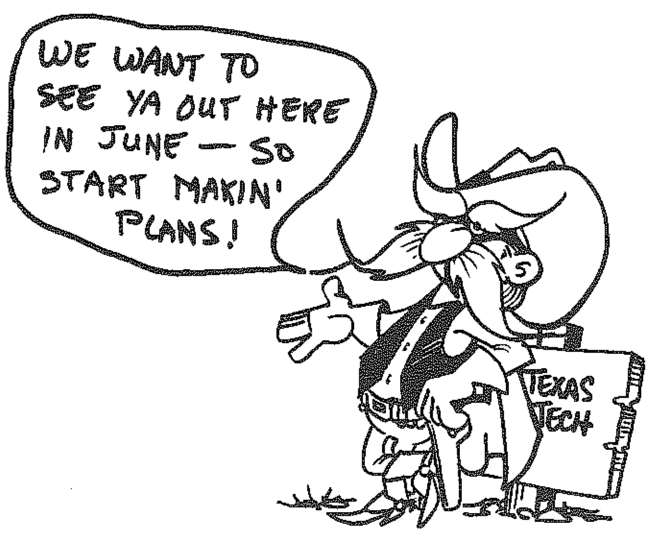
This approach to controlling a machine's condition by observing its vibration and noise finds applications in many fields, such as machine design, product testing, field service, quality control and preventive or predictive maintenance. Although graphical techniques will continue to be used by industry to solve the balancing problem, greater emphasis is being placed on the computer to detect and analyze vibrations and, finally, to correct the problem once it is identified.

(Continued on page 43)



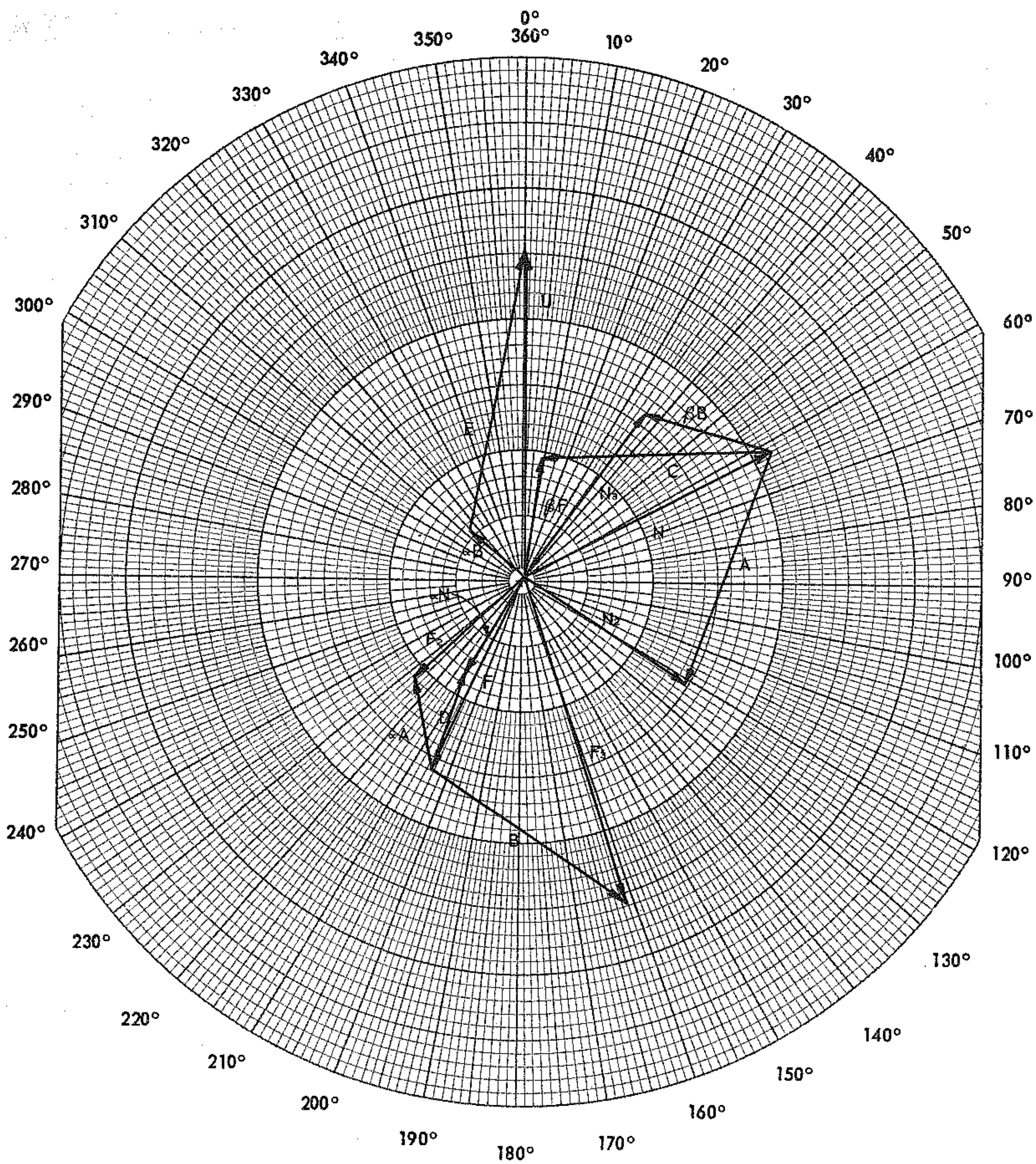
TYPICAL MACHINERY VIBRATION MONITORING SYSTEM

Figure 5



Appendix 1 (from Application Report No. 327, IRD Mechanalysis, Inc.)

TYPICAL EXAMPLE
TWO-PLANE VECTOR CALCULATIONS



Variations of Projection Systems Using A Computer

Edward V. Mochel
Associate Professor
Engineering Graphics Division
School of Engineering and Applied Science
University of Virginia

This article describes some computer programs which involve interesting geometric projections. These programs have no immediate practical value, but it is not difficult to imagine a similar type of output being of value in map projections or possible optical systems. The main purpose of introducing these programs is to illustrate the versatility of the computer as a drawing aid by producing projections which would be quite difficult to produce by conventional practices because of the tremendous amount of tedious construction required.

The three types of projection which this article will describe are: (1) spherical fisheye perspective, (2) a type of cylindrical fisheye perspective and (3) conventional perspective.

The first two projection systems can be described by comparing them to the conventional perspective system. In ordinary perspective (including one, two and three point perspective) the size of the image is dependent only upon the relative distances between the object, the observer and the image plane, all distances measured perpendicular to the image plane. In Figure 1, an observer at O views point P and sees its image M on the image plane. The size of the image (its coordinate, e) is obtained in the proportion

$$\frac{e}{d} = \frac{b}{a} \quad \text{or} \quad e = \left(\frac{b}{a}\right)d$$

A similar proportion can be set up for any point behind the paper. If a coordinate system is introduced as shown in Figure 2, it can be seen that the y coordinate of M is dependent on three factors: (1) the distance between the observer and the image plane (b); (2) the original y coordinate of P (d), and (3) the distance between the observer and the point being observed (a). The distance a is actually the difference between the distance b and the z coordinate of P $(b - z_P)$. This means that

$$y_M = y_P \left(\frac{b}{b - z_P}\right)$$

or that the y coordinate of the perspective image of P is dependent on its original y and z coordinates, but independent of its original x coordinate (x_P). Of course, the position of the observer (b) is also a factor. However, if we shift P over to a new position P' changing x_P but not y_P or z_P, the height of the image (y_M) is unchanged.

If the three dimensional distance (between observer and object) becomes a factor in our proportional distance relationship, we obtain a spherical fisheye perspective projection. In Figure 3, a sphere with radius b is shown with its center J on the z axis and tangent to the XY image plane at the origin O. If an observer at J sees a point K, its image on the sphere will be point L. The following proportions result:

$$\frac{x_L}{x_K} = \frac{y_L}{y_K} = \frac{b}{JK}$$

where JK is the distance from J to K.

$$JK = \sqrt{x_K^2 + y_K^2 + (b - z_K)^2}$$

where $(b - z_K)$ is the distance between J and K measured along the z axis. The coordinates of the image L are

$$x_M = x_L = x_K \frac{b}{\sqrt{x_K^2 + y_K^2 + (b - z_K)^2}}$$

and

$$y_L = y_K \frac{b}{\sqrt{x_K^2 + y_K^2 + (b - z_K)^2}} = y_M$$

This projection can be considered two dimensional by plotting only the new x and y coordinates (x_L, y_L) disregarding the new z_L. This in effect projects L onto the picture plane at point M.

An example of this type of projection is shown in Figure 4c, comparing it with a con-

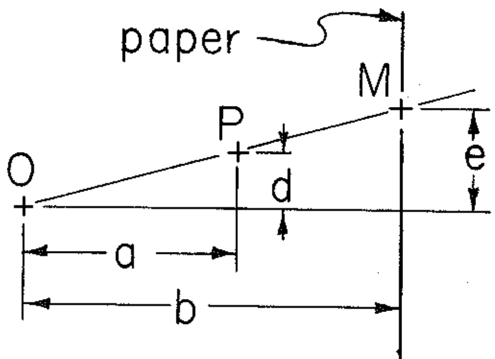


Figure 1

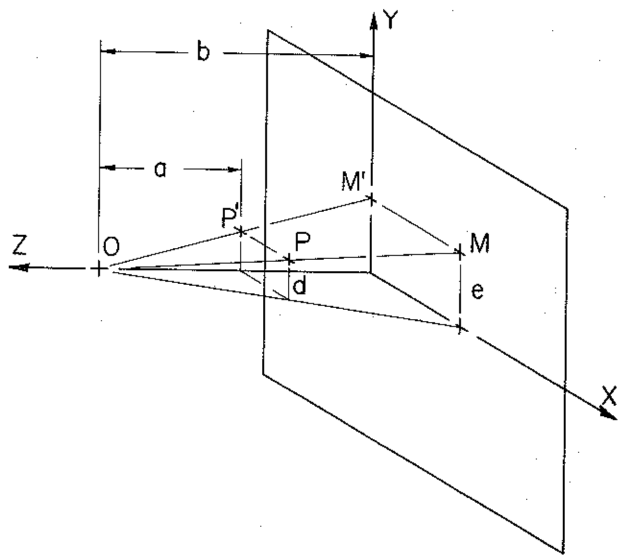


Figure 2

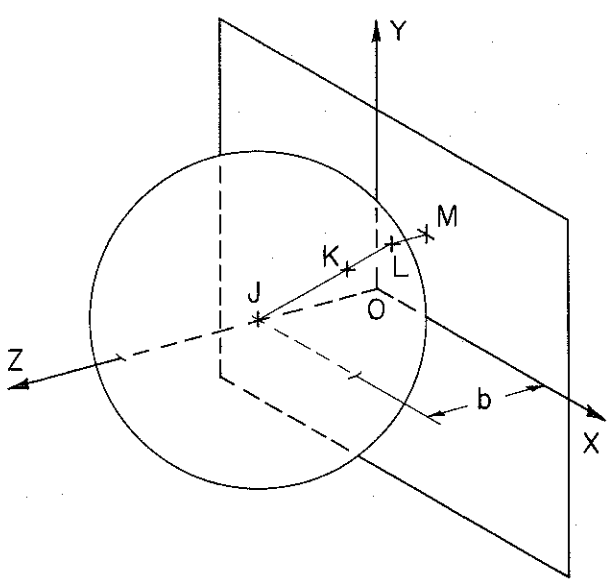


Figure 3

ventional perspective of the same object, Figure 4b and an axonometric projection, Figure 4a. In viewing this type of projection, notice how the center of the projection is relatively unchanged while the edges of the picture undergo distortion. This is similar to the effect produced in photography by fisheye lenses. Thus, I have named it spherical fisheye perspective (SFEP).

Mathematically, the image produced in Figure 4a is obtained by just plotting the present x and y values, and ignoring the z coordinate. The image produced in Figure 4b is obtained by the following relationship for each point:

$$x \text{ (plotted)} = x \left(\frac{b}{b - z} \right)$$

and

$$y \text{ (plotted)} = y \left(\frac{b}{b - z} \right)$$

All four images in Figure 4 are views of the same object in the same position in space with the observer and the image plane also unchanged. The only variable is the type of projection used.

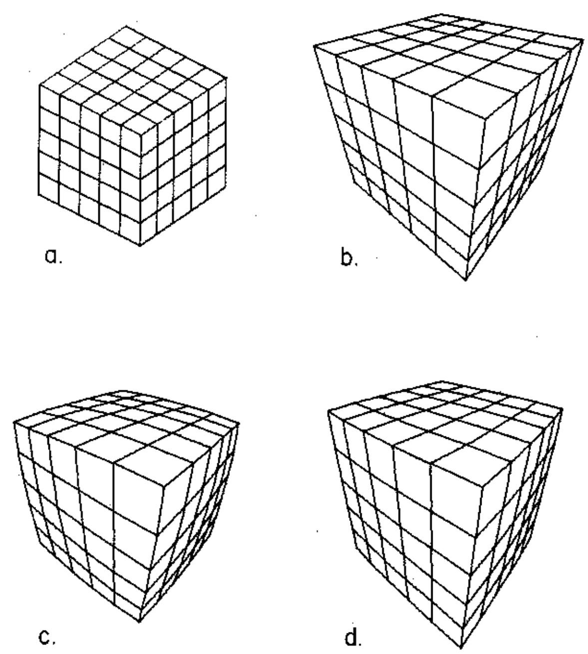


Figure 4

Many similar types of projection can be used for a variety of results. In Figure 5, a vertical circular cylinder is introduced tangent to the image plane with the observer located at point J on the axis of the cylinder. The observer at J views any point in space (K), and his line of sight pierces the cylinder wall at point

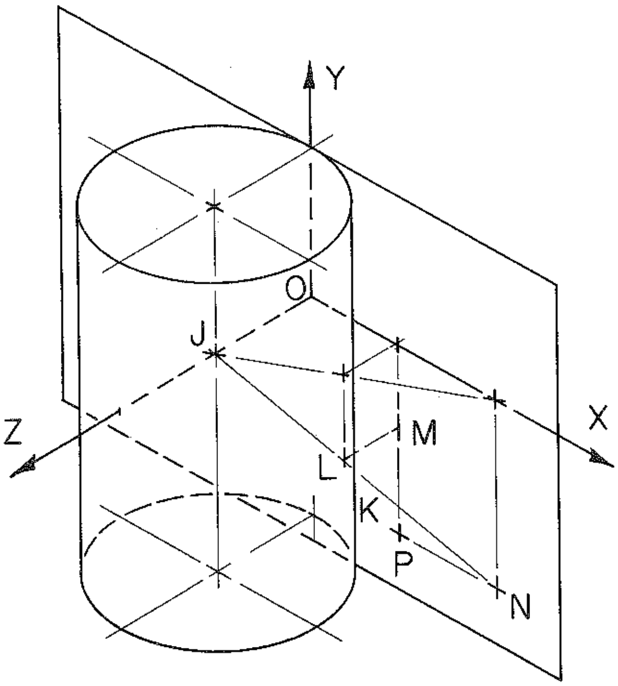


Figure 5

L. This is also shown in Figure 6. The x coordinate of L now determines the x coordinate of the image of K. The proportion which expresses this is:

$$\frac{x_L}{x_K} = \frac{JL}{JK}, \quad \text{so } x_L = x_K \frac{b}{\sqrt{(b-z)^2 + x_K^2}} = x_M$$

as JL = b and JK is the hypotenuse of a right triangle with one leg = x_K and the other is $(b - z_K)$.

Now that the x coordinate has been obtained by these manipulations, several variations on this theme are possible when the y coordinate is chosen. One simple method to select the y for our picture is to use the original y unchanged so y_K (plotter) = y_K. Another possibility is to do for y what has been done for x, that is, introduce a second cylinder with horizontal axis and tangent to the image plane. This analogous situation would then give the new y coordinate as:

$$y(\text{plotter}) = y_K \frac{b}{\sqrt{(b-z_K)^2 + y_K^2}} = y_M$$

Still another possibility would be to get the y coordinate from a conventional perspective arrangement. This is shown in Figure 7 where the proportion would be:

$$\frac{y_N}{y_K} = \frac{b}{(b-z_K)} \quad \text{or } y(\text{plotter}) = \frac{b}{(b-z_K)} y_K = y_N$$

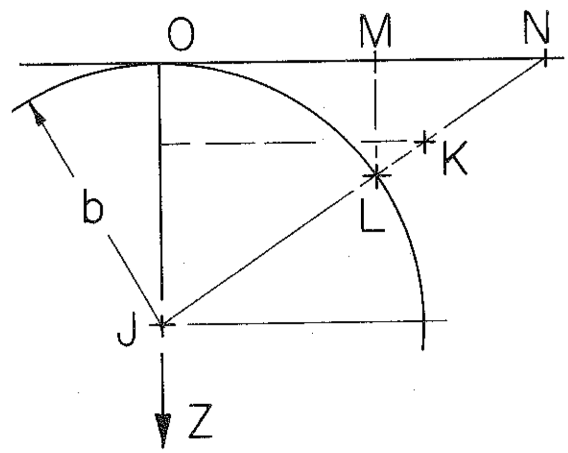


Figure 6

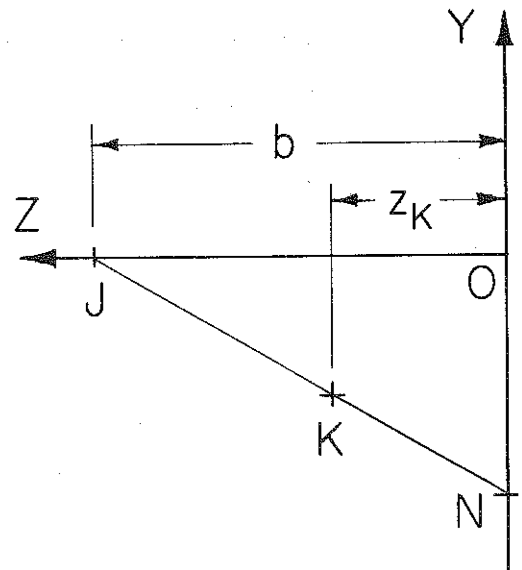


Figure 7

This particular set of circumstances yields an elongated image and was the system used to produce the image in Figure 4d. In Figure 5, this combination of x and y projections would produce point P. $y_P = y_N$ and $x_P = x_M$

In describing these two examples, I believe the reader can easily imagine many other interesting types of projects which would be fun to try. Once the basic program is written, all these variations can be obtained by merely changing a few cards each time the program is run.

The basic program would probably contain these major parts:

1. Read in data describing the object to be drawn, and store these data.

2. Provisions for moving the object (rotation, translation); scaling the data.

3. Mathematical relationships which determine which type of projection will be used.

4. Plotting the image.

Up to now, this article has dealt entirely with item 3 on the above list. Now a few comments in item 4.

As shown in Figure 4, some of the images produced require that curved lines be drawn. This makes it necessary to include an additional portion in the computer program which does the following work.

When the plotter pen is going from one datum point to the next, it is either up (not drawing a line) or down (drawing a line). If pen is down, the program computes how far it is going to move on the paper, and then breaks this path into N equal steps. The number of steps is a function of the distance in inches it will travel. For example, about 4 steps per inch will generally give good results as most curves in these drawings have a large radius of curvature.

I hope this article will inspire you to try out some of your own original projection systems.

1971 DRAFTSMAN SALARY SURVEY

The American Institute for Design and Drafting has recently completed a survey of the salaries of draftsmen. Conducted largely among its members, employers representing a wide range of industries were contacted throughout the United States and Canada. The survey requested that employers report, without revealing their identity, (1) their geographical location, (2) their type of business, (3) the starting salaries of draftsmen in three levels of education stating the minimum education they require, (4) educational assistance provided and (5) the salary ranges and number of people for four levels of draftsmen.

As reports were tabulated, it became apparent that additional education after high school is preferred or demanded by the majority of the reporting employers and they are paying for it through higher starting salaries. Another evidence of this emphasis on higher education is that these same employers either have on-the-job training or pay up to 100% of the tuition for night, extension or correspondence schools.

The following charts summarize the information reported in the survey. All salaries listed are monthly and based on a standard 40-hour work week. None of the figures shown include information on any clerical, supervisory or administrative personnel.

AVERAGE MONTHLY STARTING SALARIES BY EDUCATIONAL LEVEL

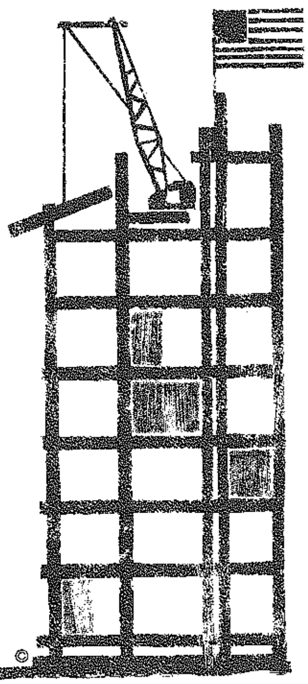
EDUCATION COMPLETED	WEST	CENTRAL	EAST	AVERAGE
High School with Drafting	$ 459	$ 346	$ 432	$ 437
2-Year Technical Training	530	510	498	506
4-Year Technical Training	645	585	557	578

AVERAGE MONTHLY SALARY RANGE BY JOB LEVEL

JOB LEVEL	WEST	CENTRAL	EAST	AVERAGE
Junior Draftsman	$462-581	$466-600	$444-590	$454-592
Draftsman	572-748	546-740	544-721	549-730
Senior Draftsman	700-893	662-851	674-862	674-862
Designer	804-1080	773-1044	768-1021	774-1036

CREATIVE DESIGN AWARDS PRESENTED AT NORTHEASTERN

First place awards for senior project -- Annual Creative Design Display, 1971 -- were presented to two of the students at an Engineering Open House at Northeastern University. The students are Harvey W. Gershman, left, and John Mustonen, right. An award to the school was received by the instructor of these students, Professor Ralph Blanchard, second from left. The presentation was made by Borah L. Kreimer, chairman of the 1971 Creative Design Display Committee.



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