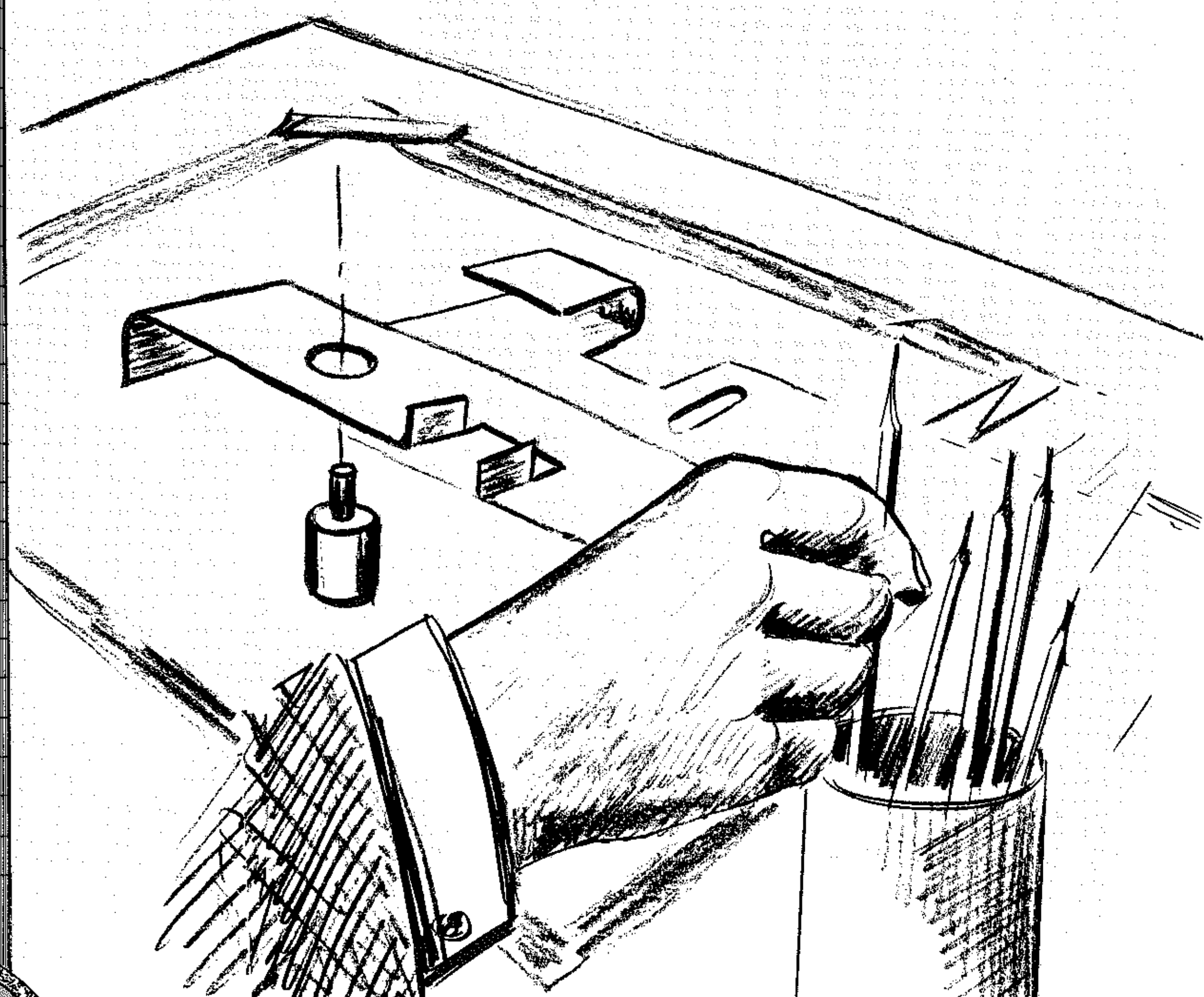
The Journal of Engineering Graphics



November (Fall) 1965 Vol. 29, No. 3, Series 87

Published by the Division of Engineering Graphics, American Society for Engineering Education.

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THE JOURNAL OF ENGINEERING GRAPHICS

November (Fall) 1965 Volume 29, Number 3, Series 87

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DEPARTMENTS

DIVISIONAL NEWS

Published for teachers and others interested in Engineering Graphics. It is published three times per year - Fall (November), Winter (February), and Spring (May). The subscription rates are $2.00 per year in the United States (single copies 75 cents). Foreign rates upon request.

FOG, VISION, OR INSIGHT

Man lives in three-dimensions and it is natural for him to think in space concepts. It is comparatively easy for him to think in two-dimensions; it is more difficult for him to think in three-dimensional concepts; but it is necessary for him to think in four-dimensions when time becomes a factor. When multiple directions in space become a part of the problem, his mental concepts begin to get foggy and he needs a visual portrayal of his ideas in order to completely and specifically convey them to others. It is vital that the engineer learns to use engineering graphic standards. Even when he may be unaware of it, his verbal or written communication alone may fail completely or is likely to distort his spatial ideas in the minds of others. Thus, perfectly good ideas in the engineering process often are lost because of lack of understanding between individuals.

Engineering graphics serves as the means for communication and transmittal of basic design information. The technical draftsman has not relieved the engineer of his full responsibility. The computer-numerical-control drafting machine system has not replaced the knowledge of graphic theory. Engineering graphics is so entwined with engineering thought processes that if graphics were removed, the achievement of the final result would be extremely difficult, and complete communication between individuals would diminish in effectiveness. Graphical techniques continue to be fundamental to the design process and serve as the major mechanism for design evolution.

Drawings play a vital role in the design and fabrication of a product. The initial design proposals, the engineering analysis, the design compromises, and the prototypes all depend upon graphical communication among engineers, designers and other personnel. Many ideas are exchanged by the use of: sketches, freehand and layout drawings, graphical plots of numerical data, and engineering reports. The engineer who cannot perform in all phases of this activity is handicapped.

During the past few years engineering has placed more emphasis on analysis techniques geared to mathematical computations. The slide rule and desk calculator are being replaced by extensive use of computers. But communication between individuals and between man and the computer continues to use the standard language of the engineer -- engineering graphics. Graphical examination often replaces page after page of computer output.

The computer takes away the burden and drudgery of the drafting board and reduces the lead time, but it must be operated by man. The man -- be he engineer or otherwise -- must instruct or instigate the operation of the computer. Industry will not long support the engineer who can only "doodle" with the computer. He must be thoroughly grounded in graphic theory to obtain maximum as well as economical use of the computer. The engineer must be able to recognize a reasonably correct answer to his problem before the computer can be an effective tool for him.

A knowledge of engineering science, coupled with the ability to communicate ideas are the prerequisites of success in today's engineering world. Company education of the graduate engineer in basic graphics is frustrating for him. He attempts to conceal his inadequate comprehension of basic theory and the result is a retarding of his progress. His supervisor also deplores the delay in production activities caused by such inadequacy.

Tomorrow's world lies in the hands of the engineer. Our job as educators is preparing the student to cope with new and complicated situations. The student must develop in ability to make critical judgments. He must assimilate sufficient engineering technology to support his decisions and give him confidence in fulfilling his responsibilities as an engineer.

Reflection on his difficulty is likely to cause the graduate engineer to lose confidence in his school and former teachers. The responsibility for current trends in engineering education is ours. We must provide our graduates with deep foundations in basic principles so that they can build to the stars tomorrow.

E. D. B.

LETTERS TO THE EDITOR

Dear Editor:

Although it has been a month since I received your letter asking for contributions to your page called "Perspective," I have not forgotten you. I have been trying to think of a masterpiece that would be sure to bring me the Pulitzer prize. Unfortunately nothing of that sort has happened and I fear that my contribution will be very prosaic. However I think that you have a very good idea and that some of the wise ones will be able to contribute some very worth while articles. For myself, I have tried twice and am not satisfied with either. I am sending both efforts along with permission to take your choice or throw them both out the window. I assure you that there will be no hard feelings if they get the treatment that they deserve.*

As for me I am busier than ever. I am the educational officer for the U. S. Power Squadron, which is an organization devoted to the teaching of safe boating. So I am back in teaching only this time I do not get any pay for it. In addition I am on the board of directors of the Yacht Club, and Lois and I are both singing in the Community Chorus. The chorus and the Community Symphony Orchestra are putting on the Creation on December 12. With a little boating now and then and taking care of a couple of acres of lawn, the days are plenty full.

I am looking forward to seeing all of the old gang in January.

Clifford H. Springer
Overiver Shores,
N. Ft. Meyers, Florida

*See Perspective Article in this issue.

Dear Editor:

I read Rule's article and would be interested to know whom he conceives as having developed "a truly, powerful cognative style." Some emphasis has been given to the word cognative; in fact it seems to be almost the key word of the article, but there is no such word in the dictionary.

I thought perhaps I should list my book on "NOMOGRAPHY" with you, published by The Shoe String Press, Inc., New Haven, First Edition 1964, 198 pages, price $9.00.

I was pleased to see Levens' article on "Computerized Nomogram Plotting." I can follow this up sometime for you in the future if you wish since for sometime now it has been possible to plot out almost any program that is wanted including the graduations and scale titles.

I am disturbed that the Division of Engineering Graphics has chosen to give up activities in nomography. The article that I sent you last year,* I believe, is an indication of how important this subject can be in modern computer techniques. I am beginning to wonder if this Division is asking how much nomography can do for it rather than how much it can do for nomography. It is through the latter type of activity, namely that of formal contributions to a field by members of the Division, that recognition comes. The prestige of the Division is not advanced by articles or people who do not make such contributions even though they spend a certain amount of time talking as though they did.

Douglas P. Adams
Associate Professor of
Mechanical Engineering, MIT

*Nomograph: C-Electronic Computation - A New Graphics for Tomorrow's Problems - Journal of Engineering Graphics, Volume 28, No. 1, Spring 1964, Series No. 82.

NEW CONTRIBUTIONS TO AWARD FUND

Divisional Chairman, Professor J. Howard Porsch of Purdue University has notified the Journal that two financial donations have been received by the Division of Engineering Graphics.

Mr. A. Kreidler, of Kreidler's Metal-W. Drahtwerke G.M.B.H., Zuffenhausen, Germany has donated one thousand dollars ($1,000.00) and Mr. Frank Oppenheimer of Gramercy Guild Group, Inc., Denver, Colorado has contributed two hundred fifty dollars ($250.00) to the Divisional Awards Fund.

This money has been deposited with the ASEE Central office through Mr. A. Leighton Collins, Executive Secretary.

The Awards Committee has been charged with formulating rules and regulations as to how these funds will be awarded by the Engineering Graphics Division. Money withdrawn shall be authorized by the chairman of the Division under the direction of the Executive Committee.

The art of teaching is the art of assisting discovery.
--Mark Van Doren

ANNOUNCEMENT DESCRIPTIVE GEOMETRY AWARD 1965

The Committee for the Descriptive Geometry Award of the Engineering Graphics Division of ASEE is pleased to announce that the Gramercy Guild Group, Inc., has again offered to provide $100 for an award in the Descriptive Geometry competition. The Committee has established the following rules for eligibility:

1. An article or paper involving descriptive geometry or dealing with the solution of a problem using descriptive geometry may compete.

2. The article or paper must have been presented or published during the calendar year.

3. Descriptive Geometry must be the primary interest of the article or paper.

4. The article or paper must be brought to the attention of the Committee. The Committee will naturally search diligently for all such contributions to the literature but is not responsible for finding all of them.

5. The article or paper will be judged on originality, resourcefulness, and effectiveness. The drafting and the use of drafting aids, etc., should be competent, but are secondary considerations.

6. A majority of the committee votes received will determine the winner.

7. The winner will be announced and the award made at the Annual Division Dinner meeting in June following the year covered by the competition.

The Committee is undertaking a search of the literature and as this is an extensive job any suggestions of suitable articles or papers will be greatly appreciated.

Kindly send any information regarding possible articles or papers to any one of the Committee members.

Committee: J. M. Coke
Colorado School of Mines

A. L. Hoag
University of Washington

A. S. Palmerlee
University of Kansas

S. M. Slaby
Princeton University

Ivan L. Hill, Chairman
Illinois Institute of Technology

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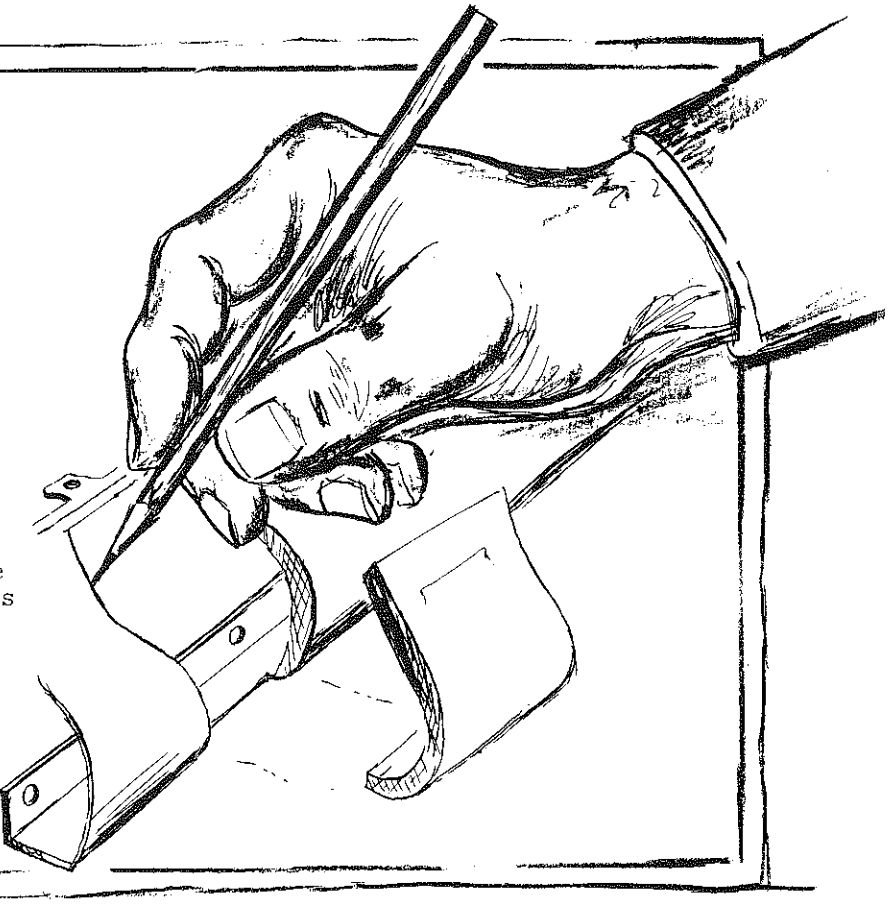
SKETCHED EXPLODED VIEWS AS A PRODUCT DESIGN ENGINEER'S TOOL

by

Richard J. Rademacher
Staff Project Engineer

AC Spark Plug Division
General Motors Corporation



This article presents a design engineering technique -- a system which was conceived, developed and refined in the competitive, pressure packed atmosphere of the automotive industry. Teachers will perform a tremendous service for their engineering students by equipping them with the vital skills of visualization and three-dimensional sketching.

Expediency and Accuracy

Success in today's competitive automotive original equipment field depends upon many interrelated factors. One significant factor is a manufacturer's ability to achieve prompt, but accurate, new product cost estimates. The Product Design Engineer must provide a maximum amount of detailed information to the Cost Estimating Group in a minimum of time. An accurate cost estimate may be required literally within hours from the time a new (or revised) product is conceived, or initially presented for review. It is required to quickly establish a selling price to quote to a potential customer.

Traditionally, new product cost estimates have been accomplished by one of two means; (a) "guesstimation" based upon experienced assumptions made with a minimum of new product information, or (b) waiting for completed product assembly drawings and component detail drawings in order to make a detailed, thorough cost analysis. However, the former technique does not provide sufficient accuracy, and the latter is not prompt enough.

Cost Estimate Requirements

To compute accurate product cost estimates, information is required by the estimator. The Product Engineer is responsible for providing the component's size, shape, configuration, material, finishes, and suggested manufacturing process, as well as the assembly sequence and means (fastening or joining techniques). Thus, when the early cost estimate characteristics of expediency and accuracy are considered, the Product Engineer is squarely behind the "eight-ball." If he takes excessive time to provide accurate information to the cost estimator, he will be criticized. If he sacrifices accuracy for speed, he is rightfully held responsible for his company possibly operating on too small a margin, operating at a loss, or losing the business to a competitor.

A Typical Product Design Situation

The instrument cluster, which will be used as an example of a typical automotive original equipment product, is the grouping of speedometer, gages, warning lights, and controls assembled in a suitable enclosure or housing, covered on the front by a transparent lens, and trimmed by a decorative bezel. It is mounted in the automobile instrument panel directly in front of the driver, just above the steering column.

The appearance of a new instrument cluster is conceived at the Styling Section where the overall theme of the new General Motors automobile's interior and exterior is developed. The Styling Section performs this service for the various GM car and truck divisions who have the right to approve, or reject, the concepts presented.

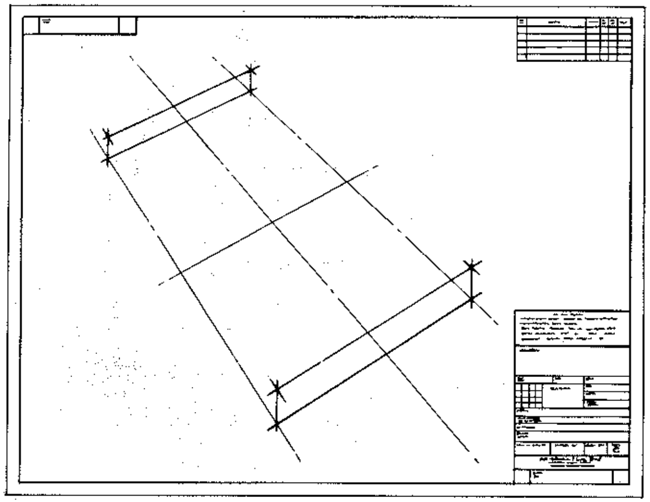


Figure 1.

The GM car and truck divisions ultimately purchase the instrument clusters from AC Spark Plug Division at a negotiated price satisfactory to the car or truck division. The basis for the product selling price quoted to the customer is the initial and most important cost estimate. In some cases, acceptance or rejection of a basic instrument panel concept is based upon the initial cost estimate.

The AC Product Engineering Department becomes involved in a new instrument cluster program soon after its conception at the Styling Section. The concept sketches and the clay model which depict only the exterior surface shape of the proposed instrument panel are studied in order to visualize internal components and construction. This preparation is necessary to communicate adequately with the various groups responsible for providing a cost estimate.

The AC Cost Estimating Department is directly responsible for providing product cost estimates. This group is assisted primarily by the Production Engineering Division which includes such groups as Tool Engineering and Design, Methods, Work Standards, and Assembly Engineering. These groups use pictorial sketches for instrument cluster estimating work.

A Unique Communication System

The Instrument Cluster Section of the Product Engineering Department at AC Spark Plug has evolved an efficient communication system to secure prompt and accurate cost estimates. This communication system is based upon rapidly but accurately prepared EXPLODED VIEW assembly sketches. These sketches depict all component parts, which when "assembled" constitute the product under consideration. The exploded view assembly sketches are similar to those found in appliance or accessory assembly instruction sheets or auto repair manuals. The notable difference, and this is extremely significant, is in the TECHNIQUE used in executing the two types of exploded view drawings. The instruction sheet variety is generally very meticulously prepared, utilizing drawing instruments and ink and using actual component detail drawings for reference. The AC instrument cluster exploded view drawing is prepared by rapid freehand sketching with pencil by a Design Engineer or Designer who mentally visualizes each component and its relationship to the assembly.

Technique of Sketched Exploded Views

A few basic requirements must be reviewed before discussing the actual technique used. First, the Design Engineer or Designer executing the sketched exploded view must possess a sense of urgency. The need for speed must be emphasized. Rapid sketching gets the job done faster, and tends to discourage the use of excessive, superfluous detail.

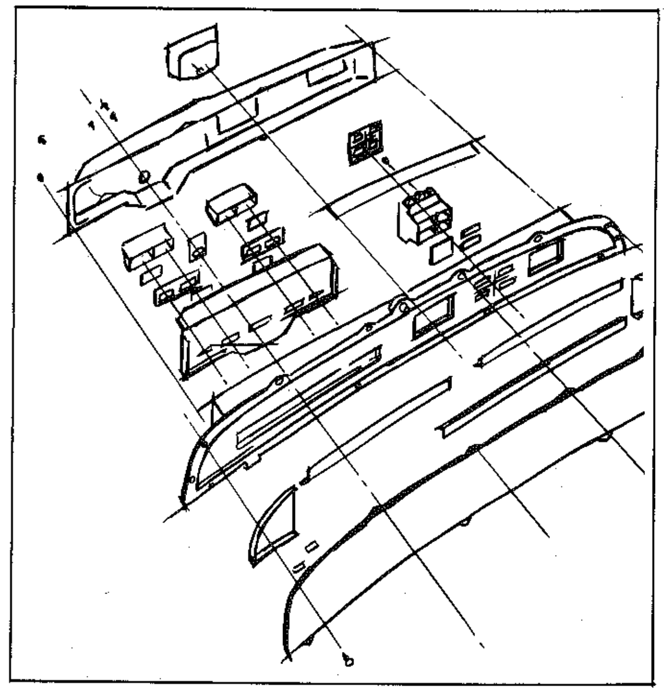


Figure 2.

These drawings are not intended to be "masterpieces." They are working drawings and, as such, contain many drafting short cuts. Accuracy is important, but only as it relates to details affecting cost, and with respect to proportion of components. Only the details which affect cost are shown.

The materials used are simply vellum and 2H pencil for a rough layout, and mylar (polyester film) and mylar 3S pencil for the final drawing. The use of mylar for the final drawing insures durability, reproducibility, and a "toothed" surface to facilitate shading and line work. Few instruments, except for

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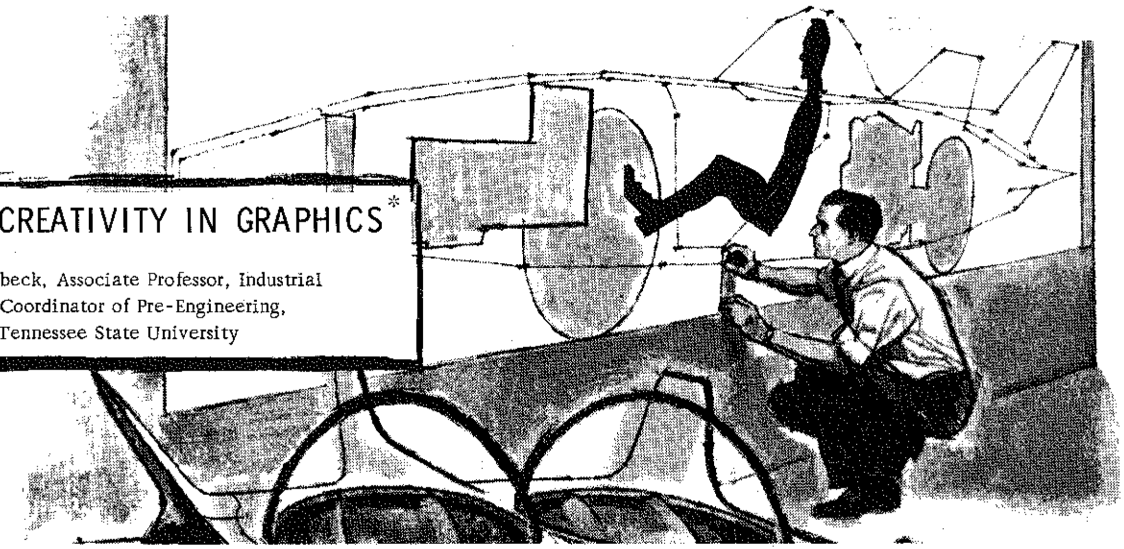

ENCOURAGING CREATIVITY IN GRAPHICS*

Harold L. Dillenbeck, Associate Professor, Industrial Education, Coordinator of Pre-Engineering, East Tennessee State University

Creativity can be likened to the weather, in that many people talk about it, some study it, but few people really do anything about it.

Webster defines creativity as "having the ability to bring into being." Are we as educators helping our students bring into being? For that matter, should we be concerned with creativity at all? I am convinced that we must do all we can to foster creative thinking and abilities.

Our products (our graduates) must be as good as we can produce. They have to be competitive on the industrial and educational markets. We must teach them to think creatively. Unfortunately, our present educational methods have a tendency to teach students to reproduce and not to produce.

Industry can make machines to reproduce nearly everything from drugs to drawings -- from automobiles to ash trays. It takes creative ability to make the first of a new product; and industry and education both need producers -- not just reproducers.

Ideally, each faculty member in school or college wishes that each of his students could hear each word he utters, and remember it in its correct context forever. This really is reproduction. This could be better achieved if each student left a recorder in the room, and the teacher spoke to a group of machines. Better still, why not have the lecture taped and have one recorder playing to the others, with no loss of learning, while both faculty and students enjoyed themselves doing something more pleasant.

Our school systems teach students facts, facts, and more facts. For example, when you come right down to it, many of our high school graduates have a greater factual knowledge than did Newton, Volta, or Galileo. They can reproduce work done by these great thinkers -- but can they think for themselves?

What can we as educators and engineers do about creativity? First, we must be able to define it and recognize creative ability. I am reminded of the student in class who had his head on his fist, his eyes closed and somewhat in the posture of a famous statue; and when the professor asked him what he was doing, he replied, "Thinking" -- "Well, stop it and listen to my lecture," snapped the teacher. Please don't get me wrong. I'm not advocating that we let a student daydream through his classes, but often when a student's thoughts stray, his imagination is loose and creative ideas begin to bud.

Creativity -- the ability to create -- is not easy to define, nor is it easy to recognize. It comes in all shapes, sizes, and disguises. Perhaps an analogy can be used in that creativity is a living, growing object like a tree. The trunk of the tree is imagination, the limbs are ideas, and the roots are grounded in, and nourished by, facts. Doctor Elizabeth Drew of Michigan State University, who has been studying creative youngsters, reports "that all children are remarkably creative in their pre-school years."[1] As they progress through school, inhibitions are developed, thoughts are censored, ideas curtailed, and creative imagination wilts and is stunted.

We talk about "the creative arts" -- yet here, too, our youngsters are really being inhibited -- "Color within the lines to make a pretty picture" -- "write an essay on George Washington" -- "Music is written in 6ths and 7ths, not discords"; "Sing it faster, this is 4/4 time"; and the buds of creativity have a heavy, frosty winter to live through.

In science we are worse. The student is told what to do, when, where, and occasionally why. If he does these things, he is rewarded with a good grade. If he wonders what happens when he mixes two chemicals, he is warned, "Don't mix anything unless I tell you. It might be explosive"; and the budding idea is mashed beyond repair. What could the teacher do? He could ask the student to check with him before mixing chemicals, and if the mixture might be dangerous, help the

*Presented April 13, 1965 to Graphics Section of South East Section of American Society for Engineering Education.

student to find a safe way to find out about the reaction.

This brings us to the crux of the problem. Each student, as each tree, is different. Some students need protection, others need freedom; some need direction, others need to be slightly curtailed. Some trees need acid soil, some alkaline; some hot weather, some cold. This means paying attention to individual differences, of cultivating them, and this is hard work. It is easier to parry a question which leads to foreign fields, than it is to answer it thoroughly. It is easier to have all the students do the same thing at the same time than it is to have each doing something different. It is easier to grade themes written about the same subject than on widely differing subjects. The teacher must do more than read his own yellowed sheaf of notes; HE MUST CARE and he must work.

It seems that we are trying to make our students conform to a particular pattern or mold; that we tend to discourage questions and concepts which are either unfamiliar or beyond our own scope of knowledge or experience. It is like trying to grow a tree in a small box. Its growth is stunted, its beauty marred, and its usefulness strictly limited.

Dr. Calvin W. Taylor, Professor of Psychology at the University of Utah, in his paper on "The Dimensions of Creative Ability in Adults"[3] indicates that there is no correlation between grades a person has achieved in a course and his creative ability. We tend to give good grades for reproduction and good memory. Students tend to use their memories as crutches and soon learn that it is better to regurgitate spoon-fed information on call than it is to produce divergent views. Perhaps this is one reason why some recruiters are wary of hiring the so-called "Brains" of the graduating class.

Dr. Taylor states:

> We also doubt that just sheer knowledge by itself will identify the creatives. A sequence of steps in the creative process has sometimes been described as preparation (accumulating knowledge), incubation, inspiration, and verification. We have no guarantee that he who loads himself with knowledge, is going to have the next steps of the creative process occur within him. Some people eventually turn out to be walking libraries with nothing new ever coming out, but they certainly can spout the old.

We as a society have frequently given adulation to people with great memories -- for example, the Quiz Kids of my generation and those "experts" we saw on television in such programs as the $64,000 Question. Creativity, however, is seldom acclaimed in its own time, except financially, by industries who strive to keep them and utilize their abilities. Industries need and reward creative ability in all departments.

Dr. Taylor goes on to say:

> Some research studies have suggested that if a person is too creative, if he has too creative an idea, he has a good chance of being in trouble. In one sense, he is the only one with this idea and may be pitied against the world; he's alone and lonely, and he may have to learn to live through this. Torrance's studies indicate that pressures are put upon him by other students and they make him recorder, so he can't continue to produce his own ideas, because he is so busy recording everyone else's ideas -- rules and procedures like this are built to get him under control. They say, 'We've got to get organized here,' and in ways like this, they tend to take care of him.
>
> A study by Jex involved science teachers who came to do graduate work at the university for their Master's degrees. They were tested with a battery of creative items. The scores were compared with how they had done the previous year, according to the ratings of their supervisor and principal. The answer was that this creativity score was correlated negatively in every case with how he was doing as a teacher the previous year, as judged by his supervisors. So the educational system, at least by that sample, may not be fond of teachers with creative characteristics. Whether these rub off on the students, we don't know, but persons are now working to resolve this question. I don't think the entire burden of proof should be on the recipients, but you watch and I think you will find that most, if not all, of the burden of proof is usually placed on the creators.
>
> An interesting question is whether we want critical or productive minds. I suspect our educational system has taught people more how to be critical, so that they have strong skills this way; so much so that they can and do destroy their own brain children fast. I suspect we don't do well in teaching them how to be productive, and how to be creative producers and create something of their own.

How can we encourage the growth of creativity in our own classes? There are many ways, and I shall suggest only a few. It is assumed that each of us is capable of creating a better atmosphere, once we realize the need.

First, students should occasionally be given open-ended problems, problems that have no purely right or wrong solutions. These problems tend to stimulate the growth of both imagination and insight. Few, if any, industrial problems have one "right" solution. One has but to look at the

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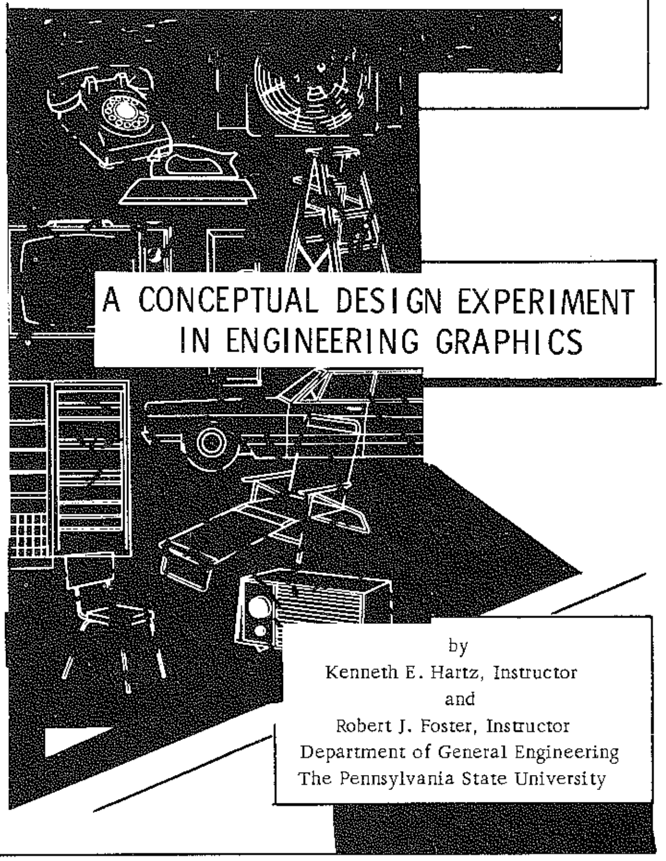

A CONCEPTUAL DESIGN EXPERIMENT IN ENGINEERING GRAPHICS

by
Kenneth E. Hartz, Instructor
and
Robert J. Foster, Instructor
Department of General Engineering
The Pennsylvania State University

This article is concerned with an attempt at The Pennsylvania State University to make engineering graphics a more vital part of the engineering curriculum by requiring the student to do creative design work at an earlier stage in his undergraduate career.

Emphasis on creativity has sometimes been reflected through greater freedom permitted engineering graphics students in performing their individual units of work. On many of the plates or drawings which the undergraduate student completes he is provided freedom in choosing specific locations of lines and some freedom in detailing of individual parts. These minor decisions which the students are allowed, however, do not fulfill the overall objective of true creativity. The student, in many instances, is not provided a problem in which he is given complete latitude. The analysis and solution of a problem are not completely his own.

As a specific example, the second graphics course at The Pennsylvania State University was formerly presented to the student on a unit-by-unit basis. The subjects covered by this course proceeded from three-dimensional representation to machine shop practices, to fasteners, and on to graphics. (Not necessarily in that order). Once the student had completed the plate on three-dimensional representation, such as axonometric drawing, he was no longer concerned with this particular subject. Toward the end of his training in graphics, the student, in most cases,

Creative projects were introduced recently at the beginning of this course, not the end. The student was also introduced to the various units as a means to solving the problems. The problems were to be completed by specific times during the course, with sufficient time allowed to apply each unit to the overall problem and to complete a solution.

received a short creative design problem in which he was presented with a problem situation and then had to devise his own solution. In the past this process had introduced the freshman engineering student or sophomore student to creative design. This introduction to a problem-design solution followed the teaching of all units of graphics. It was a situation in which the student was expected to utilize as many of these units as he had learned prior to being introduced to the problem.

Introduction of the design projects at the beginning of the course provides the following beneficial effects:

1. The student has a more intimate grasp of the goals of the course since he is immediately aware of the end point.
2. Each unit of new material is introduced as a tool to be utilized in obtaining this end point. The student is more aware of the value of each unit and is more motivated.
3. The student is aware of the details of the creative project for a longer period of time. This allows time for a more sophisticated solution and drives home to the student the need for an organized approach.
4. The student is led systematically through a design process which is more closely representative of an applied situation.

The original premise was that a single comprehensive design project could be developed which would include all facets of engineering graphics that normally would be covered. It was later found, in an attempt to develop such a single problem, that the problem would have been technically too complicated and unrealistic.

EVOLUTION OF CURRICULA IN GRAPHICS

Engineering students at The Pennsylvania State University presently are required to take two courses in graphics. The program is that of presenting basic units of information to the student in the introductory or first course in graphics. This course incorporates orthographic projection, including sketching and the use of the instruments in multiview projection and some isometric sketching. It includes other units such as fractional and decimal dimensioning, limit dimensioning, sectional views, detail drawings and auxiliary views. This information is given to the student on a unit-by-unit basis. That is, they receive information pertaining to a limited topic and are required to complete a drawing in which the principles of that unit are involved. This same unit approach was formerly used in the second course prior to the development of the design-project approach which now incorporates many of the course units.

The second course, if taught by the design-project-approach, involves the following: First axonometric projection is presented to the student followed by material on oblique drawing. After this short introduction to the course the student is introduced to the design concept. This design concept includes not only the need for a specific design solution but the steps which precede a design solution. A report of the developed solution follows completion of the design. Specifically, the student is introduced to a five-part outline consisting of the following:

I. Definition of the problem - that is, breaking it into segments which are specific and solved easily.

II. Gathering of information - by use of the laboratory for experimentation, through the library and its available material, such as textbooks, journals, reports and equipment catalogs, and lastly, consultants.

III. The analysis of information - done by technique gained from academic training and experience.

IV. The Specific Design Solution - involving first, idea sketches, followed by a preliminary layout and, in the case of some problems, a three-dimensional representation. This is then followed with the working drawings consisting of assembly drawings with the bill of material and detail drawings with specific dimensions and specifications.

V. The report - the students are expected to follow through with the report of the project as a record for future investigators. They include in the report an introduction or background to the problem which they have been assigned in the classroom plus what they have been able to gather from their own researching. It also includes a specific statement of the problem plus a discussion of the solutions considered including cost information (which may or may not be required of them) as well as the technical solution. A conclusion to the report includes a specific statement of why they chose the solution they did.

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IN MEMORIAM . . .

George Jussen Hood

Professor emeritus George Jussen Hood, 87, of the University of Kansas, died May 24, 1965 as the result of a fall. The words educator, author, engineer and inventor probably best describe Professor Hood. To students he was a friend and counselor and as head freshman advisor, he constantly kept in touch with them. During the retirement years following 1948 he continued these student contacts and following Mrs. Hood's death in 1963, he ate and visited daily with them at the Kansas Union cafeteria.

For approximately forty years Professor Hood was chairman of the Department of Engineering Drawing at the University of Kansas where he was graduated in 1902. His textbook The Geometry of Engineering Drawing has been widely used and was the first to present descriptive geometry by the "direct method." The Division of Engineering Graphics of ASEE awarded him its Distinguished Service award in 1952, and in 1955 the American Society of Mechanical Engineers awarded him the Holley medal for his invention of the "Dermatome" -- a device for cutting calibrated skin grafts of a predetermined thickness and pattern. The significance of this award is best described by the words used to specify the conditions for award: "To be bestowed for some great and unique act of genius of an engineering nature that has accomplished a great and timely public benefit."

Two of Professor Hood's three sons have distinguished themselves as engineers, and the third as a doctor of medicine. Professor Hood was a member of ASEE, Sigma Xi, Tau Beta Pi and Alpha Tau Omega. He is listed in Who's Who in Engineering and American Men of Science. He was alert, active and in good health up to the day of his death.

The Division of Engineering Graphics of ASEE is grateful for the many contributions Professor Hood has made to the fields of graphics and engineering, and extends its sympathy to his family and friends.

EDITOR'S NOTE:

For a "Personality Sketch of George J. Hood" see Volume 15, Number 2, May 1951 issue of the Journal of Engineering Drawing.

ENGINEERING GRAPHICS COURSE CONTENT DEVELOPMENT STUDY

FINAL REPORT 1965

SUPPORTED BY NATIONAL SCIENCE FOUNDATION

EDITOR'S NOTE

This project was conducted by two committees, sponsored by the National Science Foundation. The Core Committee was composed of graphics teachers who initiated the program and were responsible for details of the work. The Steering Committee members were leading industrialists and prominent engineering educators. The project was under the direction of Paul M. Reinhard, University of Detroit, and Frank A. Heacock, Princeton University, Associate Director. Over sixty engineering educators and practicing engineers, representing thirty-two accredited engineering colleges and fifteen industrial corporations, participated in this course content development study. The Editorial Staff of the Journal of Engineering Graphics have summarized the three units in the report, however you are encouraged to study the complete final report.

E.D.B.

ABSTRACT

This nationwide three-year study of engineering graphics by educators, engineers, and industrial leaders defines the future role that graphics can play in aiding in the preparation of engineering students for creative design. It also develops new, useful material that will enrich instruction in graphics at engineering colleges. Areas of technical knowledge explored and developed include the role of graphics in the conceptual aspects of design, computer-related graphics, graphic analysis and computation, and graphic solutions in space flight. A series of technical monographs on significant new applications of graphics are being published. In addition, a comprehensive bibliography with abstracts describing useful graphic solutions of engineering problems in many fields will be made available.

UNIT 1

SCOPE OF ENGINEERING GRAPHICS

Engineering graphics is one of three modes of expressing thought and manipulation of ideas and technical information. Graphics is used as an aid to visibility and as a memory-fixing device while ideas are being considered and refined. Graphics translates mathematical symbolism into physical form that may be more understandable and illuminating and whose translation is sometimes more logically followed and checked than the symbolic manipulations of mathematics. Graphics becomes a useful complement to mathematics in a wide range of scientific studies. It provides descriptions of objects or relationships that are more compact, precise, and readily interpreted than descriptions in word form. Graphics is the visual expression of thinking by means of views, graphs, and diagrams for the purpose of communicating technical information; for use in design, analysis, and computation; and for enlightenment to make study meaningful. Engineering graphics provides efficient, practical, and useful solutions of many engineering problems. It helps the student develop an insight and creative ingenuity essential for engineering progress.

The engineer must be able to coordinate and blend together the visual symbolism of graphics, the abstract symbolism of mathematics, and the written word for the best method of conceiving, expressing, describing, and solving of problems. The visual nature of graphics opens up a direct path to understanding. It is important, therefore, that the engineer be well grounded in fundamental graphic concepts so that he may employ graphics as naturally as he uses mathematics or the written word.

The continuous character of physical phenomena - time, distance, mass, force, voltage, etc. - are determined by instruments that measure by creating a graphic analog of the measured quantity. Where graphical precision can be maintained within the accepted tolerance, a graphical solution is as acceptable as a mathematical solution.

VITAL ELEMENTS OF ENGINEERING GRAPHICS

Engineers agree that creative design is one of their most important functions. When all aspects of engineering graphics are presented in a balanced course, the subject becomes an essential part of engineering education. Integration into other subjects has been given serious consideration. The committee finds that it takes time away from a planned sequence of study that is already overcrowded. Because of this overcrowding, any graphic solution taught normally requires some special application which receives little emphasis on the underlying principles of graphic theories.

In all graphical applications there are common underlying methods of thought. Graphics must be studied as a complete entity to be effective, not as a disjointed, random series of exposures. The ability to use a discipline effectively usually comes through a formal exposure to the discipline. The study finds that integration of graphics into other engineering subjects is not a desirable procedure with the student's first exposure to graphic principles. However, when the principal emphasis in a graphics course is on the production of working drawings and on the development of drafting skills, the graphics course has little value in current engineering education and then properly belongs in the trade school curriculum.

The graphics teacher must show the strength of graphics in the overall concept of engineering education. The emphasis must be on the support and contribution that graphics can provide in design analysis, and computation as well as its importance in communication. The reluctance on the part of many traditionalists to keep pace with current progress in engineering education has retarded the development of graphics.

The impact of computer-aided graphics on design should be recognized and exploited. It is also important that the engineer should develop the ability to visualize - to form a mental image or vision. Descriptive geometry helps to develop this ability, particularly in the area of spatial relations. Graphic analysis and computation also helps develop the ability to visualize, particularly in the case of the behavior of a function and the effects or restraints and variable parameters upon the shape of a curve.

Graphics is not an end in itself. An effective program of instruction recognizes the role of graphics in the design function of engineering.

UNIT 2

COURSE DEVELOPMENT AREAS

It becomes increasingly evident that there is a growing agreement that competence in design is the characteristic of the engineer that distinguishes him from the scientist. Engineers have drawn from the discoveries of relatively few pure scientists. If we are to continue to make technical progress, engineering education must develop well-qualified engineers who can and will face new and challenging problems with imagination and confidence. The engineer must be proficient in mathematics, graphics, physics, chemistry, and the engineering sciences. He should have a good background in humanities and social sciences as well as an effective command of the written and spoken English language.

Engineering as a profession is concerned primarily with design which combines components into systems and plants. The professional engineer must be capable of predicting the performance and cost of the components, systems, and plants to meet specified requirements. Tempered by judgment based on experience, he deals with the applications of science to the solutions of real engineering problems.

The making of sketches is a recording process, a reliable memory system, which the engineer uses for self-communication to help him think through the various aspects of his project. Engineers who develop the ability to visualize geometrical and physical configurations and think in graphical images have a decided advantage in creating and instructing others in achieving actual production of design. There are numerous engineering problems that in many cases the graphical solution is much quicker, more vivid, and even more practical.

The language of the conceptual aspects of design is often geometrical rather than symbolic. If one is designing an automobile or a space vehicle, the original concept occurs in the mind in geometrical configurations rather than the mathematical symbols. If any engineering discipline can contribute to design, engineering graphics is high on the list. Engineering education should give students experience early in their academic career, with a full range of graphics both in the traditional and the newer areas. The emphasis must be placed on developing the spark of originality or creativity that is so much a part of design. The objective of basic graphic courses, even in the freshman year, should be to produce a creative student rather than a specialized technician.

The key to teaching design in engineering graphics, or in any engineering discipline, is the open-end problem - one for which there are several acceptable solutions.

Graphics teachers who teach design can do so more effectively if they keep themselves currently informed about engineering practices. This can be done by industrial employment, participation in research, and interdisciplinary teaching.

The key to learning of any kind is involvement. If we wish to teach the creactive aspects of design, we must confront the student with situations demanding creative solutions. His solutions may be faulty, but the complex mental struggle which he undergoes exercises and strengthens whatever talent he possesses. With this in mind engineering graphics teachers should seriously consider design-centered problems in introductory graphics courses that will open an avenue for instilling adventure, personal satisfaction, and self-confidence in beginning engineering students.

Graphical Analysis and Computations. Familiarity with the concepts and theories used in graphic solutions should be as fundamental a need of the engineer as is his need for familiarity with mathematics. The decision about whether to teach graphic analysis as part of an overall graphics course (or broader course in engineering fundamentals), as an upper-class elective, or as a combination of these must be based on the total objectives and philosophy of each school. However, basic coverage in graphic analysis should be taught by an instructor familiar with both graphics and mathematics as well as with engineering in general.

Mathematical equations and relationships must be known and understood before programs can be written for solutions utilizing those equations and relationships. With a digital computer, many solutions follow the same reasoning used in the graphic solution. Thus a knowledge of graphics

(Continued on page 43)

DISTINGUISHED SERVICE AWARD OF THE DIVISION OF ENGINEERING GRAPHICS OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION FOR 1965

IS HEREBY PRESENTED TO:

RALPH THOMAS NORTHRUP

Professor and Head of the Department of Engineering Graphics at Wayne State University, Detroit, Michigan.

Professor Northrup is a teacher with more than thirty years of service. He received his Bachelor of Science degree from the University of Illinois and his Master of Science degree from Northwestern University. In addition, he has done graduate work at the University of Michigan. He has worked in industry as a design engineer, and is a consultant.

Ralph Northrup is the author of Graphics Workbooks and participates in the development of many types of learning aids. He has contributed articles to the Journal of Engineering Graphics and other professional magazines.

He serves on the Drafting Standards Committees of both the Society of Automotive Engineers and the American Standards Association.

Professor Northrup has been a member of the American Society for Engineering Education and the Engineering Graphics Division since 1934. He has served as Circulation Manager and Treasurer of the Journal of Engineering Graphics, Chairman of Committees, Secretary, Vice-Chairman and Chairman of the Division of Engineering Graphics.

He is an experienced administrator, having headed the department of Engineering Graphics since 1943. He is an inspiration to his students and encourages the teachers in his department to strive for excellence. His success is attested to by the fact that several of his former students teaching elsewhere, as well as members of his department, have been given the CARR Award, an honor given to young teachers for excellence in teaching.

Ralph Northrup is a strong supporter of the parent society, and an indefatigable worker in behalf of the Division. It is both the pleasure and the honor of the Division of Engineering Graphics to confer its Distinguished Service Award upon Ralph Thomas Northrup.

E. M. Griswold

Acknowledgement of the "Distinguished Service Award"

Chairman Hammond, Professor Griswold, Officers, Distinguished Guests, Ladies and Members of the Division of Engineering Graphics of the American Society for Engineering Education.

I am deeply moved and honored by being selected for the 1965 "Distinguished Service Award" granted by this division of the American Society for Engineering Education. I accept this honor of recognition with a deep feeling of humility and humbleness, knowing full well that a long list of past and present members of the division have contributed much toward its realization and fulfillment.

(Continued on page 16)

In our profession an individual receives many honors during his brief span of life and of these, some are more meaningful than others. Recognition is received when one makes a contribution to knowledge through research, invents some new device or mechanism, publishes a learned dissertation dealing with a body of knowledge and the general public receives the same with great acclaim.

We further receive honor when the lovely lady of our choice says yes to our proposal of marriage, or when some former student receives local, national, or international recognition and he expresses a personal feeling of gratitude for the small contribution we have made towards his present success.

I find myself in this latter position tonight for when I received Professor Griswold's letter informing me that, you my friends and colleagues, had selected me for the "Distinguished Service Award;" knowing full well how much present and past members of the division helped towards its fulfillment, my heart was deeply touched and my eyes became moist.

This is the second time during the last eleven years that you have bestowed honor upon me and my good wife, Elizabeth. In 1954 you honored us by selecting me Chairman of this great Division and tonight you have honored us again by granting me the Division's highest award.

In looking over the requirements for the award, I am still not sure you did not make a mistake or that I am just in a dream or state of deadened sensibility. I hasten, however, to assure you to receive the award leaves one with a pleasant feeling and that I intend to keep the certificate.

Looking backwards through rose-colored glasses to the year 1936 when I first became acquainted with the so-called "American Society for the Promotion of Engineering Education" and with the Division of Engineering Drawing, I see many faces of leaders in our field of engineering communication. Many of these leaders are no longer with us while others are still very active.

I would like to name personally each of the individuals who have played a part in making this achievement possible and who have become devoted friends of ours over the years, but for fear of omitting some name from the list and further since I consider each and every one of you as a close and dear friend, I hesitate taking such liberty. I, therefore, will just say thank you from the bottom of my heart to everyone for your contribution and faith in me.

In the brief moments remaining I would like to pay personal tribute to one individual who on that June day in 1936 met a young, slender, neophyte and very green instructor, new to the field of Engineering Drawing, now called Graphics.

As this neophyte proceeded up the steps of the Wisconsin Union while attending the annual ASPEE meeting, he met a rather short, soft-speaking individual with a slight eastern accent. This gentleman smiled, greeted me, the neophyte, with a firm warm handshake and called me by name. I assure you I was pleased to know there was one individual attending the conference whom I knew from my college days at the University of Illinois.

Dean H. H. Jordan took this young neophyte in tow and saw to it that he met the leaders in the field of drawing, now graphics, of that early period. I have always been eternally grateful for his kindness and consideration for I am sure out of that experience has come many of the warm friendships I have made with the members of this Division. Yes, I left that meeting fully convinced I wanted to be a part of the Division and to contribute towards its greatness. You became my cup of tea.

My rose-colored glasses reveal many transitions since June of 1936. Changes have taken place in graphics courses as in other engineering subject fields. Credit hours, course titles, teaching methods, contact hours, teaching materials, the aims and objectives and the methods of presentation and course emphasis have been changed over the years.

Yes, even the name of the Division has been changed and with it a greater emphasis has been placed on graphical methods as a means of engineering communication.

More recently new tools, teaching aids, textbooks, laboratory manuals, visual aids, TV teaching procedures and computer-operated plotting devices for making drawings have appeared. I am looking forward with great eagerness and anticipation to see what happens to graphics during the next 25 years. We of the old school leave the reins in your hands.

We will still be looking over your shoulder, however, to see that things don't get too far out of line.

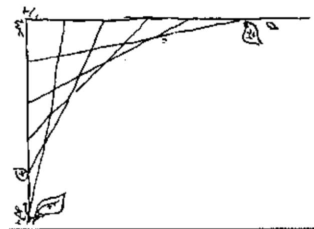
Dean J. Stuart Johnson, Vice President of Sections East of the American Society for Engineering Education, has informed me that the Goals Study Committee plans to use Detroit as one of the centers for the regional discussions of its preliminary report. They are planning these meetings in conjunction with Section and Divisional activities and have chosen to meet in Detroit at the same time our mid-winter meeting will be in session.

Inasmuch as we serve as a service department to the professional departments for the engineering college, we have a great deal at stake in relationship to their study and final report. Therefore, I would strongly urge the officers of our Division to arrange at least one session meeting with Dean Hawkins' committee in October so as to get the best considerations possible in their final report.

(Continued on page 23)

DESCRIPTIVE GEOMETRY AND DESIGN APPLICATIONS

John P. Oliver, P.E.,
Professor of Engineering Graphics
Texas A&M University



Some years ago, while discussing machine design with a professor of mechanical engineering, I was struck by the truth of his rather cynical remark, "What machine design?" He went on to explain that the teaching of machine design was like gathering a basket of apples from a certain tree. When the basket was full, there was a basket of apples which had two things in common: they were all apples and they all came from the same tree; otherwise, they were completely dissimilar.

I have given a great deal of thought to Descriptive Geometry and I have become convinced that, like machine design, the Descriptive Geometry course content represents a haphazard selection of problems having no continuity of thought and only two things in common: they are solved graphically and they involve space dimensions.

In such a jumble of ideas, it is quite impossible to teach the student to plan his solution. To me, planning is the most important work of the engineer. To conceive, or have presented to him, a problem; to analyze the problem in broad outline; to set up general steps toward its solution; to do the research necessary to obtain the information for the solution; this is the work of the engineer whether it be on the job or in the classroom.

We, as engineering teachers, cannot begin the development of the student's ability to plan his work too soon. The freshman year should begin this development and, I believe Descriptive Geometry is the best place to start. This field of study lends itself to analysis and planning more readily than any other course in the freshman curricula, including mathematics.

Quite a few years ago, Professor Warner set out to reduce Descriptive Geometry to a set of basic concepts, and I feel that his work, as far as it went, would be difficult to improve. But it seems to me that he stopped just short of the reorganization that we need to make the course purposeful. He set up the four fundamental equations:

1. The line in true length.
2. The line as a point.
3. The plane as an edge.
4. The plane in true shape.

and he gave use two very simple rules for setting up these equations:

1. The view preceding the end (point) view of a line must show that line in true length.

2. The view preceding the true shape view of a plane must show that plane as an edge.

But, he did not break the work down into its type problems. Descriptive Geometry deals basically with two types of problems: angles and distances. Beyond these basic types, there are a myriad of combinations. For instance, the angle between two intersecting lines involves not only the angle but distance along any angle from a point to a line.

Another example of continuity of thought appears in the problem of the angle between a line and a plane. Wherever this problem occurs, its analysis and the steps in its solution are basically the same.

Analysis: The angle between a line and a plane is measured in a plane containing the line and perpendicular to the given plane. This angle will appear true in any view in which the line is in true length and the plane is an edge. Steps in the solution follow the analysis:

1. Draw any edge view of the plane. Check to see if the line is in true length in this view. If not,

2. Draw true shape view of plane.

3. Draw edge view of plane looking perpendicular to the line.

Let us consider some of the applications of this solution. We find that we may not only find the angle between a line and a plane but also the distance from a point to a plane at any angle to the plane. This illustrates another of those combinations previously mentioned.

Having criticized others, I shall now lay myself open to criticism by suggesting a basic outline of course content. After the mechanics of the field - views, explanation of rules, etc. - have been covered, the problems of Descriptive Geometry may be taken up as follows:

I. Angles

  A. Between a line and a plane:

    1. Analysis as given before.

    2. Steps in solution.

    3. Problems:

      a. True length and slope of a line.

b. Angle between a line and front and side planes.

c. Angle with any plane.

d. Any distance point to plane.

e. Geometric solids on planes as bases.

B. Between two intersecting lines:

1. Analysis: the angle between two intersecting lines in space will appear true in the true shape view of the plane determined by the lines.

2. Steps in solution:

a. Draw any edge view of the plane.

b. Draw true shape view of the plane.

3. Problems:

a. Any distance from a point to a line.

b. Bisectors of angles.

c. Circle through three points.

d. To inscribe a circle within a triangle.

C. Between intersecting planes:

1. Analysis: The dihedral angle between two intersecting planes is measured in a plane perpendicular to the line of intersection between the planes. The required angle, then, will appear true in any view where the line of intersection appears as a point.

2. Steps in solution:.

a. Find line of intersection between the given planes. This may be done by edge view method or otherwise.

b. Find line of intersection in true length.

c. Find line of intersection as a point. The two planes will appear as edges in this view.

3. Problems:

a. Angle between any two planes.

b. Angle between plane.and horizontal-slope.

c. Strike and dip problems.

d. Bend angles in sheet metal.

II. Distances:

A. Point to line - Special Case - Perpendicular distance:

1. Analysis: the perpendicular (shortest) distance from a point to a line will appear true in the point view of the given line.

2. Steps in solution:

a. Find line in true length.

b. Find line as a point.

3. Problems:

a. Shortest distance from a point to a line.

b. Revolution of a point about a line as an axis.

c. True length by revolution.

d. Shortest distance between skew lines.

e. Revolution of one skew line about another as an axis.

f. Generation of warped surfaces of revolution.

B. Between skew lines - General Case -

1. Distances between skew lines which are used to form the warped surface known as the hyperbolic paraboloid are contained in a series of parallel directing planes. These planes may be set at any angle but are usually perpendicular to the top. The distances will appear true in the true shape view of these parallel planes. The axis of the surface will appear as a point in this view and all the distances will apparently intersect on this axis.

(Continued on page 21)

Perspective

WHERE DO WE GO FROM HERE?

CLIFFORD H. SPRINGER
Professor Emeritus
University of Illinois

Approximately forty years ago our secondary education system was being revised. The "Progressive Educators" were busily engaged in making school a pleasant place in which the student would enjoy learning by experiences rather than by the old rote system. They dreamed of teachers who would use all of the child psychology that had become available, and who would educate the "whole child" rather than his intellect alone.

These progressive educators, like John Dewey, were dedicated men with a new idea. Their enthusiasm and ability might well have been successful if all teachers could have been inspired like them. However, in a program of this size there were thousands of teachers, most of whom learned the slogans but were incapable of living up to the ideals of the originators.

During the last few years we have seen something quite similar happening in Engineering Education. In this field the "Progressive Educators" envision the elimination of rote learning by the total development of the whole student in the field of science. It is claimed this makes for a more complete, happier, and more useful engineer because he has been relieved of all tedious, tiring, and time-consuming work.

Theoretically it should succeed and practically it probably would if the dedicated originators of the idea could teach all of the classes. Unfortunately, there must be thousands of teachers, each interested in his own little side line as developed in his doctor's thesis. To him the most important thing in the world is his own specialty, and teach it he will.

Even as the progressive education in the secondary program failed, because of poor performance in spelling, composition and just plain figuring, so the progressive program in engineering may fail for lack of fundamentals. The original enthusiasm and inspiration could be too difficult to transmit from the few to the many.

Even though progressive education in the secondary schools has been more or less discredited, this does not mean that no good came out of the movement. Many new methods based on television, programmed learning and other ideas have been developed to bridge the gap between the old and the new. So in engineering education we can expect to see new ideas and methods developed which will in time provide us with a better educational system than either the old or the new. It is the duty of every engineering instructor to use his energies and talents to that end.

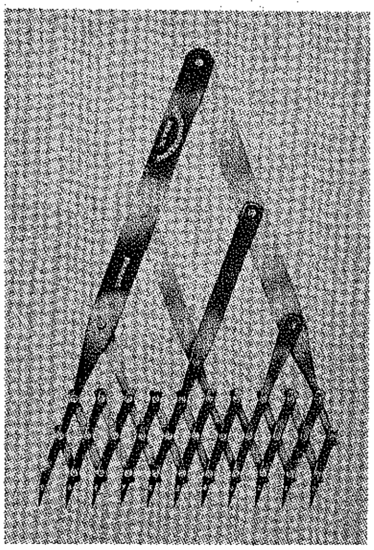
You are never going to say this to anyone, but all the same you know that things will never be quite so good around the department after you retire. There are only a few years left and there are many things that you would like to do. Of course, you have been trying for ten years to find time to do these things, but there have been too many papers to grade and too many reports to fill out. Now in the last two years you intend to make an all out effort to do the regular work and at the same time develop the great ideas. Take heed my friend! This may be the basis for the stroke or health failure that too frequently occurs right after retirement.

A much better formula for these last few years would be to begin a search for one of the younger men who is able and willing to tackle your pet projects. By taking part of your spare time to train and inspire the younger man, you are probably doing more for education and the profession than you could possibly do by going alone. Have you ever known the thrill of seeing a young man, whom you have helped to develop, take hold of a project and do it better than you could do it yourself? When you have known that feeling, the pleasure of the awards you might have received will seem small. It is true you may never receive the credit for your ideas or the work you did, but in the long run you will be just as happy with the feeling of a job well and properly done.

But since this procedure will not take so much of your time, you are now able to think of the future. The University will not stop when you retire, but in spite of anything you can do, you will and should fade from the picture. For a time you will be able to continue some of your former activities and once in awhile someone will ask for your advice, but not for long.

During these last few years you can give some thought to your future activities. Your experience over the last forty years will be very useful in some field. There are service organizations of many that can use your help. There are new things to learn and old things to perfect. There are places to go and things to see, all of which will keep you young and healthy. You might even apply all of that stored up knowledge of human foibles to write that novel that has been in the back of your mind for so long. When you meet your old friends at conventions and reunions they will all be impressed by the fact that you are still growing instead of just fading away.

THE SPACING DIVIDER



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(Continued from page 18)

2. Problems:

   a. The hyperbolic paraboloid roof.

   b. Distances between skew lines along any given bearing.

   c. Minimum distances between skew lines.

      (1) Analysis - These distances will appear true in the true shape view of directing planes positioned perpendicular to the level line of a plane containing one skew line and parallel to the other. The distances may be positioned by drawing views from this true shape view in the specified directions.

      (2) Steps in solution:

         a. Through a point on one skew line, draw a line parallel to the other skew line thus determining a plane.

         b. Draw level line in this plane.

         c. Draw a view looking along this level line. This is the true shape view of the directing planes. The skew lines will appear parallel in this view.

         d. To position the distances, draw views from this view in the specified directions and determine the apparent crossing point of the skew lines.

      (3) Problems:

         a. Shortest level distance between skew lines.

         b. Shortest distance along any given grade or angle with horizontal.

         c. Perpendicular distance.

An interesting example of widely variant problems which never-the-less lend themselves to practically identical solutions lies in the adaptation of the use of the hyperbolic paraboloid to a roof, level and grade distances along a given bearing between skews lines and minimum level and grade distances between skew lines. In each of these problems, the distances to be measured are located in parallel directing planes the location of which is the key to the solution.

Fig. 1.a presents a square panel of a roof which is to have gables at a and c and low points at b and d. Here two pair of skew lines form the gables and low points. ad and bc are in parallel vertical planes but are skewed to each other as are ab and dc. In order to have a minimum length of connecting member, the directing planes are vertical and parallel to the sides of the panel (Fig. 1.b). In the plane Y-Y, the connecting member 3-4 lies between ab and cd. In the plane X-X, 1-2 lies between bc and ad.

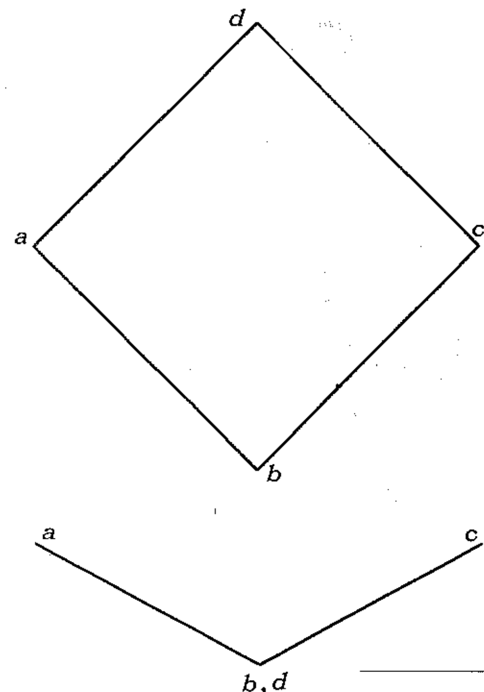

FIG. 1 a

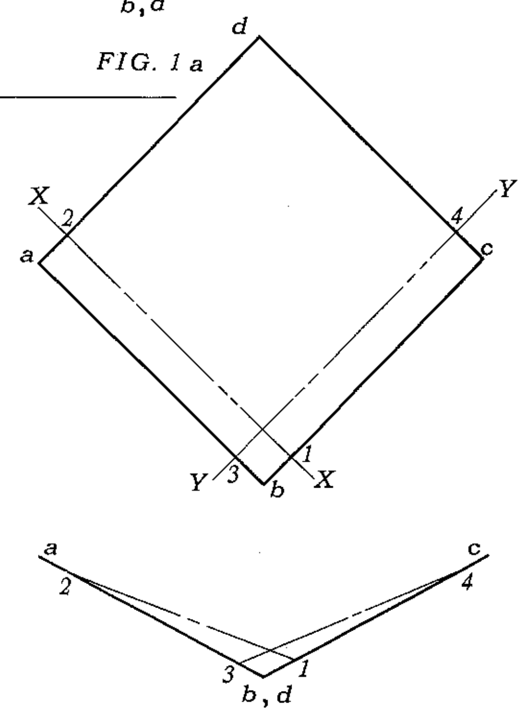

FIG 1 b

Fig. 1.c shows the roof bracing in place. The directing planes are equally spaced and parallel to each other. The positioning of the member both in plan and elevation is fixed here but the lengths of the member are still unknown. These lengths are measured in a true shape view of the directing planes (Fig. 1.d). Since the panel is square, the lengths of corresponding members in both directions will be the same so only one true shape view needs to be drawn. Note that the axes of the roof, A and B, are horizontal and perpendicular to each other.

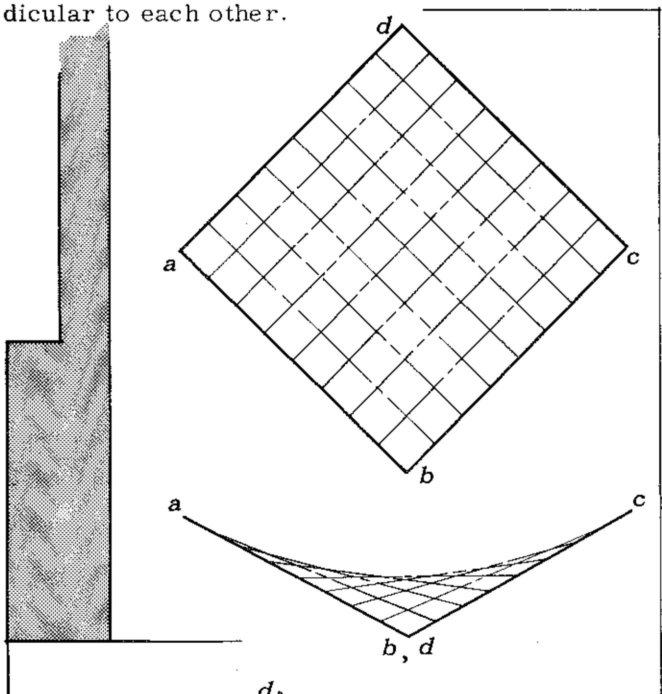

FIG. 1 c

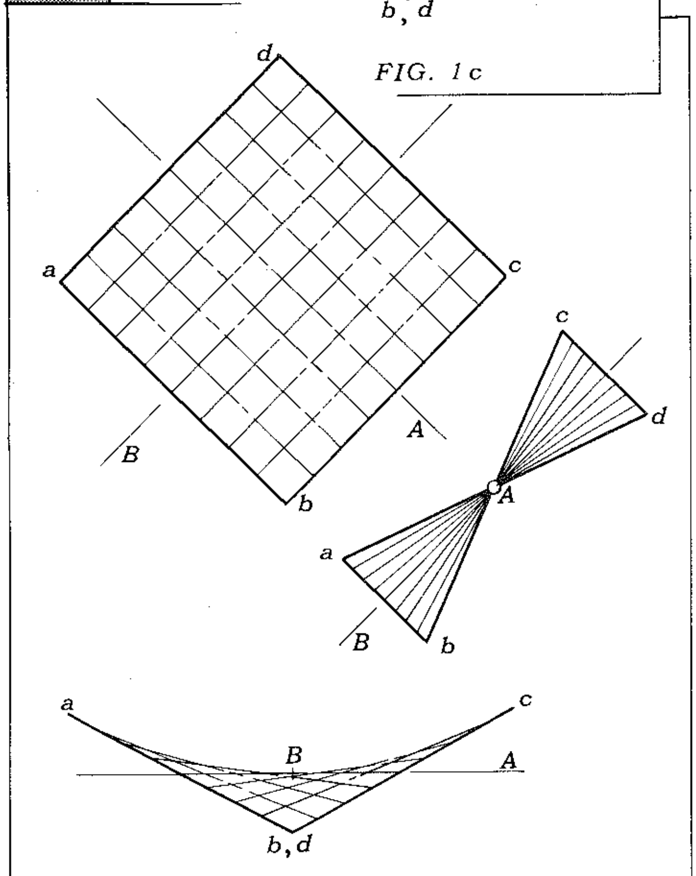

FIG. 1 d

Such a roof is very economical over wide areas. The connecting members are usually designed for both tension and compression so that they brace the gable frames against bending and at the same time prevent "kick-up" at the gables. The roof surface is formed in many ways. A simple solution is to warp ribbed mesh over the members and apply gunite as a cover. No forming is necessary.

A completely different problem, yet one involving the same principles is represented in Fig. 2.a. Given two skew lines, ab and cd. Required to position and measure a level and a -20% grade distance between the lines and which will bear N30°E.

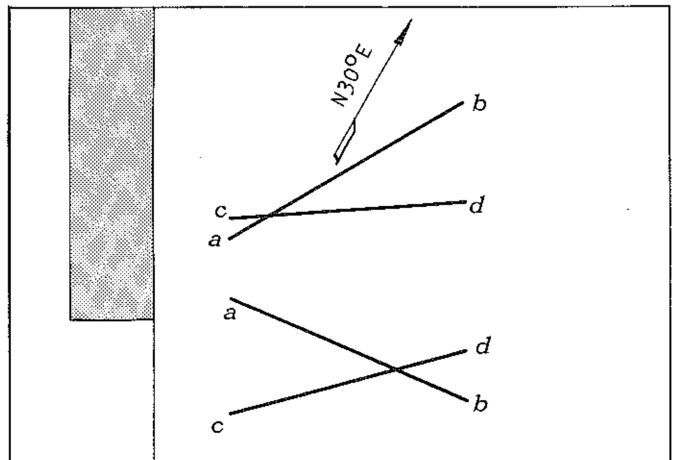

FIG 2 *a*

Here, as in the roof problem, the directing planes are fixed as to direction but their actual positions are unknown. The level distance may be found quite readily by looking at the lines with a level line of sight bearing S30°W or parallel to the directing planes. The apparent crossing point of ab and cd in the view thus obtained is the point view of the level distance, 1-2, between the lines. This distance is true length in the top view. The directing plane containing the level distance has thus been positioned. (Fig. 2.b.)

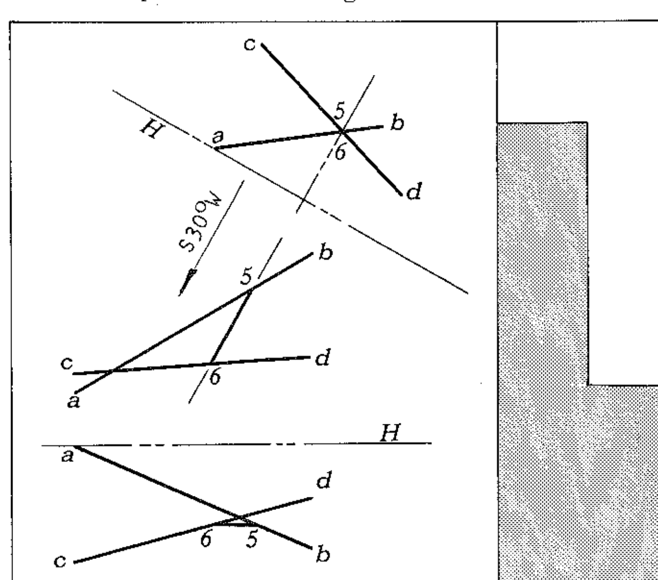

FIG 2 *b*

(Continued from page 22)

In order to locate and measure the -20% grade distance between the lines, a true shape view of the directing planes must be drawn. This view is obtained by looking N60°W with a level line of sight (Fig. 2.c). The required distance will appear true in this view but its location is still unknown. So another view must be drawn on a plane perpendicular to the directing plane but tilted to show a -20% grade line as a point. The apparent crossing point of the lines ab and cd in this view locates the -20% grade distance and, upon being projected into the true shape view, gives the true distance.

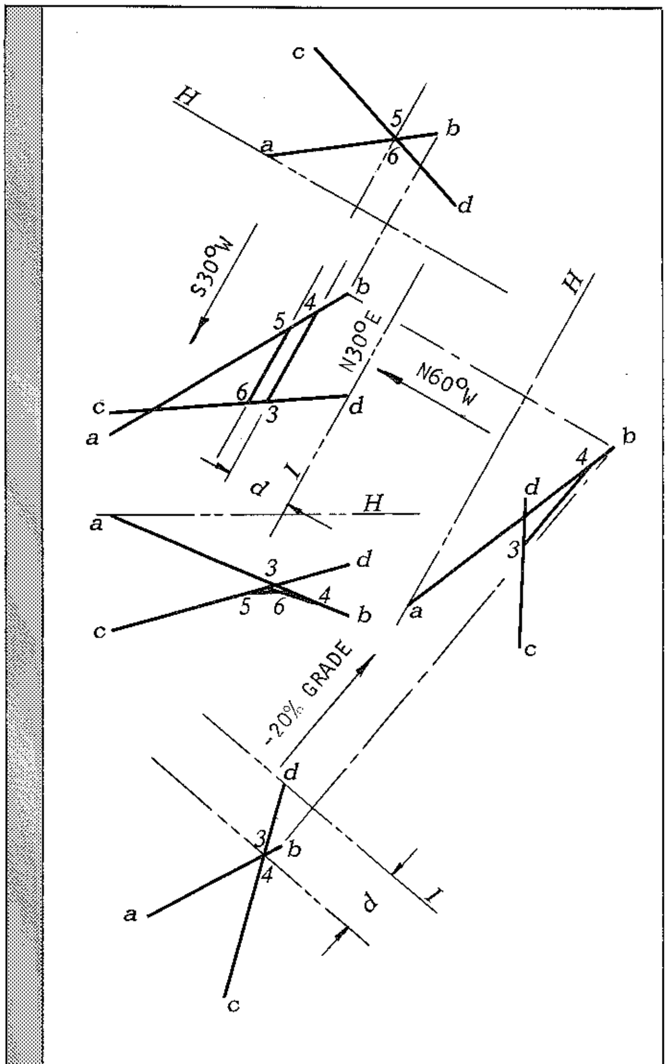

FIG 2c

Another and somewhat similar problem is the location and measurement of minimum distance between two skew lines. Here are given two skew lines, ab and 1-2, with the requirement to find the shortest level and -30% grade distances between the lines. In this problem the directing planes are known neither in position nor direction. Since the distances required are minimum, these directing planes must be positioned perpendicular to the two parallel planes containing the skewed lines. This places the planes as to direction, but

(Continued on page 24)

(Continued from page 16)

Distinguished Service Award

Perhaps you are not aware that tonight you are also honoring a native son of the great city of Chicago. It was in this city that I received my early formal and technical education. One of the schools was torn down in order to make room for the Congress Expressway. The other school, Harrison Technical High, is still standing.

In the days of Horatio Alger one would have read "Local Boy Makes Good." Thus in the granting of the Distinguished Service Award to me this evening you are also honoring many of my early teachers and this great city, for each played a part in making it possible for me to be standing here this evening. Again, on behalf of Elizabeth and myself I wish to thank you for this beautiful scroll. I shall cherish it the rest of my life. I would like to close with the following personal thoughts.

Of all the many blessings that our gracious Father sends, I thank Him most of all today for you my loyal-hearted friends.

Friends, who know about my faults
and keep on loving me still.

Friends, whose friendship changes
not with happy days or ill.

Friends, to whom my inmost secrets
safely I confide.

Friends, who make me happy just to
have them by my side.

Yes, of all the many blessings that our gracious Father sends, I thank Him most of all today for you my loyal-hearted friends. And finally, Austin Mills I believe has expressed the love and devotion of all Graphics Division members in song using the following words:

On the friendly road there is not a
frown but a smile the whole way
through.

If you fail to find what you hope to
find, it is not the road - it's you.

I will be your friend, you will be mine,
as down the friendly road we go.

Though you walk your way and I go
mine, let's all keep together since
we know, we both shall reach the
same abode at the end of the
friendly road.

Thank you from both of us.

Ralph T. Northrup

their relative positions are still unknown. These positions are determined by views whose sight lines are parallel to these directing planes (perpendicular to the level lines of the parallel planes containing the skew lines) but tilted to contain the point view of the distance required. Since only a level distance appears true in the top view, a true shape view is necessary. (Fig. 3)

Solution: Through some point on 1-2 draw a line C parallel to ab. This determines one of the two parallel planes containing the skew lines. Draw a level line in this plane. View 1 shows the true shape view of the directing planes obtained by looking along the level line. In View 1, any minimum distance between the lines will appear true length. Any view off this view will show the directing plane as an edge. A level view locates the level distance, View 2, and a 30% grade sight line locates the -30% grade distance, View 3. The shortest distance, View 4, is found as a check on the overall accuracy of the solution.

In solution of problems of this nature, the student must know that the distance required lies in one of a series of directing planes intersecting the skew lines. His problem, then, is to find the direction and location of that plane. The correctness of his solution will depend primarily on his analysis of his problem. Once a true analysis is made, the steps in its solution follow the same procedure as for any other problem of this nature.

> The primary purpose of a liberal education is to make one's mind a pleasant place in which to spend one's leisure. --Sydney J. Harris

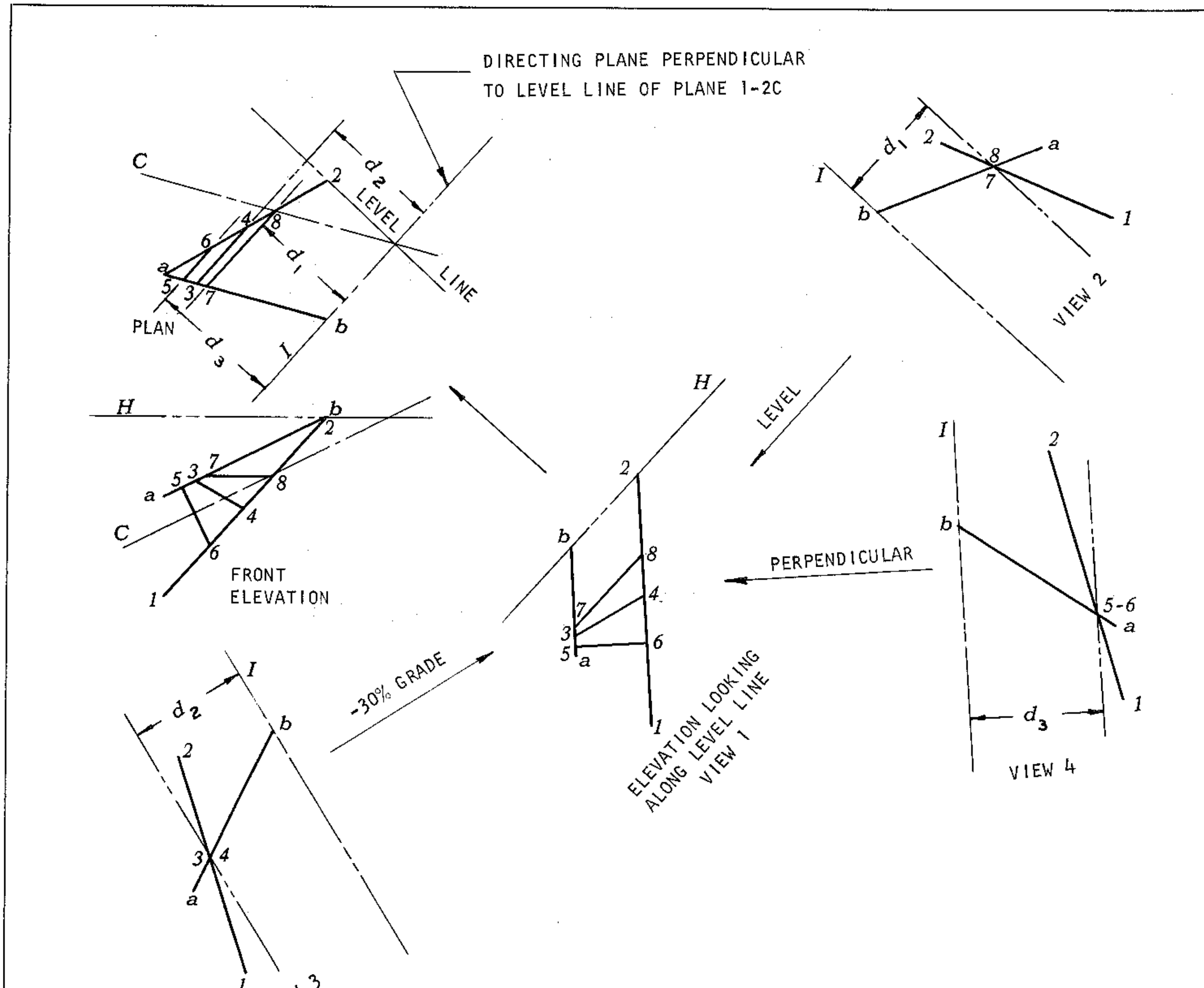

FIG 3

WHERE (SOME) ANGELS FAIL TO TREAD

(In response to Professor Irwin Wladaver's article "Where Angels Fear to Tread")

by

C. Ernesto S. Lindgren
United States Steel Corporation
Visiting Research Engineer
Princeton University

EDITOR'S NOTE:

The normal procedure in a debate is to give the affirmative side the last rebuttal. We are therefore closing the debate between Mr. Lindgren and Professor Irwin Wladaver with Mr. Lindgren's remarks in retaliation to "Where Angels Fear to Tread" - Journal of Engineering Graphics, Spring 1965, Volume 29, Number 2, Series No. 86. We are grateful for the contributions from both gentlemen who have helped to keep us on our toes and our reading more exciting.

E.D.B.

"I disagree with Lindgren in every way." "I simply don't understand his viewpoint". "I agree with Lindgren in one essential . . . . . . I agree in part with my good friend Ernesto Lindgren." So wrote my good friend Professor Irwin Wladaver in the last issue of the J.E.G. (Vol. 29, No. 2), commenting on my article "Reflections on the Fundamentals of Descriptive Geometry".

"To be or not to be that is the question", some one said in one of Shakespeare's plays.

Anyway, the dramatic reaction that my article brought upon Professor Wladaver reminds me of a meeting of about sixty Brazilian professors of Descriptive Geometry, which I attended in 1955 as a student-observer. The meeting dragged itself for two hours of book-waving, quotations, agreements, disagreements, etc. The whole thing finally came to order with these words from one of the professors: "And all I said was: the planes of projection should be, by convention, opaque". I say: he was sure glad he did not promise to eat his hat if proved otherwise.

But, was it proved to be transparent? No, it was not. To be opaque? Again, no. Then, what is it? Well, the answer is given by Professor Wladaver. But, does he see it? The answer is no.

Just read what Professor Wladaver says: "What does Monge say about the planes of projection? Virtually nothing". I ask Professor Wladaver and for that matter, I ask anyone: What did you expect him to say? and What is to be said?

For, my friend, a plane of projection is just this: a plane. And what is a plane? Well, read Euclid's Elements.

To look for what Monge has to say about planes of projection is like to search for an answer to this other question: What is the color of Napoleon's white horse? Sounds ridiculous? It is. How about this one: What is a plane of projection? It is ridiculous too.

Monge was writing to "homme de genie", who would know how to differentiate art and science, but not art and theory (?), as Professor Wladaver interprets it. For art, any art (except pop-art, of course . . .), requires also, theory. Or do you think that "L'Academie d'Arts et Sciences" was so called because the name looked nice?

And if Monge called his Descriptive Geometry an "Art", it was not because he wanted to imply that there would be no theory, as Professor Wladaver suggests when he says: "Monge goes on further with the same theme to show how the art - notice, art not theory . . . " So what, I ask? What does it mean? - It means that Monge was writing to the "homme de genie" who, because they worked with drawings were also called "artistes". And so refers to them at page 9 of his book: "De plus, comme la plupart des artistes qui font usage de la methode des projections, sont tres familiarises. . ." Monge was talking about something that "l'artiste" already knew, the method of projections, learned from predecessors of Monge, starting with Euclid (and probably others before him), followed by Heliodoro, da Vinci, Durer, Del Monte, Desargues, Frezier, etc. So, why should Monge "define" planes of projection? But Professor Wladaver exclaims: "As I see it, plane of projection is left undefined!" What is the color of Napoleon's white horse?, is in a sense, what he is trying to find out.

And more: Professor Wladaver is waving to me Monge's "feuille de dessin", which he says is "undoubtedly opaque!" Who am I to disagree? And I am not going to use the argument based on the "sheet of glass" (undoubtedly transparent, say some) used by da Vinci in his Treatise on Painting. I will not because it is ridiculous to say that the "feuille de dessin" or the "sheet of glass" IS the plane of projection. But if anyone does, I want to be shown what is the projection line. Is it a "thread", a "cord", a "rope", a "string"? And of what color? Or is it a rubber band?

The affirmation by Professor Wladaver that the adjectives "applied" and "theoretical" are devoid of differentiating significance is news for me. The way I understand it, there is in Science (and in the Arts) a three-linked chain. The first link is theory, the second is research, and the third is application. By research Monge's followers found ways of applying such things as "change of planes of projection", a descriptive geometry method whose mechanism is today

(Continued on page 40)

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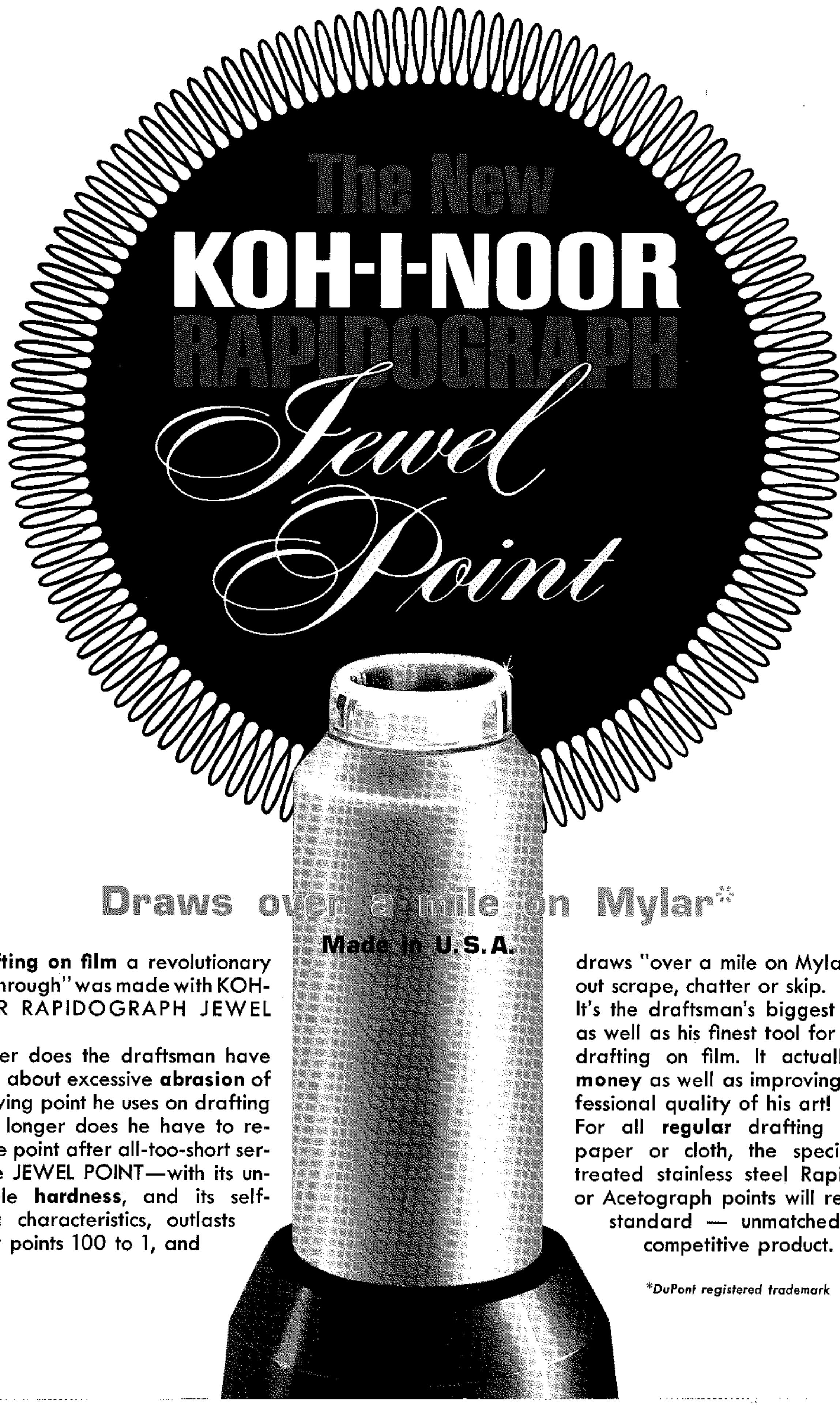

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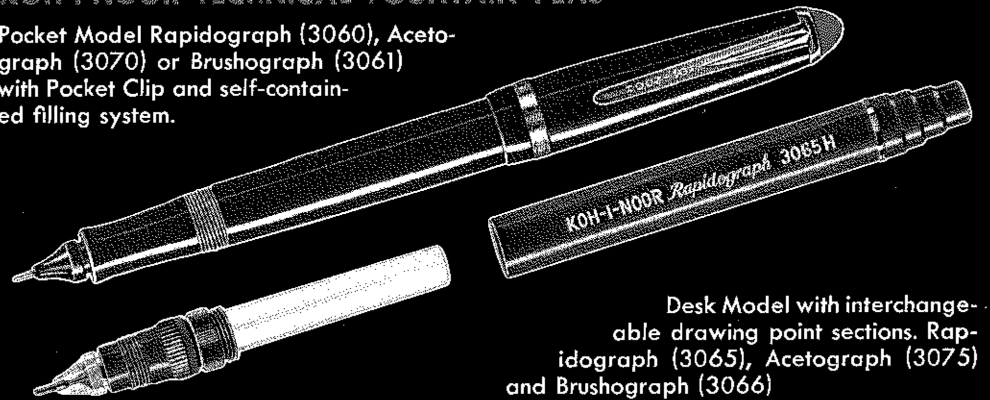

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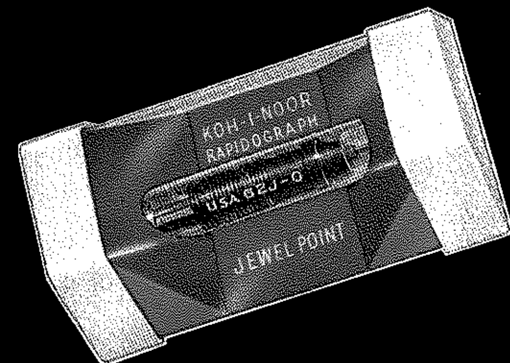

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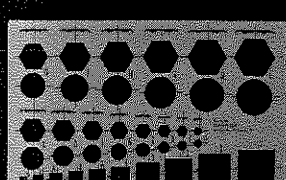

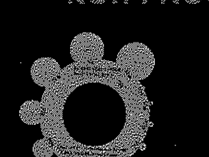

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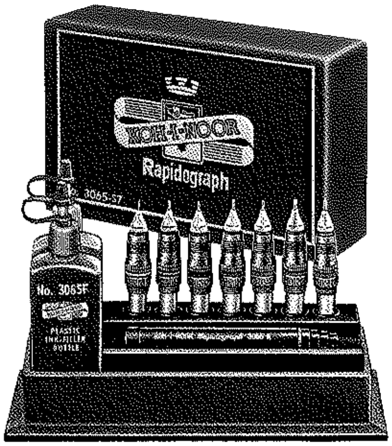

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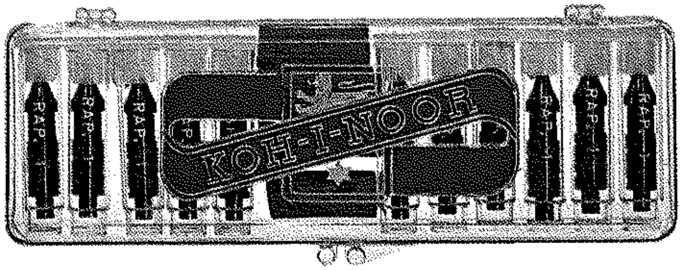

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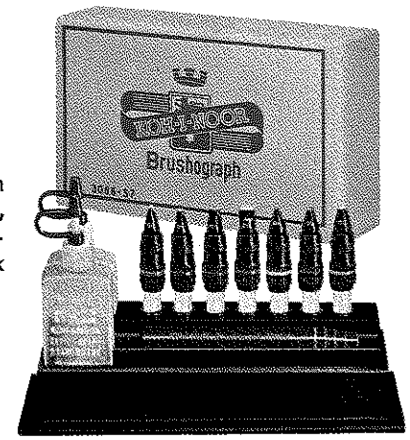

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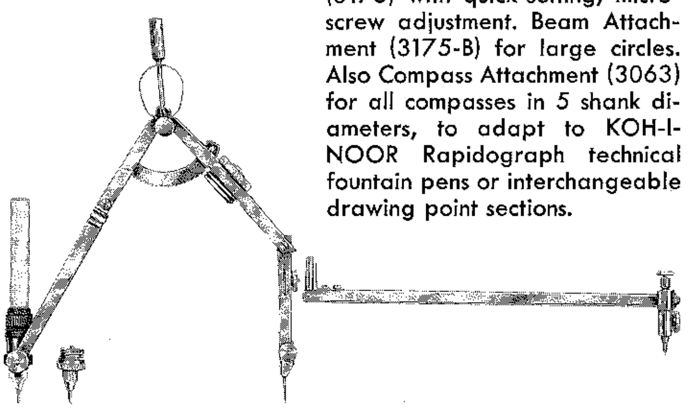

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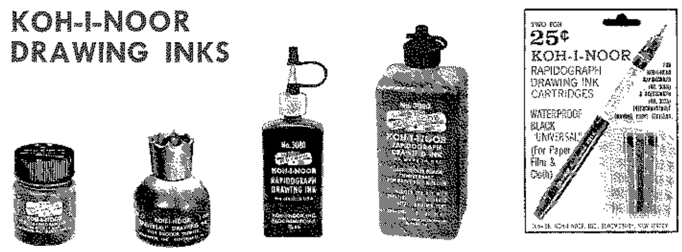

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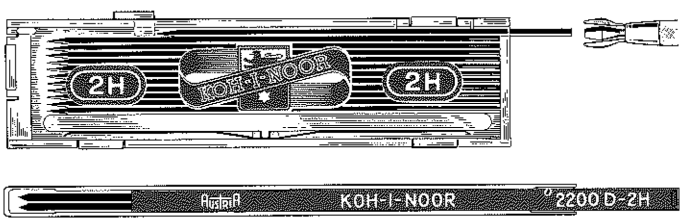

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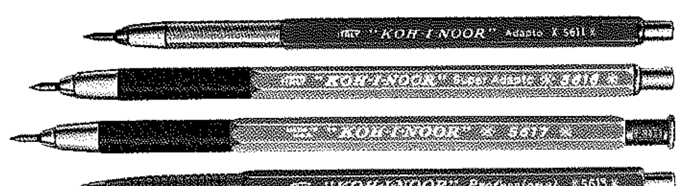

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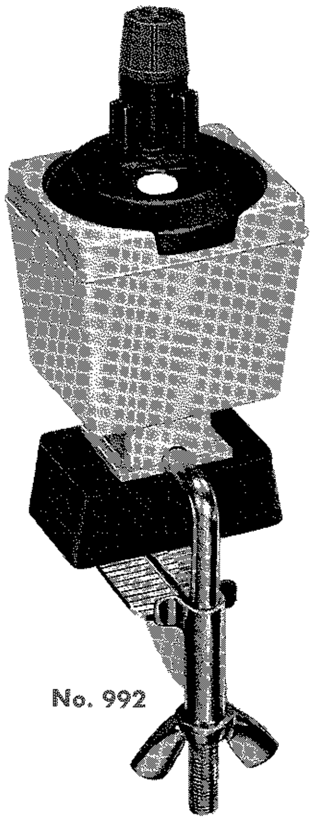

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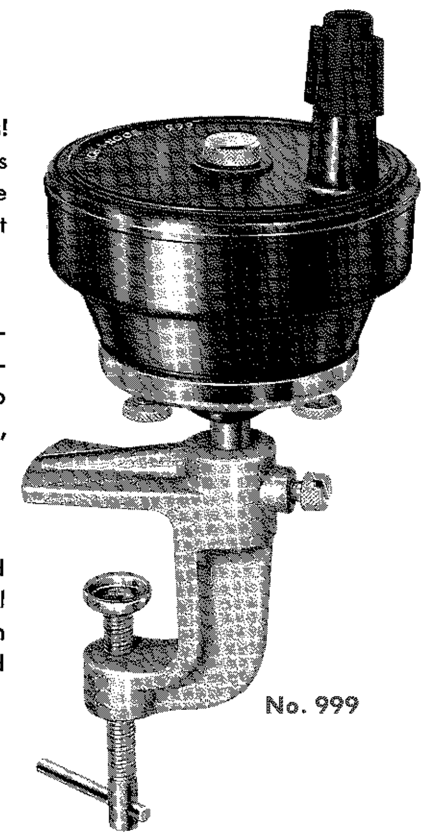

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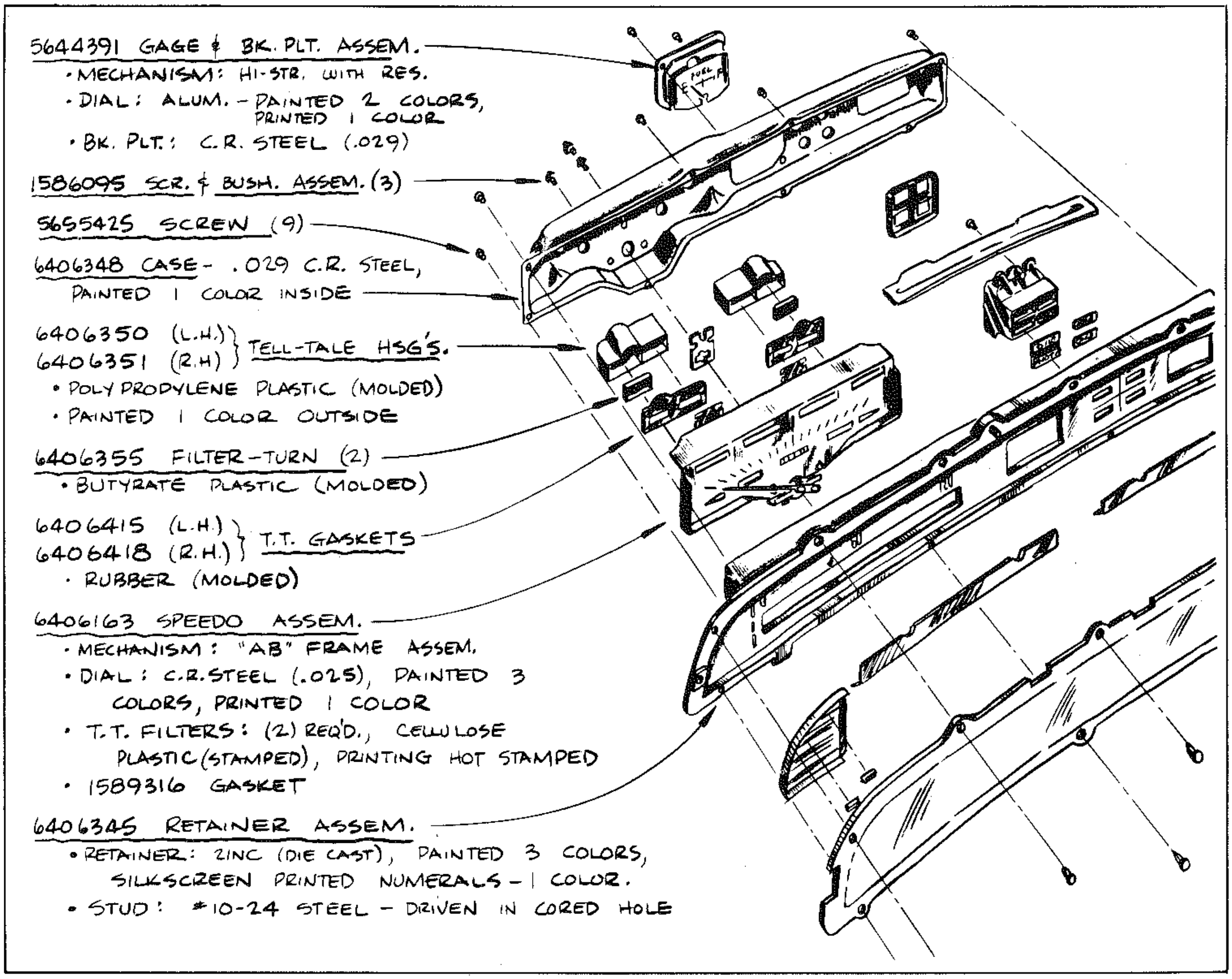


Figure 3.

a triangle and straight edge, are used. A drawing board or desk are adequate working surfaces. It is advantageous to sketch in a position which allows one to step back and view the drawing occasionally to check for proper perspective and proportion.

Procedure

The exploded view drawing procedure will now be described in detail. It must be remembered that this procedure was developed to suit the requirements of preparing cost estimates of instrument clusters. However, this system may be adapted to any product or assembly.

Rough Layout

A rough layout is made to "rough out" (outline) the basic contents of the final drawing. The "explosion" angle is established, usually diagonally on the paper. (See Figure 1). Use light weight guide lines to insure proper location of mating points on adjacent parts. The proper perspective angles are established at this time by slightly converging the guide lines as they extend from "front" to "rear." Convenient guide line "sources" and "routes" are centers of round openings which are ultimately concentric in the assembly. Others are locator pins or assembly fastening screws.

Using the guide lines, sketch the overall size, shape, proportion, and relationship of the major parts to be "exploded." Be certain of the assembly and dis-assembly sequence of component parts since this may affect cost. A bare minimum of detail is required on the "rough." (See Figure 2).

Final Drawing

The final drawing is made by securing the mylar drawing sheet over the rough layout on the drawing surface. Starting with the front or nearest component, and referring to the guide lines and rough shapes on the rough layout underneath, sketch the component outline. Quality of pencil line work is important at this stage. It eliminates the need for further re-working or touch-up. A soft grade of pencil, made for use on mylar, is used. When the front component outline is completed, begin the component directly behind it. Continue working in assembly sequence from front to rear.

If an existing component mechanism assembly, such as a standard speedometer, is specified, sketch the outside shape of the assembly only. Additional detail is not necessary since the cost of the existent mechanism is already established.

When all components are outlined, trace the guide lines using dot-dash lines which are of a lighter weight than the component outlines.

The printed descriptive information is added last. This supplemental information provides data and specifications about each component. It includes: part number, part name, material and thickness, finish, and suggested manufacturing process. Printed information must be accurate and thorough. An oversight may be costly. Position the "blocks" of lettering adjacent to the applicable component for clarity and neatness. The "blocks" are connected with the component by carefully placed arrows. (See Figure 3).

Shading

Shading of the exploded view components is recommended for communicating three-dimensional shapes. This is especially desirable when complex parts or assemblies are involved. Shading or adding shadows to sketched objects is a "ticklish" job. For the Design Engineer with artistic talent, shading of a drawing comes naturally. But, for the average person, shading of three-dimensional shapes on a two-dimensional drawing may be a difficult task. Therefore, in order to attain a degree of proficiency, some practice is required. A few pointers may be helpful.

Imagine a point or small area source of light which is falling on the exploded view components. The light source at the upper left or upper right in front of the part is most effective. (See Figure 4). Then visualize the light and dark areas appearing on the components as a result of the light source. Visualization may be the most difficult portion of the technique to master. As the dark shadow areas are visualized, darken them with the pencil. The darker the shadow, the darker the penciled area must be. The lightest areas are not touched with the pencil. Shading techniques are often difficult for the novice to develop. There is no substitute for practice. Experience has indicated that even the least artistically inclined person can learn basic shading techniques. Sheer determination can compensate for a lack of natural talent.

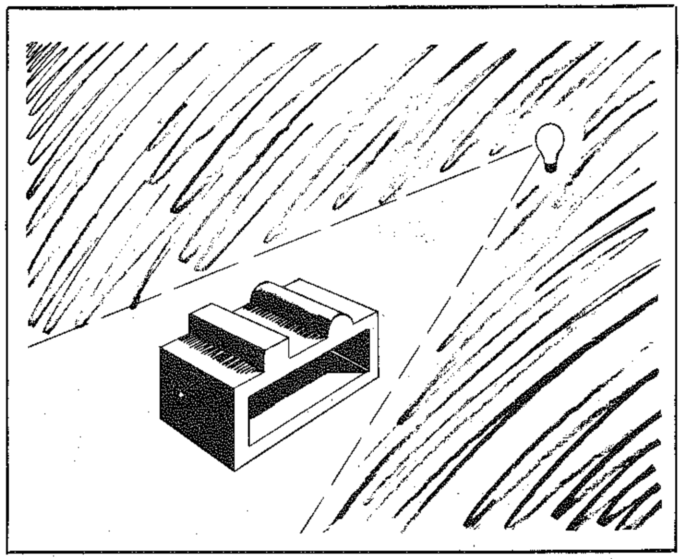


Figure 4.

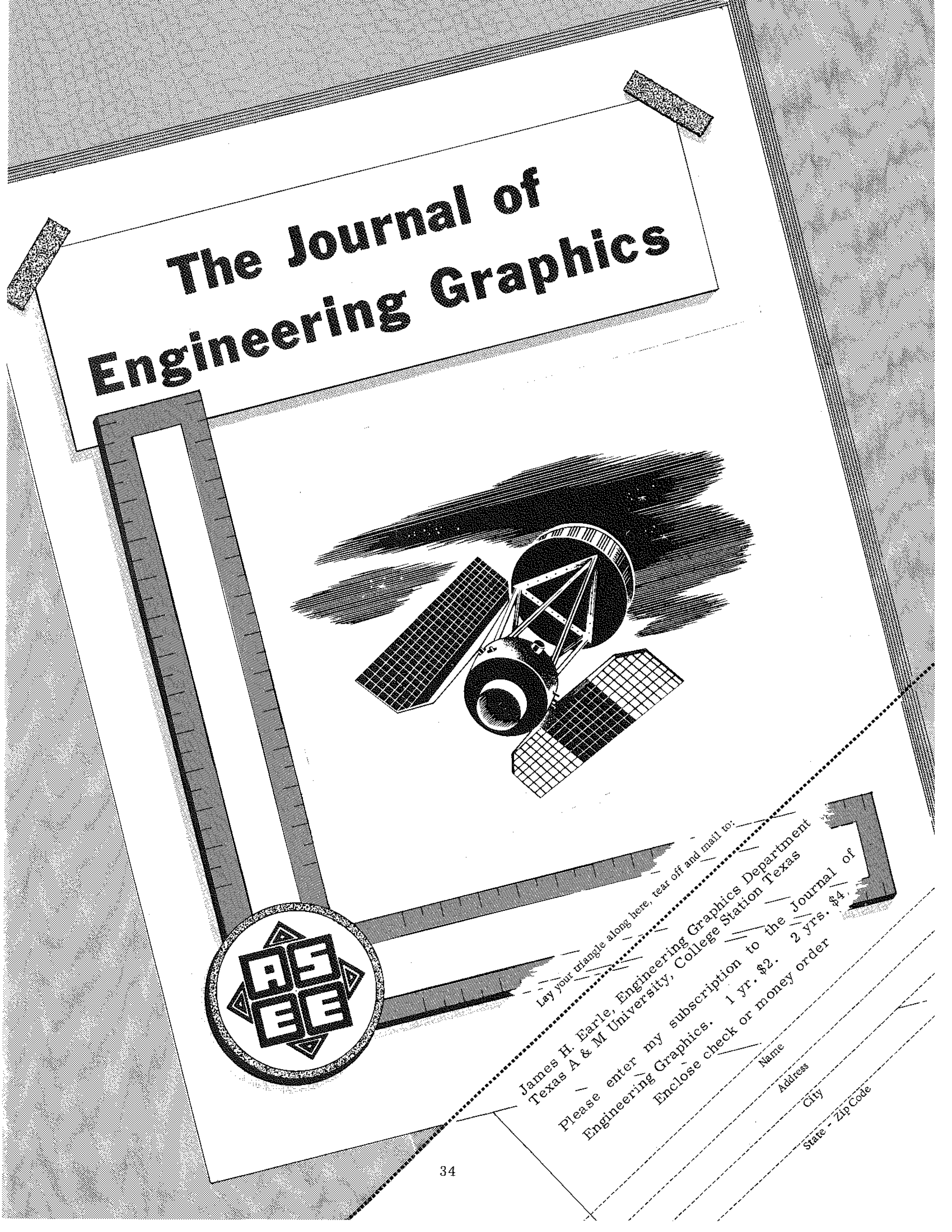
Summary

It must be emphatically stated that sketched exploded view drawings are effective and efficient tools for the Product Design Engineer The technique described has become an established cost estimating procedure in the Instrument Cluster Product Engineering Department at AC Spark Plug Division of General Motors. The value of graphical communication skills cannot be overestimated.

Artistic talent is definitely advantageous in preparation of exploded view sketches, but it is not a prerequisite. Most Designers and Product Engineers can become fairly proficient with practice and determination. The inherent personal traits required for design sketching are perception, visualization, knowledge of basic parts, and patience. Most Designers and Product Engineers possess these traits in varying degrees.

Engineering teachers could perform a valuable service to industry if they would teach the fundamentals of preparing sketched exploded view assembly drawings in addition to the traditional mechanical drawing, orthographic projection, and descriptive geometry. In this time-conscious age, a sketching technique can provide the time which can be the difference between success or failure of a product, or its creator.

> The real danger of our technological age is not so much that machines will begin to think like men, but that men will begin to think like machines.
>
> --Sydney J. Harris



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interpreted (in Technical Drawing) as "auxiliary planes of projections". Remembering that the descriptive method of change of plane of projection is not Monge's creation we can see here, the three-linked chain. The method was first proposed by Desargues (1581-1661), simplified and refined by Frezier (1682-1773) and Theodore Olivier (1793-1853). Therefore we can say that Desargues and Monge provided the theory, Frezier and Olivier the research, "l'artistes" that followed the application. And Monge is called the "theoretician" because without his Descriptive Geometry, T. Olivier could not have completed what Frezier had attempted by working only with what Desargues provided. The impressive works of Theodore Olivier are a demonstration of what a researcher should be. The book by Monge does not make him one. He had the vision all right, but he very well knew that even an "art" needs theory. And he gave it to us.

But where does Monge begin this theory? Well, right there at page 8, item 6, of his book: "On appelle projection d'un point sur un plane . . .", a passage that Professor Wladaver translated for us, read one, two, or more times, without recognizing it? Why? Because he fails to see that when Monge talks about point, plane, he is talking about geometric elements, concepts of which are to be found in Euclid's Elements. But, how does Professor Wladaver classify the Elements? It is a Synthetic Geometry all right. But . . . is it "applied" Geometry? Or is it "theoretical" Geometry? Or perhaps there is no "differentiating significance" between the two? If there is not, of what color are Euclid's planes? Are they opaque, transparent? Are they a "feuille de dessin"? If they are, what kind of glue did Euclid use to put together a few "feuilles de dessin" to make a pyramid?

In regard to the observer, an opinion about which I already discussed in my other article, says Professor Wladaver: "I conclude that projective geometry requires one observer at point-S and he can move around in space in any manner at all". Let me ask this: Where does this observer fit in the two basic operation of projective geometry, projecting and cutting? And what does Professor Wladaver do when projecting from a line? (See Projective Geometry by Luigi Cremona). Does he stretch the "poor soul" like a rubber band?

I do not see what the fact of mentioning or not mentioning projection planes has to do with being more or less theoretical. The theoretical facts, and the most interesting ones, in the saying of Henri Poincare (Science and Method) "are those which can be used several times, those which have a chance of recurring". So, if I identify a complete quadrangle in the plane of the orthographic projections of two concurrent lines, the interesting fact is that I am discovering a new relationship, of which any observer (and you may move him around any way you like) cannot be aware of, by looking at those same lines, in space. Because a "view" is what the observer sees in space, and those interested in this alone are not interested in the complete quadrangle. But, if I use projective concepts (theoretical concepts) not only do I find the complete quadrangle but also, through its projective relations, become aware of the same things that the "observer" sees.

But even though Professor Wladaver claims that he cannot understand my viewpoint he summarizes this viewpoint by saying: "the existence or non-existence of observers is not a matter of descriptive geometry". For this is what I am asking: then, why even bother to mention them? - But the question is not a matter of semantics or philosophy either. It is a question of rightly applying projective concepts to descriptive geometry, a necessity resulting from the tremendous task carried on by Luigi Cremona when he interrelated all (or most of it) available information on projective properties into one single book, his now famous "Projective Geometry", a denomination given by Cremona himself. And you are not applying them rightly when you start to talk about "observers".

If you read Professor V. P. Borecky's paper "Theoretical Projective Geometry - Application to Engineering Mechanics", Technical Seminar Series, Report No. 13, Department of Graphics and Engineering Drawing, Princeton University, you will see what I mean. I would like to know if it would make any sense at all, to mention "observers" in justifying those practical applications to be used by the "homme de genie", by the "engineer", by "l'artistes". (And here again is the three-linked chain: Cremona the theoretical, Borecky the researcher, the rest of us "l'artistes").

And what else is Descriptive Geometry but a mean, a method of representing projective transformations? Now, what you call it after researching for applications is your own privilege. Call it Technical Descriptive Geometry. It is all right. But, DO NOT carry back into the fundamentals of the "original" Descriptive Geometry, the concepts that suit your own private "Technical" Descriptive Geometry. If you do, let's call the center of perspective, a "horse", or perhaps a "frog", because in applied perspective, there are "views" called "horse view" and "frog view" (and perhaps they are called differently in this country).

But it is not our freedom to make this or that plane opaque or transparent, or "baptize" with peculiar names the center or centers of projection, perspective or whatever that makes the whole study of Geometry that much beautiful. The way to do it is by sticking to the basic fundamentals, the "original". That's where (some) angels fail to tread.

And if I say beautiful it is not because I advocate the study of theoretical geometry only. Not at all. I say beautiful because just a tiny sample of what that "original" is, allows all of us to understand what Poincere means by "interesting facts". And creates a challenge, the desire to look for other ways of using it. We will never find out if there are other ways or not unless we give it a try. But leave your "observer" at home. It is better to go alone than with bad company.

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The units which then follow the introduction of this problem involves specific steps to aid in solving the problem. For example, the students must gather information (step II in the outline). Some of this is provided by the instructor in the form of data which they must plot and graph in order to determine some aspect of their solution. This unit on graphics is then followed by a section on threads, fasteners, welding, and other methods for assembly of their hardware. This is then followed by a library trip to help the engineering student to become familiar with the library as a source of information, something which is a problem with all undergraduate students.

The students are then provided time to formulate ideas and go through the process of analyzing data which they have gathered. The idea sketched along with one presentation drawing of the best idea is then displayed for the other students in the classroom to review and to constructively criticize. This provides the designing student with a check on his ideas and at the same time provides other graphics students with an insight into a design solution. It is felt that this method of approach provides a check for each student, and at the same time keeps the student working. It offers all of the students in the classroom insights into other solutions.

The students are then expected to incorporate criticism from other students into the finalized form of their presentation drawing and to complete a set of working drawings. This set includes an assembly drawing, a detail drawing, and a bill of material or parts list which, when taken together, constitute a set of drawings from which their idea could be fabricated. The final step in the outline is that of reporting their ideas and solution including any information they were able to gather on their own.

RESULTS

At the completion of their second course, the students were provided a questionnaire in which they were asked to comment as to their likes and dislikes of the method of presenting graphics to them. They were also asked to compare their introductory or first-term course; that is, a unit-by-unit teaching method versus the second-term course or the design-project-approach. A large majority of the students felt that the project approach of the second-term course was far more realistic and one which provided a greater amount of motivation. The responses reflect the feelings on the part of many students that they were more highly motivated by the project-approach as opposed to the unit-approach of teaching engineering graphics.

Of greater benefit to the student was the fact hidden to many of them that their solutions were unique. Each solution that they had considered had to be thoroughly examined, the various possibilities considered, and a single solution chosen which they felt represented their best possible idea.

The following is an example of one of the problems which the students were asked to solve.

ROAD FRICTION TESTER

An insurance company is sponsoring research for the design of a road friction tester for use at the scene of accidents and for other related uses. You are asked to submit a design that will meet the following specifications:

1. Manually operated.
2. Portable by one person.
3. Continuous reading of the coefficient of friction as the device is either pulled or pushed along the highway.
4. Reading is to be dependent only on the condition of the road surface and the walking speed of the operator.
5. Number to be built: 10 to 25 on a pilot basis.
6. Cost: less than $250 each.

Needed: One design layout and as many parts detailed as time permits.

Before starting the design process, it is of interest to graph the following data to show the effect of road aggregate sharpness on the coefficient of friction. Draw the graph with care and completeness. Find the equation of the resulting curve.

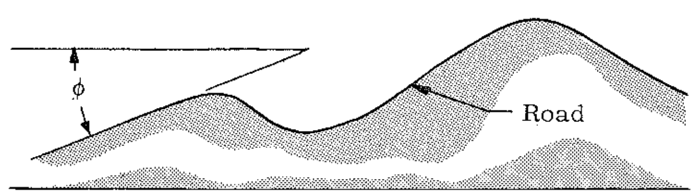
AGGREGATE AVERAGE ANGLE,

ϕ	0	10	20	30	40	50	60

COEFFICIENT OF FRICTION,

μ	.23	.36	.40	.52	.62	.66	.78

Note: Road is wet and speed is assumed constant 30 mph. ϕ is defined as:



Also make a graph to show the relationship of centrifugal force on a car to the radius of a curve, as a function of car speed.

Given: Car wt: 3500 lbs.
Range of radii: 50 ft. to 500 ft.
Speed: 30 mph and 60 mph
Angle of curve banking: 0 degrees

What is the minimum radius necessary to prevent a broadside skid when μ = 0.6 and speed = 30 mph?

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makes programming easier to understand. The increasing use of digital computers can be benefited by an increase in understanding of graphic methods.

Before the results of any program can be accepted, some answers must be checked against known solutions. The graphic analysis frequently yields a comparatively quick solution that is sufficiently accurate for checking purposes. The graphic method can provide an initial computation or an independent check and suggest or provide the framework for a precise mathematical solution.

Graphical Algebra. A consistent development of graphical theory parallel to the usual development of mathematical theory would present graphics as a unified science in tandem with mathematics.

Graphical Calculus. Graphical calculus is a very important part of an engineering graphics course. The graphical approach is such that the behavior of the function (curve) throughout the interval of integration or differentiation is vividly depicted. The visual knowledge can be of considerable help to the student in his understanding and appreciation of the formal calculus. The methods used are basically the same as the concepts used when integrating or differentiating data with the aid of a digital computer. The graphical concepts can be of use in programming the data for computer solution. The choice of problems should span many areas of engineering.

Vector Geometry (Graphic Vector Analysis). An introduction to graphic vector analysis familiarizes the student with terms which are used in subsequent courses, such as kinematics, mechanics, and physics as well as in courses in electrical engineering. The knowledge gained through such an introduction will also add to the understanding of subsequent work in vector algebra and mathematical vector analysis.

It is essential that throughout the work on vectors every effort be made to show the application of vector problems in various fields in engineering so that the students are not made to believe erroneously that graphics vectors and force systems are synonymous. The range of problems is limited only by the imagination of the teacher and the time available.

Graphic Diagrams. An understanding of the use of graphs and diagrams in the presentation of information is a necessity for the engineer. A knowledge of the proper construction of graphs and diagrams will enable him to select the forms that will best convey the information or the idea that he is trying to present. It is possible to introduce the more common forms and to teach the proper preparation of both technical graphs and popular-appeal diagrams. Examples of technical graphs should reflect current practices in the various fields of engineering.

Nomography. The use of nomographs is increasing at a rapid rate in engineering and industry because of their value in performing repetitive solutions of the same relationship. The scope of nomography could investigate the various forms of nomographs in order to select the form or combination of forms that best suit the situation at hand. A knowledge of the principles of nomography enables an intelligent use of an existing nomograph, particularly for a complicated relationship.

The introduction to nomography should include the design of functional scales, adjacent scale conversion graphs, and parallel scale alignment graphs. Mention should be made of the relationship between concurrency and parallel scale alignment graphs. The total time available will play the decisive role in deciding how much nomography to cover.

Empirical Equations. The subject of empirical equations has raised the question of whether it is a valid topic for an engineering graphics course. However, if the philosophy of the course is that it is a first course in engineering or a course in the fundamentals of engineering, then the subject of empirical equations could well be a part of the course. Probably only the linear, power, and exponential forms should be discussed in detail in an introductory course, but some mention should be made of the other possible forms.

Summation. The level of instruction contemplated is introductory, since the purpose is simply to demonstrate the general effectiveness of graphics in the area of analysis and computation. The topics suggested are those considered to be of the most general value.

COMPUTER-RELATED GRAPHICS

Even those having only a rudimentary knowledge of computers appreciate the fact that these devices have the potential to aid in contributing substantially toward the improvement of man's standard of living. To the engineer and the scientist, the electronic computer has become a sophisticated mathematical tool that has assisted in expanding the frontiers of knowledge through research at an increasingly rapid pace. It has proved to be extremely useful to the engineer in the design process.

The design process is principally composed of a number of factors including calculations, routine selection of standard materials, and necessary drawings from concept sketch through finished detail drawings and assemblies. The design process also involves feedback from the completed end product and its interim steps.

Creativity in design is the function of the engineer or the engineering team. This factor cannot be automated since creativity cannot be programmed. Calculations, however, and the routine selection of standard materials are being handled with increased effectiveness through the use of computers.

Visual Displays. Electronic displays are esentially high-speed plots generated on a cathoderay tube from electronic-computer outputs. Presently the quality of line work on these displays could be improved. However, the essential information is available and easily determined. The drawing can be prepared in a fraction of a second. In general, because of present economics and the complexity of the programming involved, this type of display lends itself best to standard drawings and formats.

The area of drawing displays has seen much development to date. A great variety of applications have been made. Pictorial drawings, both axonometrics and perspectives, as well as animated movies which have had such assignments as depicting the landing of aircraft on a carrier. Getting a pictorial idea of a finished product from any point of view in a relative few minutes is at the designer's touch. The control unit accepts information from an input media, reads it, stores it, interprets it, and generates electrical command pulses which, when acted upon, cause the system to function properly.

To determine the numerical description of a complex geometric configuration would require the calculation of many thousands of digital values - a monumental task for an individual to perform. The general-purpose digital computer works these problems almost instantly. In the future, digital computers can be expected to literally allow for production of parts of almost unimaginable geometric complexity by means of rapid mathematical definition and numerical description.

Computer-aided Design and Analysis. The simplest computer programming languages are artificial and unnatural. It is tedious work to program a problem, however well-understood the solution process may be, so that the computer can carry out its execution. The problem must be understood well enough so that the details of the arithmetical and logical operations required to obtain a solution can be written down completely and in exquisite detail. The entire solution process must be described from start to finish before any action can be taken by the computer.

Many systems and devices that are the ultimate objectives of engineering designers have a physical geometric configuration. It is possible to use the computer as an expert graphics assistant and drawing on a cathoderay tube, with the cooperation of the computer, is a magical way to perform one of the most important and most tedious of the tasks of the design process.

Some engineers presently tend to avoid graphic methods because such methods require a manual dexterity that not everyone has developed. But drawing with the aid of the computer is magically easy. Such a mechanism will remove every barrier to creative thought - the engineer or scientist will in the future embrace rather than reject a graphical approach to his problems. It is logical that this new and attractive way of approaching complex problems will reawaken interest in graphic methods and that there will be a renaissance of interest in graphics instruction in universities. The day may not be far off when a classroom of the future will contain a graphic console for each student, all connected to a computer, so that the instructor and students can embark as a team on an intellectual exploration of any design problem.

Immediate Classroom Applications. The design and analysis relationship holds great promise. Its potential development serves to exemplify the need on the part of the engineer for the "graphic mind." The setting of a potentiometer knob or the selection of a resister or capacitor represents the selection of a control factor in an engineering process of design. Thus, the student is placed in a very real situation and is afforded an opportunity to think through and make decisions of an engineering nature. The analog computer can save much time and money by solving equations or simulating systems that would be very time consuming, expensive, or possibly dangerous to man. The modern digital computer provides an effective backup and motivating influence for graphics instruction. Computer-related graphics is a potentially rich field for a complete understanding on the part of engineering students as to the place of graphics in the design concept of engineering. It can give positive aid in the development of the ability of conceptualization in the design process. As a tool, graphics may be used effectively in approximate calculations related to various problems in both engineering and science.

UNIT 3

EVALUATION AND RECOMMENDATIONS

Graphics has significant relevance to the important engineering function of design. Conceptual design is the ingenious work of a creative imagination which forms mental images of ideas while it conceives and plans the ways to satisfy a given need or to perform a desired function. Graphics translates these mental images into design sketches which crystallize and clarify the mental planning process. Graphics aids design by means of graphic analysis and graphic layouts that determine feasibility. Graphics provides an effective method of defining the perfected plan by means of drawings which communicate the complete design to others so that it can be made real and useful.

With proper choice of open-end projects a student can be brought face to face with creative-design assignments within his grasp. Well-chosen design projects will give him interesting opportunities to devise various physical features and mechanical details with some degree of inventiveness, ingenuity, and good judgment based on his limited experience, observation, and technical knowledge. A stimulating design problem should be introduced early in the course. This should be followed continuously by a wide range of conceptual design projects drawn from all fields of engineering.

The design of a device that is to be manufactured and sold should be divided into six phases:

1. Conception of need to be satisfied by a device, and the constraints on it. Students should be given an appreciation of the factors which influence the design of a manufactured and marketed product.

2. Conception and expression of ideas for suitable prototype devices. The conceptual design utilizes creative imagination, facility in visual thinking and graphic expression, ingenuity, technical knowledge, and good judgment.

3. Refinement and detailing of prototype design with the aid of analytical and experimental optimization. Improvement of design is aided by applied me mechanics, testing for strength and physical properties, use of computers, and analysis by such graphic procedures as kinematics, graphic statics, and flux plotting.

4. Testing and evaluation of prototype. This phase of the design process should be emphasized. Presentation of the student's designs for critical review is a valuable experience in itself.

5. Final modification and formalizing of the design for production. Minimum drafting training via the medium of creative design for this step appears desirable to the extent of deserving more than elective course treatment.

6. Modification of the design throughout its useful life in response to service experience, competition, and need for price reduction. A design of this kind is never truly finished. The beginner on the road to design should be introduced to only the important principles and methods which experienced designers have found to be applicable and productive in their creative endeavor.

A basic course in engineering fundamentals, combining graphic communication and graphic analysis with conceptual design, experimentation, and elementary computer graphics can involve students as engineers in original projects during early college years. Properly organized and effectively taught by competent teachers, this type of course should give the student the preparation needed for doing design projects and further, it might serve as an excellent freshman orientation course.

COURSE STRUCTURE AND FACULTY REQUIREMENTS

Each engineering college must plot its own course and develop a program to meet its individual needs. To fulfill the role of graphics as an effective discipline in the undergraduate curriculum, graphics courses must provide students with the fundamental tool of communication. Drawings continue to be the primary vehicle for creating, communicating, and recording designs.

Graphic representation must precede analysis, and later graphics must complement analysis throughout the birth and growth of creative planning. The ability to think in terms of spatial relations, to express such thoughts graphically, and to grasp quickly the concepts of additional ideas is a vital need of the engineer. It is important for him to understand the wide scope of graphics and to appreciate the many different ways in which graphics contributes to the education of engineers.

The versatility of graphic expression makes it an ideal method for investigating, interpreting, and developing scientific theories in many fields. The inherent advantages of graphics in giving a reliable sense of direction and design choices enhances its value as a design tool in both science and engineering.

Teaching graphic analysis as a separate course has doubtful merit, but descriptive geometry in the graphics course provides an excellent introduction to the use of graphics as an analytical tool. It puts into practice the engineer's method of planning each problem through to a successful and accurate solution. It helps build insight, resourcefulness, and initiative.

The fundamental principles of graphics can be made just as meaningful when applied to modern technological concepts. Traditional courses keyed to textbooks which contain technician-level material should be completely reorganized. In a design-conscious program of graphics instruction the course content may consist of a combination of methods in approaching educational objectives.

1. With a minimum of drafting routine graphics principles can be effectively applied by means of sketches. Open-end problems drawn from all fields of engineering involve conception improvement, and presentation of original designs without detailed analysis of components.

2. A basic course in engineering fundamentals includes graphic communication, graphic analysis dealing with geometric and functional relationships, an introduction to computer-related graphics, and basic design concepts integrated in the solution of modern engineering problems.

3. The project method provides an opportunity for students to work in teams using live observed data in their open-end engineering design problems.

The future success and acceptance of engineering graphics as an essential part of engineering edu-

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INTRODUCTION TO GRAPHICAL ANALYSIS AND DESIGN

By B. LEIGHTON WELLMAN, Professor of Mechanical Engineering and Head of Division of Engineering Graphics, Worcester Polytechnic Institute. Available in Summer 1966.

This modern engineering drawing text, written by a leading scholar-teacher, is designed for the one-semester course or the first half of the two-semester course. Throughout the book freehand drawing is emphasized and applied to problem solutions whenever possible. In graphical analysis, the close correlation and remarkable equivalence of mathematical solutions is stressed. The reading and visualization of multiview drawing is thoroughly developed with logical and well-tested methods. The final chapters provide the basic elements for an introduction to engineering design. Each topic is fully illustrated, thoroughly explained, and demonstrated with examples. A large selection of problems follows each chapter.

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By ERNEST R. WEIDHAAS, The Pennsylvania State University. 120 pages, $5.50.

An engineering graphics book entirely in keeping with the trend toward engineering science. Problems on 35 sheets are directed primarily toward developing the faculty of decision in creative design.

GRAPHICS IN SPACE FLIGHT

By FRANK A. HEACOCK, Princeton University. Engineering Graphics Monograph Series. 114 pages, $4.50 (cloth), $2.50 (soft cover).

The scope of this monograph is limited to significant applications of graphics used by designers and engineers in developing space flight projects. The basic approach of the book is the direct application of graphic analysis to problems involving direction, velocity, timing, and reliability.

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(Continued from page 10)
large automobile manufacturers: Ford, General Motors, and Chrysler -- each with thousands of highly skilled, highly trained, and well-paid engineers; all trying to produce the best transportation vehicle, yet Fords, Chevrolets, and Plymouths are not identical. They differ in ride, economy, looks, and so forth.

Second, we should help the student realize that there is nothing in the world that cannot be improved. We must make the student aware of his environment. He must look at the world with an eye to possible improvements; for example, is a door knob the best way to open a door? Should it be round? Is the method used to dissect a frog the best? Would a different section show more? If he sees something different in his microscope than the others, should he investigate -- or just put down what the teacher wants?

Third, we must make the student make assumptions. He must be shown how to make them, either through trial and error, or with direction. No one knows all the facts in the world, and assumptions are a real necessity. In our problems, we tend to give all the parameters, so the student will arrive at one unique solution. Life is not like that. We must make assumptions and choices, yet life goes on whether our assumptions are true or not.

Fourth, we must encourage the student to follow his interests. We all know that active learning and active interests go together, both helping the other. Just because a student is taking a course in medicine does not mean that engineering design is beyond his scope. Several doctors have designed very useful tools and appliances because their interests and needs led in this direction.

You may be thinking "This all sounds good (or like a lot of educational gobbledly-gook), but how does it apply to me?"

I'll try to offer some specifics -- obviously not all that can be done because once you start trying to encourage creative thinking in your classes, your own creative urge will assert itself and you'll find more and better ways to do your own teaching.

In my own classes, I try to avoid problems which have only one solution. As an example, when teaching line work, lettering, orthographic projection, etc., the students are asked to draw something. I really don't care what it is, since line work, lettering, dimensioning and all fundamentals can be graded, corrected, and reviewed no matter what object the student has chosen to portray. In this case, the student is not copying a mutilated block from the text -- he is instead putting his own ideas and concepts down on paper.

When I have students do prepared sheets, I try to choose problems that have several correct solutions -- and challenge the better students to see how many different solutions they can obtain that still fit the required limits.

Let's admit that it is a lot easier to grade papers that are all of the same object -- but is the student creating? Is he putting his own ideas on paper? Is the extra time required of the faculty member worth it? I certainly believe it is.

The last project I assign my classes at the end of their freshman year is this: "Design something" -- Then after confusion has had time to subside, I try to point out that I don't know of anything that is perfectly designed -- except perhaps my wife and occasionally I feel she might need to lose a pound or two here or there. "Is that window latch the best design you can think of?" "Is the door latch needed?" "Could you improve on a light bulb?" "How about something to make it easier to drain the water from the radiator of a car?" -- "or drain the oil?"

After the projects have been completed, they are all mounted on the walls and each student's work will be judged by the rest of the classes. This helps the students see what his drawing looks like in comparison with his peers', and also helps him learn to read drawings. Believe me, the other students can spot a phoney or a "pirated" idea quickly, and they are fast with a low grade for poor work.

We all remember best that which we do by ourselves. It is no different in Graphics than in any other area of life. Our students will long remember their courses where they produce something of value to them, and graphics is an area where we can both teach and encourage creative thinking.

In conclusion, it is my belief that for creative ideas, we must search for questions that show insight into problems, attitudes and interests that challenge the student, like a botanist searches for rare plants. Then we must cultivate and provide the best environment for these, so that they can grow and reproduce themselves and produce more, An uncultivated idea is like a seed on barren ground; it is of no value unless it can be nourished and can grow, ripen, and bear fruit. How many excellent ideas have been lost because they were not allowed to grow, or because they were conceived in a hostile atmosphere? Like the weather, we can talk about creativity forever, but if we don't try, we can never do anything about it.

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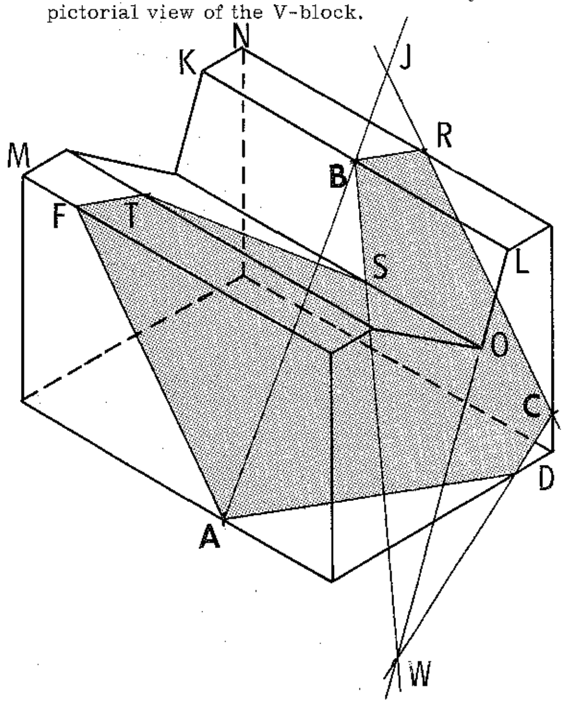
A solution to the "Can You Solve This" problem in the Spring 1965 issue, page 40.

CAN YOU SOLVE THIS?

A, B, and C are three points on an infinite plane.

Determine the intersection of this infinite plane and the V-block.

The intersection is to be solved directly on this pictorial view of the V-block.



1. Draw the line AB extended as shown.
2. Locate J by the proportion $\frac{JB}{BA} = \frac{NK}{KM}$.
3. J is the intersection of AB and plane of right side of figures.
4. JC is the intersection of plane ABC and plane of right side of figures.
5. Draw AF, the intersection of plane ABC and left side of figure, parallel to JC.
6. Draw FB, which is intersection of ABC and top surface of figure (and establishes point T). Extend FB to point R.
7. Draw AD parallel to FR.
8. Points D and C are joined to give intersection of plane ABC and front surface of block.
9. Draw LO until it intersects the line DC extended at point W. W is a point common to planes ABC and KLO. B is a point common to these same two planes. Therefore, BW is the line of intersection between KLO and ABC planes.
10. Draw BS and ST to complete intersection of plane ABC and the V-Block.

Above solution submitted by

Mary F. Blade
Associate Prof. of Mech. Engrg.
The Cooper Union,
New York, N. Y.

NEW ENGLAND ENGINEERING GRAPHICS ASSOCIATION

The 8th Annual New England Engineering Graphics Conference was held at Tufts University on May 8, 1965. The morning program was entitled Creativity-Graphics-Design, while the afternoon sessions dealt with automated teaching.

The Conference has in previous years functioned on a rather informal basis. In order to enable a closer relationship with the Engineering Graphics Division of ASEE, participants voted to establish the New England Engineering Graphics Association. The purpose of this organization, as stated in the adopted by-laws, "will be devoted to organized discussions of the methodology and techniques in the instruction of Engineering Graphics and related subjects in order to enhance its development and effectiveness in curriculum planning." Meetings will continue to be held once a year, and membership is open to anyone interested in the teaching of Engineering Graphics.

Elected to serve as the first officers of the Association were Assistant Professor Klaus E. Kroner, Basic Engineering, University of Massachusetts, as chairman, and Assistant Professor Herbert W. Yankee, Department of Mechanical Engineering, Worcester Polytechnic Institute, as secretary. The next meeting is slated to be held at W.P.I. in the spring of 1966.

Klaus E. Kroner, Chairman
New England Engineering Graphics Association

(Continued from page 45)

cation depends upon the competence and cooperation of the teachers of graphics and the helpful collaboration of other engineering teachers. Graphics staff members should have engineering degrees and some design and research experience.

In-service educational programs should be conducted to enrich the subject matter of graphics courses. To satisfy the educational needs of students for careers in engineering, it is essential that graphics courses include useful new graphic methods and applications. All significant branches of graphics should be integrated in ways that will enlarge the scope of usefulness as a means of analysis, understanding, and learning.

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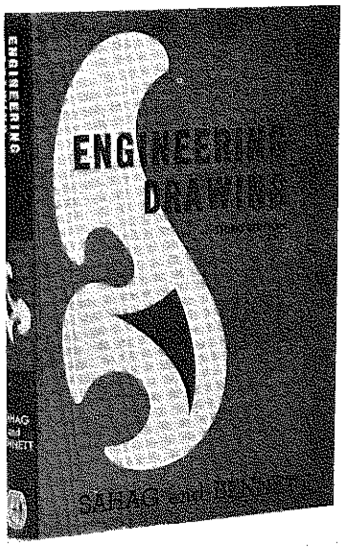

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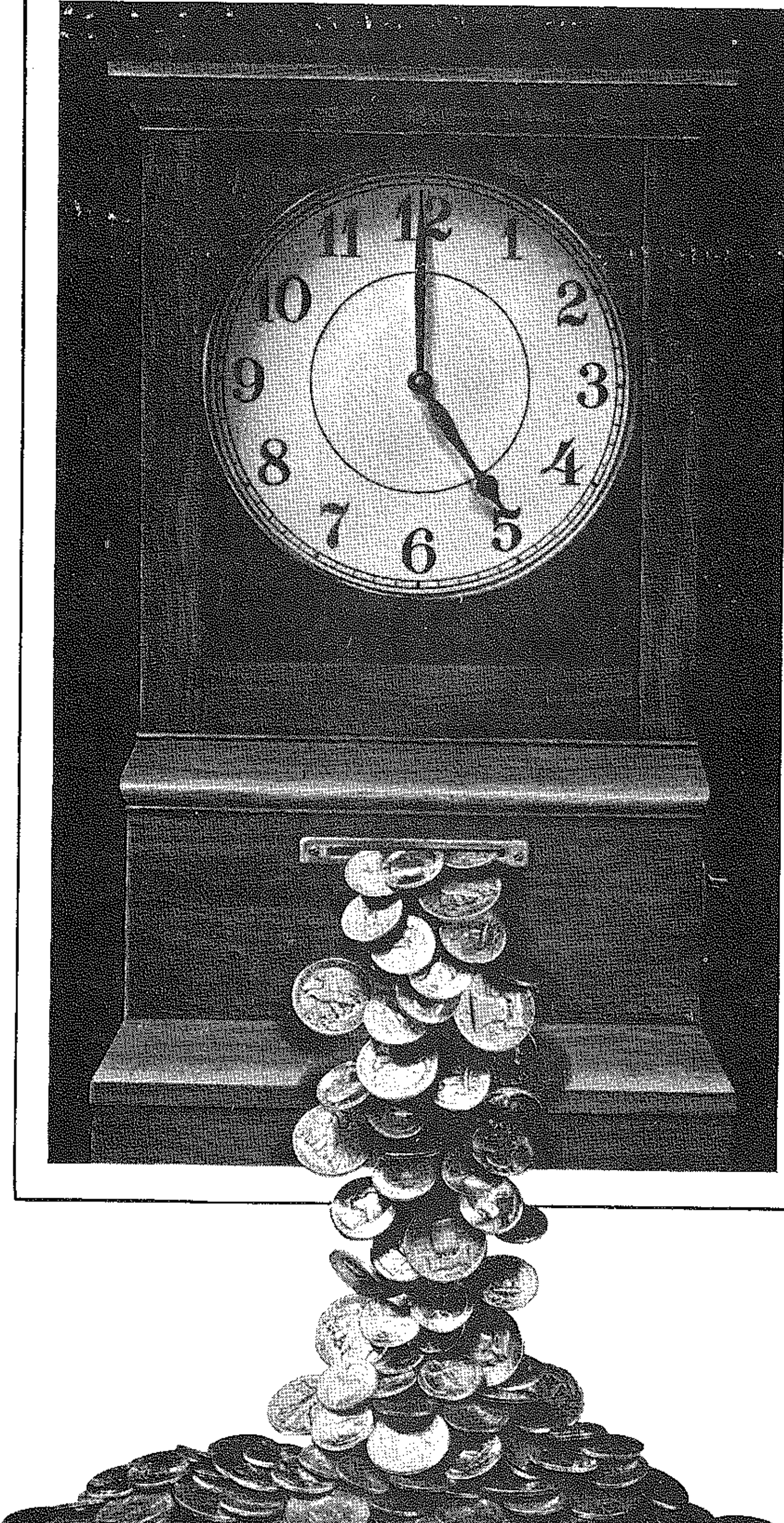

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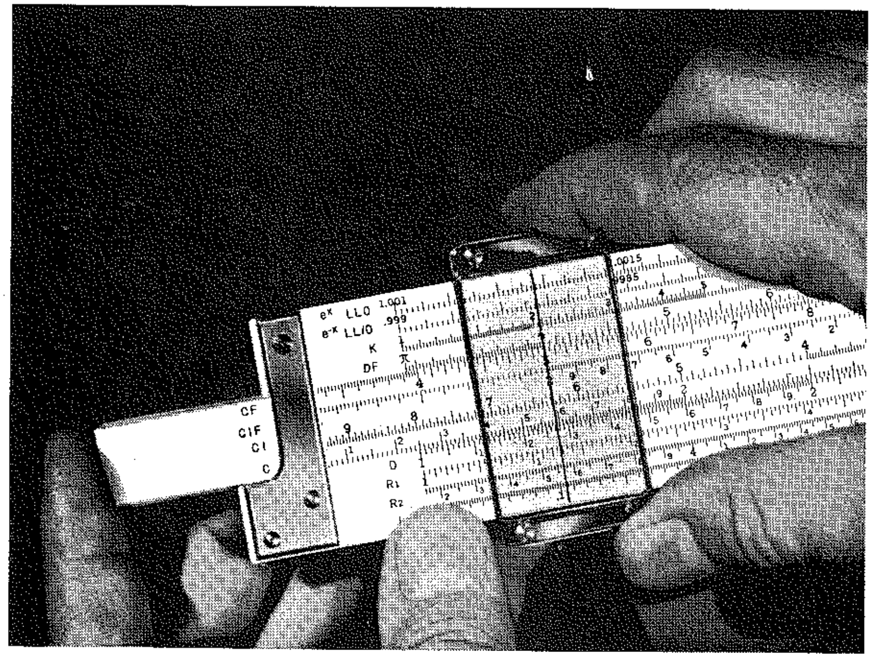

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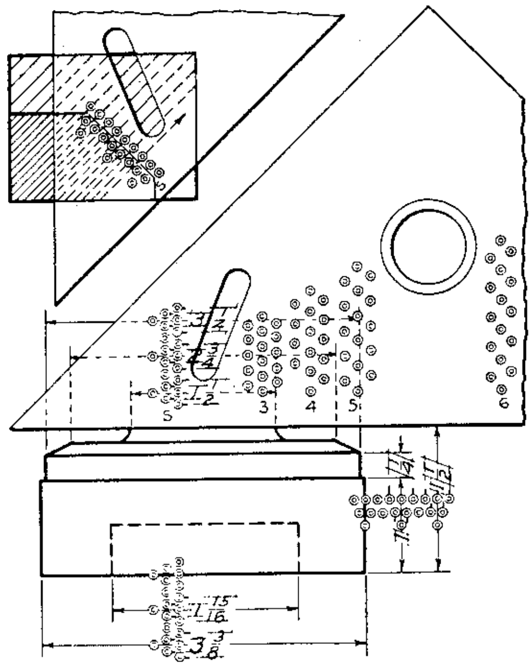

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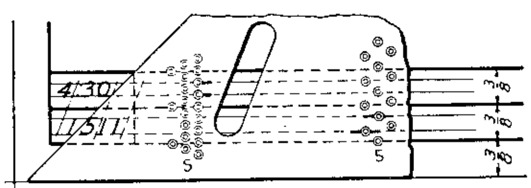

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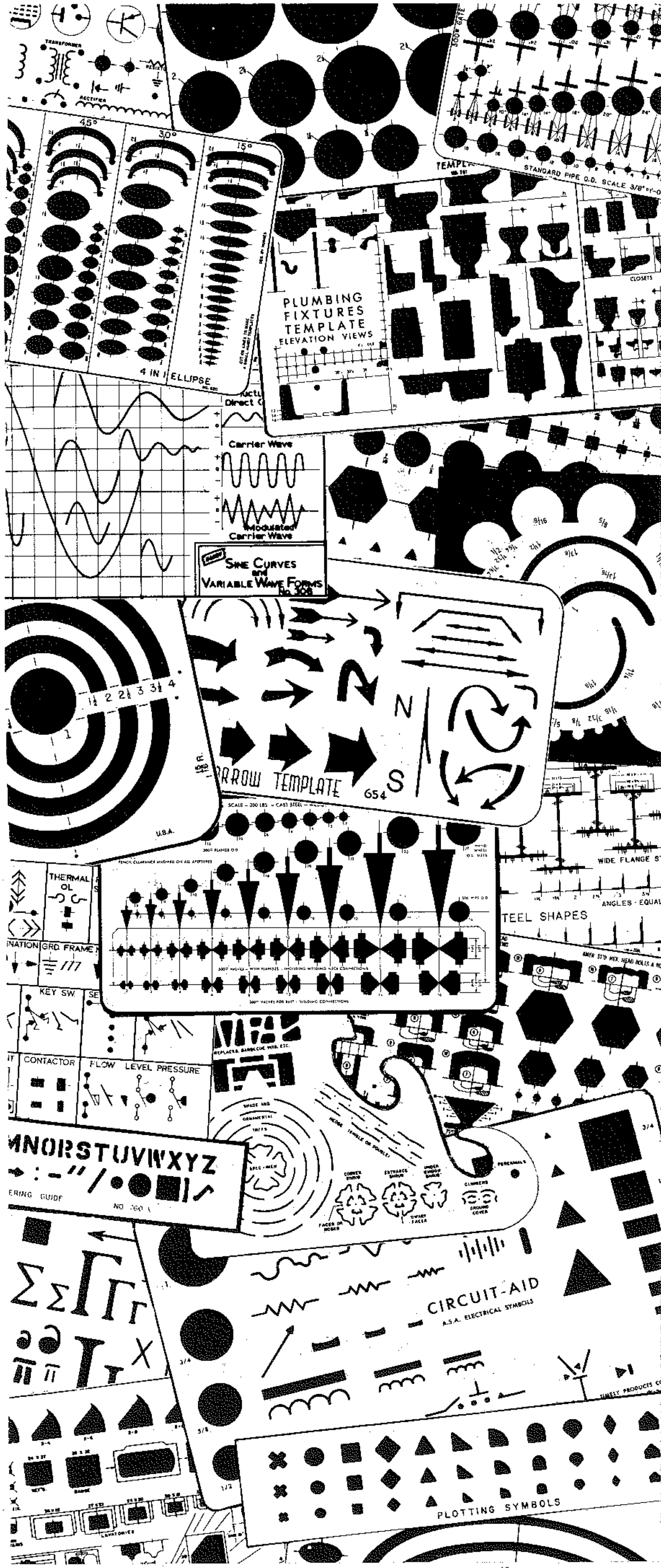

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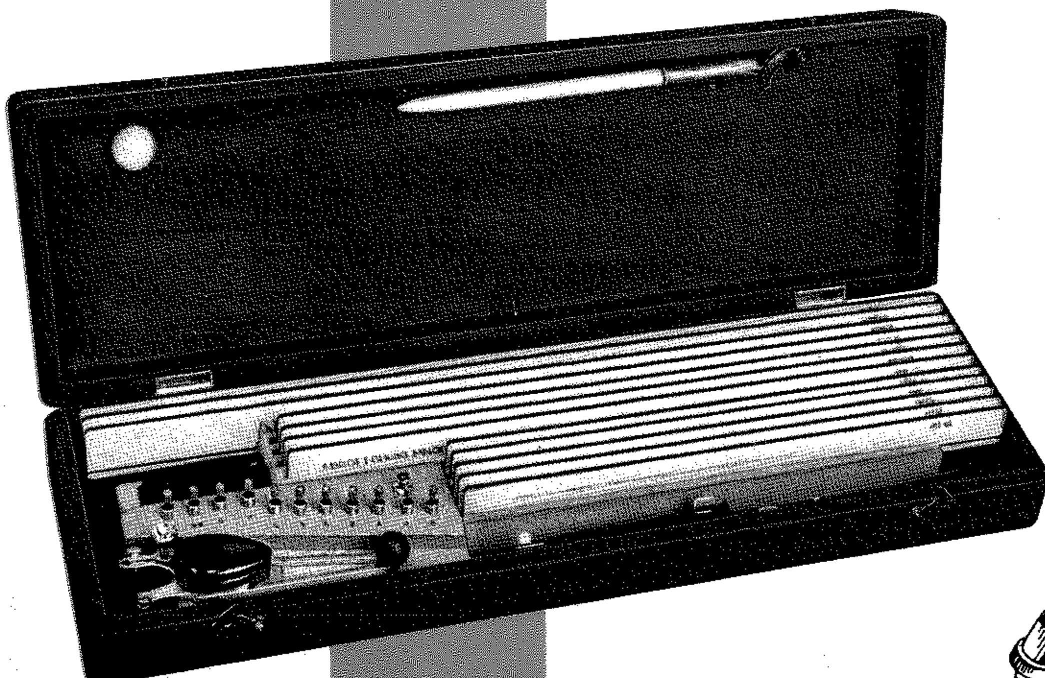

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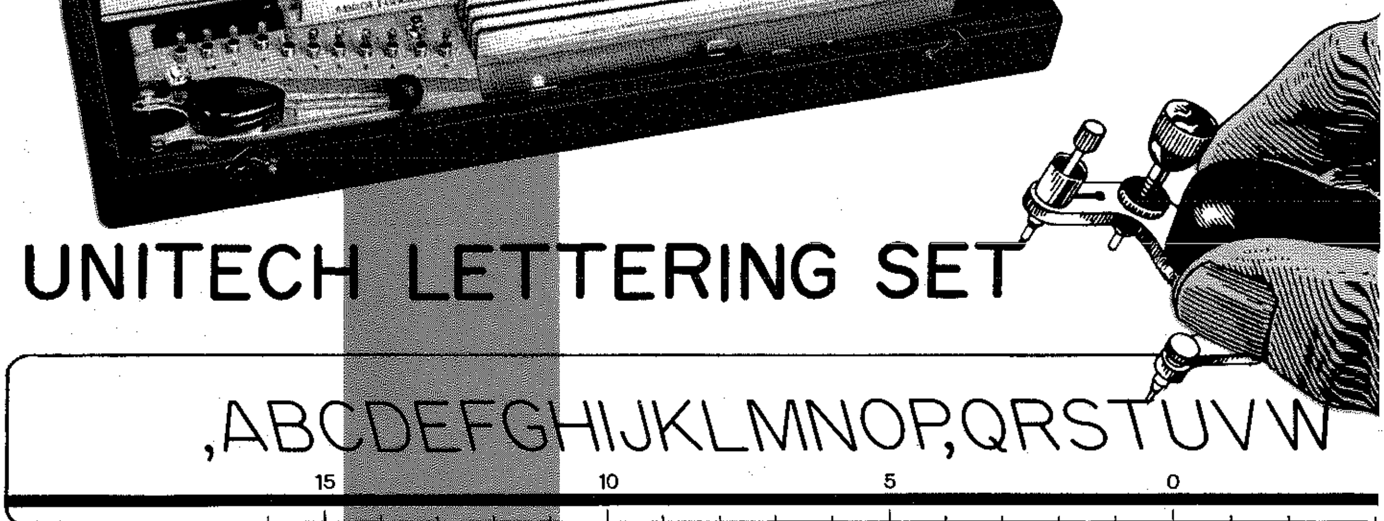

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