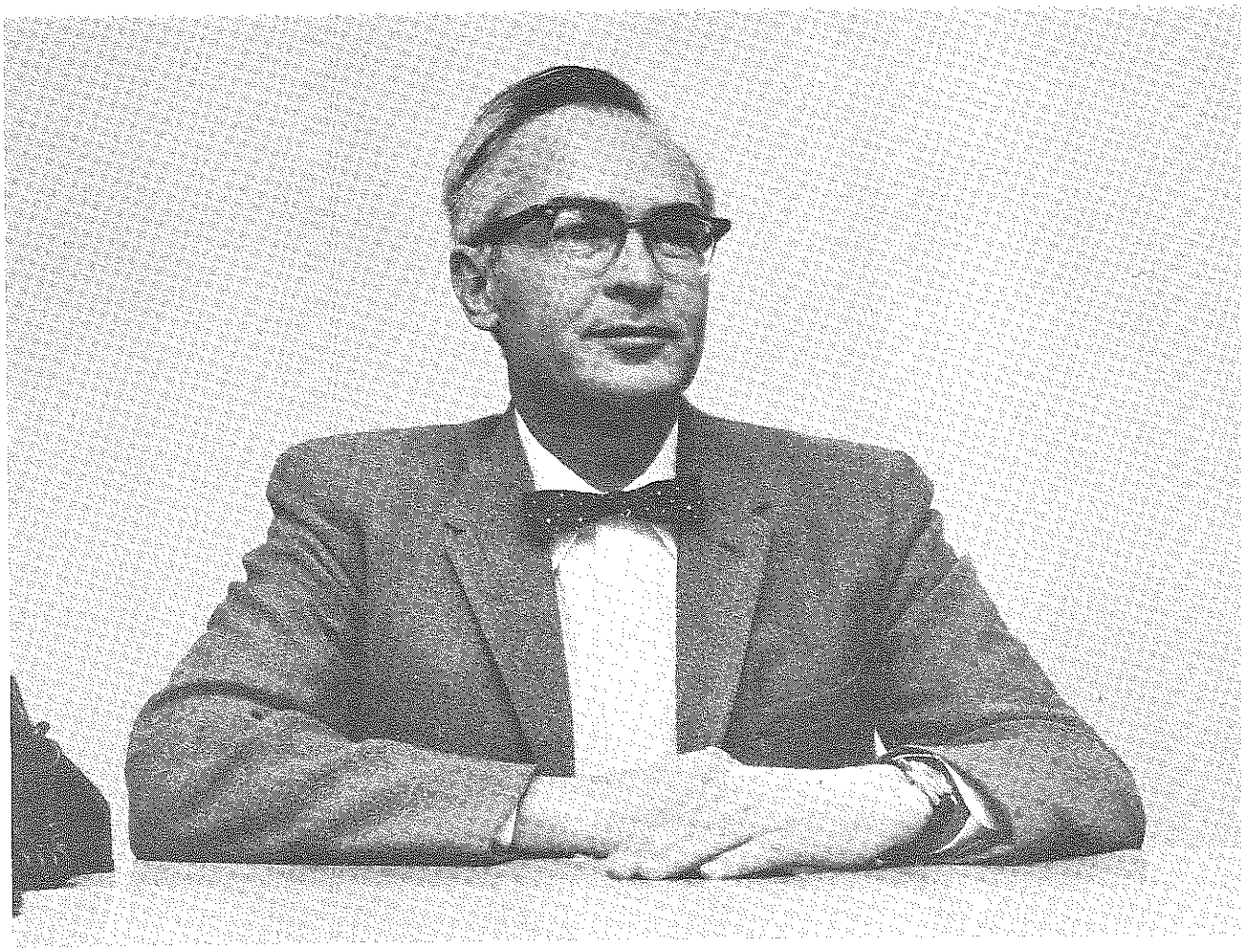
THE JOURNAL OF ENGINEERING GRAPHICS

SPRING 1968 VOLUME 32 NUMBER 2 SERIES 96



GENE PARE - Chairman of the Engineering Graphics Division, A. S. E. E. 1967 - 1968

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The Journal of Engineering Graphics

SPRING 1968 VOLUME 32 NUMBER 2 SERIES 96

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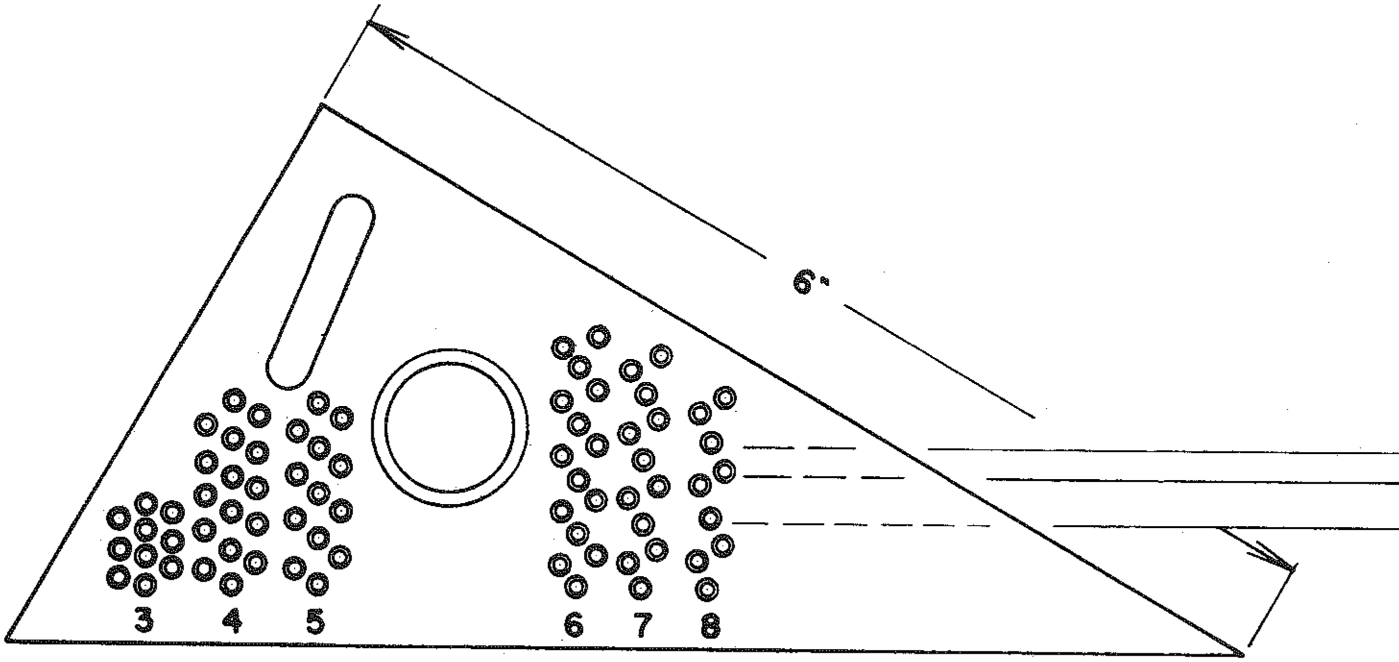
BRADDOCK LETTERING ANGLES



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Basic Graphics

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by Warren J. Luzadder, Purdue University

This new book meets the design requirements of engineers, designers, technical aids, and draftsmen who work with company computers and numerically controlled machines. It is also an excellent basic undergraduate text for courses in engineering graphics or descriptive geometry. It offers sufficient coverage for a two-term course in shop drawing. It is also well suited for use in technical institutes as well as engineering schools. The author presents the fundamentals of creative design, communication, and graphic solutions. He emphasizes the use of graphics as a language for creative design and communication and as a tool for problem solving.

The new edition includes these important changes:

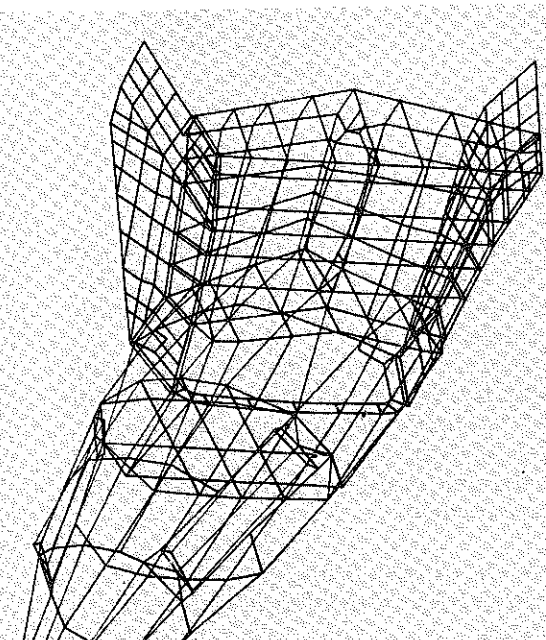
• Expanded, up-to-date coverage of descriptive geometry, and creative design • Addition of numerically controlled machines • Chapter on size description rewritten to agree with the new standard covering dimensioning, USASI Y14.5—1966 • Three new chapters cover automated drafting and computer-aided design: The Computer, Computer-aided Design and Automated Drafting, and Photodraft Systems.

TEACHING AIDS Each chapter ends with a set of problems. These problems develop the student's ability to visualize space relationships, exercise creative ability, solve problems graphically, and prepare working drawings and design sketches. Five types of problems are included: (1) design problems, (2) completion problems, (3) drawing problems to be prepared from pictorial representations, (4) working drawing problems (detailed assembly), and (5) problems requiring graphical solutions (alignment charts, vector geometry, graphical calculus, among others).

PROBLEMS IN ENGINEERING GRAPHICS, prepared for use with the first edition of **BASIC GRAPHICS,** is also applicable to the second edition. A key sheet with new reading references for the problems is available. Problem solutions are available free upon adoption. (A second edition of **PROBLEMS IN ENGINEERING GRAPHICS** is forthcoming.)

In addition, the **Purdue University Engineering Drawing Films** are very helpful as teaching aids—available from the Audio-Visual Center, Purdue University, West Lafayette, Indiana, 47907

February 1968 **656 pages** **$10.75**



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LETTERS TO THE EDITOR

Dear Professor Kreimer:

I would like to take this opportunity to express my appreciation to Professor Earle for sharing some of his design ideas with the rest of us. Not only have I gotten four problems to use in class, but they have led to several others.

Being new to the teaching profession, articles of this type can be a definite aid in presenting course content with a purpose.

Yours very truly
E. J. B.

Dear Editor:

Will Professor Earle be a regular contributor to the Journal of Engineering Graphics? His organization and presentation of his work are great.

Very truly yours
K. B. L.

Dear Editor:

I was pleased to find ideas for design problems in the November issue of the Journal, since they can help me to initiate this new topic in our freshman course. More of these would be of great value to those of us who are still groping for ideas. In fact, it seems that articles on Vectors, Descriptive Geometry and such could very well be omitted to make space for the new material which is so vital to our present work.

Please try to pass along whatever ideas that you can to help us develop a real engineering subject.

Sincerely yours
C. R.

Dear Editor:

Although the Division of Engineering Graphics is on a design kick, some of us are still firm in the belief that Engineering Graphics is a necessity for the engineer. The Journal could be an influential factor in a campaign to return us to reality.

Without Orthographic Projections, Auxiliary Views, Pictorials, Sections and Conventions, Development and Intersections as well as Descriptive Geometry, engineers of the future will have no language with which to communicate to the people in production. This, of course, would cause a vacuum that would result in little, if any, progress. Should this happen, engineering would become an obsolete profession.

To eliminate Descriptive Geometry would remove a valuable analytical tool, which is so necessary to the engineer. The methods studied, in this course, provide means for solving problems that may otherwise be impossible.

I hope that the Journal of Engineering Graphics will see fit to show that Design is the responsibility of the degree granting departments, whereas our work is in Graphics. This fad, that some of us are now following, is bound to fade out. Let us drop it before it causes us to be dropped.

Very truly yours
R. F. Z.

Dear Professor Kreimer:

I read the Special Issue of the Journal of Engineering Graphics and find it extremely informative. I was especially pleased to see some problem material that could very well be used in class, either for assignment or for discussion purposes.

Since it was impossible for me to attend the Summer School sessions at Michigan State University, there is, probably, quite a bit that I missed. However, this issue done many of us a great service in presenting a clear picture of the proceedings.

My thanks to those who were responsible for this fine publication.

Very truly yours
J. J. K.

Editors' Board

WHAT, WHEN and HOW?

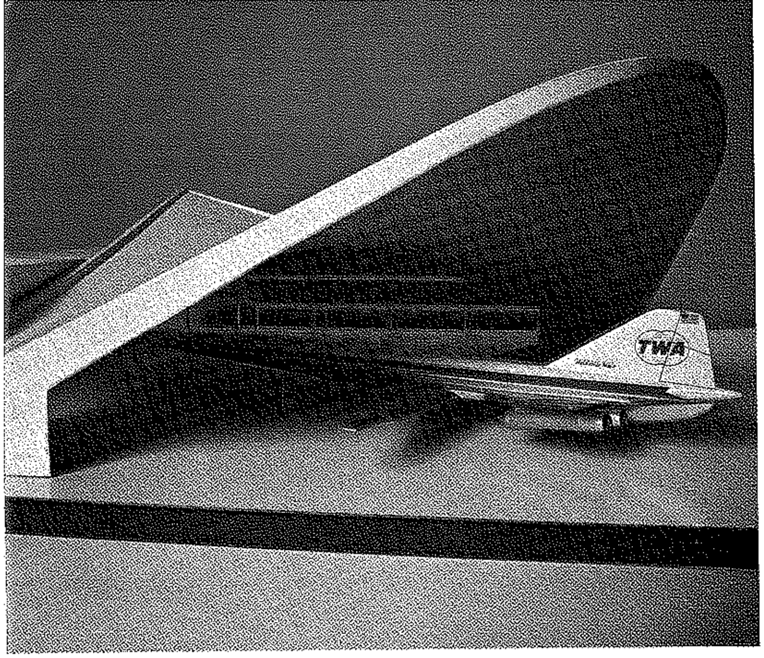
The idea of teaching "Design" at the freshman level is becoming more popular each year. There are, however, questions yet to be answered before that idea becomes fact with most of our colleagues. Until then our programs will continue to be eliminated from engineering curricula.

The first, and probably the underlying question, is "What, exactly, are we trying to accomplish?" Arguments have been presented to indicate that we must, and can, train the student to perform authentic as well as sophisticated engineering design during the one year, or less, that he is with us. Other arguments claim that since designing is a complex process, our obligation is that of developing, in the individual, a philosophy by which he may be guided in the development of a design. Another theory is that which insists the student be well grounded in certain types of "components" that are available, so as to be used in new concepts of objects or systems. There are probably many more theories concerning the GOAL for our discipline. It does not matter that we may differ in the direction reach of our destination. It does matter as to what that destination will be. Once we know our specific purpose, we can then find the methods by which each of us may best accomplish it.

Another often heard question is "What proportion of your time is spent on Design and what proportion on Graphics?" This has been answered with definite figures such as "80 percent of our course is Design and 20 percent is Graphics", or "50-50", or "30 percent Design, and 70 percent, Graphics". All of which poses another question. Why do we teach Graphics? Is it to train draftsmen? Is it to teach another method to solve mathematical problems? Is it to introduce design? Is it to train the student to think? The implication, here, is that these are two separate topics and should be presented as such. However, after careful consideration, we may find that one is a part of the other. In fact, design problems were used in the old Engineering Drawing course long before experimentation was carried out, by a few of our farsighted colleagues who have done much to help us begin to up-grade, rather than out-grade, our work. To intelligently determine the time requirements for Graphics and for Design, we must return to the original question "What are we trying to accomplish?"

"Who can help me to develop a course in Design?" Is it someone who has spent some time in a personnel office of an engineering firm? Is a time-study man qualified, if his work was done in the shop or in an engineering office? Does it have to be someone with extensive design experience? To develop such a course is not an easy task, especially at the freshman level. The 1967 Summer School at Michigan State University was a good beginning, but only a few attended its sessions. It is, now, the obligation of this privileged few to carry the information to their colleagues who were not as fortunate. The Division of Engineering Graphics will activate a Design Consultants Committee whose purpose it will be to help us (upon request) to help ourselves in developing a meaningful curriculum. Its members are people who have had success in teaching Design to freshman students, after years of trial and error. They understand the problems involved and are well qualified to assist us in overcoming the troublesome situations. By consulting this committee and studying the work of the summer school, one should be able to develop a course to be of value in the overall engineering curriculum.

"Should we drop such topics as Graphical Analysis and Descriptive Geometry?" This question implies that these topics are useless in Design. Although a great deal of the analysis may be of the mathematical variety, it may not be feasible in some instances. Therefore other analytical methods (other than logic and common sense) must be used. Our problem is to determine how much of these subjects should be included in the introductory course and their proper position in the Design Process. It is not inconceivable that electives,
(continued on page 44)



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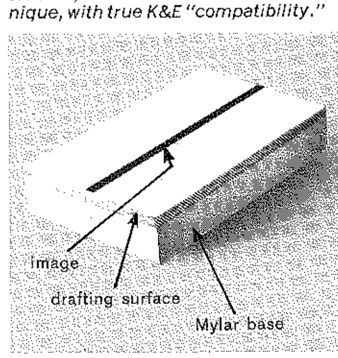

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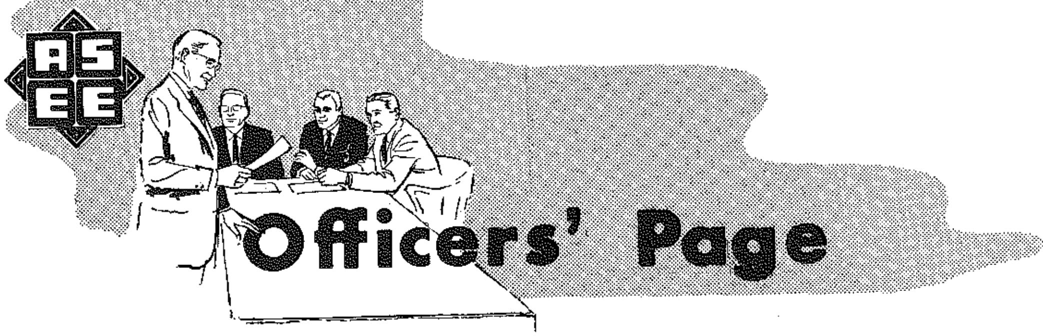

A MESSAGE FROM THE DIVISION CHAIRMAN

Eugene G. Paré

A good deal of criticism is often directed at the mathematics instructor who so often is concerned only with mathematical theory and neglects the engineering application. However, it is readily apparent that for the last decade most of our engineering science teachers are equally guilty of this same instructional deficiency. The justification for this practice is usually based on the premise that the engineering application of tomorrow will vary greatly from that of today. So theory alone is emphasized with the anticipation that the engineering graduate will readily adapt his broad theoretical background to solve the sophisticated applications of the next decade.

For the student in the basic sciences, who will be absorbed with the extension of knowledge in his own speciality, such limited theoretical objectives might well be adequate. Yet is such emphasis appropriate for other professions? Do the schools of medicine, law, and dentistry, for example, inculcate the current state of their science and art or do they just theorize about potential enhancements? In these specialities the answers are obvious; and for engineering education as well, all disciplines should strike a desirable balance between theory and application.

Yet it is also impossible to disagree that engineering applications will certainly change. So the teaching responsibility becomes more demanding in that the instructor must have both the experience and vision to anticipate the engineering needs of future generations. A blend of current practices and contemplated future applications would seem most desirable; but in any case, let us not be misled that theory alone represents adequate preparation for the graduate to assume a meaningful industrial role.

Most of us in Engineering Graphics and Design have in recent years developed a most desirable balance of graphical communication theory and its application in creative engineering design. We should now lend our experience to those critical areas of the engineering sciences that for the present seem separated from the progressive stream of creative developments in engineering education.

ENGINEERING GRAPHICS DIVISION ELECTION RESULTS

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IN THE DIVISION

Dear Colleagues:

The Engineering Graphics Division is optimistically looking forward to the ASEE Diamond Jubilee at UCLA in June. Our Introductory Creative Design and Display is mentioned as a program highlight in the ASEE program. Everyone is working to give your display a quality environment.

There is no doubt that the Display will be an inspiration and should serve as a guide to our graphics colleagues who are considering the introduction of design in their curriculum. Please accept this letter as a grateful thank you for your participation.

The following is for your convenience:

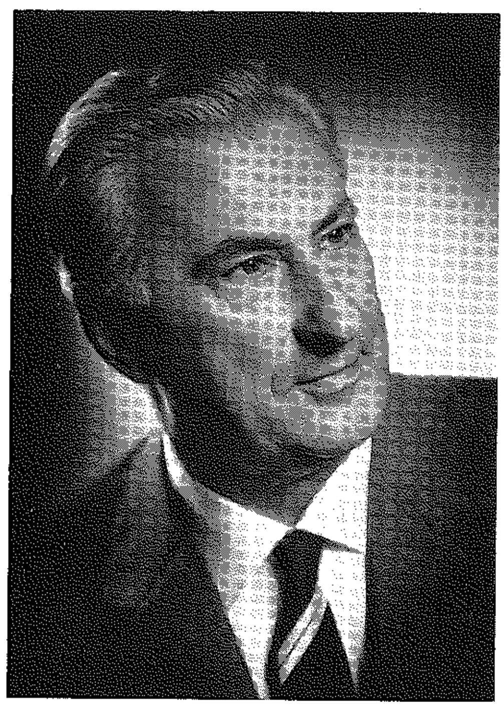
Please ship or deliver all project material to arrive before June 15 so we can have it displayed effectively Sunday, the opening day. The address is:

Professor Robert L. Ritter-
Engineering Graphics
c/o ASEE Journal Meeting
Instrumentation Facility
Department of Engineering
University of California
405 Hilgard Avenue
Los Angeles, California 90024

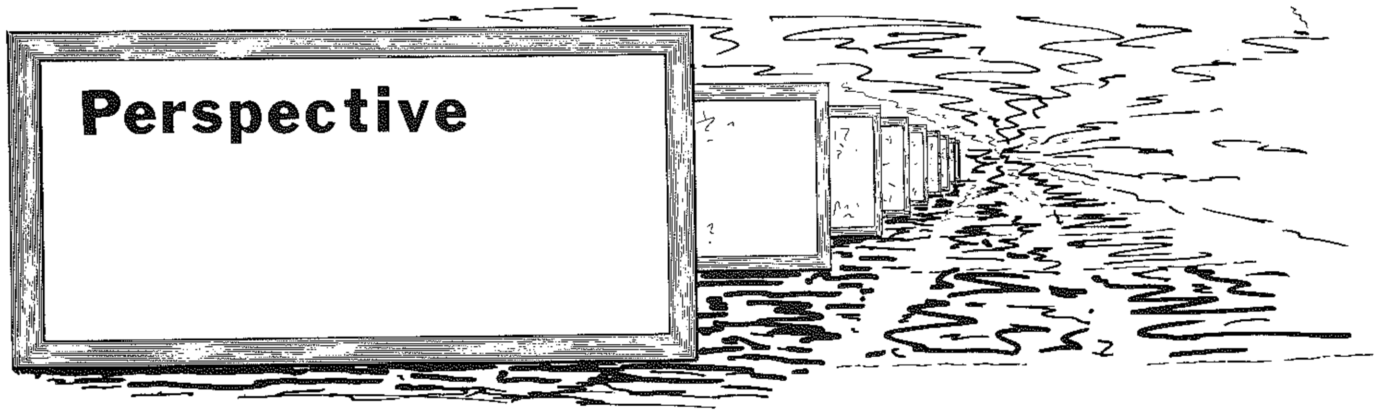
We are pleased to be able to report that Al Hoag's Awards Committee has generous monetary awards and many certificates. Hope to see you at UCLA. It would be a valuable asset to have you or a representative to discuss your project with the visitors.

Cordially yours,

John R. Barylski
Chairman-Displays Committee
SMTI-College of Engineering
New Bedford, Massachusetts



Mr. ALFRED KREIDLER of Zurich, Switzerland who has made possible the awards which will be given the deserving entries of the Design Display during the 1968 Annual Convention of A. S. E. E. from June 16 to June 20 at U. C. L. A.



GRADUATE STUDY
AT
TUFTS UNIVERSITY

MASTER OF SCIENCE IN
ENGINEERING DESIGN

INTRODUCTION

Based on the conviction that engineering design is central to the practice of engineering and therefore central to engineering education, Tufts University offers a program leading to the Master of Science degree in Engineering Design. The program will prepare students to enter engineering on a private practice basis as well as professional employment. Emphasis will be placed on total design which includes identification of need, research, analysis, experiment, prototype construction, and manufacturing and marketing the product. The primary objective of the program is to educate an engineering designer who has inventive and imaginative ideas, the ability to analyze both analytically and experimentally, and a working knowledge of the problems in implementing a design. Students will be involved in actual design situations and instruction through independent study will be encouraged. The morphology of design is an underlying theme for all courses in the program.

COURSE OFFERINGS

A minimum of 30 credits including a thesis be required for the degree. Generally at least 18 of these credits are in engineering design, the remainder in allied fields. Course offerings include:

- NUMERICAL METHODS
- INVENTIVE DESIGN
- EXPERIMENTAL DESIGN
- INTERNSHIP IN DESIGN
- COMPUTER AIDED DESIGN
- SEMINAR IN PRODUCT DESIGN
- AUTOMATION
- ADVANCED KINEMATICS
- FRACTIONAL HORSEPOWER ELECTRO-MECHANICAL DEVICES
- ADVANCED CALCULUS
- STATISTICS
- SYSTEMS DESIGN
- ADVANCED STRENGTH OF MATERIALS
- ADVANCED DYNAMICS, SHOCK, AND VIBRATIONS
- DESIGN THESIS

FACULTY

The faculty have a variety of academic and industrial experience and their interests span the major areas concerned in the program. These interest include:

- COMPUTER SCIENCE
- INVENTIVITY
- SYSTEMS DESIGN
- BIOENGINEERING
- ANALYTICAL ANALYSIS
- EXPERIMENTAL ANALYSIS
- HUMAN FACTORS
- TRANSITIONAL TECHNOLOGY
- THE ENGINEER AS AN ENTREPRENEUR

ADMISSION

A candidate for the Master of Science degree in engineering design is expected to have a satisfactory background in physics, mathematics, engineering science, and a B. S. degree in an engineering field. There is no foreign language requirement. To remedy deficiencies of preparation, an incoming student may be required to enroll in one or more undergraduate courses that do not carry credit. Applicants must submit Graduate Record Examination scores.

FINANCIAL ASSISTANCE

Fellowships, research assistantships,

teaching assistantships, and tuition scholarships are available to qualified students. Assistantships carry a stipend of $2400 plus tuition remission. Research assistants may write theses in the fields in which they assist.

ENVIRONMENT

The program is given by the Department of Engineering Graphics and Design located in Anderson Hall, a relatively new engineering building on the Tufts campus. In addition to offices and classrooms, the Department has a bio-engineering research shop and a newly constructed Design Laboratory. The laboratory contains electronic and mechanical Test equipment, prototype construction areas, machine tools for model construction, reference library, conference room, graduate assistants office, and a drafting room. Adjacent to this laboratory is an IBM 1620 computer and located in a nearby building is the University's Computation Center which includes a Honeywell H200 computer. Library facilities include the Lufkin Engineering Library in Anderson Hall, the new Wessell Library (central University library), and the Human Factors Library in the Institute of Applied and Experimental Psychology. Tufts University is located within eight miles of six other academic institutions and participates actively in the intellectual and cultural life of the Greater Boston area. Many companies that participate in the Internship in Design Course are located on route 128 ("Electronics Highway") just north of the Tufts campus. This environment provides a real-world laboratory for the practice of design and research by students in the program.

CONGRATULATIONS TO STEVE SLABY

Information was received concerning an honor that was bestowed upon the vice chairman elect of the Engineering Graphics Division, Professor Steve M. Slaby of Princeton University. His book "Fundamentals of Three-Dimensional Descriptive Geometry" was given the distinction of being the only book published by Harcourt, Brace & World, Inc., this past year, to be accepted in the American Institute of Graphic Arts' Textbook and Learning Materials Show of 1968, which took place in early February.

The work of 26 publishers was selected for display, at the show, by a jury panel consisting of the following distinguished judges; Albert Christ-Jones, Dean of Pratt Institute; Professor Gyorgy Kepes, Head of the Graphic Design Department at Massachusetts Institute of Technology and Fred M. Hechinger, Education Editor of the New York Times.

Congratulations are in order to Professor Slaby on receiving this distinct honor.

THE NEW ENGLAND ENGINEERING GRAPHICS ASSOCIATION

On Saturday, April 13, 1968, the New England Engineering Graphics Association held its annual conference at the Suburban Campus of Northeastern University. The meeting was opened by Professor Borah Kreimer who introduced Dr. Louis Vrettos, the director of the suburban facilities, to greet the attendees. One of Dr. Vrettos' duties is to act as a liason between the university and industry.

Dr. Vrettos pointed out that Graphics people seem to be in a state of panic without good reason since industry needs design people who are capable of conveying ideas as well as analyses. He read from several reports of visits to companies within more than a 50 mile radius of Boston to prove his point. Some companies are more interested in engineers who have analytical background, some want only the engineer who can apply scientific knowledge to design situations while still others require both types of engineers.

The conference continued with explanations of how design may be taught to freshman engineering students. Professor Rule of Northeastern University explained how he tries to make his students aware of the many common components that may be used in design. Pro- Kreimer reviewed his procedure of presenting the Design Process through short problems emphasizing the various steps to the concept phase of design. Professor Hill of Tufts University related the systems of orientation by the assimilation of hypothetical companies competing for a contract to design and build an object or system.

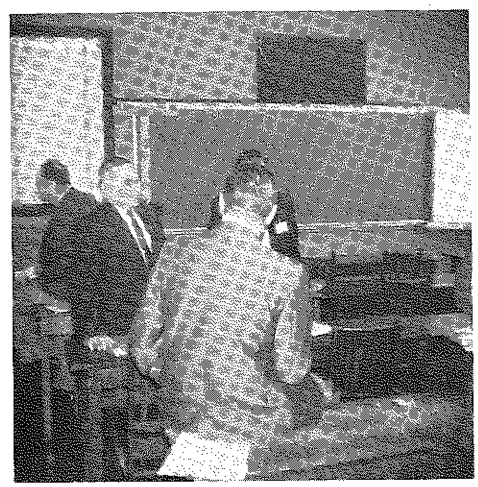
The attendees were then assigned to workshop groups where discussions on the teaching of design were held as well as participation in the experience of designing as the students might do. Transparancies were made of the work done by the workshop members and discussed during the afternoon session after a pleasant sherry social hour.

The sessions precipitated a lively discussion with benefit to all. Methods of presenting the ideas, from the sessions, were discussed. It was decided that some of the transparancies would be made available to those who would like to use them for the purpose of introducing "design" to their students.

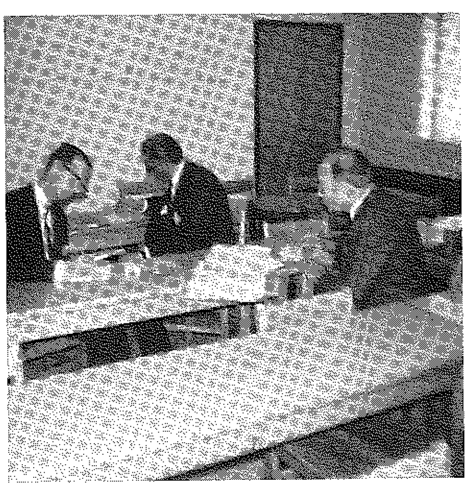
The luncheon meeting was extremely successful since there was plenty of deliciously palatable food for all. While relaxing, after the meal, over cups of well made coffee, the business part of the conference took place. Since there was only one item on the agenda - election of a chairman for the next two years - it did not detract from the important theme of the conference. The new chairman of the New England Engineering Graphics Association will be Professor Alan Karplus of Western New England College.

Although the conference was officially over at 4 P. M. several members remained for an informal discussion until after 5P. M.

Preparation



The main speaker



work session

Another work session

RCA GIVES COMPUTER TO NORTHEASTERN UNIVERSITY SUBURBAN CAMPUS

The Radio Corporation of American has presented a computer to Northeastern's Burlington Campus, where it will be utilized in freshman engineering design courses.

Associate Professors Borah L. Kreimer and Kenneth S. Woodard, both of the Graphic Science Department, are using the computer as a tool to help their students understand basic design principles. It is also anticipated that it will be used for administrative purposes at the Suburban Campus.

The computer is being housed in the former bookstore area, which will be renamed the Design and Computation Center. It was given to the University by RCA's Burlington facility.

EXAMINING COMPUTER, presented to Northeastern's Suburban Campus by the Radio Corporation of America, are (from left to right) Harry J. Woll, Chief Engineer, RCA Aerospace Systems, Burlington; William F. King, Acting Dean of Engineering; Borah L. Kreimer, Associate Professor of Graphics; and Eugene P. Tangney, Plant Manager, RCA Aerospace Systems.

DRAWING AN ANGULAR PERSPECTIVE WITH ONE VANISHING POINT

by Robert I. Duncan
Iowa State University

When drawing an angular perspective it is not uncommon for one of the vanishing points to be located off the drafting desk. Students often complain that the reason their perspective drawings are so small is that they were limited by the length of their drafting desk top. To many, it seems impossible to obtain a large drawing without using radius curves or other similar instruments.

There have been many methods used to solve this problem, all of which seem to be more complicated than need be. If one assumes that in any study of perspective both angular and parallel perspective methods will be covered, why not draw an angular perspective using parallel perspective procedures? In this way the problem of "losing" one vanishing point off the desk top can be remedied. The procedure for drawing an angular perspective using parallel perspective techniques remains the same--one must know how to locate any point in space.

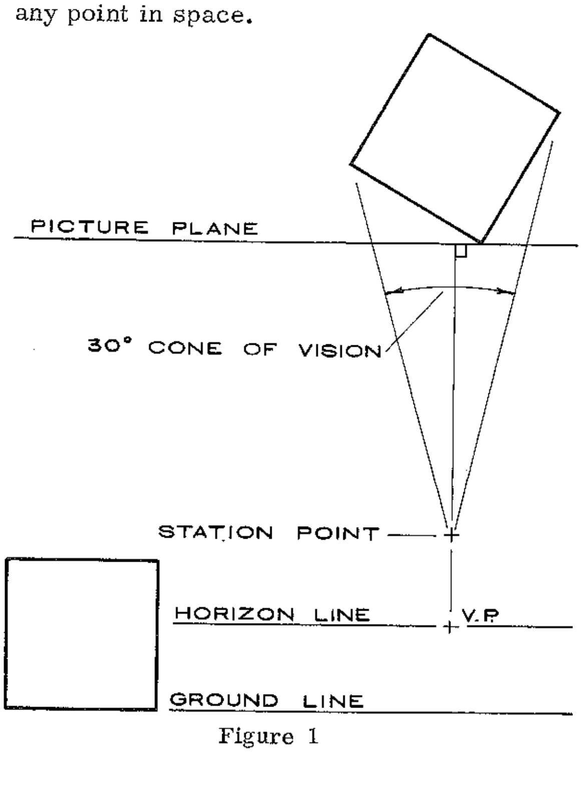


Figure 1

In Figure 1, the orthographic drawings are established and located as in any normal angular perspective. The object is positioned with respect to the picture plane and the station point is determined using a 30° cone of vision. The ground line and horizon line are positioned with respect to the elevation view of the object. The vanishing point is located on the horizon line using parallel perspective procedures.

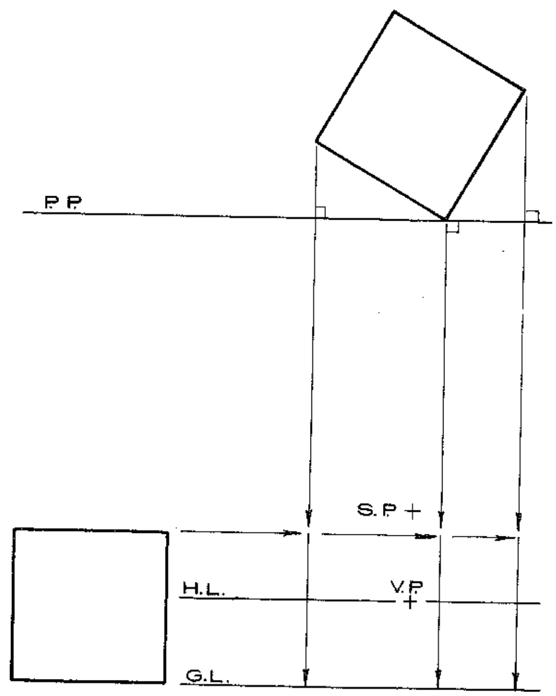


Figure 2

In Figure 2, the parallel perspective initial points are found for the corners which will show in perspective and these are projected to the ground line and the true elevations of the points are measured on them.

In Figure 3, lines are drawn from the true height initial points in the perspective drawing to the vanishing point on the horizon line.

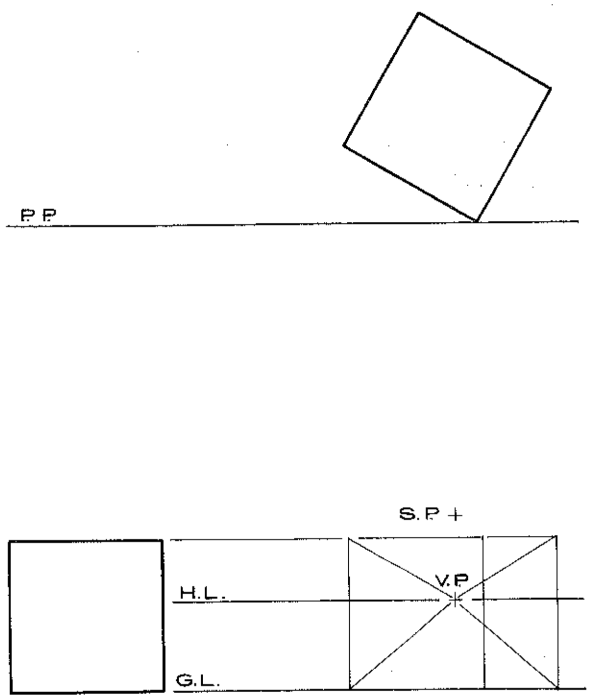


Figure 3

The final step is Figure 4 which shows lines from the station point projected to the various corners in the horizontal view, where these lines pierce the picture plane they are then projected down to the perspective drawing. The remaining step is to draw lines from each corner in the perspective drawing to the corresponding corner to complete the sides of the cube. This last remaining step actually locates those line which would vanish to a right or left vanishing point in angular perspective.

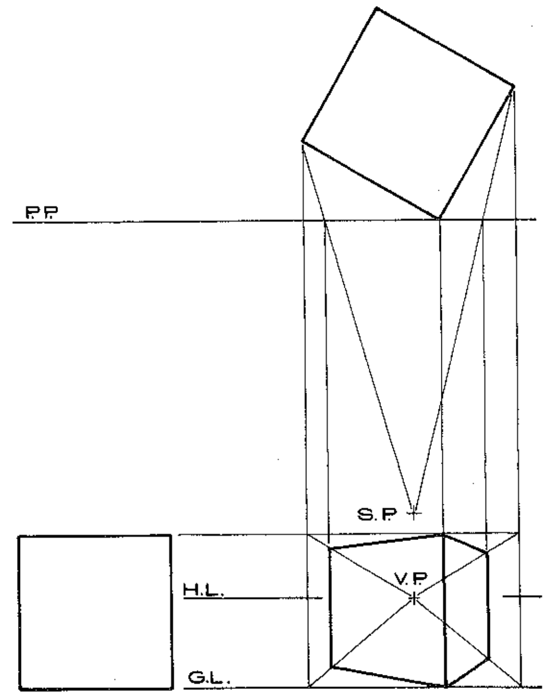
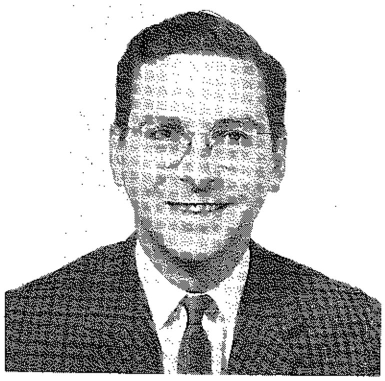


Figure 4

If one understands the theory of parallel perspective and can locate any point in space, any object can be drawn using this method whether it is parallel to or makes an angle with the picture plane. Accuracy is important using this method, especially when locating those points which will ordinarily vanish to a common point. This procedure is often used for architectural studies when a large perspective is desirable and must be drawn quickly and accurately.



DESIGN GRAPHICS - VISUAL PERCEPTION BETWEEN AN ENGINEER AND HIMSELF

by

Peter Z. Bulkeley
Director, Design Division
Mechanical Engineering Department
Stanford University

Every now and then we see or experience something which strikes us as particularly elegant in the milieu of that moment's thought. "I wish I'd written (built, composed, designed, drawn) that " And we remember this thing and imperceptably it may change the pattern of our thinking. Or maybe it confirms and reinforces ideas we already held but never felt were expressed so well.

Just this happened to me last week as I read one of the many office memos that daily burden my life. It said.

> "Communication is a vital factor in the life of an idea. While communication between a sender and receiver can be of great practical importance, the communication of messages between a sender and himself can be equally important--particularly at the formative stages of an idea where expression becomes a tool for the development and realization of the idea. "

Now these two sentences struck me as an elegant expression of a need -- one long recognized but one I'd never seen stated so clearly. Isn't it obvious, if you stop for a moment to think about it, that the engineers who will devise and mold our future environment, its products and its processes and its means of manufacture, and, yes, the ultimate strategies of use for the world's resources -- isn't it obvious that these people must have total facility in communicating idea messages within themselves if they are to make optimal use of their own creative potentials? Isn't it obvious then that we, as engineering educators, should spend not just a little but a lot of time in developing means and capacities for an engineer to build freely open pathways for communicating ideas with himself?

Now we all know that ideas and concepts can be represented in many forms -- and that few of the ideas and concepts that an engineer is likely to encounter can find whole substance in only a single of these forms. Thus in communicating with ourselves we deal with combinations -- we combine and recombine verbal forms with symbolid (mathematical) forms with visual forms in developing our ideas.

Our facility with verbal and symbolic forms of communication is usually assured us extrinsically to the formal technological training of an engineer. Education in visual forms however falls quite naturally within the province of engineering education. In the historical development of our educational process the responsibility to train engineers in visual communication has been recognized and accepted -- by our forebears and by ourselves.

If we accept this responsibility for training of engineers in means of visual communication, and I suggest we do -- we should continually assess and reassess the appropriateness and effectiveness of the job we do. Looking back to the quotation I made earlier,

> "... While communication between a sender and receiver can be of great practical importance, the communication of messages between a sender and himself can be equally important .... "

From the knowledge we have of graphics instruction in engineering curricula, it strikes me the following assertions are both plausible and timely:

1. Graphics instruction has historically stressed visual communication between <u>sender and receiver</u>, between separate individuals.

2. Graphics instruction has never stressed the development of visual pathways by which a sender can optimally communicate idea patterns with himself.

3. Graphics instruction has been preoccupied with formal representation

and relatively unconcerned with unsophisticated exposition of ideas.

If you agree with me that it's important to develop in engineers the ability to communicate visual patterns rapidly with themselves, and if you agree with me that existing graphics instruction may not now concern itself with this need -- then we together face the conclusion that graphics instruction is not serving engineering education optimally. Graphics instruction may just be "missing the boat."

Let me show you an example of what I mean by this apparent dichotomy between internal and external communication of visual forms. In mid-1959 Alcoa ran an ad in several magazines which showed, in color, an industrial designer's concept of a spherically shaped portable barbecue oven, figure 1.

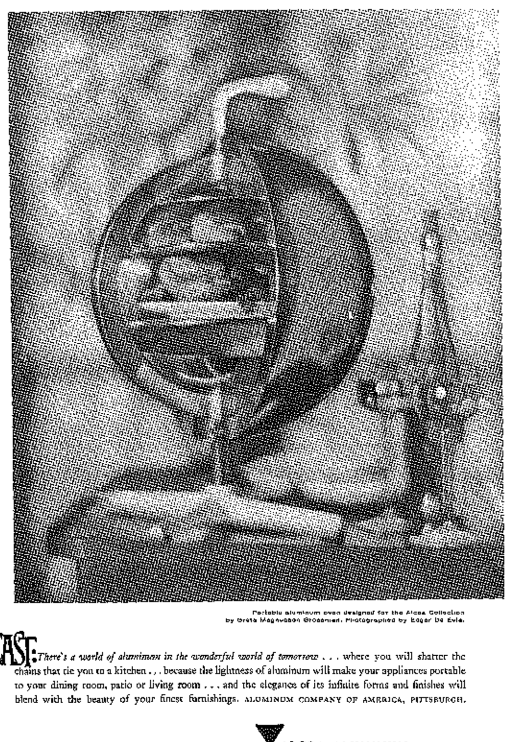


Fig. 1 -- Portable Oven from Alcoa Forecast Collection, courtesy Aluminum Company of America

The ad's picture of the oven is vague in aesthetic detail -- partly caused by artistic license taken by the photographer who shot the picture from which the ad was made. Engineering detail is almost wholly absent -- the oven model in the ad was simply a "mock-up" of a desing "concept".

There was a considerable commercial response to the ad. Large department stores pressed Alcoa for a source of ovens -- the concept appeared to be marketable. Subsequently, a private entrepreneur purchased a license to manufacture and market ovens following this design. He retained an engineer to work out the "casual details" of taking a formless advertisement -- and reducing its conceptual idea content into practice. The engineer was simply handed the ad, he had no real knowledge of the device's function or its component parts. No drawings of the oven were available -- it had to be reconstructed from scratch.

Using a plain sketchpad of paper, the engineer dissected the oven into its component parts and subassemblies -- and then explored visually, by means of rapidly made freehand pictorial sketches, various alternative means for building the overn, figure 2. (There were many parts, of course, but we will concentrate on the handle.)

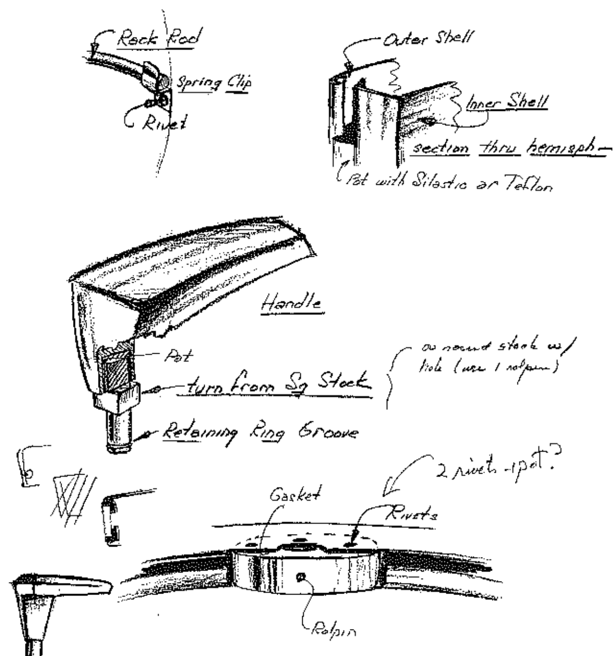


Fig. 2 -- Design Conceptualization Sketches

Verbal notations were made where needed and appropriate on the sketches. The concepts evolved gradually through several iterations and the sketches became clearer in detail and form, figure 3.

Finally, after all design details were

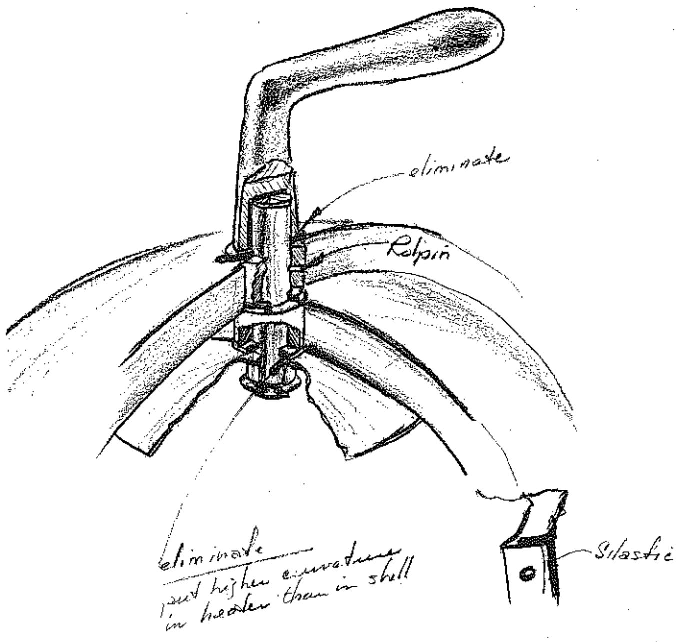


Fig. 3 -- Deisng Assembly Sketch

worked out, manufacturing processes decided upon, assembly and inspection procedures identified -- formal working drawings were prepared, figure 4.

The importance of this procession of events is obvious when we look at the development of ideas in this engineering design. The engineer communicating with himself via the sketchpad occupied a majority of the design time. The free passage of his thoughts to and from his paper provided the medium of interaction for his ideas and his mind in solving the problem. Not until the detailed function of each part, and its interrelation to the total of parts was worked out was a formal drawing made.

Clearly in this design development the engineer wasn't able to avoid the meticulous attention to detail required in finalizing his concepts through working drawings. However, that was a purely routine task compared to his initial efforts at conceptualization. The prior effort embodies the engineer's creativity, the latter represents a purely technical function.

This example, this spherical barbecue oven, is typical of new product development in contemporary technology -- regardless of the sophistication of its underlying science. In all instances the really creative contributions are the product of a single mind -- in close perceptual communication with itself.

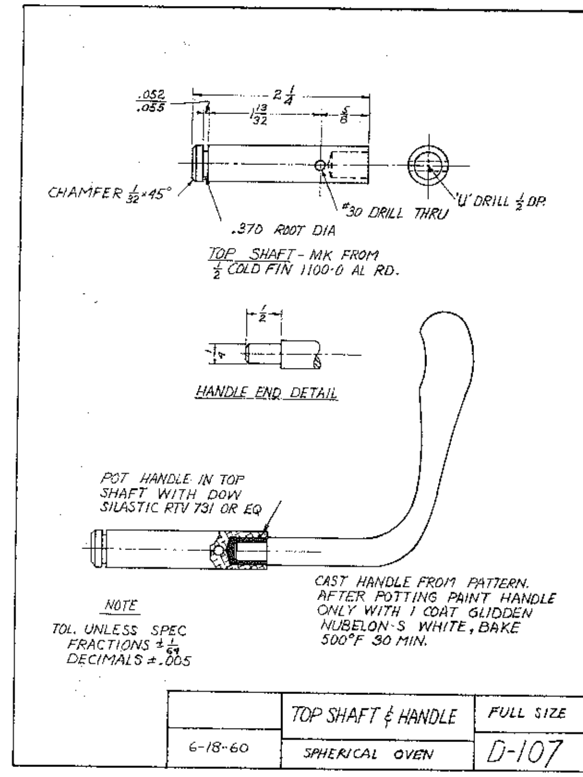


Fig. 4 -- Handle Detail

I urge you therefore to consider and to reconsider -- where best your energies as teacher are to be expended. I submit that not just a little, but, rather a lot of your effort should address itself to the training of engineers to have facility and fluency in communication visually with themselves.

Without expending much time and trouble in analyses -- you will clearly ascertain for yourselves the compelling importance of a technologist's ability to deal intellectually with the visual constructs of his own mind. And you will immediately recognize his need for visual feedback between his seeing a construct and feeling the efficacy of its function. I urge you therefore seriously to consider throwing aside many of the historically formalistic patterns of graphics instruction which now burden our collective curricula. As a far more useful alternative -- do educate the coming generations of engineers to excel at visual communication. And particularize this education to the visual communication between an engineer and himself.

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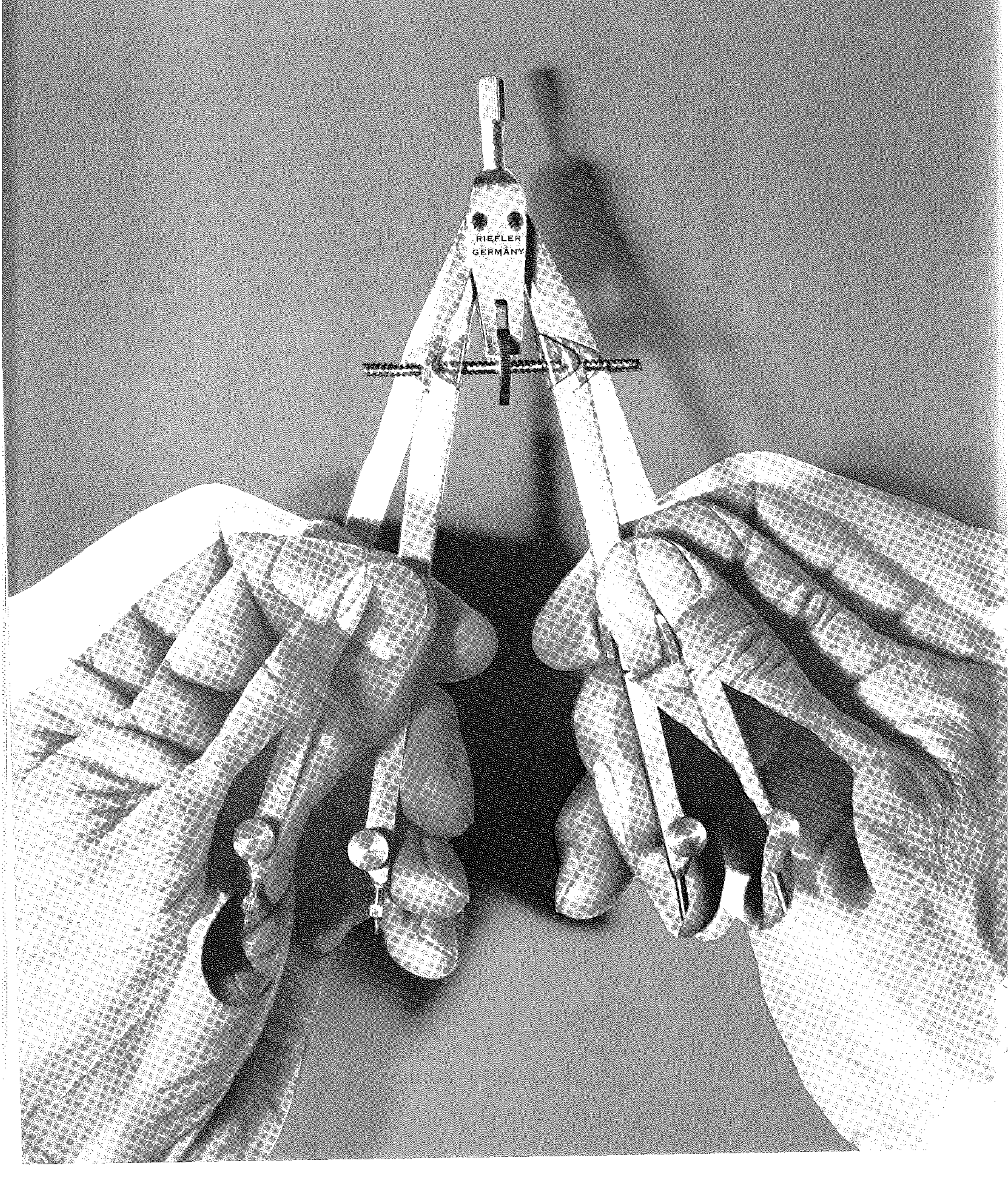

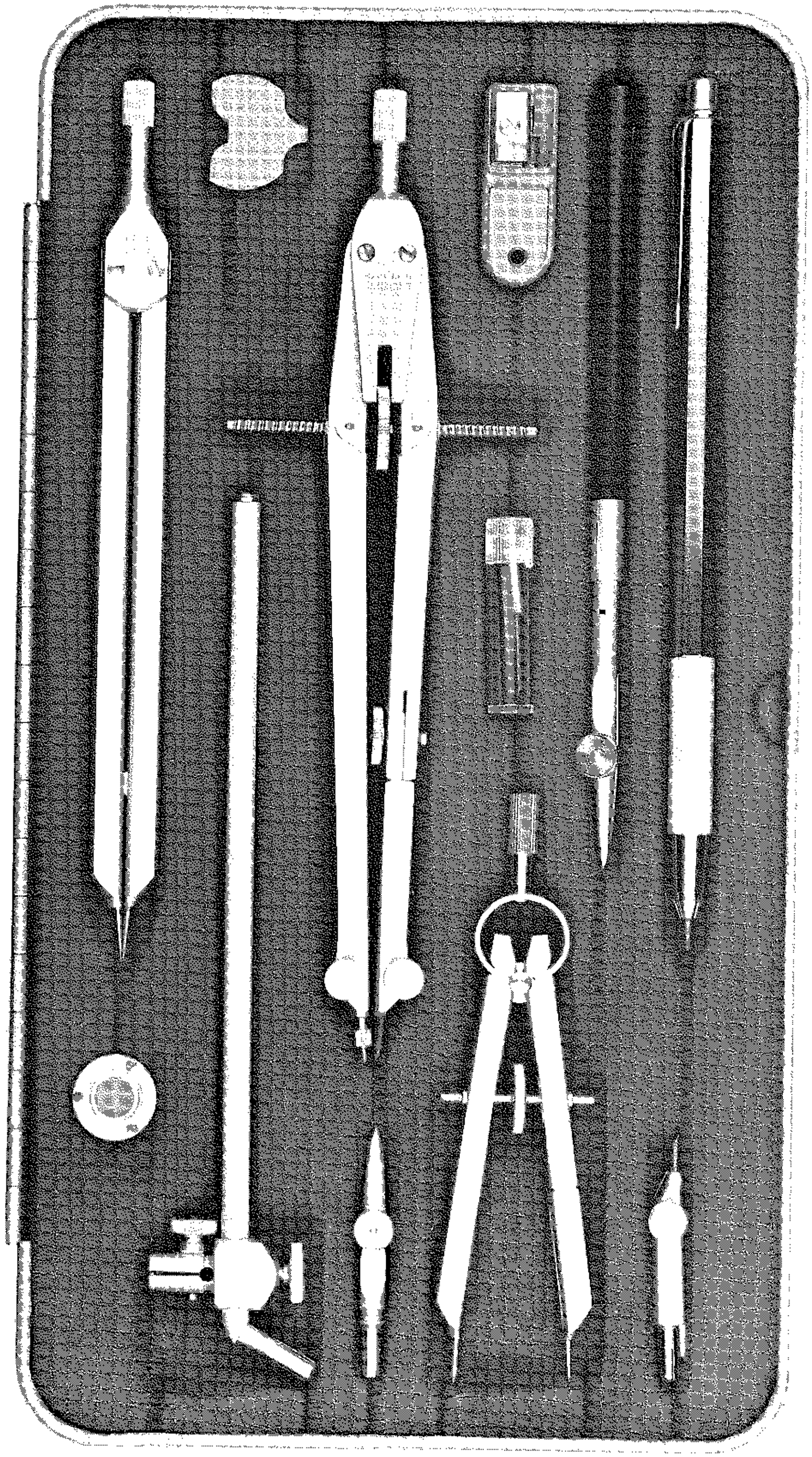

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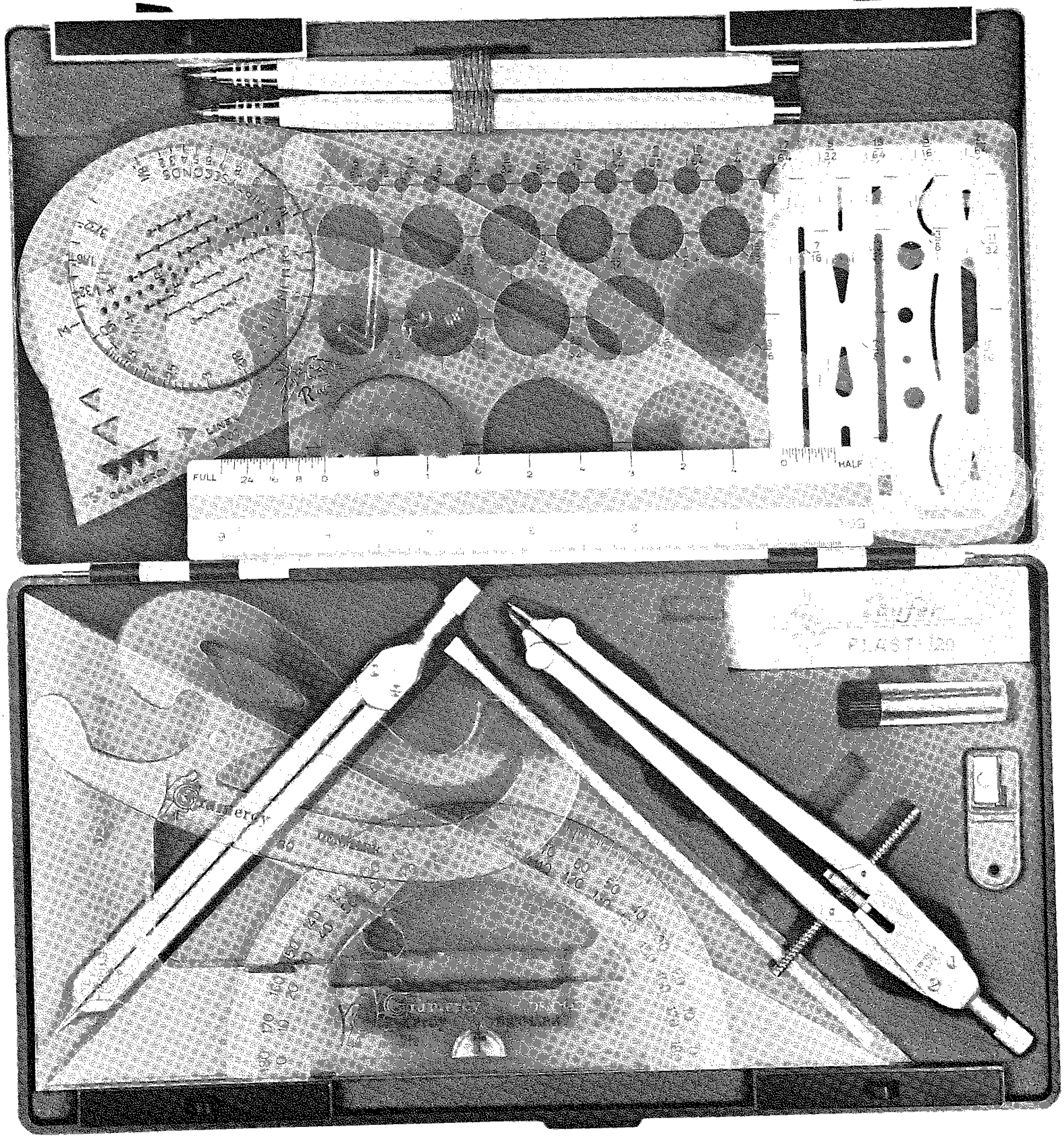

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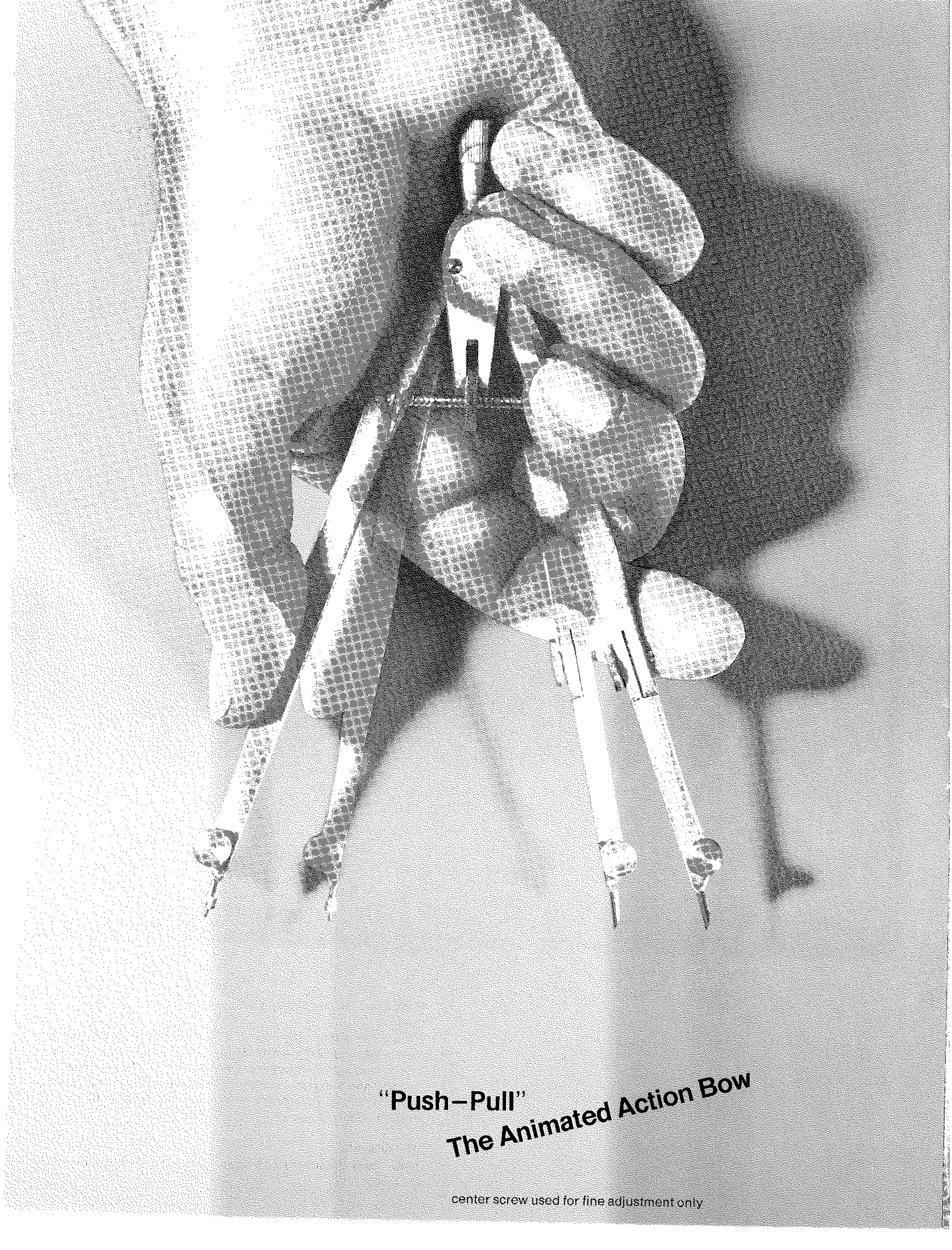
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A VISITING ENGINEER PROGRAM

by
James H. Earle
Texas A&M University

A major objective of the engineering graphics program should be the introduction of the student to engineering as a creative profession related to tangible projects with this being extremely important at the freshman level when students are undecided as to their major field of study. Many students are lost to engineering due to a lack of interest in their initial courses. They may fail to recognize the creative and stimulating aspects of the profession and may regard it as a routine career concerned with the manipulation of mathematical and scientific principles of a clerical nature. Engineering graphics can broaden their concept to give an overview of the total profession and the need for both creativity and a knowledge of engineering principles. The design problem is an effective medium for providing this perspective of engineering.

Design problems and concepts can be effectively incorporated in engineering graphics courses to emphasize the importance of graphical procedures to the creative process encountered in engineering. Both systems and product development problems are applicable for inclusion in a design oriented graphics course. Well chosen design problems can focus attention on the engineering approach and the challenges of the engineering profession, as covered in the two previous articles in the Journal of Engineering Graphics, Vol 31-3 and Vol 32-1.

Design problems can take many forms requiring a few minutes to solve or the majority of a semester. Projects may be hypothetical and unrealistic or they may be actual design problems taken from engineering case studies or from observations of engineering applications by the instructor. Problems closely related to actual engineering situations will provide a more significant introcution to the profession and the types of problems encountered by the engineer. Care must be taken to select a problem within the capabilities of the student while providing sufficient latitudes for unique and creative approaches.

Visiting Engineers

A realistic engineering design problem may warrant consultation from practicing engineers working with student design teams assigned to the problem. Practicing engineers can effectively supplement the instructor's efforts to relate class problems to engineering problems. Students can have access to professional assistance and the best introduction to engineering possible through firsthand contact with a practicing professional.

The Engineering Graphics Department of Texas A&M University recognized the benefits that could be gained from the involvement of visitiing engineers with student design teams. During the fall of 1966 the "Visiting Engineer Program" was initiated as an experimental program to determine the effectiveness of this concept. A letter was sent to the various companies who interviewed engineering graduates for employment. This letter described the proposed program and invited the firms to provide engineers as class consultants. Responses received from these industries indicated high interest in this type of program and a willingness to participate.

Thirty-seven engineers from different firms were invited to make two visits to Texas A&M University during the fall semester. Engineers were grouped in teams of three to visit two sections of approximately 36 students with a total of 810 students involved in all classes. This first experimental program provided a basis for improvement and modification of the program to its present status in its fourth consecutive semester. Significant changes have been made each semester to improve the program through a process of natural evolution with the accumulation of experience. The latest, most current program will be outlined in the following paragraphs.

Organization of the Program

After the initial contacts with approximately 400 firms during the fall of 1966, it was possible to schedule the available engineers during subsequent sessions involving different companies for three semesters without repetition. A detailed brochure was prepared to describe the role of the engineer in the program, his relationship with students and the schedule of his visits.

Classes were assigned team projects as indicated in Figure 1 with four free periods allowed for the solution of the problem. All teams were required to prepare engineering

	PERIOD 1	PERIOD 2	PERIOD 3
WEEK 2		ASSIGN PROBS	
WEEK 3		FREE PERIOD	
WEEK 4			
WEEK 5		FREE PERIOD	
WEEK 6		VISITING ENGRS	
WEEK 7			
WEEK 8			
WEEK 9		OFF PERIOD	
WEEK 10			
WEEK 11			
WEEK 12		OFF PERIOD	
WEEK 13			
WEEK 14	TEAMS PREPARE PRESENTATIONS - 3 PERIODS		
WEEK 15			
WEEK 16	PRESENTATIONS TO VISITING ENGINEERS		

Figure 1: Semester schedule for the team project

reports and to present their final solution to the visiting engineers and their class. A class of 36 students were divided into six teams of six students which allowed forty-eight man-hours per project. Three class periods of two hours were scheduled for the preparation of graphic materials to be used for the final team presentations.

Classes were assigned three projects with an equal number of teams working on each. A panel of three visiting engineers were assigned to two classes organized in this manner during their visits to the campus. This separation of teams by project reduced duplication of team effort and increased competition.

First Visit

The three engineers of each panel are assigned on the basis of their experience to provide as wide a diversification of specialization as possible. For example, engineers from the petroleum, manufacturing and aircraft industries assigned to the same team could provide a class with different views of engineering. Each Panel was scheduled to meet two sections of students in succession requiring a total of four hours. Classes were grouped in accordance to their project - 2 teams on problem A, 2 teams on problem B, and 2 teams on problem C, Figure 2. An engineer served as a consultant for each of these groups for a 30 minute interval, rotated to a second group for 30 minutes and to the final group for 30 minutes. All engineers had direct contact with all students in groups of 10-12 and discussed each of the three design problems.

The engineers were not expected to provide problem solutions in these discussions, but to provide general guidance and evaluation of preliminary ideas of the teams. They can provide a valuable insight into engineering if parallel examples encountered in professional practice are related to the groups to make problems more meaningful. Engineers are encouraged to refer to their company's operations and their methods of developing products or solving problems. The remainder

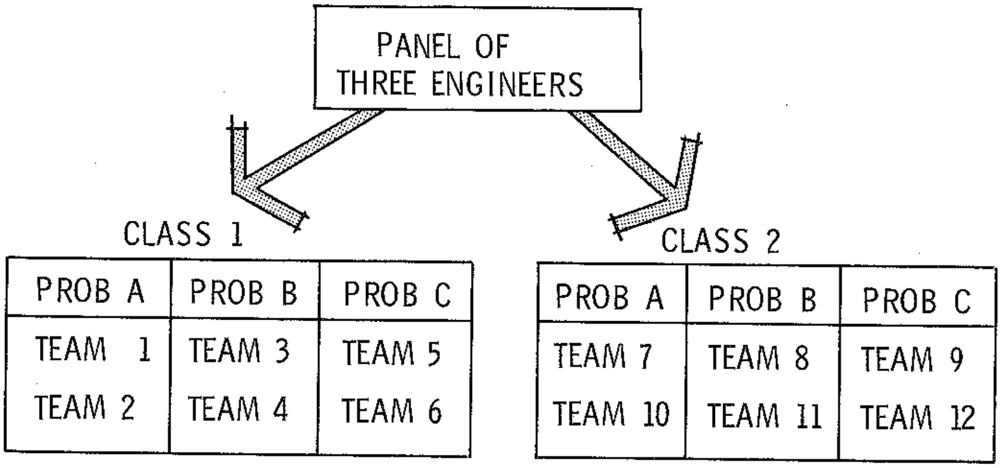


Figure 2: Organization of classes and assignment of teams by project

of the two hour period was used for a general question and answer session with the entire class participating as a group. This permits discussion in a career orientation vein.

Advisory sessions of about one hour in length are scheduled with each panel of visiting engineers and faculty members to discuss course content in relation to the needs of industry. This review is helpful to the modification of courses in keeping with current trends. Engineers are helpful as a source of new problems that can be incorporated for future assignments.

Visits from engineers have been found to be most effective if scheduled over a period of a week with no more than six visiting classes on any single day. This arrangement makes it possible for faculty members to become better acquainted with each engineer on an informal basis, whereas this would be difficult in larger groups.

Completion of Project

Student teams are provided two additional free periods in which to complete their designs and to prepare technical reports describing their solutions. Teams are encouraged to work within their available time schedule as part of the problem. Class time is devoted to the general graphics content dealing primarily with the application of graphical principles to engineering problems with only the excused class periods used for team projects.

Week 15 was devoted to the preparation of the graphical materials necessary to effectively present their problem solutions. This activity was under the supervision and direction of the instructor in class during regular meeting hours. Transparencies, flip charts and photographic slides were the most commonly used media for presentation.

Follow-Up

Questionnaires were given to the participating students and engineers to determine their acceptance of the Visiting Engineer Program and to obtain suggestions for improvement. The general consensus of opinion indicated that this association with practicing engineers was very helpful to the student in better understanding engineering and the design process. The rating of various aspects of design projects and the Visiting Engineer Program by students are shown in Figure 3. The percentages represent student evaluation of various areas of the program with 100% being the highest rating possible. Receiving the highest evaluation was the importance of the organization of ideas in approaching a design problem. Encouragement and stimulation of creativity received the second highest rating. Evaluation was made on the basis of the contribution from visiting engineers, the design problems, and the general course organization. Participating engineers endorsed the program as being a significant improvement over the usual graphics course where there is little or no emphasis on design. All indicated a desire to return during future semesters and participate again.

Summary

During the last four consecutive semesters, 132 practicing engineers have served

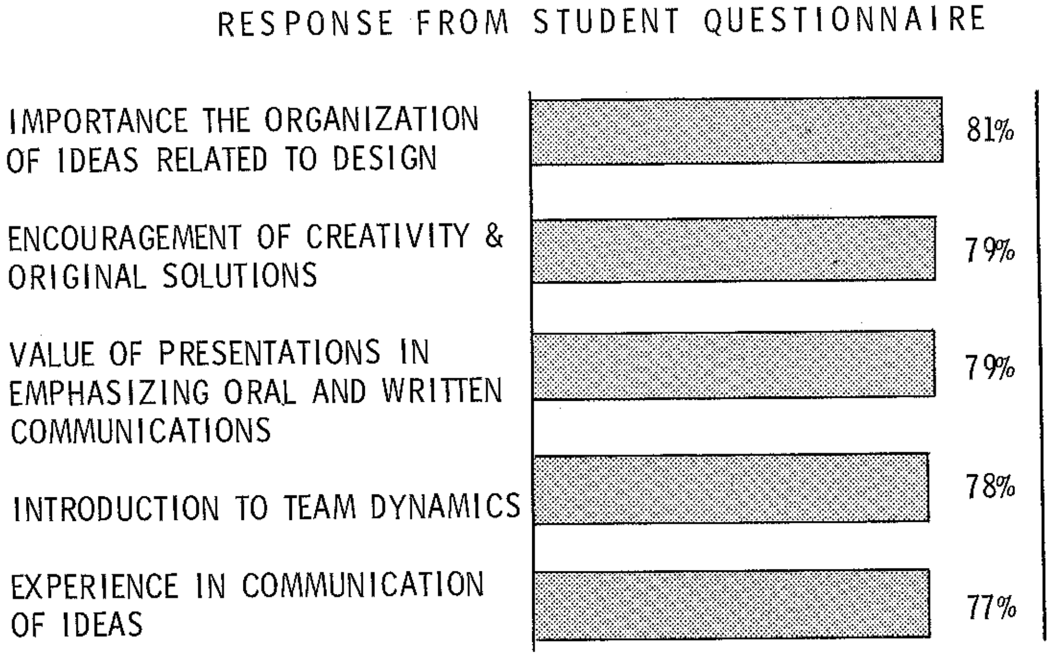


Figure 3: Student response to questions concerning value of team projects and visiting engineers

as class consultants working with student design teams on an individual basis during the first visit and returning for the presentation of the student solution on a second visit. This is an average of thirty-three engineers visiting with approximately 850 students per semester. The success of this program at Texas A&M University clearly establishes two conclusions. First, instruction of design need not be limited to a small program involving only a few students, but can work in any size program, and secondly, engineers from industry are sufficiently dedicated to their profession to participate in educational programs that are beneficial to engineering.

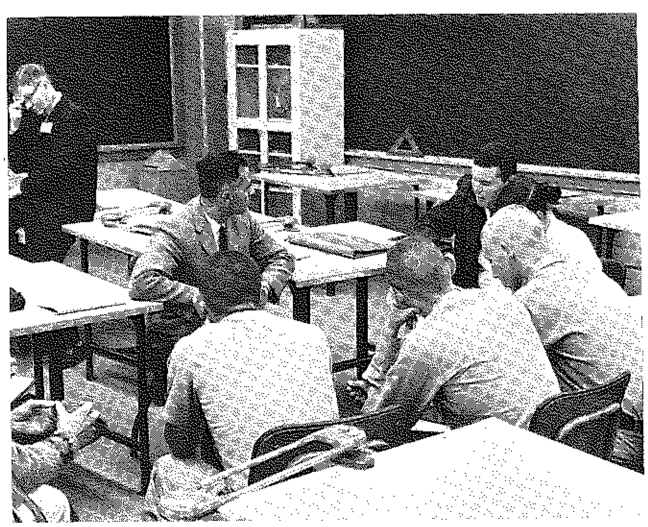


Figure 4: Visiting engineer, R. L. Howdeshell of Mobil Oil Corporation discusses a project with a design group

Figure 5: Mr. T. C. Thomas, a group head at Collins Radio, consults with student teams

The opportunities and challenges of the engineering graphics program appear to be numerous as an important area of engineering and technological education. The same basic content and graphical principles are as essential now as in previous years, but the

Figure 6: Engineers (left to right) R. L. Howdeshell of Mobil Oil, Ross Bell of Collins Radio and E. W. Boddeker of NASA review a design team's presentation

emphasis must be changed from the more limited approach of graphical communication to a more comprehensive, engineering-oriented concept. Engineering graphics principles should be presented as valuable problem solving techniques necessary to solve realistic engineering problems, rather than an entity unto itself. Students are more interested and better motivated when their graphics courses develop their ability to analyze and design in opposition to emphasis on drafting techniques.

Graphics is the cornerstone of design since even the simplest idea cannot be developed without graphical principles. Some problems can be solved with greater ease by graphical methods than by mathematical techniques. This vital area of study can be one of the engineering students' most valuable experiences when structured to relate to actual engineering projects, involving design, analysis and personal contact with practicing engineers. This experience is equally rewarding to the instructor of graphics and the growth of the engineering graphics subject areas.

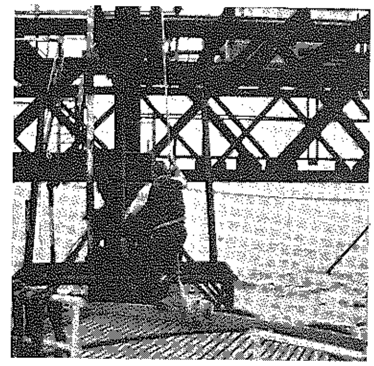
(See pages 32 and 33 for problems used in the Visiting Engineer Program)

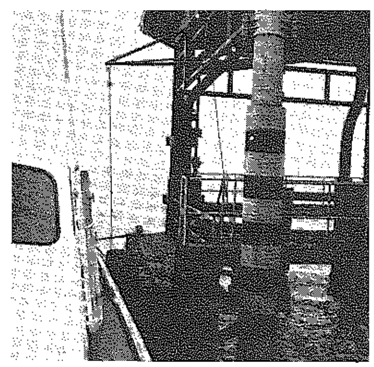
Problems Used in the

DESIGN PROJECTS

Select one of the following comprehensive problems for an individual or team project as assigned by your instructor. This assignment will be performed according to the specifications on the preceding page. Special requirements will be specified by your instructor on each problem.

1. offshore elevator





Photos courtesy of Jay C. McElroy
Transcontinental Gas Pipeline Corp.

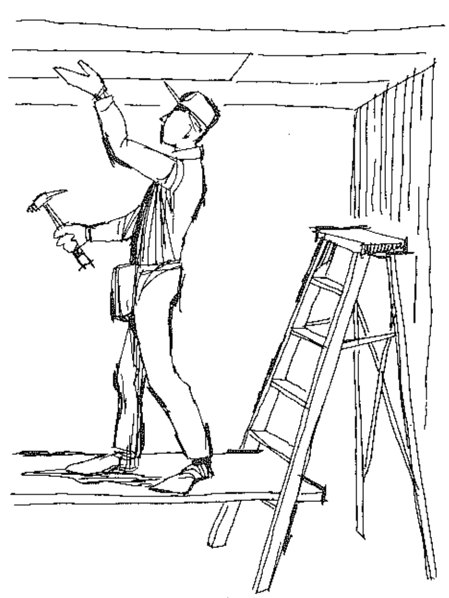
Offshore drilling platforms may be located several miles off the coast which introduces a transportation problem for work crews and supervising engineers. Helicopters and boats are used for this purpose with boats being considerably more economical. A significant problem exists when passengers board the platform from a boat that is unstable on the ocean's surface. Passengers are presently being hoisting to the platform by a rope.

Design an elevating apparatus that could be installed as a unit to improve access to and from an offshore platform. This design should be economical, safe, easy to install and simple to operate. Consideration should be given to securely lashing the boat during disembarkation. Your design should be as basic as possible with the minimum of specialized equipment.

Analyze this problem considering an average variation in ocean surface from 3 to 6 feet under moderate conditions. The average platform surface is approximately 30 feet from ocean level.

Prepare drawings and a model of your design as outlined in the design specifications. Make an estimate of the manufacturing costs, sales price, shipping weights and other pertinent information.

2. panel applicator



Workmen who install paneling, plywood, and gypsum board to walls, and ceilings in particular, often find it difficult to work without an assistant. The assistant must hold the 4' x 8' panels in position while they are being nailed which is often a loss of manpower.

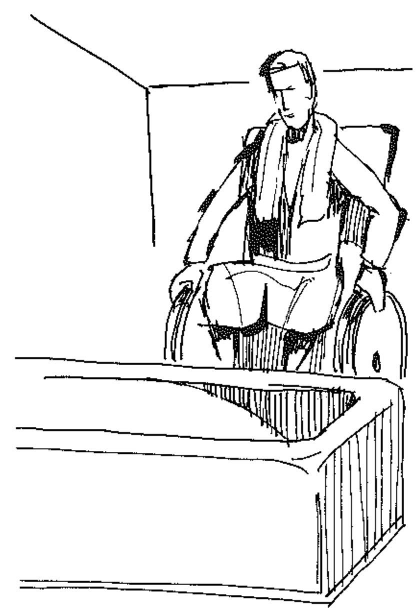
Design a device that will enable a workman to install 4' x 8' paneling without the need for assistance in holding the panels in position. This device should be portable, easy to use, and sufficiently economical to be justifiable as an additional item of equipment. Determine the variation in ceiling heights that must be considered in your design as well as adaptation to application of paneling on vertical walls.

Your design should also consider the ease of operation of the workman to insure that his work will be as efficient, comfortable and safe as possible. The final design should be an outgrowth of the analysis of the movements and operations involved in the paneling process. Compare the efficiency of one workman using this device with a two-man team conventionally used.

Prepare drawings and a model of your design as outlined in the design specifications. Make an estimate of the manufacturing costs, sales price, shipping weight, potential customers and other pertinent information.

DESIGN PROJECTS

3. bathing apparatus



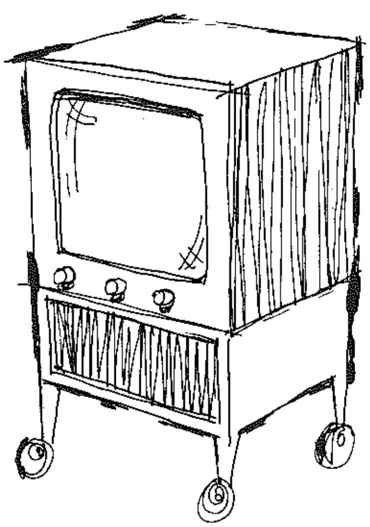
Many people are confined to a wheel chair because an inability to use their legs as a result of an accident or other misfortune. Consequently, the simple task of bathing in a conventional bathtub becomes a considerable problem. Getting into a bathtub from a wheel chair causes a severe safety problem with equal difficulty in getting out of the tub.

Design an apparatus that could assist a wheelchair patient with average arm strength in bathing without assistance from a helper. Consider a method whereby he can get out of his wheel chair into the tub and be provided with a degree of safety while in the tub. The apparatus should enable him to remove himself from the tub and return to his wheel chair.

Consideration should be given to the usual bathroom layout and fixture dimensions that would influence your design. The apparatus should be easy to install and portable, if possible, to offer the maximum market appeal.

Much of your basic data must be obtained from actual body measurements and movements involved in the different operations performed during the bathing process. Prepare drawings and a model of your design as outlined in the design specifications. Make an estimate of the manufacturing costs, sales price, shipping weight and other pertinent information.

4. adjustable tv base



A number of portable bases are available to support TV sets and to allow the set to be moved from room to room. Most of these bases are designed to support standard TV sets at a fixed height. Consequently, a fixed height limits the position of the viewer to a conventional sitting position with an unobstructed view.

Assume that your company is considering the possibility of mass producing an improved TV base that would have greater market appeal than those presently on the market. Unique features must be incorporated into your design that would have advantages over conventional models. It would be of value to the consumer if the base was equipped with a mechanism that would enable the set to be raised and lowered, as well as tilted. An adjustable height would improve viewing from a couch or bed and permit a housewife to view the set over furniture and other obstructions while doing housework. A tilting capability could be used to prevent reflections and glare from light sources that hamper viewing. The base should be portable to permit the set to be moved about the home for maximum use.

Your design must be based on the determination of the limits of adjustments required to meet the usual viewing conditions. Estimate manufacturing cost, sales price, shipping weight and other important information. Make a study of the market potential for your design including number that could be sold. Determine your potential customers and how they could be made aware of your new design.

SET NOTATION IN INTERSECTION PROBLEMS

by Ed Wilks
Georgia Institute of Technology

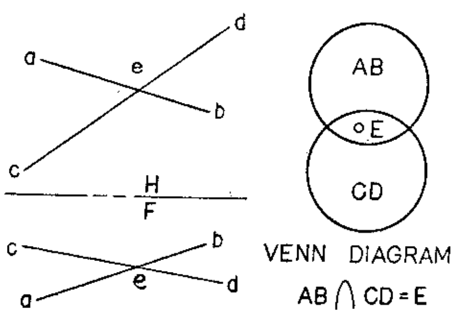
The concept of considering lines and surfaces to be sets of points offers an alternate approach to intersection problems in descriptive geometry. An intersection of two surfaces is considered to be the set of points common to the sets representing the given surfaces. Ordinary set notation facilitates concise descriptions of each step in the solution. The method is simple and can be picked up rapidly by students without previous experience in set notation.

DEFINITIONS OF TERMS

Set.........In general, a set may be any list or collection of objects. In descriptive geometry all sets are sets of points. A set may consist of an infinite number of points, a finite number, or none.

Subset...... A set contained in another set. If a second set contains all the points in a first set plus some other points, the first is said to be a subset of the second.

Venn Diagram.. Venn diagrams are graphic illustrations of the relationships between sets. Sets are represented by plain areas usually bounded by circles.



INTERSECTING LINES

FIGURE I

MEANINGS OF SYMBOLS

$\cap$..... Intersection. The intersection of two sets consists of the points common to both sets.

$\subset$..... "is contained in" or simply "is in".

Φ..... Null set or empty set. An empty set has no members (points)in it.

$\cup$..... Union or join. The union of sets is the sum of the sets. The union of two sets includes all the points in both sets.

EXAMPLES INVOLVING STRAIGHT LINES AND PLANES

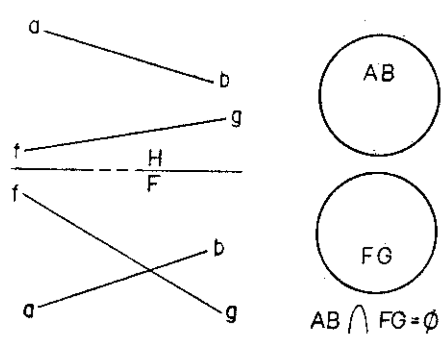
Example 1. Intersecting Lines (Fig. 1)

AB is the set of points on Line AB (an infinite number of points). CD is the set of points on Line CD. E is the point of intersection of the two lines. In set terminology, E is a set with one member in it.

The equation [AB $\cap$ CD = E] reads: "Line AB intersection Line CD equals Point E". The Venn diagram shows two overlapping circles with the single point E in the common area. There is an infinite number of points in the remaining portion of each of the circles.

Example 2. Non-intersecting Lines (Fig. 2)

AB and FG are the sets of points on lines



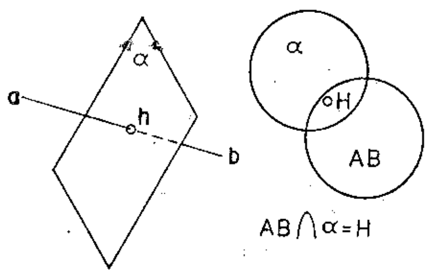
NON - INTERSECTING LINES

FIGURE 2

AB and FG. The equation [AB ⋂ FG = Φ] reads: "Line AB intersection Line FG equals the null set". Since there is no point common to both lines, the Venn diagram shows no overlapping.

Example 3. Line Piercing a Plane (Fig. 3)

H is the piercing point of Line AB in Plane **a**. The equation [AB ⋂ **a** = H] reads: "Line AB intersection Plane **a** equals point H". The single point (H) common to Line AB and Plane **a** is a subset of AB; it is also a subset of **a**. The Venn diagram has the same form as that shown in Figure 1.

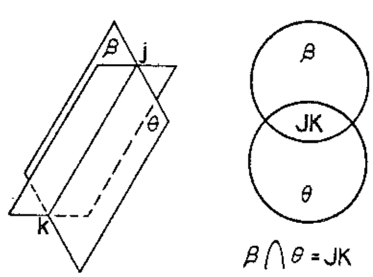


LINE PIERCING A PLANE

FIGURE 3

Example 4. Intersecting Planes (Fig. 4)

The equation [β ⋂ θ = JK] reads: "Plane intersection Plane θ equals Line JK." Each of the three sets (β θ, and JK) has an infinite number of points. JK is a subset of B; it is also a subset of θ. The Venn diagram shows overlapping circles as in Figures 1 and 3. Here no individual points are shown - this implies that there is an infinite number of points in the overlapped area.

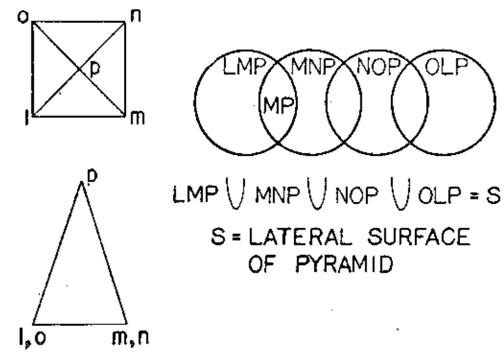


INTERSECTING PLANES

FIGURE 4

Example 5. Lateral Surface of a Pyramid (Fig. 5)

Planes are designated by letter triples in this example. LMP is the set of points in the finite portion of Plane LMP (bounded by Lines LM, MP, and PL). There is an infinite number of points in the finite portion of the plane. MNP, NOP, and OLP are similarly defined.



LATERAL SURFACE OF A PYRAMID

FIGURE 5

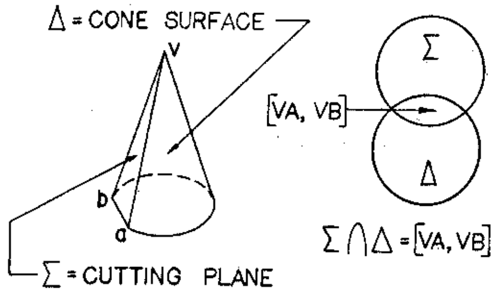
The equation [LMP ⋃ MNP ⋃ NOP ⋃ OLP = S = Lateral Surface of Pyramid] reads: "Plane LMP union Plane MNP union Plane NOP union Plane OLP equals the lateral surface of the pyramid." S represents the entire Venn diagram (all of the circles including the overlapping portions). One of the pyramid edges (MP) is shown in the diagram for illustration. MP is a subset of LMP, a subset of MNP, and also a subset of S.

EXAMPLES INVOLVING CURVED SURFACES

NOTE: Examples 6, 7, 8, and 9 cover two set notation solutions for an intersection of a cone and a cylinder. The given problem is shown in Fig. 9. Examples 6, 7, 8 show the solution divided into three separate steps. Example 9 shows a combined treatment of the same problem.

Example 6. Intersection of a Cone and a Plane Plane passing through Cone Vertex (Fig. 6)

Σ is of infinite extent and passes through Points V, A, and B. **Δ** is the set of points in the cone surface. VA is the set of points in Line VA; VB is the set of points in Line VB. [VA, VB] is the union of VA and VB; it includes all the points on both lines.



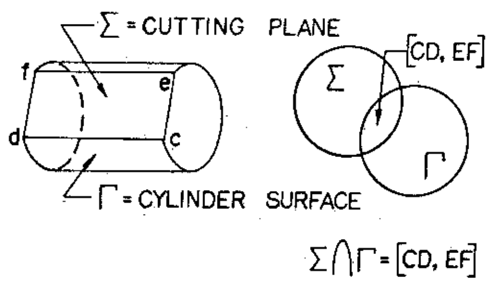
INTERSECTION OF A CONE AND A PLANE

FIGURE 6

The equation [$\Sigma \cap \Delta$ = [VA, VB]] reads: "Plane Σ intersection Cone Surface Δ equals Lines VA and VB".

Example 7. Intersection of a Cylinder and a Plane - Plane Parallel to Cylinder Axis(Fig. 7)

Σ is the cutting plane and Γ is the set of points in the surface of the cylinder. The equation [$\Sigma \cap \Gamma$ = [CD, EF]] reads: "Plane Σ intersection Cylindrical Surface Γ equals Lines CD and EF".

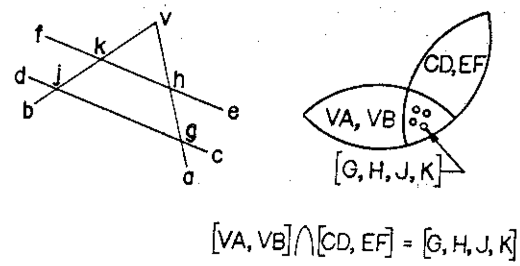


INTERSECTION OF A CYLINDER AND A PLANE

FIGURE 7

Example 8. Four Intersecting Lines (Fig. 8)

(G, H, J, K,) is the finite set of four points - G, H, J, and K. The equation [[VA, VB] $\cap$ [CD, EF] = [G, H, J, K]] reads: "Lines VA and VB intersection Lines CD and EF equals points G, H, J, K". Circular segments (instead of the usual circles) are used as boundaries in the Venn diagram. The segments are chosen to correspond to the interior portion of the combined Venn diagram of Fig. 9.



FOUR INTERSECTING LINES

FIGURE 8

Example 9. Intersection of a Cone and a Cylinder - Solution for one Cutting Plane (Fig. 9)

Ψ is the set of points on the space curve intersection of the given cone and cylinder. Horizontal, frontal, and first auxiliary projections of four points on Ψ (G, H, J, and K) are determined, using Cutting Plane

The equation [$\Sigma \cap \Delta \cap \Gamma$ = [G, H, J, K]] reads: "Plane Σ intersection Conical Surface Δ intersection Cylinder Surface Γ equals Points G, H, J, and K". The notation [G, H, J, K] $\subset \Psi$ reads: "Points G, H, J, and K are in Space Curve Ψ. Since Points G, H, J, and K are in both Δ and Γ they are in the intersection curve (Ψ).

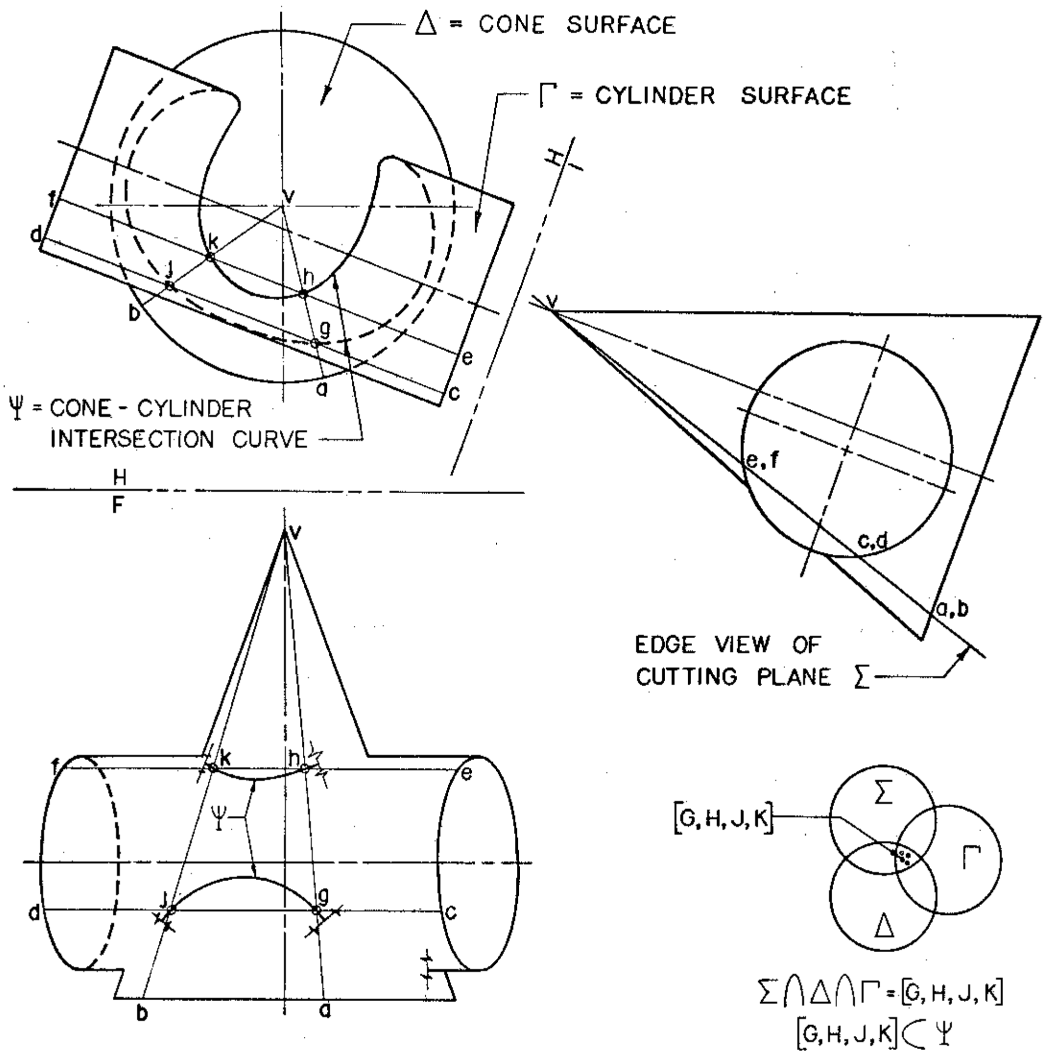
The Venn diagram shows that points G, H, J, and K are a subset of Σ, Δ, and Γ. Note that the $\Sigma - \Delta$ portion of the Venn diagram corresponds to Fig. 6; the $\Sigma - \Gamma$ portion corresponds to Fig. 7; and that the interior portion corresponds to the Venn diagram of Fig. 8.

The complete graphical solution would come from repeated partial solutions (as above) using different cutting planes in the same family as Σ. The family of planes would hinge about a line which passes through Point V and is parallel to the cylinder axis. Using the notation $\Sigma', \Sigma'', \Sigma'''$, etc, for other cutting planes: and (G', H', J', K') ; (G'', H'', J'', K''); (G''', H''', J''', K'''); etc. for the additional points on Ψ : (G, H, J, K) $\cup$ (G', H', J', K') $\cup$ (G'', H'', J'', K'') $\cup$ .... $\cup$ ($G''''\cdots^n$, $H''''\cdots^n$, $J''''\cdots^n$, $K''''\cdots^n$) = Ψ.

The preceding explanation has been in full detail as it would be presented to a student the first time he used the notation. The summary notation shown below would be sufficient for students familiar with the system.

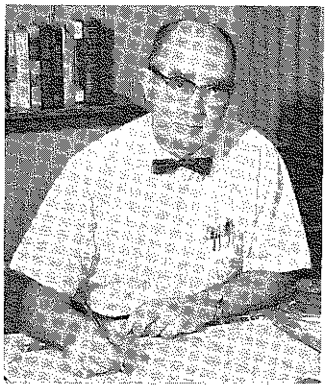
Δ = Cone
Γ = Cylinder
Σ = Cutting Plane
Ψ = Intersection Curve

$\Sigma \cap \Delta$ = (VA, VB)
$\Sigma \cap \Gamma$ = (CD, EF)
(VA, VB) $\cap$ (CD, EF) = G, H, J, K)
(G,H,J,K) $\subset \Psi$.



INTERSECTION OF A CONE AND A CYLINDER

FIGURE 9



GRAPHICS — INDISPENSABLE IN MACHINE DESIGN

By Roger A. Keech, Assistant Professor
R. Wallace Reynolds, Associate Professor
Mechanical Engineering Department
California State Polytechnic College

Machine design is a visual process. While this is readily apparent for the external styling of a particular product or device, graphic concepts of shape and form are equally important in the functional portion of any design. Motion, strength, weight, serviceability and the other more abstract aspects of a design including costs can be satisfactorily perceived, related and evaluated only with an adequate engineering layout drawing made to a precise scale.

The synthesis of any design starts in the "mind's eye" of the designer. Here, in extremely vague form, elements are arranged and rearranged rapidly by trial and error in an attempt to satisfy the specified design requirements. This can be an extremely rapid process where literally dozens of ideas are conceived and mentally rejected in a matter of a few minutes. During this portion of the design, the designer may still be analyzing the scope of problem in terms of possible solutions.

Tentative solutions must be quickly put on paper in the form of free-hand sketches before it is lost forever as a fleeting thought. These sketches should serve only as a means of preserving mental notes so that creative thought can continue. There is danger in grasping at the first solution as an only solution and if a designer dwells too lone on one sketch he may preclude alternate forms. Preliminary sketches should be removed from sight until the designer has "dreamed up" several possible approaches to a particular design problem. He can then look at all of his sketches simultaneously and improve each one with "second thoughts" or build on one solution by combining it with concepts developed in an alternate. This is a particularly useful technique when a designer is working alone since it allows a form of brainstorming dialogue which normally requires a team effort.

Freehand conceptual sketches, while containing the necessary chain of technical logic for a useful design, usually lack sufficient detail for rational analysis. A total design is a complete assembly of components containing functional surfaces, structural members, enclosures, fasteners, seals, and a host of other standard and special "real life" parts. These must be arranged in proper order and spatial relationship if the original concept is to be put into practice.

A good designer, being intimately familiar with manufacturing processes, puts more than center lines and space envelopes on his layout drawing. He should make immediate tentative decisions as to how the major parts will be fabricated, i. e., forging, casting, extrusion, rolled stock -- and automatically include their related details. Forgings require draft, which if ignored in the beginning, may cause embarrassing interference in later stages of the design. Castings require additional finish stock for subsequent machining operations and the contours generated by machine run out often must be controlled for functional purposes early in the design.

The demand for detail in an engineering layout drawing is clearly demonstrated in large companies where designer and analyst are formally divided in separate job titles. Here, the analyst needs a design to analyze at the same time the designer needs analytical information on which to base his design. This chicken vs. egg situation sometimes creates instant impasse, until the designer outlines tentative structural sections for the stress analyst who in turn deems them proper or otherwise. The ability to quickly draw and redraw details adds materially to the speed of this iterative team design process.

When completed, the engineering layout drawing is an actual two dimensional model of the designer's original idea. Its function should be clear to others and each part should sufficiently be developed for a draftsman to detail on a production drawing.

When the engineering layout drawing is conceived as an actual model or two dimensional mock-up of a conceptual configuration, it becomes the single most useful tool in teaching the engineering subject of machine design.

Machine design is an especially difficult course to teach in that it embodies the total art of engineering. A machine design may be defined as a system or group of elements so arranged and integrated into a unified functional system that it satisfies a need. This is an extremely broad, abstract definition which could never be well taught as a formal subject without a forceful means of focusing student attention to the cold realities of practical design.

A certain amount of applied psychology is required in obtaining student acceptance of the engineering layout drawing as a design technique. The term "drafting" is about as popular with senior engineering students as "English Composition". They have not yet witnessed the almost universal dependence on graphics in the design profession and are all entertaining a wistful desire to avoid getting "stuck on the board". But every boy with a mechanical bent likes to build models.

The authors and their colleagues are dedicated to the project method of teaching machine design. A student can listen to lectures and work academic problems until he knows his analytical techniques letter perfect, but until he experiences the actual processes of creative synthesis he'll never learn design. And as explained earlier, the layout drawing is a most satisfactory means of reducing to practice the products of creative effort. The solution can then be realistically evaluated by both the student and the instructor.

Engineering drawing can also be made more palatable by emphasizing technologies that lend themselves more readily to graphical rather than analytical solutions. Mechanisms, for instance, requiring kinematic synthesis often take such an appalling amount of trial and error that a pure analytical solution becomes tedious and time consuming. The relationship and application of the graphical techniques to operations to be encountered in the senior design courses should be introduced into the freshman graphics courses at every opportunity. The use of design type graphics problems will provide the best means of achieving this aim. Graphical techniques, taking advantage of instant centers and scaled vector polygons, can often be faster than a digital computer if program writing and shakedown is included in the task. Stick models with thumb tack pivots and cardboard cams often do more to demonstrate feasibility and determine optimum dimensions than reams of calculations.

Some design problems are purely graphical by their very nature. A student team in Professor Keech's class was assigned the task of designing the animation for a float, to be entered in the 1968 Rose Bowl parade at Pasadena. A particular problem was to make a mechanical cat with a moving tail. It was deemed most desirable to synthesize a genuine feline swish, where the change in curvature and consequent velocities are greatest near the tip of the tail. The solution, of course, was to simply copy (graphically) the genuine biological article. A segmented beam with pinned joints was provided with parallel cable "tendons" running its length on each side.

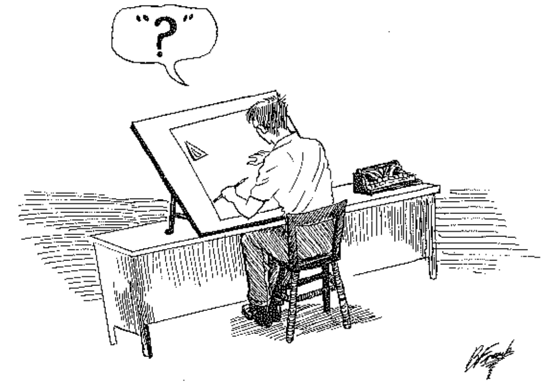
The tendons were anchored only at the tip which resulted in accumulating motion at the outer extremity. Stops were provided at each pinned joint and articulation limits were increased progressively so that the joints near the tip could swing through a greater angle. All dimensions were determined strictly by drawing the tail segments in the desired extreme positions and scaling the graphical relationship between individual parts. When tension was applied to the "tendons" on the completed full scale model, the resulting lateral "swishing" motion was realistic enough to win the "best animation" trophy for the Cal Poly float.

In summary, it takes a highly descriptive visual technique (graphics) to define a comprehensive concept (creative synthesis) and reduce the abstract to a practical fulfillment of a human need. This technique, coupled with prudent analytical verification will produce a complete design with the degree of reliability required by modern industry.

The convictions expressed in the preceding portion of this paper, which were derived from almost a decade of industrial experience by each of the authors in mechanical design, have furnished a rationale for an expanded application of graphical methods in the senior Machine Design courses at California State Polytechnic College (San Luis Obispo) in the last two years. This has been effected with the project method and organization of the class as a project team. Evolvement of this trend will be further developed during the next few years by plans to shift the content on the theory of dimensioning and geometrical tolerancing into the machine design courses. This material has previously been covered, in a somewhat rote fashion, in the basic freshman graphics courses.

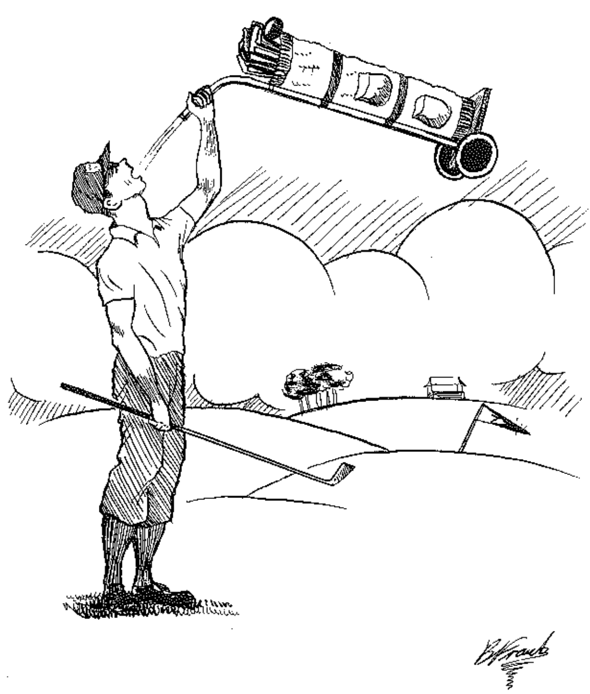
The ability to utilize the graphical appro-
(continued on page 44)

try it!

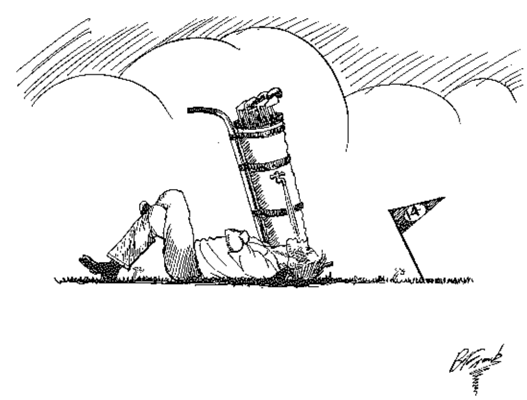


A GOLFER'S AID

During a pleasant day, while chopping at beautiful green grass and digging the soil in an attempt to hit a small white ball covered with indentations, one can develop a severe thirst. Although it has been known for golfers to carry canned liquid refreshment, such as soda-pop, the temperature of the contents will quite often not be suitable to the individual. These containers are, frequently, too cumbersome to be worthwhile to carry along on the golf course. Although some of these recreation areas have refreshment stands at stragic locations, over the thousands of yards that one passes, they are often closed when needed. Other golf courses have only the club house for the necessary respite.



It would, therefore, be desirable to design a method by which the golfer might have the privilege of relieving his thirst with his favorite beverage, and at a desirable temperature. In the process of performing this design one must remember that some people are so enthralled with the game of golf that inclement weather may be the only deterent-- at times-- but, otherwise, will play in the cold of the winter as well as the heat of the summer. Of course, there are many other considerations to be made so that it would be practical for the golfer--or duffer-- to take advantage of this newly found relief.



To begin the design properly, write the necessary preliminary specifications, research whatever may be necessary, and then sketch concepts of the methods (objects or systems or both) to meet those specifications.

Editor's Note: The Journal of Engineering Graphics will be happy to consider students' preliminary specifications and sketches of concepts for publication in a future issue if submitted by an instructor.

(Sketches by cartoonest Bill Frank of Malden, Mass.)

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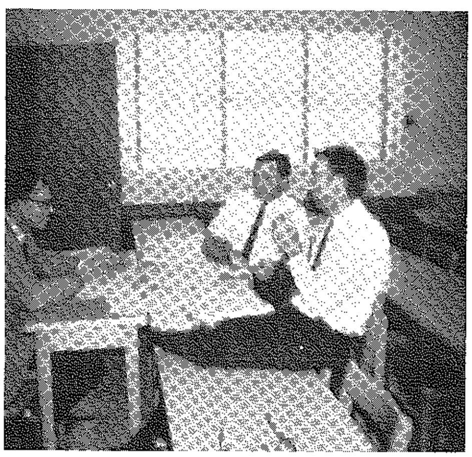
GRAPHICS - Mach. Des. (cont'd from page 37)

ach to the machine design course advocated in this article requires an adequate ability in all phases of the basic engineering graphics before the student enters the machine design course. It is felt that this must be achieved by courses at the freshman or sophomore level which emphasize the theory of the projection systems and their application to graphical solutions of spatial problems, and which are sufficient in depth to allow the student to proceed without recourse to review or extensive reference when applying the graphical methods in the design course. The present plan to move a portion of the content of the traditional freshman course into the senior course, where it will be treated in a better context, should help in providing more time in the freshman course for this in depth experience.

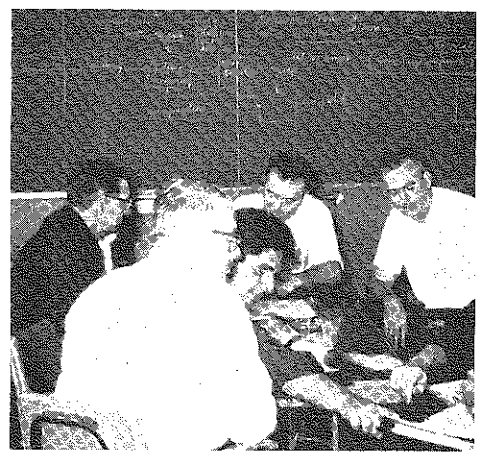
WHAT, WHEN, HOW (cont'd from page 5)

at an advanced level, might be offered to provide future engineers with a wider scope of analytical methods.

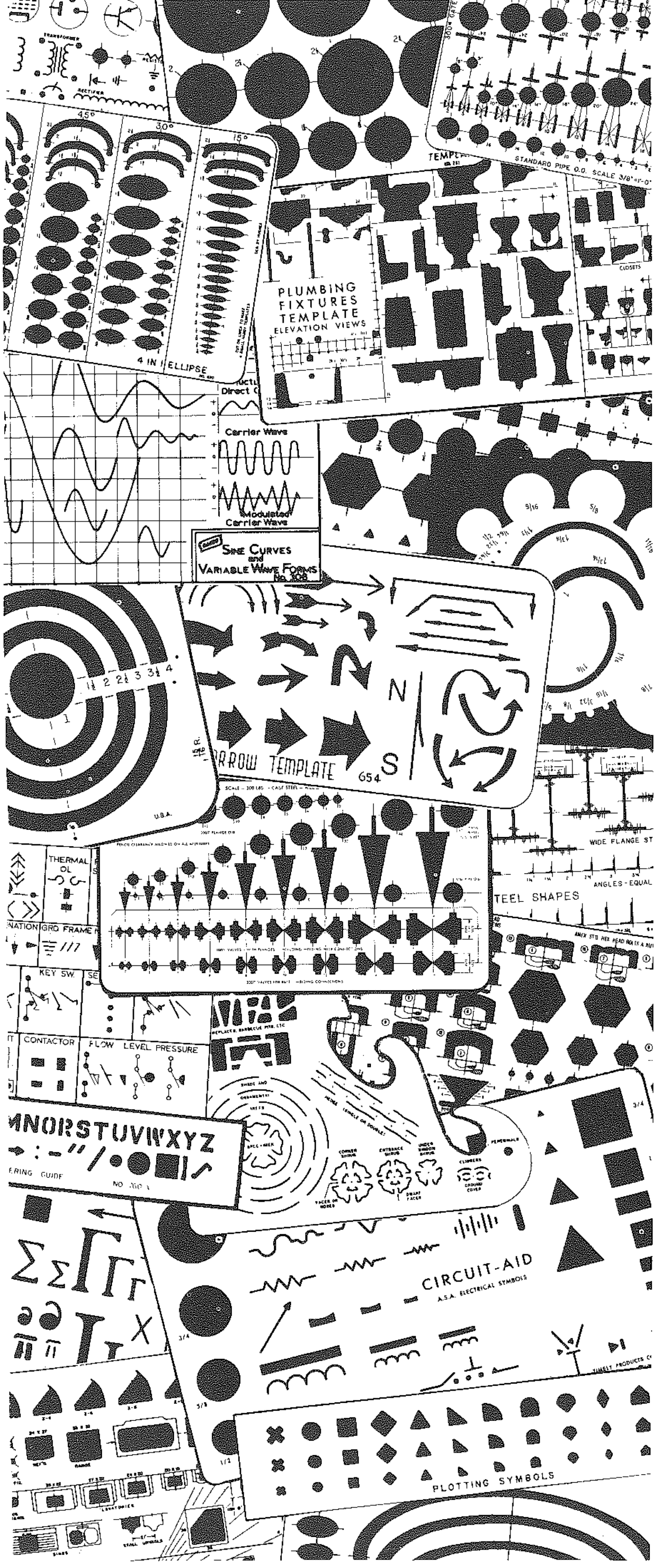
Now that we are beginning to agree that Design has a place in our discipline, let us refine our position to a specific end. What phase of Design, and how much of it is our responsibility? Once this is determined, the next step is to find the means to best accomplish that end. The Journal of Engineering Graphics will make every attempt to assist its readers in the form of articles, suggested problems and any other way that may be recommended by the membership of the Division. An excellent beginning was made with the Special Issue and we hope to have the opportunity to continue.



WHAT ?



THAT !



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