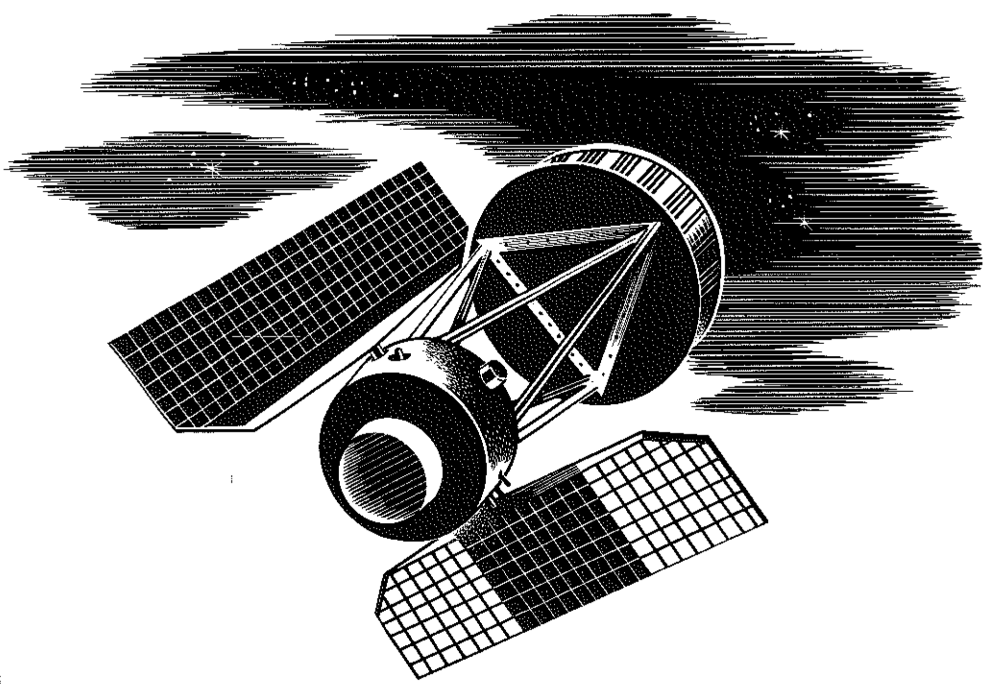
The Journal of Engineering Graphics



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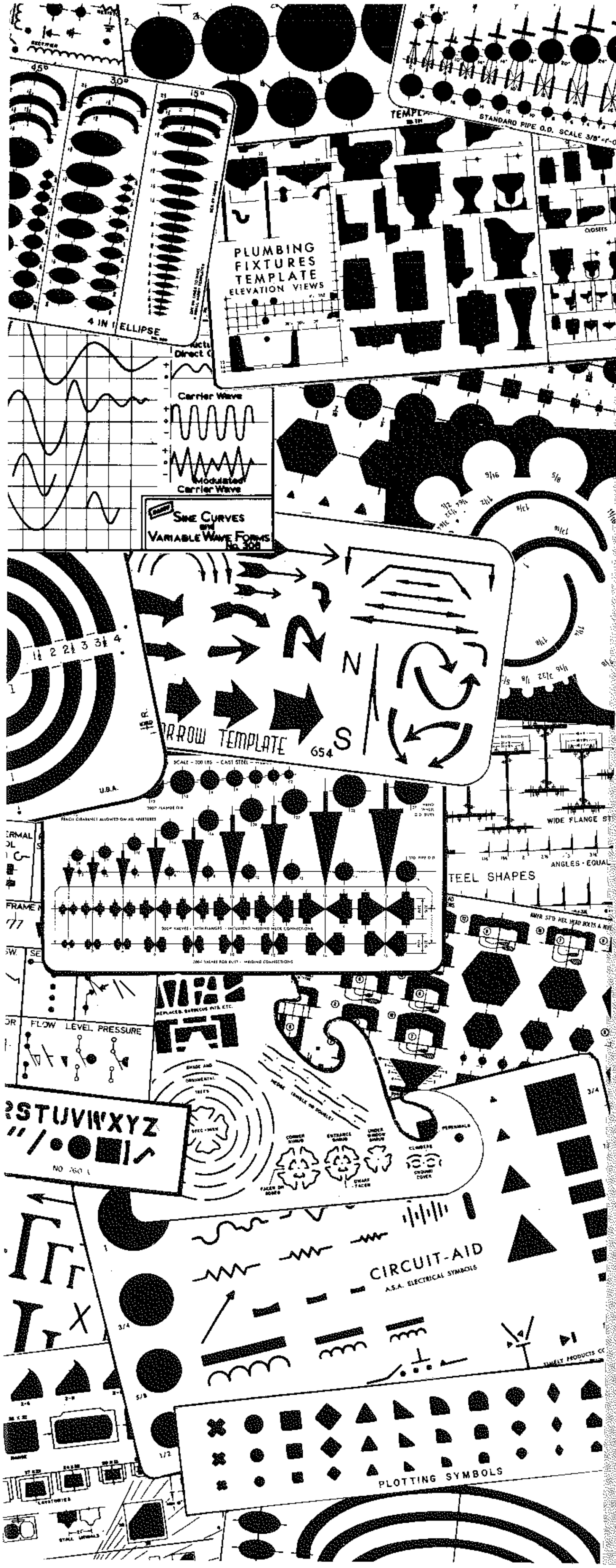

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INFORMATION FOR "JOURNAL" AUTHORS

Papers will be considered for publication written on subjects which will be of help to the graphics instructor in his classroom presentations, problem assignments in some area of graphics, articles which indicate depth of research in graphics and stimulate thought, items of news, historical information, and any other items which will stimulate and promote the professional standing and respect for engineering graphics.

Editorial considerations suggest papers of from 8 to 12 pages of typewritten copy and illustrations. Papers should be typewritten double spaced on one side of the sheet. References and footnotes should be listed on a separate sheet and should not be inserted in the text.

Each paper should be accompanied by an abstract of approximately 150 words. The first one or two sentences should clearly state the subject of the paper. The remainder of the abstract should be informative and summarize significant points covered in the paper.

Line drawings should be prepared in India ink. It is urged that mechanical lettering be used or labels should be placed on a cover sheet. Photocopies (same size or reduced) of the original drawings are acceptable if they are clean, clear, and sharp in line contrast. All lettering should be large enough to be legible when reduced 20 per cent in size. Figure numbers should be placed on the cover sheet for the drawing. Figure numbers and captions should be listed on a separate sheet.

Spelling and capitalization should follow Webster's Seventh New Collegiate Dictionary, which also offers guidance in punctuation (page 1193).

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THE JOURNAL OF ENGINEERING GRAPHICS

1937 to . . . . .

The Journal of Engineering Graphics was begun in 1937 sponsored by the American Society for Engineering Education, Division of Engineering Drawing, now known as the Division of Engineering Graphics. Since the inception of the Division, the material coverage in the field of engineering graphics has changed and expanded.

If one reviews the early writings of the contributors to the JEG, one finds emphasis placed upon skills, line weight, inking techniques, testing, better use of teaching time, the "direct method" compared to the "classical method," lettering, simple dimensioning, selection and design of equipment, and many fringe subjects.

Today, the emphasis is on design oriented courses, projection fundamentals and graphic analyses. Historically, many of the items then classified as fundamental are now only fleeting by-products and rate only a short discussion or a mere mention in average class discussions. The new emphasis is on design and integration of knowledge learned by the student in other engineering science courses.

The Division of Engineering Graphics has looked to the JEG for articles on new developments, new methods of teaching, suggested course coverage for both beginning and advanced engineering graphics, and reports on research in many areas of specialization.

Ideas suggested for the future development in engineering graphics have been presented. Some suggestions have been rejected after examination and experimentation; other ideas, first rejected by the Division on proposal, have come to be a standard procedure in many engineering schools.

Throughout this long period of development, the Journal of Engineering Drawing and Graphics has served as the primary communications agency for its subscribers. It exists primarily as a service agency to members of the Division of Engineering Graphics and records selected articles on the many subjects normally included in the broader field of study in graphical science and engineering design.

Historically, the JEG shows a record of a gradual and continuous transition from one set of objectives and course coverage to the proposal and final adoption of others. The arguments, pro and con, have been presented and the needs of engineering graphics in professional engineering applications have been discussed.

Policies and procedures have changed from time to time, but the basic control has remained with the Division of Engineering Graphics through responsibility of the editorial staff to the Divisional Board of Control and term election of the editorial officers by members of the Division. Two annual reports are made by the editorial officers to the Division.

The full review of the published material since 1937 in the Journal of Engineering Drawing and Graphics would indeed furnish a liberal education in this subject area.

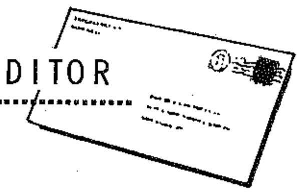
The previous editors of the JEG have brought honor to the Division by attaining national recognition of its services through listings in national magazine exchange companies and it is recognized also by the American Society for Engineering Education in the Journal of Engineering Education.

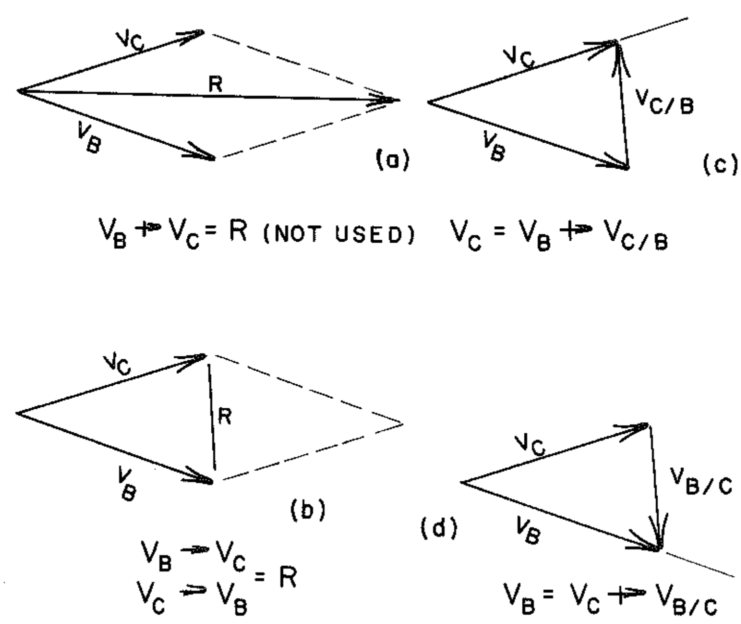
The Journal of Engineering Graphics operates on a non-profit basis and only a small working capital can be accumulated. It is supported by subscribers and friends and by advertising. Current expenses are favorably balanced by accounts receivable and a small bank balance.

Interest in the material published in the JEG is high and the enthusiasm of the membership of the Division is strong.

E.D.B.

LETTERS TO THE EDITOR





Dear Editor:

I am submitting the enclosed after reading Professor Christian's article about velocity vectors. There is nothing new in it, but I have found it to be easily understood.

In teaching Kinematics both to college students and to Junior College students in a technical drafting course, I have found the following diagrams useful and usually easily understood.

Problem: V_B is known, find V_C.

Most students are already familiar with the basic parallelogram to determine the sum of two vectors (a). For relative velocity they must use the opposite diagonal of this parallelogram (b). This diagonal must be constructed perpendicular to link BC, and will contain the relative velocity between B and C.

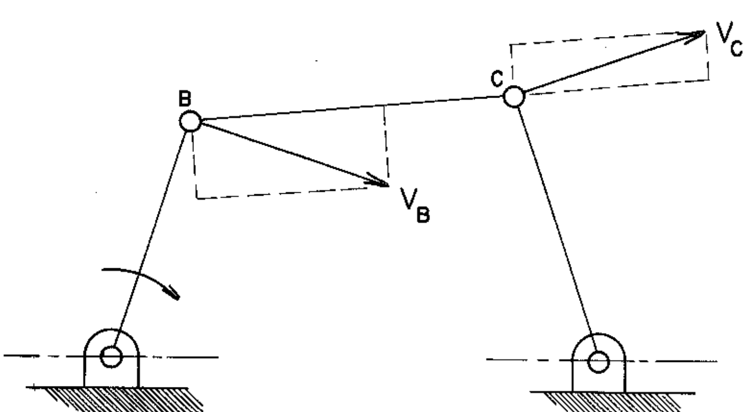
To determine the direction of the relative velocity, in (c) it is obvious that V_C is the resultant of $V_B + V_{C/B}$, and in (d) that V_B is the resultant of $V_C + V_{B/C}$.

This usually leaves little doubt about the direction of the relative velocity vector.

Very truly yours,

H. W. Blakeslee
Instructor, Technical Education
Central Florida Junior College
Ocala, Florida

UNVEXING VELOCITY VECTORS



Dear Editor:

I am sorry to have neglected answering your letter of 26 October for so long, but, after you have lived in Florida for three years, you take "retirement" literally and slow down to Florida speed.

Your suggestion that I write something for the Journal is flattering indeed to one who has always sidestepped writing for publication but I have been disassociated with Engineering Drawing too long to be able to offer anything inspirational or constructive to the membership of the Division. Cecil Spencer was an excellent choice for the first article of the series because he was always one of the most progressive members in our field and has not been away from it long enough to lose "touch."

I have been out of active participation in Graphics since 1945 when Audio-Visual Aids became my major interest, and, when I retired from Purdue in 1960 and migrated to Florida in 1961, I left behind everything related to my teaching career in engineering.

In order to write about any phase of engineering education, I should have to depend on my memory and people who know how old I am, would say that old age was catching up with me. Then, too, because I dislike what egg heads have done to engineering education during the last ten years, my comments would, to a great extent, be derogatory. Under the circumstances, I think I had best keep my big mouth shut.

Thank you for asking me but I am afraid any contribution I might make would not be constructive.

Sincerely,
Justus Rising

continued on page 48

AT THE FORK IN THE ROAD?

AT THE END OF THE ROAD?

WHERE ARE WE?

Officers' Page

With the many changes in recent years in the contents and concepts of engineering education, is the Engineering Graphics Division of ASEE keeping pace with its responsibilities? Is it studying what might take place in the future? And if so, is it incorporating plans in our present activities? These are questions to which each member of the Division needs not only to give serious thought, but to communicate his ideas to the officers for their consideration in planning.

Graphics instruction in engineering has been seriously affected, particularly within the past ten years. You are aware that time devoted to it has been reduced; the subject has been eliminated as a required course in some institutions; its effectiveness has been diluted by requiring more topics to be presented in a shorter time.

Graphics departments are being eliminated as entities and are being absorbed into one of the professional departments. Engineering graphics instructors are teaching subjects in other areas or transferring into administrative positions. "Permanent" teachers of graphics are being replaced with temporary graduate students. Non-engineers are moving into teaching positions formerly filled by engineers.

Junior and community colleges are growing in number and size. Their offerings are expanding in pre-engineering instruction, and the subjects are taught mainly by high school teachers. The parent body of ASEE is now inviting high school teachers into membership in the society.

Thus we see the de-emphasis on graphics instruction in the engineering colleges and its gradual movement to non-engineering institutions. In light of the foregoing, what is the role of the Engineering Graphics Division to be? Should it continue with its activities and programs centered around a "closed group" only, or should it in addition reach out to acquaint other schools and teachers with its objectives? What are we able to do to assist the technical institutes in the teaching of graphics? Should we encourage high school drawing teachers into membership as is being done by the parent body for high school science and mathematics teachers?

These are but a few of the questions that need answering - and soon! We must decide where we are going since we are now at a fork in the road. We cannot continue on the old road; we've got to take the new branch and explore the vistas we have not yet envisioned! We ought to take the lead in providing guides to the groups taking over what we formerly did! If we don't, the Engineering Graphics Division will be at the end of the road insofar as serving its utmost in useful purposes to all teachers of engineering graphics and to all schools offering graphics instruction for engineers!

Accordingly we should devote the year 1965-66 to a study of what the Division can do, the direction it should take, and prepare and report its findings and recommendations to the membership at the annual meeting in June 1966.

As a starter we need to arrive at as many facts as possible to provide a foundation for our actions. We dare not make snap judgments; we must consider the many facets involved. (Sometimes we have strong opinions, pro or con, but they are not always backed up with supporting facts.) Thus we need the thoughtful help of each member of the Division and the conveying of his ideas to appropriate committee members or officers of the Division along with arguments and facts. It will require working members on committees. It will require the concerted efforts of the officers in coordinating activities, evaluating committee reports, and coming forth with recommendations to the full membership for action.

This task will not be easy, but it will be less burdensome if members will assume responsibilities, and committeemen will work (not sit) on committees for which they accepted membership. As your elected chairman I shall work hard to uphold my part to continue and further the objectives of the Division. But I can't do much without your help. May I count on you?

J. Howard Porsch, Chairman-elect

RESEARCH IN ENGINEERING GRAPHICS

James H. Earle
Assistant Professor
Texas A&M University

INTRODUCTION

The purpose of this report is to briefly review the research in engineering graphics that has been conducted at Texas A & M University during the past year. Most of this research has been used or is in the process of being used for doctoral dissertations.

NEED FOR RESEARCH IN ENGINEERING GRAPHICS

Many changes in the engineering curriculum have been proposed in recent years with many different views presented. Engineering graphics, being no exception, has been exposed to many changes and proposed changes. The nature of engineering and industry demands that change be a constant aspect of an up-to-date program. However, change should always be an improvement over present systems rather than a hasty ill-founded revision not based on reliable study. The Engineering Graphics Department of Texas A & M University has participated in several studies which will in part contribute to the accumulation of data that can serve as a basis for sound improvements in graphics.

A few of the more apparent problems requiring investigation by engineering graphics departments are: (1) course content, (2) apportionment of time devoted to various subject areas, (3) placement of the advanced and slow student, (4) validation tests for advanced standing, (5) the role of the high school in graphics, and (6) teaching more material in our limited time. Many other related problems are equally important topics for study.

Course content. Surveys are necessary to determine if engineering graphics courses are adequately meeting the engineering profession's needs. Direct contact with industry and engineers, by mail or personally (as the Ernest C. Schamehorn study now in progress) will provide supplementary data for improving our course content.

Apportionment of time. A thorough analysis must be conducted on a continuing basis to evaluate the time allotted for the various areas of all graphics courses. Care should be taken to fully utilize the time in all subject areas with emphasis on sufficiently covering the most important principles.

Placement of students. Many of our students are more advanced than others upon entry into college graphics. Provisions should be considered for exploiting this advanced training by properly placing each student in a section comparable to his ability. The identification of the ability level of students is a problem requiring investigation.

Advanced standing tests. Determination of the proper policy concerning the validation of a course based on previous training deserves study. The question of whether a student should bypass a course or whether he should be assigned to an advanced section needs to be resolved.

The role of high school drawing. With recent improvements in high school drafting programs, educators are interested in college engineering graphics program. Are we adequately utilizing the background received in high school and to what extent does high school drafting contribute to the engineering graphics student in college?

Teaching more material in limited time. All curricula have been expanded and inflated to the extent that many engineering programs are now five years in duration instead of the customary four. Engineering graphics courses have found it necessary to teach more material and usually to more students than in the past. Many unexplored frontiers in the area of teaching methods are in need of analysis and experimentation for engineering graphics.

The above mentioned problems must be solved in great part by means of extensive and current research conducted by engineering graphics departments. Such research should be accumulated on a continuing basis and made available to be effective and meaningful.

DALE LEMONS RESEARCH

The Texas A&M University Engineering Graphics Department participated in a research study during the 1963-64 Fall Semester that was designed in part to evaluate the effectiveness of high school drafting with respect to college graphics. This study was conducted as a doctoral problem by Dale Lemons, an instructor of graphics at Texas A&M who is now teaching at Murray State Teachers College in Kentucky. This preliminary report is available with Mr. Lemons' permission.

The purpose of the Lemons Study was to determine the comparative scores of students with varying degrees of high school drawing backgrounds and with no high school drawing as a means for advanced placement in college graphics. All students were given a comprehensive examination during the first class meeting covering the material to be presented in the college course. This examination had been tested and revised by means of a pilot study the previous Spring Semester. No drawing instruments were required to complete the test -- all questions were objective to facilitate grading.

Table I shows the averages earned by each group of students categorized by their high school drawing background. As would be expected, those with no drawing earned lower grades than those with varying degrees of high school drawing. It was significant to note that there was a relationship between test scores and the number of semesters of high school drawing completed. Other pertinent data is supplied in Table I.

TABLE I

TEST RESULTS - FIRST DAY OF CLASS

H.S. Draw. (sem.)	0	1	2	3	4	4+
No. of Students	333	45	179	17	55	5
% of Total	52.5	7.1	28.2	2.7	8.7	.8
Average of Test Gr.	22.0	28.5	35.4	38.4	40.8	49.5
Stand. Deviation	10.0	8.5	10.7	10.3	10.9	7.5
Time Required (min.)	49.1	58.4	62.5	----59.1---------		
Stand. Dev. (time)	19.2	14.7	12.6	-----8.2---------		

The same test was administered to the same students at the close of the semester as a final examination. These grades were averaged and applied to a normal distribution curve to render 10% A's, 20% B's, 40% C's, 20% D's, and 10% F's. Using this curve as a basis for the scores earned on the first day, determination was made of the number of students who had earned sufficient scores to have received a C grade at the beginning of the course. Only seven students were successful in scoring within the C range. Table II itemizes the data accumulated. It should be noted that the variation in number of students listing their number of semesters of high school drawing is probably due to their inclusion of college course in this accounting. These discrepencies will be corrected at a later date by reviewing each student's data sheet.

TABLE II

TEST RESULTS - LAST DAY OF SEMESTER

H.S. Draw. (sem.)	0	1	2	3	4	4+
No. of Students	279	62	153	12	35	17
% of Total	50.0	11.1	27.4	2.2	6.3	3.0
Average Test Gr.	60.7	60.3	64.3	66.3	67.6	70.1
Stand. Deviation	10.9	9.7	8.9	7.0	7.5	9.2

These figures indicate that high school drawing does contribute to a student's performance in engineering graphics at the college level; however, high school drawing is not an adequate criteria for replacing engineering graphics. It is believed that the validity of this method of testing is sound since all students were exposed to the same test at the first and last of the course.

The Lemons Test was divided into ten subject area subdivisions: (1) Projection theory, (2) Lettering, (3) Instruments, (4) Geometric construction, (5) Lines, (6) Orthographic projection, (7) Dimensioning, (8) Multi-view projection, (9) Sections, and (10) Threads. An analysis of the scores earned by each of these areas serves as a guideline for future course revisions and scheduling of material to be increased or decreased. Figure 1 illustrates the comparison of the scores earned by those with high school drawing on the first day versus their scores on the last day of the course by area.

The Lemons Study accumulated much additional information -- some not yet analyzed -- which will not be presented in this report. Other information includes data pertaining to the geographical source of students, comparison of high school grades, ages, and academic majors.

AMOGENE DeVANEY TEST

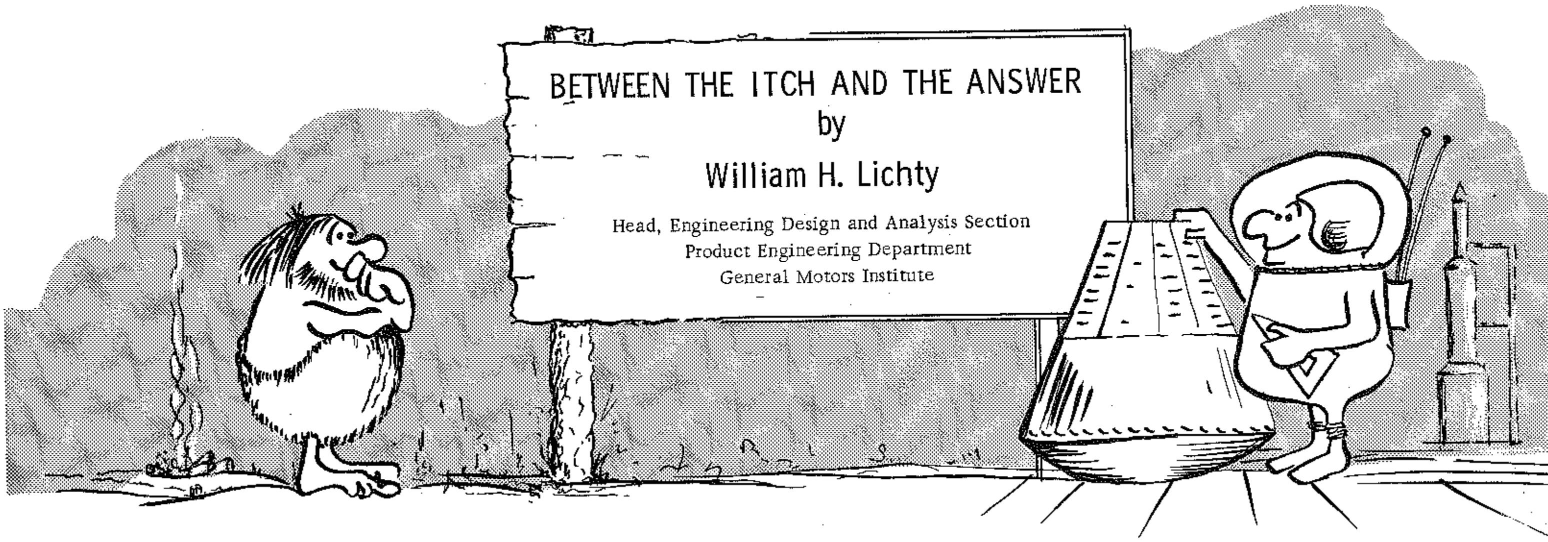
An experimental test used to measure spatial relations and reasoning in engineering graphics, which was designed by Professor Amogene DeVaney, was administered to all descriptive geometry students at Texas A&M University at the close of the 1964 Spring Semester. The results of the test are to be evaluated and reported in the form of a doctoral dissertation.

COMPARATIVE SCORES OF THOSE WITH HIGH SCHOOL DRAWING

	% First Day	% Last Day
PROJ. THEORY	34.2	58.0
LETTERING	27.1	58.0
INSTRUMENTS	49.5	77.8
GEOMETRIC CONST.	46.6	70.5
LINES	46.1	72.8
ORTHO. PROJ.	28.1	52.0
DIMENSIONING	26.0	54.0
MULTI-VIEW PROJ.	45.5	66.6
SECTIONS	10. 8	60.0
THREADS	19.7	70.5

FIGURE 1

continued on page 16-



Some years ago I assigned a class the derivation of a particular equation. When the assignment was turned in, I promptly turned back the papers with the admonition that they had not gone back to fundamentals.

"You want us to go back to scratch, eh?" said one member of the class. "Scratch, nothing," commented another, "he wants us to go clear back to the itch!"

In many respects, this is the situation for engineering design. It begins with an itch. The itch may be supplied in various forms -- scientific discovery, dissatisfaction with present systems or devices, increasing material wants, well defined needs, or the pressure to provide more service to the consumer in smaller packages at lower cost. In consumer goods, industry frequently supplies the itch.

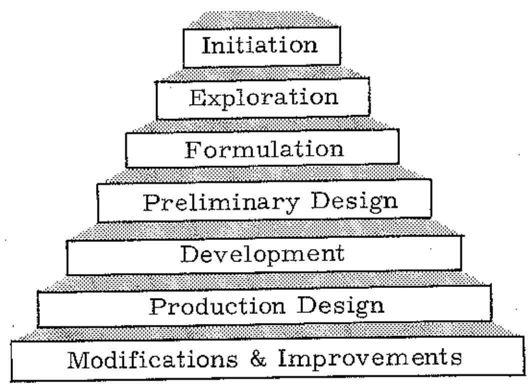
Design is the means by which engineering supplies a response to an itch. E. S. Taylor has defined engineering design[1] as "The process of applying various techniques and scientific principles for the purpose of defining a device, a process, or a system in sufficient detail to permit its physical realization."

The purpose of this article is to examine the role of graphics in this total process and to discuss a program of engineering education into which graphics is integrated.

Engineering Design as a Discipline

Much has been written in recent years about engineering design as a discipline. In addition to Taylor's statement (above), Rosenstein[2] has defined design as "an iterative, decision-making process." Asimow describes[3] it as "a purposeful activity directed toward the goal of fulfilling human needs . . ."

The total process of design has been presented in various numbers of steps beginning with a loosely defined goal and proceeding to a satisfactory material solution in the hands of the purchaser or user.[4] Typical is the following seven-step development:



Each of these steps can be expanded in considerable detail. Asimow develops such a program, complete with symbolism for inputs, decisions, and outputs.[5] Feedback loops may be added in great profusion. The above seven steps will suffice for this discussion.

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[1] "The Interim Report on Engineering Design," Massachusetts Institute of Technology, 1959.

[2] A. B. Rosenstein, "Design as a Basis for a Unified Engineering Curriculum," a paper presented at the First Conference on Engineering Design Education at Case Institute of Technology, September 8-9, 1960.

[3] "Introduction to Design" Morris Asimow, Prentice-Hall, Inc., Englewood Cliffs, N. J., 1962.

[4] The November 1964 issue of the Journal of Engineering Graphics included an article of this nature by William S. Chalk of the University of Washington.

[5] op cit

Design in industry does follow a rational pattern. Opportunity for inventiveness and decision-making exists at many stages in the process. The designer, the draftsman, the development engineer, the laboratory technician, and others all participate in bringing a new design to fruition. It is not always recognized that big opportunities often start with small problems.

Since design is a rational process by which engineering achievements are accomplished, it is appropriate that this discipline be taught as an integral part of an engineering curriculum.

The Function of Graphics in Engineering Design

Graphics serves two principal functions in engineering design:

1. As a method of exploring, developing, and analyzing ideas.

2. As a means of communicating ideas, intent, or specifications.

The ability to sketch is important, if not essential to carrying out these functions. (Maurice Olley[6] is said to have prescribed the entire chassis of the first Corvette on an 8-1/2 x 11 sheet of paper.)

Ideas take shape and gain realism on paper. A common deterent to young engineers' development of this capability is their apparent unwillingness to give up one line of approach and start a fresh one. (This observation is also applicable to efforts at writing.) Sketches induce creativity. New ideas and mental images evolve with sketching -- and new sketches must follow.

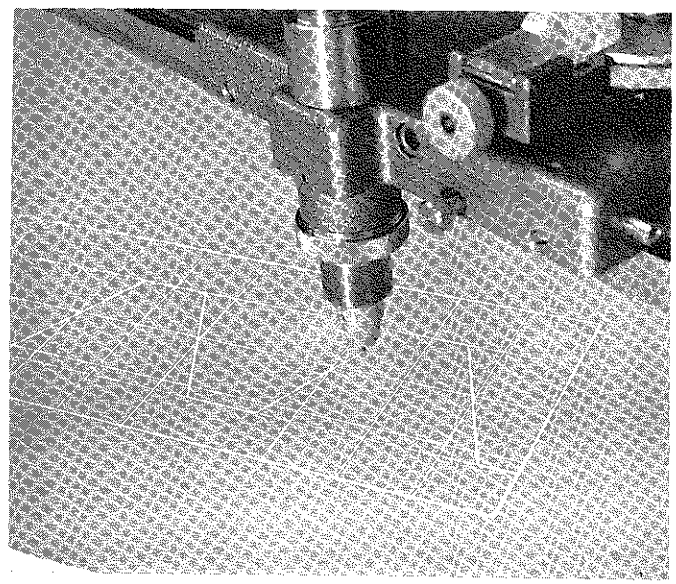
Ideas are as difficult to describe as they are to analyze while still in the mind. A sheaf of good sketches can provide the basis for decision and subsequent action in a conference. Too often conferences involving many high-priced man-hours revolve around word pictures and hand waving which are subject to a variety of interpretations and distortions.

The sketching phase is followed by schematics, kinematic diagrams, space diagrams, and preliminary layouts. These basic analyses often determine the constraints within which computer studies are started, components selected, critical loads calculated, and crucial decisions (often irreversible) are made with regard to the system.

Again, it is less expensive to scrap a design than to scrap a model or prototype later on. Any designer who has been through a total program can probably display a real art collection of discarded designs. These -- and the earlier rejected sketches -- are often valuable parts of the record. Invariably someone will ask, rather late in the program, "why didn't you do it this (another) way?" Graphical evidence of investigation of that particular idea, if it has been explored, is nice to have readily at hand.

As the design undergoes many compromises and changes, its evolution is a matter of record -- on paper. Similarly, the final design emerges and is released for production. What the drawing says is the final word. Production, inspection, and service go by these specifications.

Computer-aided assists are rapidly taking the drudgery out of these final steps. Body designers communicate with the computer in their own language. Design outputs go directly by tape to various points of use. Machines reduce three-dimensional models to digitalized information. Automatic drafting machines convert tapes to accurate line drawings while tape-controlled machine tools produce accurate surfaces.



The migration to computer-aided design is bringing about a reduction in the man-hours required for repetitive drafting activity and an increased need for higher skills. Industry has already found it necessary to train (or re-train) draftsmen and designers in advanced techniques of graphics.

Graphics, in one form or another, is practiced by many and must be understood by nearly all engineers involved in design, production, quality control, and service of systems and devices.

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[6] A well-known chassis engineer, Mr. Olley served successively with Rolls Royce, the British Ministry of Supply in two world wars, General Motors Engineering Staff in charge of ride and suspension development, and more recently as Director of Research and Development for Chevrolet; now retired.

WHERE ANGELS FEAR TO TREAD

by

IRWIN WLADAVER

Associate Professor of
Engineering Graphics
New York University

Anyone foolhardy enough to tangle voluntarily with the redoubtable C. Ernesto S. Lindgren ought to have his head examined. Therefore, under separate cover I'm sending you that useless appendage of mine. If you find anything in it, please tell my psychiatrist.

My admiration for Lindgren's provocative, pioneering, and imaginative scholarship is unbounded. Not that I understand his three-dimensional pictures of his four-dimensional descriptive geometry, nor do I altogether understand his "Reflections on the Fundamentals of Descriptive Geometry," the most recent issue of this JOURNAL, Vol. 29, No. 1. But this must be a reflection on me; - the topic was only three-dimensional, and I'm supposed to be able to handle 3-D fairly adequately.

If I am not violating Lindgren's meaning, he says that some modern writers unjustifiably ascribe to the planes of projection certain physical characteristics, specifically "transparency" or "opacity;" and that these attributes lead to "variations" in the classical Mongean system; and that they are "time and time again, in complete disagreement with the geometric properties of the elements of the Mongean system." Somehow he relates these attributes to conditions of visibility of lines of solids. Furthermore, if I am still not misinterpreting Lindgren, he feels that the existence of an "observer," while perhaps required when dealing with applications, is ruled out when dealing with purely theoretical concepts.

I disagree with Lindgren in every way. It may be that I failed to understand his reasoning because he tried to deal with these matters without giving any specific examples. I simply don't understand his viewpoint. Descriptive geometry is descriptive geometry. The adjectives "applied" and "theoretical" are devoid of differentiating significance, except perhaps in titles of textbooks.

And to suggest that Gaspard Monge was "theoretical" because he did not refer to either transparency or opacity of planes of projection stuns me. No author of descriptive geometry has ever been more practical. I translate from Monge's "Programme" (Introduction) as follows: "In order to pull the French Nation out of its present dependence on foreign industry, it is necessary, first, to direct national education toward the recognition of objects that demand exactness, something that has been totally neglected until this very day; and to accustom our mechanics (artistes) to handle all kinds of tools that serve to bring precision into their work . . ."

Monge goes on further with the same theme to show how the art - notice, art not theory - of descriptive geometry could achieve this goal. I give his famous statement: "This art has two principal purposes. The first is to represent with exactness on drawings (dessins) that have only two dimensions, objects that have three of them and that are susceptible of rigorous definition. From this point of view, it is a language essential to the engineer (homme de genie) who conceives a project; to those who will supervise the actual work; and finally to those workmen who have to make the different parts.

"The second purpose of descriptive geometry," he goes on to say, "is to deduce from the exact description of bodies everything that necessarily follows concerning their shapes and their positions. In a sense it is a means for searching out the truth."

What could be more practical? Still, this does not deny Lindgren's implication that Monge "idealized" the whole system. In my sense, every line I draw is an attempt to idealize reality. Nor do I find fault with Lindgren's claim that Monge did not refer to transparency or opacity of the planes of projection. Then what does Monge say about the planes of projection? Virtually nothing!

And yet, what do you make of the following: As far as I can read and translate Monge's precise French, the first time after the "Programme" that the idea of projection is broached is in the first sentence. The word "plane" is not mentioned. Instead, Monge says "une feuille de dessin," which I take to mean a sheet of drawing paper, undoubtedly opaque!

The matter is then dropped in favor of a discussion on ways of locating points in space by means of spheres and cylinders. Then he returns to define projection: "One calls 'projection' of a point on a plane the foot of a perpendicular dropped from the point to the plane. This being assumed, if one has two (intersecting) planes whose space positions are known, and if one gives on each of these planes the projection of the point whose position one wishes to define, the point will be completely determined.

As I see it, plane of projection is left undefined! Then of course nothing can be said about its transparency or opacity. I suspect Monge never gave such things a thought, although he was one of the great geometers of all time.

At any rate, we'll never know whether he equated his planes of projection with sheets of paper on which drawings were to be made. About ten lines after defining projection he says, "In the following paragraphs will be shown the method of procedure to be employed on a sheet of drawing paper."

Does this have anything whatever to do with the practical or theoretical nature of Monge as against that of other writers? I see no connection.

As for visibility of solids, I claim that the visibility of lines of solids depends exclusively on the position of the "observers." An argument over the existence or non-existence of observers is not a matter of descriptive geometry; it's an argument in semantics or in philosophy. Neither the quadrant nor anything else determines which lines are visible and which are hidden. The transparency or opacity of the planes of projection is irrelevant, in my opinion. If you want to consider the planes of projection in the first quadrant opaque and in the third quadrant transparent, go ahead. Divide space into octants if you must; the result is all one. And in the end, the result is all one: visibility depends on the position of the observers.

You cannot dispense with an observer at infinity. I don't care how you rotate the planes into coincidence either. You may note that Monge doesn't say much about the basic rotation. What he does say is: "The necessity of managing to have both projections on a single sheet . . ." suggests that ". . . the vertical plane be turned on its intersection with the horizontal plane, as though hinged, to coincide with the horizontal plane." By far the most interesting aspect of this is that, according to Monge, these planes of projection need not be taken as vertical and horizontal at all. All that is required is that the planes of projection be non-parallel; after that the rotation is not directionally specified, except that in Monge's examples in my edition all the illustrations are opened into first quadrant.

I agree with Lindgren in one essential: If we are representing points or lines only - not solids we don't need observers. But when we're representing solids, visibility and observers are interdependent. There is no dichotomy between theory and application.

In the sense that descriptive geometry is an idealization, it is entirely theoretical. The fact that you can get answers that may be relevent to reality serves only to make the theory of descriptive geometry that much the sounder. And practical!

As for practicality against theory, what would we say of an eminent author of a most successful descriptive geometry text book who never mentions planes of projection at all? Professor B. Leighton Wellman deals with "views," strongly implying observers, but he completely abjures planes of projection. Wellman must therefore be more theoretical than Monge, yet he claims "Technical" in his title and I think he's right.

As for the practice of invoking projective geometry when discussing descriptive geometry, I must say that here I agree in part with my good friend, Ernesto Lingren. Both are essentially theoretical. But they are both practical, too. Doesn't it all depend on what you do with the results you get? Furthermore, a basic fact often overlooked is that descriptive geometry and projective geometry are identical except in one respect, a very important one to be sure.

If you take the center of perspective, S, or what is sometimes referred to in projective geometry as the station point, and remove it to infinity, then projective geometry becomes descriptive geometry. This is the same thing as saying that descriptive geometry, all of it, is a special case of projective geometry.

And so I reach conclusions exactly opposite those of Lindgren. I conclude that projective geometry requires one observer at point-S and he can move around in space in any manner at all; descriptive geometry requires two observers or at least one moving from one infinity to another. Projective geometry requires a minimum of one plane of projection; descriptive geometry requires two.

As far as transparency and opacity of these planes are concerned, they aren't of the slightest importance as long as you can see your way clearly through them. Practically speaking, that's my theory.

INDEX IN THE MAKING

It has been suggested by several members of the Division of Engineering Graphics that the JOURNAL publish a complete INDEX.

Your editorial staff has been working on this project and expect to make it at least a 1955 to 1965 reference. The previous indexing provided by Professor Irwin Wladaver, New York University, provides the framework upon which the new index is being built.

E. D. B.

The New Graphics

by: J. Gerardi
Associate Dean
College of Engineering
University of Detroit

It appears that in this era of change, the word "new" must precede any product or service in order to attract attention.

Our mathmetician friends used the work "new" and applied terminology normally used in more advanced courses to old theories and concepts. By showing that young minds could understand many of the concepts used in higher mathematics, and by excellent means of communicating the advantages of their new methodology, the mathematicians were able to sell their ideas to educators and the public. As all of us know, they have been successful because today schools offer courses in new mathematics even to parents so that they may appreciate the objectives of the new system. Many of the courses for parents are of sufficient length and planned to train parents to help their children. The point here is that, by employing good public relations and by taking a positive approach, the mathematicians have been able to convince an entire nation that the changes which they made and which they wished to implement even at grade school level would be of great benefit to all.

Those of us who are involved in teaching graphics do not have to convince an entire nation that the changes we have made and implemented will produce better engineers. We do, however, have the job of convincing the leaders in engineering education that graphics is not drafting and that the new aspects of graphics do, in fact, improve the product of our engineering schools. How should this be done? There is no single solution, but let's take a lesson from the mathematicians. Let's talk and write about the "new" aspects of graphics at every possible opportunity.

If we agree that there is a difference between mechanical drawing and graphics, perhaps, we should emphasize the difference. Any serious discussion on the subject would immediately call for a definition of the term graphics. An attempt is made here to define graphics: Graphics is the art and science of delineating an engineering design or system and transferring the disciplines of math and science, which may be inherent in the project, into graphical models for analysis. Of course, this definition is subject to criticism, but we must admit that it is different. Mechanical drawing, unlike graphics, does not include a knowledge of higher mathematics, engineering mechanics, and other disciplines.

In engineering colleges there are very few, if any, graphics teachers who emphasize drafting skills. Most graphics courses today include some form of graphical math, statics, design and, in many instances, computer analysis.

A new trend seems to be taking shape - conceptual design or, as some call it, creative design. Regardless of whether it is conceptual or creative, the important thing is that design is coming back to engineering and that there is no better place than at the freshman level to begin the study of this very important function of engineering. Let us not, however, make the mistake of using the word "design" as a synonyn for drafting. Design should involve work on the so called, "open-end" projects and help students develop their creative talents by communicating their ideas in graphical form. In addition, the nature of the design should include some scientific or mathematical parameters for analysis. Moreover, the design must be such that judgment is apparent and economic factors have been considered.

Grading is also changing. Formerly, a grade was pretty much determined by the number of plates turned in, the "pretty pictures" on them, and examinations. Today grades are determined by knowledge, amount and quality of library research, judgment used in the formulation and solution of a problem, and the ability to design or compose numerous components into a working system for an end product. This is true of many graphics courses and, particularly, of design related to open-ended projects.

A review of recent literature on the subject of graphics shows numerous new facets in graphics. None of us can or should teach all that has been proposed. It is a fact, however, that practically all teachers of engineering graphics have made their courses more sophisticated and scientific and that we now have "new" graphics.

continued from page 8

Professor DeVaney has granted permission to report the results of the averages with respect to the number of semesters of high school drafting completed. The 356 students included in the study are essentially the same ones who were included in the previous Fall study. Figure 2 shows that high school drawing has an effect on a student's performance on spatial reasoning test after a full year of engineering graphics in college. This difference is somewhat less than at the end of the first semester of college engineering graphics, but follows the same general pattern. These results strengthened the validity of the first battery of experimental tests.

HIGH SCHOOL DRAWING SEMESTERS

0	79.0%
1	80.0%
2	80.5%
3	87%
4+	82%

STUDENT PERFORMANCE ON SPATIAL REASONING TEST

FIGURE 2

COZZENS STUDY

Another research study now being finalized was conducted during the 1964 Spring Semester at Texas A&M University by Charles R. Cozzens, an instructor in the Engineering Graphics Department. This investigation was concerned with the development of a self-grading problem format enabling a student to solve his descriptive geometry problems and then grade himself according to a grading scale immediately after completion of the work. The results of this study should prove interesting when statistically analyzed.

EARLE RESEARCH

A study was conducted by the author at Texas A&M University during the Spring of 1963 to evaluate the effectiveness of programmed instruction principles to the teaching of descriptive geometry. This research involving 2,840 samples was compiled in a dissertation entitled "An Experimental Comparison of Three Self-Instruction Formats for Descriptive Geometry." Although no attempt will be made to fully cover the study, Figure 3 briefly illustrates a rough summation of the final results. The significance of this investigation lies in the fact that there are many ways in which instruction in engineering graphics can be improved and thereby facilitate the addition of more material in our courses with better results.

CONVENTIONAL METHOD	72%
LECTURE METHOD	87%
STEP METHOD IN COLOR	92%

COMPARISON OF THREE METHODS OF PRESENTING DESCRIPTIVE GEOMETRY

FIGURE 3

The conventional method is defined as the process whereby students were required to solve basic descriptive geometry problems with no instruction, but merely access to a testbook illustration and explanation. The lecture method employed the same textbook method plus an explanatory lecture from the teacher. The step method in color was a format using programmed instruction principles printed in two colors to aid the student in distinguishing between the various steps of the problem solution.

RESEARCH CONDUCTED ELSEWHERE

Much research is now in progress in various areas of the Nation that will contribute more information on which to base our course revisions. Many more studies other than those mentioned below are probably in existence, but these are representative of recent efforts.

Clayton Chance of the University of Texas conducted a noteworthy study in the use of the overhead projector with successive colored transparencies in the teaching of descriptive geometry. He concluded that this method of instruction saved class time, improved student grades, and improved the quality of presentations.

Professor Robert Borri of the University of Illinois has recently reported his findings concerning the analysis of engineering graphics grades with respect to high school drafting completed. He concludes that the students who have no high school drawing (58%) earn somewhat lower grades than those with one to three years of high school drafting. It was further concluded that students who intend to pursue the engineering curriculum should enroll in high school drafting to build a sufficient background for college graphics.

Robert E. Blum, a Texas A&M University graduate student, is designing a test to measure the achievement of college drawing students to be used as a placement instrument. This project will be undertaken at a number of colleges and universities next Fall.

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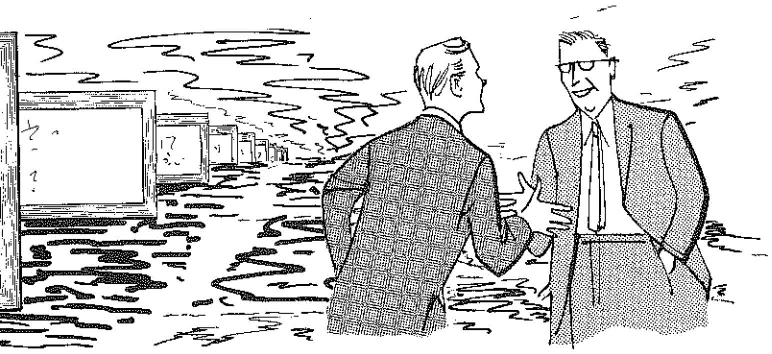
Perspective

THE NEW STUDENT

Frank M. Warner
Professor Emeritus
General Engineering
University of Washington



Time passes so quickly. It is difficult for us, as teachers, to remember when we were freshmen and how much we would have given for some intimate talks with our instructors. We put much effort into deciding the best way to present facts to a student. But the first thing we should do is to open the door so facts may enter in. It is like driving a herd of cattle up to a corral to feed them and then forget to open the gate. Those facts, so carefully prepared, do not always get inside. What can we do about it?

The answer is very simple; it is to find out as soon as possible, by personal acquaintance, all the information we can about him. We should very early sell the idea to him that we are deeply and personally interested in his welfare. We should make him feel sure that we are always for him and never against him and that we have faith in him. We know he has the grades but he should know that grades alone are no guarantee of success. What the student needs most is help in developing worthwhile personal characteristics, such as attitude, proper habits of work, careful thinking, good professional ethics, honesty in work and faith in himself and in his instructor. This can best be accomplished by personal interviews, not with all students but with those whom we deem to be in need of help. And those in need may be students who have personality problems, or who seem to be uncooperative, or who may have personal problems at home or maybe they are just scared. We can not hope to cure all his problems, but just letting him talk them over with his instructor will break down the barrier for him so he will feel free to come in at any time. Let me illustrate by a personal example.

One of my students, who was afraid to come to my office, finally came in one day after I had asked him many times. He really looked scared and probably was afraid he would be given a lecture about his work. Imagine his surprise when I never even mentioned his class work. I just asked him if he had any idea what I wanted to do when I retire. When I told him I wanted to be a one-man band and play traps, cymbals, guitar and mouth organ all at the same time, he broke out in laughter. But the door was opened and from then on we could talk freely about his habits and hopes in engineering, etc. Next time we could talk about class work because there would be a next time. We have all had many experiences like this and we all realize that we can not possibly cure, or even help, every student to solve his problem. But when we do succeed, it may mean the student is started on his way to a more successful career.

From forty years of teaching experience I could quote many examples to illustrate my point. However I will give you only one example. A new student entered my class who had worked for several years as a union steel worker. He was clumsy and he did poor work and he knew it. He came into my office one day determined to quit college. But I saw possibilities in him and proceeded to do my very best teaching. I encouraged him and told him I had lots of faith in him. I assured him that he had more possibilities of success than anyone in the whole class. I reminded him that he had had lots of practical experience and knew what engineering was all about and would get much more out of his class work than the others. He believed me and went back to class. He graduated with high honors, he took graduate work at M.I.T. receiving all "A" grades. During the war he held a highly technical position with the navy and, when I last heard, he was a professor in one of our very high-class technical colleges. His whole life was changed by personal interest. I will admit it would have been far easier for me to let him drop the course.

The facts learned in the first year will soon be forgotten. But the student will long remember your influence on his life. You are the one who taught him good habits of work, to think clearly, to be kind and helpful to others, to be fair and square, to appreciate a friend and to have faith in himself.

I have always contended that the following two statements are true.

1. That teaching freshmen is the most important, the most difficult and the most rewarding college teaching job.

2. That ten per cent of the value of our teaching to freshmen lies in teaching subject matter. But ninety per cent of the real value of teaching freshmen lies in our understanding of the student and our personal relations with him. I have much proof of this. Having had thousands of students in my classes, I have never had a single letter from any student talking about the way I taught the subject matter. But I have had a great many letters from students thanking me for help, understanding and inspiration.

Please pardon any personal reference and the examples as they are only used in the hope of inspiring some teacher to take a more personal interest in his students and their problems.

"SYMMETRY IN A FOUR-DIMENSIONAL SPACE"

C. Ernesto S. Lindgren
Visiting Research Engineer
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EDITOR'S NOTE:

This paper was presented at Princeton by C. Ernesto S. Lindgren. Mr. Lindgren presently is a Visiting Research Engineer with the Department of Graphics & Engineering Drawing, and is on leave from the United States Steel Corporation.

Mr. Lindgren would appreciate receiving reactions to the ideas presented in his paper. All correspondence should be addressed to him in care of the Department of Graphics and Engineering Drawing at Princeton University.

INTRODUCTION

One who studies four-dimensional geometry arrives at answers to certain problems that seem very unusual in the face of comparable solutions of similar problems of three-dimensional geometry. A striking example is the case of the intersection of two planes not situated within the same three-dimensional space. Their intersection is a point. Another example: A line and a plane, situated within distinct spaces, may not have a common point.

As one becomes more involved with higher geometry, such problems cease to sound improbable. They begin to be part of one's daily thoughts and they lead to the understanding of other problems. These in turn, at the beginning, are again looked upon with a certain degree of sceptism.

It is very probable that this is the same feeling of the reader who, perhaps for the first time, is facing the notions presented above. On the other hand, for those who are accustomed to these concepts they should be remembered and their understanding reaffirmed.

Independently of the state of mind of each one of us in regard to these problems, the important thing to bear in mind is that we should make an effort in analyzing the consequences of all the geometric structures made possible by those new relationships between geometric elements in the four-dimensional space. This is the reason for dedicating this seminar paper to an analysis of the concept of symmetry that is considered to be a common notion in three-dimensional space. What happens if we extend this notion of symmetry to a four-dimensional space? There is no immediate answer to this question. For by using the geometric propositions of four-dimensional space we are able to define new relations, using them as tools to, for example, draw a line perpendicular to three others, to execuite rotations about a plane, etc. This is all well and good, but what have we constructed? The answer to this question, I think, is much more a greater challenge than to develop a whole new series of theorems, exception being made to the difficulty of setting the proper foundations on which these theorems are based.

This seminar paper is intended to bring to your attention one of these questions. In essence it deals with the basic concepts of four-dimensional geometry and some of the ideas presented above. For the benefit of those who are not comfortably familiar with the concept of a four-dimensional space, we have included a brief discussion of the problem which will, at least partially, give a general idea of how this concept can be properly understood and justified.

PRELIMINARY CONSIDERATIONS

Proposition:

"The intersection of two planes not belonging to the same space may be a point."

Before demonstrating this proposition let us briefly recall some basic relationships among geometric elements. We say for example, that two points determine a line to which they belong; two lines belonging to the same point also belong to the same plane; two planes determine a line (See Figures 1-a, 1-b, and 1-c).

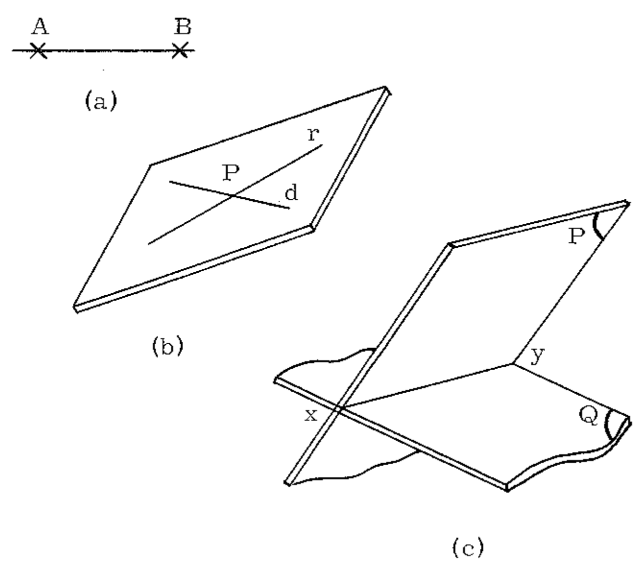


FIGURE 1

Let a point be referred to as the space of zero dimension, the line as a space of one dimension, and the plane as a space of two dimensions. Here the word "dimension" implies degrees of freedom.

Observe that in each of these cases, two spaces with the same number of dimensions can only co-exist in a space that has, at least, one more dimension than the spaces under consideration. This is what makes us immediately consider the existence of a three-dimensional space within which two planes are imbedded.

Based on this last consideration, even though we might be in danger of being accused of abusing the prerogatives of the synthetical reasoning, we could say that:

> "Two planes (belonging to the same line) determine a three-dimensional space to which they belong."

For the time being the reader is asked to disregard the condition enclosed by the parenthesis. Even if this condition is eliminated at this preliminary stage, it would have to be added at a later time. Nevertheless its inclusion is still the assertion of a known fact, considering the figure 1-c to which we direct our attention.

Now let us look closely at the new statement and synthesize it. First of all, notice the use of the article a, when we say "a three-dimensional space" (we also could say "the three-dimensional space"). The implication here is that we may, from here on, refer to another three-dimensional space, by the same manner as we refer to another plane, not the plane of two lines belonging to the same point. Second, the consideration of at least a second three-dimensional space will lead us into concluding that they can only co-exist within a four-dimensional space. Third, it will not be long until we finally will say that: "Two three-dimensional spaces determine a plane to which they belong," and perhaps draw a pictorial view of this new relationship. (See figure 1-d.)

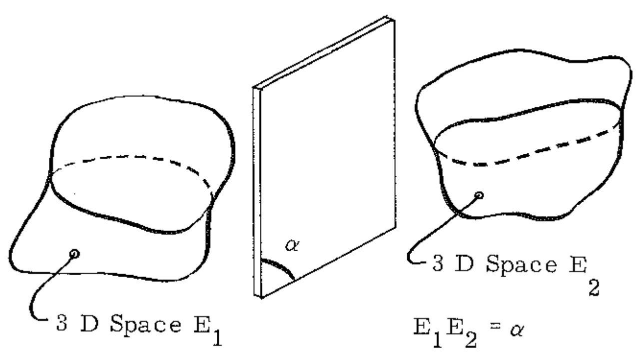


FIGURE 1-d

Evidently, within each of the 3-D spaces E_1 and E_2 shown in figure 1-d, we can consider other planes, lines and points, interrelated by geometric properties as we know them.

Let then β be a plane of E_1 and γ a plane of E_2. (See figure 2).

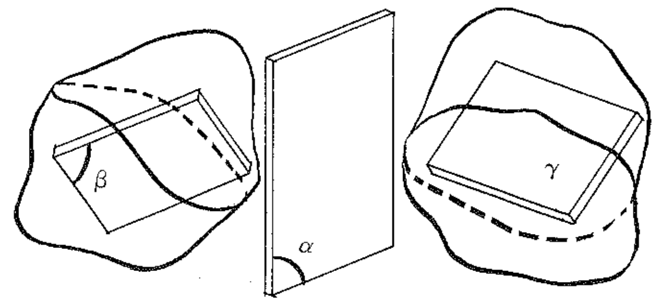


FIGURE 2

As established, $E_1E_2 = \alpha$

Since α belongs to E_1,

$\alpha\beta$ = line AB, (see figure 3-a)

and because α also belongs to E_2

$\alpha\gamma$ = line CD (see figure 3-b)

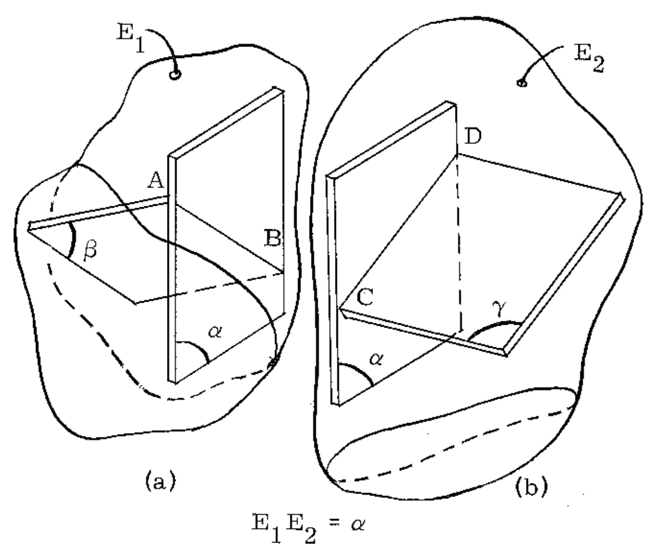


FIGURE 3

To demonstrate the original proposition, all that is necessary is to show that AB and CD do not coincide. Even though this could be the case, it cannot be considered as a general rule, for AB and CD could indeed coincide. However this last possibility would involve the consideration of determining a plane in 3-D space E_1 and a plane in 3-D space E_2 so that each belongs to the same line of α. But in α we could admit a line CD not coincident with AB, and consider that to the first, belongs a plane γ of E_2 and to the second a plane β of E_1.

Therefore, in this last assumption, the lines AB and CD of α, determine a point P. If we say that AB is the geometric locus of points of β that belongs to α and that CD is the geometric locus of points of γ belonging to α, the point P is common to both loci and consequently to both planes. It is their intersection.

$\beta\gamma$ = point P (see figure 4)

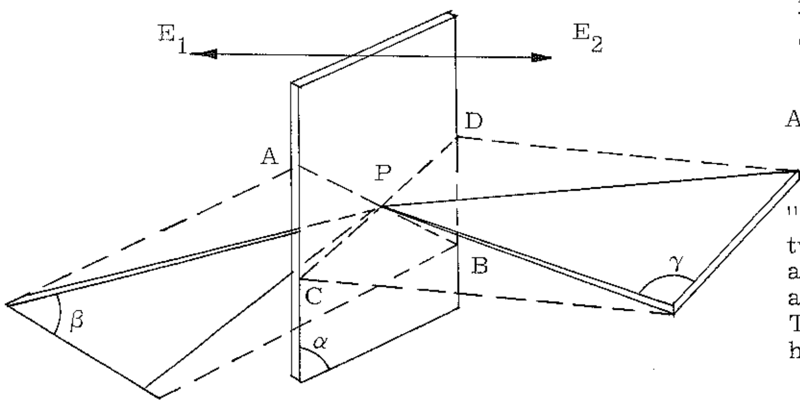


FIGURE 4

This demonstration differs from the statements made by Dr. Henry Parker Manning in his "Geometry of Four-Dimensions" (The MacMillan Company, 1928, New York).

From page 51 of this book I quote:

"Theorem 2: From the points of the figures given in each of the following cases we can obtain just the points of a hyperplane* if we take all points collinear with any two of them and all points collinear with any two obtained by this process:

1. A plane and a point not in it, or a plane and a line that intersects it but does not lie in it;

2. Two lines not in one plane;

3. Three lines through one point but not in one plane;

4. Two planes intersecting in a line.

We can indeed, speak of a line or a plane as one of the things with which we start in the process of obtaining a hyperplane (compare this with Art. 10).

It follows from (1) that a line and a plane which do not lie in a given hyperplane do not intersect at all, and from (4) that two planes which do not lie in a given hyperplane cannot have more than one point in common."

*A hyperplane consists of the points that we get if we take four points not points of one plane, all points collinear with any two of them, and all points collinear with any two obtained by this process. (G.F.D. - H. P. Manning, page 24).

Apparently we get all the points of ordinary space by taking four non-coplanar points, all points collinear with any two of them, and all points collinear with any two obtained by this process. The space of our experience will therefore be regarded as a hyperplane. (Page 52)

And from page 234, I quote:

"Two lines in a plane always intersect, and any two lines which intersect lie in a plane. A line and a plane in a hyperplane intersect, and a line and a plane which intersect lie in a hyperplane. Thus a line and plane which do not lie in a hyperplane do not intersect even at infinity."

In the face of this contradiction I would like to make the following comments:

1. If two planes do not belong to the same 3-D space (referred to as "hyperplane" by Manning) their point of intersection belongs to the plane intersection of the two 3-D spaces to which they respectively belong. (See figures 4 and 5).

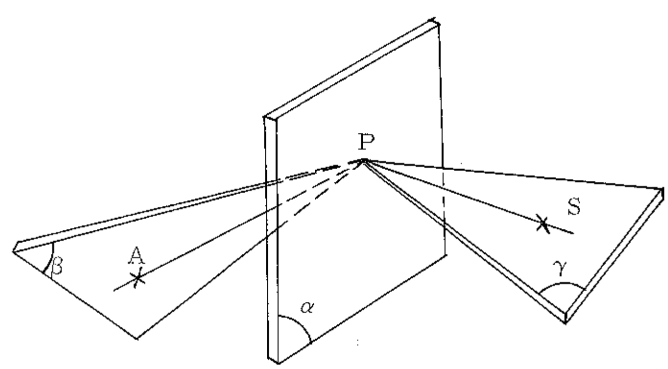


FIGURE 5

2. In the plane β it is always possible to select a point A. This point and the point P will determine a line belonging to β. Since P belongs to γ, the intersection of the line AP of the space E_1 with the plane γ of the space E_2 is the point P.

3. In fact the line AP and the plane α determine the space E_1 and the line SP (being S a point of plane γ) and the plane α determine the space E_2.

4. The theorem should be reworded in order to cover the possibility shown.

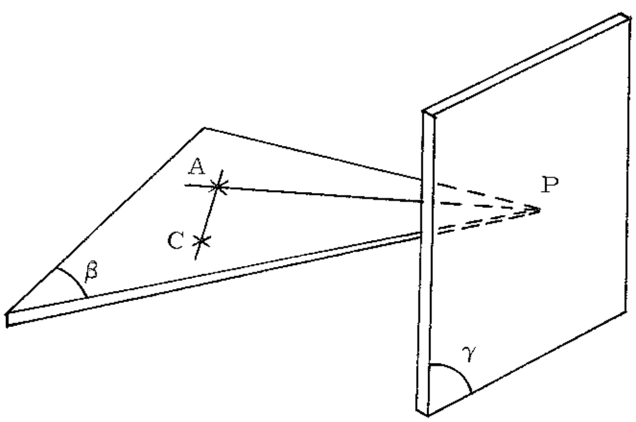
Proposition:

"A line and a plane not belonging to the same space may not intersect at all."

Let β and γ be two planes of the spaces E_1 and E_2 respectively. The two planes intersect in a point P.

Let AB be a line of β, also belonging to the point P.

Since P is the only common point to the two planes, then, every line of β that intersects γ belongs to P, and every line of β that belongs to A and to P also belongs to B. Finally, any line of β that belongs to A but does not belong to B, also does not belong to P. Such is the case of line AC. (See figure 6)



AC and γ do not intersect

FIGURE 6

Notion of planes absolutely perpendicular:

Two planes that intersect in a point are said to be absolutely perpendicular when every line of one through the common point is perpendicular to every line of the other through that point. (See figure 7)

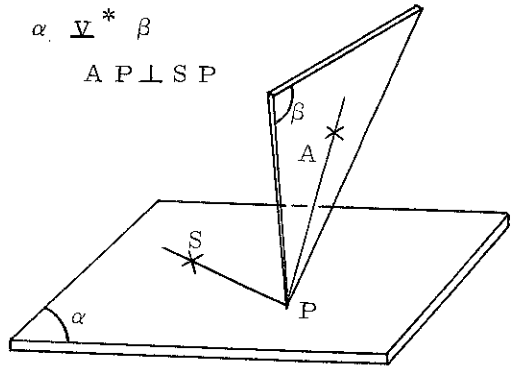
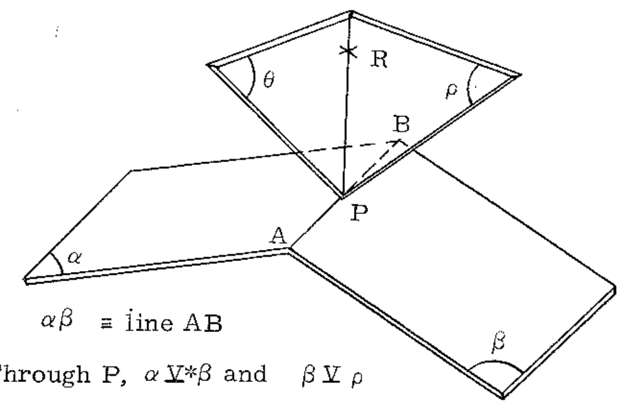


FIGURE 7

Synthetical geometry demonstrates that to a point of a plane belongs one and only one plane absolutely perpendicular to the first. It is also demonstrated that the two absolutely perpendicular planes to two others, at a point of their line of intersection, belong to the same space and therefore intersect along a line. (See figure 8)



$\alpha\beta \equiv$ line AB

Through P, $\alpha \underline{V}^* \beta$ and $\beta \underline{V} \rho$

Then $\theta\rho \equiv$ line PR

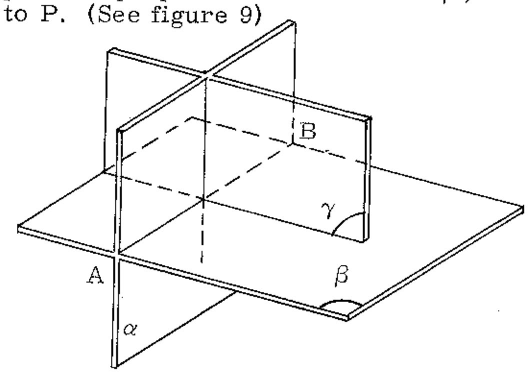
FIGURE 8

If we consider the case of α and β being perpendicular, then θ and ρ are also perpendicular.

If $\alpha \perp \beta$, follows that $\theta \perp \rho$.

*The symbol $\underline{V}$ means "absolutely perpendicular to "as $\perp$ means perpendicular to."

In this case, we can still consider a third plane γ perpendicular to α and β, belonging to P. (See figure 9)



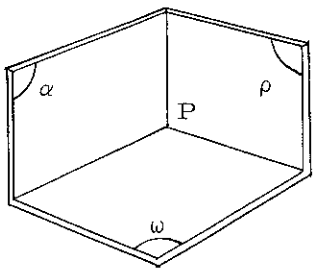
$\alpha \perp \beta$

$\alpha \perp \gamma$

$\beta \perp \gamma$

FIGURE 9

In addition, the intersection of α and β (line AB) and of ρ and θ (line PR) determine a plane perpendicular to α, β, θ, and ρ. Therefore three planes α, β, ω and θ, ρ, ω are perpendicular and belong to the same line. In consequence, the planes β and θ, α and ρ, are also perpendicular, being plane ω perpendicular to their intersections. (See figures 10-a and 10-b).

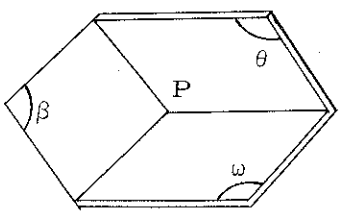


$\omega \perp \alpha$

$\omega \perp \rho$

$\alpha \perp \rho$

(a)



$\omega \perp \theta$

$\omega \perp \beta$

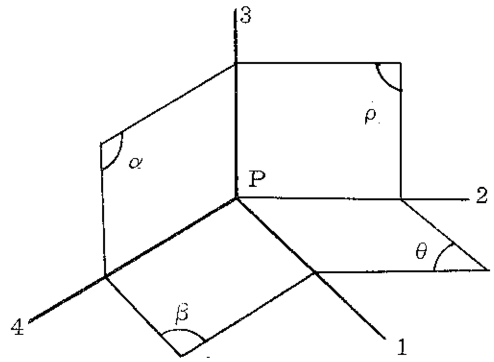
$\theta \perp \beta$

(b)

FIGURE 10

The result is the consideration of six planes belonging to a point P. Figure 11 shows all six planes and we can identify the familiar 4-axis arrangement, perpendicular to each other. The spaces, planes and lines so related form the system of reference for the descriptive and analytical methods.

Let us deal with two perpendicular planes and their two respective absolutely perpendicular planes. (See figure 12)



$\alpha \perp \beta$

$\beta \veebar \rho$

FIGURE 12

Symmetry:

Let us consider first the planes α and β of figure 12 and a segment AB of β. We propose to determine the symmetrical segment of AB in relation to α. The construction is shown in figure 13. Let it be shown that P is middle of A_0B_0.

$BB_1 \perp$ Line 4

$AA_1 \perp$ Line 4

$BB_0 = B_0B_1$

$AA_0 = A_0A_1$

$A_0P = PB_0$

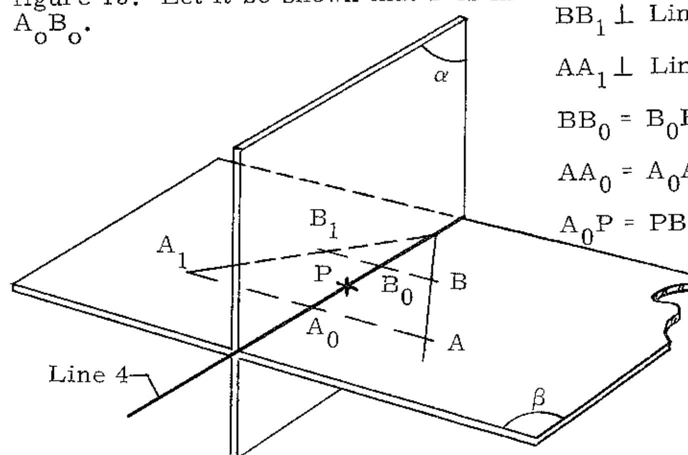
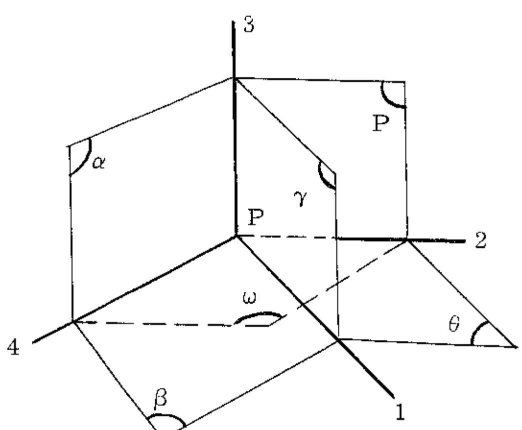


FIGURE 13



$\alpha \veebar \theta$	$\alpha\theta \equiv$ Point P
$\beta \veebar \rho$	$\beta\rho \equiv$ Point P
$\gamma \veebar \omega$	$\gamma\omega \equiv$ Point P

$\alpha \perp \beta$	$\alpha\beta \equiv$ Line 4
$\alpha \perp \omega$	$\alpha\omega \equiv$ Line 4
$\beta \perp \omega$	$\beta\omega \equiv$ Line 4
$\alpha \perp \gamma$	$\alpha\gamma \equiv$ Line 3
$\alpha \perp \rho$	$\alpha\rho \equiv$ Line 3
$\gamma \perp \rho$	$\gamma\rho \equiv$ Line 3
$\theta \perp \rho$	$\theta\rho \equiv$ Line 2
$\theta \perp \omega$	$\theta\omega \equiv$ Line 2
$\omega \perp \rho$	$\omega\rho \equiv$ Line 2
$\beta \perp \gamma$	$\beta\gamma \equiv$ Line 1
$\theta \perp \gamma$	$\theta\gamma \equiv$ Line 1
$\beta \perp \theta$	$\beta\theta \equiv$ Line 1

FIGURE 11

Consider now the planes β and ρ, that are absolutely perpendicular. In determining the symmetry of AB in relation to ρ, we shall draw through A and B two perpendicular lines to the plane ρ. Both lines, due to the definition of planes absolutely perpendicular, will belong to point P, which is then their foot. From this point (on which A_o and B_o coincide) we see that $A_oA_1 = A_oA$ and $B_oB_1 = B_oB$. (See figure 14)

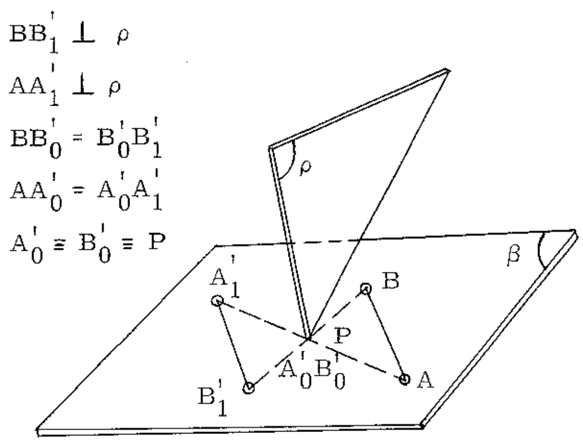


FIGURE 14

Examination of figures 13 and 14, and figure 15 which shows the given space conditions in orthographic projection, leads to the following conclusions:

a. In a four-dimensional space, a segment of a line belonging to a given plane has two symmetrical segments: one in relation to a plane perpendicular to the given plane through a point P in this plane, and the second in relation to the plane absolutely perpendicular to the given plane, through the same point P.

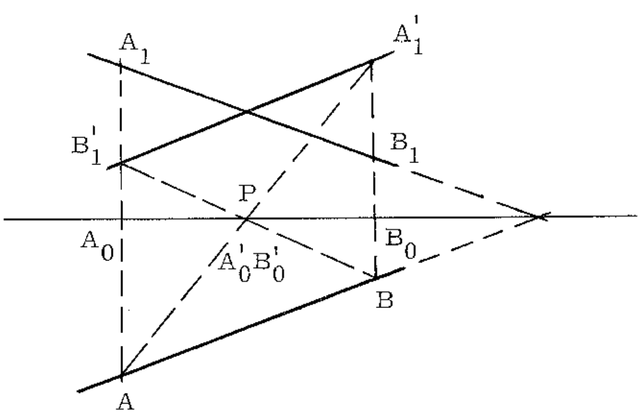


FIGURE 15

b. The first symmetry is of the standard mirror-reflection type; the second symmetry is the same as symmetry about a point.

c. If we relate two mirrors to each of these planes, and calling A the left point, and B the right point, an observer looking at the first symmetry will see A_1 as right and B_1 as left; but an observer looking at the second symmetry will see A_1' as left and B_1' as right.

d. If we assign L for left, R for right, L_1 for the symmetry of R and R_1 for the symmetry of L, and keeping in mind that both cases are symmetrical about a plane, we have for the first symmetry

$L = R_1$ and $R = L_1$

but for the second symmetry

$L \neq R_1$ and $R \neq L_1$

and in fact $L = L_1$ and $R = R_1$.

Evidently the second case of symmetry contradicts the standard law of symmetry in a standard plane mirror-reflection. Nevertheless it is a symmetry about a plane mirror.

Conclusion:

Imagine now an individual that has a complete view of all three planes: plane β, plane α perpendicular to β, plane ρ absolutely perpendicular to β. If he relates a mirror to each of the two planes, α and ρ, he will be able to draw A_1B_1 symmetrical to AB in relation to α and $A_1'B_1$ symmetrical to AB in relation to ρ.

In examining the first conclusion above, located as we are in a three-dimensional space of β and α, we would say that it is in perfect harmony with our experiences. However, if the conclusion is that of the second case (and this is possible, since that individual would not realize the existence of three-dimensional beings, by the same token that we do not admit the existence of two-dimensional beings), we certainly would wonder - "What happened to the symmetry?"

If we think that this case of symmetry is beyond the scope of the "real" problem of our three-dimensional world, let it be said that regardless of the plane about which the symmetry is determined, the symmetry of a point is found on a plane of which we are aware of (plane β) and that the point that remains to be accepted is the fact that we are not aware of one of the planes (plane ρ) about which the symmetry can be obtained.

Compare our situation with that of the two-dimensional being. (See figure 16)

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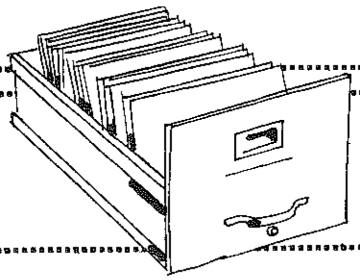
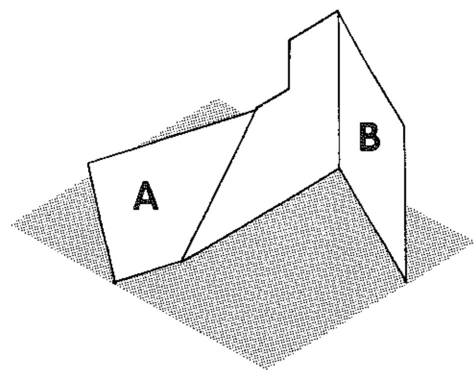
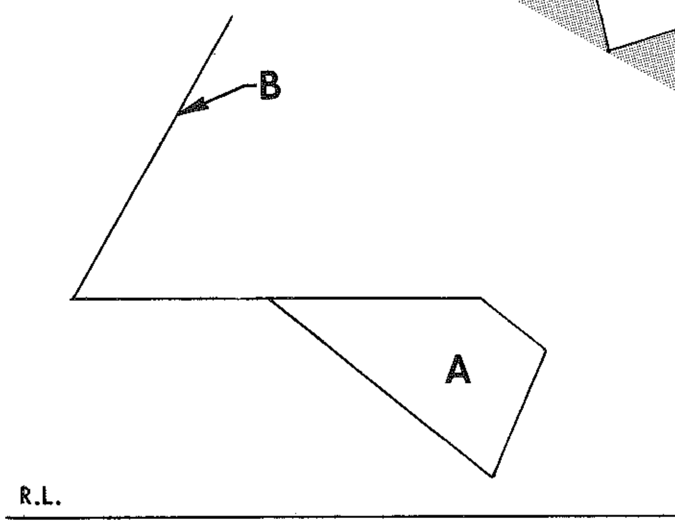


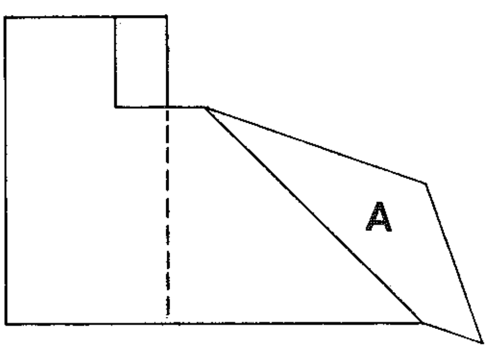
file to file

Many "on the line" teachers have ideas, suggestions, techniques, problems, and questions they would like to share with the society. "FILE TO FILE" provides the place for exchange of professional information. If you have an item for exchange, submit it to "FILE TO FILE," E. D. Black, General Motors Institute, Flint, Michigan.

DRYING FIXTURE DESIGN







CONDITION:

Both surfaces of mounting tab A are coated with a slow drying contact-type adhesive. Design specifications require these coatings to be of uniform thickness. Presently the coatings are applied evenly but they sag and run before drying.

PROBLEM:

How can runs and sags be prevented from forming while the adhesive is drying?

SOLUTION:

Design a simple fixture which will hold tab A in a horizontal position. The part should remain in the fixture until the adhesive is dry.

Any clamps used must exert force on surface B.

FILE TO FILE

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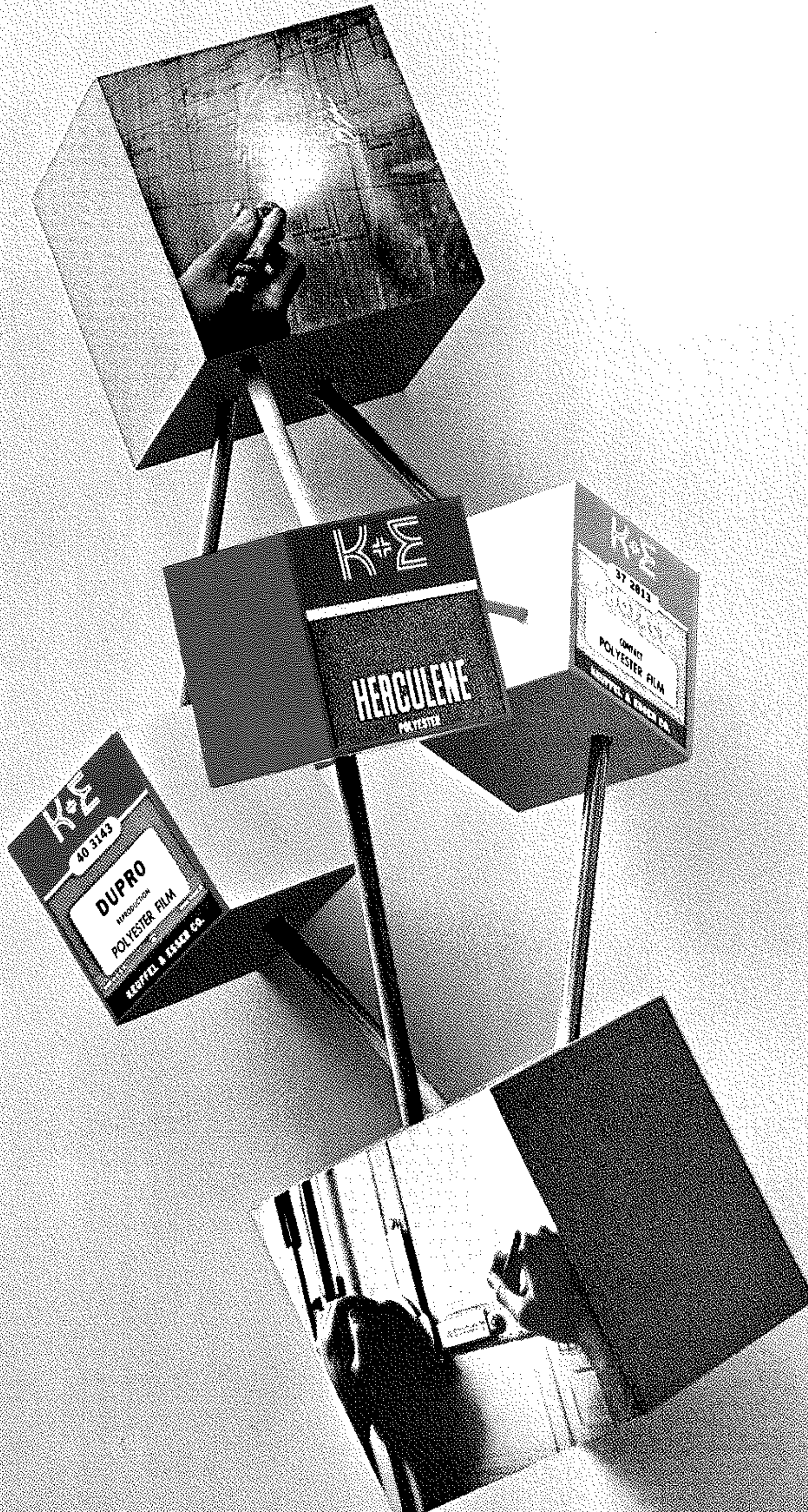


Synthesis:
One solution for two separate problems.

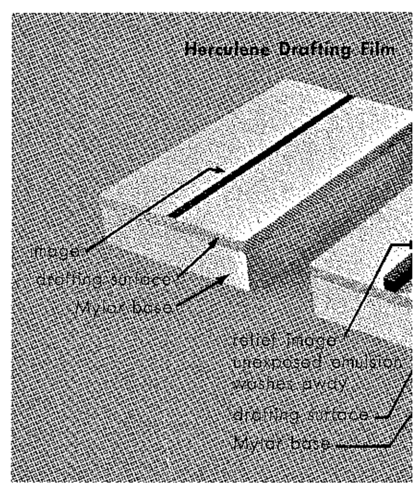
An"Engineered Surface"from K&E strikes the perfec

Working with both drafting and reproduction throughout their modern development, we think of them in a different way than most: we think of them as two parts of a total effort, not as separate or opposing functions. The result is that we study the needs of each in terms of the *total* requirement. It would be easier to isolate the problems of reproduction and solve them without regard to drafting. But this is a compromise we refuse to accept here or in any other area of the creative engineer's needs. We feel such a course violates sound engineering logic. Hence the synthesis.

We did it the hard way—developed what we call the "Compatibles"—Herculene®, Photact®, Dupro® films. These materials are highly complex in conception: a variety of subsurfaces and surfaces that combine to form our "engineered" surface. The result is a systems approach to greater adaptability and a broader dimension of usage in both drafting room and reproduction department.

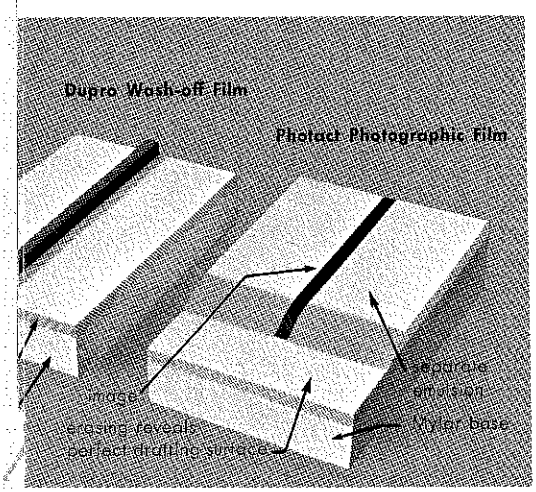
You'll find compatibility of purpose throughout our line of more than 9,000 items. We've mentioned a number of examples of what we mean elsewhere on this page. Each example shows how we take knowledge and experience gained in one area and use it in another to make the products we develop more useful, more versatile than would ever be possible with a limited perspective on the engineer and his problems.

What's the result? Keuffel & Esser takes the drudgery out of the engineer's day. Gives him more flexibility and broader scope in developing his creative ideas. Get full information on any of these products. Just call your local K&E branch or write Keuffel & Esser Company, Hoboken, N.J.



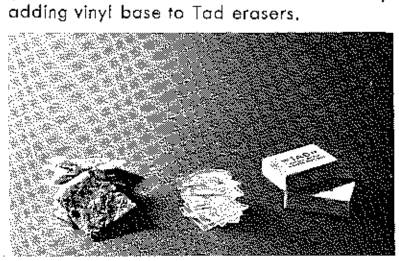
The Compatibles have the same Mylar polyester base, the same flawless K&E engineered drafting surface (in the sensitized products, it's directly under the emulsion). As a result, all

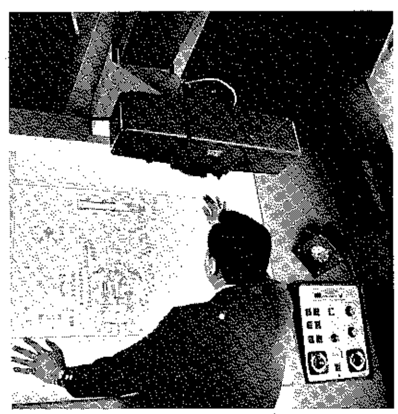
balance between drafting room and reproduction.



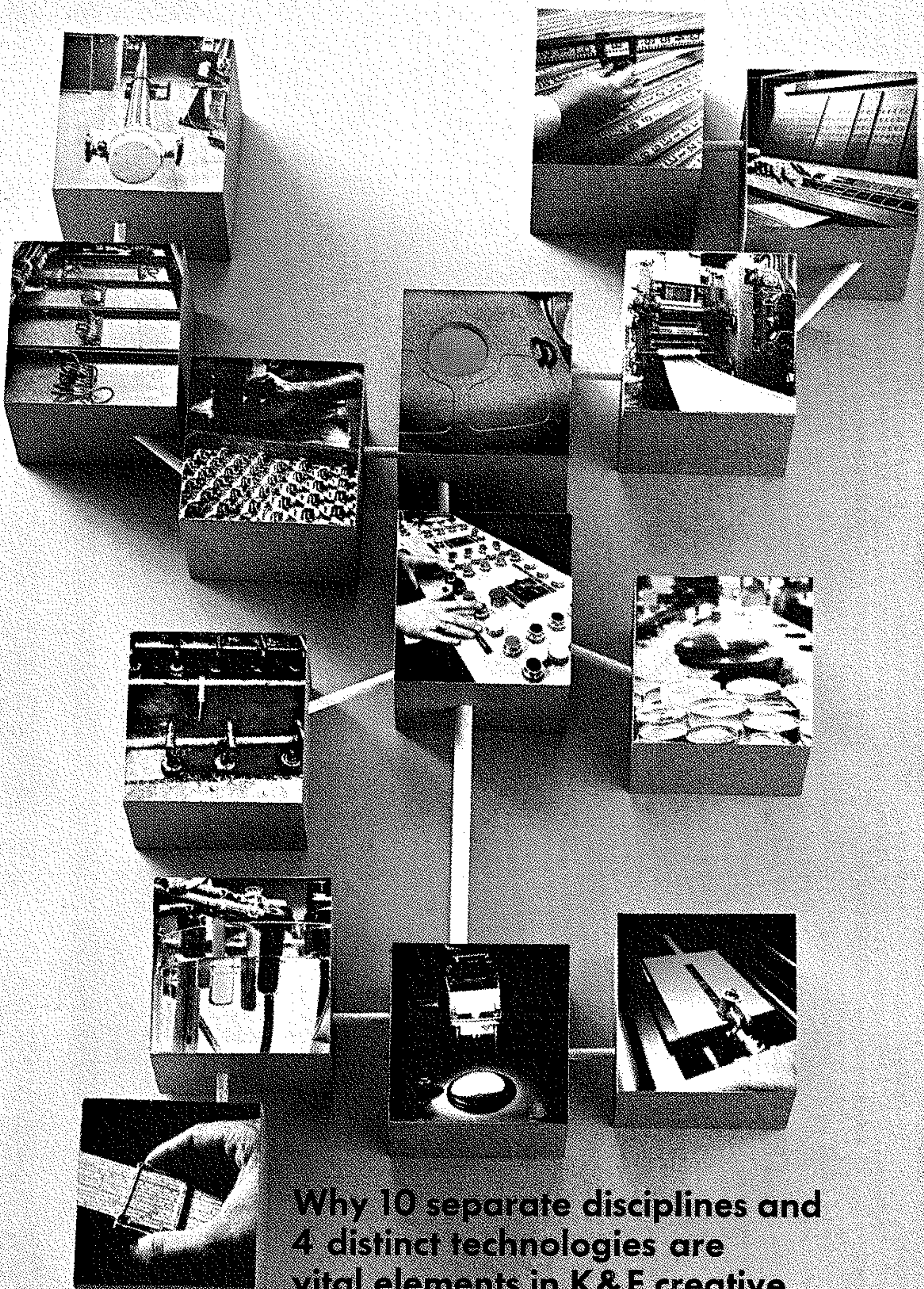
three have the same durability and reliability: accept the same drafting, erasure, contact and microfilming techniques. Draftsman and darkroom operator complement each other with smoother, faster work.

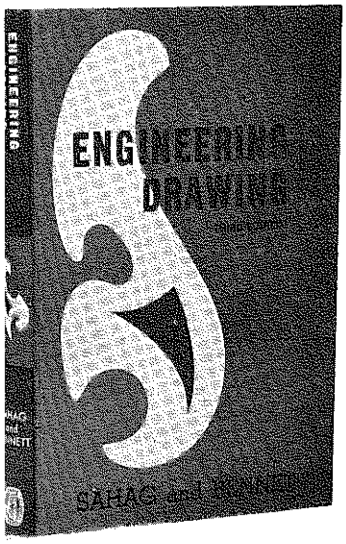
Compatibility in small details—a special combination of plastic and graphite in Ruwe pencils retains graphite "feel" while producing intense blacks on film. Excellent for microfilm or diazo reproduction. Clean, ghost-free erasures on film are obtained by adding vinyl base to Tad erasers.





Microfilming designed for engineers—a rare marriage of experience in drafting and reproduction media *plus* optical know-how (first American optical glass was made at K&E) guarantees that a K&E miniaturization system from camera/projector to viewer/printer meets the most critical requirements of drafting room and reproduction.





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Symmetry in a Four-Dimensional Space

continued from page 24

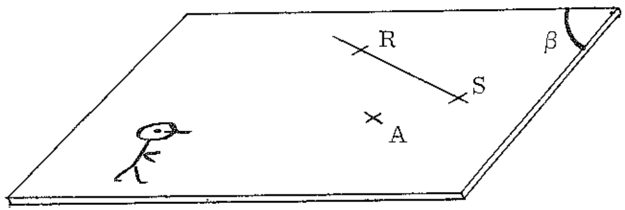

FIGURE 16

Here, a two-dimensional being is aware of points and lines, and by philosophical explanations of the two-dimensional Euclid, Aristotle, Russel, Poincare, etc., he will be aware of the two-dimensionality of his world.

In studying symmetry about a line, he would propose the following problem:

> Given a point A and a point P, in my plane, determine the symmetry of A in relation to a line belonging to P.

Naturally, this two-dimensional being expects to see the symmetry of A and therefore, the line through P, should be a line of his plane. Consequently the expected solution should be that of figure 17.

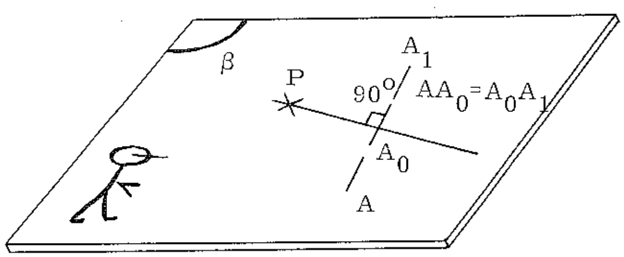

FIGURE 17

However, let us suppose that one of us, decides to give some assistance to him, having in mind that the symmetry of A should belong to his plane but disregarding the fact that he is not aware of a three-dimensional world. In this case, our solution could be that given in figure 18, where the symmetry is obtained in relation to a line belonging to P, but perpendicular to the plane.

The point A_1' belongs to the plane β and is the symmetry of A in relation to a line. However, for our two-dimensional friend, A_1' is nothing more than the symmetry of a point in relation to another. But since he is sure that we would correctly follow his instructions, and therefore give the symmetry of A in relation to a line and not to a point, he also will wonder - "What happened to the symmetry?"

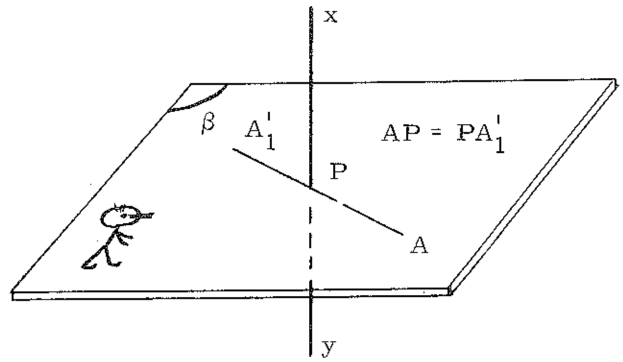

FIGURE 18

To give you an example where this problem of symmetry in the four-dimensional space might be applied is a formidable task. But I will at least attempt to present a crude example and possibly the reader could then be able to compare the elements involved in the example with those real problems with which he has experience.

Assume the planes, α , β , and ρ , so that α β, β V ρ all planes belonging to a given point P of β . Assume next a point A of β and a moving point B, also in β , traveling towards A. The problem is proposed as follows: when B coincides with A, we should obtain the symmetry of A in relation to a plane belonging to P and perpendicular to β .

Then let us accept the fact that we are aware of the plane ρ , even though we cannot conceive its physical relation to β .

Therefore we could expect to obtain the symmetry of A, either in relation to α or in relation to ρ . (See figures 19-a, 19-b).

continued on page 40

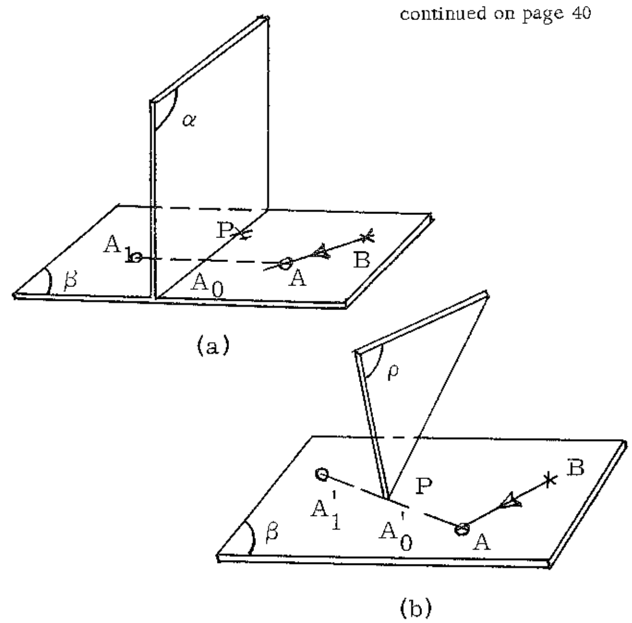

FIGURE 19

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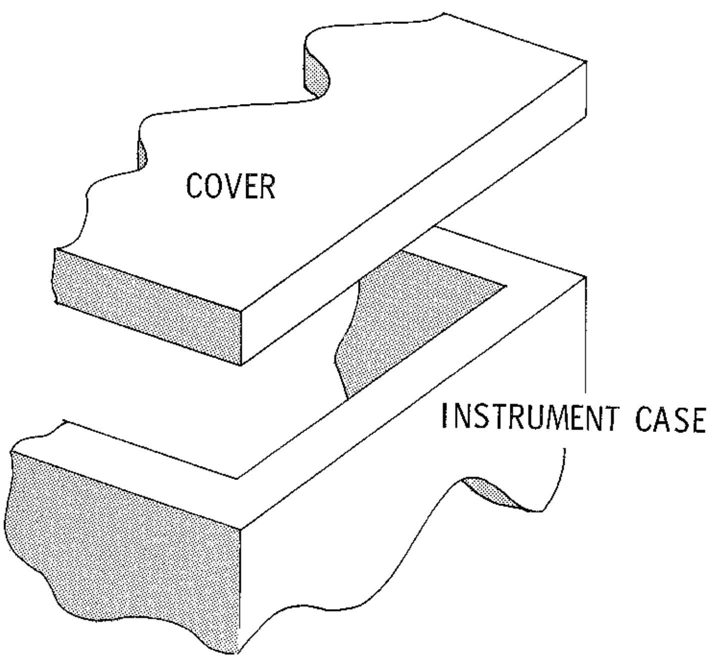
COMMUNICATION OF A DESIGN SOLUTION



To the Student:

Design a hinge and stop mechanism to be attached to the cover and the instrument case. The hinge must permit the cover to rotate from a horizontal position through an angle of 135°. A stop must be provided to prevent further rotation. The stop need not be a part of the hinge mechanism. The cover and case are made of .50 inch thick material, and they are 6.00 inches long in the dimension shown. Machining operations are permitted on both the cover and the case.

The primary purpose of this assignment is to communicate your ideas with freehand drawings.

To the Teacher:

The student should be asked to submit two or more solutions to this design problem. He should be free to choose the type or types of graphical communication to convey his design intent to best advantage.

Between the Itch and the Answer
continued from page 10

Design Education

Engineering design as a discipline is an integral part of the engineering curriculum at General Motors Institute. In turn, graphics is keyed into the design program.

Included among the basic "tool courses" are a four-credit hour course in Graphics for Engineers and a three-credit hour course in Kinematics. The first of these teaches fundamentals of projection through successive auxiliary views (descriptive geometry) and the application of these principles to curved surfaces and static space problems. Kinematics emphasizes the graphical solutions of engineering problems while relating these methods to analytical solutions of dynamic systems. (A typical three-dimensional problem of this nature, also involving descriptive geometry, was presented by Professor Short in the February 1965 issue of the JEG.)

The first course actually labeled design is taken by all sophomores in their second semester. This course, Introduction to Design, will be described in some detail in a forthcoming issue of the ASEE Journal of Engineering Education. Here the student is introduced to design as a discipline and is called upon to use his knowledge of basic sciences, mathematics, manufacturing processes, social studies, and communication. Case histories and outside speakers are employed to emphasize the use of the design process in industry. Also, the students' experience is drawn upon in the course.

The design process is explored in this course from concept to completed design. In addition to methodology, the student is introduced to factors motivating design and factors influencing design. He makes feasibility studies, sketches, preliminary layouts, and at least one completed design including specifications.

After taking Introduction to Design, the student is exposed to higher level mathematics and engineering sciences. These advanced theory courses prepare him for greater penetration and understanding of the design process.

The second stage of design for all mechanical engineering students is a rigorous course in Engineering Analysis at the senior I level. The student analyzes problems generated from real engineering situations and must define the problem, decide which of the many subject areas that he has studied are applicable, select a method of approach, decide what degree of accuracy is needed, and carry out a solution. Problems are devised to draw on his knowledge of mechanics, thermodynamics, fluid mechanics, heat transfer, electricity, and other engineering sciences. Most problems cut across two or more disciplines and are of the "open ended" variety.

A third stage of engineering design is provided in one or more courses in applied design in a particular option (e.g., processing, automotive, heat transfer). Those who are quick to criticize "applied" courses should understand that these are not old "rule of thumb" exercises. In a brief course in gas turbine design a student will not only make use of his thermodynamics, fluid mechanics, statics, and dynamics but will also learn something of gas dynamics as he studies nozzle design, fatigue considerations in blade design, and material limitations in cycle analysis. He will not be an expert in gas turbine design, but he will have been introduced to the subject and will have had the opportunity to explore some of the basic problems.

During this final stage of his program the student will produce a design. He will not detail all -- and perhaps not any -- of the parts. He will, however, follow the design process through the sketching and layout or preliminary design stage. He will be called upon to defend his decisions, support the major specifications, and communicate these to his fellow students and the faculty. He makes use of material not found in textbooks and may contact experts in particular areas. Parts may be fabricated to his specifications and he will perhaps run laboratory tests to determine needed data. He must exercise his own creative abilities.

Integration of Graphics

The intent of this article thus far has been to show: (1) Engineering design as a rational discipline practiced in industry; (2) Graphics as an integral part of the design discipline; and (3) A program of engineering design education incorporated into an engineering curriculum. The task remaining now to complete this pattern is to discuss the place of graphics in the education program.

As indicated in the previous section, graphics is taught as a course to freshmen and then used to solve problems and communicate ideas in other courses. Subject matter which can be classified as graphics is also included in a sophomore course in design. This represents a break from tradition and provides an opportunity for more effective learning through better student motivation.

The single course in Graphics for Engineers at the freshman level was organized to provide students with a better understanding of spacial relationships and an ability to use this knowledge in design and other problem solving activity. Included as topics are standard orthographic projection, sectional and assembly views, successive auxiliary views and applications of descriptive geometry. Points and lines of intersection, application of principles of revolution, the use of grid lines and the description of contoured surfaces are a part of this course. This course is lean and tough. Freehand sketching is used extensively and emphasis is placed on understanding rather than skill. The importance of accuracy for graphical solutions is not neglected, however.

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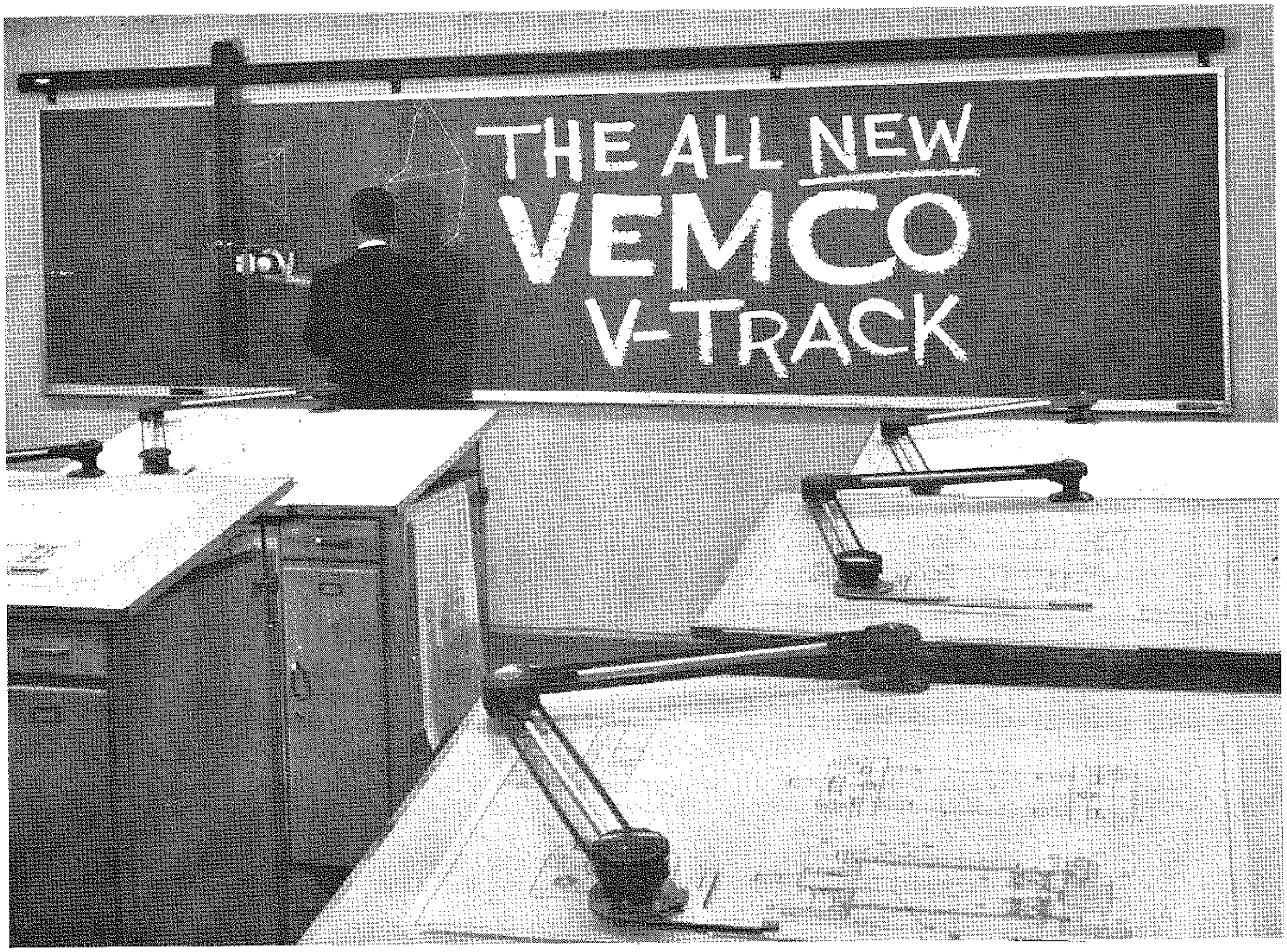
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Between the Itch and the Answer
continued from page 36

The students take up the problems of design representation and specification at the point of need. Surface finish, assembly fits, hardness, methods of joining and fastening, etc., will now have meaning as a result of previous courses. The need to establish valid tolerances will be apparent and methods of doing so can be discussed at close proximity to their use.

Closure

At the Second Conference on Engineering Design held at UCLA in September, 1962, Professor J. Morely English, at that time on leave from UCLA, made a rather emphatic statement regarding graphics. As a result of his then current activity as manager of an industry producing items items for the space program, he protested vigorously "the absurdity of eliminating drawing from engineering curriculums." "Graphics remains," he said, "the life blood -- the essential communication method -- of industry." Only a few of the most dedicated will deny, however, that untold hours of student time were expended over drawing boards in past years of engineering education on activities of extremely low productivity in learning.

An itch is defined in one dictionary as a sensation causing a desire to scratch. If the analogy is taken beyond the realm of epidermal irritations, then the scratching can be interpreted in terms of an answer to a problem.

Engineering is an activity devoted to the adaptation of man to his environment and environment to man. The profession of engineering forms an environment itself within which its practitioners must adapt themselves. Schools of engineering have some responsibility toward assisting in this adaption. No one knows all the problems -- certainly not all the answers.

Integrating graphics into a design program provides for exploration, analysis and communication. Scrutiny and judgment by the users -- the teachers of design -- are required. Graphics becomes an active associate rather than being isolated as an atrophied appendage. A team-teaching approach is needed in which both the graphics teacher and design teacher either grow to understand each other better or become, in effect or in reality, one man.

COMMON SENSE is instinct. Enough of it is genius.

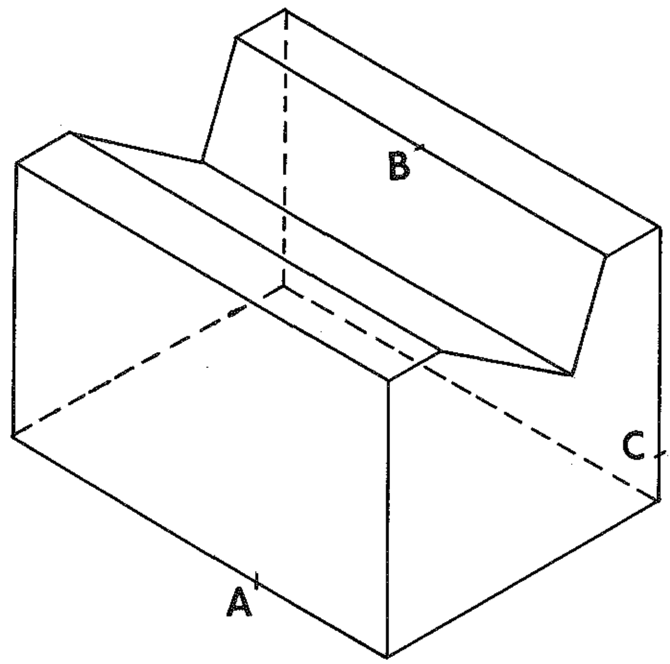
George Bernard Shaw

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.



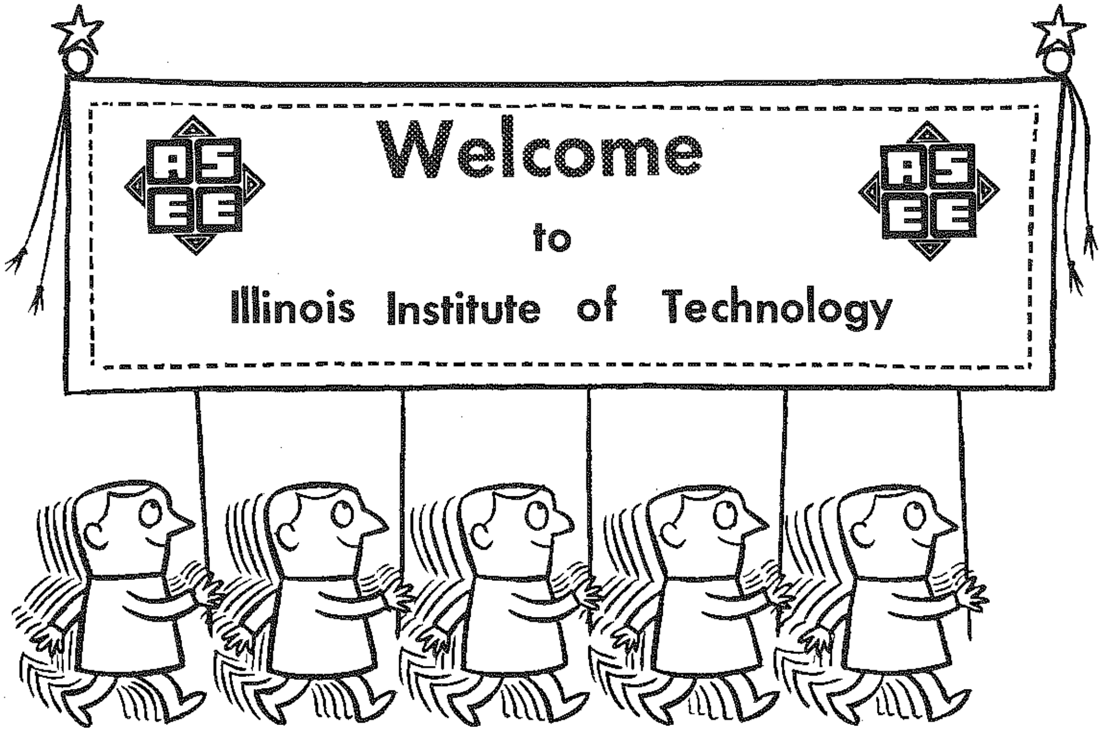
Symmetry in a Four-Dimensional Space
continued from page 32

First for the sake of clarifying the example suppose that there is a velocity v, which we shall call "critical" (it could perhaps be the electrical charge of the point, or its mass, etc., etc.), and that the following was being observed:

for every velocity $\underline{v_1 < v}$ the symmetry of A is obtained in relation to α, and for every velocity $\underline{v_1 > v}$ the symmetry of A is obtained in relation to ρ.

Then, by using this method we could separate two groups of points B of β: those with a velocity greater than $\underline{v}$ and those with a velocity less than $\underline{v}$, by the simple observation of the position of symmetry of the point A.

If all points Bs are those that supposedly obey a certain law, then by this process we will be able to point out those that do and those that do not obey the said law.



The Illinois Institute of Technology is pleased to serve as host for the 73rd annual meeting of the American Society for Engineering Education on June 21-25, 1965. This ASEE meeting with its theme of "World Wide Engineering Education," promises to be of particular significance for many delegates from other countries are expected to attend the World Congress on Engineering Education in conjunction with the convention.

Chicago, the site of the 1965 ASEE meeting, is the second largest city in the United States, the fourth largest in the world. Its major airport O'Hare Field is the busiest in the world, and the city is the world's greatest railroad center. Chicago is readily accessible by bus, car, private plane and boat. The City is also famous for its lake front, museums, theatres, restaurants, sports events and outstanding educational institutions.

Illinois Tech is a privately-supported, independent, coeducational institution offering undergraduate and graduate programs in engineering and engineering graphics, the physical and biological sciences, the social sciences and humanities, business management, industrial design, architecture, and city planning. The university, with its research affiliates, ranks third in the nation among all technological institutions in combined expenditures for education and research.

The IIT campus, which covers 24 city blocks, is located thirty blocks south of Chicago's Loop and adjacent to the Dan Ryan expressway. The overall plan of the IIT campus was created by the world-famous architect, Ludwig Mies van der Rohe, who headed the department of architecture for nearly twenty years. He designed a number of buildings on campus including Crown Hall which has been cited as an "immortal contribution to the architecture of Chicago and the world."

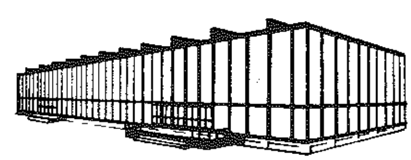
The total enrollment at IIT last fall was 7,823 including 6,097 undergraduates and 1,726 graduate students. Of this total 2,569 were day students and 5,254 were evening students. Some 40 states and 51 countries were represented in the student body.

The headquarters for the ASEE meeting will be in the new Hermann Union building. The facilities of this building plus the other new buildings on campus will provide excellent accommodations for the luncheons, dinners, and sessions.

The Technical Drawing department staff is pleased to welcome the annual ASEE meeting on campus and we wish to extend a special welcome to our many friends in engineering graphics. We wish to urge everyone to attend the fine program and entertainment planned for the delegates and their families. Make your reservations now for a week of business and pleasure in Chicago and while you are on campus we do hope you will visit with us in the department.

See you in June at IIT.

I. L. Hill, Director
Technical Drawing
Department



DEPARTMENT OF TECHNICAL DRAWING

A MATHEMATICAL METHOD FOR THE CONSTRUCTION OF AN ELLIPSE

by

Ralph T. Northrup, Department Head
Department of Engineering Graphics
Wayne State University
Detroit, Michigan

Many technical papers have been written and many seminars have been held emphasizing the need for teaching graphics from an integrated viewpoint. The mathematical method for the construction of an ellipse accomplishes in part this mission.

The four methods most frequently presented in textbooks are the "Pin and String Application," the "Trammel Method," the "Concentric Circle Method" and the "Conjugate Diameter Method." Each of these methods approach the solution strictly from a geometric construction application.

The "Mathematical Method" produces an ellipse whose shape and form is equal to or better than any of the previously enumerated methods. The writer feels therefore, the method discussed in this article is worthy of consideration since it not only employs the activity of graphical construction but also the application of mathematics.

Let us assume a right circular cylinder with its axis in a vertical position is intersected by an inclined plane whose slope angle is greater than zero (0) degrees and less than ninety (90) degrees. The resulting cross section obtained will be an ellipse.

The "Mathematical Method" requires the designer or draftsman to use the values of the trigonometric functions of the slope angle of the intersecting plane in order to accurately construct the ellipse. The relationship between the major and minor axes of the ellipse and the secant of the slope angle of the intersecting plane is:

$$\frac{\text{Major axis}}{\text{Minor axis}} = \left\{\begin{array}{l}\text{secant of the angle of the} \\ \text{intersecting plane}\end{array}\right.$$

The several values required for the radii used in the construction may be calculated when the slope angle of the intersecting plane and the radius of the major or minor axes are known. The necessary dimensions for the construction may be determined using tables showing the values for natural sine, cosine, tangent, secant, square and square roots of members, or the required values may be calculated mathematically.

Figure I shows the several radii used in the construction and the location of their centers.

Before starting the construction, the engineer or draftsman should decide the length of the radius of either the major diameter or minor diameter of the ellipse and the slope angle of the intersecting plane.

It will facilitate the construction work somewhat, if the required lengths of each of the radii are arranged in table form as shown below.

Table of Required Values Used for Constructing Figure I

1. Angle $\theta = 63^{\circ} - 30'$

2. R = (Radius of minor axis of the ellipse) = 1"

3. R_1 = (Radius of major axis of the ellipse) = 2"

4. $R_2 = R\sqrt{\text{Secant of the slope angle of the intersecting plane}} = 1.496"$

5. $R_3 = 0I \times \sin\theta = 4.010"$

$$\text{Length of } 0I = \frac{CO}{\cos\theta} = \frac{2.000"}{.4462"} = 4.482"$$

$$\text{Length of } CI = 0I \times \sin\theta = 4.482" \times .8949" = 4.010"$$

6. $R_4 = \frac{OB}{\tan\theta} = \frac{1}{2.005"} = .4995"$

7. $R_5 = R_2 - R_4 = 1.496" - .4995" = .9965"$

8. $R_6 = R_3 - R_2 = 4.010" - 1.496" = 2.514"$

In Figures I & II, the writer represented an ellipse whose slope angle of the intersecting plane was equal to sixty-three degrees and thirty minutes. $63^{\circ} - 30'$.

In constructing the "Mathematical Ellipse" one may proceed in part in a similar manner as when using the "Concentric Circle Method." The important difference in this procedure is that each of the several radii used in the construction of the ellipse have been calculated mathematically and are drawn using the compass, in place of drawing the ellipse through a series of derived points as in the "Concentric Circle Method."

When graphically representing elliptical springs, tanks, arches, etc., the designer or draftsman may employ this method for communicating his representation to others.

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Construction Procedure

1. Draw a horizontal axis line (AB) of sufficient length such that points (A) and (B) respectively may be obtained as the limit points of the major axis of the ellipse as shown in Figure I.

2. Construct a vertical axis line (CD) perpendicular to the horizontal axis line (AB) at its mid-point (E). The vertical axis line should be of sufficient length so points (H) and (I) may be located.

3. Using the point (E) as determined by the intersection of the major and minor axis lines, construct two concentric circles, one to represent the minor diameter and the other the major diameter of the desired ellipse.

   The points where the major diameter circle intersects the horizontal axis line are labeled as points (A) and (B) respectively. Points (C) and (D) are located respectively on the vertical axis line where the minor diameter circle intersects the vertical line above and below the horizontal axis line. See Figure I.

   (In this construction a radius of 1" was used for the minor axis and a 2" radius for the major axis).

4. Construct a horizontal line tangent to the minor axis circle at point (C), and a line tangent to the major axis circle at (B). Extend these two tangent lines until they intersect at point (O).

5. Connect points (C) and (B) with a straight line.

6. From point (O) construct a line perpendicular to line (CB) and extend it until the line intersects the vertical axis line. This perpendicular line will locate two centers (G) and (I) respectively and the angle theta (63^{o} - 30') in Figure I. Angle theta is employed in determining the several radii used in constructing the ellipse. Figure I.

   If the same procedure is followed for the lower left segment using a line (AD) and a perpendicular from point (P) centers (F) and (H) can be found.

7. Using a measurement equal to R_4 (.4995") and centers (F) and (G) construct arcs tangent to the major diameter circle at points (A) and (B) respectively. These two arcs will form the extremities of the major axis of the ellipse.

8. With points (H) and (I) as centers respectively and a radius of R_3 (4.010") draw arcs tangent to the minor circle at points (D) and (C) respectively. These two arcs will form the minor part of the ellipse as shown in Figure I.

9. Using points (H) and (I) respectively as centers, draw bisecting arcs (R_6) whose radius in each case is equal to 2.514".

10. Using points (F) and (G) respectively as centers and with a radius equal to (R_5) (.9965") draw the bisecting circle arcs so as to intersect the two previous arcs drawn in step (9) above. These two arcs will locate four more center points (J), (K), (L), (M) to be used in constructing the ellipse.

11. Using the center points (J) and (K) respectively and with a radius equal to the value of (R_2) (1.496") construct two circle arcs tangent to the (R_3) and (R_4) arcs respectively to enclose the lower part of the ellipse.

    In a like manner use points (L) and (M) to enclose the upper part of the ellipse.

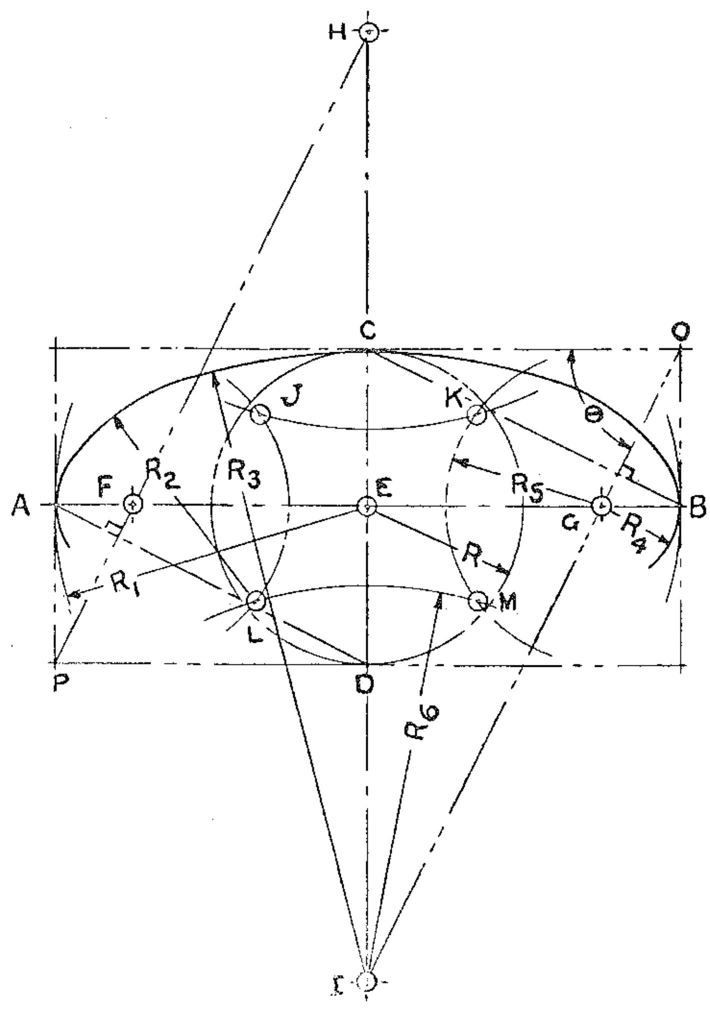

Figure 1

continued on page 48

Be Susceptible to the Graphical Approach

Douglas P. Adams, Associate Professor
Mechanical Engineering
Massachusetts Institute of Technology

You can say what size and shape you wish an object to have, or you can write it with algebraic symbols, or you can draw it -- these are the chief ways of communicating dimensions and relationships which will specify what these quantitative properties should be. Computers don't object to your doing this. The analog computer has always been a patron exclusively of graphical output -- the continuous line that tells how large something is and what shape it has. The digital computer has revolutionized techniques for carrying through limitless difficult algebraic relations and emerging with answers. Happily, one of its most recent and popular developments is the attachment of a graphical output-plotter which can take the prodigal numerical values and draw that simple, continuous graphical representation these values imply, permitting rapid assimilation, interpretation, and quick design decisions. An inverse relation exists also, since graphical processes lend themselves to both digital and analog computer procedures. These graphical steps frequently make a natural flow diagram and programming sequence toward the solution for these procedures.

So graphics is no mere handmaiden of algebraic processes. It stands in its own right as a major communicant of the quantitative message and a purveyor of computational art. Engineering drawing and descriptive geometry are but two tiny plots within its broad holdings. For instance, much of the thinking and programming of plane and space kinematics has always been and continues to be graphical. Even where its modern analytical tools become as abstruse as involved matrix techniques, motor algebra and dual quaternions, the graphical method forms the underlying conceptual tool guiding the formulation of the problem and motivating the sequence of steps taken.

Can graphics as a modern tool find completely new outlets of expression, new media for development, new philosophies of attack? The countable bit is one such item in that big, new wing of the arsenal of graphical weaponry. This little mite, when counted singly, in cumulative and sometimes weighted form, by the ten millions per second, gives a convenient way of expressing relationships easily handled by electronic servants. This technique is as truly graphical as a sine curve. I have described its power in nomographic-electronic computation in previous issues of the Journal.

Breadth of interest, greater comprehension and the use of ever new techniques is the nutriment on which progress in graphics must ultimately be sustained. The secret of its advance will lie in the command by graphics practitioners of wider and wider areas revealing from day to day new susceptibility of their problems to the graphical approach. He who will carry a torch for the graphical approach will find illumined in innumerable crannies and along many major avenues new topics susceptible to it.

Walter F. Downey, Headmaster of historic Boston English High School, blazoned in many places the school slogan, "Service to Mankind is Honor and Achievement." Graphics is a broad and wonderfully effective service subject, and whoever advances its frontiers will find in his labor honor and achievement.

Research in Engineering Graphics

continued from page 16

Professor Ernest C. Schamehorn of West Virginia Institute of Technology has gathered an impressive wealth of information that will contribute to the future of graphics. It is a study of the opinions of engineering graphics educators, engineering educators of degree-granting departments, and practicing engineers concerning the content of engineering graphics courses.

SUMMARY

Research of the type reviewed in this report will help engineering graphics departments remain current and progressive in offering programs that will contribute in the fullest to the engineering curriculum. The study of engineering graphics problems should be an integral part of a department's yearly activities. Rapidly changing advancements must be constantly evaluated. The pooling of data from a number of departments would reinforce the findings from individual departments thereby providing a solid, reliable foundation for the modification of philosophy and content.

No research can be conclusive without constant revision and scrutiny. All areas of research mentioned have merely scratched the surface of the total problem. The cooperation of every engineering graphics department is needed before we have done our best.

EDITORS NOTE:

This article is a talk given by Professor James H. Earle at the Annual ASEE Division of Engineering Graphics held at the University of Maine, June 22-26, 1964. He compares research studies made in engineering graphics by members of the teaching staff at Texas A&M University and summarizes studies made by Professors Amogene F. DeVaney, Amarillo College; Clayton W. Chance, University of Texas; Robert P. Borri, University of Illinois; and Ernest C. Schamehorn, West Virginia Institute of Technology. The objective of the article is to help engineering graphics departments remain current and progressive by offering programs and courses that will contribute in the fullest to the engineering curriculum. E.D.B.

Interim Report of the Future Development Committee

Presented at the Graphic Division Mid-Year Meeting
Tampa, Florida, January 1965

The Committee wishes to concur with recent studies which point to a re-emphasis of the fact that the engineer's function is basically that of design and, furthermore, to point out that design is not practical without some knowledge of graphics. Communication in the engineering design and production process is indispensable.

In his relationship to the design and production process, the engineer should be an "idea man." Fundamentally, creative ideas are generated through the medium of graphics.

Everything we teach in the design context in engineering may be taught in the creative sense. In helping the student to think creatively in design concepts, we may, perhaps, cover less of course outlines than we have in the past. The principal idea is to encourage the student to recognize the process by which decisions are reached.

For the most part, skills are out. Those which are essential to the functioning of a course should be taught with a sense of quality rather than a sense of technique. In the teaching of our classes, we should be guided by the fact that in essence we should be teaching fundamental design principles and imparting to the student the attitude of the "graphic mind." In the teaching of design principles, we should bring out the fact the geometric configuration influences the function of whatever we are designing.

As we look toward the future, the Committee feels that we must recognize from developments such as are going on at M.I.T., General Motors, and Ford in computer-aided design that it is not too far off when the engineer-designer will be wedded directly to the computer drawing board. Under such circumstances, we will be concerned with our engineering graduate having a deeper understanding of and the ability to think graphically in his generation of new ideas which will benefit mankind.

The Committee wishes to call attention to some of the current research being conducted across the country, as reported by members of the Committee:

IOWA STATE UNIVERSITY

A program drafting machine that has been under development has recently undergone a streamlining. Detailed information concerning it will be ready for release a little later this year. By means of this machine, an individual can punch out a drawing similar to the fashion in which one plays a piano.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Contunued development by Professor Coons of the Computer-Aided Design Project: "Sketch Pad."

PENNSYLVANIA STATE COLLEGE
(Four Projects Being Conducted)

One, selection of a faculty of distinction; each member should be expert in a field peripheral to, yet, allied with, graphics. Currently, they have the nucleus of a computer-graphics oriented staff. This faculty will be supplemented by distinguished visiting professors.

Secondly, the establishment of a program of visiting lecturers to be recorded on video tape for further instruction of students and faculty. Under this program, regular staff members have also been taped.

Thirdly, the encouragement of the development of baccalaureate and associate degree programs which will serve as models of the integration of an introductory design in graphics.

The fourth item, a definite program of high school -- technical institute -- college cooperation, coupled with teacher training.

TEXAS A&M UNIVERSITY
(A Number of Research Projects in Progress or Completed)

Two studies, one completed and the other currently in progress, dealing with instruction in descriptive geometry. The study completed in the spring of 1963, involving some 2,840 samples, evaluating the effectiveness of programmed instruction principles in the teaching of descriptive geometry, has revealed that a step method, in two colors, to distinguish between the various steps of the problem solution, was 5 - 10 per cent more effective than other more conventional methods. The second study was concerned with the development of a self-grading problem format, enabling a student to solve his descriptive geometry and grade himself.

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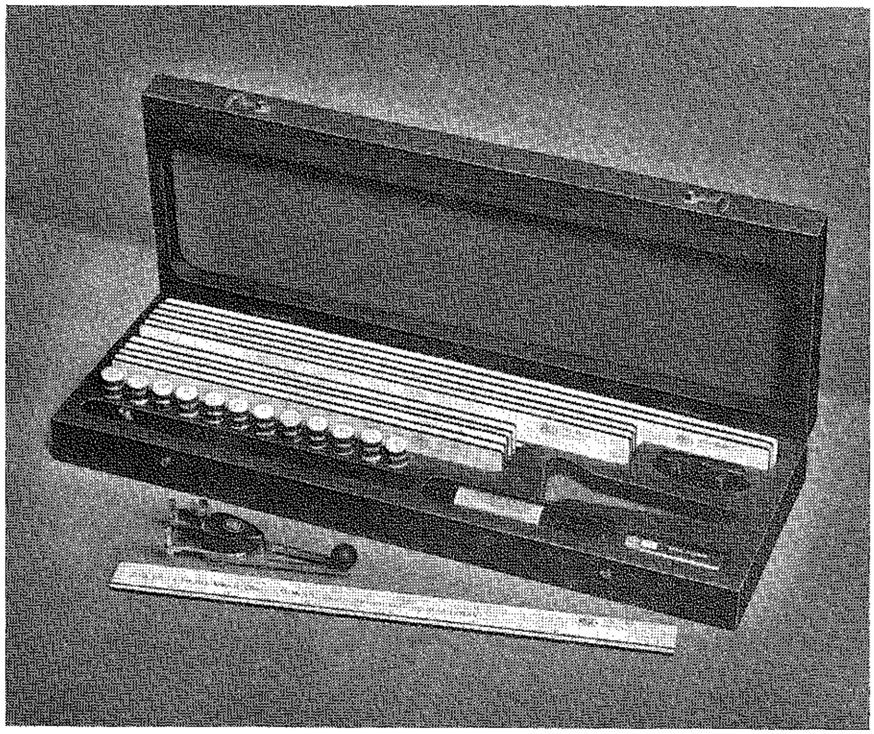
DRAFTING TRENDS



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LETTERS TO THE EDITOR

continued from page 4

Dear Editor:

When I received your letter of November 20, I almost declined your invitation to submit an article for publication.

The nature of my work at the University has changed and I seem to be getting further away from graphics. I thought it best to leave most publishing to younger people or to some of our colleagues who are beginning to make themselves heard. In short, I felt it best to fade away gracefully.

A few days following receipt of your letter, I received the Journal and the word "Perspective" gave me an idea which I thought appropriate to the column. It is enclosed.

As to suggestions for writers, I believe you should ask Steve Slaby of Princeton to give his views on the more advanced aspects of graphics; Paul Reinhard of U of D to write the results of his experiments at U of D involving Design and Computers; HowardPorschof Purdue to interpret and possibly give us a little insight into the study of the Goals of Engineering, which is currently directed from Purdue and sponsored by ASEE. Earl Black might contribute something about the program at GMI, since their objectives are quite unique and graphics at GMI would, of necessity, be quite different than at most universities. Roy Trowbridge might contribute an article on the "Inch versus The Metric System." Nothing along this line has been published in the Journal.

Please call on me if you feel I can help further.

Sincerely,

J. Geradi, Associate Dean
University of Detroit

Editor's Note:

Dean Gerardi's article "New Graphics" appears in this issue of the J.E.G. His request for something about the program at General Motors Institute is answered in the article by William H. Lichty - "BETWEEN THE ITCH AND THE ANSWER."

It should be noted that the objectives for General Motors Institute are very similar to other engineering colleges operating on the cooperative plan.

E.D.B.

Useful designs cannot be produced by calculations alone.

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12. Figure II shows the completed ellipse without the radii representation. Employing this method of construction, eight center points are used in the construction in place of a lesser or greater number of points as used in other constructions. With practice this method offers a simple and accurate procedure for drawing an ellipse.

The author wishes to acknowledge his indebtedness to Mr. Nathan L. Pavis, an alumnus of the Ecole Special des Travaux Publics et due Batiment de Paris, France and who for many years worked as a designer for the Standard Steel Spring Company of Detroit, for the idea and method of constructing an ellipse using a mathematical method.

E. V. Huntington shows part of this construction, but used a geometric method in place of a mathematical one, in the Handbook of Mechanical Engineers by Lionel S. Marks, 4th Edition, McGraw-Hill Book Company, Page 143, Article 3.

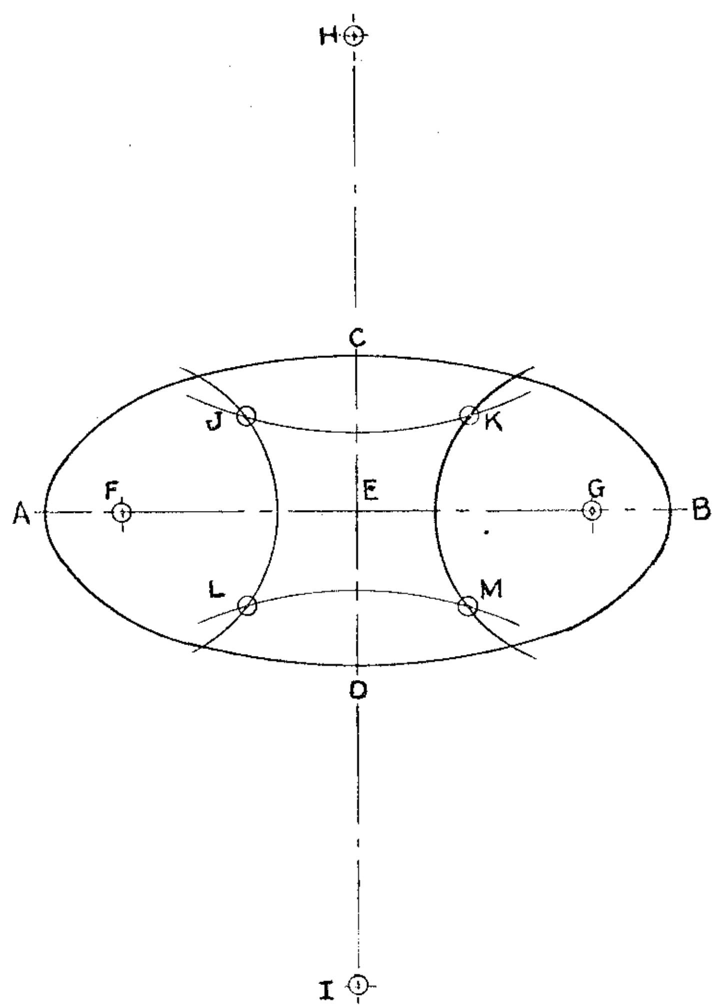
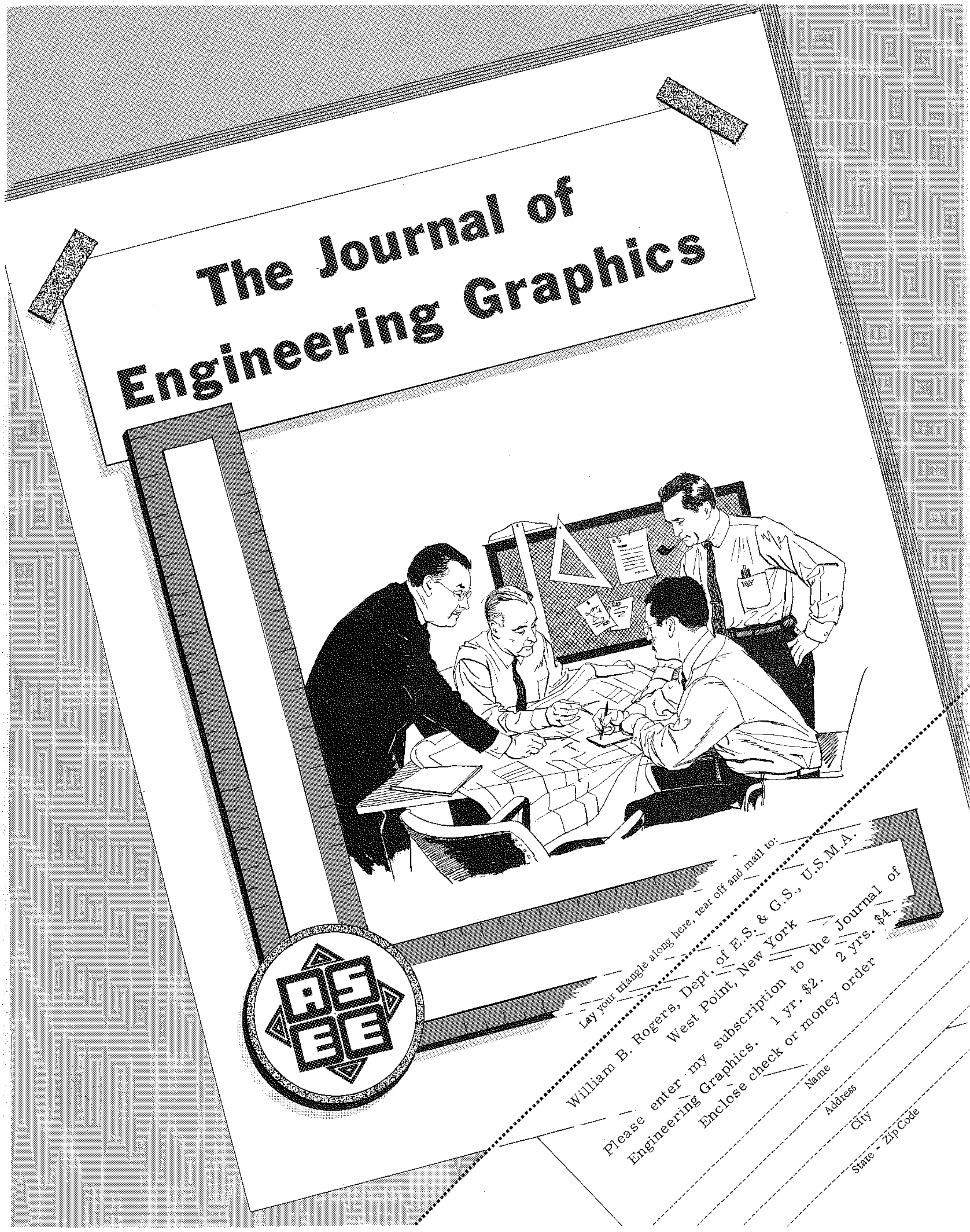


Figure 2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College faculty members can encourage high schools to upgrade their mechanical drawing courses to pre-engineering courses for college bound seniors.

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- **Auxiliary orthographic reference planes.**
- **Orthographic lines and planes.**
- **Developments.**
- **Freehand sketching.**
- **Isometric drawings.**
- **Oblique drawings.**
- **Detail drawings.**
- **Sectioning.**
- **Dimensioning.**
- **Manufacturing processes.**
- **Logarithmic and linear scales.**
- **Making linear graphs.**
- **Making semi-logarithmic graphs with a uniform abscissa.**
- **Making semi-logarithmic graphs with a logarithmic abscissa.**
- **Making full logarithmic graphs.**
- **The slide rule.**
- **Applications of logarithms.**
- **The vernier.**
- **Orientation to science.**
- **Orientation to engineering.**

Such topics as care of instruments, lettering and geometric constructions are considered by-products of the above.

- **FOR FURTHER INFORMATION** and details of the program, please contact Dr. William Huss, State University College, Oswego, New York or Professor Myron G. Mochel, Clarkson College of Technology, Potsdam, New York.

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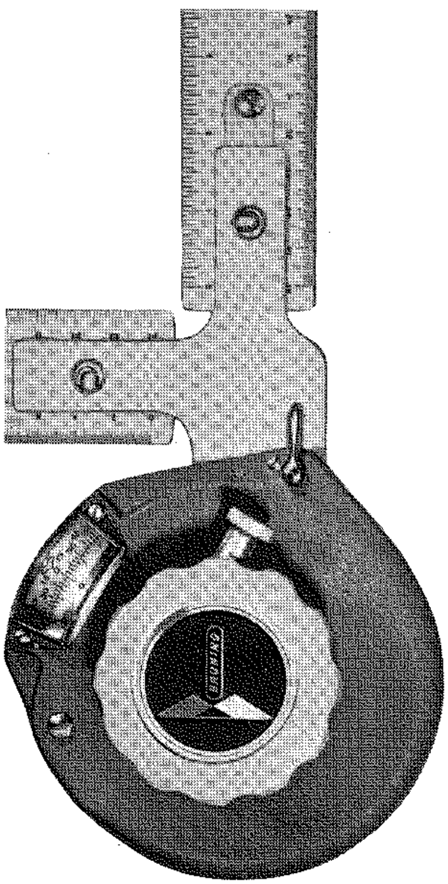

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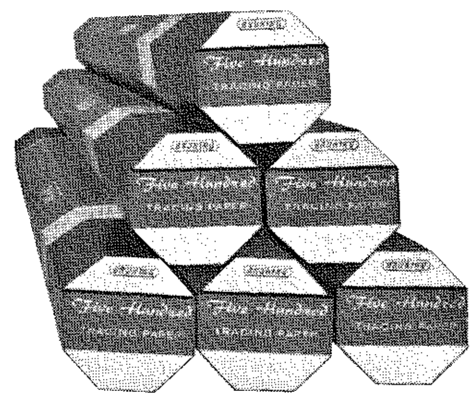

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Interim Report of the
Future Development Committee

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Three projects, one completed and the other two under investigation, concern an evaluation of high school drawing. The completed study, in which 634 students were tested, was made to determine the value of high school drawing with respect to college performance. The findings of this investigation reveal varied information that will be helpful to colleges and high schools in better serving engineering graphics students. The other two studies currently in progress in this area consist of an investigation among high school drawing teachers to determine what factors are used in grading drawings and a correlation of this information with the backgrounds of the individual drawing teachers; the third study seeks to determine the emphasis being placed on each of the subject areas taught in high school drawing courses.

In still a third area, there is currently being conducted a survey of industry to determine the needs of industry for draftsmen, and from this to determine course content.

INDUSTRIAL ACTIVITY

On the industrial level, forward strides are being made at such industrial location as Boeing Aircraft Corporation (Seattle), General Motors (DAC I Project), California Computer Products, and Ford in the development of computer-controlled displays and in the field of computer-aided design.

The Committee would also like to call particular attention to the ENGINEERING GRAPHICS MONOGRAPH SERIES being published by McGraw-Hill under the coordinating editorship of Professor Steve Slaby of Princeton Universtiy. This series is an outgrowth of the Engineering Graphics Course Content Development Study, recently supported by the National Science Foundation during the period 1961-64. The seven monographs conform to one of the objectives of the Study, which was to explore and develop course material which would enrich the educational experience of all engineering students. The Future Development Committee recommends these monographs to the attention of the Division, both as to their effect as teaching aids and to the stimulation which they will afford to continuing exploratory research in the field of engineering graphics as a tool of design, analysis and engineering communication.

C. P. Buck
Syracuse University
Chairman

IN MEMORIAM . . . . .

PROFESSOR HERBERT DENNY ORTH

It is with sadness that we announce the death of Professor Herbert Denny Orth, College of Engineering, University of Wisconsin on February 5, 1965. Professor Orth would have been 80 years old this September 15. He attended Terre Haute Public Schools, Rose Polytechnic Institute from which he received his B.S. degree. He was listed in Who's Who in Engineering and was a member of Pi Tau Sigma. He was Head of the Department of Drawing at the University of Wisconsin (until his retirement). He was a life member of ASEE having been a member since 1910. He was co-author of "Basic Engineering Drawing" and "Problems in Engineering Drawing."

The Division of Engineering Graphics extends its sincere sympathy to his family and many friends.

PROFESSOR CHARLES ELMER ROWE

Professor Charles Elmer Rowe died at his home in Austin, Texas, March 20.

Professor Rowe went to the University of Texas as Instructor in Mining Engineering in 1905 and began teaching graphics courses in 1912. He remained a member of the staff of the Drawing Department until his retirement in 1960, and was Professor Emeritus at the time of his death. He served as chairman of the department from 1927 to 1932, and again from 1937 to 1941. From 1944 to 1950 he was assistant dean of the College of Engineering. Professor Rowe was well known and respected by the older members of the Graphics Division of A.S.E.E. and was the recipient of the Distinguished Service Award in 1959.

The Division of Engineering Graphics, A.S.E.E., owes much to Professor Rowe and extends our heart-felt sympathy to his family and friends.

Trisection Flaw . . . .

John T. Rule
Department of Mechanical Engineering
Massachusetts Institute of Technology

A note on the winter issue's interesting variant on the angle trisection problem. I've been plagued for years by the useless disease of finding for myself the error in the solutions of all angle trisectors. This one is exceptionally good in its disguise. However, just to keep the record straight!

The statement of the solution in the Journal assumes that the distance SR is equal to twice the distance CB. This follows from the fact that CB is the radius of each of the three circles since it is the radius of the one centered at R; and from the fact that SR is the line of centers of the first two circles. This is a completely unproved assumption and invalidates the entire construction from the Euclidean point of view. Let us call the distance EF = FD = 1.

Then r, the radius of the 3 circles = 2; KM = 6.

Let $\angle$ ROM = α

Then $\angle$ AOM = 3α if the trisection is correct.

The construction is then only valid if the arc centered at 0 through R and S intersects the line KM at a point N such that NM = 5.

Let us establish a formula for the distance NM where N is the point of intersection of KM with the arc.

$$NM^2 = r^2 = \overline{OM}^2 \quad (1) \text{ Pythagorean Theorem}$$

$$\tan\angle KOM = \frac{KM}{OM} = \frac{6}{OM} = \tan 3\alpha$$

$$OM = \frac{6}{\tan 3\alpha} = 6 \cot 3\alpha \text{ or } OM^2 = 36 \cot^2 3\alpha \quad (2)$$

$$\sin\alpha = \frac{2}{r} \text{ or } r = \frac{2}{\sin\alpha};\ r^2 = \frac{4}{\sin^2\alpha} \quad (3)$$

substituting (2) and (3) into (1)

$$NM^2 = \frac{4}{\sin^2\alpha} - 36 \cot^2 3\alpha$$

$$\text{or } NM = 2\sqrt{\frac{1}{\sin^2\alpha} - 9 \cot^2 3\alpha}$$

This formula says that NM is a function of the size of α. Without going through the laborious calculations, this indicates that NM = 5 if, and only if, $\alpha = 7^\circ 4'$ or $3\alpha = 21^\circ 12'$ or the angle to be trisected = 42° 24' to the nearest minute! It is interesting to note that the angle in the Journal measures 46° (the dog!)

Furthermore, suppose that the angle to be trisected is 60°. Then $\alpha = 10^\circ$. $3\alpha = 30^\circ$, NM then comes out to be 4.965, very close, but not 5.00! For 90°, NM = 4.870, again reasonably close.

The construction therefore is very close for most acute angles, but is nevertheless invalid from a Euclidean point of view.

THE JOURNAL OF ENGINEERING GRAPHICS

SPRING 1965 Volume 29, Number 2 Series No. 86

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ARTICLES

DEPARTMENTS

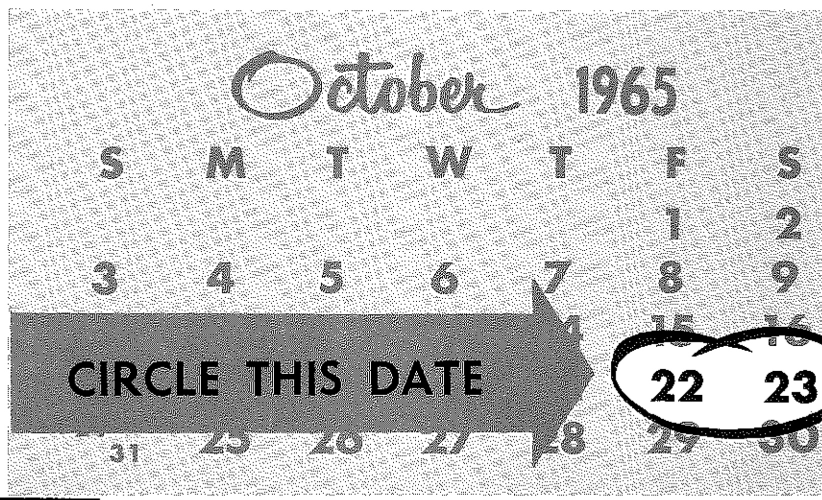
DIVISIONAL NEWS

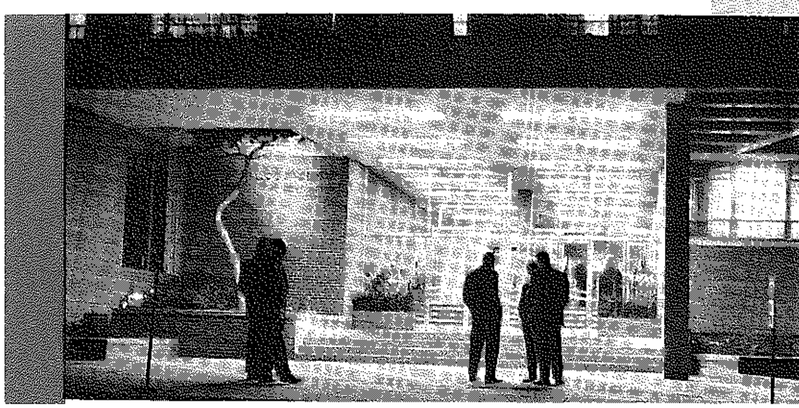
Published for teachers and others interested in Engineering Graphics. It is published three times per year - fall(November), winter(February), and spring(May). The subscription rates are $2.00 per year in the United States (single copies 75 cents). Foreign rates upon request.

American Society for Engineering Education

MID-YEAR MEETING

Engineering Graphics Division





At

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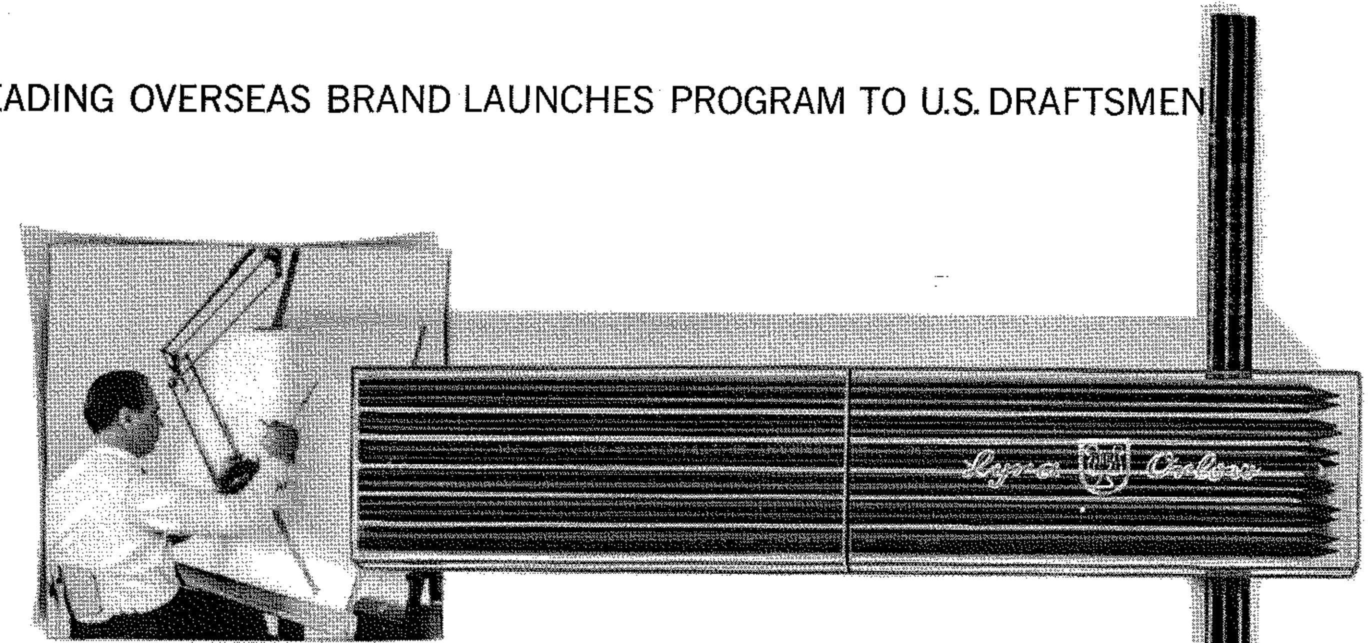

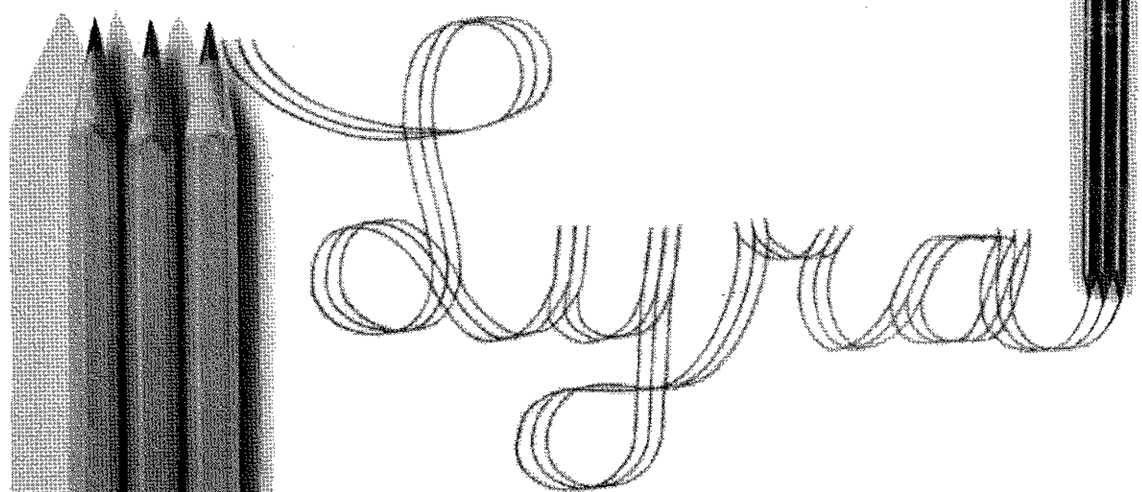

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