The Visual Mode Of Thought For Engineering Design.

THE JOURNAL OF ENGINEERING GRAPHICS

VOL. 27, NO. 2 MAY, 1963 SERIES NO. 80

PUBLISHED BY THE DIVISION OF ENGINEERING GRAPHICS AMERICAN SOCIETY FOR ENGINEERING EDUCATION

CONTENTS

Mary F. Blade
Editor
The Cooper Union
Cooper Square
New York 3, N. Y.

William B. Rogers
Circulation Manager and Treasurer
Department of ES & GS
U. S. M. A.
West Point, New York

Robert H. Hammond
Advertising Manager
Department of ES & GS
U. S. M. A.
West Point, New York

Jeanette Kowal Moylan, ART DIRECTOR

Published February, May & November Annual Subscription $1.50 Single Copy .60

EDITORIAL

The visual mode of thought is a characteristic engineering mental ability. It is exercised through the study of descriptive geometry in engineering graphics, in design drawing and sketching, and in graphic problem solving.

It is this ability to visualize and perceive spatial concepts which particularly differentiates the engineering student and practitioner from others and is his special province in the creative solution of engineering problems.

There are a million practicing engineers in the United States and they have exceptional ability to visualize. It is noteworthy that almost all of these men have been taught engineering drawing and descriptive geometry, so that graphics instructors are intimately involved in the education of engineers for creative thinking.

Most engineering schools are selecting entering students who show academic promise forecast by high-school achievement and a high scholastic aptitude measured through analytic, mathematical, and verbal tests. But engineering schools are not selecting students on the basis of their creative potential nor do they generally foster or nurture creative effort. But if we engineering graphics instructors, in the first year courses, will reorient our courses to the goal of creative design experiences and recognize the creative student, we will be furthering a basic purpose of engineering.

The old hackneyed and compromised problems must be thrown out, the single answer, closed-end problem must be imaginatively recast. The copy-book problems should become part of teaching - machine procedures. Graphics teachers should pioneer in ways to make graphics a first engineering course which will fulfill expectations of the 60 to 70,000 young men who are seeking engineering education each year.

The Journal has been featuring articles on design and on teaching with the intent of fostering creative problem solving. This month we publish a philosopher's view of design as well as a college course program for creative graphic design problems. We also feature the engineer's use of descriptive geometry as a mode of thought for engineering problem solving in heat transfer phenomenon. We also give a case study in the manner in which freshmen can apply descriptive geometry to concepts of structural chemistry. With space vehicles and lunar ladles being designed to sample a dusty moon, we must stir our students' imagination by modern engineering problems. The principles of descriptive geometry must be illustrated in a modern way. Carpentry and stereotomy can no longer stimulate our students-Moleculor interference and close packing can!

Engineering graphics instructors, if we continue to teach on a college level must do research in modern problems, new methods and application of graphics as powerful tools and mental aids to modern problem solving.

Yours sincerely,

Mary Blade

Mary Blade, editor

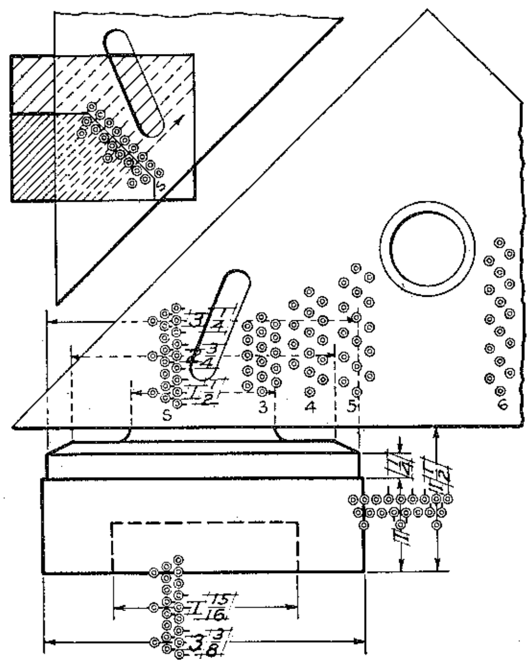
P.S. See you at the convention in Philadelphia in June.

BRADDOCK LETTERING ANGLES

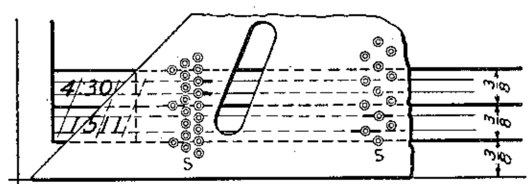
VERSATILE LETTERING TRIANGLES FOR

SYSTEMATIC
DIMENSIONING
UNIFORM
LETTERING

ACCURATE
SPACING
PRECISE
DRAWING



SYSTEMATIC DIMENSIONING



LAYING OUT TITLE STRIP

Style "A"

5"-60
6"-60
7"-60
8"-60
9"-60
4"-45
5"-45
6"-45
7"-45
8"45

6"-45 Brd.-Rowe

8"-45 Style "C"

Style "B"

5"-60
6"-60
7"-60
8"-60
9"-60
4"-45
5"-45
6"-45
7"-45
8"-45

6"-45 Brd.-Rowe

Lettering Device

8"-45 Style "B" Brd.-Rowe

Our Braddock Lettering Angles are designed to give a quick and easy method of making accurately spaced guide lines for lettering drawings, etc. The simplicity of their application permits the subject to be presented accurately and intelligently.

BRADDOCK INSTRUMENT COMPANY

PITTSBURGH 18, PA.

ENGINEERING DRAWING: Combined Textbook and Workbook
By HIRAM E. GRANT. 192 pages, $9.75.

Engineering Drawing Problems Books

ENGINEERING DRAWING PROBLEMS
By CHARLES J. VIERCK and RICHARD HANG. (to be used with *A MANUAL OF ENGINEERING DRAWING FOR STUDENTS AND DRAFTSMEN,* by French and Vierck) 109 pages, $5.50.

FUNDAMENTAL ENGINEERING DRAWING PROBLEMS
By CHARLES J. VIERCK and RICHARD HANG. (to be used with *FUNDAMENTALS OF ENGINEERING DRAWING,* by French and Vierck) 78 pages, $4.25.

ENGINEERING DRAWING PROBLEMS, Second Edition
By FRANK ZOZZORA. (to be used with *ENGINEERING DRAWING, Second Edition,* by Zozzora) 192 pages, $4.75.

ENGINEERING DRAWING PROBLEMS, Series 1
By HIRAM E. GRANT. 60 sheets, $5.00.

PROBLEMS IN ENGINEERING DRAWING, Series V
By A. S. LEVENS and A. E. EDSTROM. 136 pages, $5.50.

Engineering Graphics

GRAPHICS
By JOHN T. RULE and STEVEN A. COONS. 484 pages, $8.95.

INTRODUCTORY GRAPHICS
By J. NORMAN ARNOLD. 543 pages, $7.95.

Graphics Problems Books

CREATIVE PROBLEMS IN ENGINEERING GRAPHICS
By ERNEST R. WEIDHAAS. 290 pages, $4.95.

Descriptive Geometry

APPLIED DESCRIPTIVE GEOMETRY, Fifth Edition
By FRANK M. WARNER and MATTHEW McNEARY. 256 pages, $5.50.

GEOMETRY OF ENGINEERING DRAWING, Fourth Edition
By GEORGE J. HOOD and ALBERT S. PALMERLEE. 347 pages, $5.95.

TECHNICAL DESCRIPTIVE GEOMETRY, Second Edition
By B. LEIGHTON WELLMAN. 640 pages, $6.75.

PRACTICAL DESCRIPTIVE GEOMETRY, Regular Edition
By HIRAM E. GRANT, 253 pages, $5.50.

Descriptive Geometry Problems

APPLIED DESCRIPTIVE GEOMETRY PROBLEMS
By MATTHEW McNEARY. (to be used with *APPLIED DESCRIPTIVE GEOMETRY, Fifth Edition,* by Warner and McNeary) 136 pages, $4.25.

APPLIED DESCRIPTIVE GEOMETRY PROBLEMS
By ERNEST R. WEIDHAAS. 80 pages, $3.95.

ALTERNATE PROBLEM LAYOUTS FOR TECHNICAL DESCRIPTIVE GEOMETRY, Second Edition
By B. LEIGHTON WELLMAN. 236 pages, $4.75.

A STREETCAR NAMES DESIGN

[redacted]

By Morgan G. Thomas, Educational Director, Keuffel & Esser Co.

It should be stated at the outset that the headline of this article has been selected to reinforce a fact which, somehow, might not be gathered from the byline: that this is not an authoritative article.

Such a statement leads logically to a question: what is such an article doing in such a periodical? A learned publication such as this would seem to be doing less than its best, and missing its mission, in publishing a piece that's less than learned; but that is only one way of looking at the matter.

A journal which takes learning to the learned is engaged - this must be recognized - in a somewhat coals-to-Newcastle function; and the editor of such a magazine who really rates her readership will by instinct feel the force of such a fact, and subtly synthesize a little lighter stuff, a little less-than-learning, with the headier stuff which forms the normal measure of her medium.

. . .

One disadvantage of the title is that it gives, unfortunately or otherwise, an inadequate indication, or warning, of what is to come. For that reason, there is introduced at this point a statement of what Winston S. Churchill (the English historian as distinct from the American novelist) calls "the scheme of the work" - a term which lets a great writer convey the sense of grandness, and lets a lesser writer borrow the sound of it.

To put it bluntly, the scheme of this article is: A Philosophy of Design.

The original editorial requisition (which noun is used here, not inappropriately, in its military sense) specified The Philosophy of Design. However, that has a certain ex cathedra sound which, though tempting, provoked a prudent if involuntary humility, which into the place of the authoritative The substituted the safer and evasive A.

. . .

The reader, of course, is due an explanation of the origins, both in time and place, of all this; and such an explanation follows.

In the year 1962, a great multitude of the learned - having on its fringes the inevitable camp-followers infiltrating from the realm of commerce - assembled in a certain place, to the end that knowledge might be increased among us, and all good learning flourish and abound. That place was - and is - not only a distinguished institution of higher learning in the true sense; it can also be termed, in a still truer sense, a high institution of high learning. And at that place, among its many virtues, can be noted this characteristic: the immutability of the inevitability of discussions of Design.

From those then, this now. (Following publication - should that occur - all denunciations should be addressed to the editor, not to the author; the latter, out of consideration for the former, having done all he could to help by withholding the article as long as possible.)

. . .

Like a streetcar, a philosophy of Design - or an article about it - has to start somewhere. In making a start, the advantages of philosophy, as opposed to, say, principles, become obvious; for principles convey the restriction of being precise, while philosophy allows the latitude of being imprecise.

With that advantage, it is tempting to resort to Ruskin for a start - a route that would be as convenient as it would be obvious. No doubt about it, however, that would be a controversial route; and for the avoidance of controversy (if that is ever possible) it is better to take the route to Carlyle.

Carlyle? Yes, for the Sartor of his Resartus, with its antecedent meanings of "botch" and "patch" probably could throw more cold light on the progress of Design than any one or all of Ruskin's famed Seven Lamps.

In fact, however, it seems advisable

and appropriate to go beyond Carlyle. Keeping in mind the ecclesiastical nature of the fons et origo of this article, it is intriguing to start with another academic chapel an earlier one, which brings us to Wordsworth and which inspired a sonnet from him.

(To identify the sonnet for the benefit of professors reading this article would be an example of extreme redundancy; but for the convenience of the few of their students who might come as far as this, it is mentioned by its title of "Within King's College Chapel, Cambridge".)

The often-banal, sometimes-mawkish, always-sentimental Wordsworth can be forgotten here; in this modicum of verse he has concentrated what amounts to a wealth of thought upon Design. And all who think or teach or practice in Design can find the fullness of that thought in just four words: "...fashion'd for the sense."

The words are almost parenthetic to the thought; and in a symbolic sort of way, fittingly so. For in the long record of Design, they represent a concept which has often been parenthetic to the execution and result. For the proof, as for Wren's memorial, look about you.

Or let Belloc look about for you, and sum it up with sarcasm succinct:

"Awake my Muse! Portray the pleasing sight
That meets us where they make the Electric Light."

. . .

It is perhaps unfortunate that philosophising is like drinking. Abhorrent as the following advice will be to professors reading this article, it must be recorded here as a factual basis for the philosophising which follows:

"A little drinking is a dangerous thing.

Drink deep! or touch not the infernal spring."

Thus this philosophising of Design must dig deeper.

Drinking ... that is to say, thinking about Design often tends to a narrow parochialism of the mind, a sense of specialization which is restrictive in its outlook, a convenient reliance on unitarianism when a considerate resort to trinitarianism is really needed. There is Architectural Design (it is inconvenient to go further because of thus necessitating a suitable substitute for "trinitarianism").

These three Forms of Design are each and all Design itself; and among themselves they are both disparate and "parate", so to speak. The one relates to being sheltered; another to using; the third to being clothed. On the other hand, all have a central theme in common: all relate to covering. And that is what all Design accomplishes: the providing of a covering for something; that which is tangible, and that which is intangible; that which is physical, and that which is psychological or of the spirit.

Part of Design's problem, of course, lies in the fact that the physical is easily discerned and defined; but the psychological is so intangible that its discernment and definition are apt to generate more disagreement than agreement. The result is not surprising if Design tends to protect the interest of the physical and neglect the interest of the psychological. It is intriguing to speculate on how many Chairs and Endowments, Foundations and Projects owe their existence to the intellectual, economic, political, and sociological impacts of the resulting imbalance.

. . .

In these more recent times, Design is possibly, even probably, more a matter of cause and less a matter of effect then it was in former times. The understanding of the doctrines and techniques of constructing and artifacting has progressed from exploration to sophistication; but for most of its record, Design has operated within the restraints of cautious trial-and-error -or as someone has said of the history of building, it is a history of progress from timid to courageous construction. With the advent of sophistication, Design has burst from old restraints. The old bonds have been broken - but sometimes it seems that new ones are being forged.

Even the newest trend, of course, nurtures on the old. And this is where the streetcar of Design enters the picture. The rails are firmly fixed, and lead logically from one place to another; but the streetcar Design runs back and forth in Time from here to there; heading now in one direction, now in another; now facing forward, now facing back. And the more sophistication which Design acquires, the more the frequency with which the streetcar makes its runs, and the faster it moves.

Not, of course, that there is anything inherently and intrinsically wrong with all that; but the question does creep into the mind whether the frequency of the car's trips does not possibly constitute a service in excess of the needs of the traffic.

What is involved here is not the current question of "isn't it time we had a one-class service", but rather "isn't it time that the streetcar gave a service that considered the customer rather than the competition?"

All this leads to a possibility of the existence of a conflict between Philosophy of Design and Principles of Design. Such a conflict could be the cause or the reason for the dilemma of Design today. The dilemma is almost as easily defined as discerned: the more Design progresses, the less Design pleases. The more the practitioners of Design give, the less the patrons of Design get - a paradox with only one virtue, that it is in tune with the times.

It is a truism that present Principles of Design have evolved from past practice of Design. If much of past practice was more intuitive than informed, the results were no less satisfactory, or in many aspects gratifying - even when viewed from this modern point in time.

The Principles of Design which have evolved from the past are definable - and debatable - in various ways. The following, therefore, will serve as well as any:

a) The exterior shape should indicate an article's purpose.

b) The design of an article should permit its performance of its purpose.

c) The design of an article, to be modern, should be original.

d) Design, to be modern, should distain historic forms.

The latter two axioms are probably the roots of present problems, and responsible for the streetcar aspect of Design in its modern era. True, they involve - or should involve - a rejection of reproductionism, replicaism, and copyism; but the modern scene provides much room for suspicion that much originality is but copyism disguised. Among much that is refreshing, there is too much that is repulsive; or if not repulsive, then repetitive. And more and more, one gets the form but not the substance.

The inquirer into the reasons therefore might well conclude that in modern Design, as in all other things, there are too few leaders and too many followers. In essence, then, the practitioner is dominant and the philosopher is dominated - and the philosophy which should be in Design is largely subjected or rejected.

One result of the foregoing situation is to reduce much of Design to the status of what Carlyle calls an unwise science which:

"By geometric scale
Doth take the size of pots of ale."

That is the very role which Wordsworth is condemning when he writes:
"

"...high Heaven rejects the lore
Of nicely calculated less or more."

True, Design must have a lot of nicely calculated less or more if it is to function; but that is practice, not philosophy. To flower, as distinct from merely functioning, Design should contain the element of philosophy in order to be what it ought to be; each aspect and expression of it being, as Wordsworth puts it:

"...this immense
And glorious work of fine intelligence."

Too much of Design today is an expression of the familiar concept of "Form follows Function." The validity of the concept can not be disputed; what can be questioned is whether, as a concept, it is sufficient or complete. It can be argued that at least the expression of the concept is incomplete; a better expression of it might be this:

"Form follows Function" - and Feeling follows Form.

That is where the basis for complaint seems to lie. All too often, Feeling is just not allowed to follow Form; and as a result, too much in Design fails to recognize that mere satisfaction of the need does not always meet the need of satisfaction. In other words, outer Function does not necessarily equate with inner Feeling.

And until that corollary of Feeling is more adequately linked to the basic facts of Form and Function, the streetcar named Design will continue its coming and going, its backing and filling, its movement from older to newer and back again - and it will leave along its way few things that will give proof "that they were born for immortality."

Interview with Prof. Wilson Tripp, Kansas State University

Descriptive Geometry and Heat Transfer Studies

Engineering Graphics and Descriptive Geometry are often used by engineers and scientists in their research studies when they are visualizing or conceptualizing a problem and its method of solution. One interesting example is the research of Professor Wilson Tripp at Kansas State University. He has published a research report "Radiation Shape Factors for Plane Surfaces and Spheres, Circles or Cylinders." K.S.U. Bulletin Vol 46, No 4.April 1962. Kansas Engineering Experiment Station, Manhattan Kansas. In an interview with Professor Tripp he stated, "I believe that without knowing descriptive geometry, it would not have been possible for me to have set up the equations that are required for the final solution in the research on Radiation Shape Factors. This is particularly true for the figures in Appendix I, which deal with the case of the radiation shape factors between a finite sphere and a rectangle."

In radiant heat transfer we want to know the net rate of flow of heat (energy /time) from one surface at higher temperature to another surface at lower temperature. This radiant heat flow rate will obviously depend on the surface temperatures and physical properties such as emissivity and on the geometry. Consider, for example, a small hot surface exchanging radiation with a cooler and large parallel surface at some distance.

The net amount of radiation transferred to the large surface/time will clearly be a function of the distance between the plates since as it is increased the large plate "sees" a smaller percentage of the heat flowing out from the smaller plate. If the cooler surface completely surrounded the hot surface all the heat emitted by the smaller surface would be incident on the larger and the heat transfer rate would be high for any given set of temperatures and surface emissivities, for a given geometry.

In general, then, the heat transfer rate depends on the areas of the surfaces exchanging radiation and on how well the two areas can "see" each other. These are all functions of the relative geometries of the surface and hence are constant for a particular configuration. The effect of the geometry is given as the shape factor which is defined by the ratio (radiation emitted by surface A_1 that is intercepted by surface A_2): (total radiation emitted by surface A_1.) For the case of a completely surrounding collector (the case of an infinite separation of finite plates) the shape factor is 0.

While Professor Tripp states that the radiation shape factors have been worked out for an infinitesimal sphere, he believes his solution for the finite sphere is the first and he further believes the principles of descriptive geometry aided him in this achievement.

In engineering education we often talk about teaching our students to think. An illustration of the use of graphics as a method of thinking illustrates one of our goals in graphics education.

CREATIVE DESIGN IN ENGINEERING GRAPHICS

Ernest R. Weidhaas
Associate Professor in Charge
Engineering Graphics
The Pennsylvania State University

Note: This paper is a summary of a presentation at the ASEE graphics division midwinter meeting, January 1963.

Engineering graphics has long occupied a unique position of responsibility in the development of the fledgling engineer. In nearly all engineering schools, graphics is the first professional level course offered the undergraduate student. This, coupled with the close personal contact between student and teacher in drawing laboratories, sets the pace for the advanced design courses which follow.

How best to meet this responsibility has been the subject of recent studies. These studies show that the design element should be included with the various graphical processes traditionally taught. This design element (from simple design decisions to truly creative design) serves to place graphics in proper focus - as an aid in engineering design and as a means of communicating that design to others. In addition, it encourages the latent creative talents of these future engineering designers rather than stifling them.

The problems that follow are examples of the type that have been used successfully here at Penn State for the past three years. They are planned to include the design element without sacrificing the many graphical processes and attitudes traditionally presented. Creative design decisions are required throughout so that the student must repeatedly go through the sequence: idea, design sketch, design drawing. We foster the student's ability to approach fearlessly a brand new problem.

Creativity can be a Major Objective of Graphics. A list of the ten objectives of our introductory graphics course is given below. Upon study it can be seen that creative approaches to design problems will reinforce each objective.

The Objectives of Introductory Engineering Graphics

Develop an understanding and appreciation of the role played by the graphic language in contemporary engineering.

Teach the student to exercise his constructive imagination so that he will be more competent in engineering design.

Develop an attitude of critical and orderly thinking in solving graphical problems.

Appreciate the uses and limitations of graphical problem solutions.

Communicate graphically - reading as well as writing the graphical language.

Make legible and neat graphical descriptions of three-dimensional problems.

Use freehand drawing and pictorial representation as a quick and specific means of communication.

Acquire fundamental knowledge, appreciation and ability in standard drafting practices as a means of communicating engineering intent.

Understand various types of reference, sources and use them effectively.

Prepare for advanced studies requiring graphical communication.

Answers to some objections to our approach in fostering creativity are suggested as follows:

- A creative teaching goal uncovers more course content.

Since creative design problems do not have a unique "right answer", they are difficult to grade. However, they are more interesting and challenging, and certainly more realistic, since practical engineering problems seldom have a single best solution.

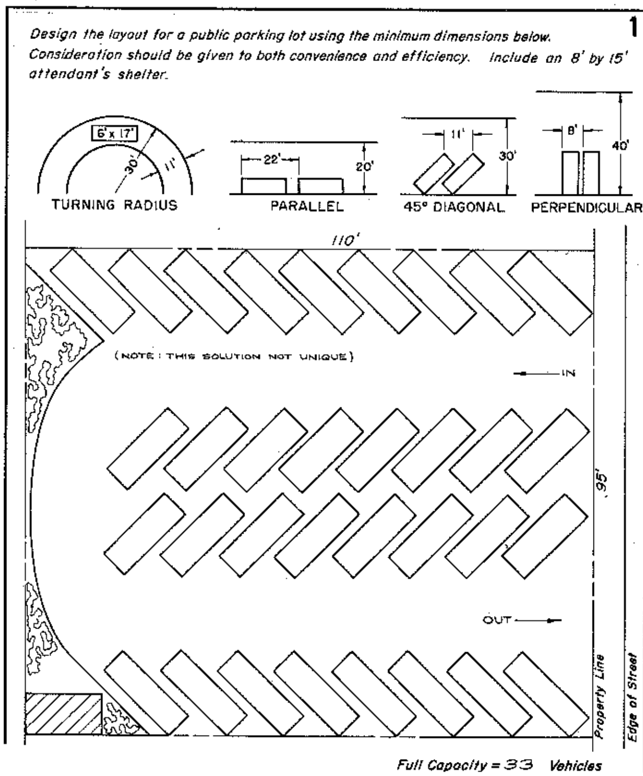
We have found that staff members must be carefully selected. Practicing engineers with a broad background of design experience to draw upon make the most successful teachers.

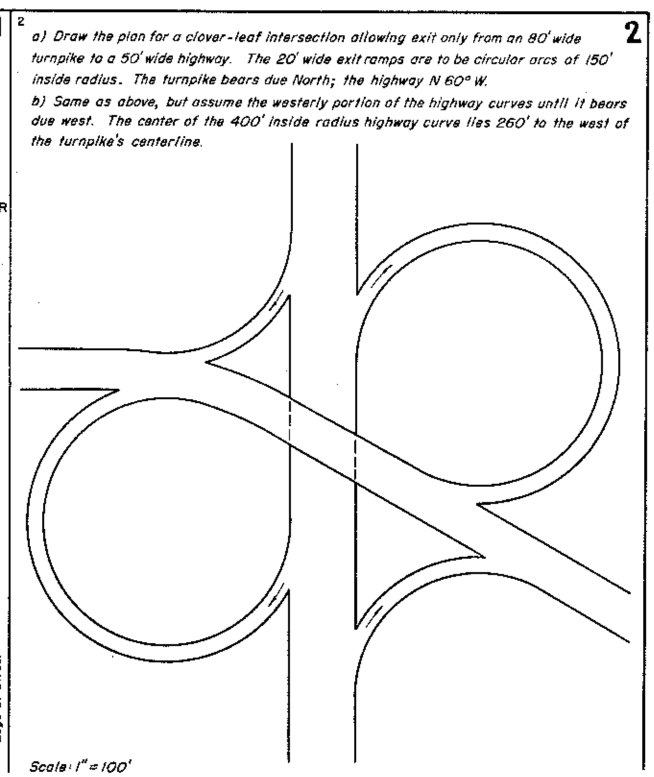
The objection most often raised is that the freshman engineer does not have sufficient design background to do a presentable job - that he must learn to walk before he can run. If the problems are carefully selected, this objection can be overcome. Certainly a start must be made somewhere, and many responsible educators believe that the freshman graphics course is ideal for this start.

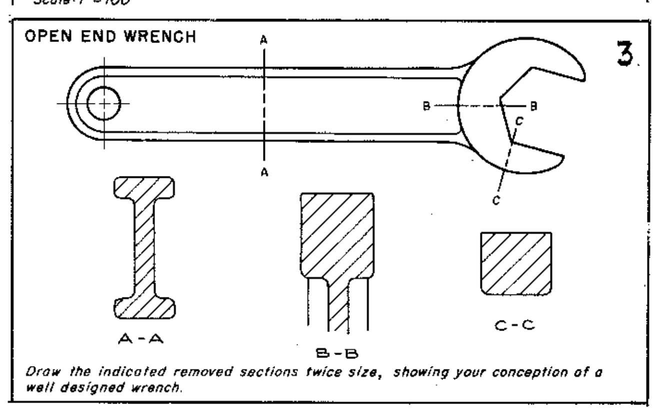
A few of our problems are presented to indicate our teaching approach.

INTRODUCTORY PROBLEMS (FIG. 1, 2, 3)

These problems introduce the students to the use of instruments; at the same time it encourages original solutions. For example, some students lay out a multi-level parking lot or specify smaller reserved spaces for compact cars.







Notice the instructions in Fig. 3 concerning the revolved section are stated, "showing your design".

The open end wrench could have rectangular or elliptical sections as well as the H section shown. These early problems are not creative in the expanded sense of the word, but they do minimize copying and encourage individuality.

DESIGN PROJECT

The introductory problems culminate in a design problem in which no information of any kind is supplied to hint at a solution. The only instructions given to the student are:

Your instructor will assign a design project. You are to create an original design and present your solution in the form of standard working drawings. Budget the time allotted to each phase of your project according to this schedule:

IDEA (1 hr). Think through various solutions - eliminating the impractical, trite, or costly.

SKETCH (1 hr.) Begin to solidify your best ideas into workable solutions. Pay particular attention to: (1) simplicity of operation (2) ruggedness combined with compactness, (3) use of a minimum number of parts, (4) ease of manufacture, assembly, and servicing.

DESIGN ASSEMBLY (2 hr.) Although this is drawn without emphasis on drafting technique, scale all parts so that workability without interference is assured.

FINISH DETAIL DRAWING (4 hr.) Fully detail all parts, changing the design assembly if necessary for manufacturing ease. Add a parts list or present this information under the title of each part.

FINISH ASSEMBLY DRAWING (2 hr.) Trace the design assembly (in pencil or ink, as assigned) adding balloons and a parts list.

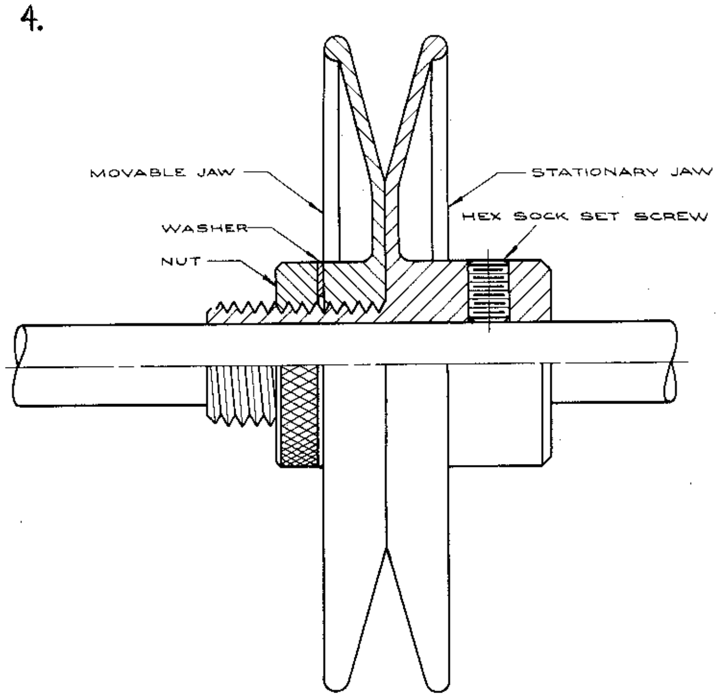
One design project is as follows: -

A toy manufacturer is introducing a new line of toy-train components to be at one-eighth full scale. Design a set of castings for
(a) the wheel and axle assembly
(b) the coupling assembly

Rapid-Sketching Design Project

Occasionally the requirements of industry do not allow time for a carefully studied design. Students are encouraged in exercising flexible work habits by doing assigned rapid-sketch projects using rapidly executed, legible lines, engineering lettering, and a proper language of lines.

4.



UNIVERSAL V-GROOVE PULLEY

Problem: To develop a broader range of pulley sizes than is possible by use of a stepped pulley.

FIGURE 4

5. HOSE COUPLING

Problem: To design a quick-connect hose coupling with identical mating parts.

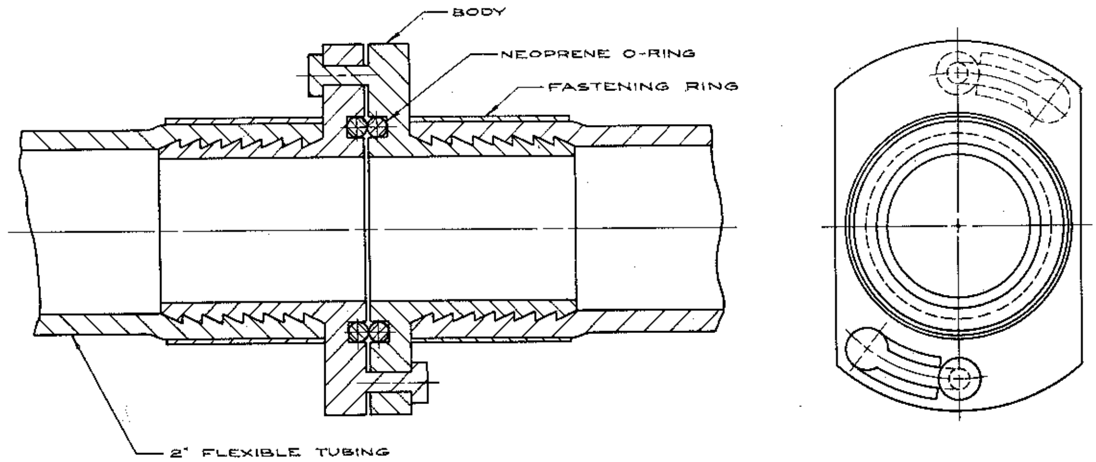


FIGURE 5

One of our instructors, Harold L. Dillenbeck, requires the student to supply both the need for a design and a solution. Above (Fig. 4 & 5) are typical freshman design solutions to such problems. They are included here to show that creativity in graphics is limited only by the instructor's - and the student's - imagination.

The following probem assignments demonstrate that the creative approach is applicable to specialized topics such as electrical drawing.

- ELECTRICAL CIRCUITRY

To supply inexpensive DC electrical energy to the magnetic coil of an electrodynamic audio speaker, design an electrical circuit capable of converting 110 volt, 60 cps AC to 107 volt. DC. Components to be used include resistors, paper capacitors, selenium half-wave rectifier, choke coil, s.p.s.t. toggle switch, fuze, two-prong receptacle, and 3" x 4" x 5" mounting case. Cost must not exceed $8.00.

- CHECK VALVE

Design a self-operating one-way check valve for low-pressure liquids. Operations are through a 2 1/2" nominal size 40 schedule steel pipeline. Flow should be axial with no flow area less than the pipe inside area when the valve is full open. The pipes are to taper thread into each end of the valve. Specify cast and machined bronze for major parts. The total length may not exceed 7"; the diameter (or width) may not exceed 5".

Descriptive Geometry and Chemistry - II

[redacted]

by Steven Vizner and Alan Repko, The Cooper Union Engineering School.

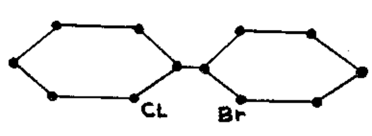
Editor's Note: -

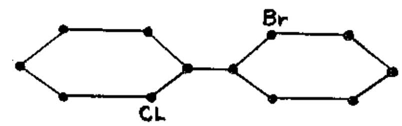
In November, 1961 the Journal carried an article on geometry and chemistry by Leonard Kaplan. Some of the Journal readers wrote to the editor to complain that the suggested application were too difficult to use in Freshman classes. Your editor therefore assigned two freshmen to study the article, carry out the solutions and make illustrative models. The following article is the result of their study which is an exciting new approach to the use of descriptive geometry in today's science and technology.

Geometry plays a big role in chemistry. Often geometrical factors will determine whether or not a reaction will take place, what the products of a reaction will be, some physical properties of a substance and the chemical bonding of a compound, especially organic compounds. There is a branch of chemistry, crystallography, which is entirely devoted to the geometry of chemicals.

A proposal for the application of Descriptive Geometry for solving problems in chemistry is given by a chemist, Leonard Kaplan in the November 1961 Issue of the Journal of Engineering Graphics. In his article on "Chemistry and Geometry" he mentions (although fails to illustrate) how elementry descriptive geometry can be employed to solve three problems in organic chemistry. These problems are: 1) interference of groups on a compound that allows rotation around a single bond, 2) determination of the most stable configuration of a cyclic compound and 3) determination of rate of reaction based upon geometric considerations.

The first of these problems is based upon an interesting chemical phenomenon. When a single bond exists between two carbon atoms that are not in the same ring, one of these atoms, and the groups attached to it will rotate in relation to the other carbon atom. If atoms or groups are attached to these carbon atoms, two different chemical compounds with different properties are produced. For example, if we take the biphenyl moleclue and put a chlorine on one side of the single bond and a bromine on the other side, two distinct compounds can exist. Pictorially they are



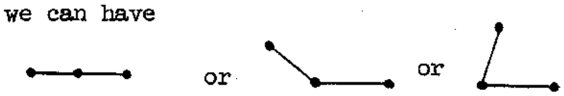


(Note-In all diagrams and models the hydrogen atoms are omitted. The effects of these atoms are considered insignificant and if put in only add to the confusion).

The first of the two compounds is known as the cis form because both atoms are on the same side of the carbon atoms with the single bond while the second form is known as trans, obviously because the atoms are on different sides of the single bond. It is conceivable that either one of these can rotate relative to the other. By the laws of chance one half of the molecules in a quantity of the chemical whose formula is $C_{12}H_{10}BrCl$ are in the trans form and one half in the cis form, all outside factors disregarded (as it happens this 50-50 situation is not true in the real chemical because outside factors such as temperatures do affect it).

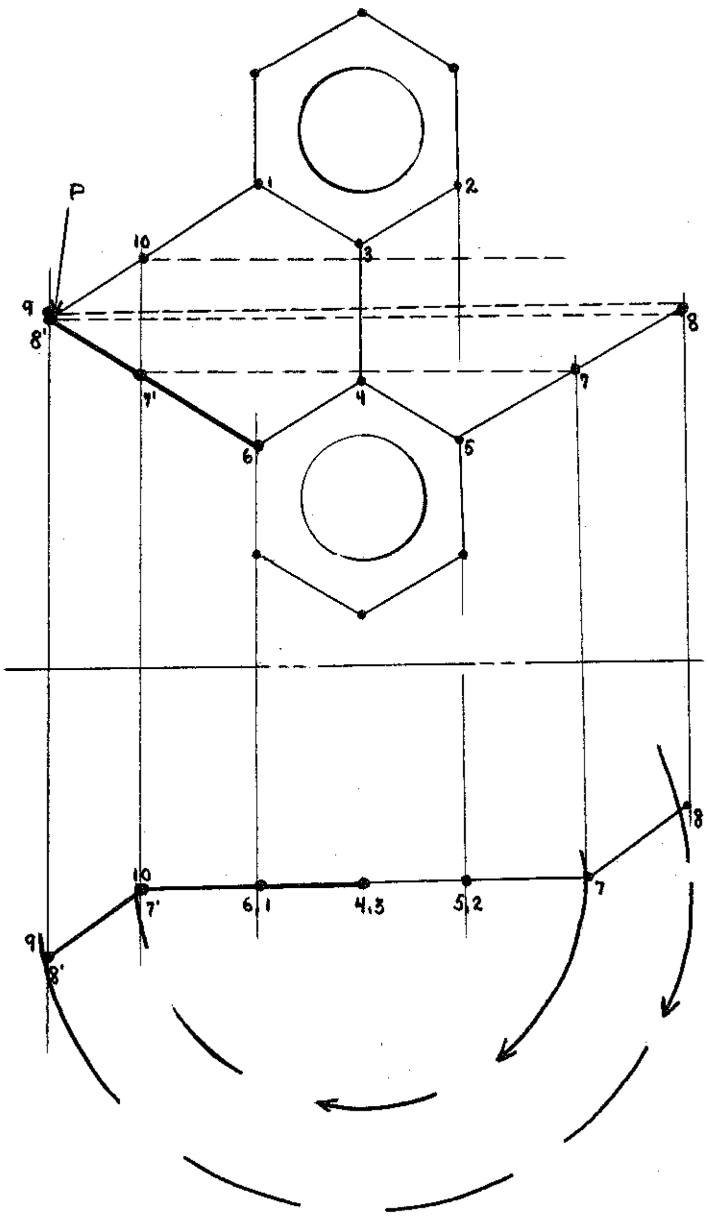
Now let us suppose that instead of a Br and a Cl attached in the positions shown we added chains of carbon atoms or for that matter chains of any atom or group of atoms. Let us call these added groups groups A and B for the time being. Now it is possible for A and B to be so long that as they rotate they hit each other. Now if we add two more groups, groups C and D, to the bare carbon atoms adjacent to the single bonded carbon atoms, they too will interfere with the rotation. The problem of seeing whether or not these groups will bump into each other can be solved by Descriptive Geometry.

The procedure given here can be followed on the model problem following this page. The first step is to accurately draw the biphenyl ring (or any compound of interest). With the biphenyl ring nature has been kind to us in that it appears to lie in one plane. Also, the distance between centers of the carbon atoms in the ring is three units while it is four units between single bonded carbons. Now once we have the biphenyl molecule we must draw the side chains. This step is somewhat harder. In the first place a ring of more then one carbon atom can exist in several ways. For example, with the propyl chain, we can have



Given a diphenyl molecule with ethyl groups on both the one and five carbon atoms and free rotation about the bond connecting carbon atoms three and four.

Find-If the two ethyl groups interfere with each other. If they do, find point P, the point of intersection.



MODEL PROBLEM

Since all would exist theoretically, we must determine the longest possible one. Also since the carbon atoms in a side chain are bonded tetrahedrally, we must determine how a space angle of 109°28' would affect the appearance of a bond in a given view. This can be solved with simple plane geometry.

All that is required to solve this problem is the top and front views of the model of the molecule. The top view will represent the molecule as a true view and the front view will represent it as an edge.

If the groups interfere with each other the lines will appear as if they are intersecting in the top view. However, it is possible that rotation about the single bond is neccessary to find the point of intersection or, in the example, if they intersect at all. In the example we revolve the right-hand ethyl group 180° before we get the point of intersection. Since in the front view all points along the two ethyl groups appear as intersection points the apparent point of intersection in the top view is the true point of intersection. In some cases the groups may be skew and we would have to rotate one group. This fulfills our qualifactions for intersecting lines.

There is one obvious fault with this method. The side chains are solid, not lines as they are represented in a solution. If a pair of chains appear as if they are missing in the drawing, they may interfere in reality. Thus the foregoing is an approximate method.

In the second part of his article, Mr. Leonard Kaplan seeks to use the methods of descriptive geometry in order to show the geometry of a certain class of compounds known as the cyclo-par-affins. These cyclo-paraffins are hydrocarbons in which the carbon atoms are arranged in the shape of a closed ring.

In his article, Mr. Kaplan neglects to mention the factor which is most responsible for the geometry of the cyclo-paraffins. This important factor is that carbon atoms possess four chemical bonds which are directed from the center to the corners of a regular tetrahedron. The chemical bonds therefore form an angle of about 109 1/2° with each other. Figure 1, below, is a drawing of a tetrahedral carbon atom.

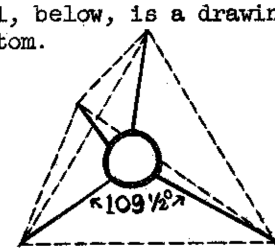


Figure 1

Now, the most stable arrangement of the carbon atoms in a cyclo-paraffin is that arrangement which produces bond angles closest to 109 1/2°. All other configurations tend to change into this more stable arrangement.

Such is the case with cyclo-pentane, C_5H_{10}. One arrangement of the carbon atoms in this cyclo-paraffin has them arranged at vertices of a plane pentagon. This configuration is quite stable for the bond angles are 108° - very close to the tetrahedral angle.

In theory, there is no limit on the number of geometric shapes possible for cyclo-paraffins. However, if we choose to observe reasonable suppositions then the number is drastically reduced. These suppositions are that:

1) all the bond angles are identical
2) all the bond lengths are identical

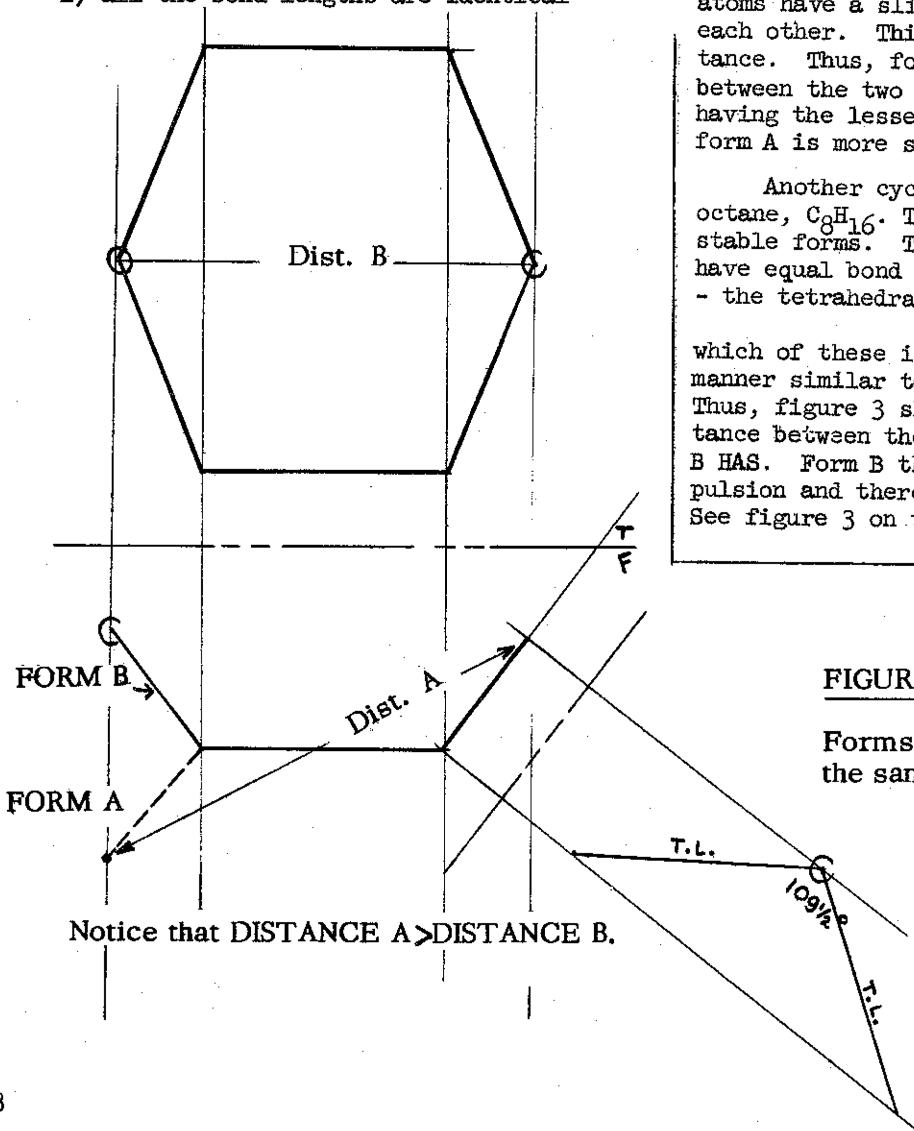


FIGURE 2 - CYCLO-HEXANE

Forms A and B are shown on the same drawing.

Another cycloparaffin discussed by Mr. Kaplan was cyclohexane, C_6H_{12}. At first thought, it might seem that a regular hexagon would do for a structure of cyclohexane. However, the bond angles in a hexagon are 120° - far from the desired 109 1/2° tetrahedral angle. The two possible structures of cyclo-hexane which utilize 109 1/2° bond angles are shown in figure 2

Figure 2 clearly shows that forms A and B of cyclo-hexane fulfill the two conditions set forth in the previous paragraph. That is, the two forms have equal bond lengths and equal bond angles of 109 1/2°.

Now that we have arrived at two stable structures for cyclo-hexane, the problem arises as to which of these is the more stable. It turns out that form A is the more stable of the two. This is explained in terms of the force of repulsion that the hydrogen atoms of hydrocarbons have for each other. Because of the nature of the chemical bond which joins carbon and hydrogen, the hydrogen atoms have a slight positive charge and thus repel each other. This force varies inversely with distance. Thus, form A which has a greater distance between the two atoms marked is the form having the lesser force of repulsion. Therefore, form A is more stable than form B.

Another cyclo-paraffin of interest is cyclo-octane, C_8H_{16}. This cyclo-paraffin also has two stable forms. That is, it has two forms which have equal bond lengths and bond angles of 109 1/2° - the tetrahedral angle. THESE TWO FORMS ARE SHOWN IN FIGURE # 3. The problem as to which of these is the more stable is tackled in a manner similar to the method in the paragraph above. Thus, figure 3 shows that form A has a greater distance between the two atoms marked than form B HAS. Form B therefore has greater forces of repulsion and therefore is less stable than form A. See figure 3 on the following page.

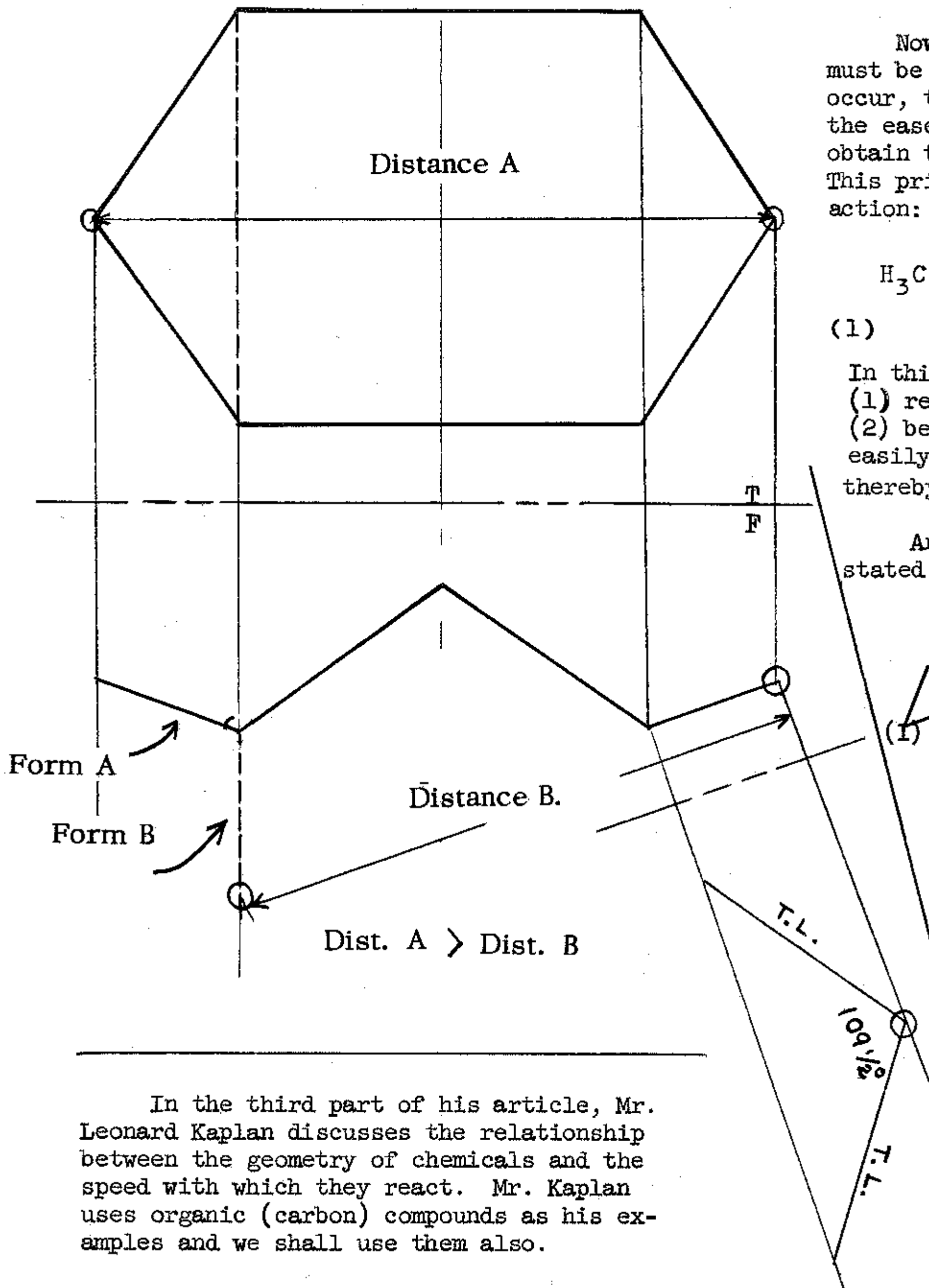
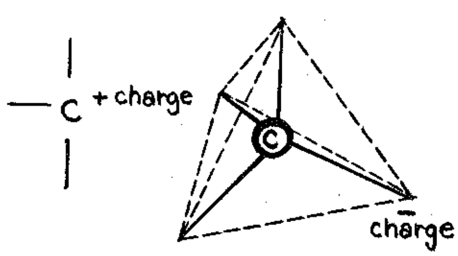


FIGURE 3 - CYCLO-OCTANE

Forms A and B are shown on the same drawing.

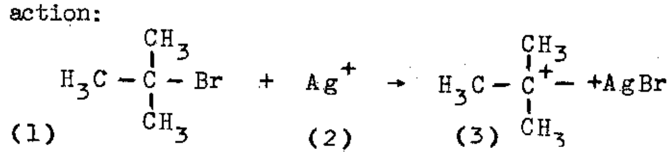
In the third part of his article, Mr. Leonard Kaplan discusses the relationship between the geometry of chemicals and the speed with which they react. Mr. Kaplan uses organic (carbon) compounds as his examples and we shall use them also.

Organic reactions often produce either a carboniumion, a carbanion, or a free radical. These three organic groups are drawn in figure 4, below.



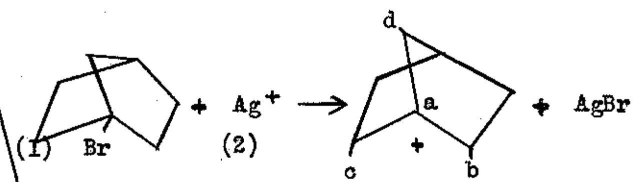
carbonium ion planar | carbanion tetrahedral | free radical structure unknown

Now, if one of these three organic groups must be produced in order for a reaction to occur, then the reaction's speed depends upon the ease with which the reacting chemical can obtain the organic group's configuration. This principle is shown by the following reaction:



In this reaction, tertiary butyl bromide (1) readily reacts with the silver ion (2) because the tert. butyl bromide can easily attain a planar configuration and thereby form a carbonium ion (3).

Another reaction which shows the principle stated above is the following:



In this reaction, 1-bromobicyclo-(2,2,1) heptane (1) reacts with silver ion (2) only with great difficulty, for it is extremely difficult for the carbonium ion (3) to form. For (3) to form, the points a, b, c, and d would have to be coplanar. This can not occur without straining the entire molecule.

Thus, in order to predict the speed of such reactions, it would be necessary to use descriptive geometry to discover the amount of distortion of bond lengths and bond angles that would be needed for the molecule to become a planar carbonium ion.

A SURVEY OF UTILIZATION OF TRAINING IN ENGINEEING DRAWING BY ENGINEERING GRADUATES EMPLOYED IN WEST COAST INDUSTRIES

by R. Wallace Reynolds
California State Polytechnic College
San Luis Obispo, California

It should be mentioned at the outset that the survey was subjective in nature, rather than statistical. The companies to be visited were selected from a total of about 300 engineering establishments in which the engineering graduates from California State Polytechnic College have beem employed. Approximately 80 of these organizations were contacted concerning an invitation to visit their engineering facilities, with approximately 50 responding with a desire to cooperate in my proposed project. Since my method of procedure entailed an extensive study to be conducted during visits covering one or two weeks at each company visited, it was necessary to select approximately 20 organizations to accommodate the time available for my tour. Companies were selected primarily to provide the most representative sample possible for the engineering activity in this area, within the confines of the invitations which had been received. The companies finally selected for the survey included:

- AiResearch Manufacturing Company, Los Angeles, California
- Autonetics Division of North American Aviation Inc., Downey, California
- The Boeing Company, Seattle, Washington
- California Division of Highways, San Luis Obispo, California
- Missile and Space Systems Division, Douglas Aircraft Company, Santa Monica, Calif.
- Federal Aviation Agency, Los Angeles, California
- Ordnance Division, Food Machinery Corporation, San Jose, California
- Hewlett-Packard Company, Palo Alto, California
- Jet Propulsion Laboratory, Pasadena, California
- Litton Systems, Inc., Woodland Hills, California
- Lockheed Missiles and Space Company, Sunnyvale, California
- U.S. Naval Ordnance Test Station, China Lake, California
- IBM Corporation, San Jose, California
- Owens-Corning Fiberglass Corporation, Santa Clara, California
- Owens-Illinois, Pacific Coast Division, San Francisco, California
- Pacific Missile Range, Point Mugu, California
- Southern California Edison Company, Los Angeles, California
- Sylvania Electric Products, Inc., Mountain View, California
- U.S. Electrical Motors Inc., Los Angeles, California
- Los Angeles Department of Water and Power, Los Angeles, California
- Western Gear Corporation, Lynwood, California
- Westinghouse Electric Corporation, Sunnyvale, California

Due to necessary adjustments in the schedule, the Owens-Corning, Owens-Illinois, and Westinghouse companies had to be eliminated from the trip. All of the other facilities were visited for periods of either one or two weeks. In a majority of the cases, the organization visited provided financial aid in the form of per diem and travel expense donations which made the study financially feasible. In all cases the hospitality and cooperation on the part of personnel in the facilities visited was splendid and indicative of the very helpful attitude toward engineering education on the part of the organizations which use our "products".

The nature of the activities while in the plants visited took various forms depending on the circumstances present. Generally a schedule was arranged which provided an opportunity to view a representative sampling of the engineering work in progress. In general, time was about equally divided between consultation and observation with supervisory personnel, and engineering employees in the lower levels of responsibility. A limited amount of time was spent with personnel who had achieved some amount of engineering training, but did not posses engineering degrees. Also, in most cases a portion of one day was spent in a tour of the production facilities, when such were a part of the organization. In all, I talked with approximately 350 engineering personnel.

While the organizational setup varied widely, most of the facilities visited had some type of project arrangement, with project teams assigned to the various products on which the company worked. The team generally consisted of a project engineer, a number of supporting engineers in the lower classifications, and the necessary designers and draftsmen. In most cases, a majority of the personnel classified as designers were men with some engineering training, but without an engineering degree, while a smaller portion of designers were degree holders. In some plants all of the designer positions were held by degree engineers, while other companies had personnel rulings which did not permit this title and rating to the holder of an engineering degree.

In addition to the project groups, or teams, most companies had staff groups such as strength (or stress analysis), weight, thermodynamics - - or, more likely astrodynamics, if the company's chief products were missiles and space systems, - reliability, value engineering, celestial mechanics, technical illustration, data processing, data retrival, reproduction (of engineering data), testing, tooling, process engineering, etc. The size, complexity and semantics of the organizational chart varied widely with the size of the organization and their field of engineering activity. In a few of the companies observed, the entire organizational structure was based on various phases of engineering work, rather than on a project basis with each group handling a certain phase of the work on all products being designed.

In about one-third of the organizations, the drafting services are entirely provided by a drafting group or "pool" which produces the necessary drawings for all other engineering groups. In some cases their output was limited to working drawings, with design drawings and layouts being prepared within project groups, but in other instances the design as well as production drawings were made by the drafting pool. In such instances the design data was delivered to the drafting group by means of verbal data and rough sketches.

Though more difficult to support with statistics from my two-inch stack of notes, I came back to the campus with a general impression that engineering personnel, viewed as a whole, in the plants I visited could be separated into two categories. One would contain primarily the older employees, who received their engineeing training prior to 1945. It would include many with some formal engineering training but no degree, as well as many with formal training in other fields, or little formal training but a wealth of parctical experience. These men are frequently in supervisory positions, as well as technician positions. Their common denominator is a "practical" or empirical approach to all engineering problems. They often produce good engineering designs, but they do it the hard way. It should be added that this category included a considerable number of engineers who received an engineering degree since 1945, but went through the prescribed courses without a high degree of comprehension of the finer points of theory.

The second category is composed mainly of younger men who have obtained an engineering degree since 1945. Frequently they have, or are about to possess advanced degrees. The category contains a few older men, usually in the higher levels of supervision, and who frequently have their academic background in the field of physics or other areas of the natural sciences -- or belong to the ranks of a gifted few who attained a high degree of insight in the theoretical aspects of pre-World War II engineering courses.

I think it might be reasonable to estimate that those in category one will be able to "phase out" in a dignified manner, but few will be left in this category when another 20 years has gone by. What does this viewpoint mean to our program of graphics instruction? To most of the engineers in the first group, the drafting courses were the foundation for their basic method of engineering procedure. To the "new breed" the instruction in drawing is simple, elementary, and something which should be picked up in high school, or can be mastered to a sufficient degree by an "apprentice" type of exposure after one goes out into the engineering profession.

Based on the observations during my survey, the situation in most engineering organizations at the present time, is a workable balance between the two categories. The outstanding weakness of the second group is their lack of knowledge about the factors which are conducive to "design for producibility" -- or, in the worst cases knowledge of any design which gets beyond the "systems and principles concepts". This shortcoming is supplied by men from the first group who can often produce good "hardware" but who realize their limitations in proceeding with efficient and precise methods of the analytical approach. Human progress being what it is, I feel certain that category one will "phase out". The task for engineering education is to insure that the present balanced team is replaced by newer generations of category two who have gained the necessary intent and ability to efficiently design hardware which will implement their precisely defined and theoretically polished systems.

Since the heart of my study was the method and amount of utilization of training in engineering graphics, the data I acquired is mostly aimed toward this determination. In those departments and positions directly concerned with design of product or "hardware" - and for the benefit of my colleagues from points east of the Rocky Mountains, the engineering and industrial activites on the West Coast are not entirely of the "think factory" configuration - the use of graphical methods is essential and the common medium of procedure. The reaction of individuals in these areas of engineering was almost unanimously in agreement with the basic premises mentioned at the beginning of this paper. If the graduate engineer cannot read drawings accurately and with facility, and convey his engineering concepts to others with sketches that do not require extensive oral explanations before they can be used, he is still technically illiterate. At least in the field of mechanical design, the novice engineer who cannot product a reasonably correct layout drawing, utilizing the common graphical techniques for the solution of spatial problems, lacks a very basic qualification required of those who traverse the road to success in engineering work at the present state of the art.

From the list of companies visited, it will be noted that a substantial portion, including the Governmental facilities, are not primarily concerned with the design of mechanical devices. In addition, in all of the companies I made special efforts to observe the activities in staff groups such as stress analysis, themodynamics, weight, planning, data reduction, etc. Again, the reaction was almost universal in the opinion that facility in reading all types of engineering drawings, which requires a thorough knowledge of the standard projection systems, is essential in the engineer's background. In a large majority of the cases, the personnel in these groups work directly with men at the drafting board in utilizing the results of their staff function. In many cases, the reports and other output of these groups require standard types of drawings and illustrations which are an intimate portion of the report, and cannot be efficiently delegated to a drafting group.

In view of the shifting emphasis on course content in many of our engineering graphics courses, I made considerable effort to determine the opinion concerning the value of training in nomography, graphical mathematics and similar areas of the graphics content. The very general reaction to such inquiry was that the preparation, including the necessary calculations was properly a job for mathematics groups, or individual specialists within the engineering organizations. While engineers within the staff groups were generally aware of the potentialities of nomograms and felt that information in this respect should be included in the graphics training, the opinion was strong that this area of graphics was a specialist activity which did not merit inclusion on a problem solving basis in a basic graphics course.

As stated before, this survey was more subjective than statistical, in nature. I have made no attempt at numerical comparisons of the hundreds of comments and observations received. I am convinced that such summarization would fit the following pattern:

1. A thorough understanding of the basic projection systems used for engineering drawing is essential. This would include multiview projection, and isometric projection. If time is available, a working knowledge of oblique and perspective projection, especially as adapted for freehand sketching, is desirable. If time available is at the minimum, multiview projection including the ability to make accurate views from any position is the bare essential.

2. Knowledge of the principles involved in the proper selection of dimensions for production drawings is second in importance, and is also the outstanding weakness in recent engineering graduates. This comment was cited more often than any other. It was agreed by many, especially among recent graduates, that this phase of drafting might well be taught with a "print reading" or lecture type of instruction which would permit covering more material in the time available.

3. Opinions concerning the importance of drafting technique, especially freehand lettering, were frequently very emphatic, and widely separated. Again lack of skill at lettering was a very frequent criticism of recent engineering graduates. With respect to line technique, compliance with conventional practices, etc. the opinion was often that is was important for the engineering graduate to have a keen appreciation of the quality required in order to instill these features into his supervisory relationships with the draftsmen.

4. It was generally agreed that much more emphasis and practice at freehand drawing is desirable. Many engineers whom I contacted felt that much of the instruction in the descriptive geometry applications could be taught by this medium.

5 A very large majority of the commentators felt that rigorous treatment of descriptive geometry was essential for the proper insight and "feel" for the three-dimensional spatial problems encountered in engineering work, and was justified for its value in promoting the necessary insight for many problems which require an analytical approach.

6. There was considerable expression that:

   a. The basic operations and applications of descriptive geometry should be closely integrated with the first study of multiview projection so that the student does not look on descriptive geometry as a fearful mental stress which has little application to the other phases of the graphics courses.

   b. Some of the more specialized applications of descriptive geometry could well be ignored in order to spend more time on other portions of the content.

   c. That graphical solutions for descriptive geometry problems should be checked by mathematical methods in order to integrate the two approaches

7. Comments very generally agreed on the need for college graphics instruction to provide more up-to-date and realistic tools and techniques. Most engineers interviewed felt that the use of drafting machines, available templates, and similar equipment in college graphics courses was highly desirable and of some importance.

8. There were frequent comments that text materials and references by instructors in graphics courses should reflect more attention to MIL and ASA standards, particularly in areas such as geometrical tolerances, checking practices, standardization of notes, etc.

9. Many commented to the effect that graduate engineers frequently suffered from an unflexible attitude and approach to problems in this area of engineering work.

   I feel that the important implication here for our graphics instruction is to properly separate and identify the factors involved, so that the student will have the correct idea about when to conform, and when to be different.

I hope, that this report and the survey on which it was based will be a useful "nibble" at the problem of correlating our graphics instruction with what the engineering graduate needs. As a member of the Relations With Industry Committee of the Graphics Division I would urge that similar studies be made in other areas of our country, and that they be correlated wherever possible through the facilities of the Graphics Division. If it has achieved nothing else, it should show that industry is ready and eager to join our efforts to find and solve their problems in this area of engineering enstruction.*

* Presented at ASEE convention June 1962.

NETWORKS OF HEXAGONS AND NON-HEXAGONS.

Readers of the Journal may read an interesting application of geometrical constraints in nature in the article, "Radiolarians: Construction of Spherical Skeleton" by English author I.J. Smalley, Department of Applied Chemistry, Northampton College, London, E.C.1, England, in the magazine SCIENCE, Vol 140, No.3565, April 26, 1963. Pp 396-7.

WHAT CAN THE HIGH SCHOOL DRAWING TEACHER DO TO HELP THE FRESHMAN ENGINEERING STUDENT?

H. P. Dale Walraven, Professor of Engineering Graphics and Assistant to Dean, College of Engineering, University of Illinois, Chicago, Illinois.

To get the best answer to this question, I proposed the same question to approximately one hundred Deans of Engineering and Engineering Professors who are national leaders in Engineering Education and Engineering Graphics.

A careful study of the remarks made by these engineering educators reflect their judgment of course content and aims of the course as designed specifically for the pre-engineering student.

SUGGESTED COURSE CONTENT FOR HIGH SCHOOL DRAWING FOR PRE-ENGINEERS

1. Theory of Orthographic Projection
2. Sketching
3. Geometric Construction
4. Auxiliary Projection
5. Sections and Connections
6. Basic Dimensioning
7. Pictorial Projection (Isometric and oblique)

It should be remarked that practically all replies stressed the same areas of study and in the given order. Intersection and Development was mentioned only once.

SUGGESTED AIMS FOR HIGH SCHOOL DRAWING COURSES

1. To develop within the student the ability to think and communicate through the medium of drawing.

2. To develop the ability to represent three-dimensional space objects on paper.

3. To develop a knowledge of the elements of accepted practice in making working drawings and an ability to read and interpret them.

4. To teach the ability to follow accurately both printed and spoken instructions.

5. To provide an appreciation of the need for intelligent and careful planning.

6. To provide a means of exploration of his talents and to interpret some of the work done by an engineer.

7. To develop speed and technique in drafting procedures and to develop an appreciation for doing the task correctly the first time.

8. To develop speed, good technique, habits of neatness, and skills in the use of the drawing instruments.

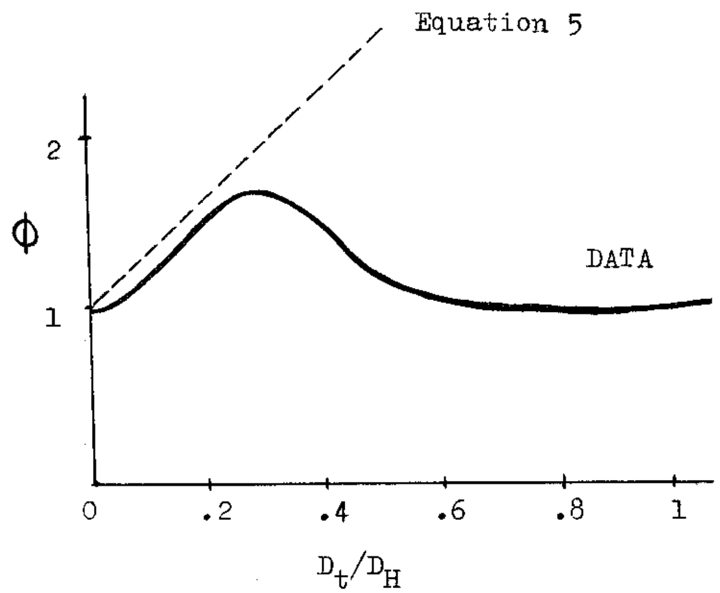
Some comments from the engineering educators are listed below, as suggestions to high-school teachers.

I would like to offer you the men who are carrying the torch and heading in high-school "more ammunition" if needed. This so-called "ammunition" is in the form of quotes from the college professor who works with the boys from your high school.
Please let me make it clear that the following remarks are offered in good faith. Let me also make it clear that I personally know the engineering educators who have made these comments. I respect them highly; they are some of the best in the field of Engineering Graphics, -- not only professors, but excellent teachers as well. I have asked them to be frank, but fair, and to the point in their comments.

Here are some of their comments -

1. "Do not dwell extensively on working drawings until proper coverage of the fundamentals have been completed. In presenting problems, do not present them in a form to copy but teach them to think."

2. "Most high school drawing courses as presented cover too much material in too little time. The high school students ordinarily do not have the background for assimilating as much material as usually presented. Again there is copying of things which do not teach them in any way to think and as a result they get a false conception of how good they are in Engineering Drawing."



Note: A similar analysis was done for pressure drop with very similar results. The maximum in the cruve of friction factor vs. D_t/D_H occured at the same value of D_t/D_H (0.27).

Bibliography

1) Colburn, A.P. "Trans. A.I.Ch.E." 29, 194-210, (1933).

2) Jeschke, D., "Z.Ver. Deut. Ing. Erganzungsheft", 24 1, (1925).

3) McAdams, W.H. "Heat Transmission" Third Edition, McGraw-Hill Book Co., Inc., N.Y. (1954)

Nomenclature

A	Area, ft.^{2}
C_p	Heat capacity, Btu/lb.°F
D_t, D_H -	Diameter of tube, helix respectively, ft.
G	Mass velocity, lb./ft.^{2}
h_i, h_c, h_{st}	Film coefficient of heat transfer for inner wall, coil, straight tube respectively, Btu/hr.ft.^{2} °F
K	Thermal conductivity, Btu/hr.ft.^{2} (°F/ft.)
Pr	Prandtl number, dimentionless physical property of fluid
Q	Heat flow, Btu/hr.
$t_{1,2}$	Temperature at points 1 and 2 respectively, °F
T	Temperature of outside medium, °F
U	Overall coefficient of heat transfer, Btu/hr.ft.^{2}°F
W	Flow rate, lb./hr.
U	Viscosity, lb/ft.hr.
ø	$j_c/j_{st}=h_c/h_{st}$, dimentionless

This leads to $\phi = 1 + 3.5\, D_t/D_H$ and a proposed increase in heat transfer with the tightening of the coil (probably due to the additional contact each particle of fluid makes with the hot wall as a result of the tortuous flow path around the helix.

According to (5), for D_t/D_H equal to 0.285, a 100% increase in h_c is obtained. Such a large increase in heat transfer coefficient seems disproportionate to the deviation from a straight tube. The published correlation seems to be highly optimistic for the range of more tightly wound helices necessary in present technology.

Part II

Geometrical Interpretation ϕ

The following investigation of the physical geometry of a helical coil indicates that ϕ should pass through a maximum and that h_c should re-approach h_{st} instead of increasing linearly with D_t/D_H as predicted by equation (5). The helix representing the center line of the coil will be shown to approach a straight line both as D_t/D_h approaches 0 and ∞. The parametric equations of a helix are:

$$X = (D_H/2)\cos\beta \quad (6)$$

$$Y = (D_H/2)\sin\beta \quad (7)$$

$$Z = (P/2\pi)\beta \quad (8)$$

where p is the helix pitch and β is an angular parameter.

As $D_H \longrightarrow 0$ the helix becomes more tightly wound and D_t/D_H approaches ∞. The parametric equations of the helix become:

$$X = 0 \quad (6a)$$

$$Y = 0 \quad (7a)$$

$$Z = (P/2\pi)\beta \quad (8a)$$

These equations represent the z-axis. The coil has thus degenerated into a vertical straight tube.

Case II

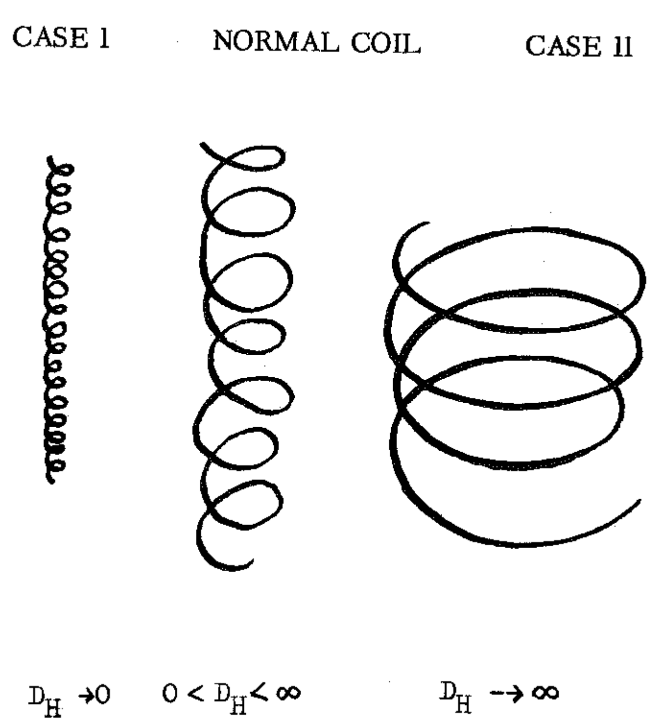
As $D_h \longrightarrow \infty$ the helix becomes more loosely wound and D_t/D_M approaches 0. The parametric equations of the helix become:

$$X = (D_H/2)\cos\beta \quad (6b)$$

$$Y = (D_H/2)\sin\beta \quad (7b)$$

with the z term negligible with respect to x and y. These equations represent a circle of diameter D_H and, since D_h is very large in this case, any finite segment of the circle will approach a horizontal straight line.

FIGURE 1



f_c therefore will be equal to f_{st}. (ϕ = 1) for D_t/D_M equal to both 0 and ∞. A curve of ϕ versus D_t/D_H should therefore curve away from equation (5) and show a maximum as D_t/D_H increases. Figure 2 shows the curve obtained by the author for the case of air flowing inside several helices:-

"Geometry and Heat Transfer" in a Helical Coil

by Henry W. Sullivan, Instructor,
The Cooper Union

GENERAL DISCUSSION

When a fluid flows through a constriction, the phenomena of heat and momentum transfer are functions of the geometry of the flow path. In the case of flow inside a helical coil, the geometry of the path is characterized by the ratio of the tube diameter to the helix diameter. Published studies have suggested that both heat transfer coefficient (a measure of the ease of heat transfer) and the friction factor (a measure of frictional resistance to flow) are linear functions of D_t/D_H. If this were true, tighter winding of a coil would result in greater heat transfer and frictional pressure drop. This study shows that both heat transfer and friction loss pass through maxima, indicating an optimal coil configuration to be designed. The existence of the maxima is predicted by an investigation of the geometry of helices for different ranges of D_t/D_H.

Part I

Introduction to Problem

To satisfy the demands of modern technology, size and shape of mechanical components have become very significant. One instance of this is the missile field where every cubic inch is crucial to a design. For example, longitudinal space for a straight, tubular heat exchanger may be conserved by coiling the length into a helix.

The total heat transferred from a fluid flowing inside a straight tube to the surrounding isothermal continuum (or vice versa) is [3]

$$Q = UA\Delta T_{\ell.m.} \qquad (1)$$

Where $\Delta T_{\ell.m.}$ is the logarithmic mean temperature difference,

$$\frac{(T - t_1) - (T - t_2)}{\ell n \dfrac{(T - t_1)}{(T - t_2)}},$$

and the other terms are defined in the nomenclature. For many instances of heat transfer (e.g. steam as the outer heating medium) the inner film coefficient of heat transfer, h_i, will be the controlling factor in U and equation (1) can be written as

$$Q = h_i \; A\Delta T_{\ell.m.} \qquad (2)$$

For the case of straight tubes.

$$j = 0.023(Re)^{-0.2} \qquad (3)$$

where $j = h_i \dfrac{Pr^{2/3}}{CpG}$ a dimensionless parameter of heat transfer and

$Re = \dfrac{DG}{\mu}$, a dimensionless parameter of flow.

Combining equations (2) and (3); noting that for a particular fluid and coil,

μ, Cp, Pr, and D

are constant and $G=W/A$

$$Q = \frac{0.023}{Pr^{2/3}} \frac{Cp(4W)}{D^2} (Re^{-0.2}) \pi Dl \; \Delta T_{\ell.m.}$$

$$Q = C_1 \; W \; Re^{-0.2} \Delta T_{\ell.m.}$$

$$Q = C_2 W^{0.8} \Delta T_{\ell.m.} \qquad (4b)$$

Equation (4b) can be used to find Q from knowledge of W, t_1, t_2, and T. If the heat transfer coefficient for a helically coiled tube, h_c, could be expressed as a simple function of h for the corresponding straight tube, a simple equation analogous to (4b) could be obtained.

If we propose a function ϕ, such that $h_c = \phi \; h_{straight}$, dimentional analysis shows ϕ to be a function of D_t / D_H (the ratio of tube diameter to coil diameter) and thus solely a function of the geometry. The accepted relationship between h_{st} and h_c is that of Jeschke[2], stated as follows in the literature of heat transfer:

$$h_c = h_i \qquad (1+3.5 \; D_t/D_H) \qquad (5)$$

"Brief Remarks on the NSF Supported Graphics Study"
P. M. Reinhard, University of Detroit

Distinguished Service Award
Presentation by Irwin Wladaver, New York University
Nomography Award
Presentation by J. H. Sarver, University of Cincinnati
Descriptive Geometry Award
Presentation by I. L. Hill, Illinois Institute of Technology

Wednesday, June 19, 10:00 - 12 Noon

Joint Conference - Engineering Graphics and Mechanical Engineering, Machine Design & Mfg. Subdivision
Theme: Educating the Design Engineer. A panel discussion.
Presiding: J. P. Vidosic, Georgia Institute of Technology
Moderator: J. S. Rising, Iowa State University
Speakers: "Engineering Graphics and Conceptual Design"
R. W. Mann, Massachusetts Institute of Technology

"Design in Industry"
L. M. Forbush, Engineer in Charge, Vehicle Development Group, General Motors Technical Center, Warren, Michigan

"The Role Material Processing Courses Play in Education for Design Engineering"
N. H. Cook, Massachusetts Institute of Technology

"The Design Process in Practice"
C. F. Hix, Valley Forge Space Technology Center, General Electric Company, Valley Forge, Pa.

Thursday, June 20, 2:00 to 4:00 P.M.

Joint Conference with Mathematics, et al.
Theme: The Impact of Computers on Engineering Education

Tuesday, June 18, 8:00 A.M. to 9:50 A.M.

Theme: Graphics and Electronic Aids
Presiding: A. C. Risser, University of Wichita
Speakers: "Designing Graphically by Computer"
S. A. Coons, Massachusetts Institute of Technology

"Engineering Graphics in Televised Instruction"
J. W. Wentworth, Manager Education Advisory Services, Radio Corporation of America, Camden, N. J.

Tuesday, June 18, 12:00 to 1:50 P.M.

Luncheon-Business Meeting, Engineering Graphics Division
Presiding: Matthew McNeary, University of Maine

Tuesday, June 18, 6:00 P.M.

Annual Dinner
Presiding: Matthew McNeary, University of Maine
Speaker: "Engineering in Egypt."
J. S. Blackman, University of Nebraska

3. "Too many high school drawing teachers merely have students copy something out of a book with no instruction as to what they are doing or why they are doing it. These students are actually handicapped in our freshman drawing course, we would rather have the student who has no drawing."

4. "High school drawing teachers should give a course which has a level of difficulty that would incur the respect of high school administrators so that these administrators would not use mechanical drawing as a dumping ground for those poor students that they are trying to get out of their hair."

5. "Students would have better background if the high school teachers knew their subject better. A rather bold statement, - but it is applicable to my situation with many students coming from small schools where mechanical drawing may be "taught" by anyone from the coach to the English or Spanish teacher."

6. "Too many teachers are not abreast with changes nor do they have a background or recent industrial experience (if any at all)."

7. "Many high school teachers are too ambitious to use exotic or too advanced materials as opposed to a concentration on basic elements."

8. "We and the student would be in much better position if his basic procedures, standards, conventions, and quality were the objective of the high school course."

9. "The high school should introduce sketching; and I do not refer to art."

10. "Help students develop ability to visualize and understand geometric forms and proportions, space relationships, functions of parts, and relative motions by requiring appropriate freehand sketches and by giving frequent tests to check on progress in graphic thinking and expression of ideas for communication to others."

11. "Although I do not think that high school drawing contributes much academically, in defense of it I would say that perhaps it may be important as a means of motivating the student; but again I am fearful lest it convey an inaccurate picture of the profession of engineering."

12. "For electrical-engineering-minded freshmen, I tell them they will need to be able to read drawings - not just wiring diagrams, and if and when they have other people reporting to them this becomes almost a certainty. Hence, there is the need to know the language for visual presentation used in relation to engineering equipment involving mechanical parts of more significant dimensions than wires have."

13. "Graphics is more important today than ever before in history; that we should strive to teach a course that will prepare the student for all phases of engineering which he will encounter in industry."

I am sure you will agree with me that it would be very difficult, if not impossible and inappropriate to arrive at specific conclusions from the study because of its incompleteness, opinions for the most part have been dealt with. However, I would like to point out some general observations I have made on the basis of information I have submitted to you and other information I have not made available to you.

These general observations are as follows:

1. Majority of the Deans and Engineering Educators feel the high school drawing teacher can greatly help the student who intends to go into engineering.

2. The value of some high school drawing courses taken by pre-engineering student is seriously questioned.

3. If the pre- engineering student is well grounded in the theory of Orthographic Projection, the college graphics course can get off to a faster start

4. The pre-engineering student should develop as much skill in lettering, line technique and sketching as possible in his high school drawing course because skill is an "ugly" word in the engineering graphics course.

5. Where the Engineering Graphics requirement has been removed in the College of Engineering both the student and the college courses suffer.

6. Majority of the Deans of Engineering and Professors of Engineering regard Graphics very highly in the engineering program.

7. High school drawing teachers should be encouraged to take additional Engineering Graphic courses offered by the Engineering Colleges.

8. The high school drawing teacher should strongly consider industrial experience along with his graduate work.

9. Last but not least a spirit of respect and willingness to cooperate with the high school drawing teacher on any matters dealing with Engineering Education was very clearly brought out in the comments of all the Deans and Engineering professors.

Editor's Note: This article is a summary of a survey conducted by Dean Walraven and presented to the Illinois Technical Drawing Teachers Assn. in 1961. The survey has continued to be of wide interest to both high-school and college teachers. There is a growing interest in the ASEE graphics Division, Educational Relations Committee proposal to sponsor a national study of high school drawing. Anyone interested should contact the chairman, Professor Robert Lang, Northeastern University.

PROGRAM - ANNUAL MEETING

Engineering Graphics Conferences
Annual Meeting of ASEE, University of Pennsylvania
June 16, - 21, 1963

Sunday, June 16, 6:00 P.M.
Executive Committee Dinner & Business Meeting (closed)
Presiding: Matthew McNeary, University of Maine

Monday, June 17, 10:00 A.M. to 12 Noon
Theme: Research and Graphics Education
Presiding: T. R. Long, West Virginia University
Speakers: "The Dissemination of Research Results in Graphics"
R. A. Campbell, The Pennsylvania State University

"A Teaching Experiment"
A. L. Hoag, University of Washington

ceptualizing tool - a thinking and talking tool.

3. Should there be graphics courses taught at the upper levels - if so, what ground should they cover and what goals should they set for themselves?

4. The use of "open-ended" design type problems in First Courses in Engineering.

5. Analysis of non-linear systems - such as phase plane plots, using graphical concepts and principles.

6. The impact of computers on the design process.

7. Employment of graphics as an integrating medium for applied science and mathematics.

8. A training program for graphics personnel.

In the discussion which took place during one meeting of the Steering Committee it was evident that the future efforts of the study should mainly be directed towards an attempt to find answers to the items previously listed Work is in progress in each of these areas of exploration and some preliminary findings are beginning to take shape.

The utilization of "open-ended" type problems has led to the consideration of the content of a first course in engineering at the freshman level. This was approached by noting that a feeling for applied science and engineering must be developed in a student as soon as possible. The most effective time seems to be during the freshman year in college. At this state, the student should sense that he is participating in an engineering environment.

A careful evlauation is being made of the intellectual aspects of the science of graphics. Unlike other sciences, graphics generates visual thinking, visual expression, and visual interpretation. This visual nature of graphics opens up a direct path to enlightenment and understanding. Instead of using symbols and numbers, graphics pictures relationships by means of lines and geometric constructions which facilitate meaningful analysis, synthesis, and design. The versatility of graphic expression makes it an ideal means for investigating, interpreting, and developing scientific theories in many fields. The inherent advantages of graphics in giving an accurate sense of direction and the best choice of a point of view enhance its value in science and engineering. As it can be applied effectively to non-linear processes which follow no law or regular pattern, graphics becomes a useful complement to mathematics in a wide range of scientific studies. The small amount of work being done in developing new graphic solutions for important current problems in the conquest of space points up the need for competent graphics teacher-scholars who could achieve the high potentials of graphics as an applied science in space technology.

It is the intent of this study to examine the role of graphics in the "new look" approach to engineering education, and to make the experience of forward looking engineering educators available to many who wish to avail themselves of the findings of the total study. Accordingly, a series of detailed monographs will be published, based on specialized aspects or areas and prepared by competent writers who have extensive working information. These monographs will be designed to improve graphics instruction by making new concepts immediately available."

The Department of Engineering Graphics at the Pennsylvania State University has received approval for the re-equipping program of the laboratories at the University Park Campus.

All laboratories will receive tilting top drafting tables and metal drawer-type cabinets for student storage. A variety of new drafting machines and X-Y plotters have been specified to be placed one per lab to allow future student and faculty evaluation.

In addition, a major effort is being made to improve and increase the instructional aids used in the Baccalaureate and Associate Degree programs at the various Penn State Campuses.

In preparing this report the Committee wishes to reiterate that it is not practical to attempt to uphold any one possible future development as being "the" probable course of action that will occur. It might be easier to say what graphics "will not" be rather than what it "will" be, but even this, of course, can be subject to uncertainty.

In keeping with this statement, the Committee wishes to present this current evaluation from the standpoint of several separate observations.

I. Fundamental Graphic Concepts

It appears that, in so far as the forseeable future is concerned and undoubtedly beyond, there will be a continuing need for the engineer to have a fundamental knowledge of spatial concepts and the ability to relate such three-dimensional concepts to a single plane of presentation. This ability is a discipline of the mind and will, therefore, continue to require fundamental training in understanding of the concepts involved.

It is possible that Engineering Colleges may increasingly give recognition to adequate high school training in technical drawing. This recognition will, of course, be based on validation procedures determined by the respective colleges. Furthermore, it is also to be anticipated that engineering colleges may increasingly impose minimum entrance requirements for graphics. Despite these observations however, fundamental appreciation of the application of spatial concepts to engineering design, through analysis and synthesis, and as a means of communication will need to be developed early in the formal educational portion of an engineer's career. This fact will continue to require the formal education of the engineering student on the college level toward a comprehensive understanding of the effectiveness and place of graphical methods in engineering design and research.

To this end, there is a definite need at present on the part of many engineering educators who are responsible for constructing and/or approving their respective curricula, for an understanding of the advances in recent years in the field of application of engineering graphics and of the overall contribution of the science as a tool of the engineer in analysis and synthesis as it pertains to research and design.

II. Graphics and Design for the Future

1. Graphics should be considered in its role as developing the visual mode of thought. Graphics has for years been considered as the visual symbolic language of the engineer, but must also be considered as vital in the creative and innovative phase of engineering design.

2. In teaching graphics we should be stressing fundamental spatial and geometric concepts which will aid the engineering designer in solving his problems involving whole concepts - not just details or embellishments.

3. Graphic means to logical analysis of design problems should be taught but not to the exclusion of innovative explanations which will lead our engineering students to solve the unknown problems of the future.

4. Computers, Models, and Visual problem-solving devices as well as the fundamental theorems of orthographic projections and descriptive geometry are all tools of the engineers which graphics may use in his design problem solving.

III. Graphical Analysis

Analysis is a basis for forming an engineering judgement. The traditional tools of analysis have been analytical geometry and the calculus. However, for anything but simple cases reduction can involve transcendental and non-analytic functions. Traditionally, the engineer overcomes these by resorting to a host of approximations: rotation of axes, transformation of coordinates, power series expansions, etc. By such means he attempts to find a manageable equation. Even going to the computer with its hours of programming generally becomes just a more accurate method of approximation.

The engineer needs, especially in the conceptual and design stage, a number of first order specific solutions to establish the basic parameters for three or four dimensional implementations. Descriptive Geometry plus the Theory of Scales and good layout drafting techniques can constitute a self-consistent, easily visualized, rigorous logic to effect all important primary analyses.

Nomograms, network charts, and special purpose slide rules can also aid in securing ball park figures in the process of developing a concept. The latter can be particularly helpful.

Machine reduction layouts of working drawings in the future will only serve to increase the need on the part of the engineer for a better understanding of and capability

Future Development Committee

C. P. Buck, Syracuse University, Chairman
E. D. Black, General Motors Institute
Mrs. M. F. Blade, The Cooper Union
F. J. Burns, Newark College of Engineering
S. A. Coons, Massachusetts Institute of Technology
R. H. Hammond, U. S. Military Academy
R. E. Lewis, Duke University
P. M. Reinhard, University of Detroit
J. S. Rising, Iowa State University
R. W. Waymack, Modesto Junior College
John T. Rule, MIT

in the use of graphics in analysis. Formalized training in depth in the construction of working drawings will not be needed. Such information can be easily acquired as needed by the engineer and will depend largely on areas of performance in which he is located.

The problem of the engineering student today and in the future is the reduction of mathematical formulation from text to drawing board. In educating engineers, "slope-line" integration and differentiation is a powerful means for increasing comprehension and understanding of analysis involved. Knowledge of auxiliary views is also invaluable as a tool of variable elimination by the rotation of axes.

IV. The Concept of the "Graphic Mind"

Every intellectual discipline by painful trial and error develops over the years successful modes of attack on the problems with which it deals. These modes of attack gradually set up a pattern of thinking within the minds of the members of the discipline - a pattern which has proved successful. Thus those practicing the discipline acquire ways of looking at problems, a "state of mind" which comes into operation whenever new problems arise.

Each discipline is in effect a mental culture which operates much in the same way as social cultures. It is somewhat esoteric in nature, has its own vocabulary and tends to circumscribe its members into a limited pattern of thought.

The physicist does not think like the biologist. The former in general thinks in terms of interrelated forms - the latter in terms of cycles of growth and decay. These are, of course, only symbols for the process is built deeply into the mental associative patterns of the individual's mind.

Many other examples could be given. The behavioral scientists exhibit their own mode of thought either "statistical" or"motivational" in nature.

In the development of engineering and science, particularly in this country, we have gradually developed the "functional" mode of thought - that is we have strongly developed a functional mathematical approach to engineering and scientific problems. Our engineers faced with a new problem tend instinctively to enmesh it in mathematical terms. The point is that this is quite an unconscious process and the individual is in general quite unaware that other approaches, that is, other "states of mind", in many instances would prove highly illuminating and frequently more creatively productive.

Europeans have much more training in geometric thinking than Americans and exhibit a much more natural tendency to think in geometric terms. This is the beginning of the "graphics mind".

With the recent growth in graphics of an awareness of the power of graphical modes of attack in three-dimensional visualization, space manipulation and analytical solution it has become increasingly obvious that there is such a thing as the "graphics state of mind", the graphics mental culture. Its possession adds another powerful string to the engineer's creative bow. It consists in thinking not only in terms of pictures but also in terms of lines as the symbols for all dynamic processes. Its processor instintively and automatically enmeshes a problem in graphical processes. He may and should also enmesh it in functional mathematical processes but the graphical mind feels more at home in the graphical mode.

A problem posed to the engineer may be attacked in many forms, but if the engineer fails to rather instinctively employ the graphical attack he is lacking a major tool.

The function of any graphical department is to instil the graphical mind into its students. If it does this the details of how it was achieved are of no importance. If it fails to do it, then, however practical the material it teaches may be, it has failed in its main mission and it has furthered the future of graphics as a purely pedestrian pursuit.

To succeed in establishing the graphical mind the student must be given material which excites his curiosity and which through employment in problem solving gives him a sense of power and, if I may say so, a sense of esthetic satisfaction. Only in this way can it built into his instinctive thought pattern.

The opportunity to develop this state of mind is before us. Let us not get lost in the curricular morass of detailed subject matter but attend to the higher challenge of developing intellectual excitement about a powerful mode of thought.

A NEW APPROACH TO TEACHING GRAPHICS

Maurice E. Hamilton - Assistant Professor - Mechanical Engineering - New Mexico State University

The greatest and most common problem beginning students of engineering graphics encounter seems to be the development of the ability to visualize in three dimensions objects shown in two dimensions. Consequently most instructors of engineering graphics find that their most difficult task with beginning students is the teaching of visualization; for once the student is able to visualize "two dimensional" objects in three dimensions, he is able to move quite easily into more sophisticated types and methods of drawing, e.g., descriptive geometry, vector analysis, etc. It would, it seems, be easier to teach engineering graphics and more subject matter could be covered if another method or a new approach could be developed that would reduce the amount of time now used in developing the ability to visualize.

Over a period of time and after a number of talks with other instructors of engineering graphics, the conclusion was reached that perhaps a new approach could be used, one that would be different from the one being used at most institutions. Most institutions follow the same general sequence, i.e., graphical construction, lettering, etc.; and they generally follow chapter by chapter a textbook, and virtually page by page a laboratory manual, which in turn follow the chapters in a textbook. Now questions arise about whether this is the best approach or are we, as instructors, doing this merely to follow the path of least resistance. Some solution must be obtained to help the student visualize easier and faster.

Now it is common knowledge that man's first efforts in making pictures was to make drawings of animals on cave walls and he progressed farther as time went on; nevertheless three dimensional pictures have always been the easiest to understand. Exploded isometrics and perspectives were used extensively during World War II because it required less time to train men to understand these. Why have instructors shied away from this area of instruction until later in the semester? Is this a sacred area because of its chapter location in textbooks? Why not let students try this area first?

So it was determined that this should be the new approach. Why not have students start in this area, where they can make isometric drawings from multiview drawings so they can actually see how each line lies in space, or why an oblique or slanted line must be placed in such a manner as to touch the correct end points. Then after drawing these isometrics, go back into missing line, missing view, and multiview problems, emphasizing pictorials strongly in each area. After all, if a student is stuck on a problem, do not all of us as instructors tell the student to sketch a rough pictorial of the object so he can better visualize it?

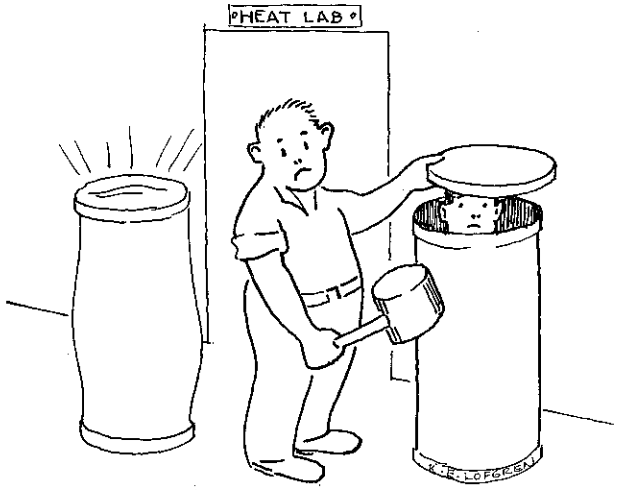
After determining that this should be the new approach, it was decided that new exercises should be drawn since most lab manuals have only three or four pictorials in them. So enough exercises were drawn to provide at least three solid weeks of work; also new plates were drawn for the remaining weeks, as each one had to be keyed to pictorials. The next problem that arose was how could this improvement, if any, be measured. Some test must be found to measure this improvement.

After consulting with Dr. Linquist of Iowa, The Psychological Corporation, and several other people in the field of testing, it was determined that perhaps the Minnesota Paper Board Form Test would be the test to use to measure improvement in the ability to visualize. Students were divided into two groups, control and experimental, using the split halves method based on the scores attained on the first test. This was done to insure uniform groupings. The control group was administered engineering graphics in the customary manner of most institutions. The experimental group was given pictorials first. After a period of eight weeks the test was given again. Several statistical devices were set up to determine if there was any difference between the two groups. A frequency polygon showed that the experimental group had improved 75% over the control group; but when statistical methods were used to find if this had any significance, it was found to have been chance. Further correspondence with The Psychological Corporation indicated that the test only measured the ability of the student to visualize in two dimensions.

So the results of that semester's work had to be thrown out, but valuable information was gathered from it. It was found that lecture time could be cut in half and that linework improvement was better than under the previous system of starting with graphical construction. It was also found, but could not be proved statistically, that the visualization was greatly improved and that less time could be used for isometrics, missing line, and missing view problems.

Again The Psychological Corporation was consulted and it was found that the only tests that they had were ones that measured aptitudes. So a test was designed that could measure the student's ability to visualize in three dimensions from two dimensional drawing. This test consisted of two views given, with the student to select the correct third view. The students for this semester's work were divided into two groups, by random selection. When they were given the test at the first class meeting it was found that their scores were 33.5 for the control group and 34.00 for the experimental group. Both groups were almost evenly divided, as the average score indicates. Initially there were 39 students in the experimental group and 41 in the control group. Several drop-outs were experienced in both groups, therefore for purpose of the experiment only 33 students were used. The average score for both groups did not

NEWS OF THE DIVISION



"I DUNNO, THEY RUN SOME KIND OF TESTS ON 'EM."

For the meaning of this cartoon by Prof. Kenneth Lofgnen, see Professor Tripp's article on shape factors in heat transfer on page 11.

Come to the Annual Meeting of ASEE in Philadelphia. Chairman of the Graphics Division, Prof. Mat McNeary has scheduled an excellent program.

There are 10,800 individual members of ASEE. We publish about 1000 Journals of Engineering Graphics. Have your colleagues subscribe!

Prof. A.S. Levens of the University of California at Berkeley has published a report "Teaching the Fundamentals of Orthogonal Projection - a study of the Thought Model Method." This report shows that a significant improvement in classroom performance can be accomplished by the use of "The Thought Model", an innovation in teaching methods. There is a strong indication that teaching of teachers in this method can be done by below instruction. The study further concludes that the film on "The Thought Model" cannot replace live classroom instruction but is useful as a supplementary device. Information concerning the six films on "The Thought Model Method" may be obtained by writing Professor Levens.

Prof. Steve Slaby of Princeton University School of Engineering and Applied Science arranged an Engineering Graphics seminar Feb. 11, 1963.

Professor Douglas P. Adams of the Department of Mechanical Engineering of the Massachusetts Institute of Technology conducted this Seminar. The subject was:

"Countable-Bit, Nomographic Electronic Computation".

Mr. Joseph E. Halicki, assistant professor of technical drawing at the Illinois Institute of Technology was recently awarded a Faculty Research Fellowship for the spring semester of the 1962-63 academic year.

Professor Halicki, who received a B. S. degree in industrial engineering from IIT, joined the faculty in 1957 as an instructor in the technical drawing department. He received a M.S. degree in Engineering Graphics from IIT in 1961. Under terms of the fellowship, he will be given a monthly stipend and relieved of three-fourths of his current teaching assignments in order to pursue his independent research concerning the graphical analysis of rational integral functions.

"Engineering Graphics in a Scientifically Oriented Engineering Curriculum", an interim report of a Course Content Development Study Project on Engineering Graphics has been released by Prof. Paul M. Reinhard, chairman. The following excerpts are from the report which may be obtained by writing the Dept. of Engineering Graphics, University of Detroit.

"The study has shown that the scope of graphics must be enlarged if it is to contribute to the enrichment of the educational experience of engineering students. During seminars of the Study Committees and at study group meetings the following topics were considered:

1. How would graphics be taught - as separate courses or integrated parts of other disciplines?

2. Use of graphics as a con-

There are a number of instruments by which the unifying process can take place and be promoted. An interdisciplinary Engineering Graphics Division committee has been created and which has for its purposes the following:

1. To provide a medium for exchanging information.
2. To direct promotional activities.
3. To develop a liaison between various divisions of engineering fields.
4. To Keep the Engineering Graphics Division and its membership posted on recent engineering curricula developments projects and studies.
5. To Keep the sister divisions and its membership advised on recent developments in engineering graphics.
6. To Encourage joint participation by ASEE members in
   a) coauthoring texts and papers
   b) research teams and cooperation
   c) membership on university and policy making committees.
7. To Promote the sponsorship of engineering graphics seminars at individual schools for the whole engineering faculty.

There are a number of other interdisciplinary activities which are at present being undertaken by Engineering Graphics Departments throughout the country:

1. The Department of Engineering Graphics of the University of Detroit is conducting a 2-year course content development study, involving engineering educators and their counterparts from industry, under the National Science Foundation grant.
2. The Engineering Graphics Department of the Pennsylvania State University is carrying on an interdisciplinary campaign which promises to make important contributions to the unifying concept of engineering education.
3. The Department of Graphics and Engineering Drawing at Princeton University is continuing to work on plans for an International Conference on Space Geometry to which we hope to invite members of all fields of engineering, mathematicians, physicists, and engineering graphicists. In addition engineering graphics courses are being developed using a unified concept approach.
4. The Engineering Graphics Division of the Mechanical Engineering Department at the Clarkson College of Technology, Potsdam, New York, has developed a new experimental "first course" in engineering giving the freshman student an interdisciplinary engineering experience in an engineering laboratory. This course was developed through the cooperation of the degree granting departments.

The reason for citing these activities is to indicate that many in the engineering graphics field consider the problem of interdisciplinary education to be an important problem and challenge. We invite all the members of the Division of Engineering Graphics to join in our efforts and to develop interdisciplinary programs of their own since what we are doing, we feel, is not only good for engineering graphics but is also good and necessary for the whole field of engineering education and engineering.

I am not so naive as to believe that one course or program is enough to make undergraduate interdisciplinary instruction complete at this early stage. Actually the course of action I propose is one which is the first step towards developing an overall consciousness in engineering education (including the establishment of this concept of unity in the minds of engineering educators) which deals with the interdisciplinary aspects of engineering concepts.

On the upper class levels, when a student reaches his professional type courses and programs, the unifying process begins taking form but even at this stage this form tends in some cases not to be as strong as it should be. Further work in this area is necessary to continue to emphasize the interrelationships of the various areas of studies a student encounters.

I have not mentioned another area into which the interdisciplinary concept enters profoundly: the area of the social sciences, the humanities, and their relationship to engineering - and engineering's relationship to them. Mankind has reached a point in his technological development where he is quite able, by design or accident, to destroy civilization as we know it. His development in the area of the social sciences and his appreciation of some of the work that has taken place in this field is far behind that of the technical scientific areas. A unifying approach between the physical sciences and engineering and the liberal arts areas is a vital necessity today. A bridge must be built between these two areas so that understanding can flow from one to the other and vice versa. It is important, in my opinion, that the engineer and the physical scientist have a real appreciation and understanding of the effects that their work has on society and civilization. It is likewise important that the social scientist appreciate the fact that many of the social and economic problems that exist today are due directly to the results of scientific and technological change. And if the social scientists are really going to help solve these problems in the real sense of the word, then they will have to be familiar with the approach that physical scientists and engineers take to solving their problems. Therefore, undergraduate interdisciplinary instruction encompasses a vast area and one wonders, with all this vastness, whether a complete and adequate job of teaching in this context can be done in the time limitation of a four-year program. These are problems which are being studied and worked on. And these are problems which, if we are to succeed as engineering educators, as a nation, as a world civilization, must be solved intelligently and, we hope, therefore without violence.

through any point. This established, in effect, a concept of higher geometry which led to hyper-space geometry dealing with concepts of four dimensional and n-dimensional spaces.

In reviewing the history of space graphics or space geometry in the practical or technological fields, it is obvious that the influence that this field has had upon scientific and technological progress is immense. Without the concepts that have been developed in this area, without the language which this area has provided the engineer and in many cases the scientist, it is difficult to see how science and technology could have progressed to the point where they are today. Therefore, to reason objectively, it would seem to me that the subject of engineering graphics, as we call it today, would offer the possibility of being the vehicle I am searching for, since obviously this discipline seems to cross all disciplines in the field of science and technology and furthermore, it involves the scientific and engineering approach.

On the basis of these qualifications, let us say that I, an engineering educator, have found the vehicle I have been looking for. It now becomes my task to use this vehicle in the development of a program or course involving interdisciplinary concepts. The content of a course such as this could include the following topics:

a) The concepts of measurement, including linear, angular, numerical, electrical, measurement of velocity, acceleration, etc.
b) Data collection and the recording of significant data.
c) The concepts of significant figures in computations.
d) Plotting and interpreting data.
e) Numerical analysis and computation - graphical, mathematical and machine.
f) Differentiation and integration - physical interpretation.
g) Introduction to principles of solid state mechanics involving conditions of static equilibrium and conditions of motion.
h) Physical properties of materials - analysis of stress strain diagrams, shear and bending moment diagrams etc.
i) Introduction to a few abstract concepts of the fourth dimension and n-dimensional spaces.
j) Special design projects - application of various engineering and physical principles to specific problems in the various fields of engineering, with particular emphasis on the engineering approach involving the use of mathematics, physics, and engineering graphics on an integrated basis.
k) Introduction to computer operations, analysis and programing using graphics as a feasibility tool.

I believe that this course could accomplish the following objectives which are directly in line with the interdisciplinary approach we desire:

1. Orient the thinking of the student towards engineering, introduce the creative aspects of engineering science, and help motivate the student to concentrate on his study of engineering.
2. Introduce the student, early in his educational career to the various branches of engineering, but more specifically to the field of engineering in a global or unified sense.
3. The course would help the student to appreciate, early in his studies, that such courses as mathematics, physics, and engineering graphics form a related, integrated, unified body of knowledge. The integration of these disciplines could be accomplished through project-type design problems, helping to develop both the engineering science approach and the student's engineering knowhow.
4. Prepare the student in a positive manner for the successful continuance of his engineering studies, by giving him a firm introduction to these studies and an insight into the nature of engineering.

Obviously a course of this type would have to be supported by the various faculties of an engineering school; this would mean that the freshman would be exposed to the various departments directly and thus have the effect of making him feel he is working in an area which is unified and not splintered.

I realize that a program such as this, of necessity, cannot be developed without considerable time and effort on the part of key engineering faculty. But I am firmly convinced that it is not impossible. I am also firmly convinced that it is vitally needed <u>now</u> on a broad scale.

In order for the program to be adopted, people in the field that we call engineering must begin to see it from a unifying viewpoint. There is already a trend in this direction in this country. For example, a few educational institutions have reorganized their engineering schools along lines which deviate from the traditional lines of Founder Societies. This may perhaps be one answer to the interdisciplinary problem now facing us. Whatever solution we decide upon as a group - we must be careful that we end up teaching <u>engineering</u> and not something else.

UNDERGRADUATE INTERDISCIPLINARY INSTRUCTION IN ENGINEERING - HOW CAN IT BE TRULY INTERDISCIPLINARY?

by

Professor Steve M. Slaby
Chairman, Department of Graphics and Engineering Drawing
School of Engineering and Applied Science
Princeton University

Webster defines "discipline" as a branch of knowledge involving research. He also defines "inter" as a prefix meaning among, between together. Therefore when we speak of undergraduate interdisciplinary instruction we mean an instruction which involves a unifying process of the various subjects, courses, disciplines, etc., that an undergraduate student studies. If we review a typical undergraduate program of study in engineering, we find that as a freshman the student's education begins basically on non-unified interdisciplinary lines. He takes a course in mathematics, a course in physics, a course in chemistry, and normally a course in engineering graphics. Nowhere in the freshman year, in general, is any attempt made in a formal manner, to unify the various concepts to which the freshman student is exposed. In his physics course a student will use some concepts involving graphics and geometry and some methods of mathematics. However we must realize that the instructional unification of concepts which takes place in physics courses at the freshman level, does not emphasize the engineering approach.

Perhaps it can be argued that it is too early at the freshman level to attempt a formal unification or interdisciplinary approach to the education of the engineer student. It may also be argued that the freshman engineering student does not have enough background nor enough understanding of the fundamentals presented in each discipline in order that a real interdisciplinary approach can be instituted in some program or some course. These I feel, are not strong arguments against attempting to present, at the freshman level, a course of study which will have the beginnings of a basic interdisciplinary approach to the presentation of engineering fundamentals. One danger which must be guarded against: when an attempt is made to create a program with the purpose of unifying the disciplines, the result could be a program which is more survey than fundamental in nature. Therefore rather than attempting to push the student into different areas of engineering at the outset, what could be done is to select those basic concepts which tend to overlap and are common to the various fields of engineering and to weld them together into a program which will not merely offer a survey of the various engineering fields but will give the student, even with his limited background, a basic insight to the engineering fundamentals and to the engineering approach.

There are many different ways of developing a program of this type. There are many problems involved in any approach which would be undertaken such as time limitation, background limitation, facility limitation, etc. Taking all of these into account, one would probably need to use one of the basic engineering disciplines as a vehicle through which the unification or interdisciplinary approach could be developed.

Generally, the first engineering course taken by freshmen engineers is engineering graphics. (Although there are other paths leading toward a unified approach at an early stage in an engineer's education, being an engineering graphics man and a graduate mechanical engineer, it is natural and understandable that I would approach this problem from the field I know best. Other approaches can be taken and it is for the engineering educators as a close knit, unified group to investigate them in order to attempt to develop a "model" approach).

A properly oriented engineering graphics course for students who have been formally exposed to a few of the elementary concepts of space and geometry, who have learned how to letter, who have learned how to make a straight line with a straight edge, and who have a reasonable facility of drawing technique (if we could have such students prepared in these categories before they enter the university or college), then the possibility of a successful interdisciplinary approach would exist in the type of engineering graphics course which I shall outline below and which, incidently exists to various degrees in a number of engineering graphics departments throughout the country. Before I outline such a course, let us assume that I am not a graphics man, and that I am completely objective, which as an engineer I always try to be. I would still have to search for a vehicle as I mentioned above which would, in itself, contain the basic ingredients from a historical point of view as well as from an engineering science fundamental point of view, which I feel would serve as a nucleus about which the unified approach could be developed. If one studies the history of the general area of space geometry, starting with Euclidian concepts of geometry and progressing to concepts of modern geometry, the impact of this field on mathematics, physics, and engineering is readily apparent. Refer to one aspect of this historical process; where the Russian mathematician Lobachevsky made a study of the results of changing the 5th postulate of Euclid's theorem. This postulate states that through any point in a plane one and only one line can be drawn parallel to a given line. Lobachevsky assumed a postulate contradicting this 5th postulate of Euclid, with the purpose of trying to prove that the 5th postulate was true by the "reductio ad absurdum" method. By this method Lobachevsky assumed that the Euclidian postulate was false and with this assumption he attempted to find contradictions in other Euclidian postulates and theorems. He discovered, with this approach, that he was unable to prove any contradiction to these postulates. In addition, he and other mathematicians later demonstrated that no contradictions were to be expected in this system. What they had done was to discover a new geometry in which many lines may be drawn parallel to a given line change significantly for either group. The test was given again after a period of eight weeks and the average score for the experimental group was 65.00, and for the control group was 54.24. The "T" score was applied to determine if there was any significance between these two groups. The "T" score for the groups was 2.34, which is at the .025 level of significance, and which is highly significant.

After running the experiment for two semesters two interesting facts were discovered. The first and most valuable fact was that students can be taught visualization easier and faster by introducing them to pictorials first and strongly emphasizing pictorials in the multiview area.

Also it was discovered that the time allotted each particular area (e.g., missing line, missing view, etc.) could be cut down due to the increased ability to visualize, which means that more time can now be spent on areas such as graphical analysis, vectors, etc. The second fact, which is believed due to better understanding of the subject and more pride in their work, is that linework and lettering was much better in the experimental group. In short, the students spend less time developing the ability to see (visualize) the object and more time on linework, lettering, and accuracy.

TABLE I

	Number	Degrees of Freedom	Mean	Sum of Squares
Experimental Group	33	32	$\overline{X}_1 = 65.90$	153,425
Control Group	33	32	$\overline{X}_2 = 54.24$	107,150
		Sum = 64	$\overline{X}_1 - \overline{X}_2 = 11.66$	$\Sigma X_2 = 260,575$

$$S^2 = \Sigma X^2/2(n-1)$$

$$S_{\overline{X}_1} - {}_{\overline{X}_2} = \sqrt{2S^2/n} =$$

$$t = \overline{X}_1 - \overline{X}_2 \quad S_{\overline{X}_1} - {}_{\overline{X}_2}$$

$$S^2 = 260,\ 575/75 = 4071.48$$

$$S_{\overline{X}_1} - {}_{\overline{X}_2} = \sqrt{2(4071.48/33} = 4.97$$

$$t = 11.66/4.97 = 2.34 = .025 \text{ or } 2.5\% \text{ Level of significance}$$

from **HOLT, RINEHART AND WINSTON, INC.**

3 approaches to engineering drawing

1. *creative design*

INTRODUCTION TO ENGINEERING DESIGN

E. G. PARÉ, L. L. FRANCIS and J. T. KIMBRELL, Washington State University

The first engineering graphics text to effectively integrate the language of graphics with important aspects of design, production, and communication. Deals realistically with both creative and financial considerations.

CONTENTS: Engineering Design: Graphic Representation and Computation; Orthographic Projection; Pictorial Drawing; Auxiliary Views; Sectional Views; Size Specification; Threads and Fastners; Conventional and Simplified Drafting Practices; Engineering Materials; Production Casting; Metal Cutting Theory; Production Machines; Forming and Fabrication; Finishing and Inspection; Component Design; Kinematics; Design Application; Appendix.

May 1963 500 pp. $7.50 tentative

2. *mechanical drawing*

BASIC PROBLEMS IN ENGINEERING DRAWING, VOLUME I

J. DYGDON, R. LOVING and J. HALICKI, Illinois Institute of Technology

Designed for introductory courses in Engineering Drawing and Graphics in technical institutes, junior, and community colleges and brief college programs, Volume I covers fundamentals or orthographic projection.

Keyed to leading Engineering Drawing and Graphics texts, it:

* provides detailed instructions for preparing each sheet.
* includes guide lines on lettering sheets.
* distinguished by the high quality of both line reproductions and the paper itself.

CONTENTS: GROUP I: Lettering; 2: Instrumental Drawing; 3: Geometric Constructions; 4: Copy Problems; 5: Freehand Sketching; 6: Identification of Surfaces; 7-12: Multiview Projection; 13: Dimensioning; 14: Working Drawings.

FEBRUARY 1963 52 plates. 128 pp. $3.75

VOLUME II — Ready for Fall

3. *standard*

DESCRIPTIVE GEOMETRY

CLARENCE E. DOUGLASS and ALBERT L. HOAG, University of Washington

The methods, principles and applications of basic descriptive geometry are concisely explained and thoroughly annotated, with well-planned illustrations and a wealth of problem material.

CONTENTS: Orthographic Projection; Lines and Planes; Point, Line, and Plane Problems; Revolution; Curved and Warped Surfaces; Intersection of Surfaces; Locus of a Line; Vectors; Geology; Minging, and Typography Problems.

1962 205 pp. $5.00

DESCRIPTIVE GEOMETRY PROBLEMS, by Albert L. Hoag

1962 128 sheets $4.00

SOLUTIONS MANUAL 64 pp. $.75

383 MADISON AVENUE, NEW YORK 17, N. Y.

LETTERS TO THE EDITOR

State University Of New York
College of Ceramics At
Alfred University
Alfred, N.Y.

Dear Mary:

In my discussions with other professors at the recent mid-winter meeting, I found that there are quite a few of us with the same problems. That is, meeting our classes in sections only.

This has some drawbacks when we wish to give a quiz on some phase of the work. It has been difficult to design separate tests for each section and still have them uniform. I have had considerable success with the following type of exam and wish to pass the idea along.

In descriptive geometry problems the attached sheet of three views of eight different points has been very valuable as a multiple test. By assigning different sets of points to each section I have been able to give quizzes that are equal in difficulty and yet different. The attached sheet has been used to solve problems in the areas for all sections, no two alike.

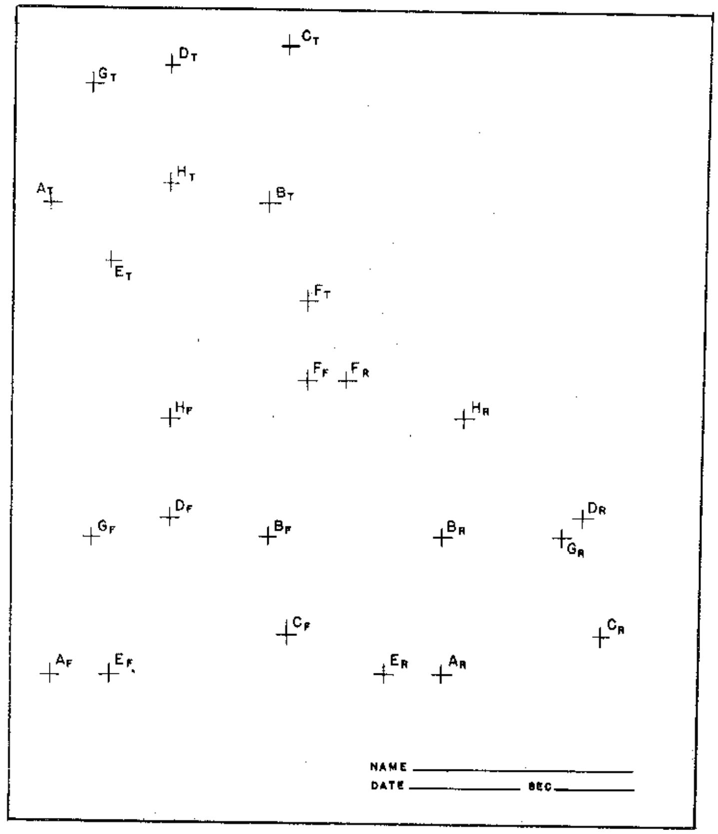
True length of lines, end view of lines, edge view of plane, normal view of plane, perpendicular distance from a point to a line, intersecting lines, parallel lines, tetrahedron studies; and there are still more possibilities.

Note that by connecting the points there are four lines that show their true length in one of the views, this is useful in many problems. It has the tendency to make the student think a little more about the problem.

I hope this idea may be of some help to others in the same predicament with lab sections.

Sincerely yours,

W. A. Earl
Instructor
Engineering Graphics



Princeton University
School Of Engineering
And Applied Science
Princeton, New Jersey
January 29, 1963

Dear Mary:

Thank you for your letter of December 18th and the paper by C. Ernesto S. Lindgren entitled "Descriptive Geometry of Four Dimensions".

You asked a number of questions in your letter and I will not answer them in order but I'll attempt to answer all of them in a random fashion.

Why is descriptive geometry of Four Dimensions interesting to the audience of the Journal? Briefly - it is interesting to the audience of the Journal because it takes the audience out of the realm of the familiar and forces them to consider something that is unfamiliar but related to their field. For example I have in my posession a masters' thesis by a student from the Polytechnic Instit. of Brooklyn. I would like to quote from the abstract of this thesis so that you can see the significance of the concept of four dimensional geometry as it relates to a specific area. "In particular, this thesis categorizes and defines fundamental relationships of geometric "cubes". .... It applies a four-dimensional cube for the first time, and moreover depicts a functional five-dimensional cube which it employs to derive consistent sets of error detection and correction codes. Variations in the geometric representation, including several new forms, and a direction for still higher ordered representations, is indicated." "This thesis significantly advances the scope of problems, and the number of variables, which can be accommodated by applying a geometric cube or hypercube. This is significant, for no other form of analysis provides as effective insight to the overall problem, and the interrelationships between the various components. The geometric "cube", although most limited in the number of variables which it can accommodate is most versatile, within its scope, in its application to new types of problems."

As you can see this is a very real application of what we consider an abstract concept. Your question relative to the importance of the subject of four dimensional geometry I think has been answered by the above quotations. I am almost tempted to say that we should publish the entire paper in the next Journal. I know that many of our colleagues will not be able to understand all of it, including myself. But with study and genuine interest in learning it seems to me that we all can benefit by an exposure to something which is slightly above us.

The paper as written seems to approach the subject in a basic fashion and develops the ideas of four dimensional descriptive geometry in a systematic manner. Therefore I say go ahead and publish the entire article in the next Journal and if it turns out that this is the only article that can be in the Journal so what - lets be bold!

Recently I received a paper from my friend Professor Arvesen in Norway which he has presented to the Royal Norwegian Society of Science this past year. This paper deals with the axonometric representation of figures in n-dimensions. It is written in French and we shall have it translated and when we do I shall send it to you for consideration for publication in the Journal.

Sincerely,

Steve M. Slaby, Chairman
Department of Graphics
and Engineering Drawing.

<u>Editor's note:</u>

The paper "Descriptive Geometry of Four Dimensions" has been recommended for publication in the Journal by Prof. Doug Adams of MIT and Prof. Steve Slaby of Princeton.

It is too long for publication in the present Journal. What action do readers recommend so that we can publish such papers?

MEMORIAL

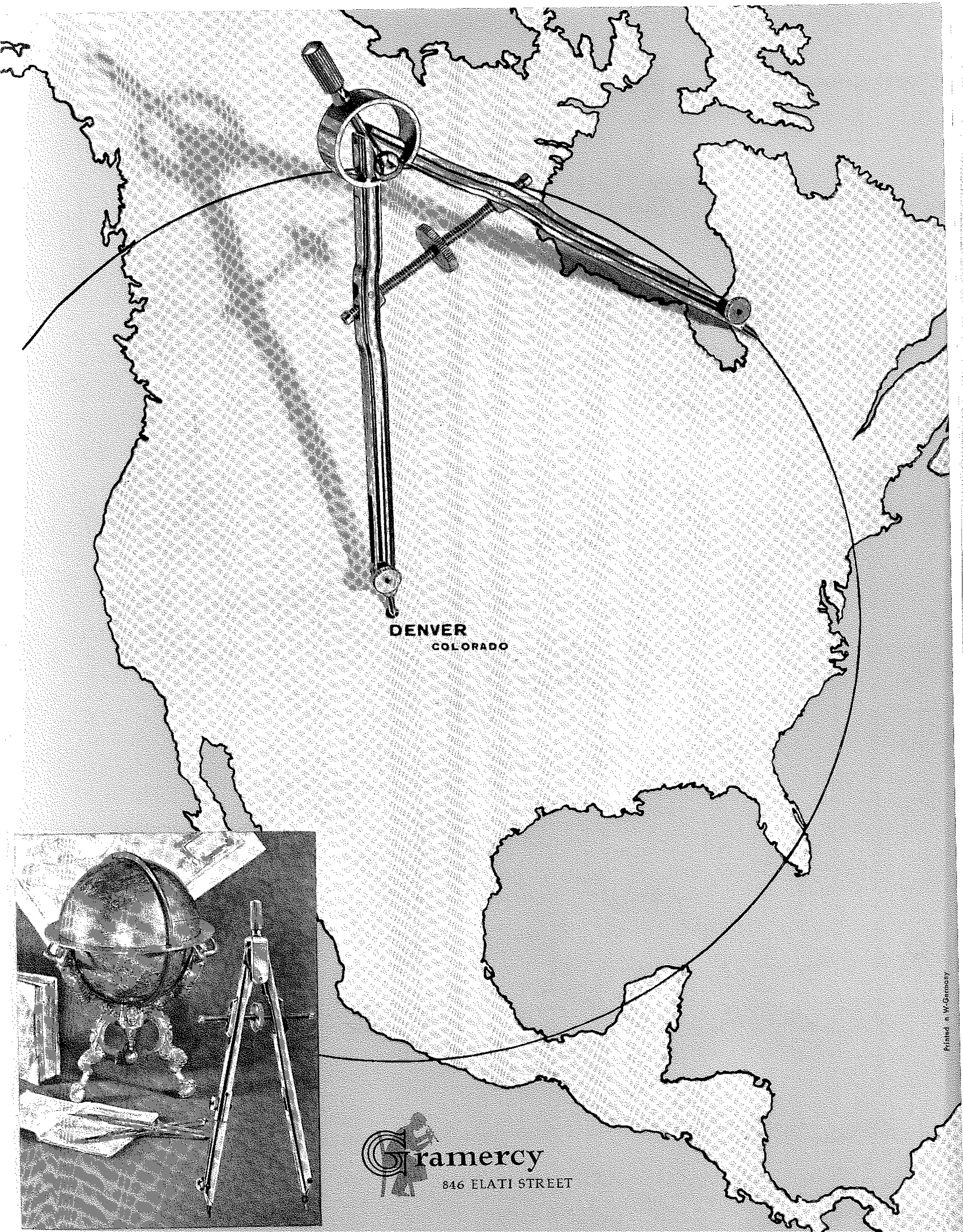
Alfred John Philby
October 27, 1906 - April 21, 1963

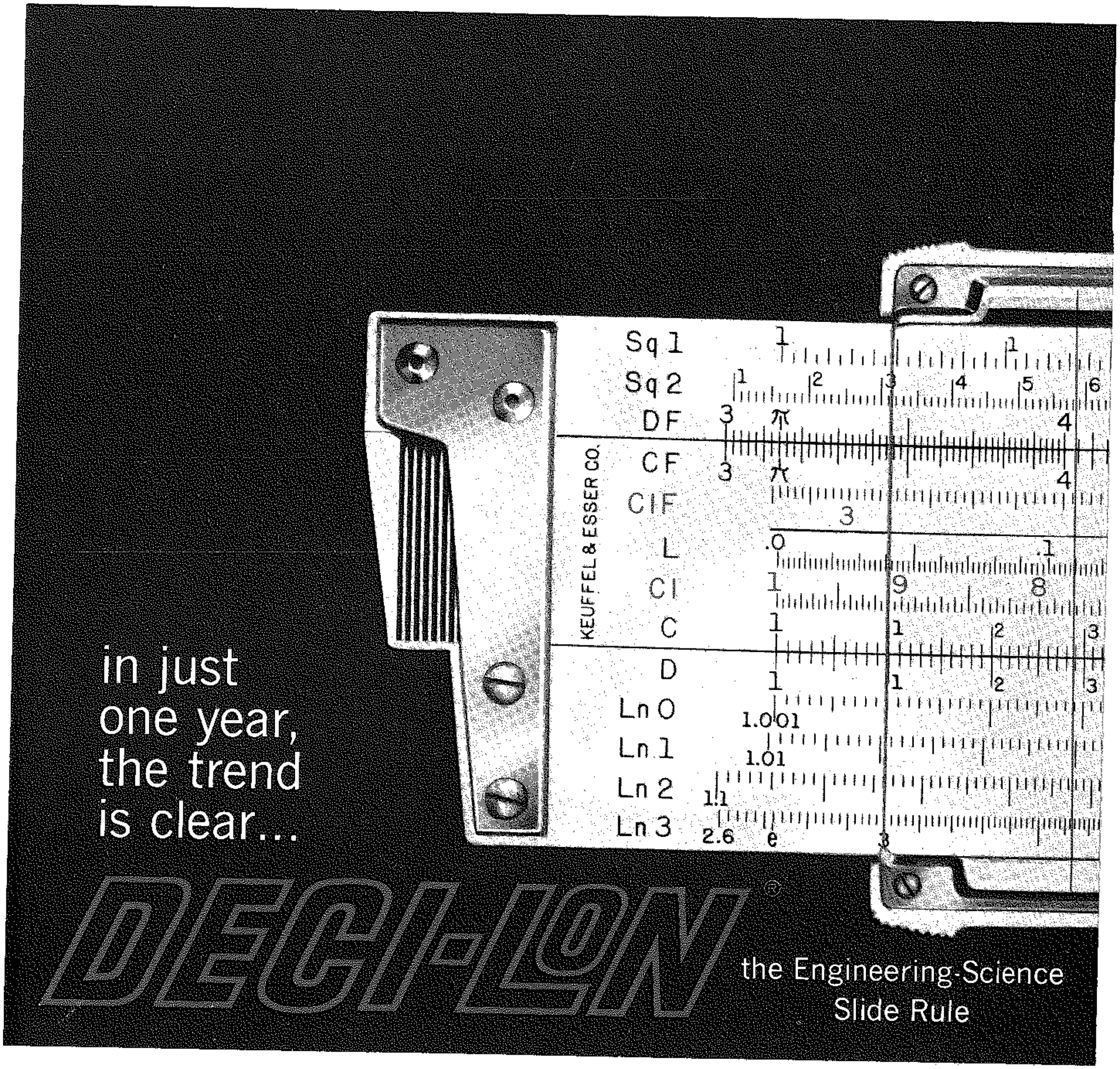
Alfred John Philby, Associate Professor of Engineering Drawing at The Ohio State University, died in Mt. Carmel Hospital on April 21, 1963.

Professor Philby was an excellent draftsman and made contributions to several editions of "Engineering Drawing" by Thomas E. French. He was co-author of "Lessons in Lettering," Books I and II, with Thomas E. French and William D. Turnbull.

He was truly a devoted teacher, and his excellent classroom procedures and chalkboard demonstrations were not exceeded by anyone at this University. He will be severely missed by his many friends throughout the engineering drawing field in the United States where he had established a reputation through his participation in meetings of the Engineering Graphics Division of the American Society for Engineering Education. Three days before his death he was notified of his election to the Executive Committee of this Division and was looking forward to accepting this assignment in Philadelphia on June 18.

It is with sorrow, mixed with admiration for his accomplishments and gratitude for his friendship, that we record his passing.


DENVER
COLORADO
Gramercy
846 ELATI STREET
Printed in W-Germany



Introduced less than 12 months ago, the DECI-LON Slide Rule is already the standard of slide-rule performance with the nation's engineers. There are four good reasons why: greater capacity, greater consistency, greater logic, greater speed. And that's greater everything of importance to slide-rule function.

With its unique grouping of 26 scales, including new scales based on natural logarithms, DECI-LON has opened up a whole new world of slide-rule capability. With its consistent and extended use of colors, functional scale symbols, and additional calibrations, DECI-LON provides easier and faster slide-rule manipulation than many ever thought possible.

For complete details on the "next logical step" in slide-rule evolution, write: Educational Division, Keuffel & Esser Co., Hoboken, N. J. We'll send you an eight-page, fact-filled brochure.

Now available in **2** sizes.

The DECI-LON Slide Rule is now offered in a handy 5" pocket size as well as the standard 10" size. The standard DECI-LON, with fine leather sheath and hard-cover instruction manual, is $25. The new pocket size, with leather sheath, leather-covered pocket clip, is $12.50.

EDUCATIONAL DIVISION
KEUFFEL & ESSER CO.