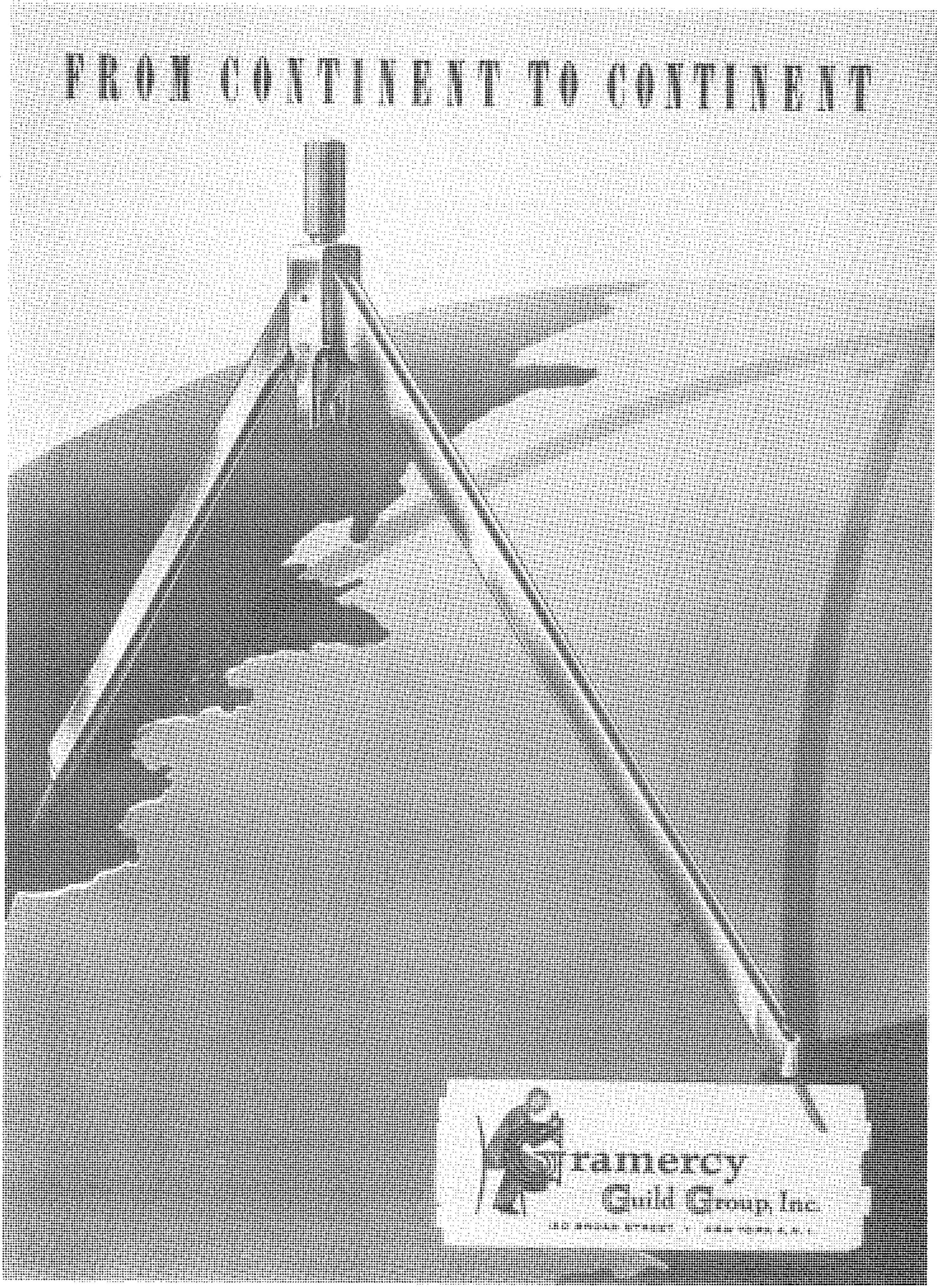
The Journal of Engineering Drawing

CONTENTS

VOL. 20, No. 2 MAY, 1956 SERIES No. 59

PUBLISHED BY THE DIVISION OF ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION.


FROM CONTINENT TO CONTINENT
Gramercy
Guild Group, Inc.

ENGINEERING DRAWING

NEW 2nd EDITION

BY

L. M. SAHAG

HEAD PROFESSOR OF ENGINEERING DRAWING

AND DESIGN

ALABAMA POLYTECHNIC INSTITUTE

The second edition of this text is very definitely a vast improvement over the first edition. With the exception of two or three chapters all chapters have been either revised and enlarged, or have been entirely rewritten. Several new chapters, such as Welding, Architectural Drawing, Aircraft Drawing, and Map Drawing have been added to this edition.

The descriptive part of various chapters are short and to the point so that students spend less time in reading the text, yet receive sufficient explanation on various topics.

Chapters on orthographic projection, dimensioning and working drawing include not only more materials, but the theory in connection with the illustrations is arranged in successive and logical order for the process of completing a working drawing.

Chapter 29 on Elementary Machine Design, together with advance materials in other chapters not only supplies sufficient information and problems for an advanced course, but it also links drawing with machine design.

Problems for each chapter follow the description of that chapter instead of being placed at the end of the text, as in the first edition. It is also worth while to note that most of the problems such as those on working drawing, structural drawing, etc., represent actual products made and used. If other texts pay very little attention to piping, here one will find complete information and actual working problems. If students taking drawing have not had trigonometry, here graphic solution is used to determine the length of a bent pipe.

Numerous tables appear in this edition, together with ASA standard symbols to be used in completing a drawing. The same tables are also used in machine design problems.

New text contains 32 chapters, 560 pages on 6 3/8 x 10 size. It has 685 text illustrations and more than 700 class room problems. *Price* - $6.00.

SUPPLEMENTARY MATERIALS:

ENGINEERING DRAWING PROBLEMS - SERIES "A"

72-- 8 1/2 x 11 plates on basic or first course in Engineering Drawing. *Price* - $2.50.

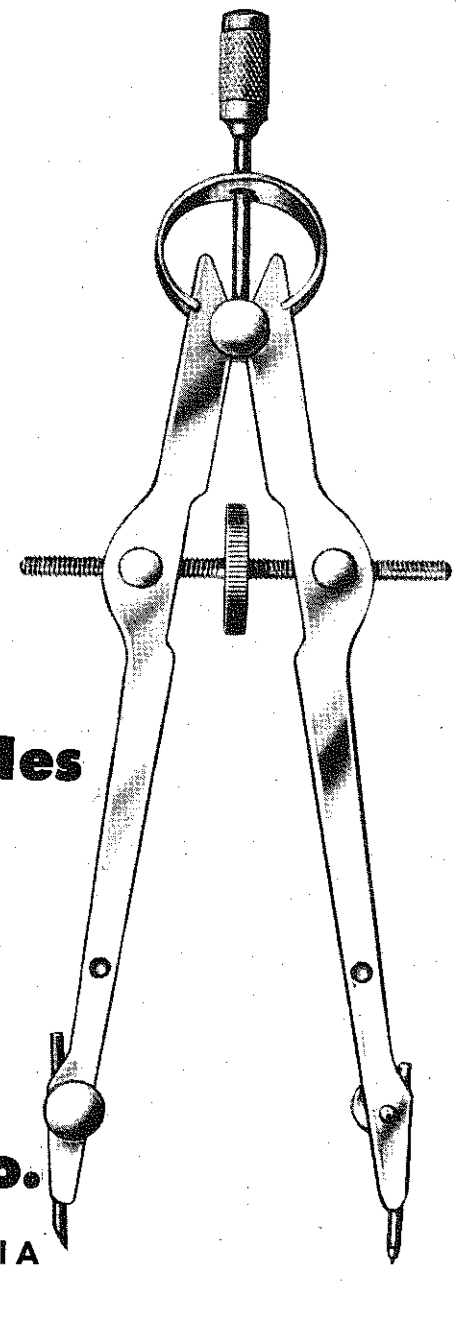
ENGINEERING DRAWING PROBLEMS - SERIES "B"

Made of 8 1/2 x 11 and 11 x 17 plates to cover the intermediate course in Engineering Drawing. *Price* - $2.50.

Both manuals are keyed to the author's text and can be so used in conjunction with other texts.

Write for copies, examine the contents and compare with other texts for its adaptability as an excellent teachable text.

Paul R. Malone, Publisher
807 Tenth Street
Tuscaloosa, Alabama



Breaking through the Resistant Crust

Photo courtesy
Monsanto Chemical Company

In the man's hands is the equivalent in Krilium of pile of compost between man and boy. Krilium is not subject to bacterial attack, lasts much longer.

Clayey soil packs hard, resists tillage, kills seedlings and keeps life-giving water and air from penetrating the surface. The Monsanto Chemical Company has developed a chemical which causes resistant clay to "open" up and become fertile and tractable. This "Krilium" may be one answer to the world's demand for more productive land.

In some men you sense a resistance that is like nothing in the world so much as hard-packed, barren and unproductive earth. With some men, perhaps it is too late. But with boys in their early teens, habits have not hardened and every educator owes it to the boy, to himself, and to society to apply some aerating and softening influence so that the native fertility and productivity in every boy can break through.

Surely educational theory agrees the lad's interest must be pulled beyond himself so that the back and forth traffic set up can increasingly get through. Certainly educators agree enthusiasm must be focused on something bigger, better and beyond the lad's own petty ego. Certainly in mechanical drafting there is golden opportunity not only in a new class, a new subject, but in the fact the boy is linking brain and hands in a task that is the first step on a road that can lead to the self-transcending goals of engineering, scientific and other creative contribution . . . with good to the world, with honor, prestige and appreciation to the giver.

What better can anybody ask? And why run the risk of contradicting all the influences brought here to bear, by permitting indifference in the selection of the drafting tools with which the boy will work? Certainly the concept of the value to boy and environment alike is worth far more than the petty economy to be gained by cheap and worthless tools.

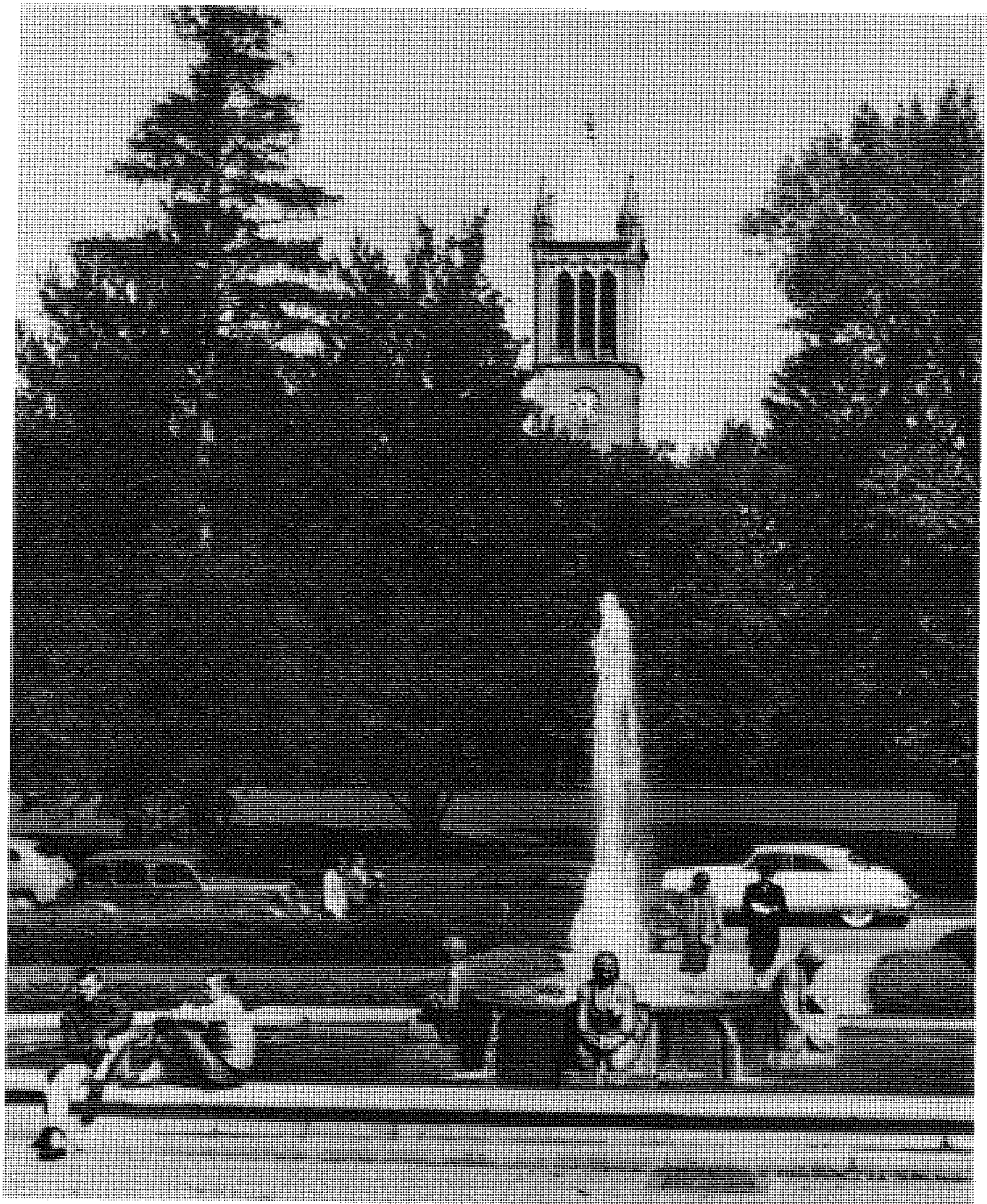
EUGENE DIETZGEN CO.

Chicago • New York • San Francisco • New Orleans • Los Angeles
Pittsburgh • Washington • Philadelphia • Milwaukee

Dealers in All Principal Cities

DIETZGEN

EVERYTHING FOR DRAFTING
SURVEYING AND PRINT-MAKING



EDITORIAL PAGE

JOURNAL OF ENGINEERING DRAWING

Published by
DIVISION OF ENGINEERING DRAWING
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

PUBLICATION COMMITTEE

Editor . . . . .Irwin Wladaver
College of Engineering
New York University
New York 53, N.Y.

Advertising Manager. . .Harold B. Howe
Rensselaer Polytechnic Institute
Troy, New York

Circulation Manager. . .Edward M. Griswold
and Treasurer
The Cooper Union
Cooper Square
New York 3, New York

PUBLISHED. . . . . FEBRUARY, MAY, NOVEMBER

Annual Subscription Price $1.25
Single Copy $0.45

ART STAFF

R.C. Carpenter . . . . . . .Purdue University
Oliver M. Stone. . . . . . .Case Institute of Technology
Frank Zozzora. . . . . . . .University of Delaware

Published in the Interest of Teachers and Others Interested in Engineering Graphics

1956 Summer School

The 1956 Summer School at Iowa State College, Ames, Iowa, may prove to be one of the memorable events in the history of the Division of Engineering Drawing. You must draw this conclusion if the diversity and general high quality of the program on page 48 are reasonable criteria for judgment. And by all indications, it should be the best attended ever.

But attendance records, whatever they are, will have greater significance when we know how many teachers are attending a summer school for the first time. The new teachers are the ones who must be depended on to keep tbe torch aflaming.

Encourage the new members of your staff to join us at Ames this coming June. Tell them how profitable and enjoyable have been the past summer schools. Even tell them the truth, if you must! Above all, be sure to get there yourself.

Our Allies, The High School Teachers

The publication committee of the JOURNAL are convinced that not enough high school teachers of drawing ever get to see this periodical. Our hard-working circulation manager, Professor Ed Griswold, has had signal success in expanding our circulation whenever he has had the name and address of a high school teacher to whom he could write a personal letter. At the same time, a letter addressed to no one in particular or a few back copies of the magazine sent to "The Drawing Department" get no response whatever.

And yet we need to reach many more high school and technical institute teachers than we do now. It is not for financial reasons -- we are in good shape financially -- but rather for reasons of continuity and communication.

Do you know any such teachers? If so, send their names and addresses to Professor Griswold. He will do the rest.

100% Schools

On occasion the JOURNAL lists the "100% schools." Apparently this expression has not been generally understood, for it seems incredible that in only seven schools in the country do all the teachers of drawing and descriptive geometry subscribe to the JOURNAL.

Let us say, then, that if all the full-time teachers of engineering drawing, graphics, or descriptive geometry are subscribers to the JOURNAL, yours is a 100% school. A part-time teacher in your department does not injure your status. Of course, we'd like to have him - or her.

Now: if you are a 100% school, let us know.

Talking About Subscriptions

Talking about subscriptions, now is the time to step up your efforts. Why now? Because it is almost inevitable that the JOURNAL will have to expand. Many of the papers to be given at the Summer School at Ames next month will be of such character that they will be worthy of publication under our banner. And they will not be available elsewhere.

The JOURNAL OF ENGINEERING DRAWING is the only publication exclusively devoted to the scholarship of our profession. It is through these pages that our colleagues keep posted on what is being thought, said, and done by the leaders in our field.

Especially in the immediate future, a new subscription or a renewal ought to be a sound investment. At least, this is the way it looks to us, from our highly prejudiced position.

Professor Street Says Thank You

When Professor William E. Street sent to the JOURNAL the program for the Summer School and Annual Meeting, he sent along a letter. In it he asked the editor to make known his gratitude for the help given to him during his tenure as Chairman of the Division of Engineering Drawing. in his own words:

". . . I would appreciate it very much if you would thank all the members of the Drawing Division of ASEE for the many suggestions and cooperation throughout 1955-56 and for the fine work that has been done by the committee and the individual members this year."

In return, if the editor could speak for the Division he would say, "We were happy to do whatever we could. Running the Division is a tough job. You've done it in fine style, graciously and efficiently. Our thanks to you."

AIM FOR AMES IN '56

By

J.S. Rising
Iowa State College

Two closely related factors will combine to make the 1956 Drawing Division Summer School a success this June 20 through 28 at Iowa State College. The first is a well balanced and worthwhile program. Please examine the quality and scope of the planned program found in this issue of the JOURNAL. Professor Street has worked long hours with the cooperation of Division members from all over the country in its preparation. You will surely agree it is a good one, worthy of your time to attend and participate.

The second factor is a large attendance. The facilities for housing and eating on the campus should prove to be very satisfactory. If preferred, off campus accommodations are available. Plans are being made to entertain your ladies while you take part in the program. The local committee is also working on weather control!

Ames is located a little to the west of the center of population but to the east of the geographical center of the United States. It is very accessible by highway, rail or air. U.S. highway 30, east and west, and 69, north and south, intersect at Ames. All Chicago and Northwestern trains stop at Ames, although far west or far east passengers will need to transfer at Omaha or Chicago. Hourly bus service comes in from Des Moines, 35 miles to the south, which is a main stop for the principal airlines from Chicago to the west or vice versa. The Braniff airline serves Des Moines from the north and south.

After reviewing the program make your plans to attend the Drawing Division Summer School and Annual ASEE Meeting this June.

STUDENT WORK AND OTHER DISPLAYS

Drawing Division Summer School
Iowa State College - June 20-28, 1956

By

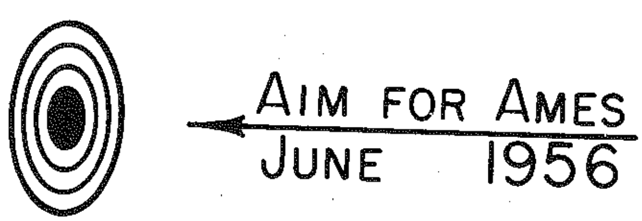
M.F. Almfeldt
Local Chairman of
Exhibits Committee

For some years past, the display of student work has proven extremely popular with the members of the Drawing Division. Since each instructor can learn new ideas and techniques by examining these samples, the committee in charge desires that as many institutions as possible participate.

Another popular and educational feature has been the display of quizzes and examinations. Since the design of worthwhile tests is extremely important, much can be learned by pooling efforts along this line. For maximum instructional value, this display ought to contain samples from all schools represented in the Drawing Division.

To facilitate handling and to prevent possible loss of material, the student work and the examinations should be in bound form. If at all possible, the exhibitor should transport his exhibit to and from Ames. However, packages may be sent prepaid to the Engineering Drawing Department, 403 Marston Hall, Iowa State College, Ames, Iowa.

A feature of this year's exhibit will be a display of handicraft hobbies, to include paintings, etchings, photographs or allied activities of the members of the Drawing Division. This should prove of interest and value, since it will serve to kindle friendships and closer relationships between members who have similar interests or hobbies. The committee invites all members of the Drawing Division to participate in this new feature. Please premount all displays.



THE DESIGN TEAM—ENGINEER AND DRAFTSMAN

By

R.C. Smith
Co-ordinator, Engineering Personnel
Allison Division
General Motors Corporation

INTRODUCTION

This article was originally intended to be a short discourse on the subject "What industry expects its young engineers to know about graphic drawing." It was quickly realized that what one industry might expect, another would not. Next, it developed that Allison's Chief Experimental Test Engineer and the chief engineers of the design departments had entirely different ideas along that line. The Chief Service Engineer had still different ideas. But the one point on which all were agreed is that the young engineer should be able to interpret accurately the most complex assembly or detail drawing. A significant fact is that all of these chief engineers at Allison have, at some time in their careers, worked on the drafting board. These are men who have the responsibility for the design and proper performance of extremely complicated mechanisms costing many thousands of dollars to produce. In the case of aircraft engines, both for civilian and military use, they have the responsibility of designing into the product factors to safeguard human lives.

PART I

It has been only a few short years since the young engineer, fresh out of college with his bachelor's degree, expected to find a job in industry only by writing letters of application and by paying calls on prospective employers until one of them offered to "try him out." Assuming that the firm was engaged in the design and production of some kind of machinery, the chances are that the young engineer was first assigned to the tracing vault. If he demonstrated interest and an acceptable degree of dependability, he was later entrusted with the job of "strengthening" lines, dimension figures, and notations on frequently used tracings. After a time, he was promoted to the job of making simple detail drawings.

Many of these men progressed in responsibilities until they eventually became design engineers. Some still work on the board, and the odds are heavy that they are assigned the most complicated layout work and that they check closely detail drawing performed by less experienced men. It is pretty safe to assume that the work they turn out is seldom criticized by the tool designers, the process engineers, or other having the responsibility of tooling for and making and assembling the pieces designed.

For the most part, these old-timers are living, idealistic answers to the question, "What does industry expect its design engineers to know about engineering graphics?" Their undergraduate curriculum emphasized engineering drawing and shop work and gave them a conventional background in mathematics, physics, engineering theory, and engineering laboratory work. This course of study, properly applied through a long and sometimes painful experience on the board, combined to provide excellent training for many of today's best design engineers. In fact, a man had to be good to stick with his profession under some of the conditions that the young engineer of less than a generation ago had to face. Those who couldn't stand the gaff sooner or later switched to some other phase of engineering or else left the field entirely.

Were those the good old days? Would we be better off if young engineers of today were required to go through the same kind of indoctrination forced upon the youngsters of only ten or fifteen years ago?

Certainly not. Technological progress since the close of World War II has made such practices as obsolete as the colonial spinning wheel. In spite of the effective work of our advertising and promotional departments, there is still a lot of truth in the old saying about the public beating a path to the house of the man who makes a better mouse trap. Modern industry, to be successful, must progress. It must bring out new products and ever improve those products by changes in design, by changes is manufacturing methods, and by substitutions of better materials. And to do these things, industry must constantly improve through vitalization and further education of its technically trained staff. Industry simply cannot afford to waste engineering brains and potential engineering talent by assigning young engineers to jobs that can be done by men without education in engineering theory.

It is realized that many will question this last statement. There are any number of progressive firms engaged in the design and manufacture of durable goods who regularly make it a practice to assign young engineers to training programs leading eventually to production supervision. There are also many young engineers who prefer the latter type of work or who prefer to use their engineering education as a stepping stone to sales or purchasing work. The writer has no quarrel with those firms or with the young engineers who prefer a field other than design or product development. However, it has been our experience that the overwhelming majority of today's young engineering graduates, particularly in mechanical and electrical engineering, express primary interest in product design, research or development work.

The industry represented by the writer, the Allison Division of General Motors Corporation, makes gas-turbine engines for aircraft and heavy-duty torqmatic transmissions for trucks,buses,railcars,and heavy off-the-road machinery. (See Figure 1). These are complicated mechanisms, which are not manufactured on a mass production basis. About 25 per cent of out total personnel is employed in product engineering departments doing research, design, development, and experimental testing of our products. Our primary manpower need is for the aeronautical or mechanical engineer with interests in aerodynamics, thermodynamics, and machine design and for the electrical engineer interested in electronics and servo-mechanisms. Other fields of engineering are also of interest to us--metallurgical, chemical, and civil--but not nearly to the extent of the aero, mechanical, or electrical.

Since product engineering plays such an important role in our organization, it follows that we need many draftsmen, layout men, and checkers. Well-qualified men in these lines are practically as hard to find as engineers. How do we get our engineers and draftsmen? To what kind of work are they assigned? What should the engineer know about the draftsman's job, and what should the draftsman know about the engineer's job? What should both know about fabrication and assembly?

These questions can only be answered in extreme brevity. It is realized that the writer's answers will give rise to and leave other questions unanswered and that many persons will take exception to some of the statements following. Opinions vary from industry to industry and even within a single industry. It must be understood that the statements set forth in this article constitute only the writer's observations.

PART II

Let us consider first things first. How do we get our engineers?

Experienced engineers are hired much as they have always been: by advertising, by referrals, and by unsolicited application. But the inexperienced engineer--the recent college graduate--that is a different story!

From the standpoint of the young man in his last college semester of engineering, this is truly a seller's market. If his grades are merely passing and if he is not afflicted with some bad personal or physical characteristics, he can spend much of his time (sometimes too much of his time) being interviewed by industry "recruiters" in his college placement office. He can take his choice of the offers made to him during some of these interviews, or he can accept numerous invitations to visit the recruiters' plants on an all-expense-paid basis for the purpose of further interview. The facts are that young engineers are in such short supply that at most schools there are at least twice as many firms trying to hire them as there are men in the graduating class. And since most of the firms who visit college campuses are trying to hire not just one but ten or more (some firms, including the writer's, are tryinp to hire more than a hundred), it can readily be seen that the better men could take their pick from at least twenty offers before they actually receive their bachelor's degrees.

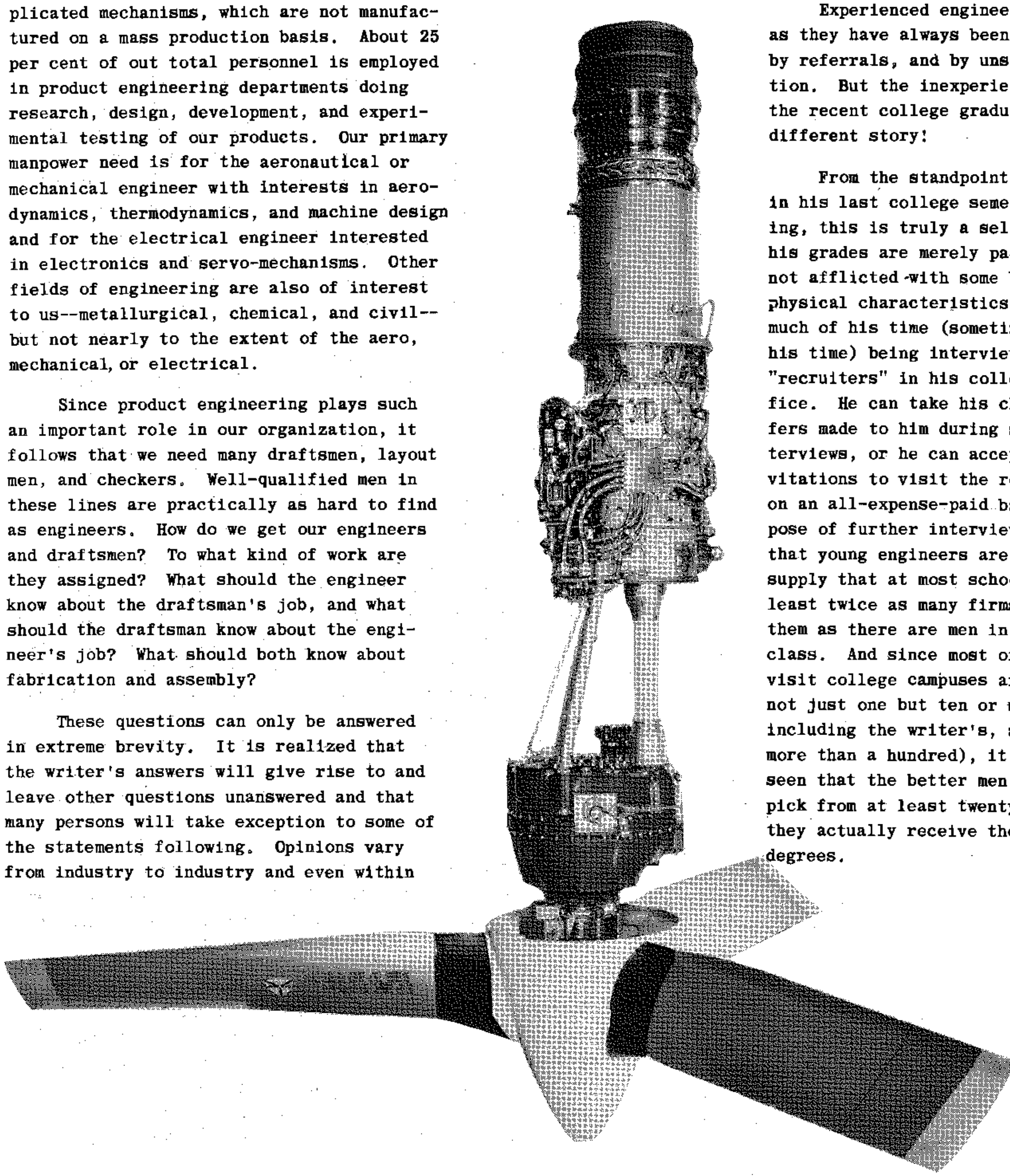


FIGURE 1
ALLISON MODEL 501-D13 Turbo-Prop Engine. Four of these engines, each developing 3750 horsepower, will power the Lockheed "Electra."

To the credit of most of these young men, it must be said that they realize that this condition is not due to any spectacular achievement on their part; that their good fortune is merely a reflection of the current situation. They exhibit a heartening degree of common sense. But at the same time, they know they would be foolish if they did not take advantage of today's conditions. Within only the last year or two, industry recruiters have noted that more and more of the better men confine their interest to just a few firms--not more than four or five --and make their final decisions after thorough consideration of all the opportunities offered by just those few firms.

Having made his decision, the young engineer, after he graduates, reports to the firm of his choice and after going through what is usually called pre-employment processing, he is put to work. If the firm was the one which he visited on an invitational basis, he has known for some time what his duties would be. The personnel man who interviewed him at college has seen to it that his duties would be explained to him during the plant visit--that he would have the opportunity to meet his supervisors and fellow workers and that he would be told as much as possible about the fringe benefits offered by the firm, about local housing conditions, and the many other factors involved in arriving at his decision to accept the firm's offer. The young engineer bought a package whose contents he knew. No pig in a poke for the young engineering graduates of today.

One of the things he learned when he visited the firm and while still an undergraduate was that the firm did not make it a practice to assign graduate engineers to the drawing boards. In some industries, the drawing board is one of the most important tools of the engineer. This is particularly true of the air-frame industry. There the board is in the same category as the slide rule, the sketch pad, and the log book at Allison. The drawings turned out by young engineers in the air-frame industry are often simply a means of training and communication. As time goes on, the engineers there diverge further and further from the status of draftsmen and develop into designers whose drawings, accurate but sketchy and incomplete, are reworked by skilled draftsmen before any pieces are made from them.

It has been several years since Allison has offered a newly graduated engineer a job on a drafting board. The fact that practically none of these young men would be willing to accept such a job is not the only reason for our discontinuance of a former practice. A much more important reason is that we have so many jobs than can be performed by no one except a man with an educational background in engineering theory, and we have found that we can get our drafting work done satisfactorily by high-school and vocational-school graduates. Since engineers are so difficult to obtain, what earthly reason is there for us to assign them to jobs that do not require engineers?

PART III

This leads us naturally to our next question--where do we get our draftsmen? The experienced detailers, layout men, and checkers are obtained in much the same way as are our experienced engineers--by advertising, referrals, and by unsolicited application. The inexperienced draftsmen usually come to us after graduating from high schools offering a course of study which emphasized mechanical drawing and shop work. Almost without exception, these boys bring a big scrap book of their high school drawings with them when they call at out personnel office and apply for a drafting job. Their line work, their lettering, their dimensioning, and their ability to make orthographic drawings of objects are usually all we could ask. What they lack is knowledge of General Motors and Allison drafting standards--standards of form, of symbols, of choice of materials, of stock sizes, of various types of fasteners, of finishes. They also lack knowledge of what we are equipped to build.

Other inexperienced draftsmen come to us after completion of drafting courses offered by vocational schools. There are several of these schools in Indianapolis. Some of the best draftsmen we have are young men who started working for us in a tool-crib, for example, and who completed a night course of one of these schools.

Depending on the ability and whether or not the newly hired inexperienced draftsman has had any shop experience, he is usually placed first in one of our tracing vaults or assigned direct to a board where he is put to work on simple detail drawings. He may be given the job of strengthening lines and figures on often-used tracings. He is expected to ask a lot of questions, to keep his eyes open, to study our drafting standards manuals--all to familiarize him with our drafting-room standards. He and one or two other young detailers work closely with one or more experienced layout men, and all of them work closely as a team with a project engineer and the latter's assistants. The engineers convey their ideas to the senior layout man by sketch and oral instruction. After the project engineer is satisfied with the layout, he initials it and becomes responsible for it. Then the layout man oversees the work of the detail draftsmen, who complete the drawings from which the individual pieces are manufactured.

This method of operation means that the project engineer must determine the proper sizes and strengths of the parts and the assembled structure. He must determine what materials will be used, how they will be fastened, joined, lubricated, and whether they can be properly machined. It is the layout man's job to "assemble" all the data given him by the engineer on a full-sized layout drawing, which accounts for all the many parts and their relation to each other and shows all the data necessary for the manufacturing departments to make and assemble the complete structure.

The reference above to the work of the manufacturing departments brings up another problem. Allison operates three "model shops." These are fully equipped fabrication and machine shops where we make test models of our products--transmissions, turbo-jet aircraft engines,and turbo-prop aircraft engines. A new model or an improvement on a production model is always made first in the model shops. Equipment in these shops is simply first-class machine tool equipment operated by better-than-usual operators. There are no especially designed machine tools because there are no long "runs" of any particular piece. The operator may be working on a different part every day of the week. This necessitates universal machine tool set-ups but few special jigs and fixtures.

The routing of a particular part through the model shop may run smoothly as clockwork. But when that same part goes into production, it may be necessary to process it on different machine tools. In that case, the drawing from which the part is made must recognize the difference between fabricating a single piece for a prototype test model and producing the part on a volume basis as it will be when it goes into production. The question might arise as to why it might not be better to prepare alternate drawings of parts, one drawing for the model shop and the other for production runs. In extreme cases this is done. But the necessity for the alternate drawing must be recognized when the part is detailed in the first instance. Otherwise, we are apt to learn too late that the piece must be completely redesigned and run the risk of the redesign resulting in performance of a lower quality than that delivered by the test prototype.

In other words, the draftsman, assuming he is grounded in absolute minimum essentials when he enters our employment, must next learn our drafting standards thoroughly and must then learn the basic purpose and general limitations of our machine tools, especially in the manufacturing departments. There is also the fact that most of the materials we use are high temperature resisting materials, which do not have the well-known characteristics of materials used in most machine design and manufacturing work. Special techniques and tools are necessary to bend and form them and to drill, cut, and machine them. Limits and finishes are so fine that a stock aircraft engine, for example, when cutaway, looks like an exhibition model used for instruction or display purposes. These fine finishes are not a production extravagance--they are absolutely necessary for proper and continued performance of the engine.

So even after the draftsman has acquired an intimate acquaintance of at least the basis machine tools at Allison, he must still keep posted on characteristics of the materials to be used. If the material can't be bent to a 1/8" radius, the senior layout man must know it and call the engineer's attention to that fact. Such apparently simple problems have delayed completion of final design drawings in many instances.

PART IV

If the top draftsmen must know all of these things, what should the engineer know about drafting?

Practically every engineer we hire must have a complete "reading" knowledge of layout and detail drawings. It must be admitted that in some departments the ability to interpret the drawing and to properly visualize the final assembly in all its elevations and sections is about all that is required of the engineers in those departments. It has always seemed to the writer that the best training for acquiring that ability is to have had considerable board experience in high school and college. For that reason, we are somewhat dismayed at the current tendency to de-emphasize or completely eliminate graphic drawing from engineering curricula in some schools.

If the young engineer is to be assigned to a product design department or to a department that will prepare him for an assignment in a design department after gaining a knowledge of the characteristics of his firm's current models, he must know nearly as much about engineering drawing as the senior layout man in the drafting department. In our case, he assumes responsibility for the latter's work after he is satisfied with the layout drawing. How can he conscientiously approve a layout drawing unless he understands and approves every line and notation on the drawing? To be sure, he may not necessarily have to design and collate the components of a gear train--the layout man must know how to do that --but the engineer must be able to follow the details of the gear train layout to assure himself that the assembly will do the work he expects it to do and that it is generally within the capability of his plant to produce.

The engineer should be able to recognize an impossible detail when he sees it. For example, two parts especially designed for a recent project reached our model shop in working-drawing form before anyone realized that they could not be made as designed except by using some specially designed fixtures and tools. Fortunately,both parts could be redesigned, so the only loss was a delay in time. But time, as everyone in industry knows, is very, very valuable

The design engineer should certainly know more about the materials to be used than does the draftsman. He must not only know the properties and characteristics of the materials he is specifying, but he should also know the basic reasons for the existence of those properties and characteristics. This latter knowledge sometimes results in subjecting the material to some process (heat treating or ceramic coating, for example) that will change some property of the material in such a way as to enhance its utilization. He must also keep abreast of the research in the field of new materials and improvements. For example, we are always quite interested in alloys

Continued on page 26

RELATION BETWEEN ENGINEERING AND MACHINE DESIGN

By

L. M. SAHAG
Alabama Polytechnic Institute

In order to justify comments made in this paper pertaining to the existing relation between Engineering Drawing and Machine Design, the following statement is quoted from the "Report on Evaluation of Engineering Education:"

"Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful for these purposes is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, and the ability to convey ideas, expecially by freehand sketching, which is the normal mode of expression in the initial stages of creative work. Though the engineer may only supervise the preparation of the drawing required to execute his design, he can hardly be expected to do this effectively unless he himself is thoroughly familiar with the graphical communication."

From this statement we learn that in design the graphic representation is very important. But to further illustrate the usefulness of the graphical solution, which is generally known as engineering drawing, and to point out its relation to machine design, it is necessary to describe, as briefly as possible, the main requirements of a machine design course.

If we study the statements made in various textbooks, we will find that the following requirements are important in designing a machine:

(a) The problem should state the purpose for which a machine is designed. It is also necessary that certain conditions should be specified. For example, to design a boiler it is necessary to state that this boiler is to generate saturated or superheated steam. The required horsepower, steam pressure, type of furnace or combustion chamber, method of firing, that is, using stoker, grates, etc., should also be given.

(b) The second step is the selection of desirable mechanisms. Our studies in kinematics of machines and also the material given in applied mechanics should serve for this purpose. It is important either to assume or to select the proper parts in proper proportion for the required displacement, velocity, and acceleration. It is not merely sufficient to select two gears for a required velocity ratio, but we should also find whether there will be any interference between the gear teeth.

(c) As a third step, force analysis will be our task. Under this requirement it will be necessary to determine all the dead loads and live loads on various parts of the machine, frictional forces, inertia forces, effect of temperature, and forces due to shape of parts.

For the problem certain values should be given and others assumed. To reach a decision in industry, it is important for the engineer to consult with other engineers and refer to other works of similar nature; and if such an engineer has several years of experience, this will constitute additional help in his design. In classwork, however, we have inexperienced students; therefore, we do not expect that most of the design will display any effect of experience. On the other hand, the courses in mechanics, graphic statics, and other allied courses, together with additional instruction and regular consultation with the instructor, should serve as a means of obtaining satisfactory results.

(d) The fourth step is the proper selection of material for its strength, rigidity, resistance to corrosion, wear, etc. In classroom work studies in strength of materials, materials of engineering, knowledge in stress analysis and stress concentration, together with additional information which may be found in machine design texts, will be used to finish this part of the design.

In order to obtain satisfactory results for the first four requirements, at the very start one must make a freehand sketch of the assembly. On this, assumed and also determined sizes should be given and the computations should be based upon these sizes. It is unwise and poor method to start any design without some form of drawing. The freehand sketch will not only be useful in design analysis, but it will also facilitate the making of the preliminary layout.

(e) The fifth step is to begin the preliminary design layout. This, naturally, will be the result of all former computations. This is generally is assembly form. It is on this drawing that actual sizes are drawn to scale. It is on this drawing also that we are able to discover if the parts are made strong and that the shape and size of certain parts do not interfere with free motion of the other parts.

(f) Revising of the assembly drawing is the sixth step. The preliminary drawing is not only revised to agree with the changes made in shapes and sizes because of new values obtained analytically, but it is also revised for the following: (a) For the method of manufacturing the parts. If a part is made of cast steel instead of cast iron, or it is to be a weldment, then there will be some difference in the design of the part. (b) The cost of manufacturing should be considered in the design. A part may be cheaply made in one locality by casting, whereas the same part may be fabricated economically as a weldment in another place. Let us not forget that as these changes are applied, possible increase or decrease in stresses must be checked. The revision should also include the requirements of safety and economical operation, elimination of undesirable protruding parts, manner of proper lubrication, safety guards, prevention of moisture, rise of temperature, and so on. Finally, the appearance of the finished machine as a compact and artistic product should not be overlooked; for this quality is one which puts two similar products, manufactured by two different concerns, in competition with each other. Such condition in the improvement of design can be easily seen in design laboratories. In a class of twenty-five students it is interesting to see how in one assignment each design varies from the others in many ways.

(g) When the preliminary drawing has undergone the needed revisions or modifications, the next step will be to begin making the detail drawings. These may be made directly on vellum paper, or they can be laid out on paper and traced on vellum paper for reproduction. In order to speed up detailing, quite often a student makes his preliminary assembly in the form known as a general detail and assembly drawing. On this he gives the main dimensions of each part so that when he begins his detailing for every size he will not attemp to use the scale.

It is here again that a student's knowledge of drawing will come very handy. First, he will know how to choose his scale; next, how many views of each will be needed; third, how each detail should be placed on a large drawing so that after the dimensions are given, details will not be crowded in one corner but will be arranged uniformly on the drawing paper.

If in a drawing class a student has learned how and where to give finish marks, tolerances, and if he understands the necessity of giving notations and bill of materials, then he will, with very little help from his design teacher, finish his drawing in better shape.

(h) After completion of detail drawings the preliminary assembly drawing is now redrawn with all the parts in their final form as shown on the detail drawings. On the final assembly drawing there will be no necessity of giving detail dimensions, but only these which will be needed for installation, packing, providing ample space for proper operation of the machine, etc. Identification of every part should be made to correspond to these given on detail drawings.

In order to confirm that the routine of starting a design work as shown above is generally accepted as a better system, which I have taught during my teaching career, and to also illustrate the present relation between design and drawing courses, I sent out two different questionnaires: one of these to those who teach engineering drawing and the second to design teachers. In this no attempt was made to submit the questionnaires to every school in the country, but only to a few from various sections.

From the drawing group the returns show that 20% operate on quarter and about 80% on semester system. Those on quarter system have two quarters of engineering drawing courses. Of those on semester system, 50% have one course in drawing, about 30% have two semesters, and 20% have three semesters of drawing courses. From these it can be seen that those who have fewer hours to teach drawing do not give as many exercise plates and are not able to give any advanced work. From the returns it is estimated that between 25 to 30% of the total course in drawing is devoted to the orthographic projection, including of course sectioning and auxiliary views, and about 15 to 20% is used for working drawings. Only a few give any problems on piping, welding or structural drawings. While freehand sketching is considered very important in design work, excessive work along this line, such as from 40 to 50% of the total course, should never be encouraged; because as much time is allowed to teach drawing, our engineering students should learn what they are supposed to know about drawing in all its phases. If in industry they make nothing but freehand sketches, drawings with arrowheads left out, or some lines omitted, it does not mean that in classrooms we should not teach them how to use a scale or make ink drawings.

On the drawing questionnaire there were two additional questions. (1) Do you think you teach sufficient drawing for industrial use? To this 50% answered yes and 50% no. (2) Do you think you teach sufficient drawing for machine design course? Answer: 50% yes and 50% no.

The questionnaire sent to the machine design teachers revealed several facts: First, the schools operating on both quarter or semester systems, with few exceptions, are all able in their lecture hours to cover the main elements of machine design, such as shafts, rivets, screws, springs, gears, belts, chains, and so on.

So far as this part of machine design course is concerned, we would say that the students at least form an idea as to what a machine design course consists of. If the instructor is able to point out certain things in regard to a problem, that is, whether from a practical standpoint the results are correct or incorrect, then the students will appreciate more the value of such a course. For instance, in gear problems the student should begin to solve the kinematics parts of the problem, and then determine the forces based upon given and assumed values. He should determine the magnitude of transmitted, endurance, dynamic, and wear forces, and carefully compare their value with each other. If the outcome of various conditions is not correct, then he should specify which terms or values should be increased or decreased to obtain satisfactory results. In other words, it is not sufficient to obtain the answer as we do this for mechanics or strength of material problems; on the contrary, in design courses the accuracy of the results must be ascertained according to the conditions as specified above, and its practical value should be considered.

With reference to design laboratory courses, the following questions were asked:

(a) Do you solve problems only on machine parts? 24.5% answered yes and 75.5% no; which indicates the laboratory period is not devoted entirely to solving problems.

(b) Do you assign simple but complete machine? 73% answered yes and 27% no, indicating again that the majority assign a complete design problem.

(c) For question (b) do you require only analytic computations? 18% yes and 82% no, indicating that problems involve drawings.

(d) For question (b) do you require computations and complete detail and assembly drawings? 65% answered complete drawings, 14% only a sketch, and 21% no drawings.

Other questions were: Do you think students learned sufficient drawing for machine design? 60% answered yes and 40% no. In this category those who have two or three semesters of drawing answered yes, while those who had one semester or two quarters of drawing answered no.

Another question: Is there close cooperation between drawing and design teachers? 60% answered yes and 40% no. If the above survey represents the same situation throughout the country, we are at liberty to state:

(a) That a machine design course should be taught both as a lecture and laboratory course.

(b) That in laboratory, solving individual problems, such as on bolts, shafts, etc., is not a proper method.

(c) That simple problems should be a part of lecture courses and serve as home work.

(d) That a laboratory problem should be a simple machine, including several elements for which lectures, handbooks, catalogs, and such, can be used to assist in the design of the components.

(e) That only simple sketches will not be sufficient, but the true design must require a complete set of drawings.

This being the case, how much importance should we attach to the teaching of engineering drawing?

In our colleges we have a few combinations, that is. in small institutions the drawing is taught in the Mechanical Engineering Department. In larger institutions a separate Engineering Drawing Department is organized where mostly drawing and descriptive geometry courses are offered. Then again we have a few colleges where all graphic courses, such as drawing, descriptive geometry, kinematics of machine, machine design, are offered in the same department. Furthermore, we also have another combination, such as the one where in the same department drawing and mechanics are taught. Speaking of the first two types, that is, separate drawing and drawing-and-design in combination, such departments are known as service departments (unless a department offers a degree). This means they offer what other departments, such as Mechanical or Electrical Departments choose to include in their curriculus. If these departments wish to have only one course in engineering drawing, then that is what we have to teach. So you can see that under these conditions, our hands are tied and we are compelled to teach as much as we can in a limited time.

At the beginning of this paper I quoted from the bulletin of the "Evaluation of Engineering Education" as to the value of design and graphic expression. If we take that statement as our criterion and compare it with the above answers, we will realize that the time allotted to drawing is not sufficient to even cover the requirements of a basic course, much less be able to give any advance material.

But what can we expect when those who map out the curriculum of other departments make such statements that drawing is the job of a draftsman and not an engineer. In advocating teaching our young engineers more about drawing, it is not intended to turn out draftsmen.

Furthermore, if in design laboratory we ask them to put on the paper the result of their computations not only in assembly but also in detail drawings, we hope to accomplish the following:

(a) To make the student a better engineer.

(b) If a drawing is submitted to a young graduate he will be able to read a drawing with less difficulty.

(c) That he will be able to supervise other persons' work and make some constructive suggestions.

(d) If someone else, let us say a professional draftsman, is making the drawings of his design, he should be able to tell whether the draftsman follows the design correctly. Furthermore, in the process of drawing he will be able to make some changes in the original design, if he finds that such changes will improve the machine.

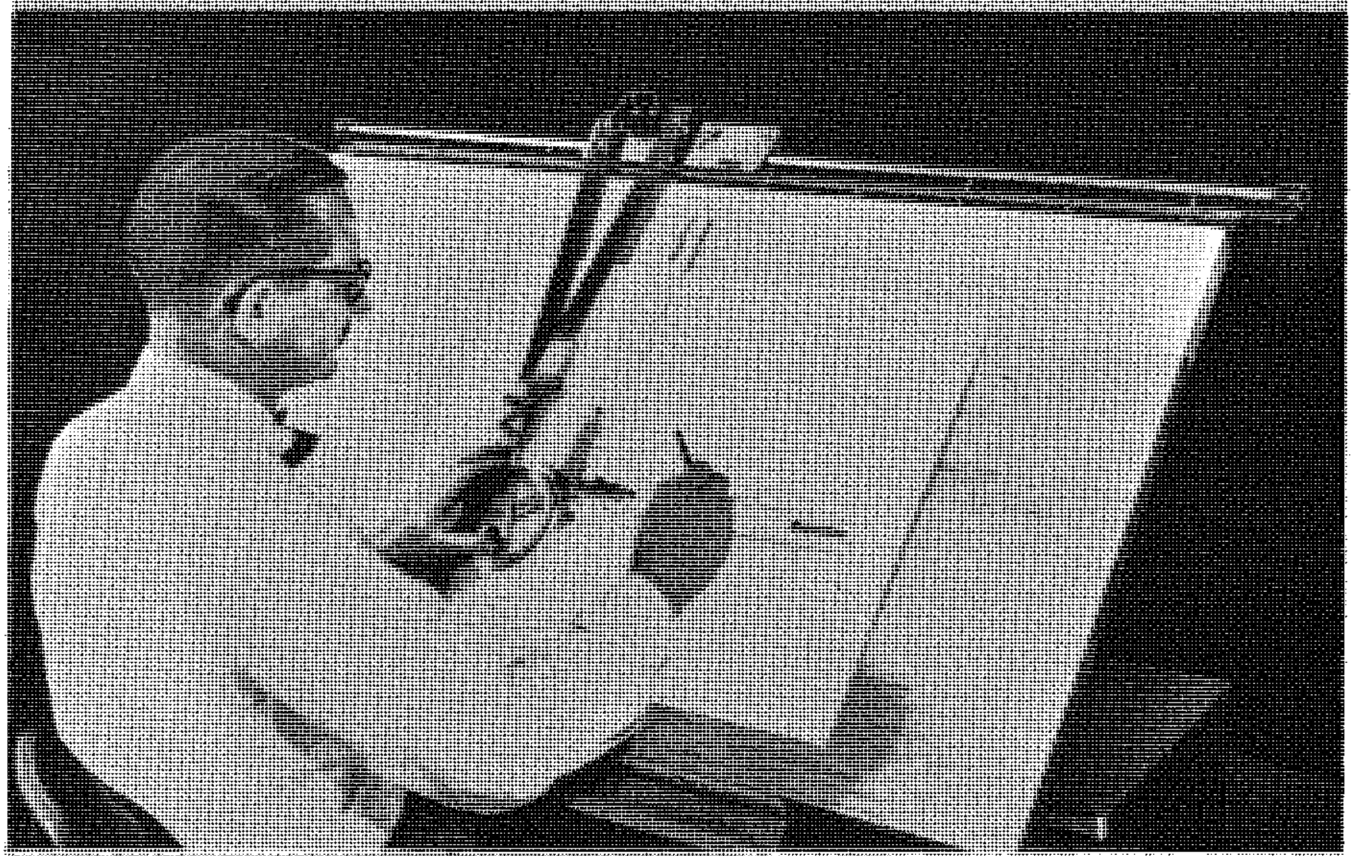
(e) If a student is taught in both drawing and design classes the sequence of making drawings, he will do better and quicker work.

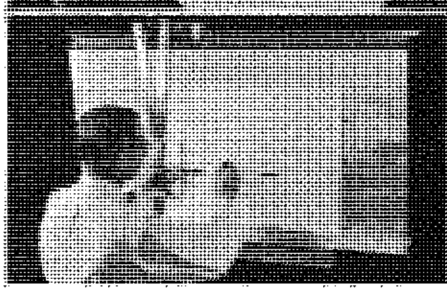
(f) Finally, having been trained in this manner, if the same routine of design is also carried out in industry, he will go out with more confidence in his ability and will tackle a job with less fear and doubt.

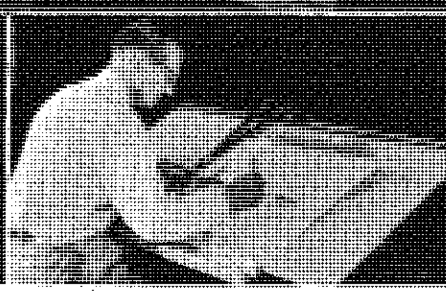
Our requirements in industry as far as drawing and design are concerned are different from what we expected 20 or 25 years ago. In spite of the fact that some individuals and a few companies are attempting to minimize the importance of good drawings, we require more carefully

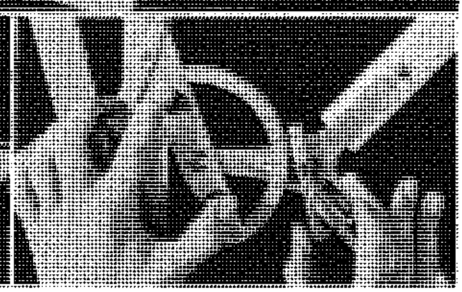
Continued on page 38

EMMERT *Draws the Accurate Line!*









• OPERATES EQUALLY WELL IN ANY POSITION

• MICROMATIC QUADRANT

EMMERT MICRO-DRAFTERS

ACCURACY, SPEED, DURABILITY, SIMPLICITY

. . . all you demand in a precision drafting instrument are the dominant features of the EMMERT Micro-Drafter.

ACCURACY . . . with the Micro-Drafter you can draw absolutely parallel lines the full length and width of the board with one continuous stroke. SPEED . . . the Micro-Drafter operates with finger-tip control, changes positions accurately in split-seconds — never a blind spot. DURABILITY . . . stainless steel, a minimum of wear points and moving parts makes this an unusually rugged instrument. SIMPLICITY . . . unmatched in any other drafting instrument. Write for complete details.

The Micro-matic Quadrant provides rapid indexing from 0° to 360° in multiples of 3° by simple lever action. Just a slight pressure of the thumb releases the worm gear permitting the desired amount of adjustment. Settings less than 3° are made by turning the worm screw.

Absolute accuracy of all angles from 0° to 360° and adjustment to 2½ minutes is assured by the Micro-matic's fine precision tooling. Fully visible at all times with clear sharp calibrations the quadrant eliminates all eye-strain.

EMMERT

MANUFACTURERS OF PRECISION DRAFTING INSTRUMENTS AND EQUIPMENT

DRAFTING PROBLEMS IN INDUSTRY AND SOME SOLUTIONS

By

R.W. Pearson
Staff Engineer, Missile and Surface Radar Engineering
Radio Corporation of America

Gentlemen, I have been asked to present for your consideration some problems relating to the general field of drafting which industry faces today. Although I am in a field allied with the electronics industry, my contacts with many other industries lend emphasis to the already well-known fact that similar, if not the same problems, plague all of us. Our needs are relatively few. We need good-thinking men and women who can convert an idea into a finished product saleable at a profit in competition with our worthy competitors. You, gentlemen, as educators have only to supply us with properly prepared raw material. Industry will do the rest.

I have put industry's requirements into simple words. Let us now examine these requirements.

I. THE NEED FOR AN "IDEAL" DRAFTSMAN

A. The "ideal" draftsman is a person who possesses knowledge in the following fields:

1. Materials and their uses
2. Machine shop and assembly plant methods and processes
3. The physics of mechanics, kinematics, heat transfer, electronics, etc.
4. Costs, and designs for cost control
5. Salesmanship and customer reactions

B. This person does not now exist, he never will! The rapidly accelerating rate of progress in each of the above fields precludes any one man or woman from reading in one lifetime even a small part of the printed matter available, much less studying and applying all of it. The foregoing statement ought to be seriously challenged. Are we to give up because we don't have time to read and apply what is to be found in the literature? Are we to sit back and say it's impossible to develop the man characterized by the above and hence do nothing about it? Is the drafting language to become dormant,then decay in a manner similar to that of classical Latin because it could not grow? I, for one, would shout "NO," for I am positive that from the combined thinking of you educators will evolve a way around our problems.

II. A CHALLENGE

I will try to point out areas in which you, as educators in our renowned technical schools, can help prepare the "raw material" for their more rapid absorption into the stream of scientific progress now surging about us. I want to emphasize that I am not criticizing the basic elements of the drafting language, nor am I qualified to state that there is room for improvement. I wish only to bring to your attention specific areas where the cold, hard facts derived from actual business experience in the field of competition dictate that research work is needed, and needed badly. It is not only possible but highly probable that some of what I say will run counter to the concepts of modern educational methods in our colleges and universities. I do not presume that these concepts are wrong. I only wish to conclude that something is missing because industry is NOT getting people sufficiently trained to fill the partial vacuums created by our phenomenal surges into the unknown. Will you accept the challenge to review and, where necessary, revitalize and create new "words" in your language to meet the needs of industry?

III. THE NEED FOR APPLICATION WORK IN MECHANICS

One of our pressing needs is to obtain technical people who can properly interpret and apply Newton's three simple laws. Even if this could be done on an average of three out of five times, progress would be phenomenal! It is true that most of the boys are subjected to courses in mechanics and kinematics, but more practice problems seem to be necessary, for the boys are not usually able to apply the principles satisfactorily. Would you give this some thought? It is not enough to teach the elementary principles - our young people must be proficient in the application of such principles to ordinary problems - for example, to know gear trains and their tolerances, advantages of one type of drive over another, mechanisms of various types, effects of extreme temperature changes on the various mechanisms, and so on. Elementary members of components (armatures of relays, for example) are given terrific accelerations during vibration and shock. Hence their proper design must be considered in a great many applications.

IV. THE NEED FOR PRACTICAL DIMENSIONING

(I shall include limits and tolerances in this topic. In my Plant the word "processing" means the developing of a sequence of operations, including the making of the necessary tools, jigs, and fixtures, to accomplish the requirements set forth in the drawing. Other plants and other industries may have different expressions which connote the same thing as our "processing.")

For years I've been an umpire in settling disputes concerning interpretation of a given drawing between Factory people on one side and engineers and draftsmen on the other. These drawings are made by better-than-average draftsmen and they are reviewed before issue by better-than-average engineers. They are interpreted by good Factory personnel, many with long years of practical experience. Yet serious disputes arise. Why? My success in trying to answer this question is not phenomenal. However, three difficulties stand out like the proverbial lighthouse in the storm. They are:

A. The universal omission from drawings of required information which is "taken for granted," or is left to "good workmanship."

B. The lack of appreciation of practical tolerances with incident high cost.

C. The need for a change in drafting semantics in light of the rapidly dwindling "Pride of Workmanship." I shall touch upon these subjects.

A. Omitted Information

The drafting language is a formidable weapon. One can eliminate the possibility of misinterpretation by adding dozens of notes, by showing scores of sectional views, by adding isometric or other three-dimensional views, as so on. But no one drawing will hold all this information. In fact, even if the draftsman made no human error, there are many items made in industry in which several volumes would not contain the necessary detailed information to prevent misinterpretation of the drawing. But how many companies can afford to write a book each time another item is to be released for production? And how many companies can afford to read that book at every machine or assembly point in the Factory? Not many, I can assure you.

It appears to me that an answer lies in the establishment for an industry, or possibly for the nation, certain well defined practices that have the same meaning throughout the country. As it stands now, each company has its own "understandings" about what is meant by the use of, or by the lack of, certain information on drawings. Need I say that the most misunderstood topics in industry are the "understandings" within and/or between departments and companies? The parts interchangeability problem is no worse than the drawing interpretability problem.

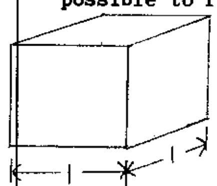
RCA's contribution toward the alleviation of this problem is the "Manufacturing Tolerance Specifications" drawing, a reproduction of which accompanies this article. The introduction of this Specification in our Plant has reduced our problems considerably. We now talk the "same language" in our Engineering and Drafting departments, in our Purchasing and Incoming Inspection departments, in our Quality Control and Factory operations, and with our vendors. These Specifications work this way. If nothing appears on the drawing concerning flatness, roundness, perpendicularity, or the like, those requirements called for in the Specifications are invoked by a suitable note on the main drawing. However, if the designer wanted a tighter or looser specification, he would have so stated on his drawing.

B. Practical Tolerances

The second great difficulty lies in the fact that the draftsman, by the very dimensional information he places on that drawing, often dictates the manner in which the Factory must process that part. A draftsman most skilled in the creating of ideas and expressing them in drafting form can cause his company undue expense if he lacks the practical shop knowledge to dimension the parts to permit minimum tool, machine and assembly costs.

Let me emphasize this point. The figure depicts a 1-inch cube. Without a specified or implied tolerance, it is impossible to make this cube! No matter what care and precision is machined into the material, it is impossible to make this cube of exactly one inch to a side.

Possibly by some super-human effort in an air-conditioned, temperature controlled room it might be possible to reduce the error to something in the order



of one-ten millionth of an inch, but the cost would be astronomically high. And what machine or process would you use? The table below gives an idea of the relative nature of the problems designed into a cube by the use of one of several different tolerances. This table is put together to demonstrate a point. It is not complete by any means. When a designer specified a given tolerance, say ± .002, few, if any machines above the milling machine in the table can be used to obtain the given tolerance. There is a choice of several machines or processes recorded below the milling machine in the table, but note what happens to the cost of the part if any of them are used.

Tolerance	Machine or Process to Make Part to Tolerance	Relative Cost of Operation
± .250	Acetylene Torch	300%
± .125	Power Saw	200%
± .060	Sand Cast	150%
± .010	Hand File	400%
± .005	Planer or Shaper	300%
± .002	Milling Machine	100%
± .0001	Surface Grinder	600%
± .00005	Precision Grinder	2000%
± .00001	Machine Lap	6000%
± .000002	???	Way, way up

My point is that if the designer is not very familiar with shop machinery and practices, he does not keep in mind the methods of processing the part, as he designs it; hence costs can go up at an awfully fast rate. We can't stand that in our business or in any business. Note that we have another set of related problems when we state that the sides must be flat within such and such a tolerance, with still another set of problems when we state that the sides must be mutually perpendicular within some tolerance.

RADIO CORPORATION OF AMERICA, ENGINEERING PRODUCTS DIVISION, CAMDEN, N.J.

PLEASE NOTE: THESE SPECIFICATIONS ARE APPLICABLE UNLESS OTHERWISE STATED ON THE DRAWINGS, IN WHICH CASE, DRAWING REQUIREMENTS PREVAIL.

96400 SHEET 1 CONT'D ON SHEET–2

These Specifications are invoked on all materials, parts and / or assemblies produced for or by Engineering Products Division.

The purpose of these Specifications is to establish the limit of quality acceptable when complete information is not given specifically on the drawing.

Good Shop Practice, at nominal cost, usually demands performance well within the tolerances specified herein. In no case shall items be accepted which exhibit workmanship not meeting these Specifications and / or the applicable drawing(s).

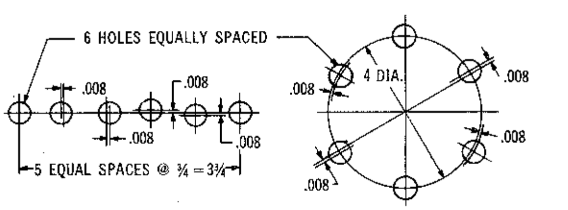
A — GENERAL

A-1 BURR REMOVAL: WHEN REMOVAL OF FLASH AND BURRS IS SPECIFIED WITHOUT QUALIFICATION, THE CHAMFER OR RADIUS SHALL NOT EXCEED 1/32 OR 10% OF METAL THICKNESS WHICHEVER IS SMALLER. FLASH AND BURR REMOVAL TOOL MARKS SHALL NOT BE SUCH AS TO REQUIRE A SECONDARY SMOOTHING OPERATION BEFORE THE PART CAN BE SATISFACTORILY PLATED, OR CAN RECEIVE AN ORGANIC FINISH.

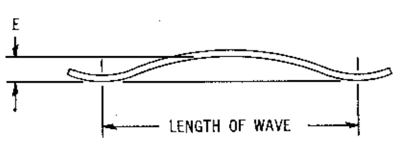
A-2 BURRS ON SCREWS, NUTS, AND SUCH HARDWARE SHALL NOT BE ACCEPTABLE.

A-3 LOCATION OF HOLES: THE LOCATION OF HOLES ON STRAIGHT LINES, CIRCULAR LINES OR WHERE MARKED "EQUALLY SPACED" SHALL NOT DEVIATE FROM THEIR CENTER LINES, IN ANY DIRECTION BY MORE THAN 1/4 OF THE TOTAL TOLERANCE OF THE OVERALL OR DIAMETRAL DIMENSION.

IN THE EXAMPLES SHOWN, THE STANDARD TOLERANCE, ACCORDING TO THE DRAWING FOR THE 3-3/4 OR THE 4 DIAMETER DIMENSION IS ±1/64 AS OBTAINED FROM TOLERANCE BLOCK ON THE DRAWING. HENCE, THE LOCATION OF EACH HOLE CANNOT DEVIATE FROM ITS CENTER LINE BY MORE THAN .008 (1/4 OF 1/32) IN ANY DIRECTION.



A-4 STOCK STRAIGHTNESS: ALL UNMACHINED SURFACES OF PARTS MADE FROM BAR, ROD, SHAPE OR TUBE STOCK SHALL BE STRAIGHT WITHIN THE TOLERANCES SET FORTH IN THE FOLLOWING TABLE:

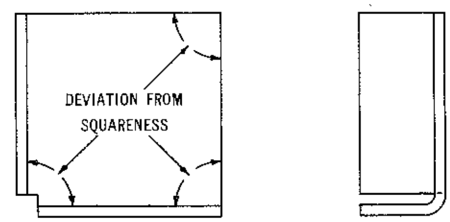


LENGTH OF WAVE IN INCHES	UP TO 12	12 TO 24	24 TO 48	48 AND OVER
MAX. PERMISSIBLE DEVIATION 'E' PER INCH	.001	.002	.003	.004

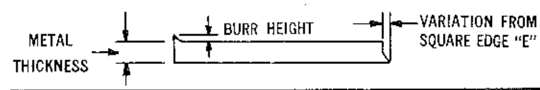
A-5 DIMENSIONS LOCATING TAPPED OR COUNTERSUNK HOLES, AND THE LIKE, ARE THE DIMENSIONS AFTER PERFORMING THE TAPPING, COUNTERSINKING ETC. OPERATIONS.

B — SHEET METAL WORK

B-1 SQUARENESS OF SIDES: BETWEEN TWO SHEARED EDGES OR TWO FORMED SIDES THE SQUARENESS SHALL BE WITHIN .015 PER LINEAR FOOT. BETWEEN A SHEARED EDGE AND A FORMED SIDE, THE SQUARENESS SHALL BE WITHIN .020 PER LINEAR FOOT.



B-2 BURR HEIGHT AND SQUARENESS OF EDGE:



MATERIAL THICKNESS	UP TO .015	.015 TO .032	.032 TO .062	.062 TO .125	.125 AND OVER
BURR HT.	.002	.003	.006	.006	.006
MAXIMUM 'E' PERMISSIBLE	.004	.006	.006	.012	.020

B-3 FLATNESS: VARIATION FROM FLATNESS SHALL NOT EXCEED THE VALUES IN TABLE BELOW. MEASUREMENTS SHALL BE MADE BY LAYING PART ON SURFACE PLATE WITH CONVEX SIDE UP. NO CLAMPS OR WEIGHTS SHALL BE USED. IN ANY ONE SURFACE, TWO WAVES NOT EXCEEDING VALUES BELOW SHALL BE PERMISSIBLE. ANY ADDITIONAL WAVES SHALL NOT EXCEED 50% OF THE VALUES BELOW.

THICKNESS OF STOCK	SURFACE DIMENSION				
	UP TO 3	3 TO 10	10 TO 24	24 TO 48	48 AND OVER
	MAX. PERMISSIBLE VARIATION FROM FLAT				
OVER .0159 TO .040	.015	.040	.080	.160	—
OVER .040 TO .093	.010	.030	.055	.110	.130
OVER .093 TO .189	.008	.025	.040	.080	.130

B-4 RIGHT ANGLE BENDS (90° DIMENSION NOT SHOWN) SHALL BE SQUARE WITHIN VALUES GIVEN IN TABLE BELOW.

FORMED PORTION (USUALLY THE SHORTER SIDE)	UP TO 1/2	1/2 TO 1 1/2	1 1/2 TO 6	6 TO 12	12 AND OVER
MAX. ALLOWABLE VARIATION FROM SEQUENCES	.010	.020	1/32	3/64 per ft.	ADD 1/32 per ft.

B-5 INSIDE RADIUS OF PIERCED SHARP CORNERS AND NOTCHES, NORMALLY SHOWN SQUARE, SHALL NOT EXCEED .015.

B-6 DIRECTION OF GRAIN IN FORMED METAL PARTS MAY RUN IN ANY DIRECTION CONVENIENT TO MANUFACTURING, PROVIDED THESE PARTS DO NOT FRACTURE AT BENDS.

REVISIONS

AP. BY F. C. BLANCHA

AP. MFG. JUNE 21, 1950

0 — REVISED & REDRAWN. A-1 BROADENED TOLERANCE. A-3 REVISED SKETCHES, CLARIFIED WORDING. A-4 DELETED. A-4 WAS A-5, SKETCH REVISED. A-5 WAS A-6. B-1 WAS B-2, WORDING CLARIFIED, SKETCH REVISED. B-2 WAS B-1 & B-3, SKETCH & TABLE REVISED. B-3 WAS B-4. B-4 WAS B-5. B-5 WAS B-6. B-6 WAS B-7. C-1 WAS C-1 & C-2. TABLE REVISED. C-2 WAS C-3 & C-12, WORDING CLARIFIED. C-3 WAS C-4 WORDING CLARIFIED, TABLE REVISED. C-4 WAS C-5 WORDING CLARIFIED, TABLE & SKETCH REVISED. C-5 WAS C-6 WORDING CLARIFIED, TOLERANCE REVISED. C-6 WAS C-7 WORDING CLARIFIED. C-7 WAS C-8. C-8 WAS C-9 WORDING CLARIFIED. C-9 WAS C-10. C-10 WAS C-11 WORDING CLARIFIED. C-11 WAS C-13. COMBINED C-12 WITH C-2. C-12 WAS C-14. D-4 WORDING CLARIFIED. D-5 WAS CLASS II FIT. E-1 WORDING CLARIFIED, TOLERANCE REVISED. E-2 WORDING CLARIFIED. E-3 WORDING CLARIFIED. E-4 DELETED. COMBINED E-5 & E-6 WORDING CLARIFIED, RENUMBERED E-4. E-5 WAS E-7

5 — A. Griffith April 14, 1955

STANDARDIZED CHANGES OR ADDITIONS REQUIRE APPROVAL OF E.P.D STANDARDIZING

VARIATIONS ON FINISHED DIMENSIONS UNLESS OTHERWISE MARKED		
BASIC DIMENSIONS	FRACTIONAL DIMENSIONS	DECIMAL DIMENSIONS
UP TO 6	± 1/64	± .005
ABOVE 6 TO 24	± 1/32	± .010
ABOVE 24	± 1/16	± .015
ANGULAR DIMENSIONS		± 1/2°

SEE PURCH. SPEC. FOR STOCK TOLERANCES

SPECIFICATIONS (MANUFACTURING TOLERANCE)

FIRST MADE FOR

DRAWN BY R. H. Sheppard 12 March '53

TRACED BY L. Shue, Oct. 19, 1954.

CHECKED BY

A SIZE **96400**

SHEET 1 CONT'D. ON SHEET 2

96400 SHEET–2 FINAL

RADIO CORPORATION OF AMERICA, ENGINEERING PRODUCTS DIVISION, CAMDEN, N. J.

C — MACHINE WORK

C-1 **BURRS:** ALL BURRS FORMED ON SCREW MACHINE PARTS EXCEPT CUT-OFF TIPS SHALL BE REMOVED: ALL BURRS FORMED BY OTHER MACHINE OPERATIONS SHALL NOT EXCEED .006. (SEE REQUIREMENT A-1 ABOVE ON BURR REMOVAL.)

CUT-OFF TIP ON ENDS OF SCREW MACHINE PARTS SHALL NOT EXCEED VALUES SHOWN IN TABLE BELOW.

DIAMETER OF STOCK	CUT-OFF TIP	
UP TO 1/4	1/64 DIA.	1/64 LG.
1/4 TO 1/2	1/32 DIA.	1/32 LG.
1/2 AND OVER	1/8 DIA.	1/32 LG.

C-2 **PARALLELISM AND SQUARENESS OF FLAT MACHINED SURFACES:** THE AMOUNT BY WHICH ONE MACHINED SURFACE MAY DEVIATE FROM BEING PARALLEL OR SQUARE WITH ANOTHER MACHINED SURFACE SHALL NOT EXCEED VALUES SHOWN IN TABLE BELOW.

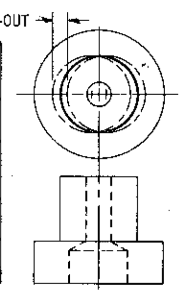
SURFACE DIMENSION				
UP TO 1	1 TO 2	2 TO 3	3 TO 4	4 AND OVER
.001	.002	.003	.0035	ADD .0005 PER INCH

C-3 **OUT OF ROUNDNESS** IS THE DIFFERENCE BETWEEN MAXIMUM AND MINIMUM DIAMETERS MEASURED AT THE SAME CROSS SECTION.

IF THE TOLERANCE ON TURNED DIA. IS:	THEN THE ALLOWABLE "OUT OF ROUNDNESS" SHALL NOT EXCEED
± .0005	.0002
± .001	.0004
± .002	.0006
± .005 OR MORE	.0008

C-4 **RUN-OUT (TOTAL INDICATOR READING) ON DIAMETER:** THE FOLLOWING TABLE APPLIES WHEN LENGTH OF PART IS NOT GREATER THAN 3 TIMES THE SMALLER DIAMETER.

TYPE OF DIAMETER	INSIDE DIA. TOL. UP TO .0025	INSIDE DIA. TOL. .0025 AND OVER	MACHINED OUTSIDE	STOCK OUTSIDE
INSIDE DIA. UP TO .0025	.0015	.006	.002	.006
INSIDE DIA. .0025 AND OVER	.006	.010	.006	.010
MACHINED OUTSIDE DIA.	.002	.006	.0015	.006
STOCK OUTSIDE DIA.	.006	.010	.006	—



FOR LENGTHS GREATER THAN 3 TIMES THE DIAMETER THE RUN-OUT TOLERANCE SHALL BE 50% GREATER THAN VALUES SHOWN IN TABLE.

C-5 **RUN-OUT ON FACE** WITH RESPECT TO AXIS OR OUTSIDE DIAMETER SHALL NOT EXCEED .002 PER INCH OF TURNED DIAMETER AND .004 PER INCH OF STOCK DIAMETERS.

C-6 **PERPENDICULARITY OF A TAPPED HOLE TO A SURFACE:** ALL TAPPED HOLES PERPENDICULAR TO A SURFACE (90° DIMENSION NOT SHOWN) SHALL NOT DEVIATE MORE THAN 1° FROM PERPENDICULARITY.

C-7 **ALLOWANCE FROM SHOULDER TO THREADS:** WHEN THREADING CLOSE TO A SHOULDER, THE LAST FULL THREAD SHALL NOT BE MORE THAN A DISTANCE OF 2-1/2 THREADS OR 1/16 WHICHEVER IS THE GREATER, FROM THE SHOULDER.

C-8 **STRAIGHTNESS:** A MACHINED CYLINDRICAL SURFACE OR A MACHINED EDGE SHALL BE STRAIGHT WITHIN .0005 PER INCH.

C-9 **RADIUS AT CORNERS** SHOWN SQUARE ON THE DRAWING SHALL NOT EXCEED .010.

C-10 **MACHINE FINISH:** ALL MACHINED PARTS SHALL EXHIBIT A SMOOTH FINISH AND SHALL NOT EXCEED A MAXIMUM READING OF 125 MICRO INCHES RMS.

C-11 **TOOL CENTER HOLES** ARE PERMISSIBLE UNLESS OTHERWISE NOTED.

C-12 **FLATNESS** OF A MACHINED SURFACE SHALL BE WITHIN .0005 PER INCH.

D — APPLIED FINISH

D-1 RCA FINISH STANDARDS NOTICES CONTAIN VALUABLE INFORMATION AND SHOULD BE CAREFULLY REVIEWED BEFORE WORK IS STARTED.

WHERE DEVIATIONS FROM THE DETAILED INSTRUCTIONS CONTAINED IN RCA FINISHING SPECIFICATIONS ARE DESIRED, SUCH DEVIATIONS MUST BE APPROVED BEFOREHAND BY THE RCA FINISH STANDARDS ENGINEER.

D-2 VENDORS SHOULD OBTAIN THROUGH THE RCA BUYER, THE APPROPRIATE RCA FINISH NOTICE, SAMPLE PANELS (FOR ORGANIC FINISHES) AND LIST OF APPROVED SOURCES OF ORGANIC FINISHING MATERIALS.

D-3 APPEARANCE (COLOR, TEXTURE, GLOSS) OF ORGANIC FINISHES MUST BE WITHIN AN ACCEPTABLE COMMERCIAL TOLERANCE OF THE CURRENT RCA SAMPLE PANEL.

D-4 ORGANIC FINISHES WHICH DO NOT INCLUDE FILLING AND/OR SURFACING OPERATIONS AND PLATED FINISHES WILL NORMALLY REVEAL IMPERFECTIONS IN THE BASE METAL. TOOL MARKS, EXCEPT LAYOUT SCRIBE LINES, NORMAL TO THE MANUFACTURING PROCESSES INVOLVED NEED NOT BE REMOVED. HOWEVER, RANDOM SCRATCHES, GOUGES AND SIMILAR EVIDENCES OF CARELESS HANDLING MUST BE REMOVED PRIOR TO THE FINISHING OPERATIONS.

D-5 MASKING, WHEN AND WHERE SPECIFIED ON THE DRAWING, IS ESSENTIAL. IF NO MASKING IS INDICATED ALL SURFACES ARE TO BE FINISHED EXCEPT INTERIOR SURFACES OF THREADED HOLES. SUCH HOLES MAY OR MAY NOT BE MASKED AT THE OPTION OF THE PROCESS ENGINEER. HOWEVER, A CLASS 2B FIT MUST BE MAINTAINED IN THE PARTS AS SUPPLIED.

D-6 DIMENSIONS ON DRAWINGS INCLUDE THE THICKNESS OF PLATING. PLATING THICKNESS MUST BE AS SPECIFIED IN FINISH NOTICES.

E — ASSEMBLY WORK

E-1 **SQUARENESS OF FRAMES, CHASSIS, CABINETS, WELDMENTS, ETC.** THE VARIATION FROM SQUARENESS SHALL NOT EXCEED .020 PER FOOT FOR THE FIRST 2 FEET PLUS .010 FOR EACH ADDITIONAL FOOT.

E-2 **FASTENINGS:**

ALL FASTENING OPERATIONS SHALL BE PERFORMED IN SUCH A MANNER AS TO INSURE THAT THE JOINED PARTS WILL NOT MOVE RELATIVE TO ONE ANOTHER UNDER NORMAL OPERATIONS.

A PART (SUCH AS A WIRING TERMINAL) RIVETED OR FASTENED TO ANOTHER PART SHALL NOT LOOSEN WHEN NORMAL HEAT IS APPLIED.

WHEN THE SPECIFIED FASTENER DOES NOT FASTEN SATISFACTORILY BECAUSE OF MATERIAL THICKNESS TOLERANCE VARIATIONS, IT SHALL BE PERMISSIBLE TO SUBSTITUTE A FASTENER OF THE SAME COMPOSITION, SHAPE AND SIZE, BUT SHORTER OR LONGER THAN SPECIFIED IN ORDER TO OBTAIN A SATSIFACTORY FASTENING.

E-3 **SOLDERED JOINTS:** "COLD" or "ROSIN" JOINTS ARE NOT ACCEPTABLE. ACID FLUXES OR ACID CLEANERS SHALL NOT BE USED IN SOLDERING ELECTRICAL JOINTS.

ACID FLUXES OR ACID CLEANERS MAY BE USED ON ALL OTHER SOLDERED JOINTS IF SUCH FLUXES AND CLEANERS ARE THOROUGHLY NEUTRALIZED CHEMICALLY.

E-4 **GAS, ARC AND RESISTANCE WELDS:** SHALL BE IN ACCORDANCE WITH CURRENT RCA MANUFACTURING SPECIFICATIONS.

E-5 **WELDING SYMBOLS:** INTERPRETATION OF WELDING SYMBOLS SHALL BE IN ACCORDANCE WITH THE LATEST AMERICAN STANDARDS ASSOCIATION INSTRUCTIONS.

SUB 5

A SIZE 96400 SHEET–2 FINAL

So there is need to impart practical knowledge on tbe importance of sensible and practical dimensioning to our embryonic designers.

C. Pride of Workmanship is Dying Out

We live in an age of "machine operators." "Craftsmen" are rapidly dying out. "Pride of Workmanship" is one of the several finenesses of our life whicb is being obliterated by this machine age. The fine flourishes and gestures which a craftsman built into his product because of his pride of workmanship, alas, are dwindling to zero. The removal of burrs, tbe elimination of rough tool marks, the protection of finished surfaces during machine and assembly operations, were taken for granted as part of a craftsman's pride. Today, if nothing is stated on the drawing about such things, the worker, backed up by his union, will share litte or no responsibility for what we used to call "sub-standard workmanship." So, there is a pressing need to review our drafting semantics in the light of such modern events. Somehow, someway, we must get maximum information on the drawing at minimum cost. Can you help us?

V. THE NEED FOR SIMPLIFIED DRAFTING PRACTICES

As competition becomes keener, management is ever looking for means to reduce costs. With care and with a clear understanding between the various elements of an organization that depend on drawings for information, certain practices in any drafting system can be reduced to minimum cost. A word of caution: carry it "too far" and you'll get into trouble. I presume every plant has an idea of how far "too far" is. However, a real problem can develop if a set of drawings are intended for your own plant; then, because of changes in policy, scope or conditions you ask a vendor to make the part to your drawings. You might get what you want; then again you might not. It depends on how far you deviated from "acceptable" practice as the vendor understands it. We feel certain that much could be gained if we had some sort of national (or at least industry) understanding in the area of simplified practices.

Simplification can be carried to extremes, wherein no drawing is required, so drafting costs are zero. I want a ball 1cm. in diameter with an eccentricity not less than 0.99. I call up Buyer Jones and order it. (Some will argue that I don't need a drawing. I will always take the opposite side. I have seen literally thousands of cases where we merely specified a vendor part as his catalogue number, only to be in trouble later.) The ball arrives but it's mild steel and I wanted stainless steel. I can't use it, so I order another ball by telephone (at my expense) specifying 18-8 steel this time. It arrives but it has a flat spot not acceptable for may application. I order another ball, - etcetera, ad infinitum. Eventually I might get the ball I want. I saved the drafting cost, but I put the vendor on Easy Street with my Company's money. So you see, the Company as a whole must save money, or no simplified drafting system is worth a hoot.

Our Drafting Managers at RCA bave done some fine work in the field of simplified drafting practice as related to RCA's specific operations.

To encourage its adoption more widely and to insure uniform application of the practices within RCA so as to avoid errors as far as is economically possible, RCA has recorded these practices in a manual, which becomes the official simplified practice. Deviations from this practice must have the approval of the Drafting Managers, who meet twice monthly to talk over their common problems. With well over 300 man-years of experience behind them. these managers don't pass over their problems lightly, you may be sure.

VI. THE NEED FOR STANDARD CASTING DIMENSIONAL REFERENCE PLANES

Any one who has designed a casting and then followed the drawing through the various steps leading to the final assembly operation will have learned of a common problem as yet unresolved. In practical work the cope in the drag, or the die in the mold, move laterally by small fractions of an inch, even though these mating parts are not supposed to do so. The result: varying degrees of inaccuracies between certain surfaces.

Today there is no universal standard in the casting industry, or in any industry using castings, which definitely defines the planes or surfaces from which principle holes or protuberances are to be dimensioned. The result is a very high casting reject rate in practically every industry. Here is an example. RCA uses thousands of magnesium parts made by the die casting method. Our drawing contains some 100 different dimensions, most of which are critical in their relationships one with the other (gear centers, for example). We send the drawing to a die-casting vendor. Without further ado, let us say, he makes a die and mold. He used some "rule of thumb" developed by himself for deciding where to start his dimensioning for making the die and mold. The part is cast, trimmed of flash, then shipped to RCA. Our incoming inspection department starts to check the part. They soon find a whole series of bosses are about 1/16 inch from where they are supposed to be according to the drawing. Other protuberances or holes seem out of place. Our inspectors start measuring again - from some other reference point or plane. With luck they might find the "standard" point or plane used by the vendor, and so they accept the part.

In the meantime, our tool making department is making a drill jig, using some point or plane on the drawing as their point (or line) of reference, which 9 times out of 10 won't be the same ones used by the die-maker. Result - the part won't fit the jig, - or worse still, five thousand castings are drilled before it is found that not enough material is left to clean up at some surface in the following milling machine operation. This is an expensive error, yet similar ones happen dozens of times daily, not only in out plant, but in many others as well, and all for the want of some standard method of referencing dimensions:

A. For the designer
B. For the pattern or die-maker
C. For the incoming material inspector
D. For the tool maker
E. For the machining operation inspector
F. For the machine operator

Would you give this some thought? Industry needs some good ideas in this area.

VII. THE NEED FOR STANDARD ROUND HOLES AND SHAFTS

If I were to tell you that we have over 800 sizes of "¼ inch" holes, or that we have over 100 snap gauges for nominal "1/8 inch" shafts, would you believe it? We didn't either, until we started an investigation in this field. We aren't through yet but it appears that we lose well over $50,000 a year in special tools alone, not counting the labor losses due to delays and interrupt one in obtaining and/or grinding special-size tools. Here is how the losses get started. One designer wants a ¼" shaft. He specified 0.250± .002. Another designer specified $0.250 \begin{smallmatrix}+.000\\-.004\end{smallmatrix}$. A third specified $0.248 \begin{smallmatrix}+.0000\\-.0003\end{smallmatrix}$. This has gone on for 800 different combinations that we have run down. There are probably many more we haven't located yet.

We thought the solution to this problem would be simple. We called on the American Standards Association. They understand the problem well but they have been stymied for the last six years by a peculiar quirk of fate. There are almost 1000 manufacturers of "holes" in this country and almost exactly 1000 manufacturers of "shafts." Shall we standardize the hole dimension and make the shaft to fit, or vice versa? The answer depends upon whether you are a "hole" or a "shaft" manufacturer, for millions of dollars are invested in gauges and tools, up to at least half of which will become obsolete if a standard is created favoring one side over the other. So the rest of industry suffers.

We at RCA decided to do something about this. We put an engineer on the problem almost full time. He visited many manufacturers in the electronics and other industries, including gauge manufacturers. They were plagued with the same problem and gladly imparted to us their existing practices and experiences. From this information we were able to devise a "Basic Hole System" covering about 25 diameters in reasonable increments from 1/8 inch to 4 inches, into which we machine or grind (a low cost operation) a shaft to one of five diamaters and tolerances to obtain a loose fit, a heavy running it, a light running fit, a snug fit, or an interference fit. Thus, with not more than 150 inspection tool sizes (25 plug gauges and 125 snap gauges), we hope to cover about 95% of our regular requirements. It works this way: if the designer uses a quarter-inch shaft in a hole, he specified the hole at $0.250 \begin{smallmatrix}+.0006\\-.0000\end{smallmatrix}$ then specified the given shaft diameter and tolerance for the kind of fit he desires. Few or no calculations are necessary. (This is simplified drafting as well.) This saves time in Drafting, in Engineering, and in the Factory. It reduces costly expenditures in the tool crib, and it reduces the "down" time caused by waiting for new or reground "special" tools.

I hope I have kindled some little fires in your imaginations. Will you accept some of these challenges I have presented to you? They pose for you many hours of fascinating research work.

(SMITH: Continued from page 14)

that have high heat resistance, that can be readily formed and machined, and that are available in dependable quantity. Much work is being done in this field, and it behooves us to keep ourselves posted in that area, among many others.

The design engineer on a project has another good reason for knowing a great deal about drafting and draftsmen. His management requires him to prepare progress schedules that show estimates of man-hours necessary for the job--man hours of analysis, of preliminary and final layout and detailing, of fabricating and assembly, and of testing. If the design engineer's schedules are to be of value, his estimates must be as accurate as possible. They can be accurate only if he works closely with the drafting group (as well as other groups) and knows enough about the work of the other groups to estimate their man-hour requirements reasonably.

PART V

Since we cannot close this article with the customary list of short, pithy statements under the sub-heading of "conclusions," let's just leave it this way:

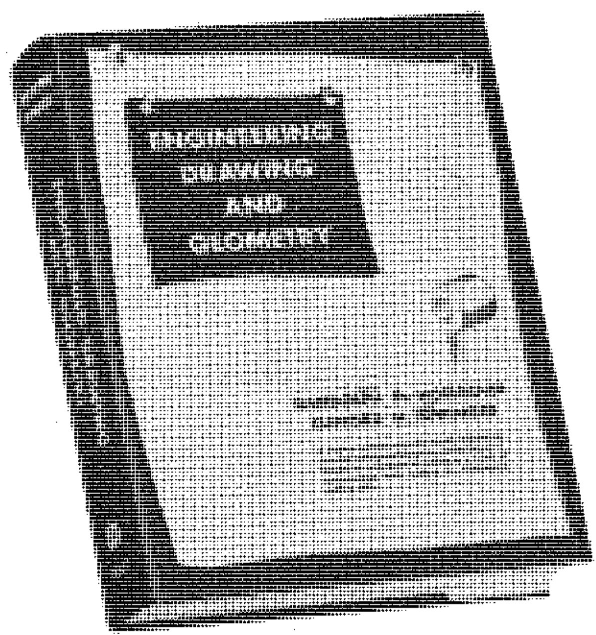
The undergraduate engineering student who expects to enter industry after his graduation should make the most of his courses in engineering drawing. If he is to succeed in the field of design engineering, he must work closely with the draftsmen and must be able to interpret the latter's work quickly and accurately. He must be able to suggest changes in the draftsman's work with the objective of turning over to the manufacturing departments drawings from which the latter can produce parts efficiently and accurately and at the least possible cost.

The design engineer cannot know too much about engineering drawing.

One text for two courses--

ENGINEERING DRAWING AND GEOMETRY

By RANDOLPH P. HOELSCHER, Professor and Head of the Department of General Engineering, and CLIFFORD H. SPRINGER, Professor of General Engineering; both of the University of Illinois.



Combines the traditional approach with modern trends

Here — in a single volume — is all the material needed for work in basic drawing courses, fundamental descriptive geometry, and advanced courses for sophomores in the professional fields. Drawing on a total teaching experience of seventy years, plus many years of engineering practice, its authors have produced a text that combines the virtues of traditional approaches and modern trends in engineering education.

Engineering Drawing and Geometry follows a set of objectives endorsed by leading authorities in the field. It is clear enough in verbal discussion and pictorial illustration to be easily understood by the freshman student. While building drafting skills it also stresses the development of reasoning processes and the importance of drafting as a means of communication.

The material in the text is presented in a way that stimulates creative imagination, develops visual perception in three dimensions, and promotes original thinking. All theory is presented in separate chapters. These are arranged so that they may be used in a combined course of drawing and descriptive geometry or in separate courses.

1956. 520 pages. 1137 illus. $8.00.

CHAPTER HEADINGS

Introduction. Lettering. Use and Care of Instruments. Geometrical Construction. Geometric Projections. Sketching. Orthographic Projection. Sectional Views. Dimensioning. Fasteners. Shop Terms and Processes. Drawings for Interchangeable Assembly. Auxiliary Projection. Geometry of Engineering Drawing. Intersections and Developments. Axonometric Projection. Oblique Projection. Perspective. Charts and Diagrams. Map Drawing. Architectural Drawing. Structural Drawing. Pipe Drawing. Machine Drawing. Tool Drawing. Welding Drawing. Reproduction of Drawings. Patent Office Drawing. Appendix.

Loaded with plus features

- Axonometric projection covered as well as standard isometric and oblique.
- Up-to-date material on design for interchangeable assembly, covering limit dimensioning, geometrical, and positional tolerancing.
- Detailed information on shop practices needed by young engineers in making drawings.
- Chapters on map drawing, structural drawing, architectural drawing, and a host of other topics, complete enough for advanced professional drafting courses or reference.
- Step-by-step procedures in both text and illustration aid student understanding.
- New and thorough treatment of freehand sketching.

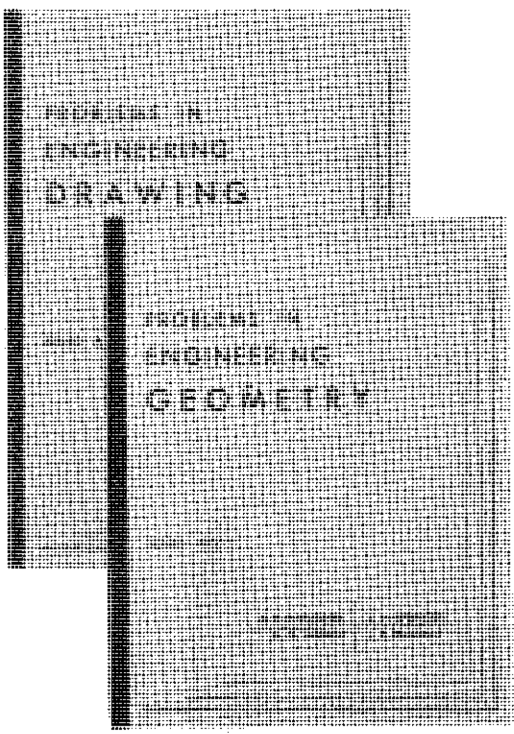
Send today for a copy on approval

JOHN WILEY & SONS, Inc. **440 Fourth Ave., New York 16, N. Y.**

--Plus all the workbooks you need

PROBLEMS IN ENGINEERING DRAWING and PROBLEMS IN ENGINEERING GEOMETRY

By RANDOLPH P. HOELSCHER and CLIFFORD H. SPRINGER
with B. O. LARSON and J. E. PEARSON



Lower price than any other workbooks

The first workbooks in both series are now available:

Problems in Engineering Drawing, Series A
1956. 61 pages plus blanks. $2.75

Problems in Engineering Geometry, Series No. 1
1956. 80 pages. $2.75

Four workbooks for each course offer balanced coverage of the material

Classroom use of *Engineering Drawing and Geometry* will be backed up by the most complete set of workbooks available for any text in either course. New sets will be published annually until there are at least four different workbooks for both drawing and geometry courses. Workbooks for Engineering Drawing will be designated by letters — A, B, C, and D. Those for Engineering Geometry will carry a numerical designation — 1, 2, 3, and 4.

Problems in Engineering Drawing and *Problems in Engineering Geometry* contain enough material for the usual three-semester hour courses without any wastage. They offer well-balanced coverage of the course material and, though the assignments are made from *Engineering Drawing and Geometry,* can be used in conjunction with other texts. Material is included for both class and home assignment and covers a wide variety of problems, including drawing from pictorials, completion problems, verbal specifications, and the practical application of theory. Freehand sketching can be chosen for many of the problems and both workbooks emphasize the auxiliary plane method for problem solution.

The material is aimed at the development of clear thinking and good judgment. It builds the student's ability to analyze practical problems by showing him how to break them down into their basic theoretical concepts. All the problems have been tried and tested in actual classroom use. They can be completed by the average student in the standard class period. Solutions to the problems are available without charge to instructors.

Completely self-contained

Each workbook measures $8\frac{1}{2}$ by 11 inches and consists of from 60 to 80 pages. All the necessary material is included — ledger paper, coordinate paper, and vellum — the student has nothing extra to buy. The books are printed on paper of a good quality which will take ink and withstand erasure. Each sheet in the workbooks is entirely self-contained. Text assignment, problem layout, and problem specifications are all included and nothing but the printed sheet is needed to work from.

Send today for copies on approval

STIPES PUBLISHING CO., **17 Taylor Street, Champaign, Illinois**

SIMPLIFIED DRAFTING

By

Jay H. Bergen
Standards Administrator
American Machine & Foundry Company

One of the most frequent arguments heard against simplified drafting is that manufacturing will spend more time interpreting drawings of the simplified type than will ever be saved in drafting.

In a recent article that appeared in one of the national trade publications, the author stated, "Two or three dollars saved in making a drawing is an immediate gain, but certainly this time saved in a drafting room is a false saving if it is more than offset by the difficulty encountered in reading this drawing in the shop. Furthermore, if the same print is read by a number of people this time loss is multiplied. Over the lifetime of the average print, inability to read the drawing will lose many work hours. Thus, over the long term, money will be lost and over simplification ends defeating its own purpose."

We at American Machine & Foundry agree wholeheartedly with this statement if, and thats a big if, confusion is caused in the shop by drawings of the simplified type.

In the Fall of 1952, the American Machine & Foundry Buffalo Engineering Department prepared detailed and assembly drawings on two similar pieces of equipment. Set "A" was prepared under what we would consider normal drafting room practices. Set "B" was prepared using our eleven rules for simplified drafting. (Fig. 1) Set "B" contained twenty percent more detail and assembly drawings than "A". However, it was prepared in thirty-four percent less time than "A".

These drawings were then released to the American Machine & Foundry Buffalo Manufacturing Department and were used by them over a period of two years for production. In August of 1955 a general discussion on this subject was held with the personnel of this manufacturing department in an effort to determine the validity of our simplified practices. The results of this discussion may be summarized as follows:

1. The Inspection Department states: "That they have had no rejects which can be attributed to misinterpretation of drawings of the simplified type."

2. The Planning Department states: "That they have had no difficulties. On the contrary, their people find far less need to go back to the engineering department for clarification of the drawings."

3. The Production Group states:

   A. Their training problem has been simplified on those jobs where the new type drawings are used.

   B. There have been so many requests from production foreman for redrawing of the old drawings to the new standard, that there is no question that the new type drawing is far more preferable.

   C. There was ready acceptance by the shop men.

   D. There was less loss of time in shop previously caused by reading and interpreting drawings and their specifications.

   E. Assembly was facilitated because the modified type of assembly drawing was more readable.

We have no argument with those individuals that promote simplified practices which have been standardized by such authorized agencies as SAE, ASA, ESI and others. We feel that standards with reference to drafting room practice are vary valuable. Action must not cease when a standard is written. Simpler and more economical practices should be constantly reviewed and investigated. We do not advocate that all companies adopt our or anybody else's suggestions for simplified drafting. However, we do feel that they should be brought to their attention so that they may determine for themselves whether or not they will save money. Our experience has proven, to our satisfaction, that we can.

We further agree that standards on present day practices should be issued and that national standards on simplified drafting practices should be held in abeyance until the majority of industry is in favor of them and our schools are prepared to teach them. We do feel however, that individual firms should write their own local standards on this subject now. These local standards will then form a solid foundation on which national and international standards may be built at a later date. American Machine & Foundry has issued standards on both 200.0 - Drafting Room Practice and 201.0 - Simplified Drafting.

A number of government agencies have reviewed simplified drafting and have not accepted it. Several are investigating it at the present time and have given every indication that they will adopt it for research and development work. Two of the major manufacturing establishments of the U.S. Army Ordnance Dept. and at least two of the Naval Shipyards have indicated their interest.

We expect our detailers, designers, group leader and group supervisors to use common sense in applying the rules of simplification. If for example, a dimension is placed within the field of the drawing, common sense should indicate that arrowheads should be used on the dimension lines. Where the lack of an arrowhead would be confusing, we expect that they will use the arrowheads. The rules as set forth in the A.M.F. publication on this subject have been worded very carefully so that they are more suggestions than commands. For example, we state, "Avoid the use of arrowheads," "Avoid the use of hand lettering," "Avoid the use of dotted lines that do not add clarification." Industry generally does a great deal more harm than good when they set down ironclad rules on how drawings should be made. Our designers and detailers are expected to have the capability, education and experience to determine the proper amount of simplification to be used in any specific case.

Some of the changes that proponents of simplification advocate are not new. For example: The earliest known drawing of the flyball-governor was made in 1788 by Matthew Boulton, an associate of James Watt. Only half of the governor is shown and below the center are the words, "Two of these legs - 1 on each side". This might well be the origin of the term that we use frequently today, "Symmetrical about the centerline." Again, in an article published in the May 21, 1914 issue of American Machinist on the "History of Drafting" Mr. George F. Summers the author stated, "Today is a day of commercialism. We study and sit up of nights to plan the work so that it can be made more cheaply. Every vestige of unnecessary expense must go." Note in this drawing of yesterday, the end views. Some employer comes along and says to his foreman, "Jim why can't you make this bolt without end views?" and Jim says, "I can, " and behold! the modernizing of the drawing has commenced. Someone else leaves out the shade lines and someone the water-color work. A bold draftsman leaves out the threads and tells about them in a note (notes are cheaper than lines). With the coming of blueprinting the putting of ink on paper drawings seemed unnecessary and lines were made bolder so that they would not "burn out" in the printing. And about this time the name "Draughtsman" seems pretty long and the newspaper man cuts it down to "Draftsman" to get more words for the same space in his "situation wanted" column.

The following quotation is taken from the editorial in the August 1955 issue of Product Engineering. "In what was to be their first steps in a promising career, many talented engineering graduates quite the design department and sometimes even engineering because they found no satisfaction in doing routine drafting work." The editorial goes on to say, "There is one job requirement that must be met in order to attract more engineering graduates to the design department and then keep them there. It is simple and usually profitable for management to apply. It is - make the job interesting and keep it so. And the way to do that is to give every man the biggest job he can handle, be he a beginner or a veteran." We agree with this basic philosophy and feel that there is a much greater sense of accomplishment in working out an unusual gear train or stress analysis than there is in cross-hatching a large assembly drawing. We want our detailers to spend more time on accuracy of dimensions and less time on the accuracy of the scale used in making the drawings or on various line weights. We want our designers to spend more time on functional improvements than on crosshatching or lettering.

Consider the practical aspects of two types of errors and their effect on a manufacturing group. First consider a drawing that is confusing. Before it reached the man in the shop it is checked for clarity several times. First by the drafting room checker. If there is any question as to clarity he will have the drawing reworked. Second, the drawing is reviewed by the group leader and group supervisor, who, in many firms, have to sign the original to indicate their approval as to its completeness. Third, by a process engineer and fourth, by a tool engineer. By the time a detail has completed these four steps, it may be assumed that it is clear, concise and accurate. If it is still not clear the man in the shop cannot understand it and he cannot produce. Any questionable point may be cleared up in minutes at this time because it is holding up production and therefore has a high priority for emergency action.

Second, consider a drawing that is lacking in proper or good functional design. Unless this lack of design is very obvious, the drawing can progress through all of the steps mentioned, parts be produced and assembled before the error becomes known. Errors of this type are much more costly because of the money tied up in scrap material and machining time. It is for this reason that our drafting personnel is urged to forget the pretty fills and concentrate on the required information. For this same reason we would request that more time be spent in the classroom on functional design and less on arrowheads and lettering. Poor design is an insidious thing which usually results in costly scrap.

11 RULES FOR SIMPLIFIED DRAFTING

1. Use description to eliminate delineation.

   Example: Instead of making a drawing of a sleeve or threaded stud, a satisfactory typewritten description of the article required may be made by a clerk.

2. Use description to eliminate projected views.

   Example: Call for hex, square, or round stock instead of drawing another view. Show the thickness of a part on a plan view instead of a projected view.

3. Omit elaborate, pictorial, or repetitive detail.

   Example: Use broken lines to represent the O.D., P.D. and B.D. of a gear instead of drawing the gear teeth. Instead of drawing the actual thread, use dotted lines or description.

4. Use keyed legend to indicate nuts, bolts and other hardware. Show outline only where necessary to indicate position.
5. Only use dotted lines to add clarification.
6. Only use cross-sectioning to add clarification.
7. Use symbols to indicate various hole sizes.
8. Avoid the use of hand lettering.
9. Avoid the use of arrow heads.
10. Use datum lines.
11. Make free-hand drawings where possible. Use cross-sectioned board cover.

Figure 1.

SIMPLIFIED DRAFTING—A NATIONAL PROBLEM

By

J. Gerardi
University of Detroit

The Drawing Division of A.S.E.E. is one medium through which we teachers of engineering drawing and graphics keep ourselves informed of the latest and best industrial practices.

This Division has been particularly interested in serving the needs of industry and takes pride in the endeavor to teach what industry wants. The contributions of industrial speakers at previous meetings have had considerable influence on what we teach. Occasionally, however, industry has been critical of what we teach but has cooperated with us to bring about mutual understanding of our basic problems.

We are expected to teach our students the best practices of engineering drawing in spite of drastic cuts in the amount of time we can allot to the subject. This is somewhat discouraging in consideration, for instance, of recent requests that we include graphics in our courses and take a more active part in research relating thereto. The fact that we have so far met these challenges without sacrificing the basic fundamentals and techniques previously taught indicates that this Division is a dynamic force in engineering education.

During the past ten years several thousand people have devoted an enormous amount of time and money towards standardization of American drafting practices. Many of us have worked on these projects because we honestly feel that in event of another emergency it is imperative that we have a system of graphical communication which can be understood on a national and international level.

Now as to the immediate subject of this presentation which on our program is called "Simplified Drafting." There is no question that this subject is of widespread interest and that misunderstanding exists as to what is involved. The term "simplified" as applied to standards of any kind has many interpretations in industry. Many organizations consider the reduction or simplification of variety of items as standardization. Others construe simplification as the reduction of essentials to the lowest common denominator. I personally favor the latter viewpoint, distinguishing definitely between standardization and simplification, but I believe that effective standardization involves a certain amount of simplification. After this brief analysis of what we are talking about we can endeavor to evaluate the merit of simplified drafting practices.

I shall attempt to summarize the simplified drafting practices presently promulgated or promoted by a number of large corporations. Most of you are familiar with the book by Messrs. Healy and Rau of General Electric Company. It was published in 1953 under the title of "Simplified Drafting" and was widely distributed to American industry and teachers of engineering drawing. It is my opinion that the book is largely responsible for the present interest regarding simplification of drafting practices.

In January, 1954, those of us who attended the midwinter meeting at the University of Pennsylvania were given copies of the practices which has been approved by the Drafting Standards Committee of R.C.A.

A few months later editors of engineering magazines, both here and in England, latched on to the idea of simplification and extolled the courage of pioneers who advocated new and extreme methods of drafting.

In May, 1954, I expressed my views on this subject in an article published in PRODUCT ENGINEERING entitled "Should Drafting Practices be Further Simplified?" This was reprinted in MACHINIST, a British publication.

During the Fall of 1954 the American Machine and Foundry Company published its version of simplification. This, too, was widely distributed to industry, vocational schools, and engineering colleges.

In the Spring of 1955 the McCormick Works, which is one of the operations of the Farm Implement Division of International Harvester, distributed a brochure entitled "Simplified Drafting Data Sheets." The data sheets were sometimes construed as representing the practice of the entire International Harvester Company, but investigation developed that the simplification was limited to the Advanced Engineering Department of the McCormick Works. Their products consist of hay loaders, hammer mills, side rakes, etc., most of which involve relatively simple components. In this connection, I have been informed that International Harvester, some years ago, investigated the advisability of simplifying its drawing systems but found that it required the services of a special committee to determine the point of demarcation between a simple drawing to which it could be applied, and an involved drawing for which it would be unsatisfactory and confusing. International Harvester's experience reflects that of the automotive, aircraft and other industries regarding the difficulty of applying extreme drafting simplification to cylinder blocks, crank cases, gear trains, compressors, fuselages, chassis and other complicated structures.

The June, 1955 issue of PRODUCT ENGINEERING contained an article by Professor Grant of Washington University which was entitled "Reducing Cost in the Drafting Room." The professor mentioned nine specific areas which, if implemented, would result in cost reduction and drafting room efficiency. However, he did not support the idea that simplified practices on a broad basis contributed to economical operation.

Proponents of simplification have invariably claimed that it has saved them thousands of dollars. We must appreciate that claims are one thing and proof is something else. We must also appreciate that long experience with any practice is the most reliable guide as to its effectiveness and ultimate economy. Many companies have undoubtedly converted to extreme simplification with immediate savings of drafting time, offset only by the time involved in training their personnel. The books on this matter, however, cannot be balanced immediately. Time will have to elapse, drafting personnel will have to change from time to time, new suppliers will have to come into the picture - all, incidentally, involving further education which costs money and may involve delay. It may be expected that, on occasion, misunderstanding as to the intent may arise with rejection of shipments involving tens of thousands of dollars requiring adjudication as to who is responsible.

I may have given the impression that I am opposed to simplification. Whether I am or not depends on the interpretation put on the term. If simplification of drafting practice means the rendition and calling out of requirements in a manner which cannot possibly be misunderstood, a manner which could be upheld in any court of law and which is practically foolproof, I am for it regardless of how many short cuts may be involved. On the other hand, if simplification is going to mean diagramatic sketches which have to be explained to those who are not familiar with the system - a code, as it were, which requires a code book to decipher - then I am not for it and contend that like all codes, it sooner or later will become too involved for even its most enthusiastic proponents, let alone the difficulty and confusion it causes.

Interpreted as I see it, simplification of drafting practices is desirable, but I mean simplification based on sound standardization of practice. Standardization in itself involves a degree of simplification in the sense that it reduces a variety of practices. I do not intend to discriminate between any of the sound practices which are now under development, but I would like to point out that the Society of Automotive Engineers and the American Standards Association are working on drafting standards which ultimately will afford a uniform national practice. In those standards great strides have been taken toward reasonable simplification of rendition which clarifies rather than confuses the intent. In many instances, the standard practices afford optional methods of rendition, some of them more expensive than others, leaving to the judgment of the draftsman or his supervision which method should be adopted or which method meets the requirements. In this connection if you have a machine shop next door to your drafting room, you do not need to go to very much trouble in preparing your drawing. You can make a sketch on a piece of yellow paper. If the foreman doesn't know what you are talking about he can come to see you, and if you are doubtful that he understands you, you can see him. But to send drawings out to 15 or 20 competitive suppliers for quotations or actual production on purchase order - that is something else. Some companies do send out drawings and then send a man to explain what the drawings are about. I am personally acquainted with companies which follow this practice and, oddly enough, they are among the proponents of drastic simplification.

You may be interested to know that many of the government services have made an extensive study of this subject - in some instances reporting their findings to the Department of Defense. To the best of my knowledge none of these agencies has accepted anything that verges on drastic simplification of practice, but all of them expressed a great deal of interest on the work SAE is doing on conventional practices which will be included in their revised drafting standards. Included among the agencies that made the studies are:

> Air Research and Development Command, Bureau of Aeronautics, Signal Corps, Transportation Corps, Chemical Corps, Quartermaster Corps, Bureau of Yards and Docks, Corps of Engineers, Bureau of Ships.

The Executive Committee of the American Standards Association Committee Y14, Chairmanned by Professor Hoelscher, investigated the so-called simplified practices and without extensive study decided to postpone action or further investigation until the current revision of the American Standard is completed. There was no protest to this action, indicating a general lack of interest in a group that is exceptionally well informed on drafting practices and requirements.

In concluding this presentation I mention an incident which took place in my office recently. A department chairman in our University happened to notice some data sheets on my desk which were entitled "Simplified Drafting." He turned to me and asked, "Is this what industry wants?" I assured him that there was no indication that all of industry either wanted or had accepted such practices. He asked me whether there was a trend in the direction. I replied to the effect that certain companies had departed from conventional practices and that there was a definite movement to encourage other companies to follow suit. I explained, however, that inasmuch as it affected the overall picture of drafting practice in this country, the conversion or interest in simplified practices was of insufficient magnitude to be glorified as a trend. I also mentioned that a reaction was setting in, and proponents of the more conventional practice were becoming aroused to active opposition of this simplification movement. My colleague concluded the discussion with a question which I was unable to answer. He asked, "If this should eventually become what industry wants, how will you justify even the small amount of time you now expend in teaching drawing?"

SIMPLIFIED DRAFTING—A NATIONAL PROBLEM

By

J. Gerardi
University of Detroit

The Drawing Division of A.S.E.E. is one medium through which we teachers of engineering drawing and graphics keep ourselves informed of the latest and best industrial practices.

This Division has been particularly interested in serving the needs of industry and takes pride in the endeavor to teach what industry wants. The contributions of industrial speakers at previous meetings have had considerable influence on what we teach. Occasionally, however, industry has been critical of what we teach but has cooperated with us to bring about mutual understanding of our basic problems.

We are expected to teach our students the best practices of engineering drawing in spite of drastic cuts in the amount of time we can allot to the subject. This is somewhat discouraging in consideration, for instance, of recent requests that we include graphics in our courses and take a more active part in research relating thereto. The fact that we have so far met these challenges without sacrificing the basic fundamentals and techniques previously taught indicates that this Division is a dynamic force in engineering education.

During the past ten years several thousand people have devoted an enormous amount of time and money towards standardization of American drafting practices. Many of us have worked on these projects because we honestly feel that in event of another emergency it is imperative that we have a system of graphical communication which can be understood on a national and international level.

Now as to the immediate subject of this presentation which on our program is called "Simplified Drafting." There is no question that this subject is of widespread interest and that misunderstanding exists as to what is involved. The term "simplified" as applied to standards of any kind has many interpretations in industry. Many organizations consider the reduction or simplification of variety of items as standardization. Others construe simplification as the reduction of essentials to the lowest common denominator. I personally favor the latter viewpoint, distinguishing definitely between standardization and simplification, but I believe that effective standardization involves a certain amount of simplification. After this brief analysis of what we are talking about we can endeavor to evaluate the merit of simplified drafting practices.

I shall attempt to summarize the simplified drafting practices presently promulgated or promoted by a number of large corporations. Most of you are familiar with the book by Messrs. Healy and Rau of General Electric Company. It was published in 1953 under the title of "Simplified Drafting" and was widely distributed to American industry and teachers of engineering drawing. It is my opinion that the book is largely responsible for the present interest regarding simplification of drafting practices.

In January, 1954, those of us who attended the midwinter meeting at the University of Pennsylvania were given copies of the practices which has been approved by the Drafting Standards Committee of R.C.A.

A few months later editors of engineering magazines, both here and in England, latched on to the idea of simplification and extolled the courage of pioneers who advocated new and extreme methods of drafting.

In May, 1954, I expressed my views on this subject in an article published in PRODUCT ENGINEERING entitled "Should Drafting Practices be Further Simplified?" This was reprinted in MACHINIST, a British publication.

During the Fall of 1954 the American Machine and Foundry Company published its version of simplification. This, too, was widely distributed to industry, vocational schools, and engineering colleges.

In the Spring of 1955 the McCormick Works, which is one of the operations of the Farm Implement Division of International Harvester, distributed a brochure entitled "Simplified Drafting Data Sheets." The data sheets were sometimes construed as representing the practice of the entire International Harvester Company, but investigation developed that the simplification was limited to the Advanced Engineering Department of the McCormick Works. Their products consist of hay loaders, hammer mills, side rakes, etc., most of which involve relatively simple components. In this connection, I have been informed that International Harvester, some years ago, investigated the advisability of simplifying its drawing systems but found that it required the services of a special committee to determine the point of demarcation between a simple drawing to which it could be applied, and an involved drawing for which it would be unsatisfactory and confusing. International Harvester's experience reflects that of the automotive, aircraft and other industries regarding the difficulty of applying extreme drafting simplification to cylinder blocks, crank cases, gear trains, compressors, fuselages, chassis and other complicated structures.

The June, 1955 issue of PRODUCT ENGINEERING contained an article by Professor Grant of Washington University which was entitled "Reducing Cost in the Drafting Room." The professor mentioned nine specific areas which, if implemented, would result in cost reduction and drafting room efficiency. However, he did not support the idea that simplified practices on a broad basis contributed to economical operation.

Proponents of simplification have invariably claimed that it has saved them thousands of dollars. We must appreciate that claims are one thing and proof is something else. We must also appreciate that long experience with any practice is the most reliable guide as to its effectiveness and ultimate economy. Many companies have undoubtedly converted to extreme simplification with immediate savings of drafting time, offset only by the time involved in training their personnel. The books on this matter, however, cannot be balanced immediately. Time will have to elapse, drafting personnel will have to change from time to time, new suppliers will have to come into the picture - all, incidentally, involving further education which costs money and may involve delay. It may be expected that, on occasion, misunderstanding as to the intent may arise with rejection of shipments involving tens of thousands of dollars requiring adjudication as to who is responsible.

I may have given the impression that I am opposed to simplification. Whether I am or not depends on the interpretation put on the term. If simplification of drafting practice means the rendition and calling out of requirements in a manner which cannot possibly be misunderstood, a manner which could be upheld in any court of law and which is practically foolproof, I am for it regardless of how many short cuts may be involved. On the other hand, if simplification is going to mean diagramatic sketches which have to be explained to those who are not familiar with the system - a code, as it were, which requires a code book to decipher - then I am not for it and contend that like all codes, it sooner or later will become too involved for even its most enthusiastic proponents,let alone the difficulty and confusion it causes.

Interpreted as I see it, simplification of drafting practices is desirable, but I mean simplification based on sound standardization of practice. Standardization in itself involves a degree of simplification in the sense that it reduces a variety of practices. I do not intend to discriminate between any of the sound practices which are now under development, but I would like to point out that the Society of Automotive Engineers and the American Standards Association are working on drafting standards which ultimately will afford a uniform national practice. In those standards great strides have been taken toward reasonable simplification of rendition which clarifies rather than confuses the intent. In many instances, the standard practices afford optional methods of rendition, some of them more expensive than others, leaving to the judgment of the draftsman or his supervision which method should be adopted or which method meets the requirements. In this connection if you have a machine shop next door to your drafting room, you do not need to go to very much trouble in preparing your drawing. You can make a sketch on a piece of yellow paper. If the foreman doesn't know what you are talking about he can come to see you, and if you are doubtful that he understands you, you can see him. But to send drawings out to 15 or 20 competitive suppliers for quotations or actual production on purchase order - that is something else. Some companies do send out drawings and then send a man to explain what the drawings are about. I am personally acquainted with companies which follow this practice and, oddly enough, they are among the proponents of drastic simplification.

You may be interested to know that many of the government services have made an extensive study of this subject - in some instances reporting their findings to the Department of Defense. To the best of my knowledge none of these agencies has accepted anything that verges on drastic simplification of practice, but all of them expressed a great deal of interest on the work SAE is doing on conventional practices which will be included in their revised drafting standards. Included among the agencies that made the studies are:

> Air Research and Development Command, Bureau of Aeronautics, Signal Corps, Transportation Corps, Chemical Corps, Quartermaster Corps, Bureau of Yards and Docks, Corps of Engineers, Bureau of Ships.

The Executive Committee of the American Standards Association Committee Y14, Chairmanned by Professor Hoelscher, investigated the so-called simplified practices and without extensive study decided to postpone action or further investigation until the current revision of the American Standard is completed. There was no protest to this action, indicating a general lack of interest in a group that is exceptionally well informed on drafting practices and requirements.

In concluding this presentation I mention an incident which took place in my office recently. A department chairman in our University happened to notice some data sheets on my desk which were entitled "Simplified Drafting." He turned to me and asked, "Is this what industry wants?" I assured him that there was no indication that all of industry either wanted or had accepted such practices. He asked me whether there was a trend in the direction. I replied to the effect that certain companies had departed from conventional practices and that there was a definite movement to encourage other companies to follow suit. I explained, however, that inasmuch as it affected the overall picture of drafting practice in this country, the conversion or interest in simplified practices was of insufficient magnitude to be glorified as a trend. I also mentioned that a reaction was setting in, and proponents of the more conventional practice were becoming aroused to active opposition of this simplification movement. My colleague concluded the discussion with a question which I was unable to answer. He asked, "If this should eventually become what industry wants, how will you justify even the small amount of time you now expend in teaching drawing?"

TEACHING INTRODUCTORY NOMOGRAPHY IN BASIC GRAPHICS COURSES

By

A.S. Levens
University of California
Berkeley, California

During the past twenty years there has been a significant growth in the application of nomography. The use of nomograms in the analysis and solution of mathematical formulas, in the treatment of experimental data, and as a time-saving method for repeated computations is indeed well recognized.

Engineering and science students should experience at least one semester's work in the field of nomography. In the few schools that offer elective courses, only a very small percentage of students take advantage of such opportunities. This is due largely to the fact that most students in engineering and science have not even heard of the word nomography - let alone understanding what it is and what it can do.

I believe, therefore, it is incumbent upon us to introduce the subject in our basic graphics courses -- at least to the extent that our students will know about functional scales, the analysis and design of concurrency charts and of the elementary types of alignment charts.

Many of us would agree that this is desirable, but would ask, "How can we provide time for an introduction to nomography in our basic graphics courses?" and "How much time would be needed?"

To answer these questions, I should point out that certain changes in many current course offerings would be necessary. At the outset I would assume the following:

a) that the engineering freshman will have had one unit of high school drawing or will take a non-credit equivalent course in college or through extension.
b) that a program for college-level work in graphics is provided--not for the training of draftsmen but rather for the education of the professional engineer.
c) that every effort be made to eliminate unnecessary duplication of material in course sequences.

With respect to the latter, re-evaluation of current course-content may bring to light several areas where duplication should be eliminated. For example, if the first course in engineering graphics has stressed the fundamental principles of orthogonal projection and their application to three-dimensional problems that arise in the various branches of engineering, the second course need not devote additional time to the theory used in "multiple auxiliary views."

A program that we have been following consists of (a) descriptive geometry including pictorial views, for the first course; (b) a second course which includes sectioning (one week), threads and fasteners (1½ weeks), dimensioning (1½ weeks), working drawings (4 weeks), graphic algebra (1 week), functional scales (1 week), empirical equations (1½ weeks), introduction to nomography (2 weeks), and quiz time (1½ weeks); (c) a third course for industrial, mechanical, and agricultural engineering students which includes graphical calculus, cams, gears, linkages, and a project-type problem. Tentatively it is planned to offer a modification of this course in the junior or senior year to precede the senior design course. Each course consists of two 3-hour periods of which approximately one hour is devoted to lecture and demonstration.

It may be argued that the second course does not provide sufficient time for such topics as threads and fasteners, and dimensioning. It should be noted, however, that the four week period devoted to working drawings affords an opportunity for additional discussion of these topics. Moreover, I believe that at best we can only provide for a good start in these areas. The young engineer who plans to enter the design field will of course need much more: knowledge of manufacturing processes and practical experience. He can gain much from design courses in the junior and senior years and to a greater extent from actual "on-the-job" work experience during summer vacation periods and after graduation.

The content of the second course as described previously can be realized if we start with a background of one unit of high school drawing and the course in descriptive geometry. In addition it is essential to use free-hand wherever appropriate and to encourage the judicious use of simplified drawing.

Students should be encouraged to use free-hand in planning the best arrangement of views in solving descriptive geometry problems as well as in the preparation of detail and assembly drawings. They should develop a natural freehand skill in "talking-with-a-pencil."

Now with respect to the introduction of nomography it is first necessary to discuss functional scales. A good start can he made in one week through discussion, demonstration and laboratory exercises.

During the two-week period devoted to the introductory phases of nomography the student learns the theory and design of elementary type forms: parallel scale and Z-type nomograms.

Let us consider the matter of "getting-it-over" to the student. The first discussion, after a few remarks on the importance of functional scales and their application to concurrency and alignment charts (both are parts of nomography), deals with the following*:

1. Definition of a scale
2. Definition of a functional scale
3. Scale equation
4. Scale modulus
5. Effective modulus
6. Applications

This is followed by exercises. Further applications of functional scales occur in the work that deals with empirical equations (simple forms), concurrency charts, and in the design of alignment cbarts.

Now with respect to the latter the discussion and and demonstration periods include:

1. Brief remarks on the type forms usually encountered (selected slides).
2. Equations of the firm, $f_1(u) + f_2(v) = f_3(w)$.
   a) Geometry of the design of nomograms of this type.
   b) Examples - complete analysis
3. Equations of the form, $f_1(u) = f_2(v).f_3(w)$.
   (a) Geometry of the design of nomograms of this type.
   (b) Examples - complete analysis.

The discussions of each type form are followed by exercises.

(After Showing of Slides)

Our experience in this field shows that the students are very enthusiastic. They are eager to learn. They derive much satisfaction from their accomplishments and more importantly they have a better appreciation of the wider scope of graphics. Several take advantage of the fuller treatment of nomography in the course which is offered as an elective in the senior year.

I am convinced that we sbould introduce elementary phases of nomography in our basic courses to give our students a start in an ever-growing field which is challenging, stimulating, and of importance to both the engineer and the scientist.

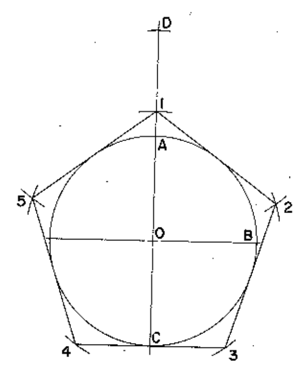
TO CIRCUMSCRIBE A PENTAGON ABOUT A CIRCLE

By

V.H. Paquet
University of Vermont

During the solution of a descriptive geometry problem, it became necessary to circumscribe a pentagon about a circle. To inscribe a pentagon in a circle is common construction and is in most text books. This construction can be adapted to the circumscribing problem without too much trouble. However to satisfy myself and my classes, I managed to come up with this solution, which as far as I can find out is original. Quite possibly I may be mistaken about this.

There is very little call for circumscribing a pentagon but in the interest of completeness and to promote this sort of a page in the JOURNAL OF ENGINEERING DRAWING, the accompanying solution is submitted.



TO CONSTRUCT A REGULAR PENTAGON HAVING GIVEN THE INSCRIBED CIRCLE

1. Draw any two perpendicular diameters.
2. With center at A and radius AO, swing arc locating D on diameter extended.
3. With center at D and radius DO, swing arcs in the vicinity of points 2 and 5.
4. Draw a perpendicular to AC at C.
5. With center at C and radius DB, swing arc locating point I on AD.
6. OI is the radius of the circumscribing circle which will intersect arcs at points 2 and 5, and line at 3 and 4.

* When Professor Levens presented this paper at the mid-winter meeting of the Drawing Division, A.S.E.E., at Illinois Institute of Technology, January 1956, he showed fifteen slides to illustrate these six items and the points also. The slides were all reproductions of figures and pages in his book, GRAPHICS IN ENGINEERING AND SCIENCE, Johnhn Wiley & Sons, Inc., New York, 1954. Because the book is easily available, the figures have been omitted here. The slides shown by Professor Levens were of the following figure and pages: 14.1; 14.2; 14.5; 14.6; 16.17 and 16.18; page 416; 16.19; part of page 420; part of page 422; 16.22, page 421; page 431; 16.32; page 438,16.36, and 16.37; 16.38,16.39, and 16.40. The showing of the slides was accompanied by appropriate remarks. In the words of Professor Levens, this was in effect a classroom type demonstration of "getting it over" to the student. *Editor's note.*

JOURNAL OF ENGINEERING DRAWING

NOMOGRAMS FOR VAN DER WAALS' EQUATION FOR REAL GASES AND FOR THE CORRESPONDING EQUATION FOR IDEAL GASES

By

Peter L. Tea
The City College, New York, N.Y.

Fig. 1 shows the nomogram for Van Der Waals' approximate equation for all real gases, in units of critical pressure, volume, and temperature, and also the nomogram for the corresponding ideal gases, eqs. 1 and 2,

$$\left(p + \frac{3}{v^2}\right)(3v - 1) = 8\,T \qquad (1)$$

$$3\,pv = 8\,T \qquad (2)$$

The surface of eq. 1 approaches the surface of eq. 2 tangentially as v and T increase, for p constant. The surface of eq. 2 is to the surface of eq. 1 like the asymptote is to the hyperbola.

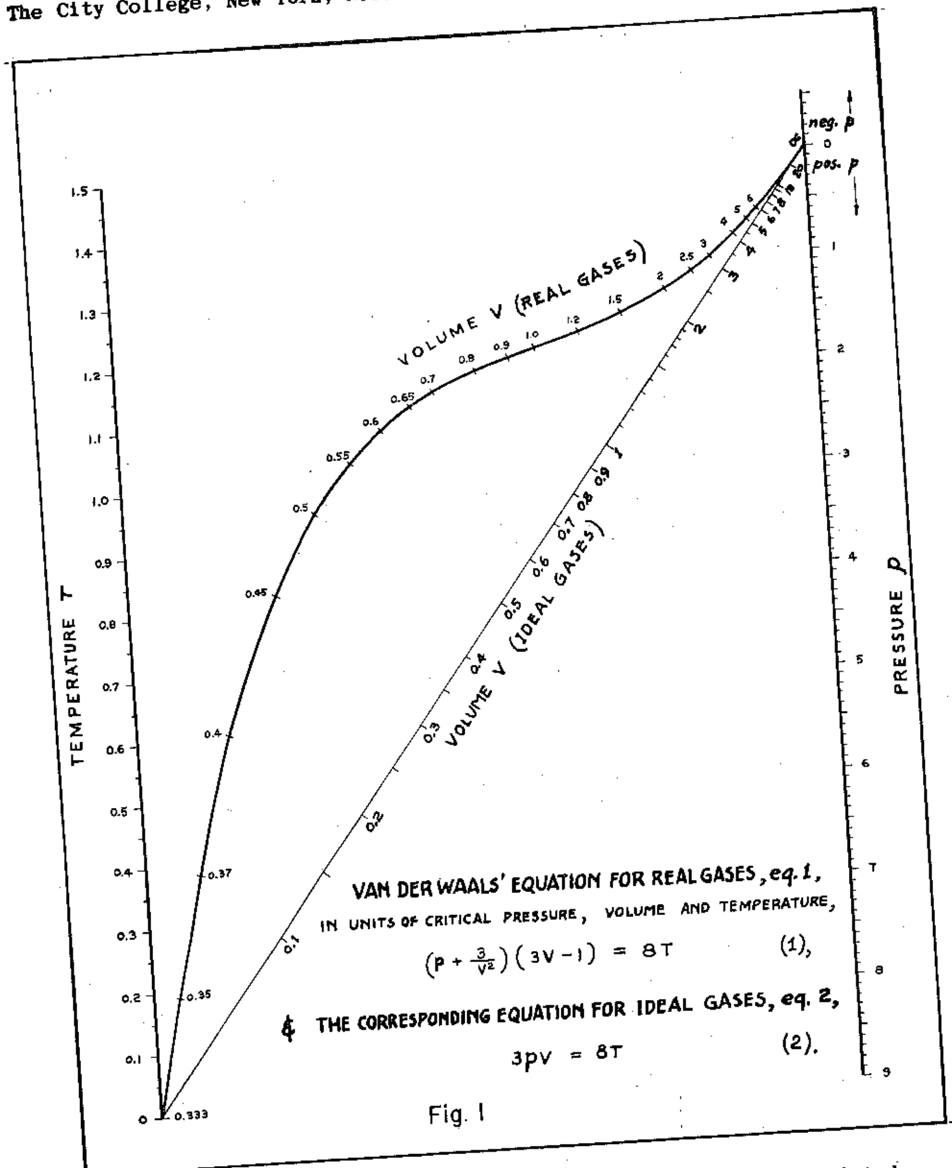


Fig. 1

A straight edge accross the scales of Fig. 1 gives a set of values of p, v, T for the ideal gases, and for the same p and T, one, two or three different values of v, for the real gases. Eq. 1 is a cubic equation in v, for any value of p and T, and there may be three real roots, or one real and two imaginary roots. For T = 0.8 and p positive there is a small range of p yielding roots, from the extreme of p = 0.53 and v = 2, and v = 0.51 where the straight edge is tangent to the v scale at v = 2, and hence v is a double root, corresponding to the maximum value of p on the isothermol for T = 0.8 on Fig. 2. The other extreme position of the straight edge for T = 0.8 yields p = —0.375 and v = 0.65, a double root for v, corresponding to the minimum value of p on the isothermal for T = 0.8. The third root is negative for v and would be found on the v curve plotted for negative values, which would have no apparent interest in physics, and there is no interest in v for negative temperatures either; but negative pressures do appear for Van Der Waals' gases.

After this nomogram was designed and drawn with scales to show up the Van Der Waals' domain to advantage, the author had occasion to use it to draw all the isothermals for T = 0.8 to 3, of Fig. 2 and 3.* The T scale was extended to T = 2 on a photostatic copy. All the necessary points for the isothermals for Figs. 2 and 3, including T = 2 were obtained from Fig. 1 extended; for T = 2.5 and 3 the isothermals were calculated.

It is interesting to point out that Fig. 1 contains two uniform scales, p and T, and only one scale, the curved scale for v, was calculated. From Fig. 1 the isothermals for any value of T within the range of the T scale can be read off point by point and any number of isothermals for Figs. 2 and 3 obtained with little calculation for Fig. 3.

It is to be noted that in obtaining points for Fig. 3 in the region of the loops in Fig. 2, the constant pressure lines of condensation and evaporation were used,

* Van Der Waals' Equation; The Liquefaction of Gases, Peter L. Tea, Vector, January 1953, The City College, New York, N.Y.

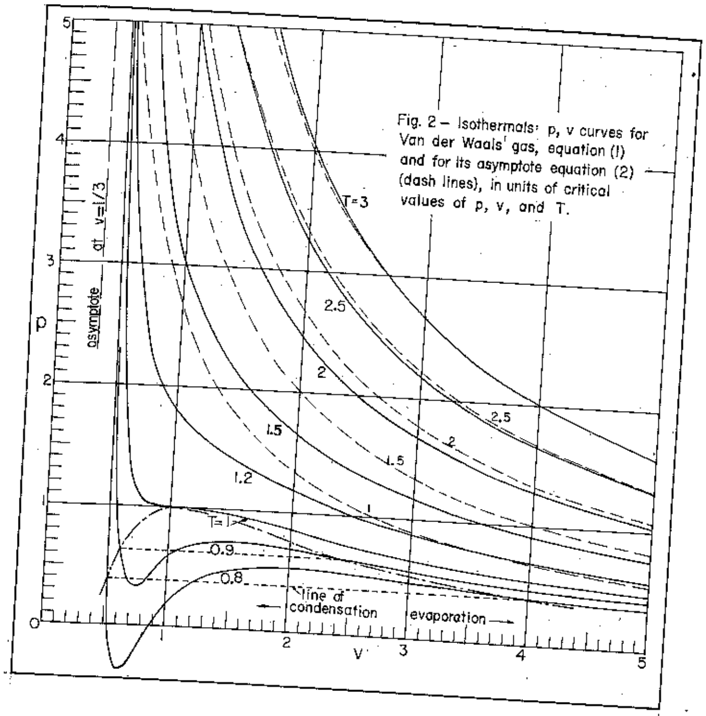


Fig. 2 – Isothermals: p, v curves for Van der Waals' gas, equation (1) and for its asymptote equation (2) (dash lines), in units of critical values of p, v, and T.

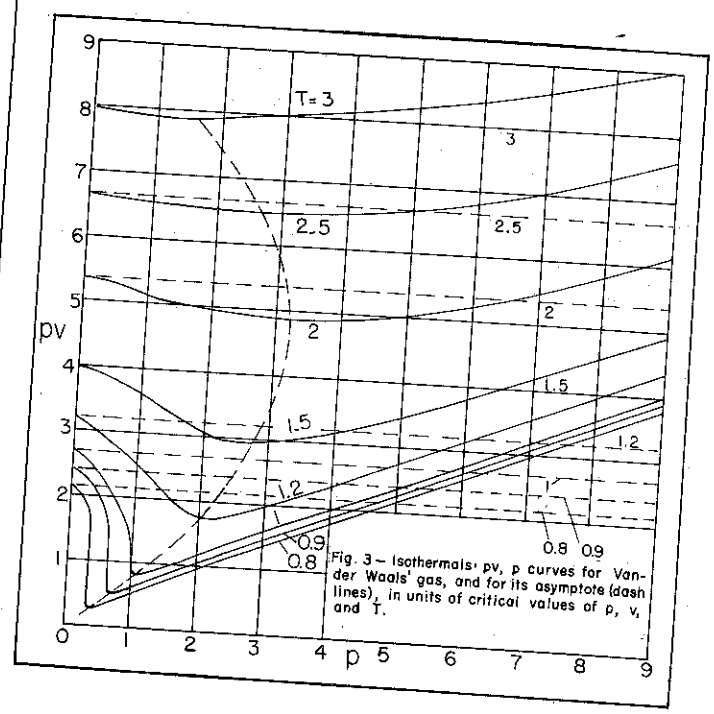


Fig. 3 – Isothermals: pv, p curves for Van-der Waals' gas, and for its asymptote (dash lines), in units of critical values of p, v, and T.

as these correspond better to real gases than the loops.

It would be of interest to the student of nomography to draw the two nomograms for higher temperature ranges, say for T = 2 to T = 10, and T = 10 to T = 100 to see how the hump in the Van Der Waals' curve becomes less and less significant, and the v curve approaches the ideal gas straight line for v.

(SAHAG: Continued from page 17)

made drawings and better designed machines. But since in drawing we have so many topics to cover, by the time we begin plates on working drawings, we realize that there is very little time left to do a good job.

In painting such a dark picture about drawing, this article does not criticize our drawing teachers. On the contrary, they are doing efficient work. Their method of teaching, preparation of tests, grading, lecture work, in comparison with teachers of other courses, are highly satisfactory. Their eagerness for constant improvement in their teaching system, eagerness to learn more about drawing can be proven by the close contact with each other by attending divisional meetings. The defect lies somewhere else, as already mentioned above.

There should be another advanced drawing course between freshman drawing and machine design. This can be called machine drawing or advanced engineering drawing. In this course incomplete sketches or drawings should be assigned, allowing the boys to assume other dimensions. Problems involving proportional parts together with two or three elementary equations will be very useful in this course. Problems which do not involve any question or strength but mostly artistic appearance can be selected as another type of problem. By the aid of calipers and measuring tapes, freehand sketches of simple machines can be prepared outside and final drawings be made in classrooms. Discussions why one design is good and another poor, of course not involving strength and stress, will serve to sharpen students' reasoning and develop their ability for careful design when the time comes.

If it is permitted to offer such a course its usefulness will be as follows: (a) it will give additional information to those who do not take machine design, such as students in Electrical Engineering; (b) it will give useful help to those who take machine design and thus there will be no need for the instructor in design to review the theory of dimensioning. It is probably for this reason tbat one machine design text has a chapter or dimensioning, (c) it will help the boys who do take machine design, but are not required to make working drawings.

In conclusion, a draftsman may not be a graduate engineer, but an engineer should be a good draftsman and tbereby a better engineer.

INTEGRATION—TREND OR FAD

By

Carson P. Buck
Syracuse University

Among engineering drawing teachers there has been an increasing use in recent years of the term "Integration." Two or three texts have appeared since 1950 that claim to be integrated, and others seem to be forthcoming. What is this integration? Is it a fad or a permanent contribution to the engineering drawing field? There are supporters for each view as well as the usual middle-of-the-roaders.

Integration might be defined as simply the combining of descriptive geometry, what is commonly refered to as engineering drawing, and graphical mathematics. How they are combined is a point on which those who favor integration are not yet in complete agreement.

The idea is not new. Prior to 1950 several of our drawing texts contained topics on some of the fundamentals of descriptive geometry. All contained problems dealing with finding the true size of inclined or oblique planes. Thus, at least some descriptive geometry had been included in general engineering drawing courses for many years. However, practically all texts made no claim of including descriptive geometry as a complete unit, leaving the job of complete coverage to separate texts and courses.

In the 1930's and 40's there apparently started to develop a definite interest in adding more and more descriptive geometry to the standard engineering drawing course. This trend moved slowly at first, gathering momentum in recent years as a number of factors contributed to the change.

In a study which I made in 1953 of the curricula of 94 engineering drawing departments representing 63% of the then ECPD accredited engineering schools, it was found that 34, or approximately 36% of those sampled, integrated descriptive geometry in some fashion. Nine departments required that descriptive geometry be taken in sequence between an elementary drawing course and an intermediate drawing course. Another nine departments gave some principles of descriptive geometry in their elementary course. Sixteen departments actually appeared to be teaching combined courses. I do not know just how much descriptive geometry was included in the combined courses offered by the last mentioned departments; at least one of the sixteen actually referred to their course as an integrated one. Most of them simply gave the title "Engineering Drawing and Descriptive Geometry" to their course. This survey was made from college catalogues and for this reason assumptions regarding course content may not be reliable, but it does seem to indicate an active interest in the combining of engineering drawing and descriptive geometry.

Several factors have contributed to the establishment and growth of the combined course. Perhaps the first contributing factor toward the integration of descriptive geometry and engineering drawing was the rise in popularity of the "direct method" approach to descript. Fundamentally, descriptive geometry is a study of the application of orthographic projection to the solution of spatial problems that fall into the categories of true position, true size, and intersection. When these problems were handled in the same manner as the common "three-view" drawing instead of the so called "Mongean" approach, it was a short jump to begin an inclusion of them as a part of a regular engineering drawing course

In some places the initial movement to integrate descriptive geometry took the form of a sequence of courses approach. It was natural to follow an introductory course in engineering drawing with one in descriptive geometry in the second semester, since the ground work in orthographic projection, the basis of descriptive geometry, had been laid in the first semester's course. A certain flexibility was permitted by some schools, in that either descript or the usual second course in engineering drawing could be taken following the basic course in engineering drawing. Those departments that required descript immediately following the first semester basic course in engineering drawing undoubtedly followed the line of reasoning that this did away, to a large extent, with the review of orthographic projection that was ordinarily necessary when descript was given in the first semester of the sophomore year and thereby necessitated a refresher as a result of the summer's gap in continuity.

The next factor to appear, unfortunately (or fortunately, depending on how one may look at it), was the increasing curtailment of drawing time. Without much question, curtailment of drawing time probably extends back to and possibly beyond the turn of the century, but it hasn't been as apparent or as greatly discussed as in the past ten or fifteen years. In fact, to-day it hardly seems that we attend a regional or national meeting that does not have mentioned at same session the fact that the time devoted to drawing is being cut down.

Reduced in most engineering schools to offering two semesters of drawing for the majority of the students in degree-granting departments, engineering drawing departments were faced in some places with the problem of what topics to omit. In some cases the problem was solved for them: some departments dropped descriptive geometry from their curricula (the desire to do this is quite

To Make a complete or "three point" perspective, no change in the basic method is necessary.

Simply make the verticals converge to a third vanishing point, and adjust the Working Layout to accomodate the geometry of this third point of convergence and its adjuncts.

E. First: set up the Working Layout (Fig. 1-E):

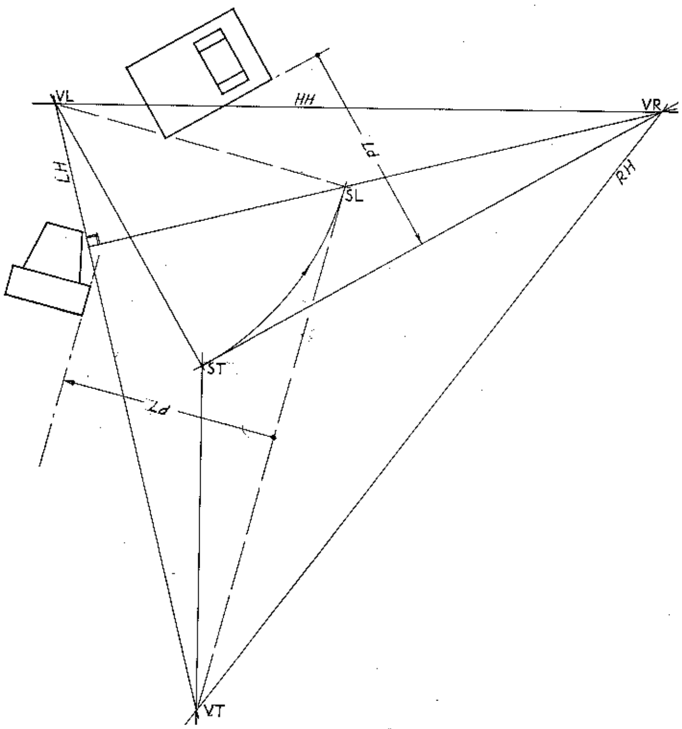


Fig. 1-E: Working Layout for Three-Point Perspective

1,2 and 3 - Same as before.

4. Draw a vertical through ST and choose VT anywhere upon it. LH and RH will now converge to VT instead of being vertical as hefore.

5. From VR draw a perpendicular to LH. Swing ST onto this perpendicular (Instead of to HH as before), locating SL. Join SL to VL and to VT (long-dash lines in figure); it will be found that they form a right angle at SL.

6. Measure Ld as before, and draw a locating-line (dash-and-dot line in figure) parallel to SL-VT at Ld distance from it.

7. Draw up the Left side view touching this locating-line as before, but inclined to keep it parallel to the VL-SL-VT right angle.

We are now ready to project the perspective, exactly as before.

F. Proceed to draw the perspective: (Fig. 1-F)

Exactly as before; project the side view from SL to LH and from there to VR; project the top view from ST to HH and from there to VT.

Any two of the three coordinate views (Top, Left, Right) can be used; or all three for a cross-check. It should be noted that the figure shows every single line actually needed to complete the perspective.

PART II: GEOMETRY: THE PLANE-OF-SIGHT PRINCPLE.

The method here presented is so much simpler and easier than any heretofore proposed for drawing three-point perspectives that it seems almost too good to be true. Therefore, a rigorous demonstration of the underlying geometry, together with the reasoning which led to it, is in order.

Traditional methods of perspective start with a basic concept stated somewhat like this (Fige 2-A):

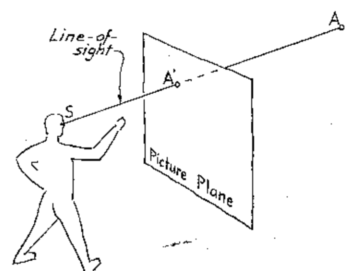


Fig. 2-A

"Take a line-of-sight from the eye (station point) to any point A of the object. Where this line-of-sight pierces the picture plane is the perspective image of point A"

The weakness of any method based wholly on the line-of-sight principle is that in order to find the piercing point, the picture plane must be in edge view. Whenever the picture plane is inclined to the object, it is necessary to redraw the object in inclined (auxiliary) views. In practical work, this is thoroughly impractical.

The well known "office method" circumvents this difficulty hy not using the front or side views at all except as a "height scale;" it introduces the vanishing points by a kind of heuristic demonstration (remember the picture of railroad tracks and telegraph poles in the desert?), and extends the lines of the object to *their* piercing points on the picture plane (a fruitful source of errors for the student). Once mastered, however, the office method is fairly easy to use, and is the only method in actual use by the vast majority of practical workers.

Since the "office method" is still essentially a piercing-point method, it cannot be extended to three-point perspective without re-drawing the object in auxiliary views; hence to most practical workers three-point perspective remains a mystery, an unattainable dream.

The "measuring-point" method, while still based on a purely heuristic concept of the vanishing points, is nonetheless a sonnd, complete geometric discipline. It can be extended logically to three-point perspective. It is the darling of teachers, textbook authors, and other "impractical" workers in the field. Its great

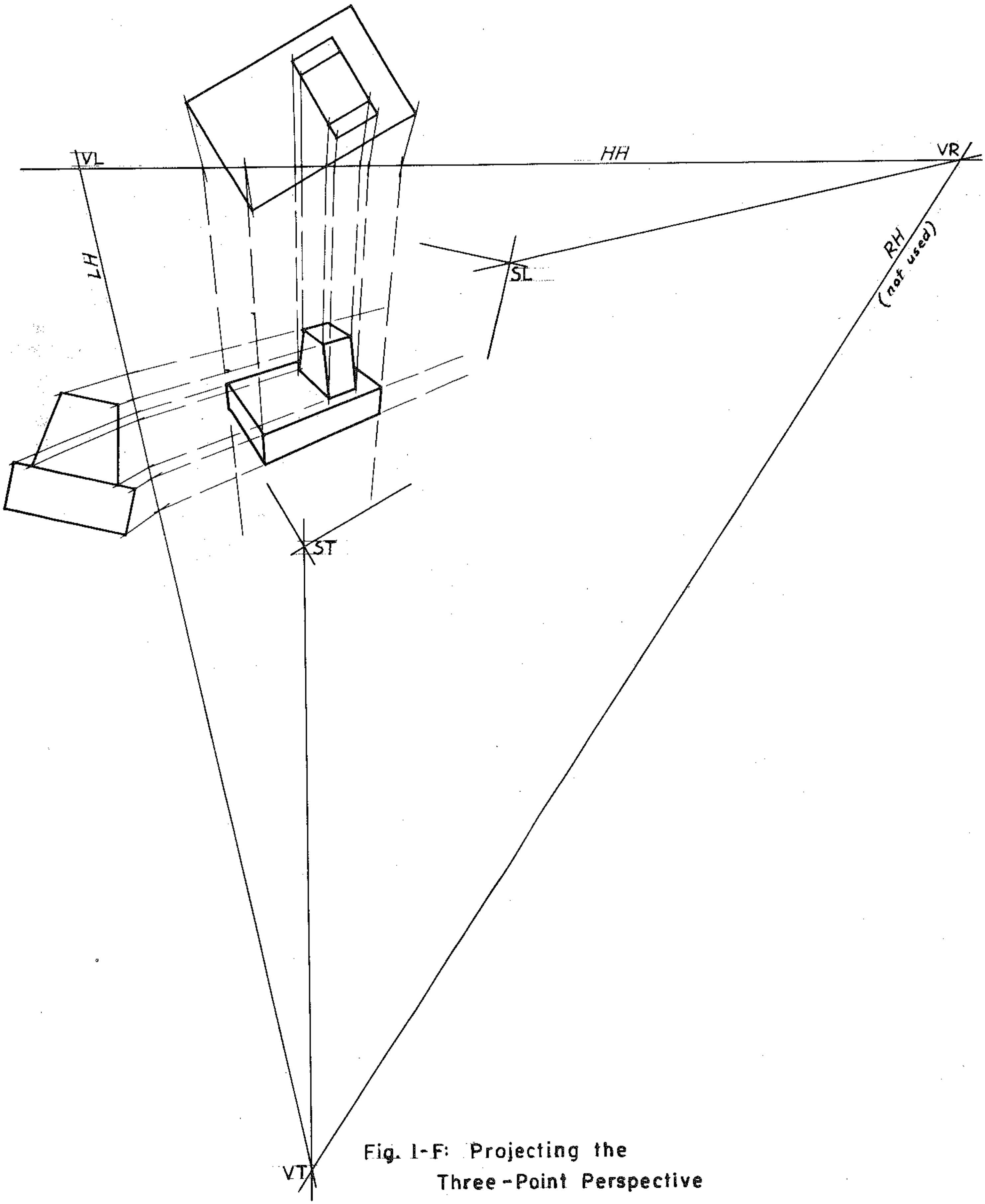


Fig. 1-F: Projecting the Three-Point Perspective

handicap is its difficulty. In the short time allotted to perspective in even the architectural, let alone the engineering courses of today, the average student simply cannot master it. For all but the expert, making a three-point perspective of a complex object by the measuring-point method can become a veritable nightmare of frustration.

The method here presented substitutes for the line-of-sight concept, another basic concept (Fig. 2-B):

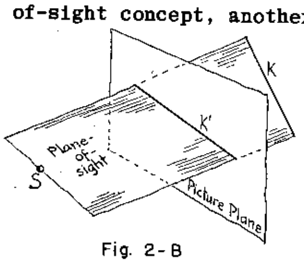
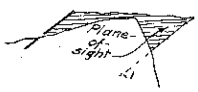


Fig. 2-B

"Join the eye (station point) to any line of the object by a Plane-of-Sight. Where this plane intersects the picture plane is the perspective image of the line."



The Plane-of-Sight, being an infinite plane, cannot be drawn (except where it appears in edge view); but *its intersections with the reference planes* of the given multi-view drawing *can be drawn.**

Let us now take the conventional "glass box" of three mutually perpendicular reference planes, positioned parallel to the three principal faces of the object. Using now the mathematical nomenclature: O for the origin and OX, OY, OZ for the axes (instead of the traditional perspective nomenclature as before); place the station point at O and let the picture plane be a random or oblique plane cutting the XYZ axes at points X, Y, and Z (Fig. 2-C).

Let k be any line in space whose perspective image is sought; the only requirement is that k be parallel to one of the axes, say OY. K is then the end-view of k on reference plane OXZ. The plane-of-sight joining O to k is therefore seen on OXZ in edge-view, as OK.

Point Q on line XZ is therefore on the plane-of-sight; and so is point Y because, remember, k was required to be parallel to OY; hence QY is the intersection of the plane-of-sight with the picture plane XYZ; that is, *QY is the perspective image of line k.*

Obviously, point Y will be common to the perspective images of all lines parallel to OY; thus the perspective images of all these parallel lines will converge at Y. The phenomenon of vanishing points is thus rigorously demonstrated, as a by-product.

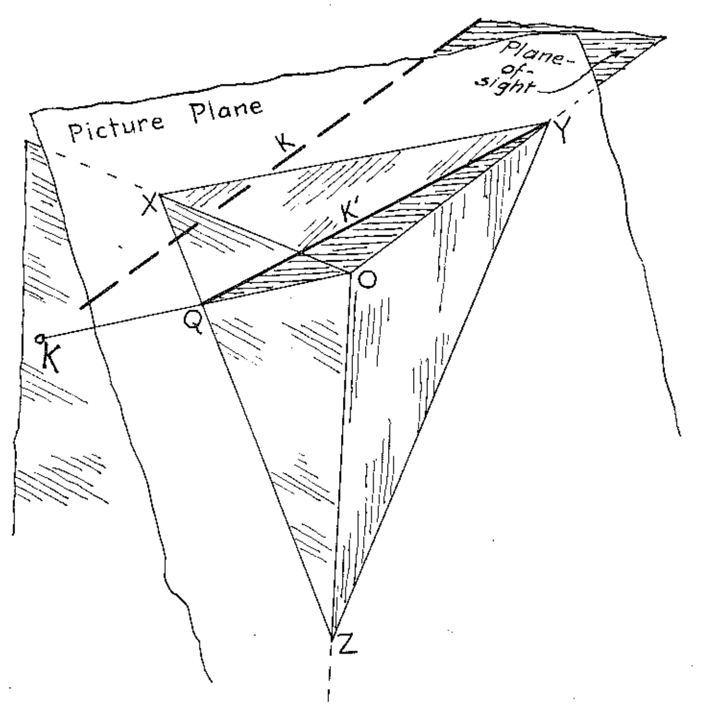


Fig. 2-C

Revolving the reference planes about their intersections XY, XZ, YZ, into the picture plane, we get Fig. 2-D.

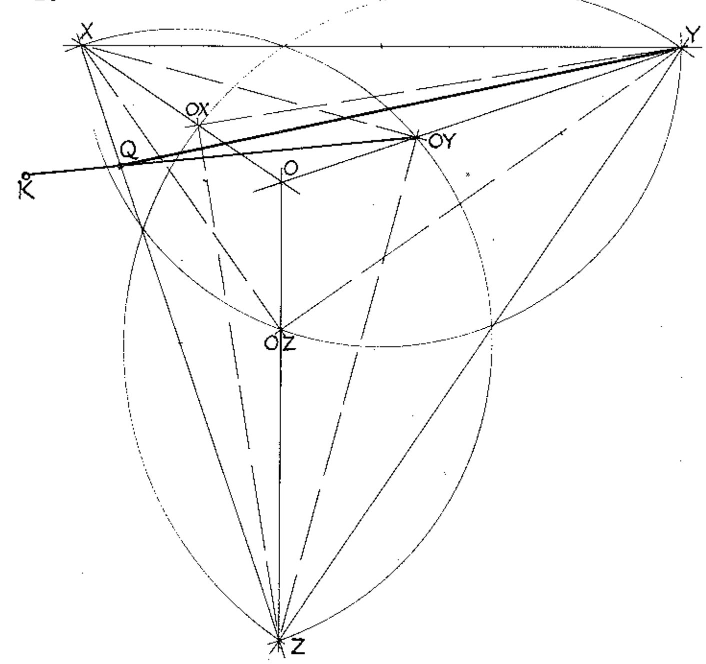


Fig. 2-D

* This is fact was Gaspard Monge's great contribution: that an infinite oblique plane is uniquely determined by its intersections (traces) with fixed reference planes. Even though we have abandoned Monge's fixed reference planes, for good reasons, in our teaching of descriptive geometry in favor of the "Direct Method," this basic Mongean concept remains a powerful working tool.

K being the end view of a line parallel to OY, its perspective image is then QY.

Fig. 2-D is seen to be identical with Fig. 1-E (Working Layout for three-point perspective). Note that K was drawn in the X-OY-Z reference plane; in the language of Fig. 1-E this means: in Left-side view.

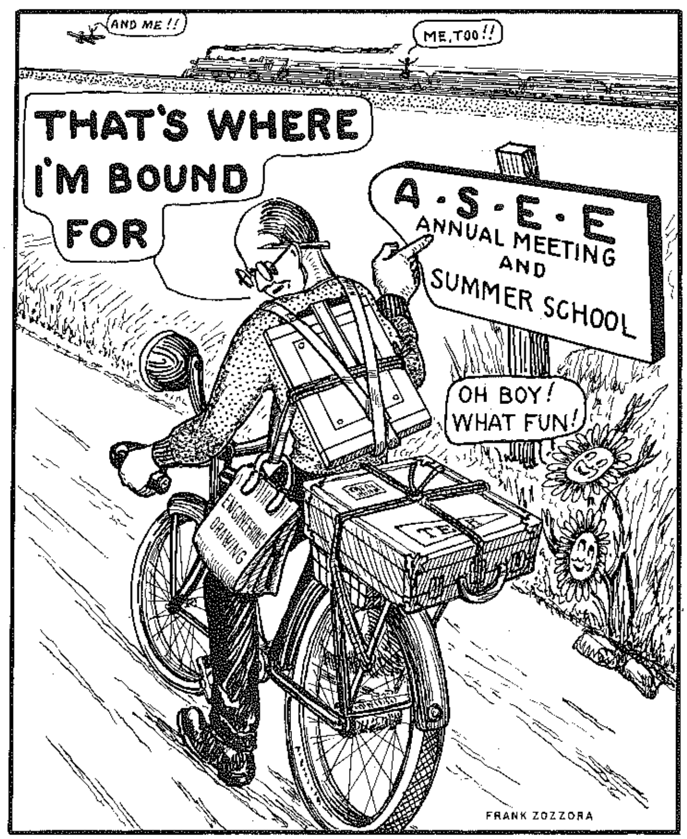
"Projecting the side view from SL onto LH" is actually the finding of Q points for each k line; "projecting thence to VR" is drawing QY, the perspective image for each k line.

Q.E.D.

Point O, the orthocenter of triangle XYZ is, of course, the foot of the perpendicular from the origin O to the picture plane, the "center of vision" of the perspective.

Fig. 2-D doubtless brings to mind Prof. Eckhart's method of Axonometric Projection, as published by him in Vienna in 1937. The resemblance is not purely coincidental. What we have here is the general theory of projection upon an oblique plane, of which the Eckhart method is a special case.

Fig. 2-D is reminiscent also of some of the diagrams in the admirable and beautifully illustrated little monograph published in 1947 at Harvard by Stanley B. Parker, A.I.A., under the title "The Vertical Vanishing Point in Linear Perspective" and devoted mostly to making out a case for three-point perspective; as well as in other books, some as early as 1875. It is indeed remarkable how near Mr. Parker and others have come to the ultimate simplicity of the method here presented, without quite getting there.



PROGRAM

ANNUAL MEETING AND 1956 SUMMER SCHOOL
Iowa State College, Ames, Iowa
June 20-28, 1956

Registration - Memorial Union
Headquarters - Room 403, Marston Hall
Meetings - Auditorium, Electrical Engineering Building

Wednesday, June 20, 1956
Program theme: Evaluation of Engineering Drawing, Descriptive Geometry, and Graphics for the Future
4:00 p.m. to 6:00 p.m. - Registration
7:30 p.m. to 9:30 p.m. - Visiting

Thursday, June 21, 1956
8:00 a.m. - Registration
9:00 a.m. - Opening Session
Presiding: James S. Rising, Iowa State College
Welcome: J.F. Downie Smith, Dean of Engineering, Iowa State College
Response: W.E. Street, Chairman, Division of Engineering Drawing, ASEE, Texas A & M College
"Objectives of Engineering Drawing in Engineering Education"- R.R. Worsencroft, University of Wisconsin)
"Correlation of Engineering Drawing Courses"-I.L. Hill, Illinois Illinois Institute of Technology.
"Motivation Needed in Teaching Engineering Drawing"- E.D. Black, General Motors Institute

Panel Discussion
W.M. Christman, University of Wisconsin
C.P. Buck, Syracuse University
H.J. Styles, Queen's University

2:00 p.m., Presiding; Dean Jasper J. Gerardi, University of Detroit
"Drawing and Descriptive Geometry Courses which Comply with the ASEE Report on Evaluation of Engineering Education, 1952-55"-
R.A. Kliphardt, Technological Institute, Northwestern University
H.C. Spencer, Illinois Institute of Technology
John T. Rule, Massachusetts Institute of Technology
C.J. Vierck, Ohio State University

Panel Discussion
C.I. Carlson, University of Illinois, Navy Pier
F.C. Bragg, Georgia Institute of Technology
C.E. Douglass, University of Washington
E.R. Weidhaas, University of Maine

7:00 p.m., Presiding: J.B. Porscb, Purdue University
"Professional Orientation As a Function of Engineering Drawing"- Samuel P. Owen, Rutgers University
"Advancement in Industrial Planning and Design as they relate to the Drawing Room"-
J.A. Carroll, The Proctor and Gamble Company

Panel Discussion
O.W. Potter, University of Minnesota
P.O. Potts, University of Michigan
O.M. Stone, Case Institute of Technology
Mary F. Blade, The Cooper Union
W.E. Dessauer, Tulane University

Friday, June 22, 1956
8:30 a.m., Group Picture - Electrical Engineering Building steps
9:00 a.m., Presiding: H.B. Howe, Rensselaer Polytechnic Institute
"Creative Problems for Basic Engineering Drawing"- Matthew McNeary, University of Maine
"A Damper on American Scientific Progress"- R.W. Pearson, Radio Corporation of America
"Graphics and the John Deere Cotton Picker Spindle"- C. Gordon Sanders, Iowa State College
"The John Deere Des Moines Works"- Arthur B. Lundahl, General Manager, John Deere Plant

Panel Discussion
E.K. Mulhausen, Lehigh University
Richard G. Huzarski, University of New Mexico
J.E. Shigley, Clemson Agricultural College
Frank Binns, Mt. Allison University

1:00 p.m., Inspection Trip, John Deere Des Moines Works
7:00 p.m., Dinner, Ladies included
"Drawing for Tomorrow"- B.L. Wellman, Worcester Polytechnic Institute
"The Far East in Three Dimensions"- B.E. Grant, Washington University
Tour of Exhibits

Saturday, June 23, 1956
9:00 a.m., presiding: J.S. Blackman, University of Nebraska
"Simplified Drafting as Proposed by the Bureau of ships"- R. Wallace Reynolds, California State Polytechnic College
"Dimensioning for Mass Production"- P.G. Belitsos, General Electric Company
"Dimensioning and Checking of Drawings"- R.M. Coleman, Texas Western College
"Function of Engineers, Designers, and Draftsmen in Industry"- W.L. Healy, General Electric Company

Panel Discussion
A.O. Remde, Waukegan High School
Allen H. Spinner, Stevens Institute of Technology
H.P. Ackert, University of Notre Dame
Mack S. Kesler, University of Utah
A.P. McDonald, The Rice Institute
F.A. Smutz, Kansas State College

2:00 p.m., Presiding: E.H. Brock, Arizona State College
"How to Make and Use Teaching Aids"-R.I. Hang, Ohio State University
"Examinations in Engineering Drawing and Descriptive Geometry"-Irwin Wladaver, New York University

Panel Discussion
Roy D. Mitchell, Odessa College
Leroy Burris, University of Arkansas

6:30 p.m., Executive Committee Dinner
7:30 p.m. to 9:30 p.m., Entertainment, for everyone

Sunday, June 24, 1956
Open for visits to points of interests
Tour of Exhibits
3:00 p.m. to 6:00 p.m., Reception at the home of James S. Rising

Monday, June 25, 1956
9:00 a.m., Presiding: A.S. Levens, University of California
"Changes in Drawing and Drafting Room Standards"-R.P. Hoelscher, University of Illinois
"American Drafting Standards in Basic Drawing Courses"- R.S. Paffenbarger, The Ohio State University
"Changes in Drawing Emphasis"- R.T. Northrup, Wayne University

Panel Discussion
W.J. Luzzader, Purdue University
L.R. Schruben, University of Southern California
L.M. Sahag, Alabama Polytechnic Institute

2:00 p.m., Presiding: John M. Russ, State University of Iowa
"Movable Scale Nomographs"-J.N. Arnold, Purdue University
"Nomograms for Beginners"-(Audience participation) Albert Jorgensen, University of Pennsylvania
"Graphical Calculus"-(Audience participation) E.M. Griswold, The Cooper Union

Panel Discussion
Douglas P. Adams, Massachusetts Institute of Technology
R.E. Lewis, Duke University
T.T. Aakhus, University of Nebraska
Lee H. Johnson, Tulane University

Tuesday, June 26, 1956
(Joint conference with English)
Theme: The Esthetic Functions of Engineering Drawing and English
2:00 p.m., Presiding: W.E. Street, Texas A & M College and Paul Fatout, Purdue University
"Esthetic Functions of English"- James H. Pittman, Newark College of Engineering, and
Frederic H. Higbee, State University of Iowa
"Esthetic Functions of Engineering Drawing"-Wayne L. Shick, University of Illinois
"The Graphic Approach to Engineering Education"- F.A. Heacock, Princeton University

Panel Discussion
John L. Bloxsome, Rose Polytechnic Institute,
Mrs. Margaret D. Blickle, Ohio State University
Dr. J.P. Abbott, Dean of the College, Texas A & M College
C.A. Newton, University of Tennessee

6:30 p.m., Dinner, Ladies included, Memorial Union
Awards: Nomograph Award
Distinguished Service Award
Speaker: Herbert V. Hake, Director of Radio and Television, Iowa State Teachers College "Making Faces"

Wednesday, June 27, 1956
12:00 noon, Luncheon and Business meeting
2:00 p.m. (Joint conference with Mathematics)
Presiding: W.E. Street, Texas A & M College and Haim Reingold, Illinois Institute of Technology
"Graphical Field Mapping"- John F. Calvert, University of Pittsburgh
"An Operational Symbolism for Graphical Processes"- S.A. Coons, Massachusetts Institute of Technology
"Graphical Analogues of Mathematical Processes"- J.F. Twigg, Massachusetts Institute of Technology

Thursday, June 28, 1956
2:00 p.m.
Demonstration of Teaching Aids in Engineering Drawing and Descriptive Geometry - Justus Rising, Purdue University and members of the Teaching Aids Committee of the Drawing Division

WHAT DO YOU BELIEVE?

By

Stuart C. Allen
Michigan College of Mining and Technology

At least one of the reasons for having a Drawing Division Summer School is to periodically evaluate what we believe. Teachers do not ordinarily think of themselves as salesmen but consciously or unconsciously we control the rate of return on our students' investment of time, money and effort in a direct proportion to the intensity of our feeling about our work. Every one of us has, at some time, been exposed to a teacher who had something to sell. The students of this teacher came away thirsty. They wanted more. There are three major factors involved in successful teaching:

1. The teacher must be sold on what he is teaching.
2. He must be well informed on what he is teaching.
3. The student should be able to see some relation between what he is doing today and what he expects to be doing tomorrow.

My son recently completed a course in mechanical drawing in the seventh grade. He has shown more than average interest in things mechanical and I had hoped that there might be some enthusiasm for this new medium of expression, but by the end of the term, he had had his fill. Too many of our own students have also had their fill when we are through with them.

Are we irrevocably committed to the ideas that looked so good in 1946 and even 1951? Anyone who has been even remotely connected with the field of graphics during the past 10 years must be aware of the doubts that assail at least some educators as to the content of their courses. Some of these questions that many of us are asking are:

1. What is essential or basic in a course in engineering graphics today, (a) from the standpoint of industry? (b) from the standpoint of the engineering school?
2. How important is the ability to sketch as compared with the ability to use instruments?
3. There is a considerable difference of opinion as to where the theory of orthographic projection may be taught to best advantage. How much of this theory is necessary?
4. How important are charts and graphs and diagrams to our engineering students?
5. Should we distinguish between descriptive geometry and engineering graphics or engineering drawing?
6. What should we be testing, (a) ability to memorize? (b) ability to rationalize? (c) ability to discriminate?
7. The word "trace" is rapidly disappearing from our texts. Is this desirable?
8. Some of us believe that information regarding the following is important: (a) Piping layouts (b) Structural layouts (c) Welding symbols. To what extent do we feel that this is basic information?
9. Does design have a place in our drawing courses? To what extent?

Would it be possible to get something approaching a composite answer to questions of this type while we have our group together at Ames? It is desirable to be an independent thinker but illuminating sometimes to know what our neighbors are thinking and why.

The above list does not cover the field by an any means but it is felt that we need to ask ourselves more questions if we are going to be an effective division of an engineering education curriculum.

SOLVE THIS ONE

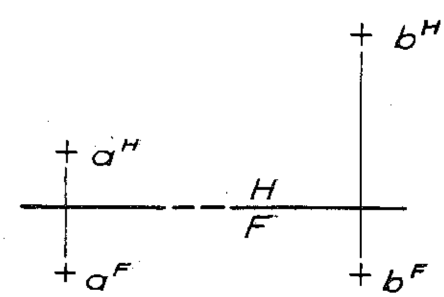
By

Elizabeth A. Kelso
and
Ernest R. Weidhaas
University of Maine

For a "Quickie" on our last Descriptive Geometry Final, we gave the following problem:

Given the top and front views of two points, A and B. (a) Locate a point X such that there will be a rising slope of 30° from point X to both points A and B. (b) How many solutions?

Although nearly everyone got this problem right, we wonder how many students could state the form of the locus of point X?



CROSSWORD PUZZLE

By

Kenneth E. Haughton
Iowa State College

This crossword puzzle has been used at Iowa State College for either a quiz or a review after covering material on several special surfaces. It provides an interesting change of pace. Try your hand.

HORIZONTAL

1. Surface formed by a straight line intersecting two straight line directrices and parallel to a plane director is a hyperbolic_____________.
4. Surface formed by a line intersecting a helix and its axis.
6. Surface generated by a straight line is a __________surface.
8. Kind of helicoid formed if generatrix makes an acute angle with the axis.
10. Height of one turn of a helix.
11. On a development one should make the joint at the shortest__________.

14-15. Surface formed by a straight line intersecting a straight line and two similarly curved parallel directrices.

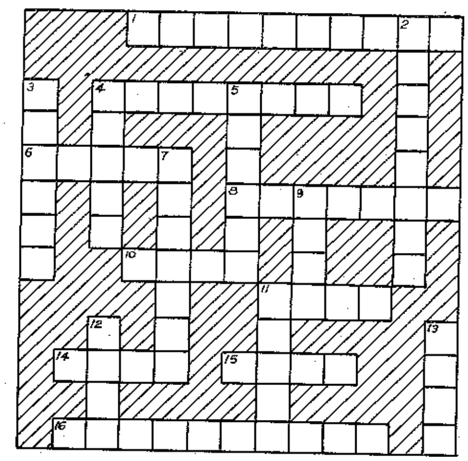
16. Kind of spiral formed by intersection of an oblique helicoid and a plane at right angles to its axis.

HORIZONTAL

1. Surface formed by a straight line intersecting two straight line directrices and parallel to a plane director is a hyperbolic _________.
4. Surface formed by a line intersecting a helix and its axis.
6. Surface generated by a straight line is a _________ surface.
8. Kind of helicoid formed if generatrix makes an acute angle with the axis.
10. Height of one turn of a helix.
11. On a development one should make the joint at the shortest ______.

14-15. Surface formed by a straight line intersecting a straight line and two similarly curved parallel directrices.

16. Kind of spiral formed by intersection of an oblique helicoid and a plane at right angles to its axis.

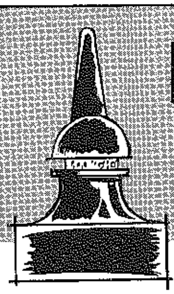


VERTICAL

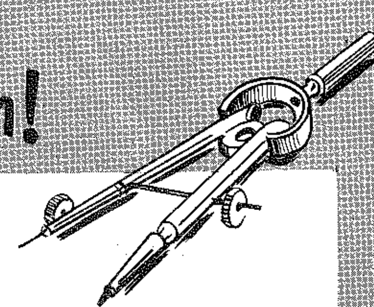
2. Curve formed by intersection of helical convolute with a plane at right angles to its axis.
3. Surface whose successive positions of the generatrix are non-parallel and non-intersecting is a __________ surface.
4. Curve formed by the intersection of a helical convolute and a cylinder if they both have a common axis.
5. Surface formed by straight line intersecting a straight line and a curved line and parallel to a plane.
7. The directrix __________ the generatrix.
9. Shortest distance between two points is a straight _________.
11. Tangent of the slope angle.
12. Number of planes on a tetrahedron.
13. Surface formed by a straight line intersecting a straight line and a closed curved line.

VERTICAL

2. Curve formed by intersection of helical convolute with a plane at right angles to its axis.
3. Surface whose successive positions of the generatrix are non-parallel and non-intersecting is a________surface.
4. Curve formed by the intersection of a helical convolute and a cylinder if they both have a common axis.
5. Surface formed by straight line intersecting a straight line and a curved line and parallel to a plane.
7. The directrix___________the generatrix.
9. Shortest distance between two points is a straight________.
11. Tangent of the slope angle.
12. Number of planes on a tetrahedron.
13. Surface formed by a straight line intersecting a straight line and a closed curved line.



For Courses in Drawing and Design!



TECHNICAL DRAWING, THIRD EDITION

By Frederick E. Giesecke, Alva Mitchell and Henry C. Spencer

Clarity and completeness in all fundamentals plus a wealth of practical information have made this book outstanding in the field of technical drawing. Emphasizing the principles of technical drawing and the relation of the subject to industry, the third edition features a large number of new problems, approximately 900 new illustrations, and new material in almost every chapter.

1949 — 851 pages — $6.00

TECHNICAL DRAWING PROBLEMS, SECOND EDITION

By Giesecke, Mitchell and Spencer — 1947 — 105 pages and 105 blanks — $4.80

TECHNICAL DRAWING PROBLEMS, SERIES TWO

By Spencer and Grant

Either of these workbooks may be used to advantage with the text, as each provides a comprehensive series of problems on the fundamental and applied aspects of technical drawing. Completely revised "Work Plans" are available in which complete instructions are given, together with all references to the third edition of *Technical Drawing*. The two workbooks present completely different sets of problems to be used in alternate years or semesters.

1948 — 138 sheets — $5.00

DESCRIPTIVE GEOMETRY

By Eugene Paré, Robert O. Loving and Ivan L. Hill

Introducing the fundamentals and applications of descriptive geometry one at a time, this text provides a thorough course, complete with problems. Illustrations throughout the book are in step-by-step form to insure comprehension of the constructions, and space analyses are presented pictorially whenever they can be used to aid visualization. A convenient review chapter at the end of the book includes laboratory problems involving several principles in each solution.

1952 — 309 pages — $4.25

DESCRIPTIVE GEOMETRY WORKSHEETS, SERIES A

1950 — 75 pages — $3.25

DESCRIPTIVE GEOMETRY WORKSHEETS, SERIES B

Designed for use with *Descriptive Geometry* or with any other standard text featuring the direct method, each worksheet contains from one to six problems and provides sufficient material for one laboratory period. In general, each new topic is introduced with fundamental, abstract or theoretical problems, followed by problems involving actual engineering situations so that the practicality of each subject is self-evident. The two workbooks present completely different sets of problems to be used in alternate years or semesters.

1954 — 75 pages — $3.25

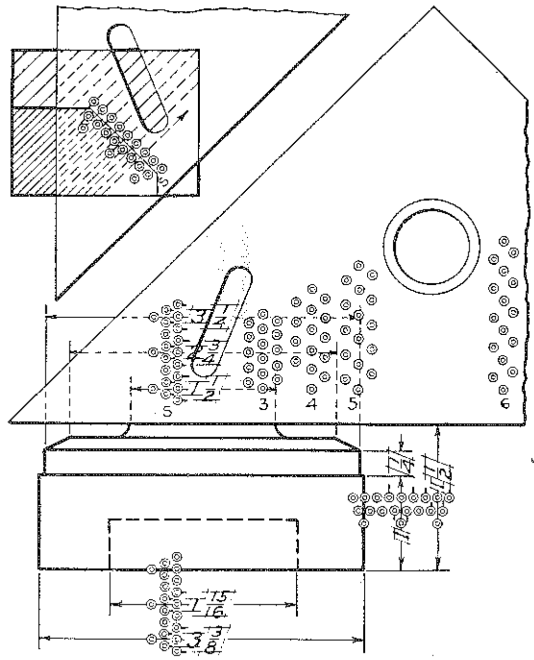
60 FIFTH AVENUE — *The Macmillan Company* — NEW YORK 11, N.Y.

BRADDOCK LETTERING ANGLES

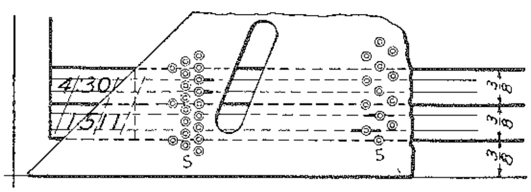
VERSATILE LETTERING TRIANGLES FOR

SYSTEMATIC
DIMENSIONING
UNIFORM
LETTERING

ACCURATE
SPACING
PRECISE
DRAWING



SYSTEMATIC DIMENSIONING



LAYING OUT TITLE STRIP

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

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

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.