The Journal of Engineering Drawing

CONTENTS

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

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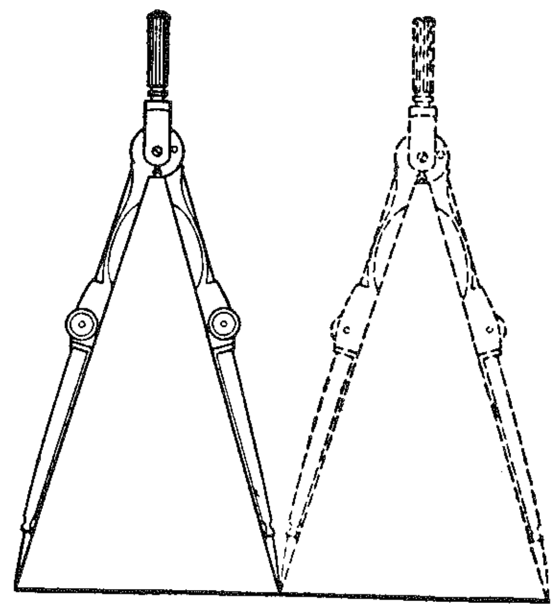

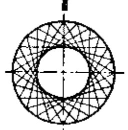

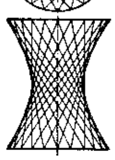

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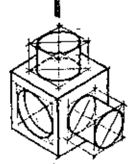

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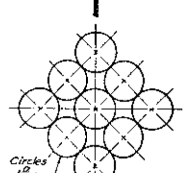

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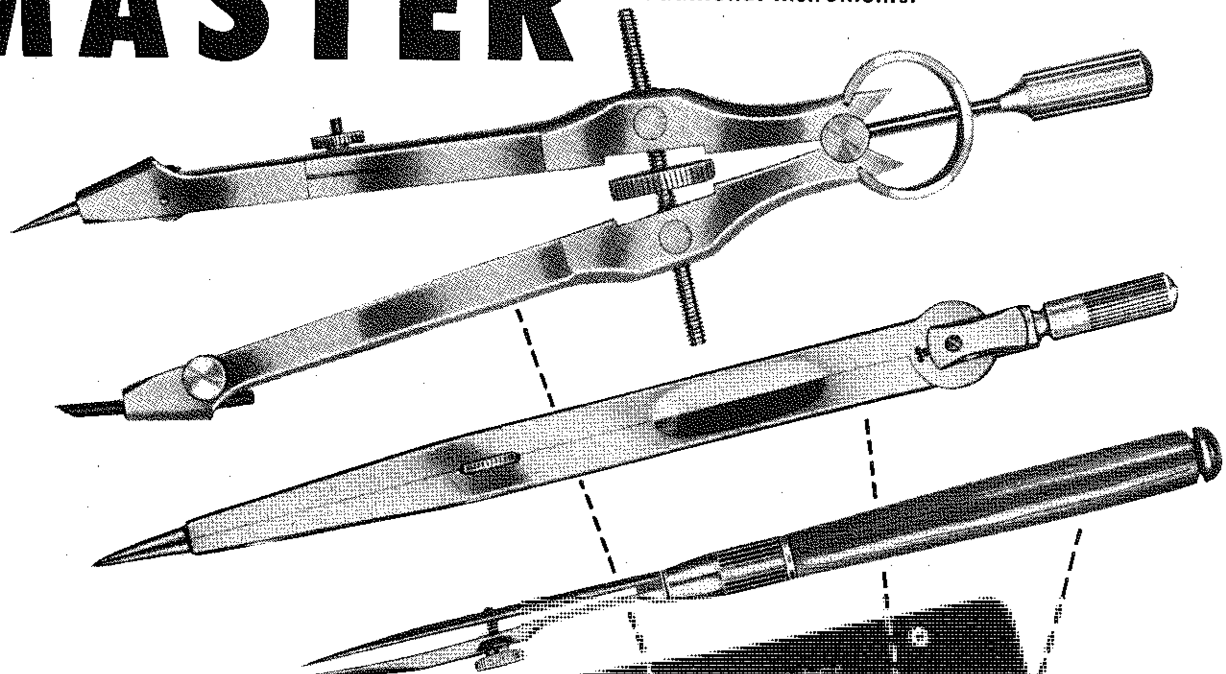

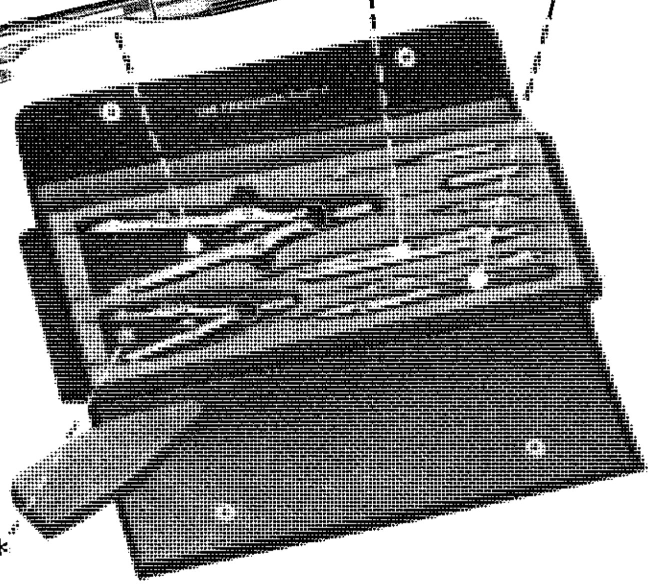

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1953 REPORT TO NATIONAL COMMITTEE

by

Drawing Division

American Society for Engineering Education

(Presented to Committee on Evaluation of Engineering Education, Dr. L.E. Grinter, Chairman)

Drawing is the universal method of recording and communicating certain types of information in the engineering profession. Therefore, before an idea takes form or a structure or a machine is built, much informational data must be developed and represented graphically. In years past instruction in drawing placed great emphasis on technique and artistic appearance, and included some training in methods of projection in all four quadrants. Most drawings were inked and much time was spent on well executed lettering. Today drawings are quickly made and well adapted to modern production methods. Drawing courses are improved, keeping pace with the rapid advances in science, industry, and technology. Our industrial success is due in large measure to efficient planning on the drawing board. The more complex the production problem, the more urgent is the need for effective drawings to show the workman exactly what is required. As future progress will depend more than ever upon better working drawings, the drawing teacher today accepts the responsibility of giving engineering students the right kind of drawing instruction, so that the engineer of tomorrow will have the best working knowledge and drafting ability to plan future developments.

Nor is it out of place here to state that drawing in all its forms is a foremost instrument in sharpening and deepening the powers of perception which features expanded treatment of the theory of drawing as an analytical tool. Strong emphasis on development of the student's geometrical and spatial ability, to equal his training in equational representation of physical bodies is needed,so that he can interpret shape and position descriptions to those who must construct them. "For working out the shape of objects, visualizing natural phenomena or setting up a basis for calculations, graphics is simple and self-checking. For these purposes, it has no competition and none appears in prospect."--A.F. Puchstein, Consulting Engineer, The Jeffery Manufacturing Company,Columbus, Ohio.

It is true that many engineers today in responsible positions have draftsmen to make their working drawings from sketches. However, an engineer cannot supervise draftsmen until he become proficient in reading and making drawings. Just as the engineer is responsible for the proper functioning of machines and machine elements, he is equally responsible for drawings showing their design, for the selection of correct dimensions, for the proper choice of materials, and many other things which a draftsman has insufficient background training to determine. He must, therefore acquire the ability to solve new problems in unusual situations, to think creatively, to continue to learn, to remain mentally vigorous, and exercise sound judgment in finding the best answer without loss of valuable drafting time. In modern industry drawings are considered legal documents, or the basis of contracts, and they must not be misinterpreted.

A large part of engineering costs on any project are involved in making and reproducing drawings. Modern reproduction methods are now being reflected in drafting room procedures. Ink work has been replaced almost entirely by pencil drawings. Freehand sketching is being increasingly emphasized. Stress is placed on the development of an engineering vocabulary. Construction of charts and diagrams and the principles of limit dimensioning have been introduced. Since dimensioning is associated with shop processes and time for shop courses has been curtailed, it is necessary to emphasize what a machine can do and what its limitations are in order to give proper drawing specifications. In descriptive geometry the draftsman's method of analyzing and solving problems by the auxiliary plane method has replaced the classical Mongean or revolution method, and as a result students are acquiring greater confidence and competence in the use of this science.

Graphics includes in its field all the fundamentals of graphical representation, and of geometrical and graphical analysis. Conventionally, it is covered in most colleges by courses in engineering drawing and descriptive geometry. These courses generally cover graphical processes of solving physical problems, fundamentals of form and design, as well as exact delineation of space objects for recording ideas. Engineering drawing is a subject of high utilitarian value. It is a technique in commercial demand and work on the drawing board is frequently the doorway to promotion. Moreover, for more than 50% of the entering students who do not complete their work in engineering, it is a professional course that offers an opportunity to enter the field of technical employment.

Engineering educators recognize spatial visualizing ability as one of the prime requisites of a good engineer. Recent research by R.R. Worsencroft of the University of Wisconsin and Mary Blade of the Cooper Union indicates that present courses in engineering drawing and descriptive geometry develop this trait in engineering students to a very significant degree over other students, and that following these courses, further development is comparatively slight. This confirms the intellectual value of training in drawing to conceive and create solutions to highly theoretical problems. Drawing introduces the obligation of conforming to standards basically necessary to all engineering practice. It trains to notice subtle differences in quality. It promotes an understanding of form and design, of the feel for various materials and their possibilities. It provides fundamental training for developing creative ability and sound engineering judgment.

Careful consideration should be given to the graphical solution of industrial problems, and sufficient time should be provided for adequate drawing courses in the various engineering curricula. Graphical computation courses including such topics as empirical equations from laboratory data, graphical differentiation and integration, and nomography offer a fertile field for applying graphical methods in fundamental courses such as mathematics, physics, and mechanics. Further, there is a need of drawing courses to bridge the gap of one or more years from drawing to design to provide essential information and give a better carry-over and continuity. Engineering graphics has broader educational functions than developing ability to represent objects by orthographic drawings and to solve space problems by descriptive geometry methods. For graphics is a comprehensive term, including not only engineering drawing and descriptive geometry, but also the advanced courses of kinematics and graphic statics and other similar courses in the various technological curricula.

Advisory committees of drawing staff members should be established to work with engineering and science students and faculties in undergraduate and graduate programs wherever graphical methods can be used to advantage in connection with thesis projects and research.

College administrators cooperating with industry should provide opportunities for fundamental research by drawing teachers. The value of such research is demonstrated by recent projects applying drawing and descriptive geometry procedures in the treatment of cancer and in the design of artificial limbs at Columbia University and the University of California by H.W. Vreeland and A.S. Levans.

* * * *

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WHERE SHALL WE DRAW THE LINE

by

C.J. Chaffins

Engineering Division - Boeing Airplane Company

Absorbing the new engineer into industry and assigning him work we must accomplish, with the assurance that it will be of interest to him, is a task of considerahle magnitude and complexity. Factors such as expansion, increased technical requirements, and a limited supply of engineers have all added to the complication of our position. In giving you my impression of the new engineer entering the aircraft industry and his reactions to the many things be encounters I shall mention some of the experiences we have had, some of the solutions we have devised, our future plans, and a few suggestions as to what might be done to alleviate some of the difficulties.

To indicate the size and scope of the Boeing Airplane Company I shall briefly mention a few pertinent facts.

Heavy aircraft has been our principal output; the B-17, the B-29, the Stratocruiser, the B-47, and the B-52 are the best known of our products since the beginning of World War II. In addition, we are manufacturing guided missiles, gas turbines, and analogue computers.

Included in our total payrool of 56,000 employees are 6,100 in our Engineering Division of which 3,900 are technical personnel.

Our Engineering Division is divided into three principal groups: Design, Research, and Administration.

Design Projects are responsible for the release of all information required by our Manufacturing Division to fabricate and assemble a completed airplane. Projects are split into several groups with each responsible for a structural component or function such as radio, electrical, wing structure, body structure, and equipment.

Research is responsible for detailed study of specific problems and development of new ideas. Some of the research units are: aerodynamics, armament, structures, power plant, mechanical equipment, and electrical.

Administration provides services to all units in the Division on such matters as personnel, education, costs and schedules, procedures and specifications, and working facilities.

All of these groups collectively and individually are involved in a coordinated effort to produce as an end result a high quality, high performance article.

Into such an organization we bring the new engineer. We find the problems management must meet in absorbing him are principally "human" problems, as contrasted with the problems of increasing technical "know bow". We have solved certain facets of the human problem, but we recognize that a great deal still remains to be done.

One portion of this basic problem which we are studying is tbat of instability. Large numbers of our new engineers in this day and age are "quick quitters". If these engineers would only remain with us long enough to learn to know their employer and their chosen industry before tbey start seeking what, from a distance, appears to be a greener field, we believe that they would make better individual progress and a greater collective contribution as engineers. Statistically, we know the man who stays at Boeing two years has only a fraction of the tendency to move as compared with the man who has been here only one year. We believe this fact results from the length of time it takes a new employee to "shake down" and become accustomed to an industrial atmosphere.

The organization of handling and scheduling work is a problem of considerable scope. Unfortunately, when our new employees first encounter this organization they feel lost in its vast size and discouraged by tbe cold, seemingly impersonal forces that regulate them. What management must find is a way to contact and indoctrinate these people with the realization that the employee has much to gain by proving that he is persistent. This is a problem which engages our imagination and attention to a great extent.

The missing link in the educational development of the young man may be the lack of attention paid to the development of his attitude. This is an abstract term, but I am thinking of his attitude toward his future, the analysis of his purpose, and the reasons for his going to the trouble of obtaining an education. What does he intend to do with his education, and with his life? There must be an objective!

The employer can provide encouragement, facilities, and opportunities, but the employer cannot inject into the individual the necessary desire, the energy, and the initiative to accomplish something with his technical training.

In the short four-year course which is customary in the preparation of the college man, I think in most cases the student's primary interest is in learning natural physical laws. He is learning how to handle them, and he is learning their applicability. He is storing them as tools for his future career, and he is usually intrigued by them to the exclusion of other factors which are going to have an equal if not greater influence on his future success. As he learns these natural laws and how to use them, he might well learn at the same time that industry as it is presently organized is the vehicle for their application.

The young graduate probably thinks of his employer as an aggregation of buildings, machines, and engineering facilities instead of an organization of people. He may be somewhat confused and frustrated on finding that his co-workers and supervisors are not as reliable as machines. He may then ask the questions, "Why don't these people behave like machines?" "Why don't they observe the same behavior towards natural laws as the machines which we use as tools?" Learning to work with people in the framework of an organization is probably the most important lesson a new employee must learn in his first year or two. If he keeps this objective in mind, then he might be more likely to stabilize. He might realize that he is growing in stature by proving he can work within a given set of human circumstances. In addition, a certain amount of prestige accrues to him by considerable period of association with a recognized company. We must somehow help the young graduate realize that two years with Allis Chalmers, General Electric, Westinghouse, Boeing, Douglas, or Lockheed is really a claim that he has developed his personality to an extent where it might prove more valuable to him than a Master's degree or a Ph. D.

Another factor the college student and potential employee should learn to recognize is the true nature of the tasks before him --- recognition of the real problem minus the many misleading side issues.

How can colleges improve a student's ability to recognize a problem and make him conscious of the fact that there is more than one solution? The analysis of problems is a factor in education to which I believe more attention should be given.

One of our engineers recently made an observation that may be of assistance in helping teach students to recognize problems. His suggestion is certainly pertinent. This employee observed tbat college professors were inclined to penalize students for collective efforts, sometimes known as "cribbing". However, he also observed that when the college graduate was employed in industry, he was penalized by industry for not participating effectively in a cooperative project.

Undoubtedly it is easier to measure the progress of a student by assigning problems which can be solved individually. Actually, we believe that what he needs most to acquire as preparation for productive employment is the ability to work in a group which is chiefly concerned with defining and recognizing a problem, and then achieving a solution through cooperative efforts. I feel sure many apparently brilliant students fail to make corresponding progress in industry because they were graded in school on their ability to work by themselves on problems not too difficult to recognize. A big difference between school and work is that schools are working on neatly defined problems and industry is working on vast projects.

Another trait an engineer should acquire in college is the ability to make decisions. He should realize that decisions are necessary and that every decision involves a gamble. If we at Boeing could enjoy the luxury of making decisions on sure things, our new airplane designs would be trouble free. However, when we roll a prototype out on the field to try it, we anticipate trouble, because in its design we have made decisions, many of which were merely intelligent gambles. In the aggregate, if you make a lot of intelligent decisions, some of them are going to be wrong, but most of them will be right, and you will make progress. If you make no decisions you make no progress!

Along with my emphasis on the human problems in technical employment, I would like to mention the need for continued broadening. We feel sure the young engineer who progresses is going to need an ability to express himself both orally and in writing. I want to go further than just advocating a course in technical English or public speaking. Our problem is much broader; it is intimately tied up with the problem of understanding and communicating with other human beings. The further one goes, the more one realizes that the humanities - literature, history, politics, religion, and art - are essential for a genuine ability to cooperate effectively with human beings. I know the four-year engineering program is all too short to hope men will be graduated who are truly developed in all of these respects. I do not think a student at the age of 21 is mature enough to gain much breadth in such subjects, even if he is kept for an extra year or two of schooling. Much of this maturing must wait for experience in working with people. About all the college should be expected to do is to awaken an interest in the humanities through an introduction to the field. In addition, you can help by letting the student know that his usefulness is related to more than an "A" in your technical course.

When the new engineer comes to Boeing, he is placed in a training program for a duration of two to four weeks depending on his assignment. This indoctrination period provides him with information about the Company, its many departments, and their functions. Its primary purpose is to help him get acquainted with us.

Although new graduates have a dislike for drafting, it is necessary that we all work with drawings, and for this reason, I shall mention something about our drawing system.

In aircraft the requirements for engineering drawings are extremely complex as compared with other industries. We have three basic types: the detail drawing showing one or more separate parts, the assembly drawing showing two or more parts fastened together plus the detail information for each part, and the installation drawing which may be a combination of all three types and, in addition, shows the unit installed in the airplane. Required detail information for each part as instruction to the shop and as a record for ourselves and the Air Force adds to this complexity. We must specify material and processing completely. Relatively few airplanes of any one model are identical, but a record of these differences still must be made.

One of the interesting facets of our operation at the Boeing Airplane Company, and, I might add, at practically any aircraft company, is the use of glass cloth. Glass cloth has been quite common in the industry for a period of four or five years and is the only dimensionally stable drawing material we have been able to find that is translucent, can be rolled for storage, and has other properties similar to cloth or vellum. Under our system, an original drawing of any part that is to be fabricated from sheet metal, extrusions, or materials which are to be cut, sawed, or routed is prepared on glass cloth. The glass cloth drawing is then placed in a contact camera, and as many duplicates as are required by the shop are furnished on photo-sensitized template stock of whatever gage is desired. Also, the Bruning light table, a large contact printer, provides great facility in the use of glass cloth inasmuch as the bed of the machine has sufficient surfact area to permit the photo reproduction of several drawings simultaneously. Completed templates, being the reproductions on metal of the original glass cloth drawing, are furnished to our shop where they may be sawed, cut and filed, or used as desired in making some sort of supplementary tool from which parts shall eventually be fabricated. One interesting fact I would like to point out is that in our production operations you will not find the mechanics making parts by using blueprints. Instead, they will have a holding or alignment fixture. This is done to simplify the job so that it requires less skill and training than otherwise might be necessary, thereby permitting us to use the available supply of labor for maximum efficiency. Substantiating evidence that glass cloth is in popular demand in our own Company is its rate of usage, which amounts to approximately 5,000 square feet per month and is gradually increasing.

Another interesting aspect of our operation, is the use of a painted metal template as an original drawing, which we have exploited as much as possible over the past 12 or 13 years. The metal template and the glass cloth end product are essentially the same; however, the metal template is necessarily reproduced by the use of an optical camera. After the glass negative has been prepared, the duplicate template is made by projecting the image on to a sensitized metal and, as with the glass cloth, the duplicate is furnished to the shop where it may be used to the best advantage. Of course, we use a great many machine drawings and we could spend considerable time discussing some of the intricacies of different types of dimensioning, cutting sections, and views. However, these are more or less common drafting practice and even though we have our own variation, I do not believe they are important to our discussion.

You undoubtedly know of lofting as a fascinating subject, a practice commonly used in both the aircraft and shipbuilding industries. It can be described as the development of surfaces such as the hull for a boat, the body or wing for an airplane, or perhaps the shape of an of an intricate duct used internally in a power-plant structure. There are two types of lofting. The first, which is the most common and the one that has been longest in use, is the cut-and-try method, whereby the trial and error shifting of lines in the three standard views .... a plan view, rear view, and side view .... will enable one to develop a smooth, faired surface. This type of lofting has been supplemented in the past few years by a second type which is called mathematical lofting. Mathematical lofting has its limitations and is primarily used in developing surfaces where we can use a second degree curve, which in effect is the use of a family of conic sections. In manufacturing airplanes, lofting is an operation absolutely vital to production. Contour lines of all types are drawn or transferred on metal templates, and the cut-out templates used in forming the plaster casts that will eventually serve as the original models for construction jigs and thousands of formed and contoured parts.

Until recently, practically all of the drafting work at Boeing was done by the new engineer. But now, because of the continuing critical engineer shortage and the increasing amount of technical man-power required to design an airplane, we have established a new program whereby we are implementing our engineer manpower with the use of draftsmen. We have proved to ourselves in the past fifteen months that it is possible to use people with less formal education in the preparation of the many drawings required for our shops to fabricate and assemble an airplane. In establishing this drafting program, we immediately discovered there was not an adequate supply of draftsmen available, and having discussed several methods by which we might obtain additional draftsmen, we came to the conclusion that it would be most expedient to conduct a training program ourselves due to the peculiar nature of our work in the preparation of aircraft drawings.

In selecting our candidates for drafting training, we are making every effort to choose those individuals who are not only best suited to drafting work, but who are most likely to remain with us as permanent employees. Careful interview screening and a battery of aptitude tests play an important role in selection procedures; the evidence of our statistical studies shows these methods have contributed materially to the success of our program. The cold hard fact of this situation is that, at the moment, we accept only 40 people out of each 100 who come to us showing an interest in drafting training. You might say that, in effect, we have taken people "off the street" for this purpose inasmuch as they come from all walks of life. The only basic requirements which have been established are that candidates must be high school graduates and must be between the ages of 21 and 50. However, other factors such as place of residence, number of dependents, and proximity to work receive consideration. We give the draftsman candidate a comprehensive course in drafting and descriptive geometry lasting for a period of five forty-hour weeks. As a supplement to this, we also assign him to a three-weeks course in familiarization, which is designed to acquaint him with the different types of drawings and drawing change procedures and the use of drawings in the Boeing Airplane Company, particularly in the factory.

One significant fact is, that in the period of fifteen months we have, on many of our projects, increased the number of draftsmen to the point where they constitute 35% of our project personnel. In all we now have over 600 assigned draftsmen. This, of course, is a substantial beginning; and we have hopes, as these men gain working experience, that we will be able to use more and more draftsmen, even up to as much as 50% of our project personnel.

You can readily see that with the use of glass cloth, metal, and of course, dimensioned drawings -- particularly the first two -- that it is essential the draftsman have a broad general knowledge of shop tools and procedure. In order to provide this knowledge, we are now offering a supplementary series of lectures to acquaint him with the many different types of tools we use in our fabrication areas, such as brake, hydro-press, shears, routers, and Yoder rolls. In addition to an expanded knowledge of tools and a thorough indoctrination in the utilization of the drawing by the shops, we are also offering the draftsman supplementary information about some of the techniques used in purchasing, production, tool design, and tool fabrication.

As the draftsman works with us, he continues to learn. I am sure you can readily see that, over a period of three or four years, he is going to become a very valuable asset to our Company and to the Engineering Division in particular.

Because of the skill and ability that must be developed, and because of the great amount of detail that must be absorbed in order to become a competent draftsman, I think you will agree that it would be completely out of the question for the universities and colleges to attempt to include such an extensive training program in their curricula for engineers. In the first place, the engineering curricula is already so heavily burdened with technical subjects that there is not sufficient time; and secondly, to provide training in several industries which will give the student a well-rounded background, regardless of where he may practice his profession, would be an insurmountable task. In any event, it is quite possible through the drafting training medium to relieve the engineer of the burden of making detail drawings and to use him to the best of his ability in learning the technique of design.

It is our hope that as we pursue this program the engineer will be more content because he is not required to prepare drawings, and the draftsman will become a skilled craftsman and will make better drawings than were made previously.

This transition in the use of engineering manpower is still in progress and, although we are making great steps toward solving our problem of having an adequate supply of people to make detail drawings, we nevertheless have the problem of providing the engineer with an ample background for undertaking design assignments.

As a supplement to his initial three weeks of familiarization, we will, in addition, offer him a series of lectures which will be of two types. First, there will be the lectures of general interest, encompassing activities of considerable scope within the Company. For example, we might have a qualified high-level speaker from the Production Department talk to a group of our engineers to tell them of the method of operation of the Production Department and its function as related to other departments, particularly Engineering. Second, there will be specialized lectures directing his attention toward subjects such as the use of fasteners, spot welding, brazing, riveting, and machining. We will also include finishes, processes, and topics of general interest which will not only acquaint the engineer with the method of operation in our various shops and divisions, but also will place him in a better position to design for maximum efficiency and producibility in our shops.

I have hoped in my brief picture of engineering manpower in an industrial setting to bring out a few of the practical problems confronting us, and to describe some of the working solutions we have devised for those problems. However, the solutions to a great many problems, as I have suggested, lie beyond the power of industrial resources and organization. These are the problems of equipping an engineer with effective, useful knowledge and abilities, as well as answering the "human problems" that I have mentioned. It may seem that I am placing too great a share of the burden on the educator's shoulders, but it does appear true, nonetheless, that the problems we encounter are, in a broad sense, those of education.

In order to reach the solutions that we vitally need, we must first attain a full understanding of what we actually mean in referring to our "problems". With that accomplished, and with an understanding of our respective responsibilities, we may, in either sense, be better prepared to draw the line. In order to clarify my picture of industry let me continue with some ideas on "fundamentals", and specifically with some views on the fundamentals of graphic representation.

In measuring technical competence, we must recognize that each school has planned a program; this program includes some balance between emphasis on fundamentals and emphasis on specialties. To illustrate what I mean by fundamentals, consider the field of mechanics. Here, the fundamentals include the analysis of stress in terms of tension, compression and shear, the measurement and calculation of stress, the distribution or flow of stress through various materials and shapes, the study of elasticity, and vibrations. My idea is that a man who is well grounded in fundamentals such as these can successfully enter employment and undertake the design of items as varied as tunnels, bridges, aircraft, or locomotives. He has mastered general principles which may quickly be applied to a variety of specialties. If, on the other hand, he has specialized in reinforced concrete at a sacrifice to an understanding of fundamentals, he will have quite a conversion problem in the event he wants to shift from the design of concrete structures to the design of aircraft.

This comparison between specialization and fundamentals may also be illustrated in the field of graphic representation. We in the aircraft industry certainly value the ability to do drafting work. However, we realize it would be inefficient to try to teach your students to be prepared to do drafting work for Boeing. If they were taught to be good draftsmen for us, they would not suit the Bureau of Reclamation, the U.S. Engineers, or North American, Douglas or any other aircraft manufacturer. We think that about all you can do is get the student well grounded in fundamentals. By fundamentals in this field I mean a thorough understanding of the means for graphic representation, orthographic projection, sections, auxiliary views, isometrics, and descriptive geometry. He might learn a little about dimensioning but most of this is better learned through his employer since systems vary to a great extent. As you know, we even get along without dimensions on most of our drawings. We do value ability to make rough, free-hand sketches; and it would be ideal if every engineering graduate were a neat careful draftsman, but I feel sure industry is more in need of fundamental understanding than of such specialized skills as these.

Specifically, the separation of descriptive geometry from drawing itself, the exclusion of lofting, the absence of a course in free-hand sketching, and over-specialization in drafting practices such as the preparation of ink drawings and the technique of drawing pictures of completed parts or assemblies are some of the items which might be modified or corrected. Along with these points for consideration, we might also include the use of elaborate sets of drafting instruments, many of which are superfluous, and some of which, by our standards, are inadequate in holding to close tolerances.

Perhaps I can elaborate on some of the points I have just mentioned. A survey of the many drafting techniques in use today, I'm sure, will bring about the realization that the demand for ink drawings is gradually diminishing. In any event, the preparation is a task for a draftsman, not an engineer. In the aircraft industry in particular, you will find that all drawings are prepared with pencil for ease of erasure and ease of maintenance, and that these drawings prove quite adequate for all purposes.

The technique of making a very complicated detail drawing of a generator, a carburetor, a distributor, or some other piece of mechanical equipment, which no doubt has been dissected to show a cross-section, is a time consuming operation, and it is questionable that the time thus expended is worth while. This sort of an approach is, for the most part, in complete conflict with an experience the engineer might have in the preparation of drawings, regardless of what industry the engineer may be engaged in. It is our common practice to design things before they are fabricated rather than after.

The use of lofting is quite common, as I mentioned before, in the aircraft industry and shipbuilding in particular, but it is also used in the automobile industry and other industries where it is necessary to describe surfaces in three dimensions. This technique which has been in use for a great many years has, strangely enough, been ignored by many of the colleges engaged in formal drafting training.

A practice that is quite common, and perhaps not too realistic, is the presentation of descriptive geometry as a subject separate from drafting. We have found in the training of draftsmen that descriptive geometry becomes much more coherent and understandable to the individual when it is presented in terms of practical application. For example, in illustrating the intersection of two lines in space, we have the draftsman run cables through a bulkhead rather than draw lines which have no direct relation to anything with which he is familiar and which are completely disassociated with the use to which he will put his knowledge at some future date.

The importance of free-hand sketching to an engineer, of course, is merely an illustration of the time-worn proverb that one picture is worth a thousand words. The ability to illustrate the essentials of an idea quickly and comprehensibly on a blackboard or on a pad of paper is important to the man who must rely on the understanding of others in his work, and the man who has this ability certainly has a valuable tool at his disposal.

As a possible solution for eliminating or at least modifying over-specialized and impractical material in some of these fields we have discussed, I might suggest a careful study be made of the possibility of injecting descriptive geometry and drafting into such courses as machine design, structural design, and shop practices. An examination of educational practices plus a comprehensive study of the demands of industry might suggest the appropriateness of a composite engineering drafting course which would point out some of the related general aspects of drafting, descriptive geometry, free-hand sketching, and lofting, and at the same time, eliminate much of the tedious detail that has been all too common in past practice.

In addition to continued concentration on fundamentals, let us also give adequate thought to ways of encouraging proper attitude and perseverence in the undergraduate, and furthermore, let us devote some effort to provide him with a better understanding of human relations.

Each day in this rapidly changing world we are confronted with new problems, new techniques, and new decisions to be made; consequently, it is essential that we constantly review our program, whether it be academic or industrial, and direct our efforts toward keeping step with the everyday changes and modifications. We must include for consideration not only the question, "Where shall we draw the line today?", but we must devote adequate thought to, "Where we draw the line tomorrow?"


I HOPE THAT THIS WILL ARRIVE SOON ENOUGH FOR ME TO RECEIVE THE NEXT ISSUE!
Prof. E. M. Griswold
Journal of Eng. Drawing
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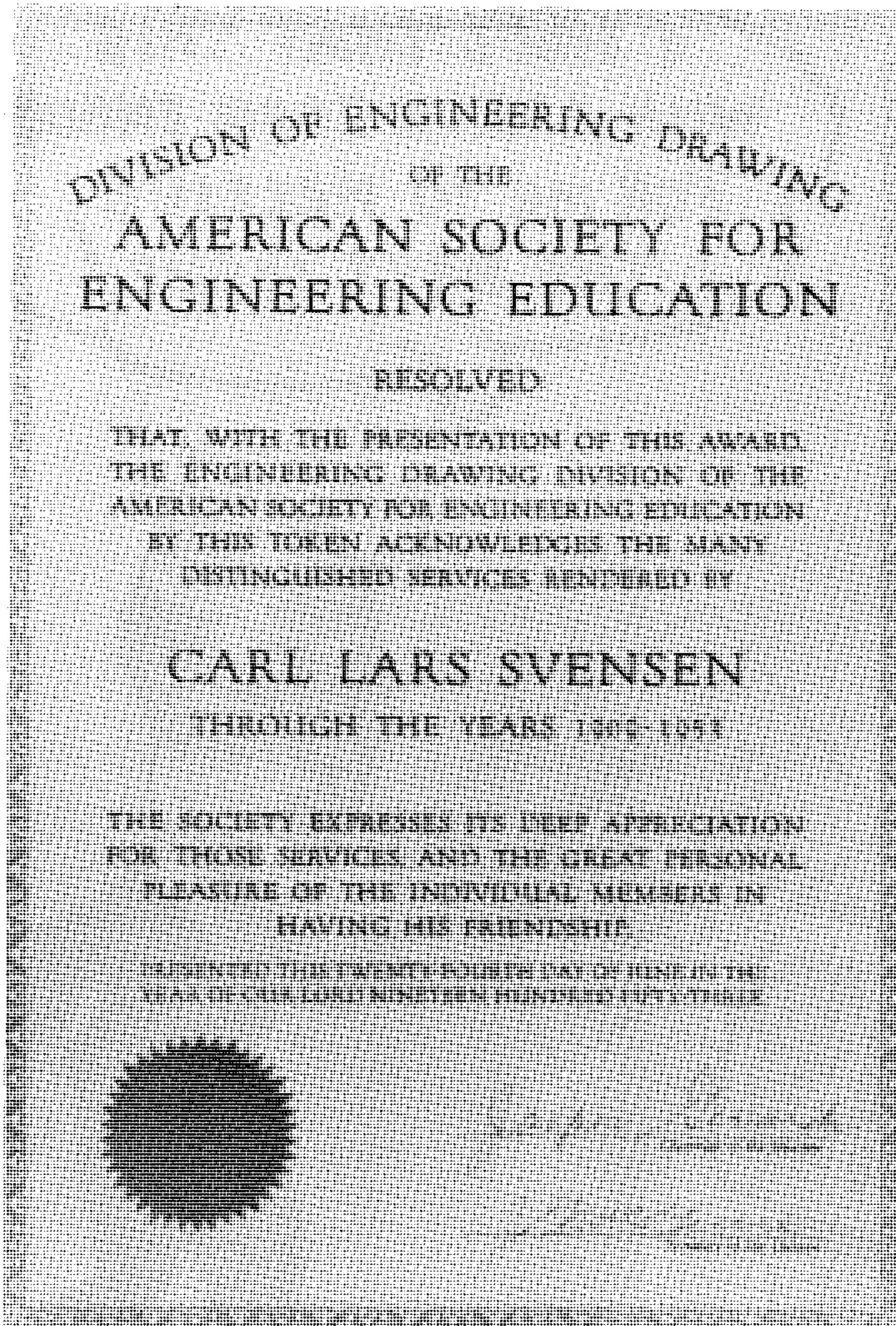

DIVISION OF ENGINEERING DRAWING
OF THE
AMERICAN SOCIETY FOR ENGINEERING EDUCATION

RESOLVED

THAT, WITH THE PRESENTATION OF THIS AWARD, THE ENGINEERING DRAWING DIVISION OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION BY THIS TOKEN ACKNOWLEDGES THE MANY DISTINGUISHED SERVICES RENDERED BY

CARL LARS SVENSEN

THROUGH THE YEARS

THE SOCIETY EXPRESSES ITS DEEP APPRECIATION FOR THOSE SERVICES AND THE GREAT PERSONAL PLEASURE OF THE INDIVIDUAL MEMBERS IN HAVING HIS FRIENDSHIP.

PRESENTED THIS TWENTY-FOURTH DAY OF JUNE IN THE YEAR OF OUR LORD NINETEEN HUNDRED FIFTY-THREE

RECIPIENTS OF ENGINEERING DRAWING AWARD

1950 - Frederic G. Higbee
1951 - Frederick E. Giesecke
1952 - George J. Hood
1953 - Carl L. Svensen

ENGINEERING DRAWING AWARD

1953

CARL LARS SVENSEN

The fourth recipient of the Engineering Drawing Award has achieved national recognition for his distinguished contributions as an inspiring and enthusiastic teacher and administrator; for his outstanding achievements as an author of numerous texts and publications; and for his recognition as one of the country's leading professional engineers and consultants.

Carl Lars Svensen, Secretary and Director of the Texas State Board of Registration for Professional Engineers, was born in Worcester, Massachusetts, April 8, 1884. He is a graduate of Tufts College in the class of 1907, where he received the degree B.S. in M.E. (honors) and the M.E. degree in 1921. He was awarded the honorary degree of LL.D. by St. Edwards University in 1942 and the degree D.Sc. in 1947 by Academie et Universite International, London, England.

Dr. Svensen's engineering experience includes work at Warren Steam Pump Company, American Steel & Wire Company, General Electric Company, and private practice. From 1908 to 1913, he taught in the Mechanical Engineering Department at Tufts and in 1914, he moved to Ohio State University where he became a Professor of Engineering Drawing, and served that department until 1923. He then moved to Lubbock, Texas, where he became head of the Engineering Drawing Department at Texas Technological College, and in 1933, he also served as Acting Registrar. In 1934, he entered the consulting field and was made Secretary and Director of the Texas State Board of Professional Engineers in 1937, which position he still holds.

Dr. Svensen is author of: A Handbook on Piping, Essentials of Drafting, Drafting for Engineers, Mechanical Drawing (with Thomas E. French), Machine Drawing, The Art of Lettering, Architectural Drafting (with Edgar Shelton), Drafting Problem Layouts (with C.H. Shuman, Jr., and W.E. Street), Aircraft Drafting, Blue-print Reading (with W.E. Street), besides many articles in educational and engineering journals and magazines.

Dr. Svensen has been very active in many professional societies such as the American Society of Mechanical Engineers, the American Society for Engineering Education since 1909, serving on the executive committee and later as chairman of the Engineering Drawing Division in the years 1939-1940, American Standards Association, National Society of Professional Engineers, The Texas Society of Architects, Texas Academy of Science, president of National Council of State Boards of Engineering Examiners 1943-1944 and the representative of this body on the Engineers' Council for Professional Development 1944-1947. He is also a member of the honorary scholastic societies of Tau Beta Pi and Sigma Xi.

As an author of graphical treatises, he has held an enviable record for the production of some of the outstanding books in engineering drawing. He has continued to revise and improve these books through the years from the time of their first publication. As an early pioneer in the Professional Engineering Societies and Boards of Registration, he has contributed immeasurably to the recognized status of all engineers. He maintains a wholesome respect of thousands of professional engineers and engineering drawing teachers throughout the United States.

THE GRAPHIC LANGUAGE AND THE PROFESSIONAL ENGINEER

Response by Carl L. Svensen Upon Receiving the Distinguished Service Award

Appreciation may be expressed in words to a certain degree, but it is truly felt in the heart. I wish that I knew how to present my feelings in our graphic language so that they could be seen.

This indeed is a climax, a triple honor for I have had two great honors in my life -- of working with the two great teachers of modern engineering drawing -- Dean Anthony of Tufts College and Professor French of Ohio State University -- of teaching with them and of associating with them in work on their great texts. It was my honor and pleasure to stand between them at the Drawing Summer School at Carnegie Institute of Technology, honor which I alone was privileged to have and a memory which has meant much to me through the years. I sat with Professor French at the first meeting of this drawing group as a separate organization of this society and at many meetings since that time.

Dean Anthony and Professor French had visions beyond their time of the importance of engineering drawing and its true meaning in professional engineering -- its meaning as a useful tool in engineering education and in the practice of engineering -- for learning, for thinking, and for doing. There was no lack of realization of the importance of the graphic language in these two leaders. Their broad concepts of the inclusive scope of engineering drawing needs to be re-emphasized today.

I have always insisted that there is a great difference between "learning to draw" and learning "drawing". As great a difference as there is between "learning to write" and "creative writing."

The first engineering registration Act was passed in 1907. Now every state and territory requires professional engineers to be licensed. Many states require an examination. Certain classes of applicants in Texas are required to pass such an examination. I have been in charge of examinations since our Board was organized in 1937. Naturally drawing has been one of the subjects covered in the Texas examinations. This is not true of all states. Over the years, I have been interested in observing and comparing the papers of the candidates. It is no coincidence that the best grades have been obtained by the men who have done well with the drawing part of the examination. The power to visualize cannot be discounted and is reflected in better work in all subjects. It is necessary to see clearly in order to think clearly. The professional engineer must do both. The truly professional engineer of today must be of a scientific mind -- he must be a scientific engineer -- to coin a new descriptive name, he must be a "scieneer." He must be truly educated in the English language, the mathematical language and the real graphic language in its true meaning and inclusiveness. Inspection of about 12,000 applications for professional engineering licenses has brought this forcibly to mind after seeing the education and the experience and the professional attainments of the applicants.

We hear of cutting down on the time allowed for teaching drawing; we hear of quick ways of giving instructions in drawing; we hear of short cuts and methods; we hear of the necessity for using pictorial drawings because so few can now read regular drawings; but why go on?

The answer is the same as for any other basic engineering subject --- a good foundation is necessary and should be recognized. Drawing is an engineering tool as well as a part of professional engineering.

We hear some say that all drawing should be from industry, should be practical applications, should be in each particular engineering field should bring in the various advanced uses of drawing, graphical and mathematical and the many possible and valuable applications. But you do not teach calculus or differential equations, or elliptic functions without a foundation of plain old algebra and trigonometry. Let's face it, we need to stress both ends of the subject. Basic knowledge is a necessity as well as a real understanding of how to use -- how to apply -- that knowledge. There must be ability to think in terms of shape, or size, of motion, of operations, of weight, of mathematical concepts in graphical form. There must be such an understanding of the basic principles of drawing that they can be used in the study and application of all engineering subjects and there must be time enough for the student to develop this ability. The professional engineer needs thorough proficiency in his three languages -- English, mathematics, and graphics. Graphics is more than the draftsman's drawing -- it is the engineer's language of space, motion, force and quantity. The professional engineer has developed from the mechanic to the scientist and his education must take this into account. Instead of trying to see how little time can be allowed there should be enough time to permit a thorough understanding so that it can be used to provide for a more thorough grasp of other engineering subjects with less effort and in less time for those other subjects. Someone should make a study of the place of drawing in professional engineering and present the whole picture from all its many points of view showing the coordination of each part of the picture. When this is done, I believe we will be on the way to the answer to the question of ample time for enginering drawing.

The Drawing Division has honored me in many ways -- on many committees, as Chairman, and now this honor which I shall cherish most highly. Through all my activities, drawing has remained a major interest and its meaning as a factor in professional engineering has developed in an ever widening inclusiveness.

Thank you for this graphic honor which you have bestowed upon me.

THE T-SQUARE PAGE

Devoted to the Interests
of Engineering Drawing

John M. Russ, *Editor*
State University of Iowa

Reliability vs. Validity of Examinations

By IRWIN WLADAVER
Assistant Professor of Engineering Drawing, New York University

Reliability and validity are the most misunderstood—or the least understood—concepts in the construction and evaluation of objectively-scored examinations. Sometimes the terms are used interchangeably by professional writers and teachers who ought to know better. But here is one case in which precision does not permit interchangeability.

It is not necessarily true, however, that reliability and validity are mutually exclusive. In fact, proof of reliability can be used to support a claim for validity. But while reliability can be *proved,* validity cannot. This statement cannot be successfully disputed, for reliability is by definition a function of statistics whereas validity is a function of human judgment, fallible as we know it to be.

The reliability of a test is a measure of its consistency. For example, if a "reliable" test were given twice to the same students—or if a retest were made with an alternate, equivalent form of the original test—the scores would be practically identical on both occasions. But we know perfectly well that we often find it impossible or undesirable to give the same test twice to the same students (except in the cases of some unhappy individuals who must take the course twice). And so three or four fairly easy statistical techniques have been devised to give "estimates" of the reliability of test scores. Proof of reliability is considered to have been obtained if the statistical manipulation gives a sufficiently high coefficient.

But the reliability of a test does not take into consideration the content of the test; all it indicates is the degree of consistency of the scores obtained. Suppose, for example, we have a group of students who know only English (if that) and we have to test them in descriptive geometry. We given them the following five questions:

1. What is your name?
2. Come si chiama?
3. Comment vous appelez-vous?
4. Vie ruhft mahn dich?
5. Kak teebyeh zahvouch?

Practically every student can answer the first question correctly and will. Unless he guesses that we have tried the same question in Italian, French, Yiddish, and Russian, he will always answer the one question correctly and always fail on the others. The test is *perfectly* reliable, that is, consistent. But we are all willing to grant that it is not a particularly good test in descriptive geometry. To say it another way, the test is completely reliable; we can get statistical proof. But the test has no validity for descriptive geometry; our judgment tells us so.

case of non-adiabatic, non-isothermal operation provides a vehicle for illustrating all the fundamental principles. Mass balances are necessary in treating the stoichiometry of the reaction or reactions. Energy balances serve to relate the temperature to position in the reactor (and the pressure also, if the pressure drop through the reactor is significant). Equilibrium relationships will be required if the chemical reactions are reversible. Three forms of rate expressions are needed for the solution: rate of chemical reaction, rate of heat transfer radially, and rate of mass transfer radially in the reactor. Finally, the optimum design solution will depend upon the cost of raw materials, cost of equipment, and operating expense, and, therefore, requires an economic balance.

Plant Design Course as an Integrating Tool

In some respects the usual plant design course in the senior year serves to correlate the separate subjects in the chemical engineering curriculum. Perhaps the most common procedure is to assign the student section a complete design for one or two different plants. This approach can be of considerable value in accomplishing the objective proposed here, provided emphasis is given to bringing together the principles studied in separate, previous courses. For example, division of the class into small groups each of which is given one phase of the plant design would not be expected to accomplish the desired result. Despite the usefulness of the design course, it is believed that the opportunities for integrating the principles of chemical engineering that exist in the other courses should not be neglected. Thus in thermodynamics 20–30 problems may be assigned each semester. If half of these involve the simultaneous application of two or more of the basic principles, considerable progress has been made in developing in the student the habit of attacking problems from the viewpoint of the fundamentals.

Conclusion

One of the important advantages of the fundamental approach is the confidence it gives the student in his ability as an engineer. He enters upon his career in industry not with the fear of insufficient factual information to attack the new problems encountered, but with the confidence based upon successful experience in solving a wide variety of problems in the university by integrating the basic principles.

REFERENCE

1. Kirkbride, C. G., "Chemical Engineering Fundamentals," Chapter 1, McGraw-Hill Book Co., Inc., New York, 1947.

The validity of a test is the degree of fidelity with which the test measures whatever it purports to measure. And this is a matter that is not at all completely amenable to statistical analysis.

It is true that some statistical evidence is desirable. For example, if a test has high reliability, we have some evidence in support of its possible validity. At least we can know that the test will report consistent scores. If the test is inconsistent in reporting scores, to that extent validity is impaired. But statistical analysis of a whole test and each item of the test can do no more than make some contribution to the validity of a test.

Points of View

In this brief article it is impossible to do much more than name some of the more important points of view from which validity can be investigated and claimed:

1. Statistical analysis.
2. The determination of validity through the use of certain groups, that is, through correlation with outside standards themselves known to be valid.
3. The extent to which the operations required of the student—by the test—appear to parallel the operations demanded by the course of study named in the title of the test.
4. The extent to which the subject matter content of the test is in agreement with the curriculum and good teaching practice.
5. The extent to which the test has been constructed according to sound practice.
6. The extent to which other teachers and experts agree to the soundness of the test.

Notice the part that human judgment plays throughout.

Reliability can be measured and a test can be said to be reliable to a specific degree, because the measurement has a mathematical basis. But validity of a test can never be 100 per cent established, since its basis rests on human judgment —even though it be relatively expert judgment, judgment like yours and mine.

Fifth College-Industry Conference Proceedings Available

Eleven papers from the 5th College-Industry Conference, sponsored by the Relations With Industry Division of ASEE at Northwestern University on January 31, 1953, are available in mimeographed form. These can be ordered from the Secretary, ASEE Office, Northwestern University, Evanston, Ill. The price is 50¢ per copy. Please enclose a remittance with your order.

TIMELY TIPS

Curves of Distortion

By ARTHUR M. HILL

Professor and Head of Mechanical Engineering, Tulane University

Volumes have been written on "good teaching techniques" and more will come in future years. But one academic practice which might be dusted off and reevaluated is that of "grading on a curve."

The teacher who is a "curve enthusiast" will probably fall into one or more of these classifications: (a) teachers who feel that a grade of A in a subject indicates a "crip" course; (b) teachers who are not able to adjust quizzes to the background of class work and student ability; (c) those who insist upon forcing each year's class into a set mold, convinced that each year there must be a fixed percentage making A, B, etc., regardless of the variation in student material; and (d) those who feel themselves in a position of power due to the awe and mystery with which they surround their grading system.

Part (b), "teachers who are not able to adjust quizzes to the background of class work and student ability," might be discussed further. Upon reflection, most any instructor should realize that the average student thinks of the dividing line between passing and failing as a grade of about 70%. It is a poor personnel relations job for an instructor to pride himself on a class average of 45%, and then prop up these grades to the passing level by curves. Why not give realistic quizzes which result in realistic grades in the first place?

Industrial firms spend many thousands of dollars in carefully defining the working conditions of their new employees. Why would it not be beneficial to start the first class meeting in a course with a concise discussion of the grading system? If the average of the quizzes in the course will count for two-fifths, why not tell the student so? Definite numerical brackets as to where grades of A, B, and C fall would be helpful. If *you* were the student, wouldn't *you* like to know?

In a short time, many of these students will be on training programs in large industrial plants. In most cases their achievements and progress are carefully recorded and graded. I have never known of a supervisor of these young engineers who had to resort to a curve to evaluate their performance.

Life is sufficiently complicated for students and faculty at best. Why not simplify things and discard the curves of distortion?

February 13, 1953

A Single Tube Square Wave Generator

By O. WILLIAM MUCKENHIRN

Associate Professor of Electrical Engineering, University of Minnesota

The ever increasing applications and associated analyses of square waves in electrical engineering has made it desirable if not necessary to introduce the student to this material in the early stages of his undergraduate curriculum. In the classroom this presents no problem but in the laboratory, experimentation by a large

VALIDITY OF EXAMINATIONS

by

Irwin Wladaver

College of Engineering
New York University

I'm going to talk with you about validity of examinations. My immediate purpose is to bring to your attention as clearly as I can the one central issue that in my opinion shows signs of serious neglect.

The issue, as I see it, is this: That validity of examinations is a social achievement and a social obligation. It is not a one-man job. And it is never possible to state that a test or examination (I use these words interchangeably) has 100 per cent validity. The best you can do is to strive to have your test achieve a high degree of validity and, consequently, to have it receive widespread acceptance as a valid instrument. The great problem, then, is (1) to realize that validity involves people and (2) that these people can all make contributions toward a degree of validity which, by its nature, is not susceptible to precise or even approximate measurement.

I don't want you to think I'm posing as an expert in psychological measurement. In fact I want to acknowledge my great obligation to four particularly useful sources. They appear in the partially annotated bibliography that I've appended to this paper and I hope you will consult them, and the other items, too, when you are ready to do some probing yourself. The four I'm referring to are these:

1. Validity, an unpublished paper by Dr. Louis E. Raths, of the New York University School of Education. This is a comprehensive treatment of validity, to which I am most deeply indebted. Besides, it's wonderful reading. I have been profoundly influenced by this work of Prof. Raths and I am grateful to him for his carte blanche permission to adapt his material.

2. Educational Measurement, (E.F. Lindquist, Ed.), a new and absolutely amazing symposium on every conceivable aspect of the subject, by the outstanding people in the United States. The American Council on Education Published the Book in 1951. Chapter 16, on Validity, is excellent and highly authoritative. Prof. E.E. Cureton of Tennessee and others contributed to the chapter. The rest of the book is equally high in quality and I earnestly recommend it to you for all aspects of educational measurements.

3. Proceedings of the Engineering Drawing Summer School (St. Louis, 1946). The whole section on examinations is particularly appropriate. The articles by Professors Vierck, Schuck, and Mann ought to be required reading and Professor Arnold's discussion that followed Dr. Mann's paper on Validity was very much to the point of today's topic.

4. Range of Human Capacities, by Dr. David Wechsler, is a most provocative book, and anyone who is not afraid of an intellecutal challenge to long-standing notions about human capacities ought to read it.

And so you see that the central issue I'm talking about is not a discovery of mine. Nor is it that writers and speakers have failed to mention it before the public. What usually happens, however, is that these persons point out the problem but rarely suggest a course of action that might conceivably lead to a minimum or tentative solution. I'm going to suggest some courses of action and see what happens - if anything.

My plan of approach is to delimit the problem, to state certain reasonable assumptions, to give acceptable definitions we can work with and some examples to show how the definitions work. Then we'll be able to attack the subject proper and - I hope - properly.

Here are the things I'm not going to do: I am not going to challenge the whole field of educational philosophy. I'm not going to take on the whole field of educational psychology. I'm not going to take an inexorable stand for or against "objective" examinations, although I do have some serious misgivings about how we arrive at grades for our students. Whether we use objective or non-objective methods of scoring tests or laboratory drawings, I have no intention of thrusting a lance into a windmill; I don't want to get knocked off my mule.

I'm going to assume that it's right to give examinations and to assign grades to our students. We don't have much choice, anyway, do we? Then let's make the process as useful and as meaningful as we can.

I'm going to make this important assumption: That educational measurement in engineering drawing and descriptive geometry has the following major functions, among others:

1. To facilitate learning on the part of our students.

2. To evaluate their work and progress toward the course objectives.

3. To aid in the improvement of instructions or, what is the same thing, to increase our own professional stature.

4. To assist us in counseling our students.

and I might as well add that these are not automatic.

I'm going to assume that, since we are experts in engineering drawing and descriptive geometry, and since we are professional teachers, it ought to be our job to make up examinations designed to serve any specific purpose we think is right; and that it's also our job to investigate the relative validity of these exams.

The important words to define and differentiate are reliability and validity, as characteristics of examinations. First, reliability: it's easy to explain and easy to illustrate. Reliability is consistency. A test is reliable to the extent that the score will be the same when it is used as a retest - or when alternate forms of the same test are used. It is a matter of statistics only. If I score 60 on a test today and 60 on the same test tomorrow, then the test is 100 per cent reliable. It doesn't make the slightest difference what the test is on. The content is immaterial.

I'll give two more examples: If your watch keeps perfect time, but you happen to have set it fifteen minutes slow, your watch is perfectly reliable. Statistically, the reliability coefficient is unity. You may miss your class every day, but your watch is reliable in the sense we're talking about. Maybe you will have no job, but you have a reliable watch.

And if I tell you, day after day, that I caught a fish that long, the story is absolutely reliable as long as the fish neither stretches nor shrinks. Maybe I'm a liar, but I'm a reliable liar. You can depend on me to report the same lie.

Thus it is that reliability is a matter of statistics. A test may have a very high reliability coefficient and all that it means is that you are measuring consistently whatever it is that you are measuring. But high statistical reliability of an examination is no assurance that the exam has high, low, or any other degree of validity - or for that matter any validity at all.

The only connection between reliability and validity is this: If you can show by a number of non-statistical operations that the test has certain kinds of validity, then proof of reliability is an additional piece of evidence in your claim for greater validity.

Now what do we mean by the word validity? To ask the question is to imply that it has a single, unique meaning. Unfortunately, this is not the case. It's easy enough to give a commonly accepted definition such as: "Validity is the extent to which a test measures what it purports to measure," or such as "The essential question of test validity is how well a test does the job it is employed to do." Both of these general statements are fine and no one quarrels with them. But from the standpoint of what to do, they are silent. They are not specific. They have no real meaning because they are empty of operations. What we have to know about a test or examination is this: What must we do, what steps must we take to determine its relative validity? Can I do it myself?

No. You can't do it yourself. No single individual can. If you look closely at the definition, you will see that human judgment is called for at every turn. The definitions say "How well," or "To what extent." The person who asks the question cannot also answer. It is true that an individual can do certain things himself. He can make tests of reliability, can get professional advice and can make improvements in the test arrangements and thus contribute to validity, but he alone cannot be the last word. Only through a period of time and use, in your school and in mine, can any test in a broad field like drawing achieve validity. For this reason, as I said at the outset, the determination or validity is a social achievement.

Let's suppose we have before us a test that we want to validate. There are four things, at least, we ought to consider and agree on. Otherwise we are beaten before we take a step.

1. We must agree on a definition of what we are trying to measure by the test.

2. We must agree on the responses that we shall consider evidence of the presence or absence of what we are trying to measure.

3. We must agree on what constitutes relative amounts of what we are trying to measure and on the way to estimate the probable error of measurement.

4. We must agree on the probable significance of the results in the general educational and professional growth of our students.

You can argue about any of these four points - you probably do - but we must reach some workable and realistic compromise. It should be perfectly obvious then, that a test-maker must be competent, capable of distinguishing the critical, the important, the relevant and the trivial elements. He must have no pet peeves and no pet devices that he feels he must spring at every opportunity. And of course he must be informed. Without these qualities, his judgment, for any intellectual purpose, must be suspect.

I said earlier that validity does not have a single, unique meaning. You should infer from this that the different concepts of validity depend upon the points of view from which you attempt to reach it. I'm going to cite eleven different, but sometimes overlapping, points of view from which to judge the degree and the kinds of validity which your test may have. Then I'll try to explain what I mean by each of them.

1. The extent of agreement between the test results and some informed, component criterion outside of the test.

2. The determination of validity through the use of criterion groups.

3. The extent to which predictions made on the basis of test results come true.

4. The extent to which the operations required of the student - by the test - are in agreement with the title and the purpose of the test.

5. The extent to which the subject-matter content of a test is in agreement with the title and its implications.

6. The extent to which a test incorporates important items and excludes non-essentials, and how nearly the test parallels good teaching practice.

7. The extent to which a test contributes to the educational and professional growth of the student; that is, the extent to which a test reflects the career for which a student is presumably preparing, and the effectiveness of this kind of validity on counseling and advisement.

8. The extent to which parts of a test are themselves valid as part scores.

9. The extent to which the test correlates with other records - and the extent to which such correlation is of little use or even spurious.

10. The extent to which statistical analyses of the test and of individual items of the test contribute to validity.

11. The extent to which the actual construction of the test conforms to sound practice and so contributes this kind of validity.

1. The extent of agreement between the test-results and some informed competent criterion outside of the test.

By this I mean the judgment of competent persons who know the purpose of the examination. For example, ask a capable teacher to rank your students in order of merit with respect to the particular trait you are testing for. Naturally, this teacher should have opportunities to judge the students in action. Then give the exam and score it. If there is substantial agreement between the test results and this informed, competent criterion, then you have the right to say that the test has some degree of this kind of validity. Naturally, the teacher who has done the ranking ought to be competent and informed and ought to know what can be expected. Generally you will have such persons working with you.

Sometimes individual ranking isn't possible, for one reason or another. In such a case, have the students divided into a number of groups, say five: Excellent, Good, Average, Below Average and Poor. And then give the test. Divide the test-scores the same way and see whether your "Excellent" students make "Excellent" grades, and so on down the line. If your "Excellent" students make "Average" scores, you may want to take some steps. If your "Excellent" students make "Poor" scores, you draw your own conclusions, but be charitable toward yourself. Perhaps you may come to believe that the other fellow's judgment was not good and that the test actually had high validity from the standpoint of teacher-opinion. That's up to you. But you can see why it's important to select a competent and informed criterion that you can stick with.

2. The determination of validity by use of criterion groups.

By a criterion group I mean a group of persons actually working in the field for which our students are preparing. If you say you are training for draftsmanship, select draftsmen for your criterion group. If you say you want to teach your students what a good engineer ought to learn from your drawing and descriptive geometry courses, then select engineers, preferably not your former students. The group you select should depend on the goals and objectives you say you have been trying to reach. Presumably the persons you select for your criterion group will be homogeneous; with respect to what you want to know, their behavior will be similar.

What you want to know is this. How did your school work in drawing help you in your present work? Was the information useful? Were the experiences useful? Have you any suggestions? What are your attitudes? What mistakes did we make? These are just a few off-the-cuff samples of questions you might ask.

To the extent that there is correspondence between your test-results and important factors related by your criterion group, this kind of validity may be present.

I must point out some dangers in this procedure. Oftentimes young graduates, especially your own former students, will tell you what they think you want to hear; especially what a terrific job you did on them. Believe it, if you must. But it doesn't give you much precise help.

Sometimes it does. A few weeks ago, my daughter said to me, "Dad, what's a left-hand screw-thread?" Naturally, I started to explain. But she added, "I really don't care. All I wanted to say was that I met a boy" (of course I was glad to hear this) "A boy who had you in drawing six years ago. The only thing he remembers about your course is that you used to drive a taxicab nights when you went to college and that one of the wheels of the Yellow Cab Company cars had a thread that went the wrong way and you didn't find out for an hour after you got a flat tire." This he remembered.

So I say this kind of information may be useful in your quest for validity of examinations and it may not.

3. The extent to which predictions made on the basis of test-results come true.

If high grades in a drawing test were fairly sure indications that a student would be a successful engineer or draftsman, you could say the test had high validity of this kind. That is, you could make predictions that would be verified in action. Isn't this what intelligence tests and aptitude tests mean to do? If they fail to predict fairly accurately, they lack this important aspect of validity.

This ought to be a good topic to investigate if you have a comprehensive test in drawing or descrip. See how closely your test-results correlate with the graduating averages of your students. Maybe there is some predictive validity present. And if there is, be sure you don't claim a cause and effect connection.

4. The extent to which operations required of the student - by the test - are in agreement with the title and the purpose of the test.

To me, this seems like the most important step of all in the search for evidence of test validity. Suppose you were giving a test in a student's understanding of the principles of sectional views. If you wanted to know whether he could identify a properly drawn sectional view, given two exterior views, this would be one kind of operation at an easy identification level. (I recommend Prof. Graney's illustration along these lines on page 343 of the 1946 summer school proceedings.) How much validity an identification test has for what you are after is certainly open to question, but it surely has some.

If, however, your test requires that a student draw an indicated Section A-A, your test is likely to have more validity for an understanding of the principles of sectioning. And if you go all the way and say, "Draw the most useful section of the object," then you are really in for it. You have to presuppose all sorts of things and hope that the student's judgment coincides with yours.

The point I'm trying to make is this: If you say the test is a test of a student's ability to think, you ought to be able to show that it does indeed measure that ability. This will take some doing.

If you dare to say that the examination is a test of a student's ability to think creatively, I urge you to define your terms with scrupulous care and then show evidence that the test does indeed measure that ability. But I don't wish to encroach upon Professor McNeary's topic - he certainly needs no help from me.

This is a good time to remind you that students in some subjects forget from 40 to 80 per cent of the facts they once learned within three months to three years. If your test is designed to ask for facts only - and it's a perfectly justifiable kind of test - you should realize that what a student learns is not so important as how he learns it. I think Professor John Rule's article in the May, 1953, Journal of Engineering Drawing carried this same implication.

To the extent that the mental operations of learning are called for on an examination, a claim for test validity can be reasonably supported.

5 and 6. The subject-matter content of a test can readily be checked against tables of contents of good textbooks; and comprehensive sampling of the field. If that's what you want, it's not hard to demonstrate. Also, if you consult with a few of your colleagues it will not take long to eliminate most of the trivia. But don't think that therefore your test is necessarily valid. All you have done is added a little weight to the balance. And you should be careful not to introduce into an exam unusual or new elements that you have not dealt with in class unless, of course, you think they are reasonable outcomes.

7. Tests in our field of engineering drawing and descriptive geometry can contribute solidly to the professional and educational growth of our students by reflecting the career for which they are preparing. It may be clear to you what an important influence on our counseling duties a good test can have. It should warn us not to try to play the part of an all-wise diety, lacking omniscience as we do, but in some fields tests have reached the quality that permits advisors to make recommendations that otherwise could not be justified.

Whether our examinations are yet good enough is something else, but this is a kind of validity we should certainly strive for.

8. When parts of a test are valid as part scores, there are obvious advantages to the student who wants to know what partial progress he has made and also to the teacher who can be reasonably sure where deficiencies in learning and teaching exist. This is another kind of validity in the overall worthwhileness of a test.

9. Correlations are often reported as evidence of test validity. I'll go along with some. For example, if a test has a high reliability coefficient, there is no automatic assurance that the test is valid, but only that it has the kind of validity that self-consistency offers. However, if a test has a low reliability coefficient, then the test validity for any purpose must be seriously in doubt.

But there are other corrections that serve little use. Don't condemn a test simply because it doesn't correlate well with other records - high school records, for example. And more than anything else about correlations: don't attribute high validity to a test on the basis of its high correlation with another test assumed to be valid. As I see it, this begs the whole question of validity. An assumption of validity may be necessary - we do it all the time. But trying to prove validity by correlation with something assumed to be valid hardly seems the way to go about it. This is an understatement.

10. I shall probably lose some friends when I say I'm quite uncomfortable about the next matter. This has to do with test-validity contributed by statistical analyses of the test and of items in the test.

I guess I don't actually understand some of the statistical manipulation. Most of the formulas, unless I'm mistaken, make an important assumption: That the trait being tested is normally distributed. I have seen no evidence that this is true in drawing. And there are other assumptions, generally not expressed, that seem to me to have shaky foundations. In addition, most of them involve nasty and forbidding algebra.

For these reasons I question the usefulness of some of the statistical analyses in the claim for validity. If you are interested in statistics, read Professor Cureton's article called, "Validity, Reliability and Baloney." You'll find it listed in my bibliography.

11. The last item has to do with the validity contributed to a test where a test is made up in conformance with sound and informed construction practice. This is a matter about which any interested person can be well posted if he takes the effort. In the bibliography I cite a small number of articles you may wish to read. They are on such subjects as: scoring examinations; problems in the use of answer blanks; examination fear; comparisons of true-false, multiple choice, completion-questions; and other related topics. And all of these have to do with validity to a greater or lesser degree.

Well, these are most of the operations reported in the literature on validity. There are only these last two brief but tremendously important points I feel I must make.

First, we must be constantly aware of the educational purpose of every test we give. The best way to stay alert to this is to state its purpose so that we can try to evaluate its influence on validity. Examinations to determine grades are certainly necessary, but a far greater purpose - perhaps the ultimate purpose - is the development in our students of resourcefulness and ingenuity.

Second, we are not hermits. Our students are working at their careers all over the country and all over the world. We are not even preparing all of them to practice engineering. We must test for knowledge, of course. But we should be testing for the kind of knowledge that leads to informed, socially desirable action. One way we can come close to this objective is to work out our testing problems together - actually to send copies of our examinations to colleagues in other schools, to use the exams in our classes, to criticize unstintingly and suggest improvements - and to accept such recommendations in a grateful spirit.

Wouldn't it be wonderful if we could say something like this: "Yes, we've trained these young people pretty well so that they can get off to a good start in the engineering profession. But more than that, we've helped them along to an education that will help them to live useful, productive, fruitful lives in any activity they ever choose." If our examinations have the kind of validity that will let us believe that this is really true, then we can indeed be proud of the work we are trying so hard to do.

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GRAPHICAL METHODS CONFERENCE

Methods of applying graphics to engineering problems in order to save time and present data more effectively will be outlined in a conference at Purdue University on November 20. This is one of the first conferences of its kind ever held.

Engineering executives of representative Indiana industries are cooperating with university staff members in planning an informative program designed to acquaint chief engineers, directors of research, and others of comparable executive level with the scope of graphical methods. It is hoped to show how these methods can contribute to the increased efficiency and effectiveness of designers and draftsmen.

"As a means of counteracting high production costs and manpower shortages in industry today, graphical methods often save man-hours of work in arriving at an answer to a problem, and usually give a clearer and more meaningful picture of the information being presented or studied," according to Prof. J. Howard Porsch, chairman of the engineering drawing section of the department of General Engineering at Purdue, who has heen named as conference chairman.

The one-day program will include an introduction to graphics, and discussions of delineation, analogous representation, problem solutions, mechanical devices, and reproduction processes. Each of the talks will be followed by a discussion period. An exhibit of graphical techniques is planned also.

The conference will show the application of graphical methods to engineering design and manufacturing. This first meeting is designed primarily for management-level engineering personnel.

MINUTES OF THE ORGANIZATION MEETING

DRAWING DIVISION-SOUTHEASTERN SECTION-A.S.E.E.
Baton Rouge, Louisiana, February 27, 1953

The meeting was held in Pleasant Hall on the campus of Louisiana State University on Friday, February 27, 1953, at 2:30 P.M. Thirteen members, representing seven colleges, were present. Professor J. E. Shigley of Clemson presided.

Upon motion, duly seconded and unanimously passed, the meeting adopted a resolution establishing a Drawing Division of the Southeastern Section of the American Society for Engineering Education, to be governed in accordance with the Articles of Procedure of the Drawing Division of the society. It was decided tbat meetings of the Division would be held in conjunction with the annual meetings of the Southeastern Section and that the program and objectives would be developed by the officers of the Division following the wishes of the membership.

The following were elected as officers of the Division for the coming year:

Chairman. . . . . .J. E. Shigley,
Clemson Agricultural College
Vice Chairman . . . . . . .W. D. Buchanan,
University of Tennessee
Secretary . . . . .A. B. Wood,
University of Tennessee

A. B. Wood, Secretary

Dr. William Ezra Street

PERSONALITY SKETCH
DR. WILLIAM EZRA STREET

by

Carl L. Svensen

Bill "Energy" Street is well known in Engineering Drawing circles for his interest and activities. What is not so well known is the background of education and experience, which with a friendly personality has made him a leader in his chosen field. Dr. Street's life has been one of continuous study and development in engineering education. He was born in Benfranklin, Texas, April 12, 1901. His education has included studies at North Texas State College, The University of Texas and Texas Technological College where he received the B.S. degree in Electrical Engineering in 1930 and the M.S. degree in Education and Psychology in 1933. The honorary degree of LL.D. was conferred on him in 1947 by Harding College.

Dr. Street's teaching career has been an all inclusive one. He has been a teacher, principal, and superintendent in public schools. While attending Texas Technological College, he was a student assistant. Later he joined the faculty of the college, first as an instructor and then as an associate professor. In 1941, after thirteen years, he left Texas Technological College to become professor and head of the Department of Engineering Drawing at the Agricultural and Mechanical College of Texas. This position he now holds, as well as being a member of the Graduate Faculty. He has been active on college committees and has carried out many important projects in addition to his teaching and departmental duties. During World War II, he organized and supervised one of the largest war training programs in the country, training more than 6000 people in extension work sponsored by the U.S. Department of Education and Texas A. and M. College.

Dr. Street is a registered professional engineer in the State of Texas and has had engineering experience in addition to his teaching experience. He has worked for such companies as the Sinclair Oil and Refining Company, Waco Construction Company, Austin Bridge Company, Lockheed Vega Aircraft Company, Consolidated-Vultee Aircraft Corporation, etc.,as well as private engineering practice.

Dr. Street's life has been a well balanced one for he has always found time to take part in the life and civic affairs of his community, ready to serve whenever called upon. An active Rotarian since 1937, he has an enviable record for both attendance and participation. He has been Chairman of important committees having to do with youth work, Boy Scouts, vocational service, etc. He has been a member of the Board of Directors and is a Past President of the Bryan Rotary Club. He has been an active worker in the Church of Christ as teacher, educational director, deacon and elder. His civic and religious life have paralleled his life work in engineering and education. During his college career,he participated in athletics and later served for five years as a faculty member of the Texas Technological College Athletic Council.

Dr. Street has found time (how or when is hard to tell) to add to the literature on engineering drawing. He is the author of a modern textbook, TECHNICAL DESCRIPTIVE GEOMETRY, published in 1948, and widely used. He has had three books of Descriptive Geometry Problems published, one in collaboration with Professor C.C. Perryman and two in collaboration with Professors C.C. Perryman and J.C. McGuire. He has collaborated with Carl L. Svensen on several books: a Manual of Blueprint Reading, Lettering Exercises, three series of Drafting Problem Layouts and with Carl L. Svensen and Professor C.H. Schumann on one book of Drafting Problem Layouts. He has also contributed numerous articles for technical journals. Dr. Street has received many honors both unofficial and official. His abilities have been recognized in many ways. He is a member of Tau Beta Pi and Phi Kappa Pi, is listed Who's Who in Engineering, Who's Who in the Southwest, Who's Who in American Education and the International Blue Book of World Notables. He is a member of many engineering societies including the American Society for Engineering Education, National Society of Professional Engineers, Texas Society of Professional Engineers, Texas Academy of Science, and others. In all of these, he has been an active participant in the work of the organization.

Dr. Street has been a constant and dependable worker in the American Society for Engineering Education and in particular in the Division of Engineering Drawing. He has been a regular attendant at both the annual and mid-winter meetings and has served as a member of the Executive Committee and committees on Descriptive Geometry Notation and Nomenclature, Standards for Pictorial Drawing,Graphic Talent Tests,Efficiency Tests in Engineering Drawing,etc., and Chairman of the Committee on Evaluation of Engineering Drawing Education. From 1941 to 1944, he was editor of the T-Square Page of the Journal of Engineering Drawing, and from 1944 to 1946, he was editor of the Journal of Engineering Drawing. In addition, he has taken part in the Division's programs and has been a valuable contributor to the advancement of engineering drawing as a part of engineering education. He was Chairman of the Mid-Winter program committee which held its meeting in College Station, Texas in 1951. Truly Dr. Street's life has been and now is a very busy one but he always finds time to take on new duties and to respond when called upon. What is more, he has the particular spirit and ability to initiate and to carry the job through with distinction. Loved by his host of friends and students, Dr. Street is one of those fortunate individuals who enjoys his friends, his work and his opportunities for service.

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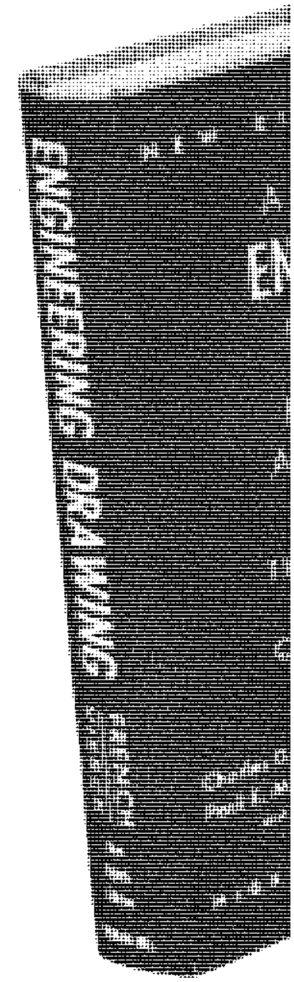

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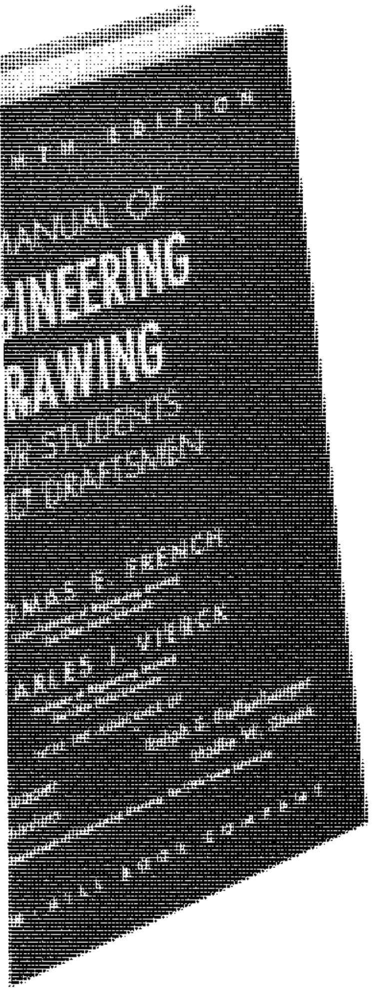

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NOMINATIONS FOR 1954 DISTINGUISHED SERVICE AWARD

The committee for this year's Engineering Drawing Division Distinguished Service Award consists of Jasper Gerardi, Clifford H. Springer, and Ralph S. Paffenbarger. This committee will meet at the time of the mid-winter meeting to make the selection from the nominations received. Will you kindly prepare your nomination, together with substantiating biographical data and mail this to Ralph S. Paffenbarger, 218 Brown Hall, Ohio State University, Columbus 10, Ohio. Nominations will be received until January 15, 1954. Refer to May, 1952, issue of the Engineering Drawing Journal for rules regarding this award. The committee is particularly anxious to have a heavy response to this notice.

TIME TO GO TO CLASS

A few days after the May issue of the Journal had been mailed to the printer, the editor was informed that Professor A. S. Levens of the University of California had expressed a willingness to give a two or three weeks course in Nomography, including Graphical Calculus, to members of the A.S.E.E. Drawing Division.

It is suggested that interested persons write to Professor Levens. His address is: Department of Engineering Design, University of California, Berkely 4, California.

Professor Levens is author of a leading text book on Nomography published by John Wiley & Sons, 1948.

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THE CIRCLE IN THE OBLIQUE POSITION

by
Paul T. Yarrington
The Ohio State University

The purpose of this article is to show a presentation, which from a teaching standpoint, creates more enthusiasm and incentive on the part of the students than a more conventional method. The increased interest of the student stems from the fact that he can use a previous concept of perpendicular line relationship. The following solution, though not original by the author, is offered as an item of interest for instructors of Descriptive Geometry.

Given the center of a circle, the diameter, and a line perpendicular to the plane of the circle, the problem may be solved by the descriptive geometric principal of a line perpendicular to a plane.

In Fig. 1, OP is a line perpendicular to the plane of a circle of known diameter; the center of this circle is at P.

Since at least one diameter will show in true length in any projection of a circle, CD shown in true length and representing a diameter of the known circle can be drawn perpendicular to OP in the top view and hence horizontal as shown in Fig. 2. In Fig. 3, EF, another diameter can be drawn perpendicular to OP in the front view and therefore is a frontal line.

The plane of the circle has now been established in the top and front views by the two intersecting lines CD and EF. CD is the major axis of the elliptical representation of the circle shown in the top view. Similarly, EF is the major axis of the elliptical representation of the circle shown in the front view. Points C,D,E, and F all lie on the circumference of the circle.

With the aid of a trammel, the plotting of the elliptical representations may be completed. In the top view of Fig. 4 "ax" on the trammel is laid off equal in length to CP, the semimajor axis of the ellipse. Point "x" is super-imposed over F, a known point on the circumference of the circle. Point "a" is placed on the line of the minor axis. The minor axis being perpendicular to CD appears to coincide with OP. The trammel intersects CD at point "b". The distance "bx" is equal in length to the semiminor axis of the elliptical representation of the circle; the construction of the trammel is now complete and the plotting of the ellipse can now be completed using the trammel in the conventional manner. The plotting of the elliptical representation in the front view is carried out in a similar manner, that is, by first constructing an appropriate trammel as shown in the front view of Fig. 4.

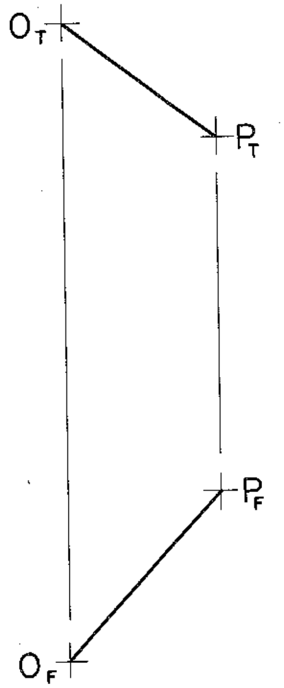


Fig. 1

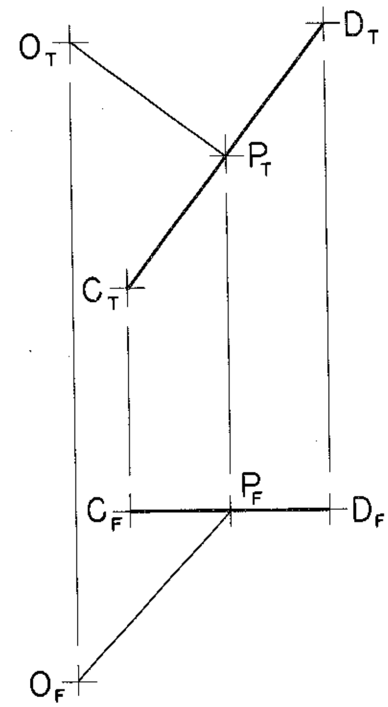


Fig. 2

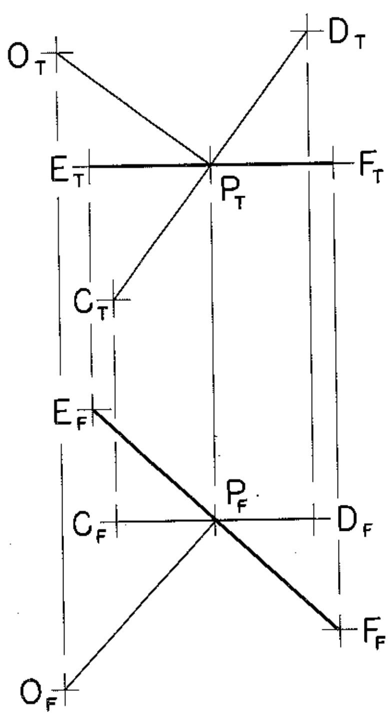


Fig. 3

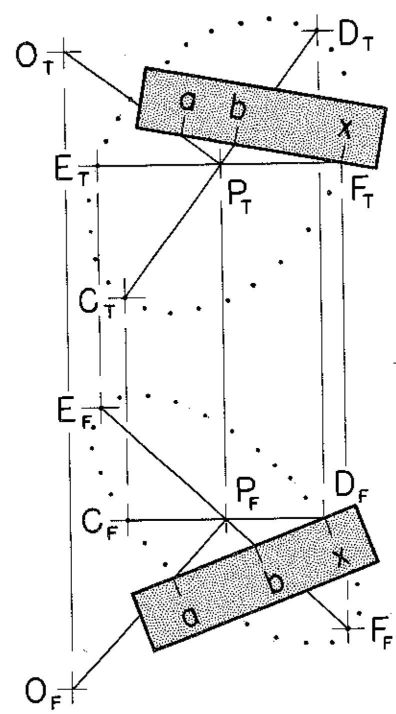


Fig. 4

A LETTER FROM THE DIVISION CHAIRMAN

Dear Colleagues:

I wish to take this opportunity to extend to you a cordial welcome to be present at the meetings of the Drawing Division during the coming year. With the present trend towards changes in the engineering curriculum, you cannot afford to miss the two meetings this year of the Division.

The program of the Midwinter Meeting as arranged by Professor Jorgensen in cooperation with your chairman, and being held at the University of Pennsylvania has been planned with the objective of the technical and cultural development of the engineering drawing faculty.

Also, do you realize that this is the twenty-fifth year that the Division has held independent meetings, and that we are one of the largest divisions of the A.S.E.E.

These thoughts are receiving serious consideration in the planning of the June meeting.

Your Executive Committee selected Philadelphia for its Midwinter Meeting because of its accessibility and the excellent facilities for technical and cultural trips.

After looking over the fine program, I am sure you will say with me — "I just can't afford to stay away."

I hope to see you in Philadelphia, so be sure to save the dates.

Sincerely yours,

Ralph T. Northrup, Chairman
Drawing Division, A.S.E.E.

PROGRAM
MIDWINTER MEETING

ENGINEERING DRAWING DIVISION OF THE A.S.E.E.
University of Pennsylvania, Philadelphia, Pennsylvania
January 28, 29, and 30, 1954

Program

Thursday, January 28:

6:00-8:00 p.m. Executive Committee Dinner and Business Meeting--Penniman Room, second floor, Houston Hall.

Friday, January 29:

8:30-9:45 a.m. Registration--Alcove, second floor, Houston Hall.

9:00-10:00 a.m. Coffee and Doughnuts (ladies invited)--Smith Room, second floor, Houston Hall.

10:00-12:00 noon General Session--Room 314 Engineering Building - Chairman: Professor John G. McGuire, Texas A & M College.
- Greetings: Dr. Charles W. MacGregor, Vice-President in charge of Engineering and Science, University of Pennsylvania.
- Response: (For the Division) Professor Ralph T. Northrup, Wayne University, Chairman of the Division.
- Technical Papers:
  - (a) "The Design of Inflatable Boats," Professor Mary Blade, Cooper Union, and Dr. Ellis Blade, Consulting Engineer, New York.
  - (b) "Drafting Problems in Industry and Some Solutions," R.W. Pearson, Manager Operations Programming Section, Engineering Products Department, Victor Division, R.C.A.
- Discussions:

12:15-1:15 p.m. Luncheon and Business Meeting--Smith Room, second floor, Houston Hall.
- Presiding: Professor Ralph T. Northrup, Chairman Drawing Division A.S.E.E.

1:30 p.m. Board Buses for Industrial Inspection Trip.

4-45 p.m. Board Buses for Return Trip to Philadelphia.

6:00-7:15 p.m. Annual Dinner (Ladies Invited)--Smith Room, second Floor, Houston Hall.

7:30-9:00 p.m. General Session--Room 314 Engineering Building - Chairman: Professor Albert Jorgensen, University of Pennsylvania.
- Technical Papers:
  - (a) "Specialized Drawing Courses Above the Freshman Level," Professor Randolph P. Hoelscher, General Engineering Drawing, University of Illinois.
  - (b) "Drafting Problems in the Bearing Industry," Sven Neilsen, Assistant Chief Engineer, S.K.F. Industries, Philadelphia, Pennsylvania.
- Discussion:

Saturday, January 30:

9:00-11:30 a.m. General Session--Room 314 Engineering Building - Chairman: Professor Theodore T. Aakhus, Vice-Chairman, Drawing Division A.S.E.E., University of Nebraska.
- Technical papers:
  - (a) "Graphics for Non-Engineers," Professor R. W. Parkinson, Ohio State University.
  - (b) "Vanishing Points and Shadows in Three-Point Perspective," Professor Wayne Shick, University of Illinois.
  - (c) "Three Dimensional Nomograms," Professor Douglas P. Adams, Massachusetts Institute of Technology.
- Discussion:

11:45 a.m.-1:00 p.m. Luncheon (Ladies Invited)--Smith Room, second floor, Houston Hall.

1:15 p.m. Board Buses at Houston Hall for Trip to Franklin Institute (Ladies Invited).

3:15 p.m. Board Buses at Franklin Institute for Trip to Independence Hall (Ladies Invited).

5:00 p.m. Board Buses at Independence Hall for Return Trip to Hotel Area.

Ladies Program

Friday, January 29:

8:30-10:00 a.m. Registration--Coffee and doughnuts (see men's program).

10:00 a.m.-5:00 p.m. Shopping--lunch and fashion show at Hotel Barclay--visit to Curtis Publishing Company.

6:00-7:15 p.m. Annual Dinner (See men's program).

Evening: Open

Saturday, January 30:

10:00-11:30 a.m. Visit to University Museum.

11:45-1:00 p.m. Luncheon (See men's program).

1:15-5:00 p.m. Trip to Franklin Institute and Independence Hall (See men's program).

FORMING TOOL CALCULATIONS — GRAPHIC AND ALGEBRAIC

by
Professor J. H. Porsch
Purdue University

(Continued from the May issue)

METHODS FOR CALCULATING

With the cutting edges analyzed let us now turn our attention to the methods for obtaining the dimensions necessary for making "forming tools". Mention was made previously to articles on the mathematical approaches. Many are formulated for specific positions of tool and product, and hence are limited in usage. Similarly, tables and nomograms are available listing or providing means for determining conversion factors. These again are limited in usage. Still others proceed in a methodical manner to the solution of the more general problem.

In many instances the format of the tables or the lengthy equations are enough to baffle even an experienced engineer in attempting to use them. Also, working with four decimal places to assure accuracy to three is not only objectionable from the viewpoint of laborious and time-consuming efforts but from the strong probability of making arithmetical errors. These undesirable features can be eliminated or reduced by using the graphical method.

For the designer, who is usually an experienced draftsman, the following are conducive to his using this method.

1) Drafting table and tools are readily at hand and hence convenient to use.

2) The designer is acquainted with a system of protection comparable to a branch of mathematics such as trigonometry or analytic geometry, but with which perhaps he is more versatile. He is able thereby to draw the views of tools and product not only in their simple but also in the more complex working positions. Thus the method is less limited than would be the case when tables, formulas, and nomograms are used.

3) In analyzing the unfamiliar conditions of the problem, the layout enables the designer to check his mental observations in a tangible manner.

4) The dimensions can be directly scaled as contrasted to the encumbering "lace" of triangles, equations, and arithmetic necessary in determining them mathematically.

5) With the reduction of operations errors are less likely to occur, and if they do, they are more readily detected.

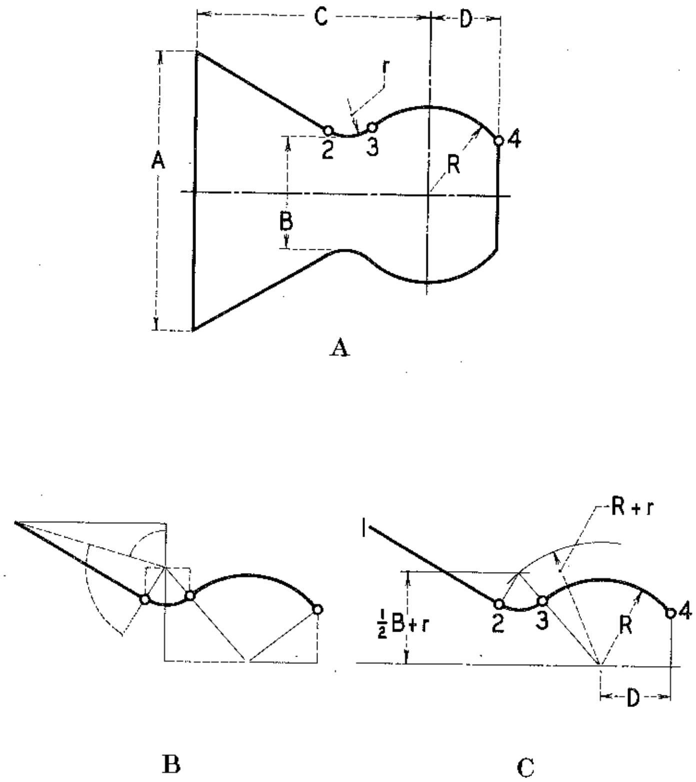


Figure No. 9

6) The substitution of approximate curves for the theoretical is quickly accomplished in contrast to the laborious process of the mathematical approach.

7) The amount of time consumed in obtaining a solution is considerably less than that required for the mathematical.

There are undoubtedly others, but these should have enough significance to warrant employing this method to a greater degree than it is used.

Yet, in spite of these advantages, how many of us will solve mathematically a simple problem rather than use the graphics? Or how many offices do we know of where graphics will not be permitted as the sole means for solving simple problems?

THE GRAPHICAL SOLUTION

To illustrate the use of both methods, your attention is called here to a simple two-dimensional problem--the outline of a formed product. See Figure 9. The

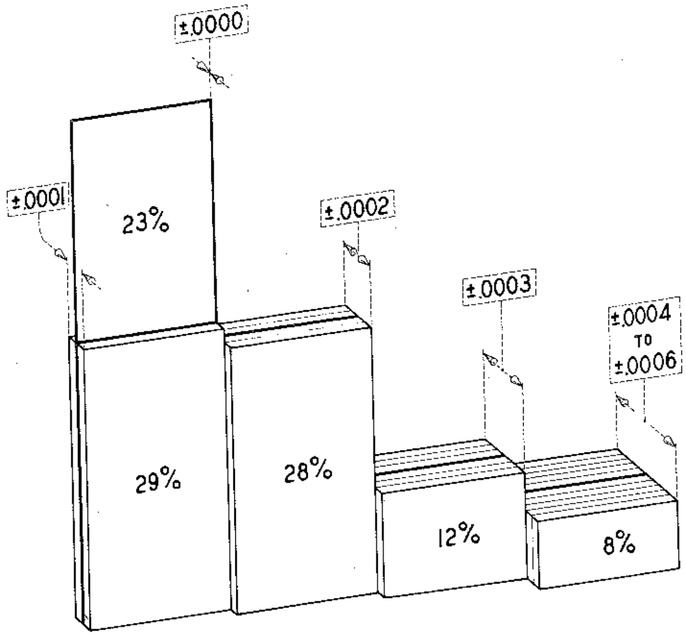


Figure No. 10

given dimensions in part A are represented by letters. We are required to obtain the coordinates of the points of changing curvature which are here encircled and numbered 2,3 and 4. If we solve the problem by trigonometric means, as shown in Part B, nine sides and angles or triangles, exclusive of addition and subtraction operations, need to be found. These are sbown by long dashed lines. The problem, as you can see, is not difficult, but time-consuming. Now compare the graphical method used in Part C. The vertical coordinate of point 4 is determined by the intersection of the loci D and R. The center of the small arc may be established by drawing its loci R + r and ½ B + r, from which tangency point 3 may be determined by connecting centers. Next, the straight line from point 1 tangent to the small arc and a perpendicular from its center to this line locates tangency number 2. The advantages seem to speak for themselves.

The question now arises as to what degree of accuracy can answers be obtained graphically. Obviously the graphical method must give an adequate answer if it is to be used. In other words it should be possible to make the drawing to a size that will permit scaling to the degree of accuracy needed. As stated earlier, the usual screw-machine product and forming tool being small, and the usual tolerances not too close, enlargements can be made to provide sufficiently accurate results. Furthermore, the answers can be obtained by using the ordinary tools of the draftsman.

To illustrate what can be done some data have been compiled to show the deviations between the graphical and mathematical answers of more than 200 calculations taken from one group of both flat and circular forming tools. Since it was the author's task to provide a

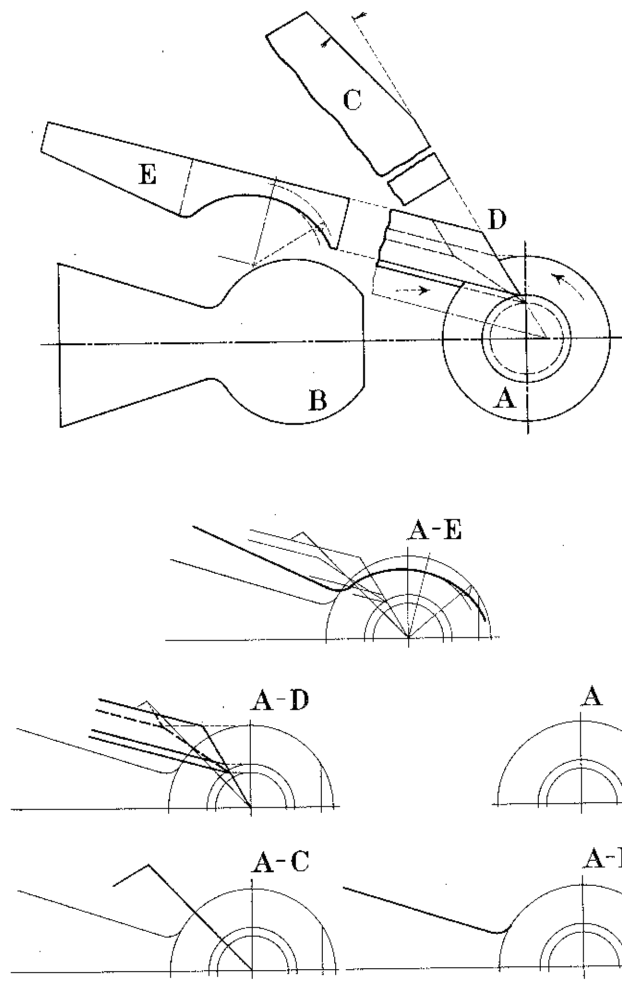


Figure No. 11

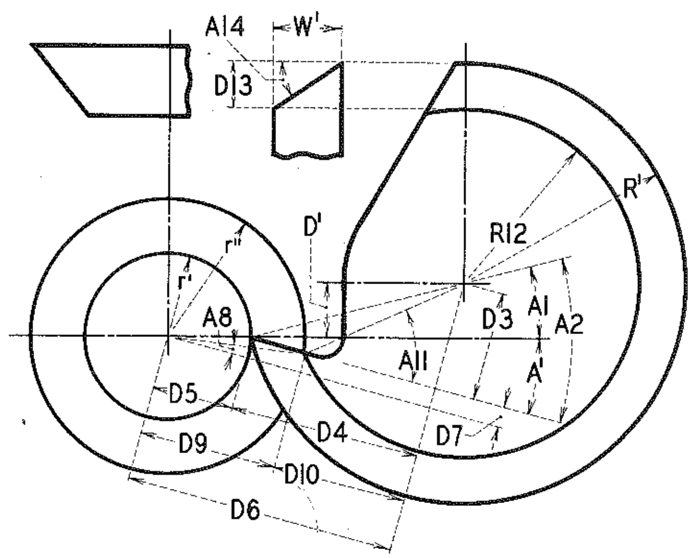
finished drawing of the tool, it was necessary also to serve as a checker. Hence, the problem was first solved graphically, and then checked mathematically. The closeness of the results was amazing. They are here presented in Figure 10 in bar chart form showing the percentages of deviations in .0001" increments. For the mathematical, decimals were carried to four places, therefore accurate to three; whereas graphical answers were measured accurately to three and approximated to the fourth. Note that roughly one-fourth of the calculations had no deviations; one-half no more than plus or minus one-tenth; only two deviations were .0006", but their relative unimportance did not warrant a check-back. These data are quite significant. It is almost needless to point out that where the usual tolerances are plus or minus .005", the graphical answers are well within these limits, although the fact cannot be overlooked that an error on the tool is doubled on the diameter of the product.

The simple tools used were a parallel straightedge, triangles, engineers scale, magnifying glass, beam compass, and sharp pencil. Unquestionably, tools must be used with care much as other tools are used to obtain the best results. For instance when using the transit to measure angles, one handles it delicately, and certain operations, such as bringing the cross-hairs to the objective always from the same direction, are carefully followed. Similarly, the straightedge was moved towards, not away from, the point or line. Angles were layed off not with a protractor but by the tangent method. All measurements were made with the use of the glass, and by sighting along the division marks of the scale. Enlargements to 50 times size were extremely easily drawn by letting each division on the engineers scale equal .001". A further break down of these units into tenths was accomplished by eye with the aid of a magnifying glass.

Other considerations were given to the elimination of human and mechanical errors in drawing lines and angles. We know, for instance, that errors existing in the original segment increases proportionately when produced. An exception may be allowed for those lines in the positions made by the straight edge and triangle combinations, such as horizontal, 15°, 90°, etc., lines. Regardless of the position, if more than one stroke is used, the produced portion is likely to be offset from the original segment. Hence, lines were layed off longer than needed, from which the shorter required lengths were taken. The laying off of angles was similarly treated.

When constructing the different views of the layout, projectors from one to another are used. These are sources of inaccuracies; hence, the distances between views were reduced to a minimum. In fact, wherever possible, views were made to overlap. By so doing added advantages were obtained; first one pencil line may serve for the lines of more than one view, and second; the total area can be reduced, thereby permitting a greater enlargement of the drawing. To illustrate these and at the same time demonstrate the graphical solution of a tool problem, a product has been selected that is to be finished by a skiving tool. (Figure 11). The product has an outline similar to the one described in Figure 9 which when revolved will generate portions of a cone, sphere, and torus. The tool, characteristically for this operation, moves tangentaially and past the center. The views necessary to obtain the answers are shown at the top of the illustration. The shape and rotation of the product are shown in views A and B; the position, shape, and movement of the tool in views C, D, and E. In order that a smoother finish may be given to the conical surface, a vise angle, as shown in view C, has been added to the corresponding portion of the tool. The cross-sectional shape of the tool is shown in view E. The arrangement of views as shown here is familar to us, but it should be apparent, with this spread-out, that there are many sources of inaccuracies. A superposition of these views reduces the total area as shown in the view lettered A-E. The successive stages shown in the lower portion of the illustration show the development of view A-E. Only the upper half of the product and the cutting edges of the tool are needed and shown. View A shows the end view of the product. View A-B shows the addition of the front view. Note that the same circles serve both views, and only the addition of three lines is needed. View A-C shows the vise angle added. The front view of the tool is added in view A-D, and finally the cross-sectional shape is developed from these stages as shown in view A-E. Another point should be noted here. When the shape of the cutting line can be defined, other means for constructing it, if possible, should be used if they are more accurate than that obtained by projection methods. In this illustration, the portion of the tool cutting the sphere is elliptical. Rather than plot a series of points from the views, as would be the case when the curve is undefined, the major and minor diameters can be determined, from which concentric circles as shown in view E, may be used to lay out the ellipse. If the sphere is not to be perfect the ellipse may be approximated by circle arcs, in which case they can be readily located here hy methods of your own choosing.

Of significant importance is the time consumed in solving these problems. The data by graphical means necessary to make a tool similar to the one shown here were obtained in 1 3/4 hours time, which started with fastening the paper to the board and ended with its removal. In checking by mathematical means, and using an electric calculator, the data required 8 hours. It might be interpreted from this that the mathematical approach is more difficult. In a few spots perhaps it is,



D' ÷ R' = TAN A1	D4 + D5 = D6	D6 − D9 = D10
A' + A1 = A2	r' x SIN A' = D7	D3 ÷ D10 = TAN A11
R' x SIN A2 = D3	D7 ÷ r'' = SIN A8	D10 ÷ COS A11 = R12
R' x COS A2 = D4	r'' x COS A8 = D9	R' − R12 = D13
r' x COS A' = D5		D13 ÷ W' = A14

Figure No. 12

which may in turn be applicable to the graphical also, but the time consumption accrues from repeating the same operation many times for closely associated dimensions. The graphical means obviates this operation, and once layed out the answers are mostly a matter of scaling.

Another factor of note is associated with the human errors in reading sealed dimensions, or in interchanging two digits, or in failing to show the square root sign, among others. The author's observations were that more mathematical than graphical errors were committed, and exasperatingly enough when hunting for the error in the mathematical one would follow in the same path and repeat the error. Advantages of the graphical were that the sources of error could usually be readily isolated. If more than one answer was wrong, the trouble might have been in the layout; if only one, the error might have been the result of misreading the scale.

THE MATHEMATICAL SOLUTION.

While there are various approaches to the mathematical solutions of these problems the one depicted in Figure 12 is more to the author's liking than others. The feature that is appealing is the methodical manner in which the dimensions are determined. A circular forming tool has been selected with top rake, the dimensions for which are needed to make a conical product. The known dimensions of the tool and the product are superscripted. Small and large R's represent radii on product and tool respectively; large A and D represent angles and distances respectively. The numbers following the letters indicate the order in which those values were computed. The successive steps to find radius R12 and angle A14 are shown at the bottom.

The tool has been ground conically, as indicated at A14; hence, the product will have a slightly dished shape. If a true cone is necessary, intermediate dimensions between the limits of W' must be calculated to fit the hyperbola made by the cutting surface, or the tool should be given a compound rake angle, in which case the cutting tool can still have a true conical surface.

NEW METHODS FOR GRINDING TOOLS.

In conclusion it is desirable to comment further upon a remark made previously regarding the machining of a tool to a prescribed profile. In relatively recent years a type of machine has been developed for grinding tools and templates to almost any shape desired, typical of which is the Sheffield Micro-Form Grinder. These machines rely on the use of an enlarged drawing of the outline of the tool and a pantograph. The usual enlargement of 50 to 1 is placed on the table, and is used as a guide for the tracer point. When the point is moved along the outline, the cross-hairs, as viewed through a powerful microscope, are proportionately positioned. The grinding wheel is then moved to meet the intersection of the cross-hairs. The size of layouts is around 20 inches square, and at the enlargement of 50 to 1 corresponds to an actual work size of 0.4 inches. For longer contours they can be divided into units of length 0.4 inches or less and the enlarged drawings superimposed on the pantograph table.

While the author has no experience in preparing the enlargements for this purpose, it appears that the graphical method could give a better profile and definitely more quickly than that obtained by calculating a series of points, plotting them, and then constructing the profile.

A still more advanced machine is the Cincinnati Milling Machine Company's Projecto-Form grinding machine. It accomplishes simultaneously the dual purpose of a profile grinding machine and optical comparator permitting continuous enlarged comparison of the work profile with a "master" drawing as the guiding operation progresses. The operator, seated conveniently in front of the viewing screen, can view the cutting wheel in action and its position with respect to the outline of tool and drawing. This machine, like the others, requires the use of an enlarged drawing but to a smaller scale. The usual enlargement is 20 to 1 although a magnification of 40 to 1 can be accommodated.

While the drawing can be made by a variety of techniques, the same company has developed a Layout Scribing Machine for cutting away the emulsion from a glass plate. The drawing will permit the projection of a bright line of light as a strong contrast to the projected shadow image. Lines are scribed by carbide tipped styli to a width of .004", and located by horizontal and vertical slides and a radius arm graduated to .001". The .004" width line on the drawing represents 0.0002" on the work piece at a 20 to 1 magnification.

In summarizing, some of the technical aspects of forming tools have been presented along with some comparisons of the graphical and mathematical calculations, and some devices wherein the graphical is used as an aid in machining the tools.

HELP ! HELP !

The November issue is in a pile,

The February issue is in the file,

For the May issue, the pages will be bare,

Unless dear readers you put some articles there.

This issue of forty-eight pages is the largest issue ever published. The number of pages of advertising is increasing steadily making larger issues possible. However, more articles are needed, particularly articles covering graphical solutions. Please give your support to our efforts to build a bigger and better magazine. Sixty pages, just an editors dream today, may be a reality in another year or two.

With our advertising manager off to a fast start and now in high gear we should turn our attention to increasing our circulation. Department heads should solicit every member of the department staff. Let each of us serve our magazine by showing our copy to a friend in industry. Tell him that our circulation manager will appreciate his subscription. The February issue will carry many articles of interest to men in industry.

Solutions received by the editor for the problem furnished by Professor Rule (see page 39), will be published. However, if we are to continue to use this page, we must have more problems of this type. Please--

HELP! HELP! HELP!

The Editor

THE TRANSFER OF IDEAS TO AID IN CREATIVE THINKING

by
Professor Matthew McNeary
University of Maine

The recent report of the Committee on Improvement of Teaching, in connection with a discussion of creative problem solving, makes the following comment: "....needed idea elements often are not brought forth because they are embedded in the memory of different situations where they were first learned and applied. The disassociation of such knowledge, so that the pertinent parts may be transferred to the new problem, represents a difficult feat.[1] It is indeed a difficult feat to transfer ideas learned in one situation to another, and it is the purpose of this paper to suggest ways in which we can teach to facilitate this transfer so that ideas already learned may be used creatively.

Psychologists have been working on an analogous problem, "transfer of training", almost continously since the era of William James, some sixty years ago, and their findings may shed some light on our search for methods to improve capacity for creative thinking. Let us examine the meaning of the term "transfer of training" and the conditions which help or hinder its development.

When learning in one situation affects the ability to learn in another situation, there is said to be transfer of training. Such transfer is positive if it helps learning in the second situation, negative if it hinders. Positive transfer to subsequent learning or problem situations should be the aim of all good teachers as they teach a course; for if a student has learned a great deal, but is unable to transfer his knowledge to another classroom or to his life-work, the course has failed to justify its existence. This is what administrators have in mind when constructing or re-arranging curricula, and it is largely on the basis of "transferability" that courses stand or fall.

How, then, can courses be taught so that there will be a maximum of transfer? Psychologists tell us that there is transfer of training from one learning situation to another when, existing in both situations, there is:[2]

(1) Similarity of contents
(2) Similarity of techniques
(3) Similarity of principles
(4) A combination of these

These principles may be illustrated by the following examples taken from the field of engineering drawing.

<u>Transfer through Similarity of Contents</u> - Our work in engineering drawing is of importance to the industries who employ our students for the obvious reason that the factual content learned has direct application, or transfer, to manufacturing (the end-all of engineering) in the design, production, and sales of its products. Students who learn about standard symbols, threads, fasteners, gears, etc., find that these reappear in similar forms in engineering practice. There is, then transfer of training because of similarity of contents in the two situations.

There is classroom transfer from courses in engineering drawing to courses in machine design because of similarity of contents of the sort just noted. Furthermore, the type of figures selected to be drawn in the usual engineering drawing course are like those that occur in machine design courses.

<u>Transfer through Similarity of Techniques</u> - If you question senior students just before graduation as to where and in what courses they have used engineering drawing training, you will find that many of them, particularly chemical and electrical engineers, have used their drawing training mostly to construct curves illustrating experimental data, and to make diagrams for technical reports. In doing this they have used techniques learned, but usually they have not had much specific instruction in chart and diagram drawing. The techniques learned have transferred, but there is little content transfer.

<u>Transfer through Similarity of Principles</u> - The study of projection, which is the primary concern of descriptive geometry, and in particular the study of orthographic projection should help a student learn structural geology, or cartography, to name a few examples, because these sciences, too, make use of projection principles. The similar principles will transfer, and they will transfer more readily if applied problems are given in the descriptive geometry course which require the student to transfer the principles specifically to structural geology and cartography.

Very frequently it is claimed that even if there are no tangible transfer values of a particular subject of study, nevertheless it has value because it trains the mind. This is called the doctrine of "formal discipline". It has been demonstrated, at least to the

1 "Improvement of Engineering Teaching", Report of the Committee on Improvement of Teaching, The Journal of Engineering Education, September, 1952, page 39.
2 "Psychology" Norman L. Munn; Houghton Miffling Company, page 121.

satisfaction of psychologists, that "formal discipline", as exemplified by the study of Latin and mathematics for its rigor alone, does not necessarily lead to improved judgment or logical thinking in other fields except when transfer occurs because of similarity of contents or principles. If mathematics were the best training for logical thinking, we should expect mathematicians to be the most logical of all individuals, and that this characteristic would be noticeable in their conduct in all areas of life. Experience does not show that mathematicians have exceptional logical powers in non-mathematical fields. The study of Latin may help you learn French, not because you can think more logically, but because it is similar to French in grammatical structure and vocabulary. In the same way, the study of descriptive geometry may help you learn mechanics, not because your mind has been trained, but because vector problems given in descriptive geometry gave some transferable content and technique.

Here is the crux of the matter. A superior individual may make transfers from one field to another without particular assistance, but for most individuals transfer is not automatic. A good teacher will see to it that applied problems are given that require the student to transfer the contents, techniques, and principles of his present course to other situations where transfer is desired, whether this be to other courses in the curriculum or to engineering practice.

Here are some specific suggestions for facilitating the transfer of ideas from engineering drawing and descriptive geometry to problems of a creative nature.

Engineering Drawing - One of the most common criticisms, and a just criticism, of engineering drawing is that it involves too much copy work. To get away from this as much as possible, and even in our basic work to require creative work of the type actually encountered in design, would be a step forward. Problems in orthographic projection in which pieces are described only verbally, as in Professors Hood's text, are extremely stimulating to the beginning student. Here is one:[3]

"A cross link is to be made from a 5" length of a 2" square steel bar. A central slot is cut into each end of the bar for a distance of 2-1/4" with a milling cutter that is 3/4" thick. The slots are turned 90 degrees with each other. The ends of the four arms are rounded to half circles of 1" radius, and 1/2" holes are drilled through on the same centers." Draw the necessary views.

Problems that give only the outline of a piece of machinery, and omit details which the student must supply, require creative effort of an elementary nature and are of value in making a drawing course more nearly like engineering practice and therefore more likely to transfer effectively to engineering practice. The Link-Belt catalog is an almost inexhaustible source of this type of problem. In it can be found flexible couplings, bearing take-ups, pulleys, clutches, etc., of all sizes that are well illustrated but only partly dimensioned. External features are usually shown completely, but internal construction is sometimes omitted, probably for security reasons. Making complete working drawings of one of these relatively simple pieces of machinery is an excellent exercise for the intermediate student.

The project method, important because of its resemblance to engineering practice, can be used quite conveniently in the teaching of engineering drawing. Using this approach, the student is given a series of exercises that are related, each being a part of a larger problem, rather than a series of unrelated exercises. Drawing the details and making an assembly drawing of a simple machine is a typical project. This sort of thing might be introduced at an earlier stage in our courses and certainly is an essential part of any basic drawing course.

If the drawing of curves and diagrams is one of the uses to which drawing technique is applied by engineers, it seems reasonable to suggest that instruction in charts and graphs should be given. Many of you have seen samples of this kind of work done by students who have had our training and have been dismayed by their ignorance of any of the principles of chart construction. These principles have been well developed in most texts and will transfer effectively if they are taught, less effectively or not at all if they are omitted or treated lightly.

Descriptive Geometry - The gradual shift in the teaching of descriptive geometry from the indirect, or plane trace method, to the direct, or auxiliary view method, logically may be claimed to have been caused by the superior transferability of the direct method to engineering practice. This is so because the auxiliary view method may be used easily in practice by anyone familiar with the principles of orthographic projection, while the concept of representing a plane by "traces" is an artificial one that is applied to most practical problems with difficulty.

In this connection, it is interesting to note that most engineering educators aged forty and over were trained in the indirect method and may not be aware of recent developments in descriptive geometry. It is important that these men be informed because they are the people who are most influential in building the curriculum.

3 "Geometry of Engineering Drawing" George J. Hood, third edition, page 284.

One seldom hears our younger graduates or staff members complaining about the unreality of descriptive geometry. If there is a local branch of the A.S.E.E. on your campus, it might be a good idea to give a lecture-demonstration to your colleagues at a local meeting to explain the direct method and show its applications.

To improve the transfer of descriptive geometry, the principle of transfer by similarity of content should be kept in mind. This means that the student should be given applied problems of the sort he is likely to meet elsewhere. These problems are legion and many good ones may be found in most of the current text books. In addition to the usual ones concerning guy wires and pipe intersections, there are many interesting applications in mechanics (three-dimensional concurrent forces), geology, cartography, and navigation. The more applications you offer, the less apologetic you are likely to feel when asked what descriptive geometry is used for.

Of necessity, beginning problems in descriptive geometry must be formalized so that they are stated in terms of point A, line AB, and plane ABC. These should be followed up, the same day, if possible, with one or more applied problems which the student must set up himself from a verbal description. Frequently, a student who can do a formalized problem easily is unable to convert a verbal statement into a formalized problem. He is unable to make the transfer. This same difficulty occurs in mathematics when a student can manipulate a given equation to get an answer, but is unable to set the equation up from a problem situation. When a line is called AB, it is one thing, but when it is called "a ray of light", for example, it is another.

It is also important, and sometimes difficult to separate relevant verbal information from irrelevant information. To bring this point home to our students, we recently included in a final examination a simple, and somewhat ridiculous, problem in which the top and front views of a mast supported by three guy wires were given. The problem was expressed in the following terms:

"Mr. T. Square, a contractor of questionable intelligence, erected a TV antenna but forgot to determine the true length of the supporting guy wires. He must have this information in order to bill the radio corporation for the steel cable. You are given the top and front views of the antenna and guy wires. It is a sunny day, and the antenna was manufactured in Rochester. It is located three miles from town. Mr. Square's brother was a plumber and is now a retired millionaire. What is the true length of the guy wires?"

By reducing the situation to absurdity, we hope the students got the point.

In conclusion, it is tempting to examine some claims for transfer of training that are debatable. Will an engineering drawing course help your students to dress more neatly? Not likely, unless you include a section on personal neatness in your syllabus. Is an engineering education the best training for any career? It is certainly the best training for a career in engineering or one related to the physical sciences, but there may be a negative transfer value or "habit interference", as the psychologists say, if a career concerned primarily with human relations is attempted. Witness the fact that few persons with engineering training are in political careers. This may be explained partly at least, by the kind of training the engineer receives, concentrating in mathematics and the physical sciences and dealing largely with inanimate objects which yield to precise methods and perform in an almost perfectly predictable manner. Human beings do not behave this way. T. V. Smith, Professor of Philosophy at Syracuse University, in a recent address on our campus said, "In human affairs we never solve problems, we only resolve predicaments." This unreliability of the human animal and the fogginess that of necessity surrounds his activities has a tendency to repel the engineer so that usually he is inclined to stay with his comfortable world of steel and concrete. This is a serious situation, because it means that some of our best brains are being lavished on the inanimate world when they are needed desperately in the world of living. Perhaps you can suggest a way to resolve this predicament.

Summary - Creative thinking relies on the recall of facts, techniques, and principles learned in past experiences. If we want learning in one situation to assist in another situation, whether it be a college course or a problem situation in engineering practice, we must demonstrate in our teaching that the two situations are:

1. Similar in contents

2. Similar in techniques

3. Similar in principles.

The transfer of ideas from college courses to engineering practice is not automatic. We must teach for transfer if we want to teach effectively.

THE IMPORTANCE OF DRAFTING TO THE DESIGN ENGINEER IN THE AIRCRAFT INDUSTRY

by

M.E. Aldrich, Consolidated Vultee Aircraft Corp.

The engineer without industrial experience seldom recognizes the significance of drafting training to the engineer. It is even more infrequent that the inexperienced engineer entering the airplane manufacturing industry recognizes the relationship of drafting to the design problem.

The importance of English, both as to speaking and writing, has been stressed until the facetiously expressed but frequently believed remark of the 20's to the effect that "Engineers ain't got no need for grammar" is seldom heard. Unfortunately, the same change in attitude toward the graphic language of engineering - i.e. drafting, has not taken place. It appears, in fact, as though any change that may have occurred in the past two decades is one of further discrediting of drafting. This is possibly due to the greatly increased specialization in many fields caused by scientific advances requiring the engineering application of more involved scientific theory. This tends to obscure to many the fact that engineering is an applied science with the final objective of creating physical articles and systems.

It thus becomes appropriate to consider whether drafting training does have the significance that I have implied and further, whether the combination of airplane product designer and draftsman is necessary.

The Engineer, if he is to deal with physical articles, and I believe we can agree that the objective of engineering is to build things, must think in three dimensions. Engineering drawing instructions and experience provides the training in the perceptive ability that enables one to think in this required manner. Drafting instruction thus becomes significant in the training of an engineer as the means of acquiring the key to the constructive imagination of the design engineer.

Drafting is however more than a training medium. It is useful in itself in the design studies that permit final evaluation and determination of the design requirement and in the preparation of the working drawings that will be used in building the "design". This drafting is in some industries performed by draftsmen without engineering training who are under the guidance of the engineer.

The airplane manufacturer does not make this separation and it is this marriage of design and drafting that frequently gives concern to the engineer considering positions in airplane design. The concern is not, in the majority of cases, due to a dislike of drafting per se. Time after time I have heard "I like drawing but I don't want to get stuck on the board as a draftsman". A brief consideration of the design requirements of any advanced airplane should remove any fear of being "stuck as a draftsman".

Every objective in the design of an airplane places a premium on weight. The design engineer's task has not been completed when he decides that magnesium, a "nice" light material, will be used for certain applications and aluminum, steel, etc. for others. Each detail part must be designed for minimum weight. This can only be achieved when the detail design is developed during the drafting by individuals that have a knowledge of engineering fundamentals such as the properties of material and statics. The detail design is an integral part of the detail drafting. The importance of minimum weight in each detail part is apparent when it is realized a single pound can represent two miles in range in a large airplane. J.S. Newell, Professor of Aeronautical Structural Engineering at Massachusetts Institute of Technology, noted years ago that "an airplane is a machine that almost doesn't work". Today, as in the past, weight is the reason for the "almost" and the graphical presentation of the design by engineers, not draftsmen, is required if minimum weight design is obtained.

Aviation has had particular appeal to many because of the rapid change in "the state of the art". Each new project presents a new horizon to every phase of design. This very fact creates the condition that places the designer on the "board". Every system or component will have no direct precedent in a past airplane, The design of the B-36 will illustrate this point. This was the third heavy bomber designed at Convair and yet the drawings from previous design used on the B-36 comprise less than 1/2 of 1% of the total. This could indicate only a larger airplane with many details similar except for size or minor details. But does it? The performance objectives of the B-36 required improved weight-strength ratios over past design. Items that appeared similar to previous drawings made use of new alloys or materials and were designed to new structural criteria. Extensive use of magnesium and metal adhesives required consideration of test data in the detail design. The design engineer doing the detail drawing frequently participated in related test programs to establish new design criteria. There was no previous experience in the method of control surface actuation. This was the first pusher propeller installation for Convair and it was the first airplane to use an AC electrical system. Experience was relied upon but it was very seldom that previous designs were used even for reference. Draftsmen could be and were used to prepare a large portion of the required drawings but the development of the design could only be accomplished by design engineers working "on the board".

Design with little or no precedent cannot be established in detail in the designer's mind. It must be developed graphically with frequent decisions and compromises. The minute by minute decisions which must be made during the graphical development can result in good design only if they are based on engineering principles.

A stable or slowly changing "state of the art" of airplane design will eliminate many of the factors that put the design engineer on the board. That state has not yet been reached. We have started work at Convair Fort Worth during the past few weeks, the detail design of a supersonic long range bomber. This airplane will use far less from the past and far more application of technical requirements to detail design than did the B-37.

It might appear from this discussion that all engineering assignments in the aircraft industry involve drafting. There are of course, many that don't. Aerodynamics, propulsion, structures, and others have many engineers that do little or no drafting. These are essentially analytical groups with a counterpart project design group. Individuals have varying aptitudes and abilities and will find the most satisfaction in work that "fits". The engineer that likes to see things built and to make them work, that wants contact with the entire factory from material procurement through fabrication to the flight line and that has coordinative and managerial ability will "fit" in a project design assignment if he has drafting ability and the constructive imagination which it develops.

HOW DO YOU DO IT?

Problem For Superior Practitioners Only

Submitted by

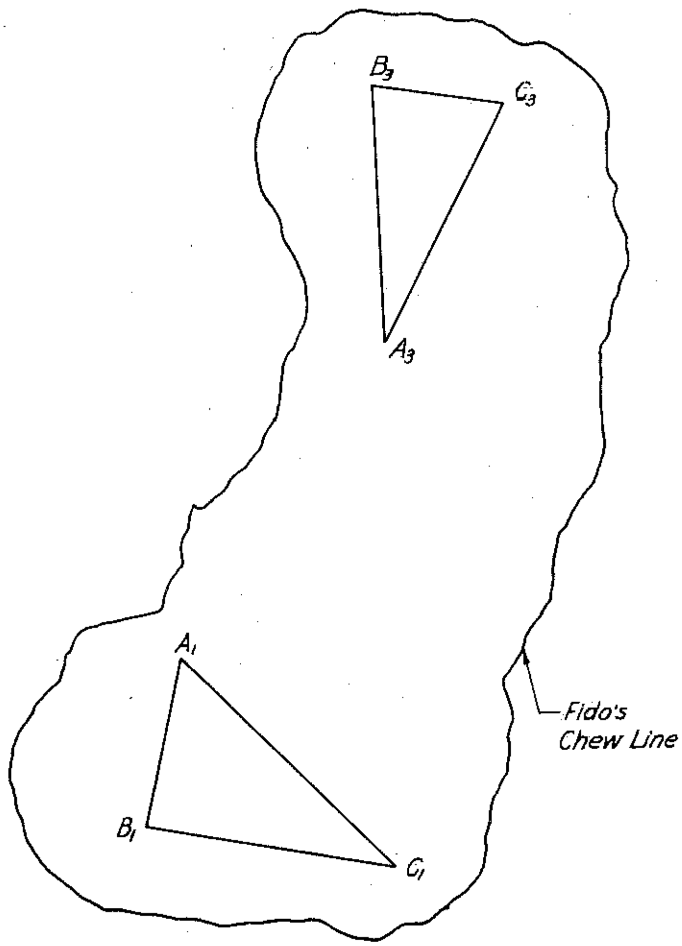
John T. Rule

(Mail your solution to the editor.)

Joe Doakes is on his first job. The boss comes in and says:

"Joe, I had three successive orthographic views of the triangle ABC. My dog Fido chewed out the central view leaving only the first and third views in their proper relation to each other. Will you find the missing central view for me? Of course, I only accept Euclidean solutions."

How can Joe find it? Is there more than one solution?

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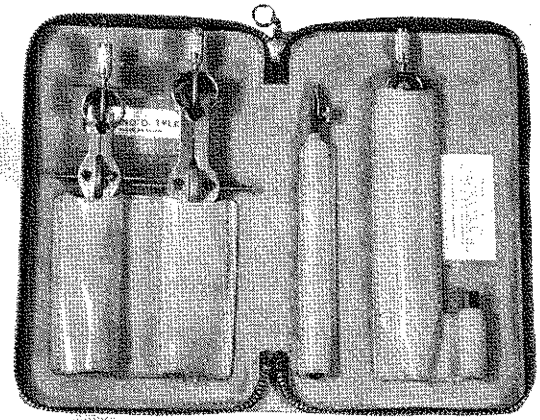

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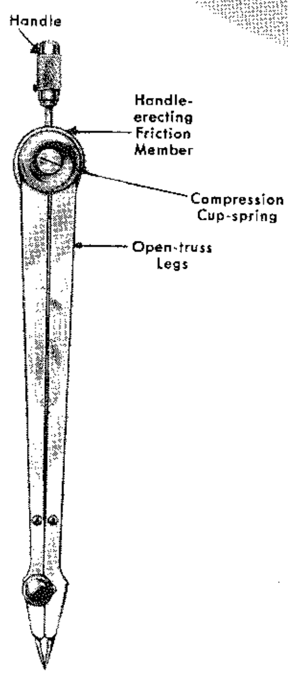

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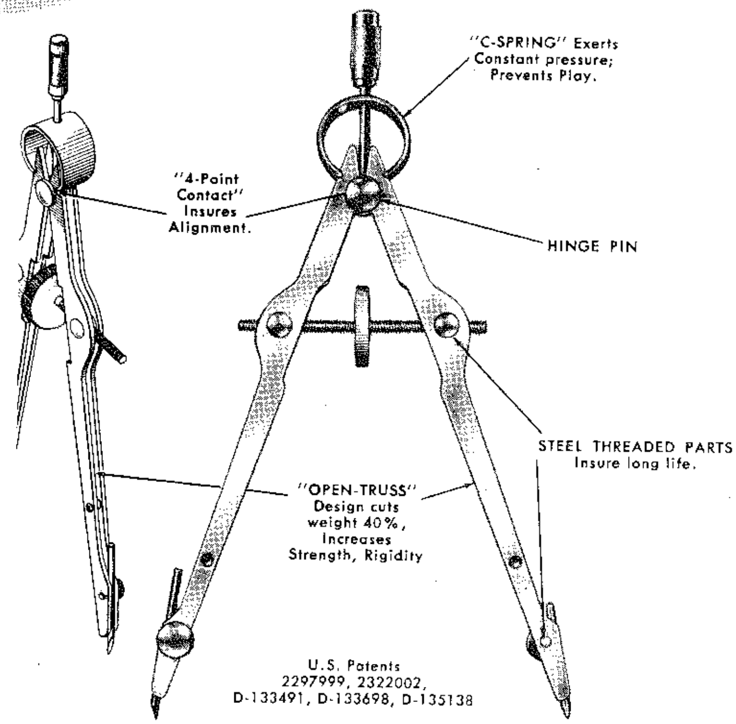

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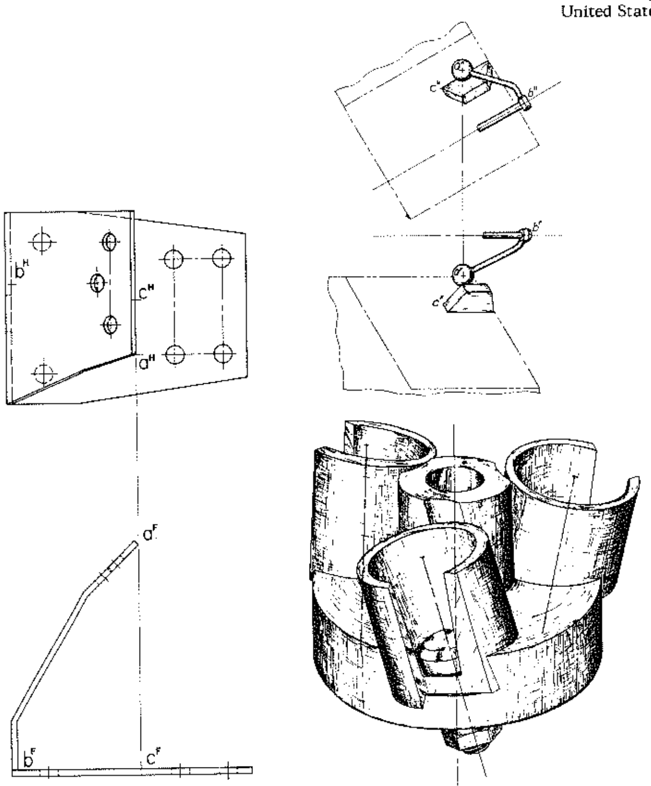


12

Conic Loci

12-1. CONE OF REVOLUTION. Certain properties of the CONE OF REVOLUTION make it particularly useful in many problems where it is desired to control angular relationships. Since the cone is generated by a straight line intersecting the axis (Art. 2-3) the surface may be used ... locus of lines passing through the ... fied angle with the ...

12-2. SELECTION OF CONE. In the cone shown in Fig. 12-2, A-B is the axis and B is the center of the base circle. The ... ments A-C, A-D ...

3

Accuracy In Graphics

3-1. INTRODUCTION. The solution of any problem can have no greater accuracy than that of the given data. If the data of a particular problem is accurate to only 0.05 of an inch, it is a waste of time and effort to use a more precise solution which would have an accuracy of, say, 0.005, since the answer will be no more accurate than the original data. A graphical solution can be as acc... mathematical solution provided ... the graphics can be ...

a) To construct an angle by the tangent method, first find the value of the tangent in a table. A four place tangent table gives sufficient accuracy for most problems. Next lay off on one leg of the angle any convenient length A-B (see Fig. 3-1). For best results ...

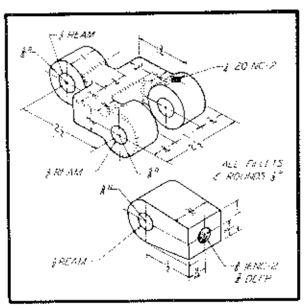
2

Common Geometrical Elements of Design

2-1. GENERAL. The greatest portion of all parts of any structure, mechanism, or design can nearly always be broken down into or represented by a few of the simpler geometrical elements listed here. These elements are desirable in any design because most of them can be defined easily, accurately and clearly – either mathematically or graphically. Further... can be produced in

2-3. DEFINITIONS. The definitions of these surfaces, which follow, are not intended to be exhaustive or complete. The graphical definitions are in three-dimensional form.

A POINT is a dimensionless element, having location only. Graphically a point is the intersection of two lines, a line and a plane, or three planes, ... should be represented by intersecting lines,



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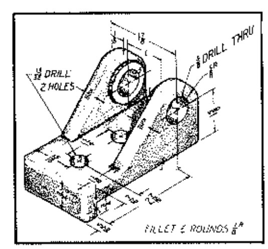

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