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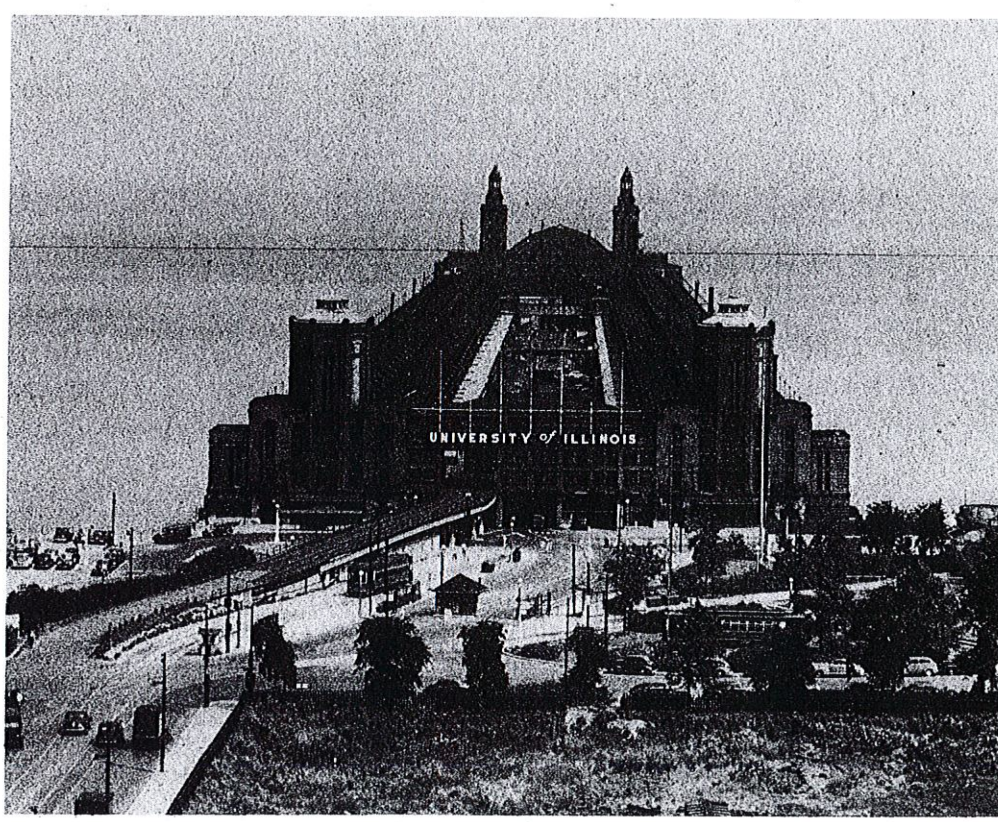

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CONTENTS

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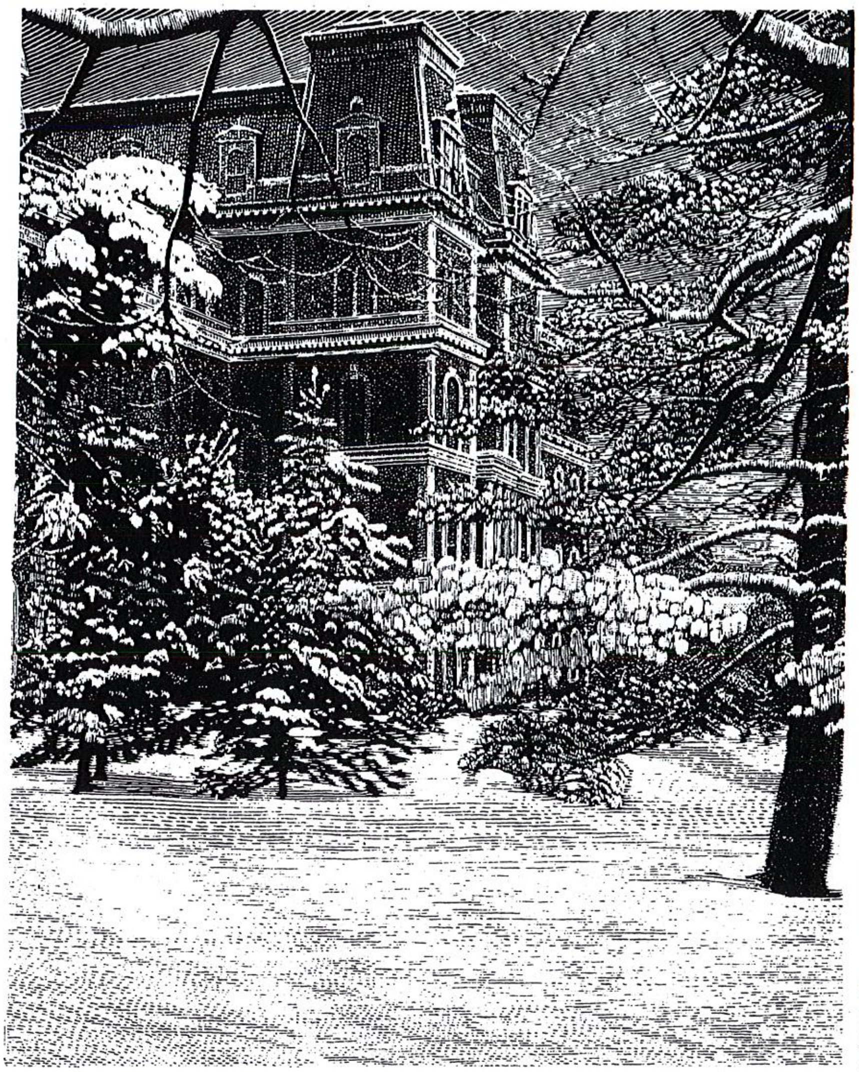

EDUCATION

I read, I study, I examine, I listen, I reflect and out of all this I try to form an Idea into which I put as much Common Sense as I can.

Marquis de Lafayette, Dec. 1777

Education: Reproduced from an original wood engraving done for Lafayette College by Warren B. Mack, A. N. A., Lafayette '15 PhB, 46 ScD.

A MESSAGE TO THE MEMBERS OF THE DIVISION OF ENGINEERING DRAWING

by

Prof. Frank A. Heacock, Chairman,
Division of Engineering Drawing A.S.E.E.
Princeton University

In all engineering colleges and universities across the land thousands of new students are thronging into our drafting rooms eager to learn how to read and write the universal language of drawing. It is our responsibility to start their engineering education by giving them thorough training in drawing and descriptive geometry. Let us re-examine our courses and teaching methods with a critical eye, guard against the danger of complacency and pet ideas, and make sure that each lecture and problem really contributes to effective teaching.

To promote maximum efficiency in a long range program we should endeaver to:

(a) make the best possible use of the time given us for the teaching of engineering drawing and descriptive geometry;

(b) keep in close touch with our colleagues in other departments to make sure that they insist upon and maintain throughout upperclass years the high standards of quality performance in all graphical work which are required in our basic courses in drawing and descriptive geometry, and also to learn what new problems can be included in our courses to give best preparation for subsequent courses and professional training;

(c) widen our horizons and expand our interests in scientific graphics in order to give our students that broad and thorough training which will encourage them to think graphically and to devise and apply graphical methods wherever they can be used to advantage.

Last spring the Committee on Advanced Graphics was appointed, consisting of Professors J.N. Arnold, A.S. Levens, H.M. McCully, J.T. Rule, and F.A. Heacock, chairman. This committee met in Minneapolis and adopted the following statement of policy:

Graphical methods have, in general, been developed for specific application in widely varying fields. Such methods are, therefore, uncorrelated and their underlying principles have not been analyzed and unified.

The purposes of this Committee are, consequently:

1. To collect and analyze graphical methods in use in all scientific fields;

2. To classify and integrate into a consistent pattern the underlying graphical principles involved;

3. To circulate this material in convenient form for use by teachers, engineers and scientists.

If this project is to be successful, it is essential that we secure the interest and cooperation of the teachers of drawing and descriptive geometry so that we may all work together in harmony to our mutual profit and satisfaction. We look forward to a constructive educational program of service directed particularly to benefit the engineering drawing departments. We favor a conservative approach. We shall not try to reform anyone nor urge drastic changes in course content or teaching methods. The inherent advantages of new graphical methods will be pointed out and the correlated material will be made available to those who wish to use it.

There are several ways in which a drawing department could participate in this project to advantage. A limited quantity of carefully selected problem material forming an introduction to advanced graphical methods could be included in the regular required courses on an option basis. Students of exceptional ability with previous drafting experience or training could be allowed to omit certain regular problems after satisfactory proficiency tests and they could be encouraged to devote the time thus saved to work on advanced graphics.

Elective courses could be offered which would include a wide range of graphical methods properly unified and adapted to the specific needs of the student groups. Such a course at the senior level devoted to the graphical analysis and solution of engineering problems would serve a most useful purpose.

A member of the drawing department staff could become actively engaged in a research

(Continued on page 35)

METHODS OF PRESENTING DIMENSIONING

by

Prof. R. E. Machovina,
Ohio State University

It is generally agreed that the dimensioning portion of an Engineering Drawing course is more troublesome for both students and teachers than any other phase of the subject. In an effort to improve the situation, the writer undertook a program of study and analysis in which some of the major and minor points of difficulty were exposed and means devised to alleviate them. Teaching methods incorporating these were developed which, toegther with a new teaching procedure, have given results considerably better than formerly obtained. The procedure also coordinates the study of dimensioning with that of working drawings through the use of a problem in which the selection of the dimensions is largely a student exercise.

For purposes of study, the subject of dimensioning was divided into three phases: 1) selection, 2) placement, and 3) technique. The meaning of "selection" is obvious, while by "placement" is meant the positioning of the dimensions on the drawing once they have been selected. By "technique" is meant the general information as to what a dimension is, its makeup, the actual delineation of the components, the special types and conditions such as radii, notes, limited space, etc., etc.

Most of the material presented in drawing courses, prior to the dimensioning phase, is factual in nature. Also, it is probably true that most of the other courses taken by the student to this stage in his career have been predominantly factual in content. By and large, he has yet to encounter those aspects of learning in which it is difficult or impossible to classify particulars as to right or wrong with which the correctness of decisions is a matter of degree on which opinions may differ. The engineering student is handicapped more in this regard than most other students due to the nature of his studies.

Expose this student, then, to the principles of dimensioning. Unless carefully guided in his thinking processes, each statement of the instructor and each textbook principle tends to become a hard and fast rule. Accompany this with the many discrepancies and conflicts constantly arising, and the result will be confused students whose lack of comprehension comes mainly from not being able to realize that in many situations the possible solutions cannot be classified as right or wrong. The condition will be intensified when the instructor gends to be dogmatic in his explanations and in the solutions which he will accept.

The material covered in the "technique" phase of dimensioning is almost entirely factual in nature. Experience has shown that students have little difficulty in comprehending this phase of the work. The most trouble is encountered with the "placement" and "selection" phases, particularly the latter; it is with these that methods of teaching fail which are based on facts and rules alone.

One of the principle objectives when teaching dimension "selection" and "Placement" should be to develop the student's reasoning ability and power of judgment to the place where he can make satisfactory decisions when conflicting conditions appear. A background of factual information for placing and selecting dimensions must be provided as a foundation upon which this ability can be built. He must early be made to realize that much of this information, although taught as rules or principles, is not inviolable, and conflicts frequently occur. He must realize that a good solution under certain circumstances may be poor under others.

The most valuable teaching aid for developing student sense of judgment in dimensioning is the lecture-demonstration. In these, the student should hear an unbiased and logical explanation of the dimension selection and placement for a fairly large number of typical objects. Above all, the explanation must be completely logical to the student, or there will be little increase in his power of judgment, and the resultant ability to handle similar situations.

In his lecture-demonstrations on the "placement" of dimensions, the instructor should show the application of the "contour principle" together with other carefully chosen principles or rules for placing dimensions on the drawing. Examples of conflict between principles should be pointed out, and logical explanations made as to why precedence is given one principle under certain conditions and another principle under other conditions. The instructor should explain why each dimension is placed where it is and not in other possible locations. Instances should be pointed out where several positions are equally good or nearly so. A gratifying increase in the student's reasoning power and judgment has resulted from the use of these lecture-demonstrations.

Judgment in selecting dimensions must be built on factual information which is most useful if it can be given to the student in the form of guiding principles. Such principles should be based upon the main factors affecting the selecting of dimensions.

If all of the factors which at one time or another influence the selection of dimensions were listed, an imposing list would result. For a part of a given type, to be produced by a known method of manufacture and to be used in a certain way, the factors influencing the selection of dimensions are greatly limited. When the above conditions are not know, it is practically impossible to arrive at a "best" collection of dimensions would probably change. When experienced draftsmen know these

(Continued on page 12)

HUMANISTIC-CULTURAL CONTRIBUTIONS INHERENT IN AND CLOSELY ASSOCIATED WITH ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY *

by

Prof. F. G. Higbee,
University of Iowa

I have been invited to present a phase of the teaching of Engineering Drawing seldom--if indeed ever--discussed in this organization. The general subject of the humanistic-social-cultural content of the engineering curriculum is somewhat new in engineering education itself. All of us are aware, of course, that powerful influences in the field of engineering education have recommended that a greater amount of time be assigned to the study of non-technical subjects broadly classified as humanistic-social studies. We are aware that faculties all over the country are proposing changes in the engineering curriculum to comply with this recommendation. I have heard casual references in informal discussions, and I have listened to some off-hand remarks on the subject, but so far I have no knowledge of a critical and analytical study being made concerning the contributions inherent in and closely associated with engineering subject matter.

At this meeting I propose to discuss with you the Humanistic-Social-Cultural contributions inherent in the subject matter in which we as teachers of engineering drawing are concerned. Because I propose to be as realistic and as specific as possible I wish to establish a common view point from which we may examine this matter together and, I hope, with benefit to ourselves as teachers and to our students.

Therefore, let it be understood when I use the term "engineering drawing" it is being used in the broadest sense and includes all of the subject matter in which we, as teachers in a broad field, are interested. In using that term I am in reality referring to the language by means of which engineers explore, record and transfer ideas.

To reach a common ground of understanding of the phrase "Humanistic-Social-Cultural" content of the engineering curriculum I feel obliged to elaborate. I am not too sure engineering faculties and engineering administrators completely grasp the general idea included within and intended to be expressed by this somewhat vague and over-elegant phrase. And I am inclined to believe that engineering students are re-acting to the introduction of such study somewhat as they would if they were about to be required to attend daily chapel.

I hasten to assure you I am not looking down my academic nose at this undertaking. I am regretting merely that an idea of such importance is being received with some skepticism rather than in an attitude of fair appraisal. Therefore, I hope in this discussion to present some rather basic ideas which seem to me to be related to this matter and very significantly related to the contributions which teachers of engineering drawing may include as their responsibility.

To begin with, we might discuss briefly what we expect to accomplish by the processing called engineering education. I think I am within conservative bounds in stating that there is a general agreement among informed persons that engineering colleges have done an acceptable job in training students in the fundamentals of engineering and of giving them a reasonably good understanding of the specialized fields of engineering in which they have chosen to major. Let us assume then we are agreed on this and focus our attention on those elements of an engineering education over and above and beyond the acquisition of technical knowledge.

Whether engineering colleges are aware of their responsibility in these associated areas of education and whether being aware of this responsibility, they are meeting it, may not be too completely evident. Certainly there is a clear duty, however, to carry on engineering training in such a fashion that embryonic engineers become indoctrinated with ideals appropriate to the character of their chosen work. The ideal engineer,-and I concede I am voicing but one man's opinion-should be possessed of a rugged and unskakeable integrity; his personal and professional ethics should be above reproach; his standards of conduct and of performance should be of the highest; his intellectual honesty beyond question; and he should be a person who can take his place in professional and intellectual society with dignity, grace, and equality.

The questions may well be asked: "Can such qualities and characteristics be taught?" Is the development of en embryonic engineer into a professional man with ideal qualities likely to be promoted by the inclusion of new subject matter in the curriculum?" What subjects can be introduced into engineering curricula which will make teachers think of engineering education as two words -- 'engineering' <u>and</u> 'education'--rather than the couplet 'engineering education'?"

The answers to these questions so far have been a recommendation to include such subjects as history, literature, economics, psychology, and the like. No teacher can very well object to either the idea or the subjects; we all know that study of such character is broadening and informative. Yet in my judgment the greatest benefit likely to accrue to engineering students from such study is not in the nature of the subject matter so much as it is in the challenge of new ideas, the stimulation of enlarged thinking, and in the manner of presentation. The only criticism I have to offer toward this general program of adding humanistic-social studies to the engineering curriculum is that we

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* Presented at the Mid-winter meeting of the Division of Engineering Drawing, December 27, 1947, Detroit Michigan.

have never completely explored the possibilities of teaching a normal engineering curriculum so as to include this type of culture as a by-product of our own engineering teaching.

In my way of thinking of this matter we are now at its very core. What contribution can engineering drawing teachers make toward the development of the professional engineer by the impact of new ideas, the stimulation of enlarged thinking, the creative atmosphere of enriched presentation, over and above and beyond the acquisition of engineering subject matter?

To make any kind of a contribution the engineering drawing teacher must have a background. It goes without saying that he himself must be a professional engineer of the quality suggested; he must be a good teacher with the best and the broadest ideals of that calling; he must be possessed of inner resources over and above the subject matter he teaches and surrounded by teaching associates emphatically indicating that the institution he serves considers his work not only important but essential.

The engineering drawing teacher has two distinct advantages; he makes contact with his students early in their educational career and often is the first engineering teacher they meet; he teaches students who usually have a natural and genuine interest in the subject matter. To capitalize on such advantages is an important teaching obligation. This natural interest may thus be enlarged and stimulated in an atmosphere of professional competence and the indoctrination into engineering and social responsibilities initiated with students in a receptive attitude. By appropriately chosen subject matter and teaching procedures the engineering drawing instructor has a golden opportunity to drive home the conviction that neatness and accuracy, systematic and orderly thinking, exactness in reading and presentation are essential; that there is no compromise between correctness and incorrectness; that promptness and completeness in the discharge of duties are as necessary as the duty itself; that shoddiness, inexactness, carelessness, ambiguity are as foreign to engineering work as is irresponsible and dishonest performance. Admittedly these are by-products but they loom large in importance in the training of a student about to take his place in a dis-ordered world.

To suggest to a group such as this that engineering drawing should be taught as a language seems somewhat trite. I do so to point out the opportunity such as presentation affords in emphasizing the hidden historical, human and literary features of a subject which might be considered as lacking in material thus to illuminate it. Of course we are conscious of the fact that drawing is a language so universally understandable that national boundaries make only comprehensible differences in its reading and writing. We are aware, too, that as a language, it has its own peculiarities of vernacular, idiom, convention, and even slang. We are, however, less mindful of its historical backgrounds, of the opportunity it has given some great men in the American industrial scene to rise to positions of great responsibility, or its influence on and contribution it has made to engineering literature.

Every drawing and problem, many, many lectures and demonstrations afford the drawing teacher a ready-made setting into which with appropriateness and point historical and human interest elements may be introduced. At the same time the literary qualities of draftmanship as compared with the written and spoken language may be pointed out and certainly to no disadvantage to our method. When we discuss the process of reproducing drawings the entire field of reproduction is opened to scrutiny; when we talk about the avoidance of unnecessary lines and views the art of cartooning is asking for a reference at least; when we suggest the need for creating a mental picture of what we are representing by lines and views we can indeed solicit an interest in the whole area of creative art.

Certainly we do not want engineers to be intellectual rough necks and assuredly such contributions as we, as teachers of engineering drawing, can make towards lifting the eyes of our students to wider horizons is to be desired. To be sure the introduction into the engineering course of such subjects as political science, philosophy, economics, history, literature, the fine arts, psychology is intended to, and will accomplish just that ideal. But let us not overlook the important element of limited time and the great pressure for the inclusion of even more technical material. These two factors are certain to circumscribe the bounds of expansion rather severely, and therefore such contributions as we can make will be welcomed.

Let us not overlook then our rather unique opportunity not only to stimulate student thinking along much broader lines but to associate that kind of thinking with engineering work. History? The discovery of descriptive geometry by Gaspard Monge in the time of Napoleon; the life of Monge; the effect of descriptive geometry on industrial management; the influence of the introduction of descriptive geometry into American education certainly is history. Philosophy? The ethical code of the engineer; the logic in scientific thinking are basic concepts in philosophy. Economics? The engineer is taught every day that things are done which are economically not worth doing; that the methods by which things <u>can</u> be done are as important often as the actual doing. Politics? Thank God, there are no politics in engineering drawing but at least we teachers can point out that what the world needs today is the kind of factual thinking required for the solution of our problems, and the kind of integrity engineers consider as essential as religion. Literature? A good engineering drawing has as much literary merit as well written prose; literature began with the spoken word, advanced through the discovery of symbols and the printing process to record ideas; and now by animated and still drawings; the spoken word by way of radio moving pictures, perhaps literature like engineering drawing itself is turning back again toward its early beginnings. In similar fashion music, the graphic and plastic arts, the theatre can all be touched upon for some common starting point. Religion? At least we can say that Tubal Cain was the first teacher of shop processes and that the probable reason for Babel's failure in building the Tower was because he had no blue prints. What else can a confusion of tongues mean than conflicting instructions with no authority?

Good teaching is but a stimulation to greater learning. Knowledge is neither bottled nor packaged.

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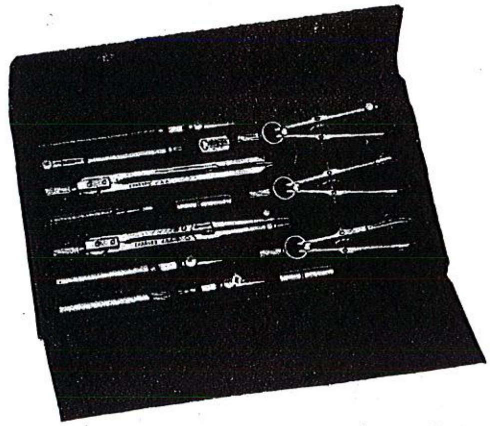

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FRANK G. HORTON, MANAGING DIRECTOR
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December 18, 1947

Professor Frank H. Heacock, Chairman
Engineering Drafting Committee of
The American Society for Engineering Education
Princeton University
Princeton, New Jersey

Dear Professor Heacock:

With the ever-increasing amount of technical knowledge that is developing in the modern world, it is inevitable that engineering colleges are continually studying their curricula to see how additional technical work can be included. In some cases, it appears that the fundamentals of engineering, on which sound engineering education is based, are threatened. It has been reported that several engineering colleges have reduced the amount of drawing to a dangerous minimum.

Representatives of industry often stress the importance of the basic subjects -- mathematics, physics, chemistry, english, engineering drawing, mechanics -- in the curriculum. After serious consideration of this attitude on the part of industry, and the trend of the colleges to reduce the basic training, particularly in engineering drawing, the following resolution was adopted unanimously by the Board of Directors of The Engineering Society of Detroit at their last meeting:

> RESOLVED that The Engineering Society of Detroit advise the Engineering Council for Professional Development and the drawing division of The American Society for Engineering Education of its vigorous support of the retention of adequate training in Engineering Drawing in all engineering curricula.

We respectfully urge that The American Society for Engineering Education lend its support to our efforts to combat the trend of the colleges to reduce the basic training in engineering drawing, and thank you in advance for anything you can do toward the attainment of this worthy objective.

Very truly yours,

Frank G. Horton

Frank G. Horton
Managing Director

FGH:mhe

conditions, they, perhaps unconsciously, eliminate those factors which will have no influence on the selection of the dimensions.

It can be said that dimensions should be so chosen and toleranced that all parts produced through their use will function properly with the other components of the machine or structure, and yet be economical to produce. On these two premises can depend the success or failure of the part, the machine and even the manufacturing organization. Ill-chosen dimensions can cause difficulty in producing parts which will function properly, and in parts the shop cannot produce economically or perhaps cannot produce at all with available equipment, all of which increases cost, confusion and delay. From these basic premises, we have the two main principles for selecting dimensions--the "functional principle" and the "process principle".

The "functional principle" recognizes that "it is essential that dimensions be given between those points or surfaces which have a specific relation to each other, or which control the location of the other component or mating parts". In other words, it calls for a correlation of the corresponding dimensions of mating parts to insure proper functioning. In addition it is equally important, on drawings intended for quantity production use, to provide dimensional tolerances for these mating dimensions to guarantee interchangeability and satisfactory functioning.

"The "process principle" recognizes that production will be simplified if the dimensions most useable in the shop are given.

The use of these principles provides an excellent foundation upon which to develop student judgment in selecting dimensions. Neglect of all the all-important "functional principle" leaves one in the dark when attempting to explain the location of finished surfaces since it is merely guesswork to provide these dimensions when the function of the part is unknown, particularly with the more complicated parts. Experienced draftsmen and teachers can usually make a fair selection without knowing the use of the part because their past experience enables them to "see" a possible, and probably logical, function for the various details of the part. The student, however, is in no such position, and the instructor's explanation, which will most likely prove vague and illogical to him. Show the student the assembly in which the part is used, and explain the function. The choice of which finished to finished surface, or functional, dimensions to select is now logical and easily understood.

The "functional" and "process" principles are best suited as lecture material prior to their application in laboratory. However, certain items should be discussed before the two principles are entertained. These are actually factors which enter into the selection of dimensions in a more or less general way, and their discussion is in order as background material for the student. These factors are: the significance of the terms "precision" and "tolerance"; mating and non-mating surfaces; types of production--unit and quantity; and the "shape break-down system" with its resultant "size" and "location" dimensions.

In connection with tolerance, the student should realize that no distance on a part can be produced to an exact or "dead" size, and that an allowable variation or tolerance must be provided or allowed for on every dimension. He should know that varying degrees of precision are frequently required on machine parts and that this results in two types of dimensions--those which can be measured with a scale, and those which require more precise means of measurement being given as three or more place decimals on the drawing. The student's attention should be called to the difference between the mating and non-mating surfaces of parts and their relationship to finish and degree of precision.

The conclusion should not be drawn that the above signifies teaching limit dimensioning in basic drawing courses. Nothing need be said concerning the selection of proper tolerances and the degrees of fit for mating parts. To provide for this advanced material, a fourth phase of dimensioning, entitled "fits of mating parts and selecting limits", might be added to the original subject breakdown of "selection", "placement" and "technique". However, it is felt that an understanding of tolerance and degree of precision is essential to, and a part of, selecting dimensions. Unless the significance of tolerance is understood, how can one provide a truly logical explanation of the reason for omitting one dimension of a chain or series of dimensions, when the overall is given?

An understanding by the student of the basic types of production, unit and quantity, will be helpful to him in understanding why some drawings may be dimensioned entirely with scaleable dimensions and others require the use of precision dimensions.

The well-known and widely taught "shape breakdown system", with its resultant "size" and "location" dimensions, provides a theoretical and systematic method to follow when choosing dimensions for a part. However, the dimensions so arrived at frequently require modification due to the practical considerations of the "functional and process principles". The "shape breakdown system" has proven valuable as a teaching aid and its use should be continued; however, the student should understand that this artificial system provides proper dimensions because the fundamental shop operations result in the basic shapes arrived at by the breakdown. In addition, he should be aware that these dimensions are subject to exceptions caused by function and processing.

It should be pointed out, when describing the "shape breakdown system", that each simple shape requires location to some other in the three principle directions (locations in other directions will be required when inclined or oblique surfaces are encountered) and that either alignment or contact of a surface of one shape with that of another eliminates the need for one location dimension.

In this connection, it is well to mention the matter of "coinciding center-lines"--one which is frequently ignored by the instructor, leaving it as a source of confusion to the student. To illustrate, picture two symmetrical shapes, say two cylinders, one a hole in the other and with axes parallel. The circular view would show two pairs of perpendicular centerlines if the cylinder axes were not coinciding. Dimensions would be necessary to locate one cylinder with respect to the other. Were the cylinder axes to coincide, the two pairs of centerlines would coincide and appear as one pair. This coincidence eliminates the need for location dimensions--however, in a sense, there are dimensions whose values are zero.

It is interesting to note that concentric cylinders not having express location dimensions on which to apply tolerances for controlling symmetry, require a special note treatment--the "tolerance of concentricity". This is actually a special case of the more general subject, "tolerance of symmetry" which is encountered whenever symmetrical conditions occur, such as shown in Fig. 1. Formerly, in cases where two shapes were obviously symmetrical or centered with respect to each other, it was common practice to omit location dimensions between them. To do so, however, did not set a definite allowable variation within which the shapes could be out of the true symmetrical position and still function satisfactorily. Present day practice, particularly with finished surfaces and quantity production work, requires such a tolerance. Thus, we find the "half dimension" being used, whose sole purpose is to provide a "tolerance of symmetry".

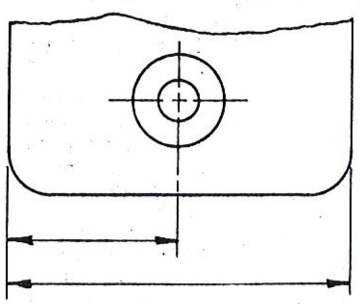

Fig. 1.

The coincidence of centerlines sometimes introduces an undesirable condition of over-dimensioning such as when the centers are drilled holes coincide with the centers of corner rounds on a cast part, Fig. 2. Methods of handling these situations are available, such as the use of reference dimensions, marking one dimension "pattern", the use of a decimal tolerance on the hole centers, etc.

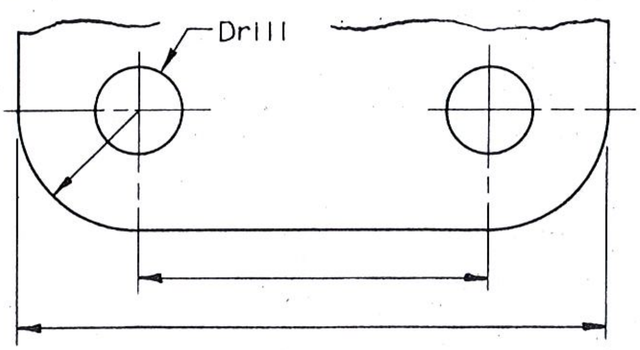

Fig. 2.

One matter which is a possible source of confusion for students is the dual application of the term "location dimension". As applied with the "shape break-down system", location dimensions may properly be given between two unfinished, or an unfinished and a finished surface as well as two finished surfaces. On the other hand, the student may hear the platitudes, "location dimensions must be given between finished surfaces", "a finished surface must be located to another finished surface", etc., from which the student may infer that location dimensions are restricted to finished surfaces. Such statements are unwise--even when the instructor limits his use of the term "location" to the finished surface sense. On occasion, there may be no other finished surface to locate to, and in some instances it is necessary to provide dimensions between finished and unfinished surfaces as "starting dimensions" for machining.

To illustrate the need for "starting dimensions", consider the drawings of a casting or forging made according to the "multiple drawing system" where separate drawings for each shop are provided. On the "machining" drawing, which contains dimensions only for machining, dimensions or the equivalent must ordinarily be provided in each of the three principle directions (assuming no inclined or oblique surfaces exist) for starting, that is, locating the first cut. Thus, in Fig. 3, dimension A provides this in one direction, and is a dimension between an unfinished and a finished surface. In another direction dimension B, a locator between finished and unfinished surfaces (centerline of unfinished cylinder), is also a "starting dimension". Coincidence of centerline provides location of the reamed hole and the start for machining in the other direction. Subsequent machining is located from the starting surfaces, as with dimensions C, D and E.

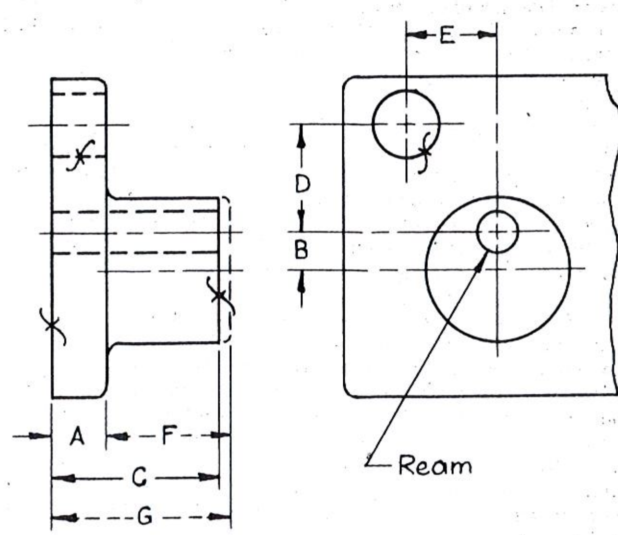

Fig. 3.

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Had the drawing of Fig. 3 been of the "casting and machining" type, that is, provided with both pattern-making and machining dimensions, dimension A would serve as a size dimension for the patternmaker as well as a starting dimension for the machining.

When a pure patternmaking dimension between two unfinished surfaces can be provided without causing over-dimensioning, it should be given in preference to an unfinished to finished dimension since it eliminates the necessity for the patternmaker to add the machining allowance before he has a useable dimension. To illustrate, assume the top of the cylindrical boss in Fig. 3 to be unfinished, as shown with the broken line. Along with the dimension A, F would be preferred over G since it is a pure patternmaker's size dimension for the cylinder and does not require any addition or subtraction before it can be used. It is interesting to note, however, when patternmaking and machining dimensions are given on the same drawing, that it is sometimes impossible to avoid requiring the addition or possible subtraction of distances by the patternmaker in order to obtain a useable value. This is illustrated by Dimension A in Figure 3. Thus the frequently heard rule, "never require the workman to add or subtract dimensions", may constitute another source of confusion to the student.

In the actual selection of dimensions, the student should be trained to follow a systematic procedure. He should be aware that selecting haphazardly will usually result in poor selection and over-dimensioning. The following probably represents the ideal systematic procedure. First, the part should be studied in connection with the mating part or parts and the dimensions meeting functional requirements selected. These should correlate with those given or to be given for the mating parts. Next, examine the part to see whether any of the manufacturing processes can be simplified by a change in the functional dimensions chosen. Such changes should be made only when the correspondingly required changes for mating parts will not cause manufacturing difficulty or malfunction. Lastly, select the remainder or non-functional dimensions being guided by the "Process principle" that is, provide dimensions most likely to be desired in manufacturing. Both the "functional and process principles" will direct the choice of dimensions for mating surfaces while the "process principle" alone will direct the choice of those for non-mating surfaces.

It is not always practical to follow the above procedure for selecting dimensions, either in the classroom or in the commercial drafting room. The difficulty lies in the possible uncertainty of manufacturing methods which makes application of the "process principle" uncertain. In the classroom, further difficulty is encountered through the lack of sufficient student knowledge and appreciation of the various shop processes. If sufficient time is available, the instructor can describe assumed manufacturing processes during his lecture-demonstrations--a procedure which has proved satisfactory.

Since the "size" and "location" dimensions arrived at by the "shape breakdown system" will in most instances fulfill the requirements of the "process principle", their use mitigates the need for strong emphasis on manufacturing processes which, incidently, are sometimes needlessly overstressed. Even though his knowledge of shop procedures is meager, the student can be trained to make a fairly good selection of dimensions through the use of the "functional principle" and the "shape breakdown system" alone. Use of the "shape breakdown system" also alleviates the possibility of the student giving many of the absurd and irrelevant dimensions he might otherwise choose.

In commercial work, particularly with quantity production, the manufacturing processes often will not be known at the time of dimensioning. This may occur when there are optional methods of manufacture, each equally good, or when the parts are to be produced by contracting firms whose equipment is not known. In such an event, one must lean heavily on the "shape breakdown system", selecting the most logical dimensions and tolerancing them so the part cannot fail to be satisfactory regardless of manufacturing methods. In this connection, the following quote from the Chevrolet Draftsman's Handbook is pertinent:

> "Taking into account all of the possibilities, it is apparent that, to be dimensioned intelligently, a detail drawing should represent the part as we expect it to be received in our inspection departments, regardless of its source of manufacture. It should deal cautiously with the method of manufacturing the part, specifying the result to be obtained rather than the method of obtaining it, in order to permit the maximum latitute in optional methods of manufacture and optional construction of designs."

Engineering Drawing is often spoken of as "the exact language". At present, it falls short of this in a dimensional sense. With unit production work, it was and is still appropriate in many instances to loosely dimension drawings, leaving important decisions to the necessarily skilled shopman qualified to do such work. With improvements in manufacturing processes and the advent and development of the quantity production system, the dimensional requirements of drawings have become more exacting; that is, increasing demands have been made for means to describe parts on drawings with greater dimensional exactness. Methods satisfying this, such as tolerancing, surface quality, etc., have been gradually evolved and added to the old procedures. Thus, dimensioning at present is a mixture of the old and the new. If drawing is to become an exact science, it would seem that dimensional practices should be discarded which were in order when much of the engineering was worked out in the shop, and which are now outmoded.

It would hardly be in accord with present practice to draw a leader to a positive cylinder and specify its size and the operation with a note, as "$2\frac{1}{2}$ Turn", yet it is common practice to apply the note, "Bore", to a hole. At least with drawing for quantity production work, it would seem more appropriate and scientific to merely give the proper dimensional limits and surface quality for the hole;

(continued on page 24)

WHAT SECONDARY SCHOOLS ARE DOING TO PREPARE STUDENTS FOR COLLEGE WORK IN ENGINEERING DRAWING

by

Chester L. Thorndike
Springfield Junior College

The chairman of your Committee on Engineering Drawing, Professor Douglas P. Adams of the Massachusetts Institute of Technology, has honored me in asking me to speak to you on the general subject, "What the Secondary Schools are Doing to Prepare Students For College Work in Engineering Drawing."

Quite some time ago I made a survey of "Mechanical Drawing in the High Schools of Massachusetts" covering cities, towns having a population of more than 5,000 and towns having a population under 5,000. The result of this survey, which included Teacher Training, Time allotment, Textbooks, and Subject Matter, impressed me with the fact that in too many instances Mechanical Drawing was being taught in a vague and casual manner. The teacher preparation, while varying in degree, did not present a major problem. The large majority of teachers had a good technical background, and others, while not as well equipped technically, has a sound practical experience acquired in industry. The source from which we are to recruit future teachers is, however, a matter for consideration.

The time allotment was generally satisfactory in the cities and towns of over 5,000 population. In the towns of less than 5,000 population the time allotment was wholly inadequate and frequently the teach time was divided between several towns and between classes in art and mechanical drawing.

The choice of textbooks indicated a very wide range of preference varying from the latest and most practical editions to those edited a generation ago. In the majority of cases a textbook was not available for each student in the class and therefore was used mainly for reference purposes.

The reports on subject matter indicated courses ranging from those which were very comprehensive and well organized to courses that were extremely superficial and contained little of real value.

Shortly after this survey was made the Mechanical Drawing Association of New England came into being and I felt that its influence must have done much to better conditions. However, from my observations at the meetings of the Association, and I have been regular in my attendance, I feel that we have not reached out to get the interest of the instructors in the smaller schools. The New England States comprise a large area and we only scratch the surface. There are too many bright young boys in these small towns who enter our technical colleges without having had the benefit of a well organized course in Mechanical Drawing.

At this time I wish to say that I feel that the Engineering Colleges, perhaps through the American Society for Engineering Education, should clearly and in detail define the material and experiences that they would like the High School boy to have when he comes to them. This should tend to unify the training of these boys in secondary schools and thus allow the Engineering College to accelerate and amplify the material of its course in Mechanical Drawing. At one college it was intimated that Mechanical Drawing could advantageously be made a requirement for admission.

I do not feel that I am in a position to speak for the Secondary Schools as a whole but I believe that in outlining the course in drawing as offered in the Technical High School in Springfield, Massachusetts I will reflect the general policies of other schools, especially those in the industrial areas.

Civic pride in Springfield runs very high and this is especially true insofar as its schools are concerned. Its secondary school system comprises a Classical or General High School, A High School of Commerce and a Technical High School. Its industries are varied and call for a high degree of skill in the manufacture of small arms, motorcycles, plastics, motors, refrigerating units and a wide variety of machine tools. This condition offers a fertile field for men technically trained. The Technical High School is very favorably regarded by our industries. The fathers of our boys work in these industries and the boys, through their home environment, acquire a taste for things technical. This school differs from the average high school in that shop work, both in wood and metal, and mechanical drawing are required in addition to the customary academic subjects. The very atmosphere of the school

(Continued on page 30)

Presented at the Annual Meeting of the New England Section, A.S.E.E. at the University of Massachusetts, Amherst, Massachusetts, October 11th, 1947.

PROBLEM SOLUTION

by

Professors Bowes and Smith
Dalhousie University
Halifax, Nova Scotia

Given two non-intersecting, non-parallel lines, and any plane. To construct a line of specified length terminating in the two given lines, and parallel to the plane.

Let AB and CD be the given lines; S the given plane; and R. the given distance.

Analysis:

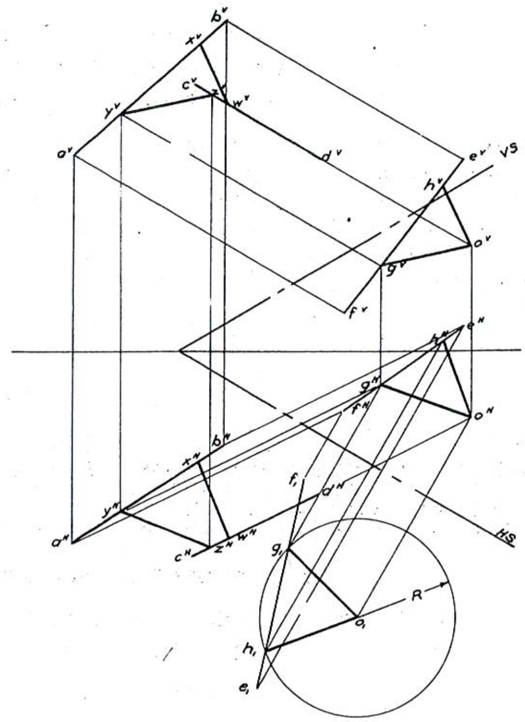
Envelop CD with an elliptical cylinder such that its sections parallel to the given plane S are circles of radius equal to given length R.

Find the two points X & Y where this cylinder is pierced by the line AB. Through these points draw too lines XW and YZ parallel to the given plane S, and intersecting CD. These two lines will satisfy the given requirements.

Construction:

1) Project AB and CD on S by means of projectors parallel to CD. CD will appear as the point O, and AB as the line FE.
2) Revolve these projections into H about HS.
3) With O as a centre and radius R, draw a circle intersecting the projection of FE in two points, G. and H.
4) Counter revolve and (again by oblique projection) locate X and Y in the line of AB.
5) Remembering that parallel lines have parallel projections, draw XW & YZ parallel to their projections on plane S.
6) Remembering XW and YZ are the required line.

Note: If the circle of step 3 is tangent to e_1f_1, there is but one solution, the shortest possible distance R that may be specified. If it does not touch e_1f_1, there is no solution.



SOLUTION TO PROBLEM
IN
JOURNAL OF ENGINEERING DRAWING.
NOVEMBER 1947

SOLVE THIS ONE

Problem: Given any two non-parallel, non-intersecting lines, AB and CD. To construct a line MN terminating in them, and making specified angles α and ϕ respectively with them.

This column is designed for the entertainment and improvement of those who enjoy putting Descriptive Geometry to work for the thing it is credited with doing best--training one in clear, logical and constructive thinking. It is open to contributions of progressive professors pet personal puzzling problems. A year's free subscription to the Journal will be entered for the reader who first submits any problem accepted for publication. A correct solution shall accompany each problem offered.

A year's subscription is also presented the reader who submits, in time for publication in the ensuing issue, the best solution. If a drawing is required, one done in ink shall accompany it as copy for reproduction. All constructions must be Euclidean; that is, only straight edge and compass should be used.

DESCRIPTIVE GEOMETRY

A DISCUSSION

by

John P. Oliver
Associate Professor Engineering Drawing
Texas A.&M. College

Since my return from the Service in July, 1946, I have heard quite a bit of discussion of several questions regarding Descriptive Geometry which I thought, apparently wishfully, had been fairly well settled by circumstances brought about by the war. For years I have been convinced that the only reason for the subject's inclusion in the curricula is that it lays the foundation for the graphical analysis of three dimensional problems in engineering and drafting practice and, since this is true, should be taught against the background of engineering and drafting application. My experience with the program of Defense Training in 1941, in which we re-organized the course so that each problem taken up was illustrated by a drafting board application from aircraft design, ship construction, or machine drawing, proved the effectiveness of this method to me.

These questions are an outgrowth of the very thing which I thought would answer them and I realize that they portray a healthy, questioning attitude toward the subject of Descriptive Geometry. Has the ease of solution under the Direct Method been harmful in that it has lessened the necessity for the student's thinking? Does not the method of Traces develop on the part of the student a greater ability to visualize than does the Direct Method? Does not this constant use of the Third Angle of projection prevent the students being able to read drawings set up in the First Angle as is the European custom? These questions I shall briefly discuss here.

The first two of these questions, I think, can be answered as one. It is not in the solution of the problem but in the analysis which must precede that solution that thinking is required and visualization is of extreme importance. The method of solution is immaterial. The easier, more readily understood that method is, the better, since it saves time. By saving time we may increase the scope of the subject matter.

For purposes of illustration, I have chosen two problems, one from the field of Civil Engineering and the other from the field of Aeronautical Engineering. Neither of these problems is difficult but I hope each will serve to illustrate the points I wish to make. In order to compare the Direct Method with the Method of Traces, I have worked each of these problems by both methods. In each problem the analysis is the same, only the method of solution is different.

Problem 1. Given the two skewed lines 1-2 and 3-4. Required to find the shortest distance from 1-2- to 3-4 measured along a 30° decline.

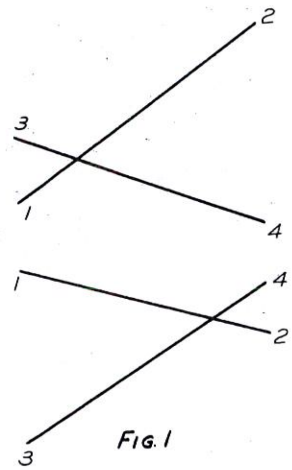


FIG. 1

This problem occurs in both Civil and Mining Engineering usually as a problem in drainage. It is necessary to find the length, slope, and bearing of the line and the location of its end points.

Analysis. The required distance is unknown in both position and direction. However, since the distance is minimum, it must be measured in a plane which is perpendicular to both the two parallel planes, each of which contains one of the lines. Thus we can find the direction of the line representing the distance. Its position may be located by obtaining a view of the two given lines on a plane perpendicular to the plane containing the required distance and sloping backward and downward 60° to the horizontal. In this view the line representing the required distance will appear as a point in the apparent crossing point of the lines 1-2 and 3-4.

Solution 1. Method of Traces. Through any point 5 on 1-2 draw a line A parallel to 3-4. Draw the traces of the plane Q containing 1-2 and A. (Only HQ need be drawn). Draw plane Y perpendicular to H and Q. Draw plane X perpendicular to Y and sloping downward and backward at 60° to H. Project 1-2 and 3-4 on X. Find the point in which the two lines apparently cross in this view. This is the end view of the line representing the required distance.

Project this point into the front and top views and find its true length and slope. Its

(Continued on page 20)

bearing is measured in the top view and the location of its end points may be plotted in this view.

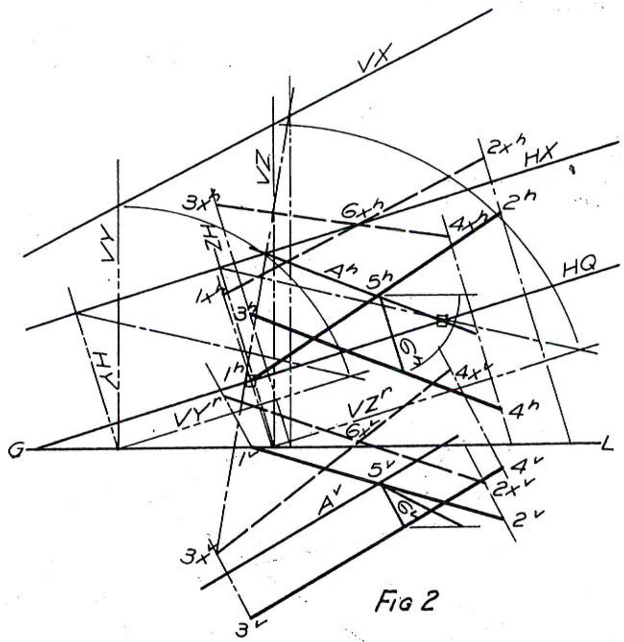


Fig 2

Solution 2. Change of Position. Through any point 5 on 1-2 draw a line A parallel to 3-4. Draw a level line in the plane 1-2-A. Assume a position from which the line of sight coincides with the level line and draw View A. In this view, any minimum distance

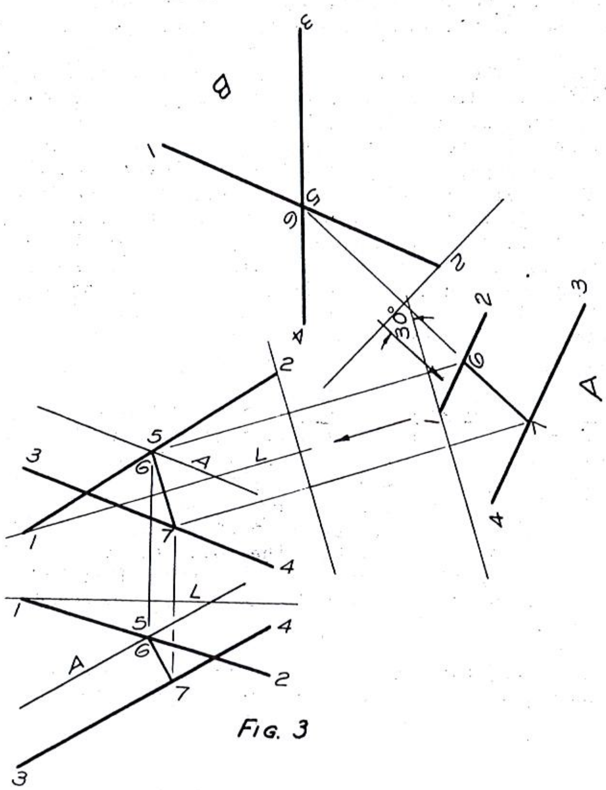


Fig. 3

between the lines such as the perpendicular, shortest level, or shortest inclined or declined distance, may be measured. However, its location cannot be determined in this view. Assume a position from which the line of sight slopes downward 30° to H from 1-2 to 3-4 and draw View B. The apparent crossing point 6-7 is the end view of the required distance. Project this back to View A and thence to the front and top views. All that remains to be done is to measure and record the true length, bearing, and slope of the distance and note the position of its end points.

Problem 2. Given the V-brace 2-1-3 and the point 4. Required to pass a cable from 4 through the V-brace so that it will clear 1-2 and 1-3 by a given distance.

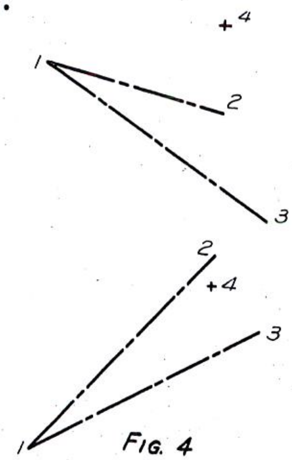


Fig. 4

Analysis. Obtain the end view of each of the members 1-2 and 3-4 and show the plane of 2-1-3 as an edge in each of these views. In these views the line representing the cable will appear in proper relationship to the members of the V-brace.

Solution 1. Method of Traces.

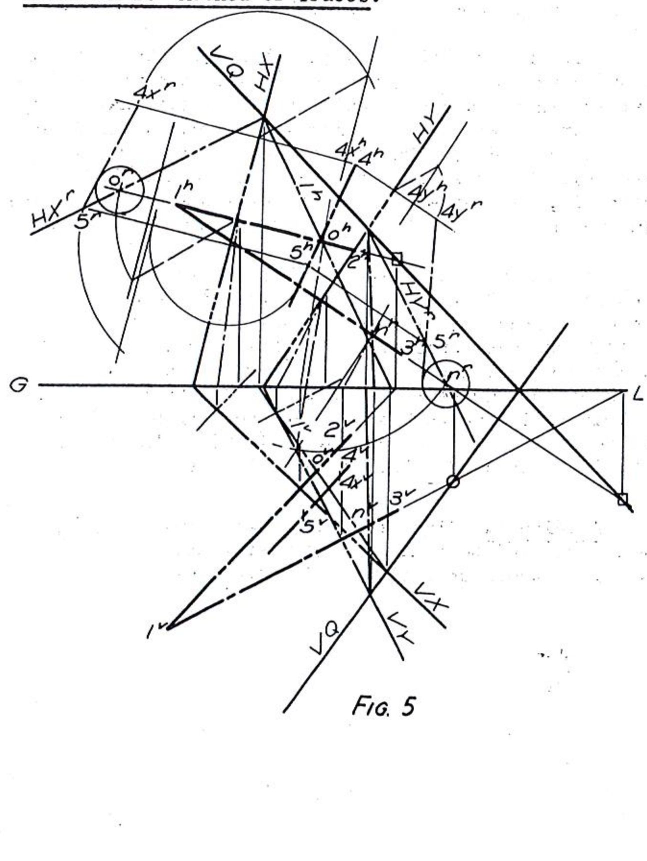


Fig. 5

Find plane Q of 2-1-3. Draw plane X perpendicular to 1-2 and intersecting Q in the line I. Find the piercing point O of 1-2 on X. Project 4 on to X obtaining point 4x. Revolve X about HX into H. Let 1-2 appear as a point, o^r, the plane X appears as an edge in HX^r, and the point 4 is shown by $4x^r$. With the given clearance as a radious and o^r as a center draw a circle. From $4x^r$ draw a tangent line to the circle, passing between 1-2 and 3-1, and intersecting HX^r in the point 5. Draw a plane Y perpendicular to 1-3. Follow the same procedure as with plane X to find the position of point 5 on Y revolved into H. Project the two views of point 5 back into plane Q and draw line 4-5. Locate the position of point 5 with respect to point 1.

Solution 2. Change of Position.

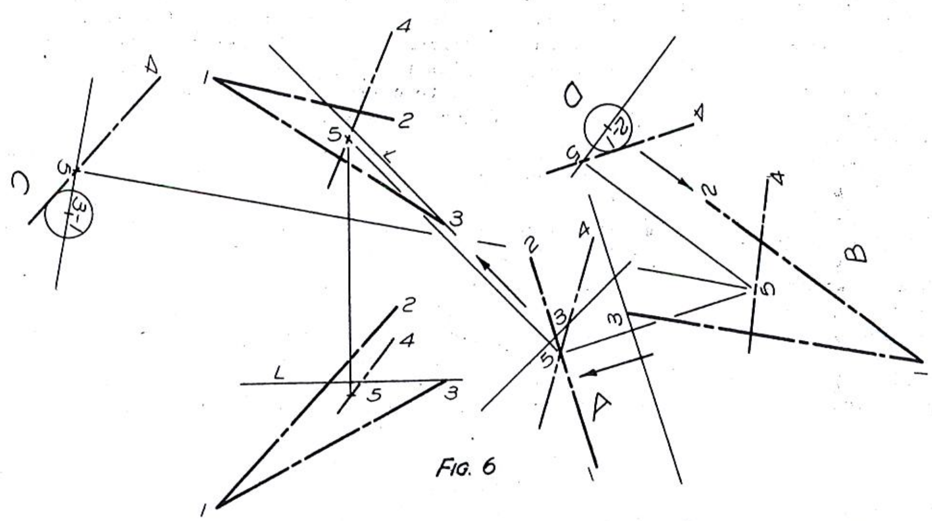


FIG. 6

Draw a level line 2-1-3. Assume a position from which the line of sight coincides with the level line and draw view A. Draw the Normal view B. Find the end views C and D of 1-3 and 1-2. In each of these views, with the end view of the line as a center and the given clearance as a radius draw a circle. From point 4 in each of these views, draw a line passing between 1-2 and 1-3, tangent to the circle, and intersecting the plane 2-1-3 in point 5. Locate 5 in the normal view and then project it back to the front and top views. Locate the position of 5 with respect to the point 1.

Let us take a moment for a comparison of the two methods. The chief weakness of the Method of Traces lies in its complexity. A glance at either of the two problems used here will bear out that statement. There are so many basic problems which must be solved before the real solution may be reached that the whole solution becomes a maze of lines exceedingly hard for the student to follow through. We must remember that, as a rule, our students are freshmen, not PHD's. In problem 1, the plane X of the oblique view is set up. HX is obvious since it must be parallel to HQ but VQ must be determined, in this case by two auxiliary planes, Y and Z, which in turn must be revolved into H in order to show the true angle X makes with H. Then the lines 1-2 and 3-4 must be projected on X by means of perpendiculars through their end points which necessitates the use of another set of auxiliary planes in finding the piercing points of these lines on X. Now, to make it worse, not a view of the lines but a horizontal and vertical view of the view of the lines has been found. The coeffieient of confusion has been greatly increased.

As a result of all this complexity, a great deal of time is wasted. Not only does the student waste time in his solution of problems but the teacher wastes a tremendous amount of time in attempting to "put over" similar solutions to his classes. I remember very distinctly my efforts to induce the individuals in my classes to understand the solution for the shortest distance between skewed lines. I still have a guilty feeling that none of them ever really understood it.

The Direct, or Change of Position, method of solution at least minimizes these difficulties and it has the added advantage of carrying over into Descriptive Geometry the same method of solution with which the student has become acquainted in his basic drawing courses. To teach Descriptive Geometry by a different method from that used in teaching Engineering Drawing is to again increase the ever present coefficient of confusion.

To answer to the third question, I think that if the student is properly grounded in the purpose of view drawing he will have no trouble in interpretation regardless of the angle used. A view of an object is an image of that object and visible from the given direction is shown. This is true regardless of where that view is complete, all data concerning that object and visible from the given direction is shown. This is true regardless of where that view is placed in relation to other views. The plan view of an object will convey the same information whether it be placed above, below, to the right or left of the front view or set off in a corner somewhere by itself. The data conveyed will be just as usable in one position as in another. The draftsman deals with views whether they be aligned in the conventional manner or not. The student should be taught with that fact in mind. Teaching of Drawing should emphasize the purpose for which the view is drawn, the information it conveys, and the utilization of that information in the solution of other parts of the problem.

In many schools, in fact in most of them Engineering Drawing and Descriptive Geometry are the only contacts that the student has with his major field. That places on the drawing teacher a double duty. Not only must he develop the student's knowledge of subject matter but he must, through proper choice of illustrative material and problems, seek to develop in the student's mind a broad picture of the field of engineering. Most students come to

(continued on page 34)

IOWA PRODUCES ANOTHER STUDY SHEET

by

John M. Russ
Professor of Engineering Drawing
University of Iowa

The author would not for anything be guilty of revealing to his fellow craftsmen that necessity is the mother of invention. He would, however, breathe his suspicion that she sometimes does produce results far and above those anticipated.

The value, as a teaching vehicle, of our Dimensioning Study Sheet, (February, 1944, Journal of Engineering Drawing) has so richly exceeded our fondest expectations at the time of its inception and execution, that it has since been reproduced in offset form, and distributed to all our students. These sheets are a constant source of sincere study and reference all the way through the size description and working drawing stages of their training.

Following the same pattern of thinking, and based on the necessity caused by the absence of this type, of presentation in acceptable form in the text book we use, a new Study Sheet on route location and related profile has been produced for our classes in topographic drawing. (See opposite page)

A blueprint of this sheet is permanently mounted in each of our student drafting rooms. Reference is made to it at every appropriate opportunity, including examinations. (It is a policy of this department to disseminate information not conceal nor hoard it. Are we unique in this respect?)

Considerable thought has been expended in clearly showing the answers to the usual questions asked by the student. For example, they frequently want to know where to place the notations for P.C. and P.T. on the alignment. The answer to this question is clearly illustrated:--on the radius line if it is long enough to carry it, otherwise in any conveniently adjacent location.

As before, if the instructor sometimes takes a backward student on a personally conducted tour to consult the mounted sheet at the front of the room, the idea soon gets around that it is a good idea to habitually check this ready source of reference.

If this presentation proves out comparably with its predecessor, it too will be duplicated in quantity, and put into general circulation. Again, it is the opinion of this department that the use of this Sheet is a distinct contribution to our teaching efficiency. Study sheet shown on Page 23.

IN MEMORIUM

Professor Harry M. McCully

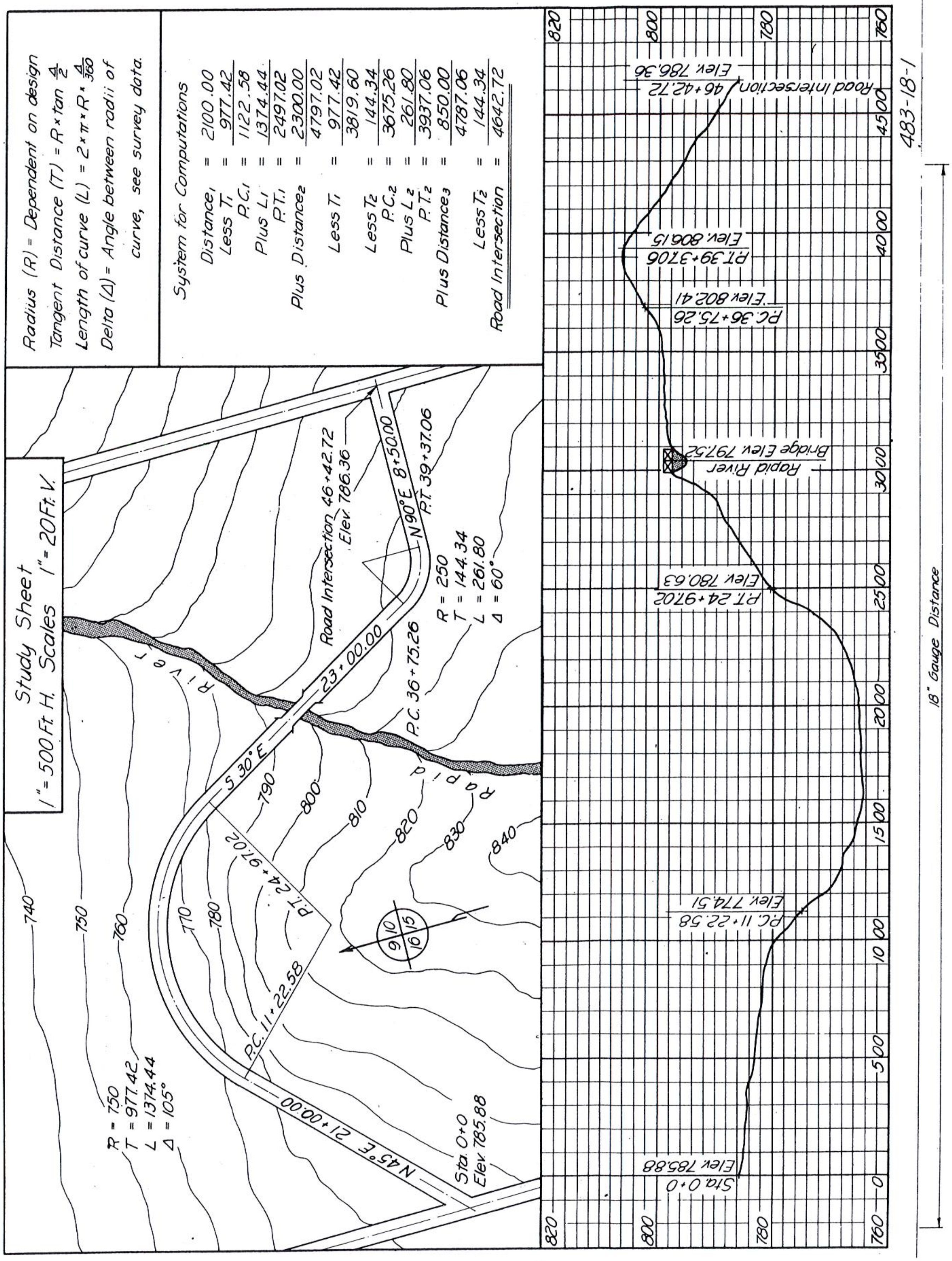
1887 - 1947

Carnegie Institute of Technology

Professor Harry M. McCully, Head of the Department of Engineering Drawing at Carnegie Institute of Technology, was a member of the Engineering Drawing Division of the A.S.E.E. since its beginning. He served as chairman of this division from 1930 to 1936 and was the founder of the Allegheny Section of the Society.

Professor McCully was admired and respected by his associates, his students and a wide circle of friends. He contributed generously for the betterment of education.

The Drawing Division of the American Society for Engineering Education unite in expressing their appreciation of his work, his wise counsel, his devotion and his friendship.


Study Sheet
1" = 500 Ft. H. Scales 1" = 20 Ft. V.
Radius (R) = Dependent on design
Tangent Distance (T) = R × tan Δ/2
Length of curve (L) = 2 × π × R × Δ/360
Delta (Δ) = Angle between radii of curve, see survey data.
System for Computations
Distance₁ = 2100.00
Less T₁ = 977.42
P.C.₁ = 1122.58
Plus L₁ = 1374.44
P.T.₁ = 2497.02
Plus Distance₂ = 2300.00
= 4797.02
Less T₁ = 977.42
= 3819.60
Less T₂ = 144.34
P.C.₂ = 3675.26
Plus L₂ = 261.80
P.T.₂ = 3937.06
Plus Distance₃ = 850.00
= 4787.06
Less T₂ = 144.34
Road Intersection = 4642.72
Road Intersection 46+42.72
Elev. 786.36
N 90° E 8+50.00
P.T. 39+37.06
R = 250
T = 144.34
L = 261.80
Δ = 60°
P.C. 36+75.26
23+00.00
S 30° E
Rapid River
P.T. 24+97.02
P.C. 11+22.58
R = 750
T = 977.42
L = 1374.44
Δ = 105°
N 45° E 21+00.00
Sta. 0+0
Elev. 785.88
740
750
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770
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790
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9 10
16 15
Sta. 0+0 Elev. 785.88
P.C. 11+22.58 Elev. 774.51
P.T. 24+97.02 Elev. 780.63
Rapid River
Bridge Elev. 797.52
P.C. 36+75.26 Elev. 802.41
P.T. 39+37.06 Elev. 806.15
Road Intersection 46+42.72 Elev. 786.36
0
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1500
2000
2500
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3500
4000
4500
760
780
800
820
483-18-1
18" Gauge Distance

(continued from page 9)

Culture is compounded of many subtle elements; it is not acquired by study alone. A wise university president once suggested to me that culture was something you define more by a lack than by a possession. He explained further that for an engineer the study of Greek would be cultural, for a classicist a course in shopwork would be a refinement. So, therefore, let the contributions to be made by the engineering drawing teacher be like flashes of light stabbing through the dark areas over and above and beyond his subject matter illuminating for one bright moment vague spots in the engineering educational shadows. And because these educational spotlights are focused by the unprejudiced hands of engineering drawing teachers, students may not feel like Kipling's traveller who believed that "when a town advertises that it is prosperous or a woman that she is virtuous, it is well to take the other road."

Teachers in general, and engineering drawing teachers no less, have a grave responsibility. Look back upon your own college experiences and the chances are you will recall some great personality standing out like a splendid beacon against that somewhat misty background. What he taught you may not recall, what he was you will always remember. The effect of our teaching, the influence we have may not always be evident, but you can be assured--as I was most dramatically assured not too long ago--that in what we do and what we teach and what we say in the performance of what may seem like our routine chores may have a profound and lasting effect in the shaping of ideals, of thought, of human destiny.

* * * *

(continued from page 14)

these requirements, regardless of how they are met, would guarantee satisfactory functioning. Means of attaining the specifications would actually be decided by the operation planners or shop supervisors. It is encouraging to note that the U.S. Army Ordnance publication "Ordnance Manual on Dimensioning and Tolerancing" states that "machining operations such as 'drill', 'ream', or 'bore' are not to be specified on the drawing".

Incidentally, the above publication presents new and simple procedures for indicating positional and locational tolerances which go far toward making Engineering Drawing the really exact language it should be. The positional tolerancing methods provide simple and exact means for controlling the parallelism, perpendicularity, concentricity, and symmetry of surfaces and have much to commend their use over the cumbersome and troublesome notes otherwise necessary when these conditions must be controlled. The locational tolerancing system, besides being simpler, provides advantages over that commonly used. Through its application, conditions can be toleranced which would be almost impossible to control using the conventional tolerancing system. Drawing instructors, teaching more than the bare fundamentals of dimensioning, will find it profitable to be familiar with the above "Ordnance Manual", and also with the work of Mr. C.A. Gladman of the National Physical Laboratory, Great Britain, upon whose ideas the above mentioned locational tolerancing system is largely based. A drawing course on advanced dimensioning alone could easily be developed using the "Ordnance Manual on Dimensioning and Tolerancing" as its text.

The material presented when teaching dimensioning may be classified into three catagories: the formal lecture, student laboratory work, and the laboratory-lecture-demonstration. In the procedure followed by the writer, the first formal lecture is largely on the "technique and placement" phases, and on the "shape breakdown system". The second formal lecture covers the "selection" phase in which the "functional and process principles" are presented, together with a discussion of mating and non-mating surfaces, precision, tolerance, types of production, etc. This is followed by a lecture in which the complete decimal system of dimensioning, baseline dimensioning, and the systems of standard gages for sheet, wire, etc., are discussed. In addition, limit dimensioning is described to the extent of terminology, methods for expressing limits on the drawing, and how it makes possible interchangeable parts. This discussion is necessary so the student can understand and "write" the limits provided for the functional dimensions on the working drawing problem which follows. The student is not expected to select limits, this being left to the advanced drawing courses.

In connection with the first lecture, it has been found helpful to provide the student in the beginning with a description of what a dimension is to do and how it does it, such as:

> A dimension is used as a means to indicate the numerical distance between two points, two parallel lines, two parallel planes, or a combination thereof, on the object being depicted. Normally, this is done by writing the numberal value applies, while the dimension line indicates the direction in which the value applies.

With this introduction and the accompanying blackboard sketches, several points are made clear to the student which otherwise are often left for him to discover.

With the procedure followed in the laboratory, the student dimensions a series of objects presented on worksheets with printed views. The function of each practical object is made clear through the use of a pictorial assembly, or by using a part from an assembly in the textbook. After a part has been dimensioned, the instructor gives a lecture-demonstration at the blackboard, first on the selection of the dimensions, and second on the placement. The explanation must be carefully planned in advance so it will be entirely relevant and logical to the student, particularly in regard to selection. The various dimension possibilities should be pointed out for each situation, and the reasons given for each selection made.

(continued on page 32)

ARTICULATED HYPERBOLOIDS AND PARABOLOIDS

by

E. J. Nystrom
Helsinki, Finland

The ruled surface generated by a straight line s revolving about another a not in the same plane is an unparted hyperboloid of revolution. The point of the generatrix nearest the axis a will describe the circle of the gorge.

The surface can evidently also be generated by rotating a line t, which is placed the same as s except that it has the opposite inclination with respect to a. The hyperboloid is thus double ruled. The elements of the ruled surface or generatrices of opposite systems (s) and (t) must always intersect. No two elements of the same system intersect.

A model of the unparted hyperboloid can easily be constructed in representing a number of equally spaced elements of each system by rigid, thin rods of the same length.

If some or all elements of a hyperboloid are bound in their intersection points in such a way, that they are able to rotate with respect to one another but not to slide, one might suppose, that the construction would be stiff. In reality it can, however, be deformed. This was found by O. HENRICI in England in 1874. The demonstration can easily be given in the case of the hyperboloid of revolution:

If the axis a is taken vertical, each projection of an element of one system in the top and the front view (Figure 1) is also the projection of an element of the second system. The front view lies between two horizontal lines.

The top view consists of tangents in equally spaced points of the gorge circle. If the number of represented elements is fixed, the form of the top view is completely determined, only its size can vary.

If the rod construction is deformable, the height of itself and its front view varies, further the size but not the form of the top view.

Each generatrix of the hyperboloid is by the intersecting elements divided into portions. Their lengths have certain ratios to one another, which are the same measured from the surface itself and from each projection respectively.

The rods being of given length and the ratios of their portions being fixed through the top view, the portion of every rod between the points of intersection with any two consecutive rods of the opposite system is also fixed and independent of the instantaneous intersection angles. From this fact results the deformability of the hyperboloid.

The hyperboloid can, at least theoretically, be deformed until certain limiting or degenerate forms:

a) all elements coinciding with the axis,
b) all elements being tangent of the gorge circle and consequently lying in its plane.

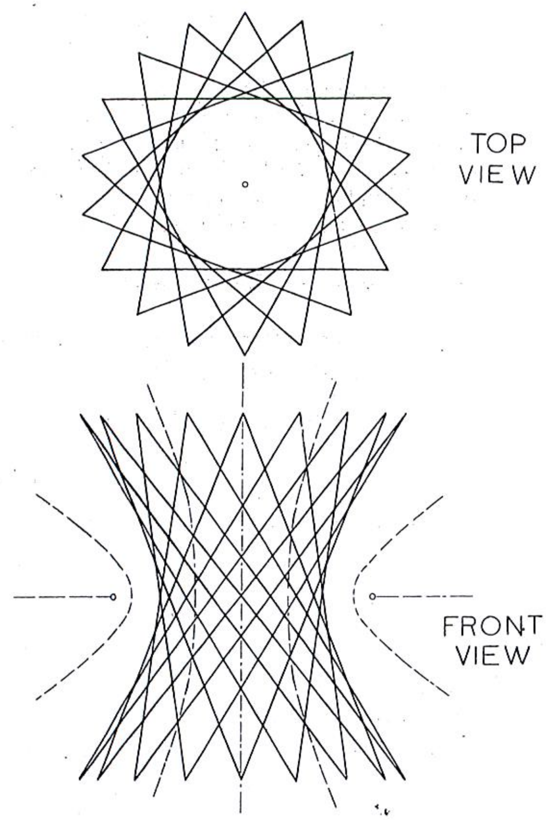

FIG. I.

(The deformation of the hyperboloid into a (double) plane portion is not a development such as applicable to single curved surfaces. The hyperboloid is a double curved or warped surface and not developable.)

In the front view all elements of the variable hyperboloid appear tangent of a hyperbola, the points of contact being those, in which the elements intersect the frontal plane containing the axis. Two symmetrical elements always are parallel to this plane, their projections are the asymptotes of the hyperbola.

(continued on page 28)

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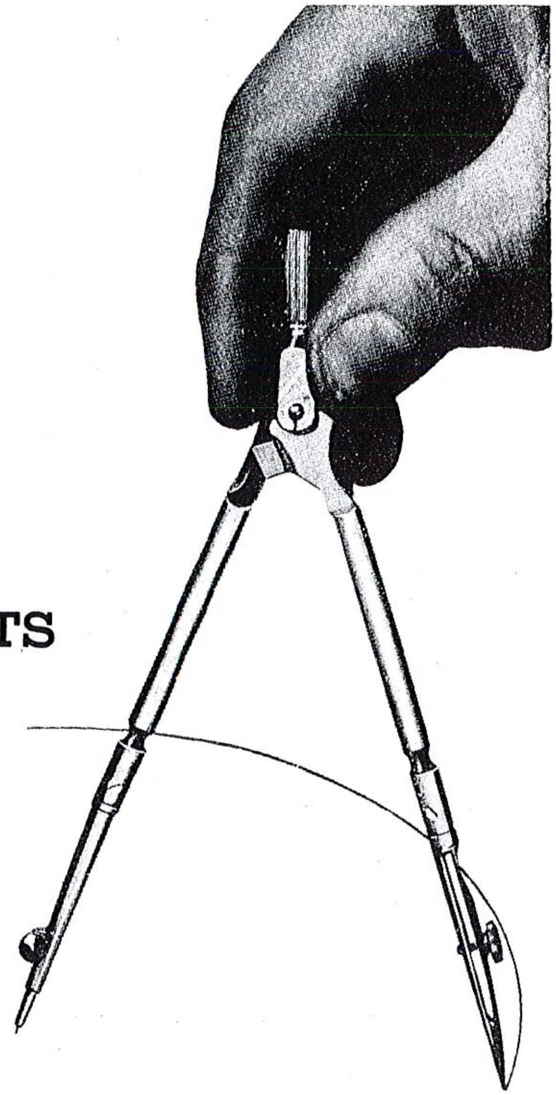

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COMMITTEE ON ADVANCED CREDITS ANNOUNCEMENT

by
Prof. Ralph S. Paffenbarger

The Committee on Advanced Credits ASEE wishes to announce the availability of the experimental copies of the Unit Tests in Engineering Drawing as follows:

1. Use of Instruments
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3. Orthographic Projection II
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7. Screw Threads and Threaded Fastenings
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9. Working Drawings
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These tests may be obtained in small quantities free of charge by writing The Project Office, 437 West 59th Street, New York 19, New York. They are to be kept confidential and returned after using. Grading service will be furnished with these tests. As soon as the final tests are available they may be purchased from the same source at a slight cost, not to exceed five cents per copy. We request prompt trial of these tests so that we might have a basis of validation and quick formulation of the final drafts of each of these. Final draft copies will be available as soon as they can be prepared after this time.

The Committee would appreciate your noting all the criticisms of each unit that you may use, and forward these with suggested improvements to the Chairman of the Committee as soon as possible.

Ralph S. Paffenbarger
Dept. of Engineering Drawing
Brown Hall
The Ohio State University
Columbus 10, Ohio

(continued from page 26)

It is interesting to characterize the system of coaxial hyperbolas in the front view: The comparison of the well-known construction of the foci shows, that their distance is equal to the true length of the portions of the hyperboloid having in the top view the length of the diameter of the gorge circle. The ratio of the diameter to the length of the elements in the top view being invariable, the true length of the considered portions of the elements are always the same. The hyperbolas are confocal.

A general or elliptic unparted hyperboloid is generated by the motion of a straight line intersecting three fixed straight lines taken at random. This surface also is double ruled and deformable if realized in the same manner as the hyperboloid of revolution considered above. The proof however is more complicated.

The intersection points on the elements of a ruled hyperboloid are not equally spaced but they are equally spaced the nearer, the denser the points are and the greater the gorge circle is. From this fact we can conclude:

If the opposite sides of a skew quadrilateral ABCD (Figure 2) are divided into equal parts, the joining lines of corresponding points always intersect. The double ruled surface thus obtained, as a limiting form of a hyperboloid, is a hyperbolic paraboloid of quite general form.

A model realized as described above, will be deformable. As degenerate forms of this surface in both directions plane figures are obtained. They consist of tangents to an arch of a parabola.

The deformability of the paraboloid can directly be shown as follows:

The plane through the line AB parallel to DC and the plane through line BC parallel to AD are parallel to one another. A system of equally spaced parallel planes then contain the corresponding division points of AD and DC. A second system of parallel planes contains the division points of AD and BC. The two systems of parallel planes are forming a system of prisms. It is evidently deformable. From the fact, that the elements of the paraboloid are lying in the faces of the prisms, results the deformability of the paraboloid.

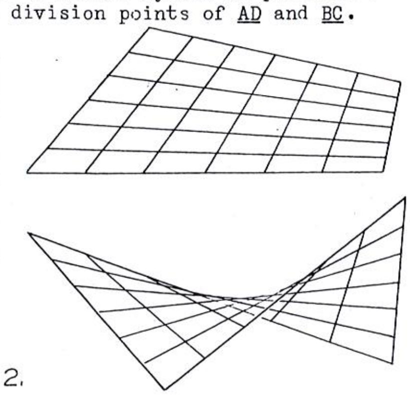

FIG. 2.

TECHNICAL DESCRIPTIVE GEOMETRY PROBLEMS

by

WILLIAM E. STREET
Professor and Head of the Engineering Drawing Department, Agricultural and Mechanical College of Texas.

CONNER C. PERRYMAN
Professor of Engineering Drawing, Texas Technological College.

JOHN G. McGUIRE
Professor of Engineering Drawing, Agricultural and Mechanical College of Texas.

Published in August, 1947, the problems in this text are organized for use with any suitable text book although designed with a view towards Professor Street's forthcoming book TECHNICAL DESCRIPTIVE GEOMETRY. They have been selected to emphasize descriptive geometry fundamentals applicable to all technical fields. Methods of solution have been painstakingly correlated with industrial drawing methods as set forth in all standard works on Engineering Drawing. It is for the generally accepted freshman course.

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(Continued from page 15)

reeks of things technical and the boys like it.

The College Preparatory course includes the academic subjects necessary for meeting the entrance requirements for any liberal arts or technical college and in addition requires that the boy take ½ year of patternmaking, 1 year of machine shop and 1½ years of mechanical drawing with the option of another year of drawing or shop if he chooses to elect it.

The General course is outlined for the boy who will probably conclude his formal education upon graduation from high school. This course is strong in mathematics and science, omits the foreign languages, and requires the boy to take 1 year of patternmaking, 2 years of machine shop and 3 years of mechanical drawing. Commercial art, machine woodwork, electronics, and architectural drawing are elective subjects available to the boy in this course.

The shop courses aid in the teaching of drawing as the boy becomes acquainted with the common shop terms and machine operations, and vice versa the teaching of shop courses is accelerated as the boy learns to lay out and dimension his drawings correctly.

In the first year of drawing we take up engineering lettering (including numerals, fractions and titles) and the placement of views (3rd angle only). Students acquire style and technique through progressive problems starting with straight lines only, then compass problems, and finally problems involving straight lines, arcs and circles. A few of these problems are dimensioned. In fastenings they study the forms of threads, the helix, helix angle, pitch and lead, single and multiple threads, conventional thread representation, cap, machine and set screws, keys, and springs. Boys who leave school at the end of the freshman year thus have a working knowledge of drawings and can correctly read simple blueprints.

The 2nd year starts out with a study of the geometric solids. The plane surface group comprises prisms and pyramids, right, oblique and truncated. The single curved surface group consists of the cylinder and cone, right, oblique and truncated. These surfaces are developed. Related geometry, the true length of a line, rectification of an arc, etc. are taken up as the occasion requires. The conic sections are laid out both from projection and geometric constructions. The intersection of solids involves the intersections of plane surface objects, plane surface and singly-curved surface objects and double-curved surface objects. The surfaces are developed, pricked through onto another sheet and the models made.

Pictorial drawing comprises isometric drawing with the object at, above and below eye level and including the isometric and non-isometric line and the circle, arcs of a circle and the irregular curve. Oblique drawing includes Cavalier and Cabinet drawing and objects on which proportionate lengths are used on the third axis to produce more pleasing results.

All boys in the drawing classes are now taking machine shop so at this time we stress working drawings and dimensioning. All work is in pencil on tracing paper and we follow current shop methods in detailing. Auxiliary views, sections, violation of theory are covered. A simple assembly drawing is made and finally the boys go to the blueprint room to make a blueprint from what they consider the best drawing they have laid out and to see other reproduction processes demonstrated.

This concludes the required drawing for the College Preparatory boy although, as I have said previously, a considerable number of these boys take the final year of drawing as an elective subject. Boys leaving school at the end of this year have a substantial background in drawing.

The senior year of drawing which is required of all General Course boys starts with simple mechanisms. In gearing we lay out the tooth curves, i.e. the cycloid, epicycloid, hypocycloid and involute. The cycloidal system of gearing is briefly discussed and then we concentrate on the involute type of gear. On the board we lay out a commercial drawing of spur gears, both $14\frac{1}{2}^{\circ}$ and stub tooth, a rack and gear, a bevel gear and a worm and gear. The materials of gears, methods of cutting and hardening are discussed. In the shop the boy cuts a spur and a bevel gear. The related mathematics is covered as required.

Types of belting (leather, fabric, rubber impregnated) and chain drives are covered illustrating the transmission of power by flexible connectors. Types of belt applications are also covered, such as open, crossed and quarter turn.

In the transmission of motion by means of cams, we lay out the common cam motion diagrams and usually an edge plate cam and a cylindrical cam. The pressure angle is discussed. The automatic screw machine in our shop well illustrates the cam in action.

A few simple linkages are laid out, especially the quick return motion which the boy sees on our shapers.

In the final semester of drawing the boy makes an assembly drawing of a fairly

(Continued on page 35)

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Successful teaching of dimensioning, especially with "selection", depends to a large degree upon aroused student interest. To insure gaining this, the student must be made to feel the importance of dimensioning, perhaps even to the extent that he regards the orthographic views as merely a medium by means of which the dimensions can be indicated. Logical explanations of the dimension selection for parts whose functions are known, will make clear how improper dimensioning may cause malfunction of the parts or difficulty in the shop, and readily bring out the importance of proper dimensioning.

The dimensioning work sheets used are designed to illustrate various teaching points. The first sheet contains a number of theoretical simple shapes and with it is furnished a duplicate sheet which has been dimensioned (Slide 1). The student in copying the dimensions, develops skill and knowledge of the "technique" phase, while the lecture-demonstration emphasizes the "selection" from the "shape breakdown" standpoint and the dimension "placement".

Each subsequent sheet shows a practical object for which the function is known. Since the various basic methods for producing parts introduce peculiarities in the proper selection of dimensions to meet shop requirements, and often in the orthographic views as well, at least one part to be produced by each of the principle basic methods is used. These peculiarities are discussed in the lecture-demonstration along with the dimensioning. Throughout the series, the fundamentals of "functional principle", "Process principle" and "shape breakdown" are emphasized over and over until their application as a systematic procedure becomes second nature to the student.

The second dimensioning sheet shows a part to be produced by machining from solid stock (Slide 2). This kind of part is the best of the practical objects to start with, since but one type shop or workman need be considered when applying the "process principle". In addition to the dimensioning, the student is introduced to standard stock sizes and shapes, cold and hot rolled conditions, etc.

The third and fourth sheets illustrate sand castings. A general explanation is given of the various types of castings, the manufacturing processes involved and the materials used. Emphasis is placed on sand castings, the patternmaker, draft, fillets and rounds, cast and finished surfaces, machining allowance, the importance of finish marks, the need to dimension for two types of workmen, etc. It is pointed out how time and material are conserved through the use of castings for intricate parts versus machining from the solid. The four types of drawings, "pattern", "casting" (unmachined) "machining" (machining dimensions only), and "casting and machining", which might be made for castings are discussed. It is pointed out how the two types of workmen are usually provided with their dimensional information on the single drawing ("casting and machining") of the finished part. One of the castings dimensioned is usually of a type containing a shape difficult to break down for patternmaker's "size" dimensions and requiring instead dimensions like those most useable when making the drawing since the shape will be drawin on a board by the patternmaker for bandsawing.

The casting used with the third sheet (Slide 3) is represented by two sets of drawings -- one as the rough or unmachined casting (labeled "casting") and the other as the finished part (labeled "machining"). The "casting" drawing is dimensioned with the patternmaker in mind, giving dimensions for producing the rough casting, while the "machining" drawing contains only the dimensions for finishing. This procedure has considerable merit since it permits a separation of the patternmaking and machining dimensions for study purposes. It may be pointed out in the discussion that the engineering department can easily control the machining allowance through this system.

The casting on the fourth sheet (Slide 4) is represented by views of the finished part only. Applying dimensions for both patternmaking and machining on the one drawing introduces selection conflicts which are more readily understood and solved by the student after he has dimensioned the third sheet, Since the machining dimensions for castings are usually functional, it should be apparent why precedence is given the machining in conflicts between patternmaking and machining dimensions. Such conflicts were not incurred in the system followed on sheet three. The extreme importance of the finish marks on a casting drawing of the type occurring on sheet four should be pointed out.

The fifth sheet shows a drop forging (Slide 5). A general description of forging types and production practices is given, with emphasis on those produced by closed impression dies. The similarity between castings and forgings, in that they both exist as rough and as machined parts, is mentioned; also, that closed impression die forgings in the rough or unmachined stage require dimensions for the die-sinking. The significance of forging draft and its treatment on drawings is discussed, along with parting lines and planes, flash, trimming, etc. Sheet five follows the common practice of providing views of the unmachined forging (labeled "forging") and views of the finished forging (labeled "machining"). Selection of dimensions for the unmachined forging is simplified by considering the draft as having been removed when the dimensioning is performed. This results in giving those dimensions which are parallel with the parting plane, at the smallest place on the object, that is, at the bottom of the die cavity. Reasons why this usually satisfies the diesinker's requirements are discussed. The draft, when uniform, is provided for in a general note.

A sheet metal part (Slide 6) is used on the last dimensioning drawing. With this the procedure is much the same as before, explanations being given on manufacturing procedure, template makers requirements, etc. Attention is called to the desirability of keeping dimensions to one side or the other of the part, in so far as practical, to assist the template maker. The treatment and methods of specifying stock, bend radii and bend relief are discussed, along with

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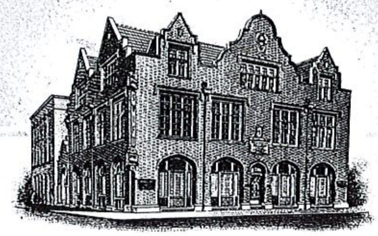

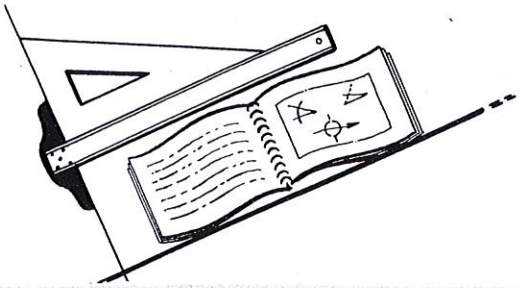

(continued from page 32)

mold lines and their use in the dimensioning.

Following the laboratory sheets on dimensioning, the working drawing problem is introduced. Formerly, this problem was presented as a dimensioned pictorial or orthographic assembly. The dimensions given on such drawings are commonly those most suited for making the drawings, rather than those most appropriate for the functional and shop requirements of the parts. Student tendency to use the furnished dimensions for the detail drawings, whether they are appropriate or not, results in little application of judgment and reasoning in dimension selection. To avoid this, the problem is now presented in the form of a design drawing (Slide 7) from which the student obtains the information necessary to produce a complete set of working drawings suitable for quantity production of the unit. The design drawing contains no dimensions excepting those involving close fits, in which case the decimal limits are provided; all other dimensions are obtained by scaling the design drawing. Thus the student must choose the greater part of the dimensions himself and correlate them with those selected for mating parts. Although the instructor provides guidance in this, the student is on his own for the most part and must apply the knowledge and judgment gained from the previous dimensioning work.

To complete set of working drawings, includes the details, the parts list and the assembly, with each detail on a separate sheet which has a printed title strip containing general tolerances. All drawings are on vellum so skill can be acquired in making pencil drawings suitable for reproduction. The student is placed in the position of a commercial detailer and must supply any information not given on the design drawing, such as clearances, tap drill sizes, etc. Considerable student interest is aroused with this type problem and the results have been gratifying. More interest is developed with problems based on simple machines which can be detailed in their entirety than with units taken from larger machines and whose application may not be clearly understood.

In conclusion, it can be said that there is no easy or simple way to train students to dimension with a competence comparable to that gained through years of experience by the commercial detailer. The factors which would have to be covered are too many and varied. It has been demonstrated, however, that a student trained in the use of the "shape breakdown" sysetm as modified by the "functional and process Principles" and with an understanding of the factors discussed in this paper, is able to assume a commercial detailing position and perform creditably in his dimensioning. The commercial draftsman, with his "loose" and specialized dimensioning practices is little concerned with the procedures and exactness required in dimensioning for quantity production, and would have much to learn if placed in that work. To train students in the dimensioning practices of all branches of drawing in a basic drawing course would be an impossibility with the time available. It is wiser, therefore, to concentrate on one branch. The most logical choice for this is machine drawing, because machinery is the common meeting ground for all engineers. In this, it would seem wiser to teach toward the exactness of size description required with the quantity production system, rather than to the "looser" methods of fifty years ago. The writer would like to see the teaching of dimensioning developed to a higher level and on a completely scientific basis wherein the presentation is entirely logical and understandable to the student. This can be accomplished only after the many factors influencing the selection and placement of dimensions have been isolated and evaluated in importance and teaching methods developed for presenting them.

(continued from page 21)

college with at best a hazy idea of the scope and possibilities of the engineering field. It is the duty of the drawing teacher to help them to clarify that picture and to choose more intelligently the field into which they will most readily fit.

In order to affect such orientation, the teacher should simplify to the maximum the presentation of basic principles so that he may devote the greater part of his time to illustrative material and applications taken directly from the practical field. No problem should be taken up which is not immediately applied to some phase of engineering or of the supporting science. This is not an easy thing to do and must of necessity involve a great amount of reaserch on the part of the individual teacher but the goal is well worth the price. Those teachers who stand out clearly in my memory are the ones who carried me out into the general field of application through the medium of illustrative material brought in from all over this country and, in one case, from foreign countries. They created in me a greater interest by making the work of the engineer a living thing about me at that moment rather than something hidden by the future.

(Continued from page 5)

project conducted by an engineering or science department. By demonstrating the advantages of solving certain problems graphically he could win the support of research organizations to the contribution which we believe graphics can make to the solution of many of their problems. This would lead to the development of new and useful graphical methods.

The current technical literature contains many examples of applied graphics and the new textbooks make frequent reference to graphical methods of analysis. A good many thoughtful people in various fields of learning and research are adopting graphical methods, because they recognize their intrinsic advantages. This is our rightful domain which we should claim and develop without delay. Here is an outstanding opportunity for development in our field.

Recently I prepared a bibliography of graphical methods containing references to four hundred articles which have been published during the last ten years. The list has been mimeographed and I shall be glad to send a copy to any colleague upon request. As soon as possible we expect to classify the list and add a brief abstract to each reference.

During the Minneapolis meeting last June I suggested to a number of our colleagues that Detroit would be a good place for our midwinter meeting, and my suggestion met with general approval. So the midwinter meeting of the Division of Engineering Drawing was held in Detroit on Saturday, December 27, in the Rackham Educational Memorial Building whose excellent facilities were made available to us through the courtesy of the Engineering Society of Detroit. The host institutions were Wayne University and the University of Detroit. Professor R.T. Northrup was Chairman of the local Committee which planned the program and made all arrangements for the meeting.

As Detroit is the center of the automotive industry we had two interesting speakers who explained the use of Drawings in automobile research, design and development. Mr. A.B. Grisinger of the Kaiser-Fraser Corporation spoke on "Body, Art and Styling" and Mr. J.R. Holmes, of the Chrysler Corporation gave a talk on "Chassis Design & Development." Prof. R.R. Worsencroft, of the University of Wisconsin, presented the college viewpoint in a paper entitled "Shall We Give College Credit for High School Drawing". Three McGraw-Hill sound motion picture Text-Films were shown, illustrating "The Drawings and the Shop", "Sections and Conventions" and "Selection of Dimensions".

The Drawing Division dinner was featured by the presence of a President and three Deans from the host institutions. Professor F.G. Higbee, of the State University of Iowa, gave an inspiring address on "Humanistic - Cultural Contributions Associated with Engineering Drawing". The midwinter meeting was attended by 77 persons, including drawing teachers from 25 colleges and 5 schools in 12 States, as distant as Texas and Alabama, and 9 representatives from industry. It was generally agreed that the meeting was a real success.

In the morning of the midwinter meeting the Executive Committee of the Drawing Division met in Webster Hall of Wayne University and planned the program for our annual meeting at Austin, Texas, in June. There will be a joint conference of the Drawing Division with the Machine Design group of the Mechanical Engineering Division of the Society. In another conference Professor C.E. Rowe, of the University of Texas, will give a demonstration of his excellent collection of visual aid models. And we plan to hold a teaching clinic on engineering drawing and descriptive geometry for the benefit of new instructors who need counsel and guidance in their teaching problems. All members of the Division are cordially invited to attend the annual meeting, June 14-18, 1948.

The Executive Committee also decided to change the election procedure for Division officers to promote a wider participation by members of the Division. A nominating ballot and then an election ballot will be mailed to Division members by the Nominating Committee. All members are urged to take part in the nomination and election of Division officers and mail their ballots promptly.

(Continued from page 30)

complicated machine unit. The design of each piece and the material used is discussed in relation to its function. Plain and anti-friction bearings and lubrication of these bearings is taken up. The machine operations are analyzed which brings up the subject of gages, jigs and fixtures necessary for quantity production. Tolerances on mating parts are studied and the unilateral and bilateral systems of expressing tolerances compared.

It must be evident by now that this course in drawing is not laid out solely for the purpose of fitting the boy for the engineering colleges. It does prepare the student for further technical education but the real objective is to give a general basic background, both theoretical and practical, that will be of immediate value to the boy who must conclude his formal education at the high school level.