The Journal of Engineering Drawing

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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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Midwest Engineer
November 1952

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By E. G. Paré, R. O. Loving, and I. L. Hill

Illinois Institute of Technology

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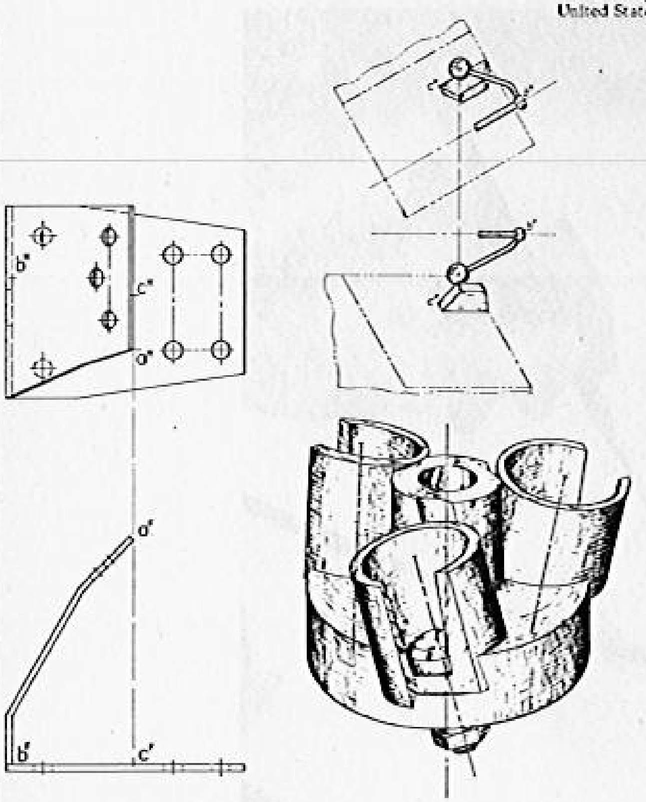

12

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 ... locus of lines passing through the ... fixed angle with ...

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 ac... 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.

PROBLEMS IN ENGINEERING DRAWING

ABRIDGED

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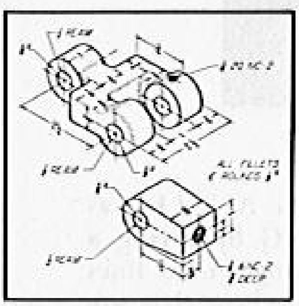

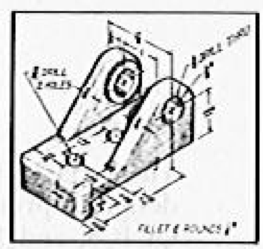

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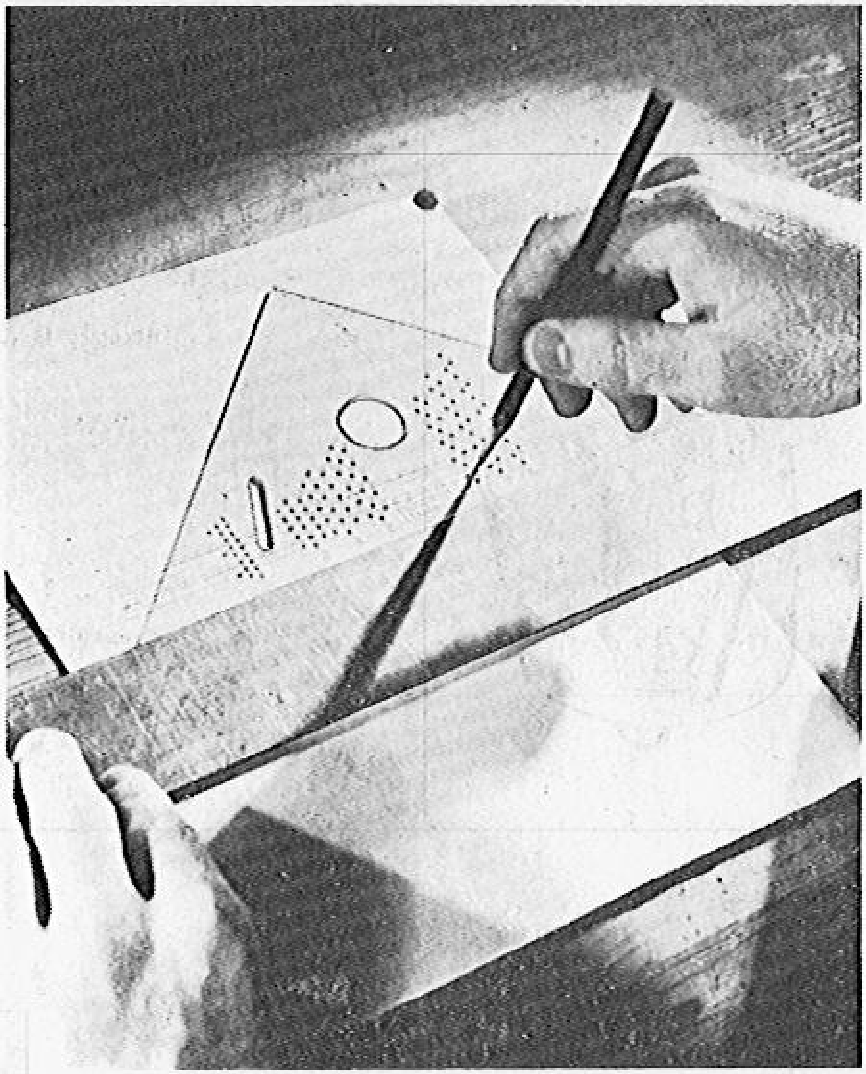

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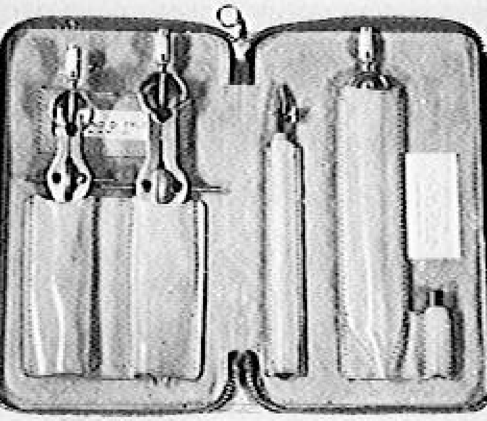

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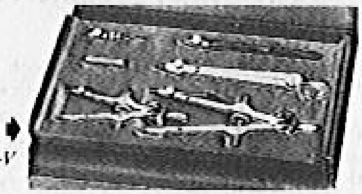

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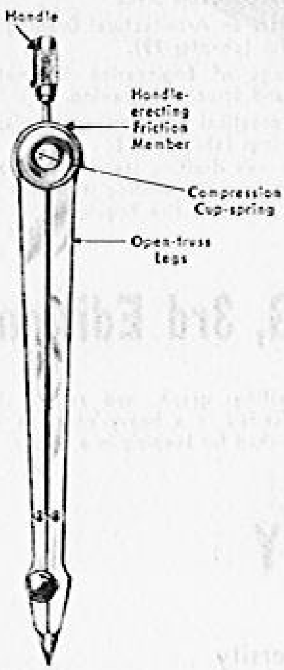

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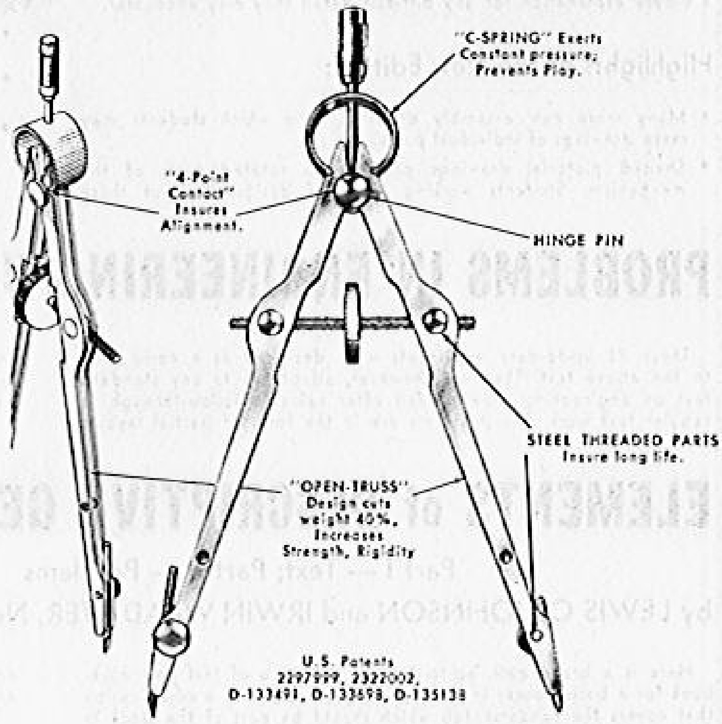

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BRITISH AND AMERICAN METHODS OF EXPRESSING TOLERANCES ON DRAWINGS

by
S. B. Elrod
Purdue University

The title given above might conceivably lead to a voluminous report, since there seems to be about as many methods of expressing tolerances on drawings as there are industries producing drawings. It is my purpose to limit this discussion to the "traditional" American method as compared to that proposed in the British Standards Institute BS-308:1952.

In using the term "traditional" American method I have arbitrarily selected three common methods which I feel should fall in that category. These methods are illustrated by Item A in Figure 1. The first being the common practice of indicating limit dimensions, in terms of the high and low limit; the second the very ordinary practice of giving the basic dimension with a bilateral tolerance, illustrated in this case by the dimension 2.00 plus or minus .01; the third practice, is that where the basic dimension is given with unequal bilateral tolerances separately stated. When one of these figures is zero the result is a unilateral tolerance as indicated by the third item under A.

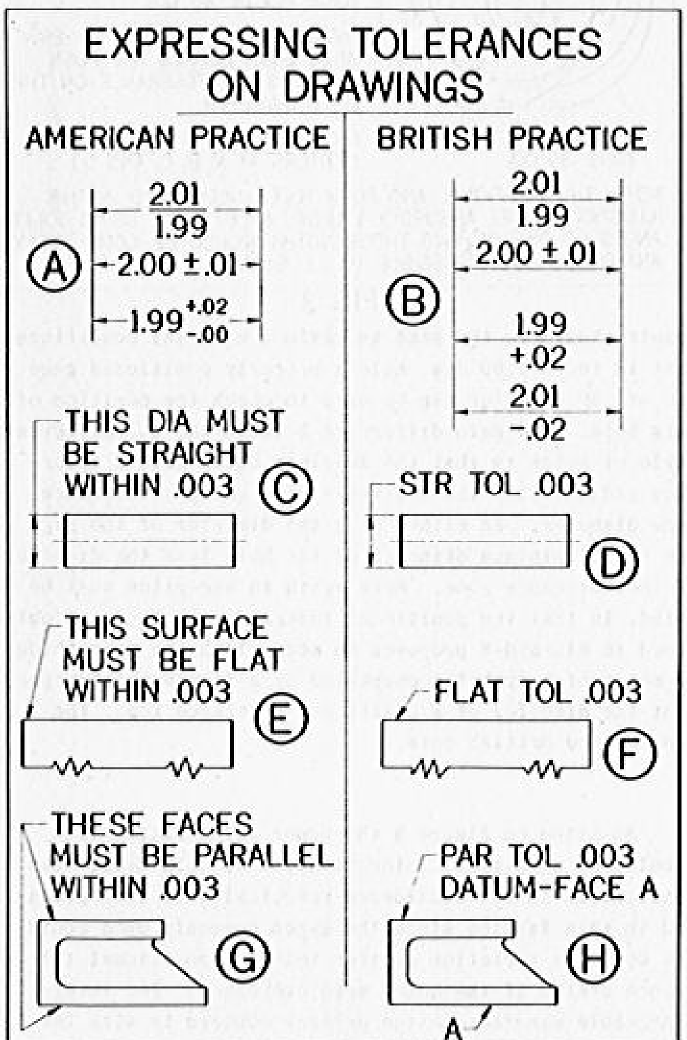

FIG 1

On the first two of these items there is no difference between the traditional American practice and the proposed British practice as shown by Item B. However, where the American practice usually requires showing the zero value for a unilateral tolerance, the British practice requires that only the basic dimensions be given along with the permissible variation, whether it be plus or minus. Whenever a tolerance is expressed in this fashion it is to be assumed that it is a unilateral tolerance and that the zero value can be omitted.

Some American industries are beginning to work to this concept. Notably those who follow MIL-STD-8 or other such military standards. It is conceivable that this latter practice will someday soon be accepted standard practice for the entire American industry.

All of these details are purely mechanical matters. The mechanics of expressing a tolerance on a dimension is in itself a rather minor detail. Of much more importance is the control we expect to maintain with these tolerances, and the degree of interchangeability which can be accomplished by their judicious use. Having been involved, to a considerable degree, in the study of positional and geometrical tolerancing for the past year the mechanical aspects of the problem appear very minor indeed to me. In this field of positional and geometrical tolerances it is felt by many that our British cousins are way ahead of us, at least in thought if not in actual practice.

Five years ago I attempted to present parts of this problem to you in my paper "Modern Dimensioning Practice." This paper was limited largely to hole location (positional tolerancing) with only a touch of geometrical tolerancing. Since that time much work has been done on this subject and much research performed. I was very much pleased to find an old friend of ours, John G. Perrin, whom many of you know, was investigating this field at Pratt & Whitney as far back as 1937. They had discovered that, in spite of extremely accurate gages and careful inspection, they were accepting and successfully using parts which would have been rejected if checked strictly to the tolerances on the drawing. This indicated that the gaging methods were accepting usable parts which might be rejected by other methods of inspection. Years of study reveal that this was an inherent weakness

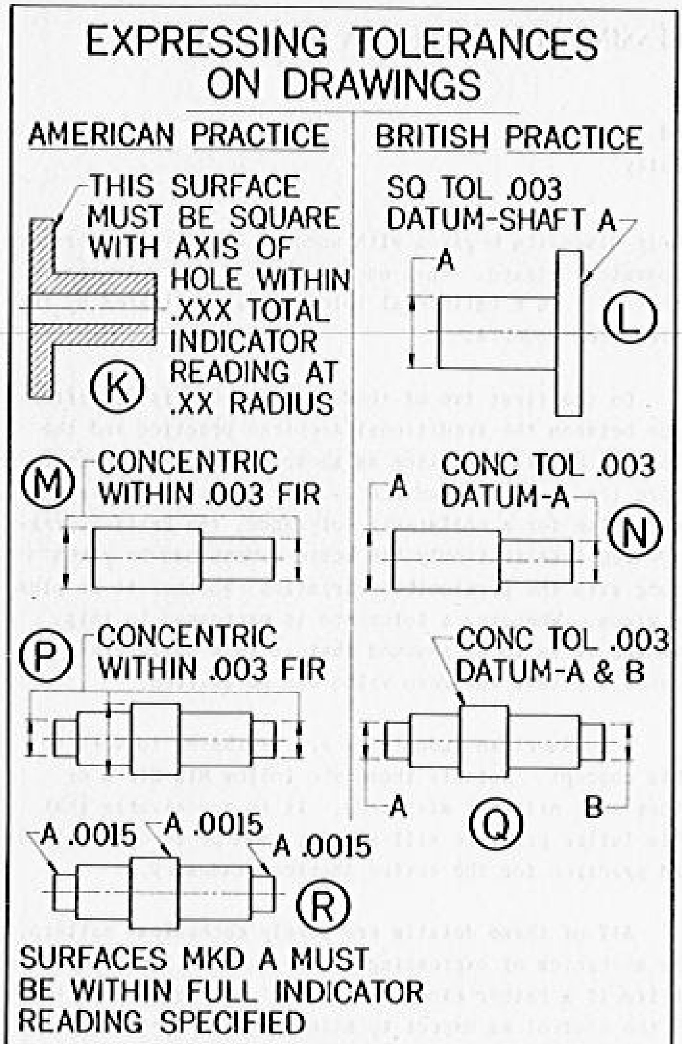

FIG 2

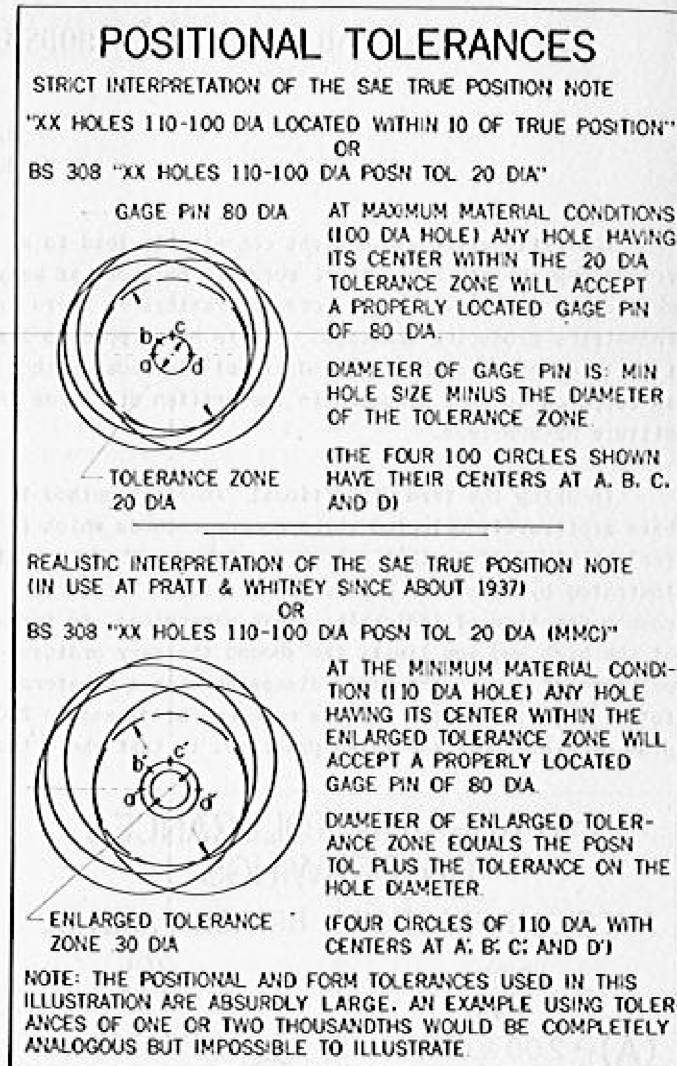

FIG 3

of any system of rectilinear dimensioning and tolerancing. The upshot of it was that a system of dimensioning had to be devised to conform to the method of gaging.

One way out of the dilemma, and one which incidentally has been used in many cases, is simply to state on the drawing how the part is to be gaged. One way in which this has been accomplished for hole locations is to state simply that holes must be within a diameter range and must accept a gage pin of a specified diameter located in the nominal position. Since the usual practice in this country frowns upon such items as this on a drawing it becomes necessary to say essentially the same thing without dictating gaging practice. To the best of my knowledge the earliest attempt to put this on a drawing is illustrated by the first example of Figure 3 from the SAE Aeronautical Drafting Manual. This note reads "XX HOLES 1.10-1.00 DIAMETER LOCATED WITHIN .10 OF TRUE POSITION." The Automotive Drafting Manual has the same note except that they use the word "nominal" in place of true.

The British proposal says exactly the same thing in a much briefer form "XX HOLE 1.10-1.00 DIA. POSN. TOL. .20 DIA." Regardless of which of these notes is used the result should be the same as maximum material conditions, that is for a 1.00 dia. hole a properly positioned gage pin of .80 diameter can be used to check the position of this hole. The main difference between the two different style of notes is that the American notes give a tolerance radius while the British system gives a tolerance zone diameter. In either case the diameter of the gage pin is the minimum diameter of the hole less the diameter of the tolerance zone. Here again an exception must be noted, in that the positional tolerancing methods as outlined in MIL-STD-8 proposes to accomplish the same thing by means of a symbol accompanied by a figure which represent the diameter of a positional tolerance zone, the same as the British note.

As noted on Figure 3 the upper illustration is labeled as a "strict" interpretation of this note. Its application is not considered practical when interpretated in this fashion since the gages commonly used could not detect a variation greater than the positional tolerance stated if the holes were oversized. For interchangeable manufacture the primary concern is with the surface of the hole, rather than the center.

The realistic interpretation of the SAE note and the amended note that the British proposed to accomplish the same thing is shown by the lower example of Figure 3. The addition of the symbol (MMC) to the British note justifies a realistic interpretation gaged on surfaces rather than theoretical centers.

If any of the holes described by such a note happen to be of a maximum diameter and are perfect in all other respects, that is, perpendicular to surface, etc., then the actual center of that hole can fall outside the .20 positional tolerance zone and still function perfectly. Let's take for example the 1.00 diameter hole with its center at a in the upper illustration, if that hole is enlarged to 1.10 diameter its center may move to the left along the horizontal center line to the new position a^1 shown below, and the distance from a to a^1 is equal to the increase in the radius of the hole or in this case .05. Thus the annular ring surrounding the .20 positional tolerance zone is .05 wide, which gives us an enlarged positional tolerance zone of .03 diameter. More simply, it can be said that the diameter of the tolerance zone is equal to the diameter of the positional tolerance plus the amount of the tolerance on the diameter of the hole.

While some segments of American industry have discovered the immense value of such a system of positional tolerancing for the location of holes in mating parts very few if any have ever stopped to realize that the outside diameters of shafts, rotors, etc., present exactly the same problem. All such surfaces of constant diameter are circular cylinders regardless of whether they be holes or shafts.

Items M and N of Figure 2 represent one of the simplest examples. The typical example illustrated at M is one of the most universally misinterpreted notes to be found on any drawing. When pressed for an interpretation of this Note I frequently get an answer "Oh, they are just concentric within three-thousandths of an inch, that's all" - accompanied by a shrug of the shoulders. Conversely the slightly shorter note proposed by the British practice leaves very little doubt when one understands that the term concentricity tolerance means exactly the same thing as positional tolerance. The items illustrated at P and Q provide a more interesting application in that the end cylinders might well be the bearing surfaces on which this shaft rotates. For precision manufacture it is easily possible that the larger diameter need be held reasonably true in an operating position. To accomplish that the British very simply give their concentricity tolerance relative to those surfaces. Arguments exist here as to what happens if those surfaces are not perfect. The usual interpretation is that the concentricity tolerance zone has an axis which coincides with the mean axis of surfaces A and B, however imperfect they may be.

Item R illustrates another method proposed by some

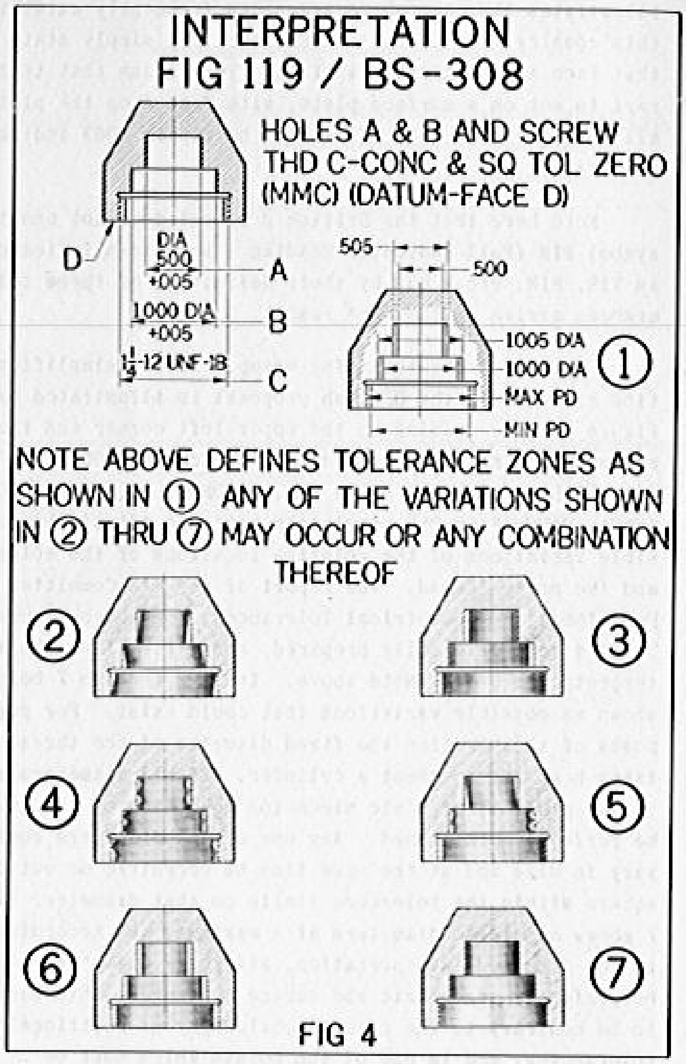

FIG 4

American industries, which has been the subject of much controversy for several years. The so-called "A Note" of the SAE Aeronautical Drafting Manual is an example of this type of note. It is very likely that the SAE will expand the coverage of this material in the near future to include datum surface references.

The outstanding example of simplification in the British method is illustrated by the two Items K and L at the top of Figure 2. Item K is copied directly from the SAE Automotive Drafting Manual while Item L is copied from BS-308. The interpretation might be slightly different. If the indicator reading radius of Item K was the outside diameter of the flange the notes would mean exactly the same thing except for the fact that the British note refers to a cylindrical surface while the American note refers to a theoretical axis of a hole. However, either of these notes could be adapted to the opposite condition in that respect.

Other samples of simplification are illustrated in Figure 1. By simply defining what is meant by a straightness tolerance, a flatness tolerance or a parallel tolerance the British states them very simply. Item G illustrates the case where arguments frequently exist in this country. In Item H the British very simply state that Face A is the datum surface. This means that if the part is set on a surface plate, with Face A on the plate all points on the other face must be within .003 indicator reading.

Note here that the British proposal does not use the symbol FIR (Full Indicator Reading - sometimes indicated as TIR, FIM, etc.) but by their definition of these tolerances arrive at the same result.

Probably the outstanding example of the simplification effected by the British proposal is illustrated by Figure 4. The drawing in the upper left corner and the accompanying note are copied exactly from BS-308. The note "HOLES A & B AND SCREW THD. C-CONC. & SQ. TOL. ZERO (MMC) (DATUM-FACE D)" completely controls all of the possible variations of the relative locations of the holes and the screw thread. The report of the SAE Committee on Positional and Geometrical Tolerances, for which Figures 3 and 4 were originally prepared, shows Item 1 as the interpretation of the Note above. Items 2 through 7 being shown as possible variations that could exist. For purposes of illustration the fixed diameter of the thread is taken here to represent a cylinder. If all diameters run to the minimum, or basic dimension then each of them must be perfectly positioned. Any one of the diameters could vary in size and at the same time be eccentric or out of square within the tolerance limits on that diameter. Item 7 shows all three diameters at a maximum, and according to the accepted interpretation, all three diameters must be perfectly concentric and square. However, this seems to be contrary to the general philosophy of positional tolerancing, and is one of the points which must be cleared up. The caption under Figure 119 of BS-308 has been suggested by some as being a better note to put on the drawing than the one shown. This caption reads as follows: "Combined tolerance for squareness and concentricity included in limits of size." This would seem to bear out the extreme case illustrated at No. 7.

Several interesting reactions to this note has been observed. The general concensus in most of the Detroit area, that is the Automotive industry, is that the shops would not accept it. The word zero when used in connection with any tolerances seem to "scare" many persons. However, some branches of the Automotive industry and some branches of others claim that they work to this concept at all times. A liberal interpretation of paragraph 2.5.1 of MIL-STD-8 leads to such a system, and in the opinion of some is all that is needed to accomplish the same thing as the Note on Figure 119. We have contacted the Defense Department Agency, responsible for MIL-STD-8 regarding this interpretation, but have not as yet found out just how far they intend for it to apply.

Much effort is being made to work out a common method, not only in merely placing the tolerance on the drawing but also in the underlying philosophy.

There is no noticeable difference in British and American drawing practice except in this area of Positional and Geometrical tolerancing, and it is hoped that an understanding can soon be reached. If these practices can be coordinated then drawings of both countries could be used by either without being redrawn as has been necessary in the past.

In the event of another emergency the benefit of a common method could conceivably effect savings of countless millions of dollars and, of even greater importance, precious time.

Professor H. C. Spencer

PERSONALITY SKETCH of PROFESSOR H. C. SPENCER

by
Professor I.L. Hill
Illinois Institute of Technology

Professor H. C. Spencer is the Director of the Department of Technical Drawing of the Illinois Institute of Technology. For many years he has been active in the affairs of the Division of Engineering Drawing and has contributed much to the improvement of the teaching of technical drawing. His ability to organize and plan to the smallest detail is recognized by all who have come to know him.

Professor Spencer was born March 5, 1903, in Mangum, Oklahoma, and received his high school education at Oak Cliff High School of Dallas, Texas. During his spare time in high school and while working his way through Baylor University, he worked as a draftsman and as a commercial artist. His first commercial technical drawing assignment was a large map of Texas, showing all oil fields and geological data. Other commercial experiences consisted of working in Dallas, Texas, for the Louchard Co., and the White Engraving Co., plus working for a summer as a draftsman in Chicago while studying at the Chicago Academy of Fine Arts. He spent a summer in New York City studying at the Grand Central School of Art and the Art Students League of New York. In addition, he attended Ohio State University for a summer and studied under the late Dr. French.

Professor Spencer and Juanita Hixson of West, Texas, were married while both were attending Baylor University. During his senior year, he was commissioned to paint full life oil portraits of Dr. S. P. Brooks, president, and Dr. A. J. Armstrong, director of the Browning Library. These portraits now hang at Baylor University. He graduated with an A. B. Degree in 1929. His present hobbies, when he can find the time, are oil painting and pencil and ink drawings.

Professor Spencer began his teaching career in 1926 as a drafting instructor at Ballinger High School, Ballinger, Texas. He accepted an instructorship in the Engineering Drawing Department at Texas A & M College in 1930 and while an instructor there obtained a B. S. Degree in Architecture and a M. S. Degree in Industrial Education. He advanced to full professor and head of the department in 1940. In 1941, Professor Spencer accepted the opportunity to establish and build a Technical Drawing Department at the Illinois Institute of Technology. The department has grown steadily since its inception and is now the only department in the country offering a B. S. Degree in Technical Drawing and a M. S. Degree in Engineering Graphics. Aside from his many contributions to the literature of this field, Professor Spencer is most proud of the part he has had in the accomplishments of the department.

His activities in the Division are numerous. He has been a member of A.S.E.E. since 1932 and has been secretary to the Division, member of the Executive Committee, Chairman, representative of the Division to the Council of A.S.E.E., and a member of the faculty of the 1946 Engineering Drawing Summer School. He is a member of the ASA Y-14 Sectional Committee and is chairman of the Subcommittee on Line Conventions, Sectioning and Lettering. He is also consultant to the SAE Aeronautical Drafting Committee S-1.

He is a member of the Southern States Art League, Western Society of Engineers, American Vocational Association, Illinois Vocational Association, and American Association of University Professors.

On campus, Professor Spencer is a member of the Curriculum Committee, Discipline Committee, and has served on the Presidential Selection Committee whose work culminated in the appointment by the board of trustees of President J. T. Rettaliata. He is an honorary member and faculty advisor to Triangle Fraternity and has served as a member of the Faculty Council, president of the Faculty Club, and for three years faculty chairman of the Junior-Week Open House Committee.

He is listed in "Who's Who in Engineering," "Who's Who in American Education," "Who's Who in Texas," "Who's Who in Chicago" and "Who's Who in American Art."

Professor Spencer's numerous writings began in 1933 with the first edition of "Technical Drawing" with Professor A. Mitchell and the late Dr. F. E. Giesecke. The book is now in its third edition and is in general use. Other books which followed:

"Technical Drawing for High Schools" - Books I and II with E. L. Williams (Macmillan, 1934).

"Technical Drawing Practice" with Giesecke and Mitchell (Macmillan, 1932).

"Technical Drawing Problems" with Giesecke and Mitchell (Macmillan, 1934).

"Lettering Exercises" with Giesecke and Mitchell (Macmillan, 1937).

"Engineering Preview" with Dr. L. E. Grinter and others (Macmillan, 1945).

"The Blueprint Language" with H. E. Grant (Macmillan, 1946).

"Technical Drawing Problems - Series 2" with Grant (Macmillan, 1948).

"Technical Lettering Practice" with Grant (Macmillan, 1949).

The total sale of his publications has nearly reached the one million mark.

Professor Spencer has long been interested in the educational value of slides and movies, and the department of technical drawing makes extensive use of such visual aids. He collaborated with H. L. Minkler in producing the motion picture "Instrumental Drawing," and with I. L. Hill in "Vertical Capital Letters," both in Kodochrome. In addition, he has served as consultant to the U.S. Office of Education, Jam Handy Co., and Ray-Bell Films for several educational films.

As a teacher, he has tried to emulate Professor A. Mitchell with whom he studied and under whose supervision he later taught. Professor Spencer is a friend to all students and associates, who admire him for his patience, kindliness, perserverence and understanding. He always takes the time to lend a guiding hand. His chief interests center around the activities of the Technical Drawing Department, its courses, faculty, and students, and the philosophy of teaching technical drawing.

DEGREE CURRICULA IN TECHNICAL DRAWING AND ENGINEERING GRAPHICS

by
Professor H. C. Spencer

In the fall of 1951 the Illinois Institute of Technology introduced a new curriculum leading to a B. S. Degree in Technical Drawing. This was followed, in the fall of 1953, by the introduction of a graduate program leading to an M. S. Degree in Engineering Graphics. The curricula are designed specifically to provide both undergrate and graduate training for teachers in this field.

At the high school level, the mechanical drawing teacher is trained in industrial arts or industrial education. "Mechanical drawing" is one topic among many, such as woodwork, sheet metal work, electric shop, and so on. The training in drawing is necessarily limited. Yet in thousands of schools, particularly the large technical high schools, the drawing teacher teaches only drawing and should be a specialist with a thorough grounding in technological fundamentals. Actually, he needs the basic technical training given to engineering students plus a much more comprehensive training in all the branches of drawing.

At the college level the young drawing teacher is usually recruited from the ranks of engineering graduates. Fortunately, he has the basic technological background, but his drawing is extremely limited. He may be familiar with the elements of soil mechanics, the theory of indeterminate structures, ultra-high-frequency waves, thermodynamics, or spectroscopy, but he probably has had no more than two or three semesters of drawing. His knowledge of axonometry is limited to a few simple isometrics, his experience in perspective is limited to three or four blocks drawn in angular perspective, and he may know nothing about topographic maps, structural drawing, architectural drafting, or machine design, to name only a few. If he is a chemical or an electrical engineer, he may have had no more than three or four semester hours of drawing, and he may not have had any descriptive geometry, which is the basis of all drawing. In short, the young engineering graduate starts out his career as a teacher of drawing with very little professional drawing training in his specialized field.

Compare the qualifications of the beginning drawing teacher with those of the beginning teachers in other departments. In chemistry, physics, or mathematics, for example, the doctor's degree is almost mandatory to obtain an instructorship. It is amply clear that more extensive training is needed by the drawing teacher if he is to be on a par professionally with his colleagues in other departments.

Of course, many drawing teachers, by dent of summer work in industry and a great deal of individual study become what we might call experts in the field. However, these are the people who made professional men of themselves despite the lack of formal training.

In setting up the undergraduate curriculum in technical drawing, the aim was to include the basic technological background required of the engineering student, plus a wide variety of courses in drawing, and certain courses in teaching methods. Hence, the first two years of the undergraduate program is practically the same as that for mechanical engineering. This is followed, in the junior and senior years, by the sequence of courses prerequisite to and including machine design, with statics, dynamics, mechanics of materials, mechanisms, and metallurgy required. The education sequence includes the basic courses in education followed by certain courses in which application is made specifically to the teaching of drawing, including visual aids, methods of teaching technical drawing and practice teaching. Most important of all is the variety of courses in the different phases of drawing, both theory and practice, including advanced descriptive geometry, technical sketching, architectural drafting, elementary product design, pictorial representation, structural drafting, and topographic drafting.

The opportunity for the development of the undergraduate program was available at the Illinois Institute of Technology because of the considerable number of varied courses in technical drawing already listed in the catalog. The department has regularly conducted a large evening program in which courses were offered to meet the needs of adult education in a diversified manufacturing area. Altogether, thirty undergraduate courses are offered, although all may not be available during any given semester. Thus, it was only necessary to prepare the new curriculum to meet the needs of drawing teachers, making use in most cases of courses already available. It was, of course, necessary to convince the administration that the proposed curriculum would be conducted on the same high level as other engineering curricula and would meet a definite need.

At the present writing, the undergraduate program is too new to have produced graduates, but the first student will be graduated in February, 1954. Altogether some twenty-five students are in the program in various stages of development, some in day school, some in the evening division, and some continuing through summer work. For the present, where full classes are not available, the students are taught on a conference basis, and this has proved very satisfactory. Most staff members have one or more of these students who are directed individually. The result is most stimulating, as it gives the teacher an opportunity to work with students in advanced or special subjects who are vitally interested in what they are learning.

The graduate program is designed primarily for the drawing teacher who already has a degree in technical drawing, engineering, or architecture, and who desires an advanced degree in his teaching field rather than in his undergraduate area. The program started last fall with two graduate students, both of whom are drawing teachers with engineering degrees. For the graduate curriculum ten new graduate courses were set up and will be listed in the next issue of the graduate school catalog. These include descriptive geometry systems, engineering graphics, nomographic charts, audio-visual aids design, technical illustration, industrial drafting procedures, problems in course design, tests and measurements in graphics, research and thesis, and special problems. Individual programs are determined in consultation with the departmental faculty advisor. Of the total of 32 semester hours required for graduation, as many as 12 semester hours of junior and senior undergraduate courses may be included.

Every member of the staff of the technical drawing department, especially Professors I. L. Hill, Eugene Paré, R. O. Loving and Frank Hrachovsky, has contributed, through many staff and committee meetings, to the development of the undergraduate and graduate programs. Professor Hill is in direct charge of all students, and advises them concerning their problems. Although this program has entailed a great deal of planning and study on the part of staff members, it has been stimulating and constructive.

Experience with these curricula will undoubtedly show that changes in courses and perhaps changes in pattern will be necessary. We sincerely hope that we may have the benefit of suggestions and criticisms from experienced teachers who have given thought to these problems.

KNOW YOUR COMMITTEES

Dear Members of the Division of Engineering Drawing:

I am including herewith a list of our standing committees and the personnel of the same. The success of our Division depends on the active participation of all the members working together and not just the efforts of the few whose names appear below.

If you have suggestions and ideas affecting the Division, will you get in touch with either the Chairman or one of the members of the standing committee whose responsibility it will become to see that the information is brought to the attention of the committees and officers of the organization so that the same can receive due consideration.

It is my desire that these committees be functional and not static.

Thank you for your consideration in this matter.

Very truly yours,

Ralph T. Northrup
Chairman

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IN MEMORIAM — DR. F. E. GIESECKE

Members of the Engineering Drawing Division were saddened by the death of Dr. F. E. Giesecke who passed away as the result of a heart ailment on June 29, 1953, at the age of 84. Dr. Giesecke was a pioneer in the teaching of drawing and descriptive geometry. He was the first to introduce axonometry in this country, it having been taught previously in Europe. Dr. Giesecke obtained his B.S. degree at Texas A. & M. College, his Masters degree from the University of Illinois, and his Doctor's degree from Massachusetts Institute of Technology. His education included extensive study in Germany before he went to Massachusetts Institute of Technology. He received the Distinguished Service Award of the Engineering Drawing Division at Michigan State College in recognition of his work as an outstanding educational leader and as an author.

GRAPHICAL METHODS FOR THE LOCALIZATION OF RADIUM NEEDLE IMPLANTS FOR DOSAGE CALCULATIONS IN THE TREATMENT OF CANCER*†

by
Professor Howard W. Yreeland
Columbia University

The Department of Graphics at Columbia University has recently had the opportunity to investigate the possible application of graphics as a solution to a long standing problem in the treatment of cancer.

The problem involves the accurate localization of radium sources in the human body.

Dr. Morton M. Kligerman, of the Department of Radiology, College of Physicians and Surgeons, Columbia Presbyterian Medical Center was inclined to think that an approach through descriptive geometry might offer a practical and relatively simple solution. It is not surprising that graphical techniques were considered, for the science of healing has become so technical that its problems have already reached into every branch of our profession.

Therefore, at Dr. Kligerman's instigation the theoretical possibilities of a solution were examined. At present, we can report on our studies of the problem and of the experimental verification of several solutions. The more practical problems of application still have to be ironed out, but we are making steady progress.

Our work is concerned with the application of radium in the treatment of cancer of such parts as the womb, urinary bladder, tongue, and areas about the head and neck. Whenever ionizing electro-magnetic radiations are used as a treatment, it is necessary to subject every part of the cancer to a completely lethal dose. In order to assure this, an accurate knowledge of the amount of radiation delivered is necessary. Such information is also needed to determine the effect of the treatment on nearby healthy tissue. It is in the attempt to measure radium dosage that the problem discussed in this paper is encountered.

When radium is used as the source of ionizing radiations, needles or tubes, made of gold or platinum, and containing radium salts are implanted in the tumor. To adequately treat the cancer, the implant is made in a prescribed geometric pattern which will produce a homogeneous dose throughout the tumor volume. When this is achieved, all portions of the tumor will receive a destructive dose of radiation if the implant is left in place for the proper time. A limitation is imposed, however, by the requirement that the amount of radiation delivered throughout the surrounding normal structures be within tolerance. The overall objective, then, is to deliver a dose which will cause complete and permanent regression of the cancer without causing any important permanent damage to the normal tissue.

But this ideal implant is difficult to achieve in practice and x-ray films, or radiographs, sometimes show variations sufficiently different from what is desired to cause concern over whether all portions of the tumor are receiving an adequate dosage. Unless the implant is radically different, however, it is allowed to remain, but

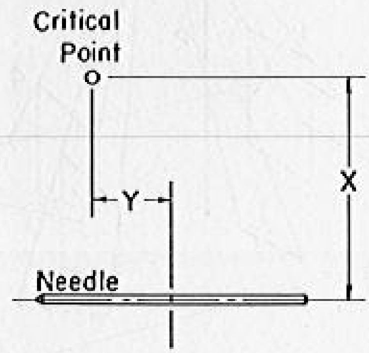


Figure No. 1

it is then necessary to determine from the radiographs the true distribution of radium so that it may be left in the body for a period of time sufficient to assure a minimum lethal dose.

This determination begins with the identification on the films of the "critical points." These may be points in the tumor which are suspected of getting too low a dose, or points in the normal tissue which are receiving too much radiation. The identification is made by a radiotherapist who at the same time prescribes the dose (maximum or minimum, as the case may be) for each point. Next, and here is where our problem enters, it is necessary to establish the true position of each needle with respect to every critical point, so the dose can be calculated for the radiotherapist.

A set of tables has been devised (the Quimby Tables) which requires the coordinate dimensions shown in Fig. 1.

These dimensions are:

- X, the true distance of the critical point from the axis of the needle, measured perpendicular to the axis, and
- Y, the true distance of the critical point from the mid-point of the needle, measured parallel to the axis.

On the basis of these measurements and the radiation characteristics of the source, the Quimby Tables make it possible to calculate the hourly contribution of each source at a chosen critical point. The summation of these rates divided into the prescribed dose gives the number of hours which the implant should remain.

The localization problem is obviously a variation of our old friend "the shortest distance from a point to a line," but complicated by the fact that the given views are radiographs. Looking ahead, however, at the prospect of our solution becoming a hospital technique suitable for persons not trained in graphics, the problem is more broadly states as follows:

By what simple and quick graphical method can the

* From the Department of Graphics, Columbia University, and the Department of Radiology, College of Physicians and Surgeons, Columbia University, and the Radiologic Service of the Presbyterian Hospital, New York.

† This work has been supported in part by funds from the Damon Runyon Memorial Fund.

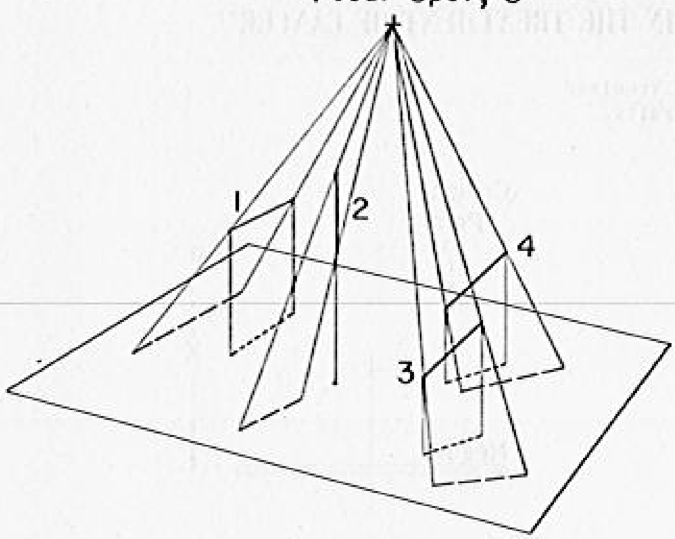


Figure No. 2

true coordinate dimensions X and Y be accurately determined from radiographs of the implant?

ORTHOGRAPHIC AND POINT-SOURCE PROJECTION

The projection of an implant is cast by rays which emit at the focal spot of the X-ray tube. In modern rotating anode type tubes the effective area of this source is only two or four millimeters square and can be considered a point at the usual working distances.

Figure 2 represents the X-ray projection of an implant and with it, for comparison, the orthographic projection.

Note the following characteristics of the point-source image:

a) Needle #1, which is parallel to the film, projects longer than its true length.
b) Needle #2, which is perpendicular to the film, projects as a line.
c) Needles #3 and #4, which are oblique and parallel to each other, project as non-parallel lines of different lengths.

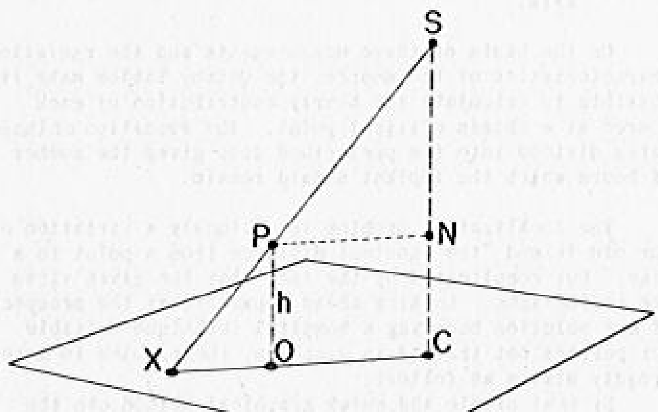


Figure No. 3

Having in mind the type of solutions which are used in orthographic projection, the radiograph is obviously unsuitable as a source of quantitative information.

Consider then the possibility of correcting the point-source radiograph of an implant to its orthographic equivalent. This would allow the application of the more familiar graphical constructions in solving for the required distances.

Figure 3 illustrates the principles by which this correction can be achieved.

S is the focal spot of the tube.
P is an end point of an implanted needle.
X is the X-ray projection of P.
O is the required ortho projection.

Point C is the projection of the one and only X-ray which falls perpendicular to the plane of the film.

Obviously, all the projectors lie in a plane and point O is on the line joining points C and X. If NP is parallel to CX, the following relationships may be stated:

$$\frac{NP}{CX} = \frac{NS}{CS}$$

but NP = CO, and NS = CS - CN, therefore

$$\frac{CO}{CX} = \frac{CS - CN}{CS}$$

Since CN = OP = h, the height of the point above the film, and CS = 100 cm in practice, this expression simplifies to:

$$\frac{CO}{CX} = \frac{100 - h}{100}$$

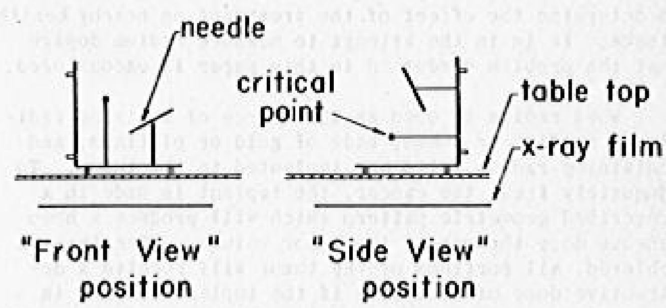


Figure No. 4

If, then, the following are known:

a) the focal spot to film distance,
b) the height of the point above the film,
c) the location of point C,

the radiograph of a point can be connected to point C by a line drawn on the film, and the orthographic projection of the point located along the line by the proportion stated above.

By this method, all the end points of the needles in the radiograph of an implant together with the designated critical points can be established in orthographic projection. Two such corrected films, representing views displaced by 90 degrees make it possible to solve the distance relationships by straightforward methods.

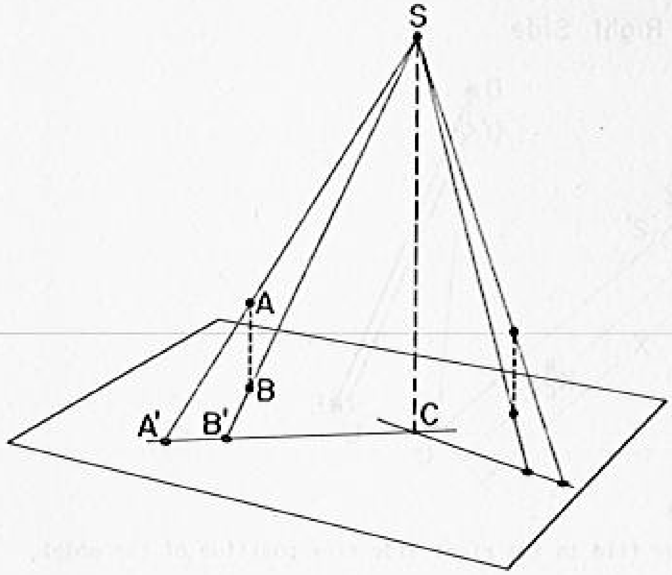


Figure No. 5

As a means of testing this theory, a model of an implant was made consisting of 5 needles (sewing variety) and 2 critical points (BB shot), so that 10 separate point to line relationships could be checked.

For practical reasons it was decided to rotate the model through 90°, keeping the film in a fixed horizontal position and the tube directly above it at a distance of 100 cm. (Figure 4)

Figure 5 illustrates a principle whereby the point C can be located.

AB is a radio-opaque line perpendicular to the plane of the film. Its X-ray projection is A'B'.

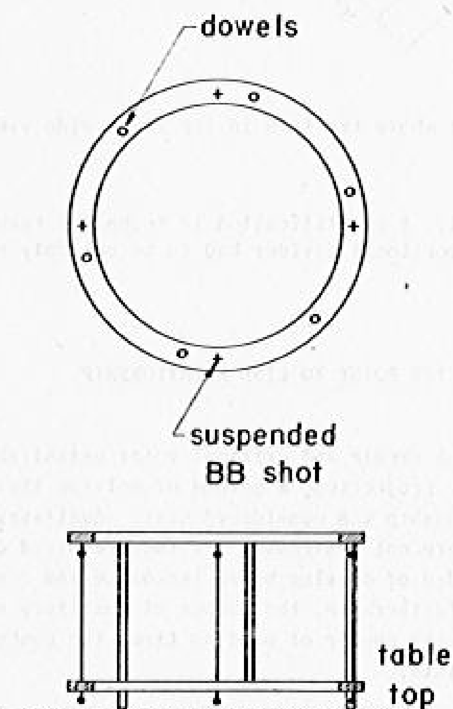


Figure No. 6

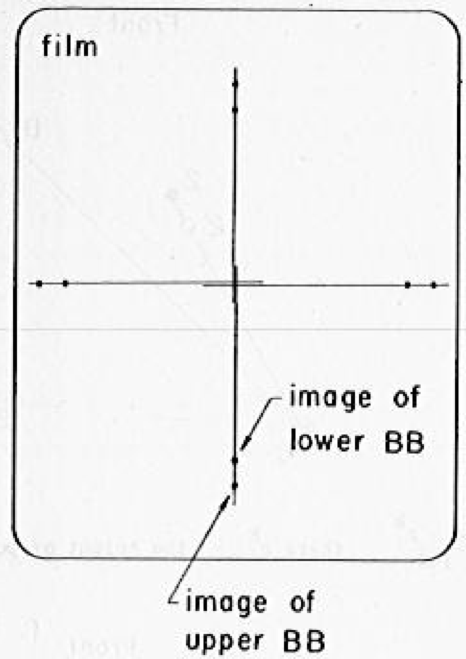


Figure No. 7

Obviously parallel lines AB and CS determine a plane which includes lines SA and SB. The intersection between this plane and the plane of the film is determined by the piercing points of lines SA and SB, which are points A' and B'. The piercing point of line CS or, indeed, any other line in the plane, then lies somewhere along the intersection.

If a second line similar to AB is projected on the film, the two extended projections of the lines will cross at the point C.

In order to accomplish this location of point C in the tests, a "point C locator" was constructed. (Fig. 6)

This consisted of two wooden hoops set one above the other, separated by vertical dowels, and supported by three short legs. Equally spaced above this framework, four pairs of BB shot were suspended on threads, so that they represented the end points of vertical lines.

In making the test radiographs, the point C locator was placed over the model of the implant, so that the projections of the "vertical lines" were included.

Point C was then located as shown in Figure 7. The four lines were found to close upon a rectangle roughly 1/8" x 1/4".

TRUE CORRECTION TO ORTHOGRAPHIC

Correcting the radiograph of a point requires knowing the height of the point above the film. The reasons which will be given later, the heights of the critical points and needle end points on the model were obtained by direct measurement, a convenience not possible with an actual implant.

Figure 8 shows the front and right side views of one of the needles (DE), one of the critical points (2), and point C as traced from the test radiographs.

Each point was joined to C and long that line its

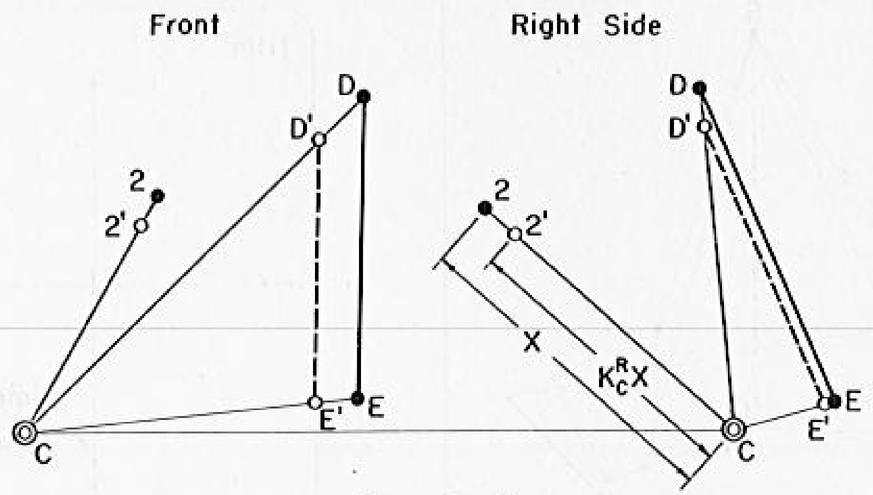


Figure No. 8

$K_2^R = \frac{100 - h_2^R}{100}$ where h_2^R = the height of point 2 above the film in the right side view position of the model.

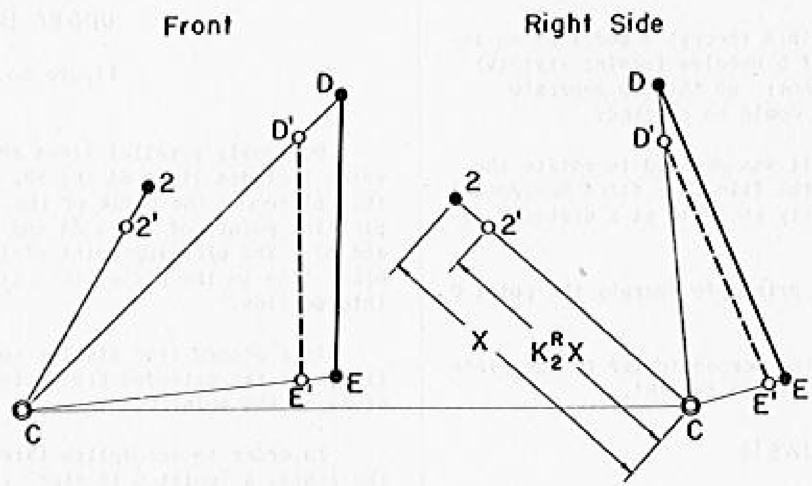


Figure No. 9

$K_C^R = \frac{100 - h_C^R}{100}$ where h_C^R = the height of the center of the implant above the film in the right side view position of the model.

orthographic established by applying the proportion previously derived. For "h", the exact distance of the point above the film was used. A proportional divider, calibrated for direct adjustment made this operation relatively simple.

This correction by individual factors gives a theoretically exact orthographic projection of the implant.

APPROXIMATE CORRECTION TO ORTHOGRAPHIC

Compared to the focal spot to film distance of 100 cm., the differences between heights of the points of an implant are not great. Accordingly, an approximate method of correction was tested.

Figure 9 shows the same needle and point. In this case, only one correction factor was used in each view, and this based on the height above film of the approximate center of the implant for that particular position of the model. A simplification in technique resulted since a proportional divider had to be set only once for each view.

SOLUTION OF THE POINT TO LINE RELATIONSHIP

With the needle and critical point established in orthographic projection, a method of solving the point to line relationship was considered next. Auxiliary view solutions were not desirable, for they required considerable knowledge of drawing board technique and descriptive geometry. Furthermore, the number of auxiliary views would equal the number of needles times the number of critical points.

It was decided, instead, to use the method of triangulation.

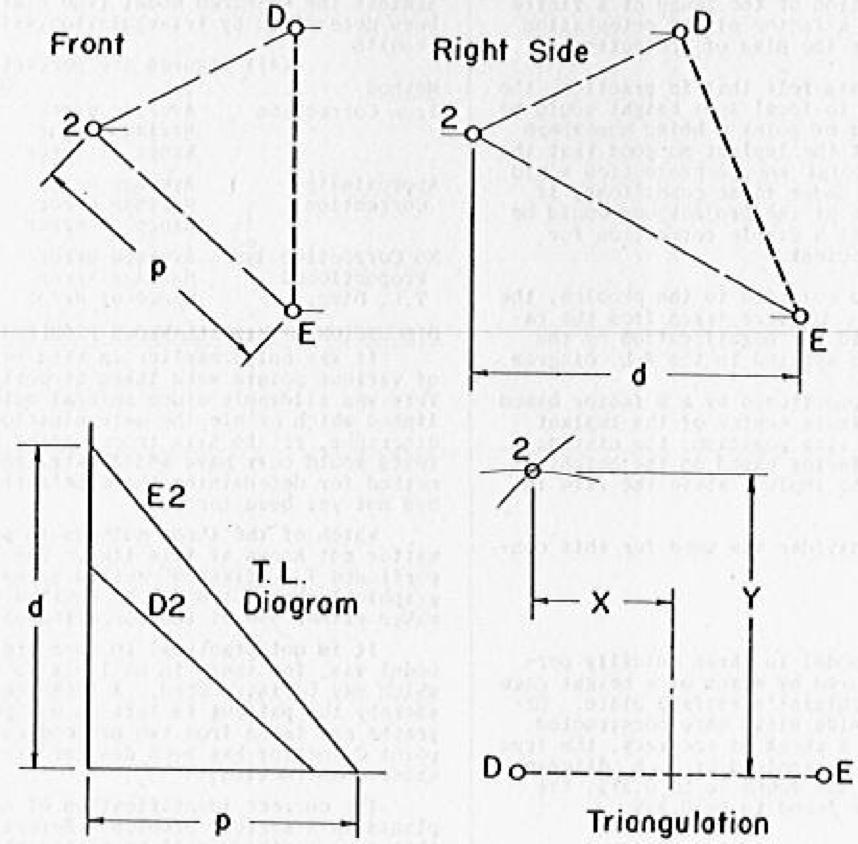


Figure No. 10

TRIANGULATION

The needle and point determine a triangular plane which can be constructed in normal view if the true lengths of the three sides are known. The length of one side, the needle, is already known, but the other two distances must be obtained from the orthographic views.

Figure 10 shows the familiar true length (T.L.) diagram, used in this case to find the true lengths of 2D and 2E from orthographic views of the implant. The depth of the lines (d) in the side view and the projected length of the lines (p) in the front view were made the sides of a right triangle whose hypotenuse was the true length.

On a horizontal line drawn equal in length to the needle DE, the plane of the needle and the critical point was constructed in normal view by triangulation. Arcs were drawn about points D and E, equal respectively to D2 and E2. The crossing of these arcs established point 2 and coordinates X and Y were measured directly.

The advantages of this method are that it requires a minimum of T-square and triangle work and a minimum of working space. One T.L. diagram can serve for all the point and needle relationships and one base line, such as DE, can be used in the triangulation constructions of other needles of the same length.

ANOTHER SOLUTION:

NO CORRECTION TO ORTHOGRAPHIC, BUT T.L. DIAGRAM PROPORTIONED

For a given needle and critical point, the information necessary from the radiographs of the implant is the true length of the distance from each end point to the critical point. This determination without correction of the radiographs to orthographic projection is not simple.

The effect of point source projection usually is to magnify an object with respect to its orthographic, but under certain conditions it can produce a smaller image. The magnification of a dimensionless point is simple, being only a function of the height of the point and the height of the source above the plane of projection.

Figure 11 shows the point source projection of a point upon a plane of projection. For CS = 100 cm., it can be shown that the ratio of the size of the point to the size of its image (a factor k) is given by:

$$\frac{\bar{P}}{\bar{X}} = \frac{100 - h}{100} = k$$

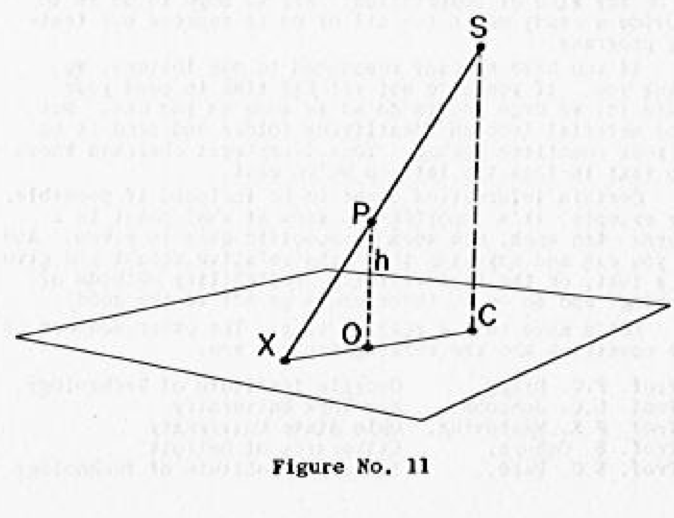


Figure No. 11

The size and configuration of the image of a finite figure, however, is as much a factor of its orientation in space as its height above the plan of projection.

On the other hand, it was felt that in practice, the ratio of the implant height to focal spot height would be so small, and the likelihood of point C being somewhere in the midst of the image of the implant so good that the distortion effects of the point source projection would be at a minimum. Moreover, under these conditions, it was felt that the appearance of the projections would be so close to orthographic that a simple correction for magnification would be sufficient.

Accordingly, as a third solution to the problem, the distances p and d (see Figure 10) were taken from the radiographs directly, corrected for magnification by the formula given above, and then applied in the T.L. diagram.

The distance p were proportioned by a k factor based on the height of the approximate center of the implant above the film in the front view position; the distances d were proportioned by a k factor based on the height of the approximate center of the implant above the film in the side view position.

Again, a proportional divider was used for this construction.

RESULTS

The dimensions of the model in three mutually perpendicular planes were measured by means of a height gage with dial indicator on a machinist's surface plate. Orthographic front and right side views were constructed from the dimensions and, as a check of accuracy, the true lengths of the five needles determined by T. L. diagram. The average amount of error was found to be 0.27%; the greatest amount of error was found to be 0.33%.

The three methods of solution were then checked against the measured model (the distances X and Y had been determined by triangulation) with the following results:

(All figures are percentages)

Method		Distance X	Distance Y
True Correction	Average error	1.87	1.84
	Maximum error	2.40	
	Range of error	0.80	
Approximate Correction	Average error	2.25	2.14
	Maximum error	4.30	
	Range of error	8.20	
No Correction, but Proportioned T.L. Diag.	Average error	2.41	2.30
	Maximum error	4.70	
	Range of error	8.00	

DISCUSSION OF MISCELLANEOUS PROBLEMS

It was noted earlier in this report that the heights of various points were taken directly from the model. This was allowable since several methods have been published which enable the determination of heights from radiographs, yet to have incorporated one of them in the tests would only have added extraneous error. A new method for determining these heights has been devised but has not yet been tested.

Which of the three methods to put to practice is a matter not known at this time. The "no correction - proportioned T.L. diagram" method seems the simplest, but a graphical shortcut has been devised which for the moment makes either one of the corrected methods as easy to use.

It is not practical to turn the patient 90° as the model was, for there is no limit to the amount of error which may be introduced. A technique has been planned whereby the patient is left in one position and radiographs are taken from two perpendicular directions. A point C locator has been designed to permit this and is under construction.

The correct identification of needles in large implants is a serious problem. Several theories for making this more positive will be tested when the new localization methods are put to use.

DISPLAY OF TESTS AT UNIVERSITY OF ILLINOIS
A.S.E.E. MEETING, JUNE 14-18, 1954

Irwin Wladaver, Chairman of Committee

Tests in Engineering Drawing and descriptive geometry will be on display at the University of Illinois Meeting of the A.S.E.E., June 14 - 17, 1954. We expect many institutions to contribute typical examples of their tests, quizzes, and examinations.

The work of our students has always been an interesting feature of the meetings of the Drawing Division. Professor Ralph T. Northrup, Chairman of our Division, felt that a natural extension of this feature would be a display of the tests we use to evaluate our students' work. And so Professor Northrup put this feeling into action. He appointed a committee to gather a substantial array of tests and to display them at Urbana, Illinois, this coming June.

The type of tests you use is not at issue. "Objective," "standard," "subjective," or whatever else you name them is not a matter of present concern. Nor is it to be any kind of competition. All we hope to do is to provide a ready means for all of us to improve our testing programs.

If you have already responded to our letters, we thank you. If you have not yet had time to send your tests in, we urge you to do so as soon as you can. Put your material into an identifying folder and send it on to your committee-member. Your department chairman knows who that is from the letters we've sent.

Certain information ought to be included if possible. For example, it's important to know at what point in a course - 4th week, 6th week - a specific quiz is given. And if you can add anything about the relative weight you give to a test, or the test-validity, reliability, methods of scoring, and so on -- these would be all to the good.

Let's make this a real showing. The other members of the committee who are working for you are:

Prof. F.C. Bragg,	Georgia Institute of Technology
Prof. L.O. Johnson,	New York University
Prof. P.E. Machovina,	Ohio State University
Prof. S. Osborn,	University of Detroit
Prof. E.G. Paré,	Illinois Institute of Technology
Prof. J.M. Russ,	University of Iowa
Prof. H.C. Spencer,	Illinois Institute of Technology
Prof. H.C. Thompson,	Purdue University
Prof. F.M. Warner,	University of Washington
Miss Grace Wilson,	University of Illinois

We all hope to see you (and your tests) at Urbana, Illinois, in June.

A LETTER TO THE EDITOR

Dear Warren:

With barks of delight, my dog Bona Fida submits her solution to the problem caused by Professor John Rule's dog, Fido.

All I did was to send Fida up to (or is it down to) Cambridge. I knew she'd have no trouble smelling her way to Fido's hangout and when she got there she simply appealed to Fido's chivalry. What would any self-respecting dog do under the circumstances? Naturally, he came across. I don't know exactly how Fida did it to Fido: Maybe she dug it out with her little spade.

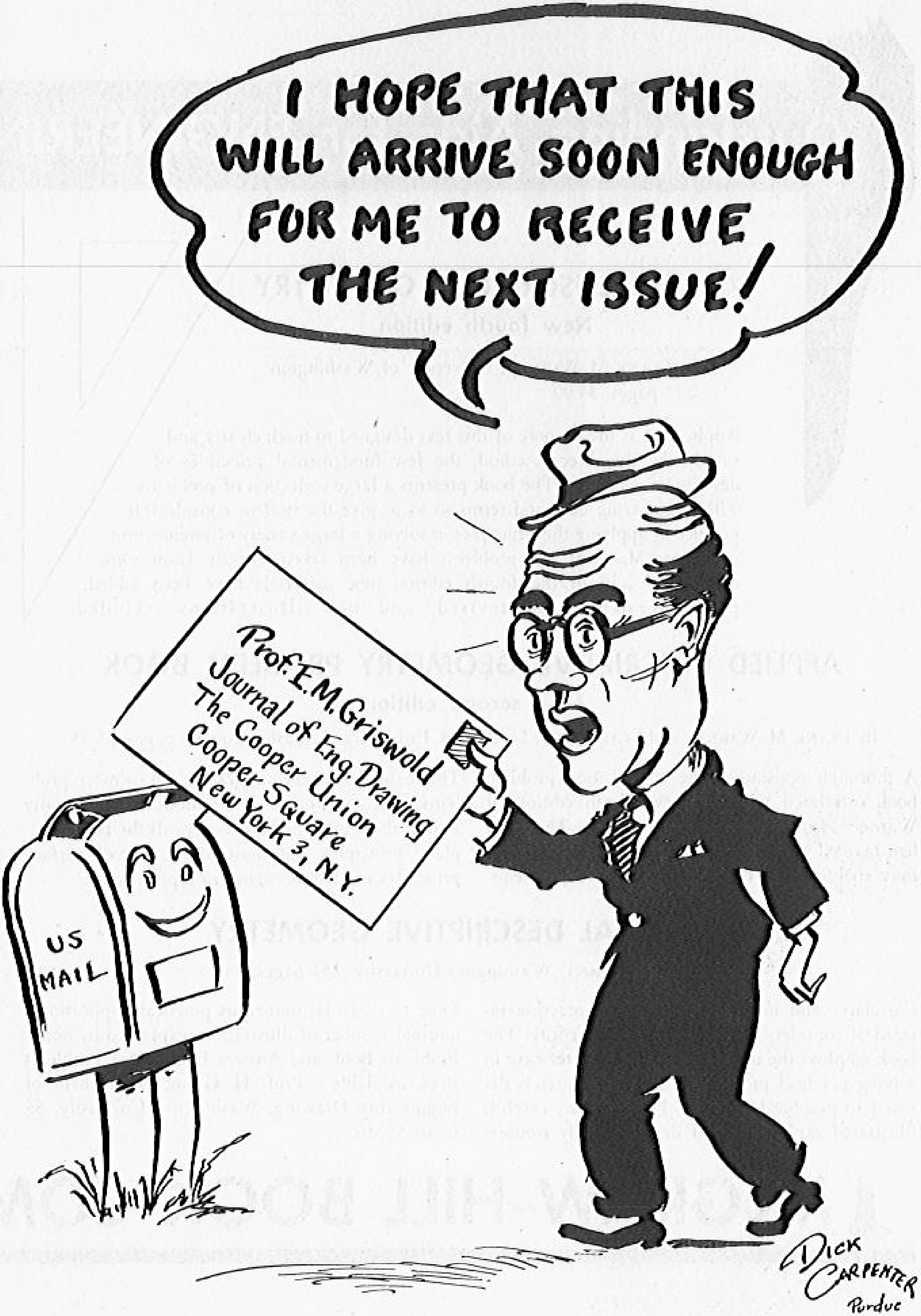
I sent her to Massachusetts with instructions to find out not only what the solution was but also how the solution was reached. But no luck. Fido went only so far and no further. "It was enough I gave you the answer," he growled. And he continued in his best and broadest Bostonian accent, "I ain't gonna tell you no more; not even how many solutions you could get if you had any brains."

And not another word could my Fida get from Fido. As Fida confided to me later, "That Fido is a dog, Yes, sir. A real son of a bitch."

Cordially yours,

Vlad

Irwin Wladaver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By THOMAS E. FRENCH, and CHARLES J. VIERCK, The Ohio State University. 715 pages, 6⅛x9¼, 1,090 illus., $8.00 (text edition available)

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GRAPHICAL COMMUNICATIONS — AN AID TO CREATIVE ACTIVITY

by
Dean L. E. Grinter, President of A.S.E.E.
University of Florida

When I was asked to address the Drawing Division at the Annual convention it was made clear that the invitation was being extended to me as Chairman of the Council Committee on Evaluation of Engineering Education. It is my purpose, therefore, to discuss briefly the difficult task assigned to this important committee and then to relate its objectives to those which I conceive to be the objectives of the Drawing Division. If the result brings home to you a great sense of your own responsibility for the future of engineering education, I shall be very pleased. Because, only as groups such as yours accept their part of the responsibility for the real future of engineering education can the Committee on Evaluation be relieved of its responsibility for indicating the way.

The charge to the Committee on Evaluation was made by President S. C. Hollister over a year ago. This charge was to determine how we should go about the education of the leaders of the engineering profession who will take over by 1975. It is evident to all of us that engineering education of the 1900-1910 decade did a good job of training the leaders for the 1920-1930 period. Engineering educators began to raise questions, however, when leadership in the development of electronics came out of physics rather than engineering, when soil mechanics and aerodynamics and mechanics of solids and fluids were introduced and then developed in this country so largely by European engineers. We noted that the training in physics and chemistry, and particularly mathematics, of these European engineers clearly surpassed our own even though they lacked our practical design work and had been trained in poorly equipped laboratories.

Then, of course, nuclear energy was thrust into our relatively unwilling and certainly inexpert hands by the inquiry minded physicists. We are now digesting the first meal of nuclear engineering, but this process is going on in industry and in government officers, not primarily in the colleges of engineering. Our 150 colleges have been too busy turning the crank that produces the uniform product known as typical 4-year engineering graduates to become really excited by the greatest revolution to the history of science and engineering. The Colleges of Engineering are located momentarily in the "eye" of a hurricane. No matter which direction the storm moves we are certain to have to rebuild a considerable part of the structure of engineering education as we have long known it.

I believe this to be true because engineering education has always maintained two objectives to be met by one curriculum pattern. These purposes are first to develop those who desire to become the specialists and scientists in the engineering profession and second those whose objectives would be met by a general-professional education in engineering. By general-professional education in engineering we mean education for service in the borderline areas between engineering and (1) business, management, law, agriculture, or any other profession, (2) between engineering and a science such as geology, geophysics or biology, or (3) between engineering and the technologies of construction, production processes, operation, maintenance or those specialized applications such as air conditioning, wood technology and so on. Hence, general-professional engineering education should probably be less specialized then our present curricula with more opportunities for exploration of other fields of knowledge.

Professional-scientific education for leadership 25 years from now would be expected to develop persons of competence in dealing with the new knowledge which is certain to appear as the end product of research in the pure sciences and in the engineering sciences of mechanics, electronics, thermodynamics, heat transfer and fluid flow. These engineering sciences are now the complete responsibility of the engineering profession. We must do the research as well as make the applications. The physicist has been overwhelmed by his responsibility for investigating the nucleus of the atom and has given up research in the scientific background of engineering. It seems unnecessary to elaborate upon the simple reasons why a single approach to engineering education can no longer bridge the widening stream between the general-professional objective and the professional-scientific objective. We straddled this gap, although not without difficulty, before 1940, but science and therefore the appropoate professional-scientific objectives in engineering education have undergone a revolution since 1940. We already have hundreds of new materials, new processes and new methods that are never mentioned in the classroom. How can we educate engineers to deal with the hundreds more that will spring forth next year or the year after, and to make original contributions toward producing these new materials and processes? This is the new job demanded of professional-scientific engineering education of the near future.

I now want to try to analyze how this revolution in engineering itself will influence the requirements placed upon the drawing teachers in our engineering colleges. Instead of looking at present courses, let us try to look at the engineer of the future and his place in industry or government. The shortage of engineers is real. Also, there is every reason to believe that except for short periods of recession it will be permanent. Industry is moving steadily toward a larger and larger percentage of engineers in its total list of employees. The ratio is one-to-fifty on the average, but G.E. uses one-to-twenty and others will try to follow suit. If Dean Hollister's analysis of the available raw material is correct, and I believe it is, there will not be enough students with I.Q.'s that permit college graduation to meet the demands for doctors, lawyers, bankers, scientists, and engineers. Hence, industry must start, as it now has, to make better use of its engineers. This means that engineers will be given technical aids for such work as drafting, which is one of the engineers jobs that can be delegated in large measure.

If we adopt the concept that the engineer need not be trained to produce engineering drawings but that his job is to supervise their production, I believe that a subtle but important difference will develop in the choice and presentation of subject matter in our classes in technical or engineering drawing. Let the teacher test each bit of subject matter by this measure and he may be amazed at the change he desires to make in his course. One may wonder whether the individual who supervises the production of drawings need not know as much about drawing techniques as the draftsman himself. This would certainly be true of a chief draftsman but I visualize the supervision of the engineer to be of an entirely different character. It is not his job to tell the draftsman how to present the graphical result desired. He merely needs to communicate his needs in a commonly understood language. The draftsman under the supervision of a chief draftsman should be capable of producing the results desired as soon as the requirements have been communicated.

What are the responsibilities of engineering education in developing this capacity of engineers to communicate rapidly and clearly with draftsmen? I believe the required knowledge and training are two-fold. First the engineer needs ability far beyond his present training in technical drawing and engineering graphics which are the perfect media for transmitting his thoughts not only to the draftsman but to his associated group of workers and to his superiors. Secondly, he needs to be able to understand the language of the blueprint itself since that language is an exact method of technical communication between engineers draftsmen, estimators, and construction, production or maintenance men. Any capacity that the engineer may have developed toward personal production of a drawing will have trivial value in the future as compared to these overriding needs for ability to communicate ideas crudely by technical sketching and exactly by blueprint reading and the use of engineering charts. Technical sketching is also one of those media by which the engineer draws creative ideas forth from the recesses of his mind and presents them for his own analytical study. As such, technical sketching can be taught as a part of the creative process in engineering education.

I am sure that those who wish to do so can develop a well documented case for the importance of the present methods of teaching engineering drawing as prerequisite to the knowledge I have indicated as essential to the engineer of the future. In fact, every teacher has good arguments readily at hand for justifying the old ways of developing an engineer. But a revolution can seldom be stopped and can never be turned back. We are in the midst of a decade that will be considered a period of scientific and engineering development of such sharp gradient that no word other than revolution can be considered adequately descriptive. In such a period it is inevitable that long established traditions will crumble. I was taught technical drawing in much the same way that I see it being taught in our colleges today. But it was confidently assumed by my teachers that I would earn my living for a time, at least, as an engineering draftsman. Actually in several years in industry where I worked in a drafting room I was never asked to make a drawing although I worked continually with drawings and prints. During this period too I taught myself to do sketching and to understand and make charts. This experience was no doubt unusual in 1930, but is rapidly approaching the norm for present-day baccalaureate graduates. As long as employees could hire engineers at about the same salary as that of a draftsman, engineers, and draftsmen were essentially indistinguishable. However, times are changing in that regard. I believe that the salary spread between engineers and draftsmen will rapidly increase in the years ahead and that the time is approaching when engineers will not even be permitted by union-company regulations to make a drawing. It is such relatively radical changes in perspective that lead me to suggest the survey of your courses in drawing from the viewpoint strictly of graphical communication. If any technique is to be included I suggest that the great value to the engineer of ability to communicate by free-hand sketches and charts be recognized more fully.

The opportunity to contribute to the development of the creative capacity in engineers lies almost untouched in the classroom in drawing. We know that whenever an engineer starts the process of attempting to create a new machine, structure or process his pencil is soon at work either writing equations or making sketches. The facility you train into his mind-hand relationship will bear directly upon his later success in bringing vague mental images into clear, working relationships expressed graphically in a language that is universal to engineers. Those who move forcefully and fearlessly to achieve this capacity for their students in technical drawing will earn the greatest praise from the engineers of the future.

HAVE YOU RENEWED YOUR SUBSCRIPTION ?

THE ROLE OF GRAPHICS IN ENGINEERING EDUCATION

by
Professor Frank A. Heacock
Princeton University

The purpose of this paper is to show the value and importance of graphics as an essential part of engineering education. The scope of the subject is broad enough to include not only the basic graphics courses in engineering drawing and descriptive geometry, but also the advanced graphics courses and other courses in the engineering curriculum that may be taught most effectively when graphic methods are employed. To understand and appreciate the educational value of graphics, we must appraise its objectives and realize the significant benefits that the engineering student derives from a well-rounded program of graphics instruction.

Graphics is both an art and a science. Considered as an art, the most popular form of graphics is engineering drawing, which has become the universal method of recording and communicating information in the engineering profession. 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 in industry and technology 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 to tomorrow will have the best working knowledge and drafting ability to plan future developments.

The widespread usefulness of engineering drawing and its importance as a vital factor in industry overshadow its other educational functions. When properly taught engineering drawing does more for the student then develop drafting skill. It is the freshman's first professional course and it trains his mind as well as his hand and eye. While he is learning to make drawings that conform to accepted standards of drafting practice, the student acquires the ability to observe intensely, to visualize and think constructively in three dimensions, and to express his ideas by means of technical sketches. The development of correct thinking habits in relation to the planning, drafting, and interpretation of drawings and technical sketches is an important objective in the teaching of engineering drawing.

The science of graphics is introduced to the student in descriptive geometry, which provides graphic solutions for a wide range of three-dimensional problems involving form, position, direction, size, and geometric relationships. The transition from engineering drawing to descriptive geometry is a natural one, because both are based upon the same system of representation, orthographic projection. On this foundation descriptive geometry builds a sound structure of logical reasoning, established facts, and realistic planning which culminates in an accurate solution on the drawing board. It puts into practice the engineer's method of thinking each problem through to a successful conclusion. It trains the student to analyze a situation step-by-step, to organize his thoughts and direct them toward a definite objective. It exercises the imagination and it promotes the growth of the power of visualization. Descriptive geometry provides an excellent introduction to the study of graphics as an analytical tool.

An important feature of descriptive geometry is the direction of sight, the choice of a strategic point of view from which the problem may be seen to best advantage. Thus a line may appear as a point or a plane may show edgewise as a line in order to reveal true distances or relationships. The new facts discovered at each viewpoint build up the mental picture until it becomes a complete realization. In the analysis of problems by descriptive geometry methods the student learns how to size up a situation from any desired angle. The nimble, mental shift from one point of view to another makes the mind supple and stimulates the imagination. It gives the student a confident sense of direction when dealing with complex problems in our world of three dimensions. It orients his thinking, makes him resourceful, and develops good judgment in the selection of methods of solution.

In engineering education it is the responsibility of the graphics teacher to help the student develop a graphic mind, which is an asset of great value to the student while he is in college and after he enters his profession. Let us consider the graphic mind to determine what it is, how it works, and what we should do to develop it more effectively. It will be helpful to analyze the learning process and show how the graphic approach makes it easier for students to understand the theory involved in the difficult courses in the engineering curriculum.

Educators agree that the eye is the open door to the mind. Students acquire many forms of knowledge more rapidly from pictures and demonstrations than from the words they read in textbooks or hear in lectures. Therefore visual aids to learning are popular in all branches of education. Most students are picture-minded and they prefer textbooks that are full of clarifying illustrations. A good picture is worth a thousand words because it tells its story at a glance. In engineering textbooks, however, pictorial illustrations are not always adequate. When the subject to be pictured is complicated, and particularly when its interior construction must be shown, two or more related orthographic views are necessary to convey the full meaning. Or the text discussion may require a different kind of illustration, such as a graph, diagram, or contour map. If the student has actually drawn similar graphic representations, he can interpret these illustrations quickly and with complete understanding. Personal experience on the drawing board with the various graphic methods is the minimum requirement for a graphic mind.

The engineering student devotes a large part of his first two years in college to the study of mathematics, chemistry, and physics. These basic courses provide a background of fundamental principles that are essential to all engineers. Such courses are usually taught by faculty members who have no engineering experience and there is a tendency toward the abstract approach. As most engineers dislike abstractions, the student who is developing a graphic mind has an advantage in his own concrete approach to learning, even where no graphs are employed in text or lectures. Engineering drawing has sharpened his perception by requiring him to visualize the form, proportions, size, position, and function of physical objects. Then his mental vision has been deepened and made more adaptable by the analysis of geometric relationships in the study of descriptive geometry. This rewarding experience helps him to develop a keener insight, which he can apply to his studies to gain a firm grasp of the fundamental principles of mathematics and science.

In the development of engineering education a group of mechanics courses has become the backbone of the curriculum. Engineers must study statics, strength of materials, dynamics, and fluid mechanics to gain a working knowledge of their fundamental concepts. In this setting we can describe the graphic mind and show how it attacks engineering problems. It is a versatile type of intellect that is constantly aware of the graphic nature of things and instinctively pictures ideas in terms of geometric figures.

In the study of statics, for example, we have the basic concept of force which has the properties of magnitude, direction, and position. The mind pictures a force as a vector, a straight line with an arrowhead on it. When drawn to scale the length of the vector represents the magnitude of the force. The direction of the vector is made parallel to the line of action of the force, and the arrowhead shows which way the force acts. If several forces act at a common point, the vectors that represent them are drawn to scale in consecutive order and direction to form a closed polygon called a vector diagram. The closing vector which completes the diagram gives the magnitude and direction of a force that will hold all the other forces in equilibrium, a force equal and opposite to their resultant. If the forces involved do not lie in the same plane two orthographic views of the vector diagram are necessary. In such cases the methods of descriptive geometry are used to determine three unknown forces which act at a common point with a known force, for a system that is in equilibrium. Graphic statics provides a well developed procedure of graphic analysis for accurately determining in one continuous operation the stresses, or internal forces, in all members of framed structures. Graphic statics deals with bodies at rest, but the vector principle is also a powerful tool for solving problems involving motion. In kinematics, for example, vectors are indispensable for representing displacement, velocity, and acceleration, which form a solid base for the study of all mechanisms. Each course in the mechanics group offers abundant opportunities for the application of graphic methods. The solution of mechanics problems by means of vectors and related diagrams clarifies the basic relationships and gives the student a better understanding of every factor involved.

Engineering colleges are expected to develop a program for the training of engineers with ability to do creative work in the field of engineering design. Creative ability calls for originality, resourcefulness, ingenuity, and a constructive imagination. These essential habits of thought can be developed by a progressive program of instruction in graphics. The constructive thinking habits established by graphics courses at freshman level form a sound foundation for continued development of creative mental vision. This may be furthered by requiring the student to make frequent use of graphic methods in subsequent engineering courses. Facility in devising and applying graphic procedures wherever they can be employed to advantage is a necessary skill in all branches of engineering. In advanced courses a series of functional sketches provides the essential framework for the progressive development of ideas in projects designed to promote creative thinking. By clarifying relationships and by revealing possibilities for further development, each sketch gives a better grasp of the problem and becomes a springboard for accelerated progress. Instead of learning how to do specific things in a limited area, the student acquires the ability to solve new problems in unusual situations. Thus the project method, reinforced by a full utilization of graphic aids, offers most promise in college training for the creative practical phases of engineering design.

As education and research are closely related, each helps the other, particularly at the graduate level. Teachers of engineering drawing and descriptive geometry can render a valuable service by acting as advisors to graduate students who are working on thesis projects and by assisting colleagues who are engaged in research. This arrangement facilitates the graphic analysis and interpretation of experimental data. Actual experience in setting up research problems and solving them by graphic methods leads to the discovery of important unsolved problems that challenge our best efforts. The versatility of the graphic approach has been demonstrated in recent research projects. Professor A.S. Levens at the University of California has applied graphic analysis to the successful development of a greatly improved artificial leg for veteran amputees. And at Columbia University Professor H.W. Vreeland is using descriptive geometry methods in the accurate control of radium dosage in cancer therapy. These significant achievements challenge the graphics teacher to devote his talents to research projects in science and engineering.

The future of graphics is of interest to all of us. How will engineering drawing and descriptive geometry be taught twenty years from now to meet the changing needs of engineering education? It is a safe prediction that these basic courses will widen their scope in order to keep pace with the expanding pattern of graphic applications in industry, science and technology. To make the best possible use of available teaching time the problems in engineering drawing should be consolidated to eliminate repetition and duplication of effort. Each problem may well combine many new characteristics of instructional value to the student. In order to simplify drawings and make them easier to read with full understanding, we shall probably adopt an abbreviated method of drafting and dimensioning, featuring the omission of unnecessary details, which will save valuable time on the drawing board. Drafting standards will be revised in keeping with the more efficient drafting methods required by industry.

Courses in engineering drawing will devote more time and greater emphasis to technical sketching. The student should acquire facility in making functional sketches in various technical applications. The drawing project method will offer the future engineer actual practice in developing a real problem which will awaken new interests and stimulate the motivation that spells success in engineering. Affording opportunities for creative thinking, each project would require a systematic approach to the best solution of the problem through the medium of the idea sketch and progressive development sketches. Good judgment will be reflected in the final design sketch and its companion working drawing. Thus the drawing project would give the student the right start in his college training for the design function of engineering.

What future changes are likely in the teaching of descriptive geometry? This applied science provides the necessary background for the study of graphics as an analytical tool. Future courses in descriptive geometry may well condense their treatment of intersections, warped surfaces, and axonometry in order to save at least a third of the teaching time which should be devoted to problems in advanced graphics and an introduction to graphic analysis. This new material should be closely coordinated with fundamental problems in the various mechanics courses and in specialized fields of engineering. Many technical investigations dealing with forces, motion, velocity, and acceleration are based to a large extent upon the use of vectors and related geometric constructions. Wherever the problems involve three dimensions the methods of descriptive geometry can be applied to advantage. An introduction to graphic methods of computation, such as nomographs and graphic calculus, would give the student greater confidence in these useful tools when he encounters them in subsequent studies. Applications of graphic principles to the interpretation of experimental data should be included in the new material of analytical graphics. The illuminating experience of step-by-step graphic analysis will give the student tangible verification of fundamental concepts and require orderly, effective reasoning. This wider scope of instruction will enhance the value of graphics in the education of future engineers.

Many interesting articles have been published in recent technical journals describing new applications of graphics to the solution of technical problems in various fields of engineering, science, business, and industry. This widespread awakening of interest in graphic methods offers a challenge to the teachers of graphics. In closing I would like to urge my colleagues to explore the fertile fields of advanced graphics and to engage in graphics research projects of a fundamental nature. This fruitful personal experience will enrich their teaching of the graphics courses and strengthen the role of graphics in engineering education.

EDITOR'S CORNER

Tenet insanabile multos scribendi cacoëthes
(The incurable itch of writing possesses many)

JUVENAL, Satire, VII

During the last few months some of you, who are the present day leaders in the field of engineering graphics, have expressed to the editor your deep concern about the varied expressions of opinion appearing in articles in the Journal and in the Preliminary Report of the Committee for the Evaluation of Engineering Education. The fact that many of you are becoming intensely interested in trends in engineering education is a good sign that we as a group are prepared to develop and to justify our courses in the engineering curricula of today and the future. In this issue the reader will find two articles which are well worth the time spent in reading them. These papers were prepared by Dean L.E. Grinter, President of A.S.E.E. and Professor F.A. Heacock.

We are in sympathy with the desire of our educational leaders to establish a philosophy of engineering education which can guide the training of our engineers for leadership twenty-five years hence. Should there be trends which will create a change of pattern in engineering education, we must be observant to changing patterns and be prepared to keep in step with developments. If our courses are to meet professional requirements we must join with our colleagues to make a complete study of engineering curricula and arrive at a clear understanding of the objectives of professional engineering education. It is not enough that we establish objectives for our own courses for our objectives must be a part of the broader objectives of engineering education.

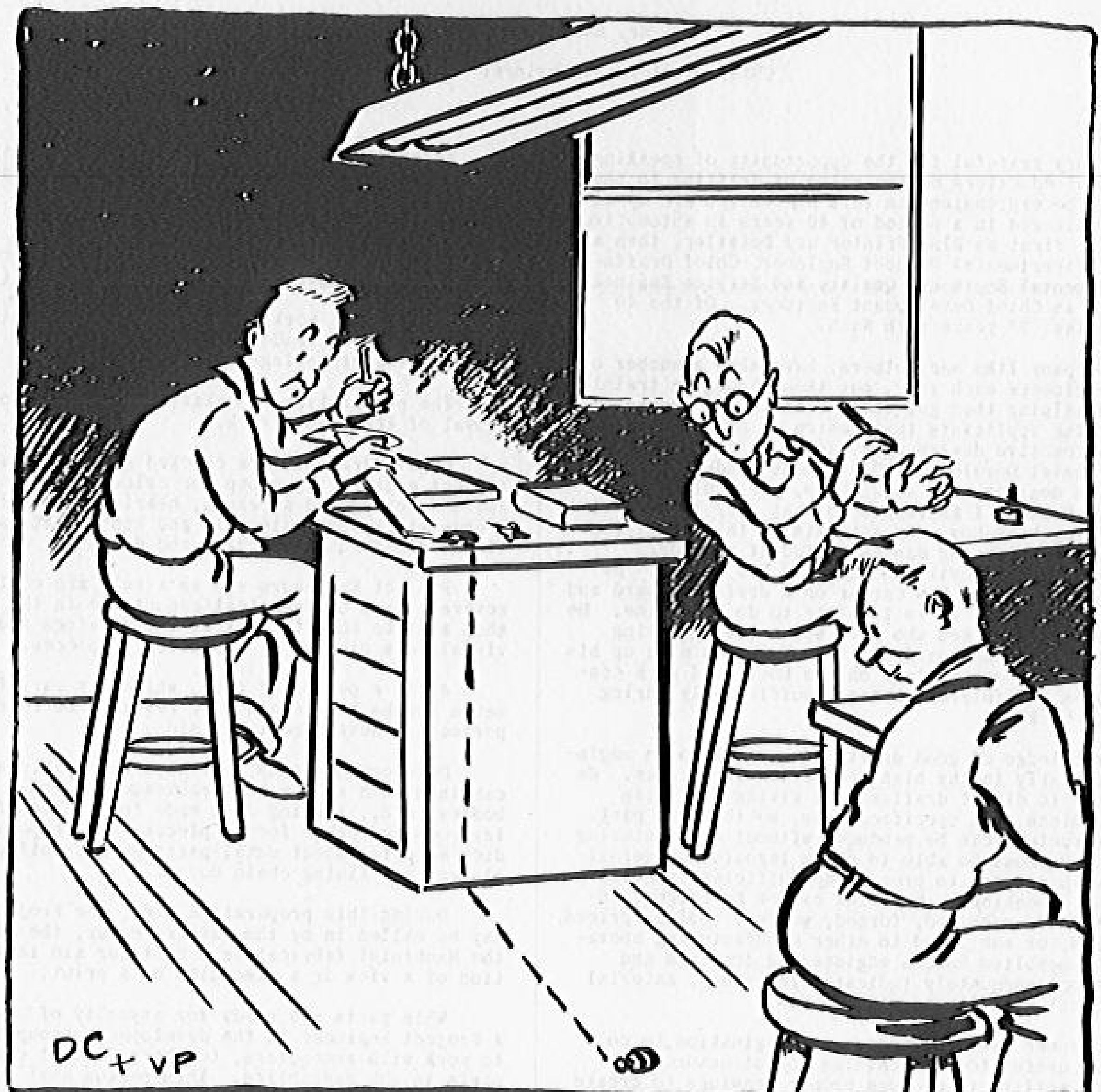
The concept that graphics is a tool for analysis as well as a form of communication and that our courses develop ability in spatial visualization is not new to any of us. Furthermore, the frequent suggestion that more sketching be offered should not cause us to be disturbed. In sketching we have the opportunity to stimulate creative thinking for most creative engineering is started and developed from ideas in the form of sketches. It may also be true that we can present problems to our students which are designed to encourage a willingness on their part to develop novel individual solutions to a particular situation and to exercise some judgment in so doing.

Since educational trends should be nation-wide, changes should be made gradually after careful study rather than by upsetting everything in an attitude of desperation. Changes, if any are needed, should represent the thinking of many industrial and educational leaders.

Carefully directed experimentation should be encouraged if we are to improve our methods of presentation and the content of our courses. An exchange of ideas between institutions should prove helpful in this endeavor.

In view of the fact that many needed changes have been made in our courses over the last twenty-five years we may reasonably expect continued improvement during the next twenty-five.

LIFE'S MESSY MOMENT



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DRAFTING — THE KEY TO ENGINEERING

by

Mr. Earl L. Monson

Chief Development Engineer - Nash Motors

I am very grateful for the opportunity of speaking to a group of educators on the value of drafting to the engineer. The expressions in this discussion are my impressions gathered in a period of 40 years in automotive engineering, first as Blue Printer and Detailer, then a Draftsman, Experimental Project Engineer, Chief Draftsman, Experimental Engineer, Quality and Service Engineer and finally as Chief Development Engineer. Of the 40 years, the last 33 years with Nash.

Our company like many others, has taken a number of graduate engineers each year, put them through a training course and helping them get their feet on the ground in industry. The applicants that desire or show an aptitude for automotive design work, are generally started in the Experimental Development Department conducted by your speaker. In dealing with these boys, particularly the post war graduates, I am impressed that they lack sufficient drafting know-how. My analysis of this condition indicates that the young man as a student considers drafting a necessary evil in obtaining his degree. He has a fear of starting his career on a drafting board and remaining there until it is too late to do otherwise. He has seen or heard of men who have spent their working lives on the drafting board and therefore has made up his mind that he will never start on the board and as a consequence does not interest himself sufficiently during his college work.

The knowledge of good drafting is vital to an engineer, particularly in the high production industries. He must be able to direct draftsmen in giving his ideas form, dimensions, and specifications, so that the part, unit, or structure can be produced without manufacturing confusion. He must be able to check layouts and detail drawings with respect to proper and sufficient specifications and dimensions. Material cannot be bought, inspected, stored, machined, forged, welded, tooled, priced, or assembled, or subjected to other manufacturing operations and assemblies unless engineering drawings and specifications adequately indicate dimensions, material and functional relation to other parts.

An engineer with the necessary imagination to conceive a new useful tool, mechanism, or structure, but without the ability to produce proper drawings to create the product can be compared to a person with a remarkable story in his mind, but unable to write. Neither one has the proper value to mankind. The engineering profession has its language, its alphabet and its lines. These are engaged to express and record a dream or an idea and make it become a reality. Next to mathematics, the craft of the draftsman is foundational to design, fabrication, and inspection of a product. It reveals much more than a photograph.

Let's go through the steps from conception to birth of a unit, say a new automotive engine for a new model car to be placed in production some time in the future. Let's note the importance of drawings in this hypothetical case. The styling, and size of the vehicle have been established, and the approximate weight estimated. The Chief Engineer discusses with management the type and approximate torque and horsepower such a vehicle requires. Following this discussion, the Chief Engineer discusses the subject with the engine design group or possibly his whole staff of mechanical designers. In this discussion the number of cylinders, the bore and stroke, type of engine whether it shall be L Head, Valve in Head of what have you, will be reasonably well established.

Several Cross Sections made by Engine Layout Draftsman under direction of Engine Designer are submitted to management for discussion and final decision on one particular design.

One or more Layouts are made showing complete cross sections and complete longitudinal sections (full size).

This layout work is directed by the Design Engineer and decisions are made following discussions with other members of engineering staff.

The preparation of detail drawings follow the approval of the layout work.

Detail drawings are checked and then passed to the project engineering group for calculations on crankshaft and connecting rod stresses, bearing loads, limit or tolerance stack-ups, material, and heat treat specifications, dimensional checking and dozens of other items.

Project Engineers who as a rule are college men with several years of practical experience in the experimental shop must be able to look at the drawings and immediately visualize a picture of the piece or pieces.

After a period of time, which may vary from five to seven months the details are ready to be released to Experimental Development Division.

Development group must have wood patterns made for castings such as for the crankcase, cylinder head, pump bodies, etc., forging dies made for crankshaft, connecting rods and other forged pieces, and temporary forming dies made for sheet metal parts such as oil pan, side plates, and timing chain cover.

During this preparation time, the Project Engineer may be called in by the Pattern Maker, the Die Maker, or the Machinist fabricating a part for aid in interpretation of a view or a dimension on a print.

When parts are ready for assembly of say ten engines, a Project Engineer in the development group is assigned to work with assemblers, to check fits of correlated parts in sub assemblies. This person must constantly check against print dimensions and tolerances for interferences in order to be able to submit a coherent report to the engine design group for necessary changes.

Approximately a year of development and testing time is required before the drawings can be released for tooling and subsequent production of the engine. It would take a great many hours to give a clear picture of what goes on during the year I speak of, but that is not important here. I intended to bring out the importance of the drafting know-how necessary in the creation of the subject unit.

Before final release of the drawings for production, the development group screen all detail drawings checking against development and test data to make sure that all required changes are shown on the drawings. This group also must have an intimate knowledge of drafting in order to properly examine the final drawings.

I maintain that the student can not hope for success in an engineering position in industry if he is not familiar with the fundamental subjects of all technical activity, - Engineering drawing and Descriptive Geometry.

SOME GLEANINGS FROM COMMERCIAL ART

by
R. C. Carpenter
Purdue University

Anyone who has been around drawing for any length of time, either in the realm of practice or instruction, knows that he is called upon rather frequently to do some extracurricular work -- quite often on a project and in a field with which he is not too familiar. It is with the idea of being of some assistance to anyone confronted with the unexpected that the author, fresh from several years association with publishing, advertising, and the graphic arts, has ventured to jot down the ideas that follow.

We all know that there are "tricks in all trades" and commercial art has at least its full share. While not all of the following will be useful or novel to any one reader, it is hoped that a few will find something to see them through a perplexing job.

I. USE OF THE PEN

The commercial artist, working in black and white, is, like the draftsman confronted with myriad straight lines. He is usually extremely facile with the T-square, triangles, and the ruling pen. But, because of the time involved in filling and adjusting the ruling pen, he often uses a common pen to draw straight lines in ink.

Using an ordinary stub pen and a ruler with a metal edge, he can draw much more rapidly and with considerable more freedom than if he confined himself entirely to the ruling pen. The trick is mostly confidence. Tip the ruler towards you a little with the fingers of the left hand, place the nib of the pen firmly against the metal edge -- and draw. With a little practice, your line will have all the pristine crispness of one made by the ruling pen.

Of course, this method permits drawing only one weight of line. But with two or three size pen points mounted individually in holders, it is surprising how much latitude in the weight of lines can be secured. And as far as speed is concerned, this method must be at least twice as fast.

When drawing for reproduction, the use of opaque or Chinese white is commonly used for making corrections. Not so common is the use of lampblack to correct lines or black areas which must be drawn over areas already touched up in white. The trick here is to use a good red sable brush of about #1 weight, tip the ruler, and draw with the brush in much the same manner that the straight pen is used.

Lampblack water color is obtainable at any good supply house that handles draftsman and art supplies.

II. SHORT CUTS ON COLOR

Many of us are confronted with finishing a poster or similar job that requires the use of one or more colors. While tempera and show card colors are fairly familiar, not so many seem to know how to use pastel, while is a flexible medium and ideal for use in rendering a flat color background.

The best product on the market for this work is Nupastels, a favorite for layout in advertising concerns. The sticks come in assortments of up to 48 colors, are hard enough so that they do not crumble badly and are capable of making a straight line in skillful hands.

Let us assume you have an area 7" x 9" which you desire to color uniformly. Rule off the area with a hard pencil. Place a sheet of paper along one edge; hold it down firmly with one hand, while you push the pastel over the edge of the paper onto the area to be colored. As soon as you have colored the complete side of the area, use your finger as a stump and rub the pastel firmly into both the paper and the colored area. When you remove the paper you will have a line as straight as if done with a straight edge.

Or, let us suppose your hand slipped; you have smudged your line a little in one place. Put the paper back over the colored area. Line up a kneaded eraser and go as close to the edge of the paper as you care to. A little patient rubbing will correct your smudge.

Only a little practice is necessary to become quite proficient in the laying of pastel. When the four edges of your area are finished, go in boldly and rub the pastel over the remainder of your area. After you have the pastel laid in the areas desired, be sure to blow on fixatif which will stop any further smearing. The surface will take any additional ink or paint you wish to apply.

Another useful way to use pastel is to completely cover a sheet of paper a little larger than the area you desire to color. When complete, and fixatif has been applied, cut out the paper to the required size and mount it in place with adhesive.

The adhesive for this purpose can be rubber cement with which nearly everyone is familar. However, a new product known as poster cement should not be overlooked. This adhesive requires spreading on only one of the two sheets to be attached. Put it on one surface, let it dry completely, then press it down firmly against the other surface -- that's all there is to it.

While poster cement is cleaner, easier to use, and does a job more neatly than rubber cement, it has two disadvantages:

a. The union between paper is not as strong as that between two surfaces of rubber cement which have been allowed to dry separately.
b. A paper that has had poster cement applied to it cannot be laid down on any kind of surface without sticking. This usually means areas must be cut with scissors rather than with a razor blade.

III. TRACING AND ENLARGING

Sometimes it is desired to trace large letters or a design onto bristol board or some other drawing surface. The lettering can be worked out in detail on tracing cloth, layout or bond paper. If the latter two are used, the back of the paper can be rubbed with graphite, pencil or colored pastel. If much of this work is done and exceedingly fine lines are used, a special paper for this purpose may be prepared by pouncing English vermilion on both sides. The paper can be used for tracing for a long period of time -- one application of the vermilion is suitable for almost one hundred ordinary tracings.

Another trick worth knowing is that of enlarging or reducing "on the diagonal." Suppose you have a design you wish to draw to a different size. Take any convenient measurements and enclose it in a square or oblong.

Draw the diagonals between the four corners. Draw a horizontal and vertical line through the center. Now with the oblong divided into quarters, begin again and divide the quarters with diagonals. This goes on until you have your lines complex or fine enough for your purpose.

To enlarge the design, draw another oblong of the size desired. The only requirement is that the diagonals be the same.

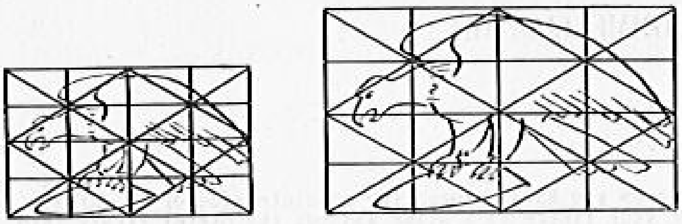

Figure a.

This system has several advantages over the better known enlargement or reduction by squares since no exact relationship between squares need be measured off. In fact, no measurements of any kind are necessary once the size of the two objects is decided upon.

IV. SIMPLE ARTIST PERSPECTIVE

One of the greatest differences between the artist trained in an art school and the draftsman or engineer is

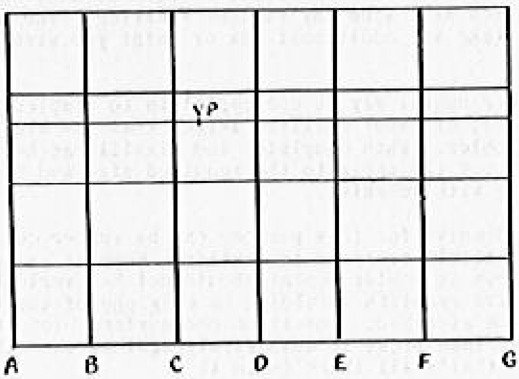

Figure b.

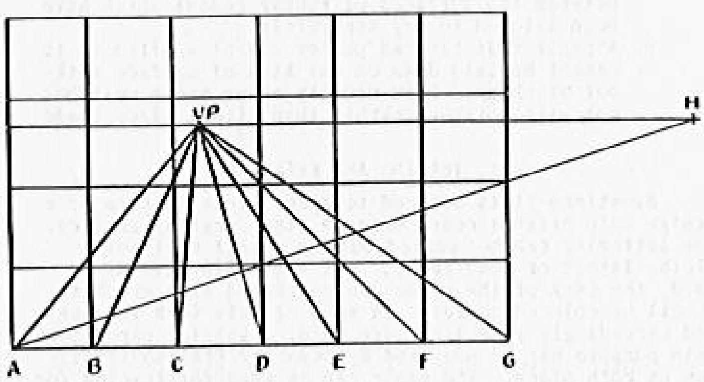

Figure c

the manner in which they apply perspective. Without going into a discussion on this rather involved subject, I should like to point out a simple method of obtaining pictorial perspective.

a. ONE-POINT PERSPECTIVE

Measure off an oblong which will become the picture plane. Select a point as the vanishing point. Draw the horizon through the vanishing point parallel to the bottom line of the picture plane.

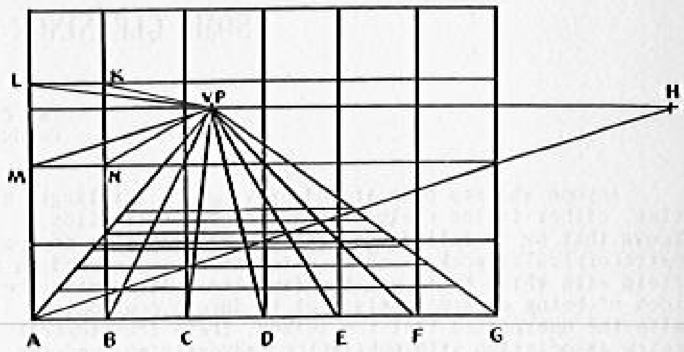

Figure d.

Now divide the picture plane into any number of convenient squares:

From the points on the bottom of the picture plane, labeled A through G, draw diagonals to VP. Next, from A draw any suitable diagonal to a point on the horizon such as H.

Where the line AH crosses each of the diagonals, B-VP, C-VP, etc., draw a line horizontal to line AG. These lines will end by giving you a complete set of squares in perspective which are proportioned for measurement. By drawing diagonals from other points above such as K, L, M, and N, to VP, vertical perspective may be obtained by extending verticals from the points on the horizontal grid.

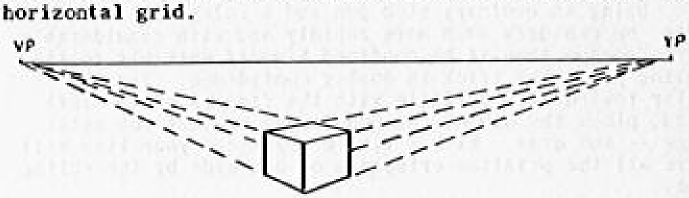

Figure e.

b. TWO-POINT PERSPECTIVE

Let us start by selecting a horizon and two vanishing points. Next, set up an arbitrary unit of measurement -- a cube. Draw the necessary lines by projecting from the vanishing points.

We can assign any measurements we desire to the dimensions of the cube. For example, let us assume that we wish to make a perspective drawing of a house, the measurements of which are 20' x 25' x 22½'. We assign values of 5' each to the sides of the cube.

We then proceed as follows:

1. Draw diagonals AC and BD.
2. Draw vertical line EF.
3. Draw GH and project to VP.
4. Draw BH and project to extension of AD. This will be point K.
5. Construct a vertical line at K. This will be the side of a second cube, distant 10' from A. The third cube could be constructed in like manner but let us jump instead to the construction of the fourth cube.
6. Through J, draw line BJ and extend to the continuation of line AK. Label this point as L. It will be 20' from A.

In similar manner we can obtain 5 cubes to give us the length of the house. The vertical edge of the cube can be duplicated a sufficient number of times for vertical measurements. Thus we obtain a drawing shown in Figure g.

The roof line has been drawn in with heavy lines. Additional details are evolved in similar fashion.

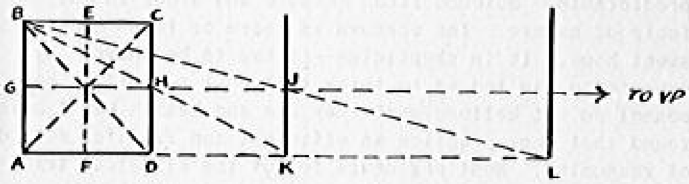

Figure f.

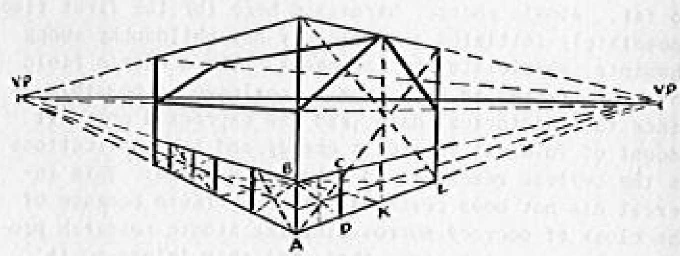

Figure g.

USE OF GRAPHICS EXPLORED

The use of graphics as a method of clearly expressing ideas or conveying instructions is a field virtually untouched by industry and the armed forces, and this presents a real challenge to educators, it was stated at the first Engineering Graphics conference at Purdue University, November 20, 1953.

Approximately 70 persons representing a number of universities and several leading industries attended the exploratory meeting, which was the first of its kind ever held.

Among the schools represented were the University of Wisconsin, University of Michigan, Michigan State College, Ohio State University, Wayne University, and the U. S. Military Academy at West Point, as well as the Naval Ordnance department, both Indianapolis and Washington, D.C., and the General Motors Institute, Flint, Michigan.

The urgent need for men trained to express thoughts and directions by means of the written and spoken word as well as by engineering tools and graphical aids was discussed by several speakers. Graphical methods have unlimited uses it was stated.

Prof. J. Howard Porsch, of Purdue, conference chairman, spoke on the scope of graphics. Various techniques in using these aids, including delineation, analagous representation, problem solutions, computing devices, and reproduction processes, were discussed by other staff members.

Representing industry on the program were F.A. Ryder, Stewart-Warner corporation; G. E. Chapman, Allison Division of General Motors; G. F. Switzer, Indianapolis Power and Light Company; W. V. Covert, Diamond Chain Company; K. L. Nielsen and E. B. Godley, U. S. Naval Ordnance, all of Indianapolis; and M. P. Fodroci, Studebaker Corporation, South Bend.

Six states and the District of Columbia were represented by those in attendance.

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ENGINEERING DRAWING IN THE ATOMIC ENGINEERING FIELD

by
Eugene H. Brock
Texas A & M College

Of foremost interest to all engineers today is the field of Atomic Energy. Hence, quite properly and logically, we in the collegiate teaching profession are all particularly interested in how this relatively new industry will effect, if any, our present and future academic responsibilities and curricula requirements. The object of this paper is to establish and perhaps clarify the position of technical drawings in the atomic industries as well as its value as a basic tool of the engineer working in that industry. It will perhaps be easier to evaluate these facts by separating the discussion into two parts. It seems feasible to entitle these parts, "What is an Atomic Engineer," and, "Drawing as a Catalyzer in the Engineer--Scientist Relationship."

I wish to point out before beginning any discussion of these two important topics that security regulations pertaining to anything "atomic" will prevent any reference to actual work being carried on in the various atomic research plants. This fact will also eliminate references and illustrations of engineering working conditions that I would like to bring to you if it were not for these restrictions.

Let me begin with a bit of atomic history. The atomic age burst into being on a hot July 16th, 1945, the actual time being 5:30 A.M., Mountain War time. This event is perhaps the greatest single act in our history and certainly is the greatest challenge by man of nature so far. Atomic energy, harnessed here for the first time, immediately initiated a completely new philosophy among chemists, physicists and engineers. The academic field has appropriated as much atomic knowledge as possible since that historical date, and has expressed no small amount of interest in atomic energy and its implications in the college research and teaching program. This interest has not been rewarded with many facts because of the cloak of secrecy surrounding the atomic research program. However, I believe that when this 'close-mouth' policy is discarded our colleges will begin immediately the development of techniques pertaining to fundamental industrial practices. Many men will devote the best of their knowledge and imagination, their enterprise, and above all, their patience and wisdom to the development of the atomic sciences. It is not inconceivable that our institutions will expand their curricula to include a definite program for the undergraduate in the atomic sciences and atomic engineering.

While the influence of atomic energy may be more significant in the science curricula than in engineering, a certain mastery of engineering fundamentals and a discipline in engineering methods must be included in any course of study which pretends to prepare the student for work in the atomic industries. Perhaps the field of engineering education which will be influenced most is that beyond the undergraduate program in the graduate and post-collegiate years. I stress this fact because most of the atomic developments pertaining to engineering have been in fields of application rather than in basic theory.

I hope this very brief initial discussion of where I believe the academic element fits into the atomic development pattern is not considered more than just a small bit of philosophizing on my part. I have very few facts with which I could substantiate a sound approach to academic requisites in this varied work.

Let us get back to the first portion of the discussion, "What is an Atomic Engineer?" Basically he is the same fellow you saw graduating earlier this month in any one of the various engineering courses in which your college offers a degree. Perhaps he will need several years of good practical application of the knowledge he has gained in his collegiate studies before he is qualified to work as an engineer in the atomic field. But this is true in most branches of engineering. Upon entering the atomic industry he will immediately find himself associating with the so-called "long-hairs"; the chemists, mathematicians, astro-physicists, nuclear physicists and other related theoretical personnel. He must work in complete harmony with this group if he is to accomplish his objective of becoming an "Atomic Engineer." I am using the term "Atomic Engineer" rather loosely because actually the engineer will retain his identity in his chosen engineering field. He may be a mechanical engineer, or on the other hand an electrical engineer, but in all instances, he will be faced with the task of becoming familiar with those things pertaining to atomic research. The engineer must accept the philosophy of the theoretical groups. His is a dual role. He must think as an engineer-practically and objectively, but he must further conceive the philosophy of the associated theoretical scientists.

Science has a passion for the repetitive and predictable. Science finds measure and order in the facts of nature. The unknown is 'more or less' home sweet home. It is skepticism--it has to be shown. My experience has led me to think that most scientific personnel do not believe what they see and hear. But I have found that they practice an efficient and fruitful method of reasoning. Most engineers follow the classical tradition of indulging them. This cannot be true for the atomic engineer. He must consider the scientist as a fellow traveler and in many instances throw aside his own mannerisms and accept this new friendhip in its entirely.

I do not wish to imply that the engineer follows the leadership of the scientist in all instances. This is far from true. Nearly all of the research centers dealing with the various phases of atomic energy have an engineering department entirely unattached to any other section of laboratory personnel. Normally this group of engineers involves itself with solving process problems, design of and/or improving structures, time and motion studies, improving of existing plant facilities augmenting the engineering personnel of research groups when needed. Individual sections are established in civil, electrical, architectural, mechanical, and chemical engineering. These groups are closely related to the research sections, but do not ordinarily concern themselves with the original conception of a design. Theirs is the problem of carrying to final design stages those ideas which have been originated and carried through the preliminary stages in other sections of the research establishment.

Then there is the group of outside engineering firms which carry on the design of very large projects--particularly where outside construction contractors are to be called in for construction bids. Since these firms do not have an understanding of the construction problem assigned, there is usually from one to three engineers from the research establishment who work with them until the design is completed. Other engineers follow the construction until it is completed. For your interest all such personnel normally have the same FBI clearance as required for research personnel.

My particular problem as an engineer in the atomic program was to assist in the development of housing for various research or process equipment and in many instances design the equipment used in the two phases. We all learned to work together and in many instances gained considerable knowledge of each other's work. This fact not only made mutual respect possible, but made it possible to work out more economical and efficient solutions to the many and varied problems. I have always believed that such an understanding of the other fellow's problems made for better engineering.

As I look back to my initial training period I have charged myself with six months for the purpose of gaining knowledge and developing new work habits. This was a different but interesting six months and I learned much. As a matter of fact, after this trial period the engineering actually became a very simple thing. (Much of the factual data that I had obtained in my formal education I soon discarded as excess baggage--) During the training period one very important fact came to my

(Continued on page 36)

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(Continued from page 34)

attention. It was the discovery that the most important tool we had was engineering graphics. Frankly, it was the only real common language we had. Nearly every problem was new; and every problem created a need for new engineering developments. We sketched and threw the sketches away and sketched again. But each sketch made for progress and we could all see what we were trying to do. We were all in the same conversation. The engineer needed the research man and in turn the research man needed the engineer, but each needed a means of clear-cut communication. Along with the discovery of the importance of the graphic language I found that neatness and accuracy was a requisite of understanding; I hope that each of you are stressing this fact in your classes. In our work, those engineers who fared the best invariably were those who had good grounding in the basic sciences and who were able to visualize from a few facts a spatial picture, and secondly, who were able to develop graphically the spatial visualization. I do not believe that the engineer has too many sources of opportunities to develop either of these latter points except in his basic engineering drawing courses. I know that you will bear me out in this very important point.

The last few points I have made tend to lead me directly into the second phase of this paper: "Drawing as a Catalyzer in the Engineer--Scientist Relationship."

I have attempted to stress the fact that engineering graphics is the common language of the engineer and the scientist. This is true wherever this association exists. It is not pecularly singular to the atomic energy field but it is of peculiar importance in that field because of the continuous program of development. It is important because of the spirit of trying the new and because a two-way conversation in which both parties understand each other completely must be possible. I sincerely believe that engineering drawing, or whatever you have named your technical drawing, is the most complete and satisfying answer to this problem.

Drawings have been a means of recording ideas and events since the time of Solomon's Temple, but the language of drafting as we know it today is a rather recent introduction to the technical field. Drawing, like engineering, is not a static course and I know that each of you are continuously attempting to improve teaching methods and that you are continuously asking yourself this question, "What part of the drawing courses should I emphasize?" and, "Should I offer more freehand sketching?" and I am sure many other important questions. While I believe personally that all of us should make every effort to improve methods of presentation and contents, I believe that the most important phase in our teaching of technical drawing is that part which leads the student to realize the significance of his drafting courses to his future in any engineering profession or allied fields. I want to emphasize this point because I believe that one of the most important items in the learning of engineering drawing is the desire to become efficient in drafting --both in theory and in technique. I found that more than 75% of those engineers concerned with the atomic energy program had to do some sort of drawing--freehand or otherwise. I stated previously that those engineers that seemingly got along the best were those who were proficient in this seemingly menial task. I have also stressed the development of the spatial visualization faculty. The failure to conceive mentally is in too many instances due to the lack of practice. Preparatory and high schools do not require students to do spatial visualization. The speed of travel in the average college technical drafting course does not allow much time for acquiring this facility unless the student is willing to practice as he goes about his daily chores. Many young engineers whom I contacted were pathetically short of this very necessary requisite of success and were retarded in their advancement. Most of the other difficulties that atomic engineers seemed to develop were the results of sloppy work. Work always slowed down when sloppy drawings were used in planning meetings and I noted that many of the scientific personnel seemed to measure one's ability and thinking by the character of drawings presented. I don't wish to imply that good draftsmanship was their sole gauge of engineering ability, but it was unmistakably one of the measuring sticks used. I have pointed up briefly a few requisites and some of the difficulties which are common in the atomic energy engineering work and which you are well aware of as being common to all engineering departments. So you see problems in atomic engineering are the same as would be normal in any engineering position and much of it follows the same routine practice.

ASA graphical representations are adhered to in nearly all graphical presentation. Such a procedure is essential since much of the manufacturing of engineering equipment is done by sub-contractors not directly connected with the atomic program. All of the drawings follow the normal view procedure with as many notes as deemed necessary.

Briefly summarizing those facts which seem to have bearing upon our common interests in the technical drawing field and their relationship and use in the atomic engineering field I find that:

1. Freehand sketching is a very important tool in that it provides a quick and efficient means of keeping up with the thinking at a planning or developmental meeting of engineers and scientists.
2. Technical drawing is a common language that permits the atomic scientist and the engineer to understand each other's problems.
3. The ability to visualize as one would learn in technical drawing is of major importance to the atomic engineer.
4. And the ability to transmit the spatial visualization to graphic presentations is very essential.

As a final summary of this paper I would like to add that I do not believe that the atomic engineering curriculum, should such a program develop, will effect the requirements or contents of our present drafting courses. I do not believe any changes above the normal good practice of continued improvement is essential.

ENGINEERING DRAWING

By JOSEF V. LOMBARDO, Queens College;
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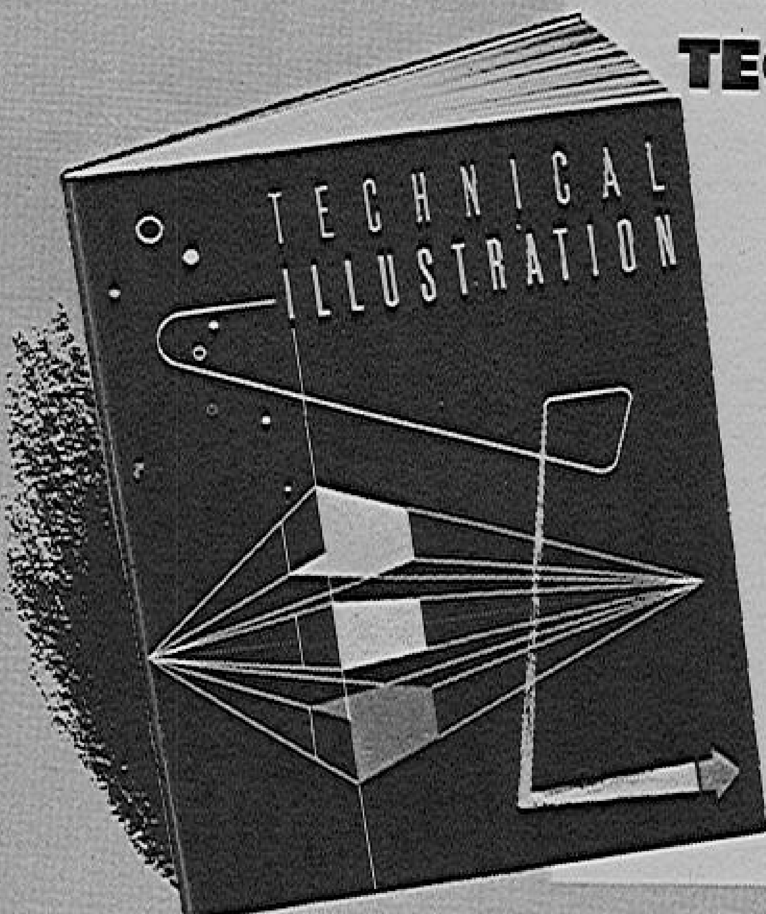

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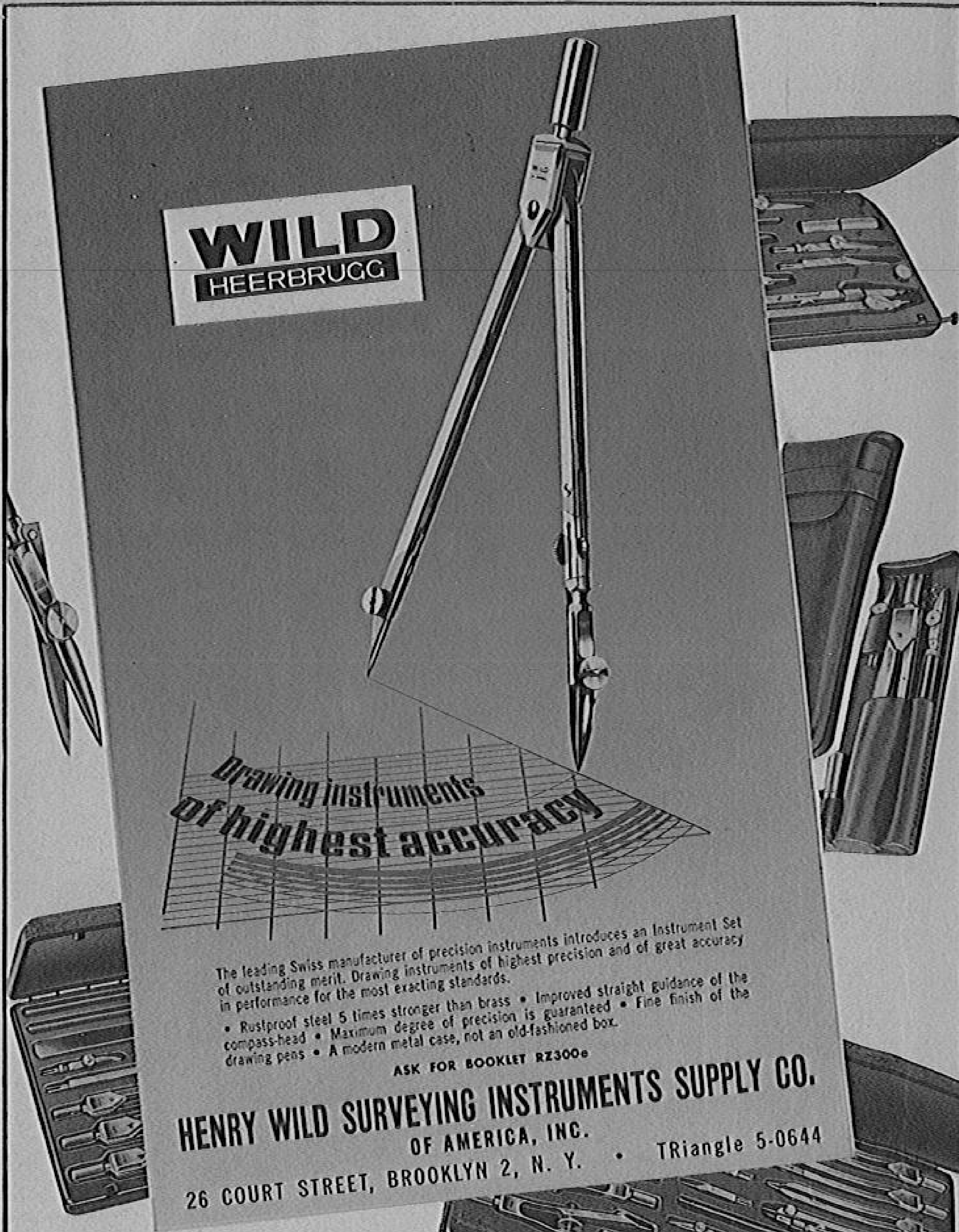
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