JOURNAL OF ENGINEERING DRAWING

VOL. 13 NO. 1 FEBRUARY, 1949 SERIES NO. 37

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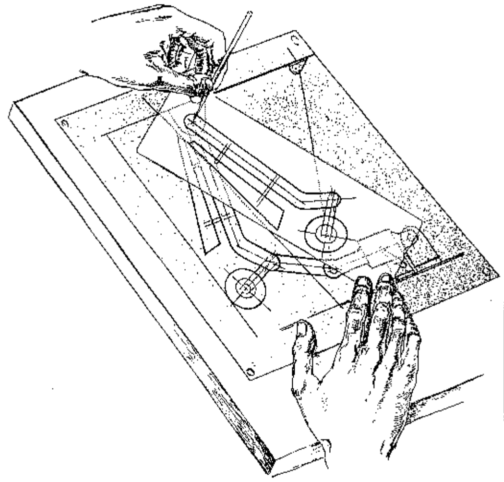

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PUBLISHED IN THE INTEREST OF TEACHERS OF ENGINEERING DRAWING AND RELATED SUBJECTS

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CONTENTS

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PUBLISHED IN FEBRUARY, MAY, AND NOVEMBER BY THE DIVISION OF ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

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His invention of Descriptive Geometry opened up horizons unlimited.

J.E.S.

A MESSAGE TO THE ENGINEERING DRAWING DIVISION

by

Henry Cecil Spencer

Illinois Institute of Technology; Chairman, Division of Engineering Drawing, A.S.E.E.

Our colleagues in other departments, the physicists, the mathematicians, the mechanical engineers, the architects and all the rest have their specialized professional societies, The American Physical Society, The American Mathematical Society, The American Society of Mechanical Engineers, and so on. In most cases, a progressive man is active in several societies in his specialized field, and in addition, may be a member of the A.A.U.P. or the A.S.E.E. or both.

Engineering Drawing teachers do not have an "American Society of Engineering Drawing" or an "American Society of Descriptive Geometry". But, twenty-one years ago, at Chapel Hill, S.C. our No. 1 group, the Engineering Drawing Division of the A.S.E.E., was born. Since that time, it has been one of the most active divisions of the Society.

We often pat ourselves on the back when comparing our Division with others in the A.S.E.E. But the Engineering Drawing teacher's relation to the A.S.E.E. is unique. The A.S.E.E. is without question our No. 1 society. The Engineering Drawing Division is to the engineering drawing teacher what the A.S.M.E. is to the mechanical engineering teacher or the A.I.A. to the architect. The Engineering Drawing Division is the only common meeting ground for teachers in our field. Why shouldn't our Division be prominent compared to other divisions of the A.S.E.E.? It seems to me that our Division is only a weak shadow of what it really should be in terms of membership and professional activity.

Here we are, one of the most numerous groups among all engineering teachers, and look at the unimposing proportions of our Division! What percentage of college engineering drawing teachers in the country are members of their only specific professional group, the Engineering Drawing Division of the A.S.E.E.? 20%? 30%? I doubt if it would be any higher. By way of contrast, what percentage of mechanical engineering teachers are members of the A.S.M.E.? I do not know what the percentage is, but it is difficult for me to visualize any respectable teacher of mechanical engineering who is not a member of the A.S.M.E. It is like trying to think of a doctor who is not a member of the American Medical Association. Would you be willing to have your child "doctored" by a physician who was not progressive enough even to be a member of the American Medical Association? Dr. Fishbein tells me that about 90 per cent of all U.S. doctors are members of the A.M.A.

I recently attended the A.S.M.E. annual meeting in New York, and was re-impressed by the size and activity of that organization. It may be argued that the A.S.M.E. cannot be compared with an association of engineering drawing teachers, since the A.S.M.E. includes industrial elements as well. To some extent this contention is valid, and there are other differences as well. But, why don't we give some thought to bringing industry actively and permanently into our group? We try to have speakers from industry frequently on our programs. This is certainly the least we can do. But shouldn't we go further in bringing industry into our group? What can we do to keep our Division in close touch with industry through participation of its members in our group? What do you suggest?

This wide gap between industry and our group was quite noticeable at the recent organization meeting in New York of the Z14 Sectional Committee on Standard Drawings and Drafting Room Practice. A relatively small number of engineering drawing teachers are, as individuals, keeping in close touch with industry; but the Engineering Drawing Division, as a group, is a society of professors which tends to be quite separate from industry.

I do not know the answers to all these questions but I do suggest that we should have many dues-paying members of our Division from industry. Our group should be representative not only of college teachers of engineering drawing, but of men primarily concerned with drafting in industry. What should we do to build up this side of our membership?

In summary, I should like to repeat that our Division has made excellent progress, but that when we recognize what a loud voice it could and should have before the public, we realize that we have hardly begun.

When there is a big job to be done, I always like to think first of what we can do in our own back yard. Certainly, in view of the fact that our Division is the one meeting place for our profession in existance, no full-time regular engineering drawing teacher, of whatever rank, should fail to be a member and actively participate in its activities. He should read the JOURNAL OF ENGINEERING EDUCATION regularly, which will go far toward keeping him in contact with current trends in engineering education.

In addition, and I cannot emphasize this too much, every engineering drawing teacher in the United States should be a subscriber to the JOURNAL OF ENGINEERING DRAWING, and should keep a careful file of its issues. It is the only journal published specifically in our field and, through the years, its accumulated issues constitute the best professional literature we have.

At this time the A.S.E.E. is conducting a nation-wide membership drive. Now would be an excellent time for each member to persuade some non-member to join the Society and start his professional growth as a teacher of engineering drawing. Now is the time for every department head to canvass his staff with a view to obtaining 100% membership. In my opinion, membership in the A.S.E.E. should be required as a condition of permanent employment for every full-time teacher of engineering drawing.

For membership blanks, write to Professor A.B. Bronwell, Secretary of the A.S.E.E., Northwestern Technological Institute, Evanston, Illinois.

MODERN DIMENSIONING PRACTICE

by

Professor S. B. Elrod, Purdue University

Modern dimensioning practice is the result of one hundred and fifty some odd years of evolution. In the late 1700's a French commission was appointed to develop a scientific dimensional system, the result being the widely used Metric System. Since that time dimensioning practice has undergone many evolutionary, and sometime seemingly revolutionary changes. To enumerate, let alone explain, the results of all these changes would be not only a colossal task, but would probably be equally tedious. A brief discussion of a few pertinent aspects of current dimensioning and tolerancing practice might be more appropriate, and I propose to limit myself to a discussion of a few such items which I find to be of particular interest to a large number of engineers and teachers today.

The greatest strides in the evolution and development of Dimensioning Practice have taken place in the past two decades. Prior to the first world war only a small minority of industries had progressed beyond the stage of custom manufacturing. In general only basic dimensions were put on a drawing, and little effort was made in selecting those dimensions. The rapid growth of mass production, particularly in the automotive industry, and the industries producing goods for World War I, brought out the necessity for refinements in dimensioning practice and tolerancing.

With characteristic inertia, it was not until a few years after World War I that the drawing courses in many engineering colleges began to recognize the problem of tolerancing. In many cases the only tolerances used then were perhaps ± .001 for close close work and ±.005 for rougher work, used along with the old expressions "Slip fit," "Drive fit," etc., which still left much to the judgment of the machinist. The colleges are not to be too severely criticized for this lag, since many industries continued to work on this same basis for several years, and some individual companies have never progressed beyond this level.

There are in existence even today a large number of firms that are not concerned with the refinements of present day dimensioning practice. In such places there are no tolerances, express or implied, on any of their drawings. Basic dimensions are given, frequently to 1/64" and sometime in decimal form to three or four places. Under such circumstances the individual mechanic, foreman, etc., is entirely responsible for maintaining dimensions which will be satisfactorily close to the basic dimensions given. The use of a system such as this is comparable to giving a mechanic a set of drawings for a steam engine and saying: "Here is a set of drawings for an engine, make me one about the same size, and be sure it will run."

In contrast to this we have today a few industries that have gone to great length to work out a system of dimensioning which leaves absolutely nothing to the judgment of the mechanic, the sole responsibility for the functioning of the parts resting within the engineering department. In some such industries every dimension on the drawing carries a specific tolerance (or is expressed as a limit dimension) and the degree of finish for every surface is specified. It is questionable whether or not such a system would be economically feasible in very many highly competitive industries unless designs were highly stabilized, however, it does give us a goal to work for in all fields.

OBJECTIVES

Any person or organization that attempts to develop or improve practices, processes, etc., in any field needs to have an ultimate goal, or ideal. This ideal may never be reached, but any progress in its direction is usually quite beneficial. The ideal to be worked toward in Dimensioning Practice might be stated thusly. "The ultimate objectives are: the ability to produce a complete set of separate working drawings for a large number of complex parts, each of which are to be manufactured by a separate organization, with no liaison; the ability to use all parts so produced, with no selection, in the assembly of mechanisms, all of which will function properly and efficiently; and at the same time keep drafting time and effort to a minimum."

DECIMAL DIMENSIONING

Any great progress in this field would be quite difficult if we are to be limited to fractional dimensions. The newer proposals seem to neglect fractions entirely and are based on the decimal system. The two place decimal system which was inaugurated by the late Carl E. Johanssen in the Ford Motor Company's plants has gained ground rapidly, being adopted by a considerable portion of the automotive industry, and by well over 80% of the aircraft industry. The system has all of the advantages of the metric system, without the necessity of a vast re-educational and re-tooling program, and if it had been proposed earlier, might well have been prohibited by law, as was the Metric System in England prior to 1897.

Surveys conducted periodically show that the shift to decimal dimensioning continues steadily, if not at an increasing pace. When one considers the effect of this continued trend, it may be that we should be preparing to change over completely within the next decade.

All of the following discussion is illustrated in decimal form, for the reason indicated above, and because the writer was forcibly converted six years ago, and would gladly forego any return to a fractional system.

FUNCTIONAL DIMENSIONING

There has been a tendency in the past for most discussions of dimensioning to start with the assumption that the processes involved in the manufacture of the part was the governing factor in dimensioning it. The present need for performance and interchangeability has invalidated that assumption, for in many cases the proper functioning of the part is paramount. In any case the tendency is to consider function first and processing becomes secondary, however important.

In the new proposed American Standard, Principles Governing Design and Dimensioning with Applications of Tolerances and Allowances for Interchangeable Manufacture, we find the following statement "4. In examining the project to determine its suitability for economical manufacturing, inspection and assembly requirements, primary datum surfaces must be established from functional considerations."

Ordnance Manual, arts. 380.01, 380.02 and .03 read as follows:

"Dimension and tolerance surfaces in the order of their importance in the functioning of the mechanism. The relationships left without direct dimensioning and tolerancing should be those of least importance. Dimension directly to the surfaces which make contact with other parts in the operation of the mechanism. Having placed dimensions and tolerances in accordance with functional requirements, study the design to see whether any rearrangements would make machining faster or less expensive. On Ordnance drawings do not rearrange dimensions and tolerances for machineability unless this can be done without materially affecting the accuracy and the utility of the design."

Other contemporary works on dimensioning express essentially the same ideas, the emphasis being placed on function, with processing secondary.

DIMENSIONAL CONTROL

We have been concerned for several years over the tendency of draftsmen to locate the centers of circle arcs by coordinate dimensions. During the war the writer was a member of the Production Design group of an airframe manufacturer. One of the duties of that group was to exercise control of drafting practice, and we were especially concerned with dimensioning and tolerancing. In an effort to combat this and other troublesome tendencies we coined several maxims which were rather effective. Two of these were "Dimension the drawing to show the size and shape of the finished parts; not to show how the drawing was made," and "If you can't "mike" it, don't put it on the drawing." The general practice being that any dimension which disagreed with either of the above statements must be marked as "REFERENCE," which means that such dimension is for record or information only, is not to be checked, nor to be used for processing.

It may well be that some of these tendencies which we were trying to overcome can be blamed directly on our own profession. ASA Z 14.1 and many of the current textbooks and manuals have an illustration similar to that shown in old Fig. 19, which is taken from the current SAE Aeronautical Drafting Manual. This illustration is a perfect example of how to dimension a part to show how the drawing was made, but a very poor way to dimension such a part for production. Each of the coordinate dimensions given on this

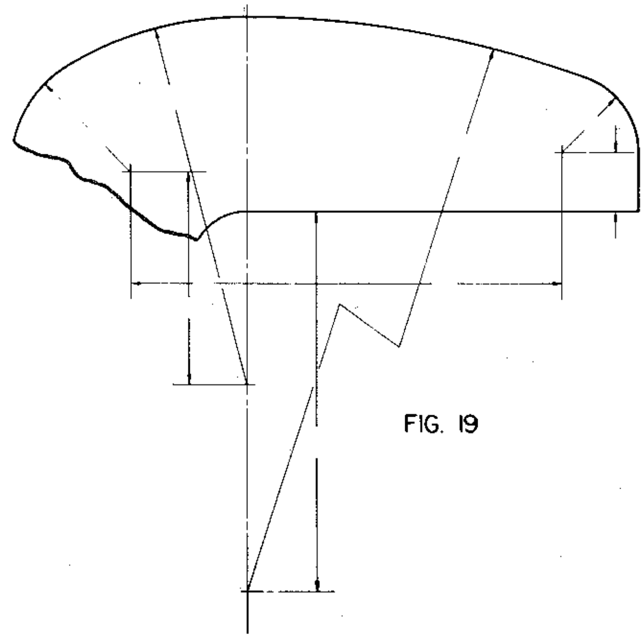
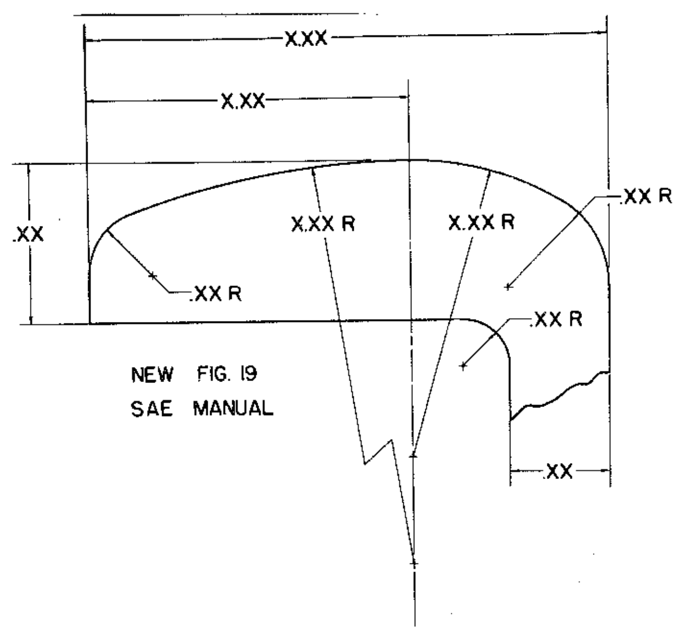


FIG. 19

illustration should, if desired, be given only as reference dimensions; in fact this is suggested in the Ordnance Manual, par. 372.2.

This illustration will soon be replaced by one similar to that show in new Fig. 19. A short examination will show the advantages of such a system of



NEW FIG. 19
SAE MANUAL

dimension only, and the centers of all circle arcs are controlled entirely by the location of these surfaces. Much closer control of the shape can be attained in this way with the same tolerances. An even simpler example can be illustrated by Figs. 24 and 25 from the Ordnance Manual concerning dimensioning of slots or external surfaces with rounded ends. In either case the two

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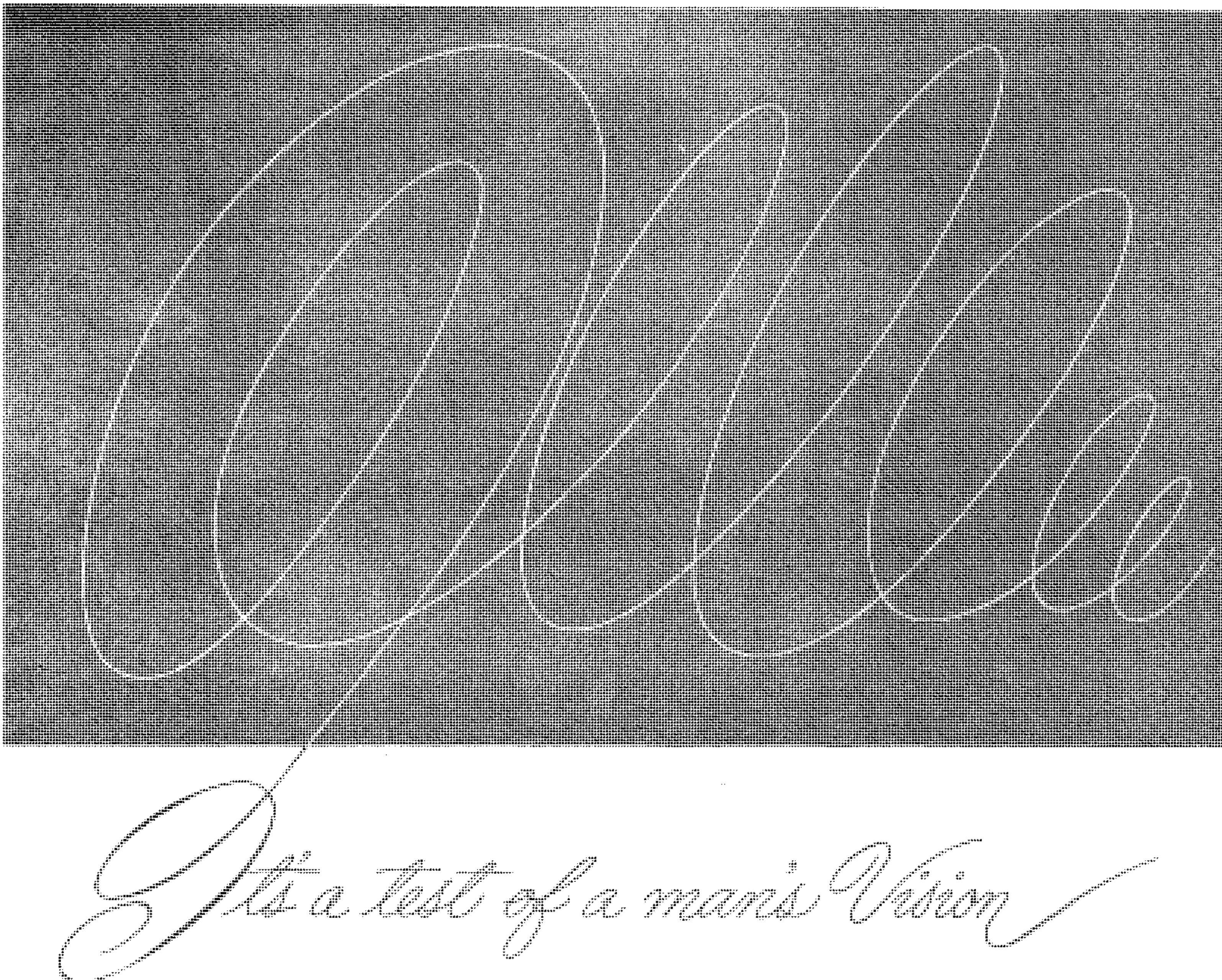

This is a piece of wire, ordinary steel wire. Most men, encountering such a bit of metal in their path, would not give it a second glance, let alone a second thought. Yet . . . in the hands of men of vision . . . it becomes a vital component in a miracle—the miracle of magnetic wire-recording which in the years to come may well affect the lives of millions of people.

So it is with the ordinary metal of human nature, by some men thought not worth a second look. Yet it must be obvious that from this common clay are fashioned tomorrow's citizens for good or for ill. Educators with insight and penetration know that here alone is the source from which achievement in any field is to be drawn. Every boy in school possesses more energy than he can ever use . . . far more talent than will ordinarily see the light of day . . . hungers and urges toward the boy knows not what and cannot know unless someone points the way.

How shall this pointing be done? How shall energy be mobilized toward a worthwhile goal? How shall ambition be strengthened? How can a feeling for craftsmanship be aroused and sound standards established? How indeed if the educator fails in his primary responsibility?

The very drawing instruments a boy uses in mechanical drafting are a case in point. These are the instruments used by engineers whose exploits can fire the imagination and stir the desire to emulate in every mechanically minded lad . . . especially if the boy, at the threshold of manhood, has the inspiration of tools worthy of grown men. The selection of his drawing instruments is an initial step on the road that leads to adult achievement. Here, too, "Well begun is half done." All men respond to fine workmanship. Shall the quality of the student's equipment be less than enough to win his respect? The human mind moves by analogy, from small to great, from near to far. In what direction shall these near, "small" steps lead? *Any educator who weighs these questions knows that to let a boy work with any but the finest equipment he can afford is to contradict all that the educator has learned about the fundamental educational process.*

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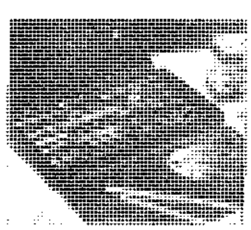


DIETZGEN

EVERYTHING FOR DRAFTING AND SURVEYING

PROBLEM SOLUTION

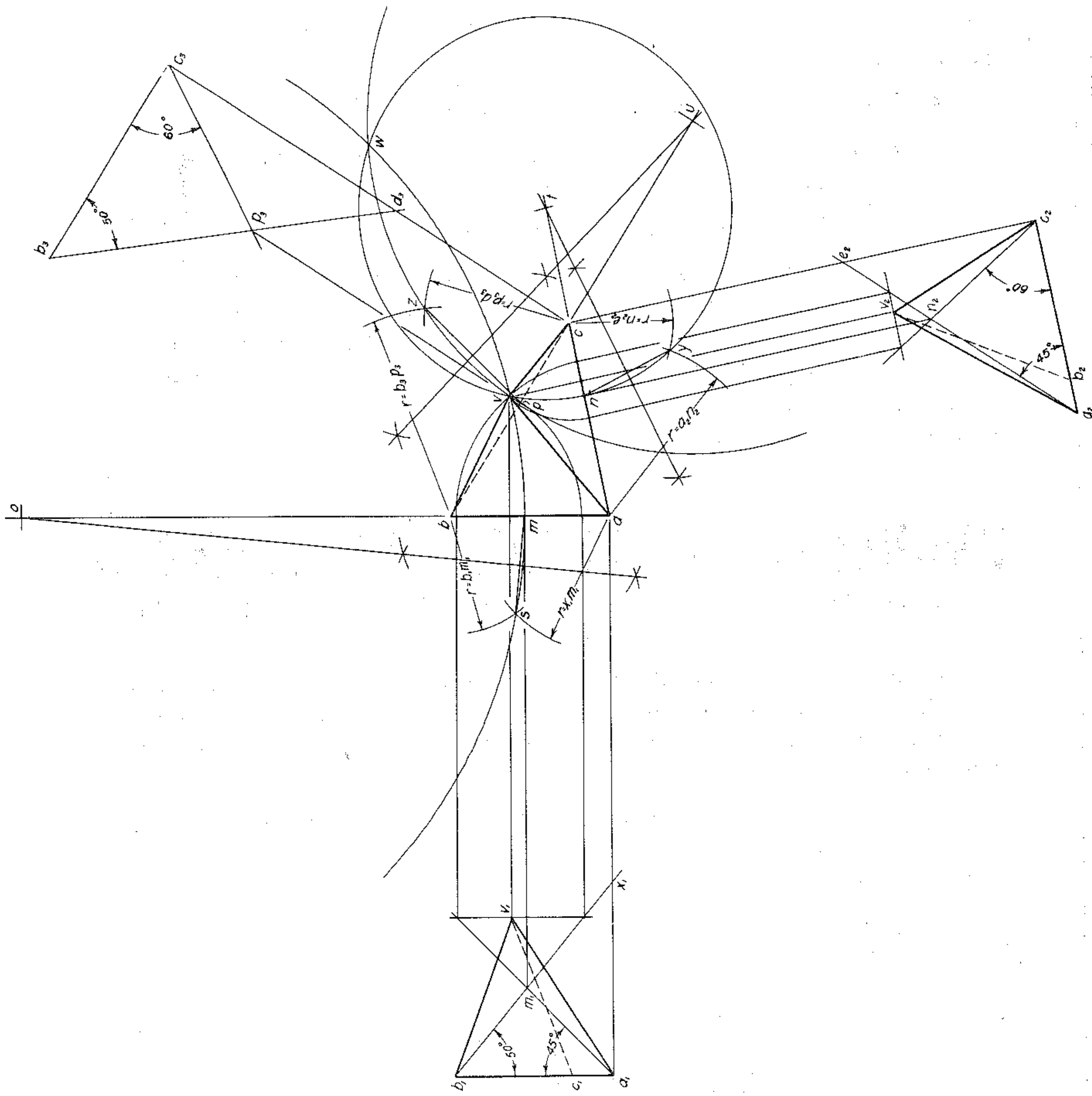
by

Professor H. D. Orth, University of Wisconsin

Problem: Given any triangle ABC. It is required to construct a pyramid with this triangle as base, and with the lateral edges inclined specified angles to the plane of the base.

Analysis: Three right circular cones with vertices at the corners of the given triangle, with axes perpendicular to the plane of the triangle and elements making

(Continued on page 33)



TEACHING CLINIC IN ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY

Members of the Teaching Clinic: Professors H. C. Spencer, F. G. Higbee, Ralph S. Paffenbarger, R. P. Hoelscher, F. M. Warner, John T. Rule, G. Gerardi. (Editor's note) The following six articles are a partial presentation of the contents of a teaching clinic that was conducted on Tuesday, June 15, 1948, at the University of Texas; Professor McNeil of Texas presided. Professor Spencer started the discussion. His topic was blackboards and their use in the classroom. He gave an excellent demonstration of blackboard sketching technique and emphasized in this discussion the importance of preparation of sketches prior to class demonstration. No written paper is now available covering his discussion.

STIMULATING STUDENT INTEREST IN ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY

by

Professor F. G. Higbee
University of Iowa

Maintaining and enlarging student interest in Engineering Drawing and of creating and developing student interest in Descriptive Geometry more accurately describes the teacher's responsibiliyt and opportunity in this discussion than does the topic assigned.

Students already have a lively and motivating interest in engineering drawing when they first begin the course. They know so little about descriptive geometry they have neither an interest in nor a prejudice against that subject, except perhaps as they become acquainted in college they hear rumors and tall tales about its complexities.

Therefore, I am proposing to comment on the teacher's opportunity and duty in maintaining and enlarging the natural interest students have in engineering drawing, and of indoctrinating students with a belief that descriptive geometry is as much an important and a necessary part of the graphic language of drawing as is grammar of the written language.

Rather than having to stimulate interest in engineering drawing the teacher's concern should be primarily the organization of the content of the course to hold the natural interest of his students and to convince them of their ability to become progressively better draftsmen while at the same time to insist upon standards of draftsmanship which grow more and more exacting as the course continues.

Once the student realizes, equipped as he is with an efficient kit of tools for making all the constructions required, that with a working knowledge of basic principles he can now write in the most successful language ever devised for the recording and transferring of creative ideas, he now can be made to understand the importance of quality work. In my judgment interest in engineering drawing is established. The teacher's important missionary work is to make the student understand and believe that established drafting standards and acceptable standards of workmanship are essential features of engineering drawings.

To indoctrinate students with the belief that descriptive geometry is an important and necessary part of engineering drawing is, I concede, a difficult and baffling assignment. I am of the opinion that teaching descriptive geometry as a separate and distinct course tends to aggravate the difficulties the teacher has to face. But whether descriptive geometry is taught as a distinct course or is absorbed into the course in engineering drawing, there are certain points about its presentation which rightly used contribute largely to the attitude of students.

As teachers of engineering drawing we know, of course, that descriptive geometry probably is the first and undoubtedly one of the best educational disciplines for teaching the engineering method of thinking; we are well aware that the methods of descriptive geometry offer a satisfactory, quick, and illustrative system for the solution of many engineering problems; we constantly emphasize that descriptive geometry is the name for that graphic system by means of which creative thinking is made evident to others. It is, we declare, the very space geometry of representation, the geometry of the drawing board and, if we get desperate as we ofttimes do, we invent other names and other attention-claiming phrases to describe the usefulness of this subject we are trying so hard to "decurse"!

There is nothing new in this problem. Teachers began to face it when descriptive geometry was introduced into the United States in 1816; teachers continued the discussions when this society was founded in 1893. I do not expect to solve the problem in the ten minutes allotted to me at this time in 1948.

I shall, however, offer these suggestions. In whatever fashion most expedient, whether as a separate course or as a part of a general engineering drawing course, teach descriptive geometry primarily as a drawing subject. Choose only material which you can readily identify as having direct and practical application. Eliminate the so-called "pretty" problem. State problems in engineering terms and relate them to engineering work.

As a final suggestion, always have available a stock of apparently simple problems in the form of drawings which seem to be complete representations. Assign these problems when you think students need to be reminded that drawing is not mere pencil pushing. About the time they get stalled trying to "copy" a drawing, and discover for themselves--or from a subtle suggestion of yours--that involved therein is one or more principles of descriptive geometry which must be applied, a more respectful attitude toward the usefulness of the subject rapidly develops.

PREPARATION OF QUIZZES AND EXAMINATIONS

by

Ralph S. Paffenbarger
Ohio State University

From the standpoint of preparation of quizzes and examinations in Engineering Drawing, the following points should be considered:

- 1st - Type
  - A. Objective
    1. True and false
    2. Completion
    3. Multiple choice
  - B. Performance
- 2nd - Coverage or content
- 3rd - Evaluation-Per cent term grade
- 4th - Time Allotment
- 5th - Final form from results analyzed

The type test should be selected on the basis of what is to be tested. Under the objective classification we have listed three types. The first, true or false with the grading corrective factors to penalize the guesser. It has matched limitations and is generally classed the poorer type of the objective quizzes. Several years ago when true-false examinations were quite the popular type, I gave a final examination that was being given in an advanced drawing course to our secretary who was a Smith College graduate and a Phi Beta Kappa. Even though she had no knowledge of the subject, she made an A grade in the test; and had she been taking that examination for proficiency, she would have been given credit in an advanced drawing course without very much knowledge of the basic courses. This gave me a very bad opinion of the true-false type.

The completion type, requiring a short statement to finish a sentence, is much preferred over the essay type since it reduces the volume of reading matter and is desirable in some instances of testing the student's knowledge of fixed conclusions of important fundamentals.

The multiple choice type is the most popular of the objective type and may be used with 3 to 5 options. When material is such that it will lend itself well to the seledtion of these options, 5 is preferable for the reason that it reduces the factor of guessing. The multiple choice type in drawing examinations is particularly popular because of the possibility of its comprehensive coverage of the material and the elimination of the factor of the grader's judgment which frequently is at wide variance. Scoring of these tests is positive and rapid. They may be scored either with stencils, or if proper blanks are used, they may be machined scored. The tests are capable of standardization, getting wide spread results, and from the analysis from quarter to quarter, with continued use their reliability can be readily established. Another advantage of these tests is the stimulation of extensive preparation on the part of the student.

In general the objective type quizzes tests knowledge, visualization, and understanding of the subject matter. They may be strictly a word type test without reference to drawings, or they may be a view type; and the majority of the questions are of the view type.

The one objection to multiple choice is that it does not measure drafting skills, however, this is adequately done through the laboratory assignments and students are well classified from the standpoint of performance on this basis.

The performance test, nevertheless, has its place in the testing program and should not be wholly discarded. In connection with the performance tests, they are frequently designed so that they do not give wide enough spread in the grade range. That is to say they might be entirely too easy or too hard and a class would be unfairly measured by such a test. The performance type likewise does not give you the possible coverage in a limited time that a multiple choice examination gives.

Dealing with the second factor, that of coverage or content, much depends on the period in the course at which you are measuring, as well as the time available for such measurement. As already mentioned the multiple choice type gives much more comprehensive coverage of subject matter in a limited time.

The next point mentioned, that of evaluation or per cent of term grade is of prime importance in the design of a test. All tests in basic drawing courses should weight more heavily than actual laboratory grades for the reason that the student is then expressing himself wholly upon his own knowledge of the subject, without the aid of a book or the instructor's help. In connection with the evaluation with reference to quizzes, all quizzes should be evaluated on a time and coverage basis; that is to say if you spend twice as much time in testing throughout the quarter as you do on the final examination, these quizzes should weight more heavily than the final. First of all, final examinations should be given in all basic drawing courses and the per cent of term grade on all tests should exceed that of the laboratory work. Frequently schools will reduce drawing tests to a minimum, feeling that the students are sufficiently measured through laboratory assignments. From my experience this is entirely wrong, and I have always maintained that drawing is not a subject of mere copy and proper delineation of line work and lettering, but is a subject which necessitates considerable power of visualization and clear thinking.

In connection with the time available, quizzes should be carefully analyzed to see that sufficient time is allotted for the particular test in question.

Time may be established through experimental sampling in small sections, or preferably with student assistants in the department before they are actually used in the classroom. This is an important item and should be very carefully analyzed. Frequently in the multiple choice type the tests are designed so that very few students can complete the entire quiz. Where speed is a factor wider spreads are generally obtained, and this is quite desirable when establishing the mark for term grades.

Too frequently we are satisfied with tests without a knowledge of whether they are properly measuring. In connection with the revision and improvement of tests we should score results to validate our questions and revise in accordance with results shown to improve them in every respect. The prime function of any time test is to appraise or estimate with all possible accuracy the extent of the student's mastery of the factual content in the subject that he is studying. In connection with Engineering Drawing we test a student's power not only to read but to write the language and his ability to make useful application of this power, and more especially with our graphic language do we develop his power to think and visualize in terms of practical engineering projects.

For economy of time we should have a sampling of material to give us the greatest range of coverage in the least possible time consistent with reliable measurement. Questions of whatever type must be entirely clear and ambiguity eliminated. The format should be consistent with the drafting practice maintained, and should be reproduced with the most accurate methods from exceptionally well executed drawings.

OBJECTIVES OF ENGINEERING DRAWING COURSES

by

Dean R. P. Hoelscher
University of Illinois

In presenting this brief discussion for which ten minutes has been allotted, no attempt has been made to outline a set of hard and fast objectives to which we should all adhere, but rather to emphasize the importance of having some very definite objectives and to point out that these aims may vary somewhat from time to time and differ somewhat between schools and even between classes.

In setting up a course of instruction, we must first of all have certain over-all and far reaching objectives in which we establish exactly what we are trying to accomplish. These ultimate goals will not vary so much. To implement these major objectives, we need to plan more in detail and set up minor or specific goals for each unit of work, whether that be for a day or a week.

Our detailed objectives and perhaps even our major goals, to some extent, will depend somewhat upon the organization of our schools. For example, if we imagine ourselves in a school where each major curricula department teaches its own drawing courses, the aims of these departmental drawing courses will not necessarily be the same.

Or again, if we imagine ourselves to be in a school in which drawing is taught by a service department handling all engineers, our aims will be influenced by the method of registration. If students in all curricula are indiscriminately registered in sections, our objectives would be somewhat different than if we segregated mechanical engineers in one section, civil engineers in another, and so on.

Whatever the situation under which we work, having set up certain goals, our job is not finished until we examine and reexamine year by year the methods and means we use to achieve our aims. The question should frequently be raised, "Are we using the best assignments, the best problems, the best in visual aids for the purpose intended?"

In doing all this, we should not overlook the fact that there are also certain secondary objectives of a broad nature which are achieved by the personal influence of the teacher as an individual. One man may inspire his students to attain a professional attitude in his work and an altruistic outlook as a citizen; another may have the opposite affect.

With this statement as a background, the young teacher may well ask, "Are there no definite goals toward which we must all strive?" The answer to this is, "Yes."

One of our broad objectives is "to contribute our portion, and it is a very important part, to changing the incoming freshman from the inmaturity of youth to the more experienced status of the potential engineer." I would like to emphasize the word, "change," for that is the essential part of the process we call education.

Those of you, who attended the Drawing Division Summer School at Washington University in St. Louis two years ago, will recall the intensive discussion which centered around the cause of the resistance of our graduates to beginning their careers in the drafting room.

The teachers tended to put the responsibility upon industry, and the representatives of industry present placed it upon the teachers with equal vigor. We have perhaps stated our objectives, both to our students and to ourselves, a bit too bluntly by saying that our objective was to train them to be engineers, parenthetically or by way of inference, we have implied, "rather than draftsmen." While this may be true, our method should be such that the student will not be averse to the use of the drawing board.

We teach our students one of the two methods by which engineers communicate their ideas to each other and transmit them to skilled workmen. We have emphasized the importance of drawing as a graphic language and we have analyzed it for penmanship,

(Continued on page 15)

(Continued from page 13)

grammar, and rhetoric. All of this is very good, and it is one of our major objectives, but it seems to me that we may have failed somewhat in recognizing as one of our broad objectives that drafting is a useful tool in thinking. Many times it is just as important a working tool as mathematics and indeed sometimes the only tool by which problems can be solved. We must equally emphasize that it is a method of solving problems not merely a way of presenting a finished solution.

Our descriptive geometry is not so much a training in visualization as it is a logical reasoning process, by means of which ultimate visualization may take place. This is particularly true in the more complicated problems which require the ultimate skill of the draftsman. In the beginning he does not know what the solution of his problem is going to look like, but after he has brought to bear the methods of drafting and descriptive geometry, he has a drawing and from this drawing he knows, and anyone else may know what the object looks like, or whether this part of a machine has ample clearance, or whether another part can be reasonably assembled.

As a working tool for analysis and design, drafting is inextricably associated with manufacturing costs. Our students are too immature to receive much instruction along this line, but it should be one of our objectives to show them that careful work on the drawing board may, for example, save an ounce of material on a part which in mass production may mean thousands of dollars. Or careful study on the board may eliminate some one or more machining operations in production with a consequent saving in costs.

Another of our objectives has been the development of manual skills; in lettering, the use of instruments, making the correct weight of lines, proper arrowheads, freehand sketching, and the like. Sometimes, I believe we have overemphasized this objective. True enough, our students should be able to make satisfactory drawing with reasonable speed and we cannot neglect this phase of our work, but it is equally important that the student recognize that the purpose for which a drawing is to be used will determine the time and care which should go into its execution.

For example, in development work, where a drawing is to be used only once and then by a skilled workman, who is perhaps as familiar with the job as is the draftsman, a rough pencil drawing or even a well made freehand sketch may be entirely adequate. A drawing for final production, on the other hand, should be carefully made, perhaps even inked so that blueprints, which may be sent to various plants are clear and unmistakable.

With these broad objectives outlined, may I take up one or two details and elaborate upon the effect of department organization upon such aims?

To illustrate, let us assume that our classes represent students in all curricula and our subject is dimensioning. Upon such conditions our sole objective cannot be machine dimensioning with its heavy emphasis on limits, tolerances, and surface finish. The civil engineer, the architectural engineer, and even mechanical engineers in some situations, do not require these refinements at all. The structural engineer has still other requirements.

Our objective in such cases then must be to show the fundamental requirements of all dimensioning so that an object can be manufactured or constructed, and at the same time to show when and where the refinements of limit dimensions are required. This in itself is a big task.

On the other hand, if our classes are segregated by curricula, mechanical engineering students could be given more work in production dimensioning and civil engineers could specialize in their own field.

One of the representatives of industry at our 1946 Summer School gave as a reason for the reluctance of our graduates to work on the drawing board the fact that in many cases they were not sure of themselves and were reluctant to undertake the responsibility of making a drawing that was going to be used in production.

We must, therefore, aim at a fundamental complete and thorough mastery of the principles of orthographic projection so that our graduates feel competent to undertake any problem.

Second, we should give them some definite knowledge about the fundamental principles of dimensioning mentioned before. They should be familiar with standard parts that can be purchased on the open market and how to represent them by symbols and how to specify them on the drawing or in a bill of materials. This involves not only the simpler every day items such as bolts, screws, keys, ball and roller bearings, but also the host of other items to be found in such publications as the S.A.E. Handbook, the pamphlets of the American Standards Association, Sweet's Engineering Index, and others.

Other objectives, which we may consider as a by-product of our methods of teaching, are those mentioned by Mr. Griswold such as "orderly methods of procedure, accuracy in all its aspects, neatness, and thoroughness." I have called these objectives by-products, not because they are less important, but rather because we do not make specific assignments on them. The achievement of these aims is very important and it depends almost entirely upon the teacher rather than the course material or departmental organization.

In large drawing departments or small, it is a good practice to review our objectives frequently so that we do not settle into the humdrum of routine work and overlook them entirely. There is an inspiration to be gained in keeping ever before us a definite objective which we are striving to attain. This inspiration is essential to successful teaching.

(Continued on page 27)

LUCITE MODELS FOR STUDENT USE IN CLASSROOMS

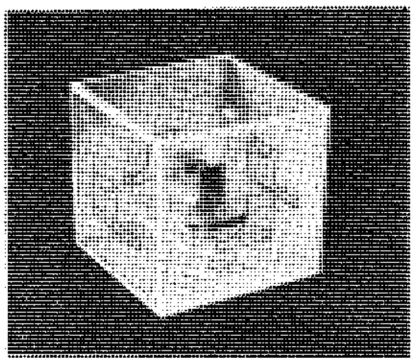
by

John C. Seeger and Harry D. Richardson

Louisiana Polytechnic Institute

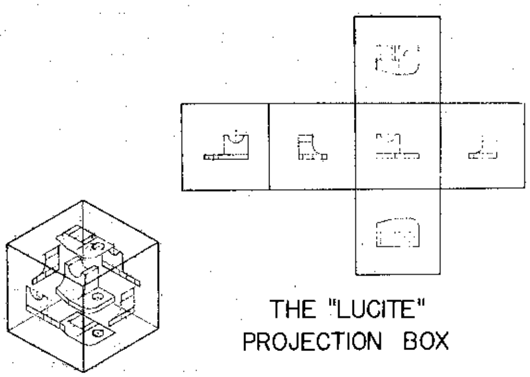
INTRODUCTION:

Projection is often explained by asking the students to visualize lines and points on an imaginary plane that is between the observer and the object to be projected. The process of learning the fundamentals of projection is difficult enough for the average student without asking him to also have a clear concept of anything as nebulous as an imaginary plane. To substitute real material, such as clear, transparent Lucite, for the imaginary plane will allow the student to concentrate on the fundamentals of projection.



The photograph shows a cube made of Lucite in which is a small model that is used for demonstrating the principles of projection. On the six sides of the cube are orthographic projections of the object. Chart I shows this Lucite box "developed" to indicate the relative positions of the six normal planes of projection.

For classroom explanations, the teacher uses the model and Chart I with additional blackboard sketches.



THE "LUCITE" PROJECTION BOX

This chart is large and must remain tacked to the wall, but the Lucite model is small and is passed along to each student.

It has been observed in classes that students studied the details of the different views and compared hidden lines with object lines in opposing views. The reaction of both beginning and advanced students was that such a model greatly clarified the principles of projection.

Working with Lucite requires a slightly different technique from some other materials. By trial and error, the following ideas for fabricating Lucite have evolved.

MATERIALS: (For one $4\frac{1}{2}$" Lucite cube.)

a. 1 piece of clear, transparent Lucite 12" x 18" x 1/10".

b. 6 ounces of glacial acetic acid.

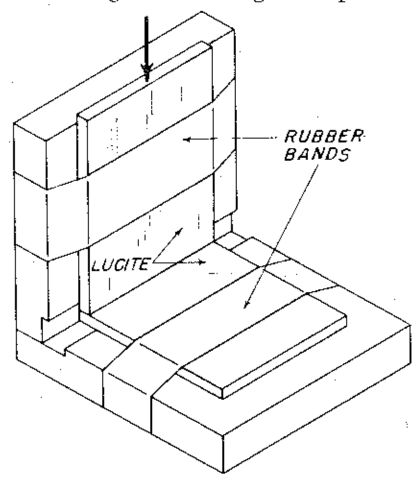
c. 1 small bottle of red fingernail polish.

d. 2 small machine screws to secure the machined part.

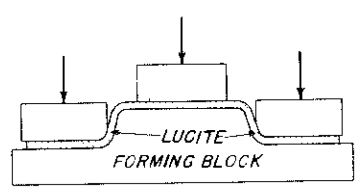
e. 1 small machined part for demonstrating orthographic projection.[1]

JIGS:

The jigs in sketches 1 and 2 were made from pine and used in forming and welding as explained below.



SKETCH I



SKETCH II

[1]Spencer, Henry C., and Grant, Hiram E., "Technical Drawing Problems". Plate B-3.

N.B. - White tape was placed on all corners of the box and white paper was placed on the bottom, rear, and left sides so that the details could be clearly photographed.

Mr. H.L. Henry, formerly on the faculty of Illinois Institute of Thechnology and now on the faculty of Louisiana Polytechnic Institute, has been of great assistance in making models for student use in teaching engineering drawing.

CUTTING LUCITE:

Lucite is shipped from the manufacturer with a heavy masking paper on both sides to protect the highly polished surfaces. If this paper is removed before sawing, the surfaces will certainly be scratched on the saw table.

Lucite can be satisfactorily sawed on a fine-toothed band saw running at a speed of 8,000 to 12,000 fpm. Hold the material firmly against the table and feed at a slow uniform rate. Any chatter is likely to crack the material and break the corners off as the blade clears the edge. In laying out the cuts, leave ample space for sanding the edges to smooth plane surfaces.

WELDING LUCITE:

Lucite is easily welded with a solvent cement like glacial acetic acid. The acid softens the edges to be joined and they are then pressed firmly together until the solvent evaporates and the joint hardens. Listed are the steps to be followed in welding:

a. Sand the edges to be joined with emery cloth to insure a good fit.

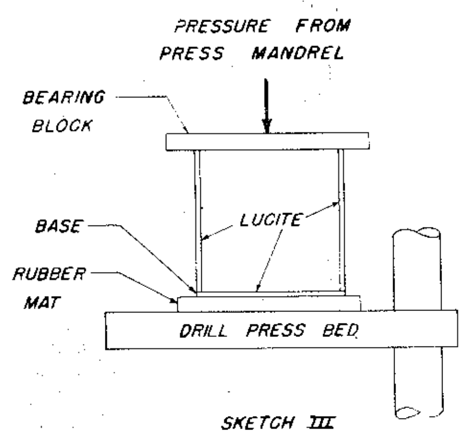
b. In a glass tray, pour a small amount of glacial acetic acid. Heat the acid to approximately 120 degrees Fahrenheit.

c. Uniformly heat the entire surface of <u>one</u> of the pieces of Lucite to be joined until it is <u>slightly</u> hotter than the acid. (Do not overheat the Lucite.)

d. Dip the edge to be joined into the acetic acid for approximately two and one-half minutes, or until a "cushion" of soft plastic is formed. (If the piece of Lucite dipped into the acid is colder than the acid, the fumes will condense on the surface and begin to run down. This will cause the surface to become wavy and the transparency will be impaired. It is permissible to cover the surface with a special masking paper to prevent this condensation, but it must be impervious to the fumes and must not allow the acid to travel up by capillary action.)

e. The edges to be joined are placed together in the jig shown in sketch 1. The pressure should squeeze out all the air bubbles and be evenly applied throughout the length of the joint. The jig arrangement allows the weight to exert constant pressure even though the joint shrinks during the setting process. About fifteen p.s.i. is satisfactory for good joints. Excessive pressure will cause crazing and detract from the appearance of the model.

f. Welding on the top and bottom will require a different pressure arrangement. A simple way is to follow sketch 3. The sides are heated and dipped in the warm acid as previously explained. To compensate for slight deviations in the edges of the sides and for shrinkage, the top is laid on a thick rubber mat on the drill press table. The soft edges of the sides are carefully placed on the Lucite top and the drill press mandrel is lowered and locked in place. (It is not satisfactory to place a weight on the box to exert the pressure because the weight will not be laterally supported and will move on the soft "cushion" of plastic.)



SKETCH III

POLISHING:

The joints should be sanded and polished after waiting several days to allow complete setting and shrinking. It is possible to polish the joints to a high gloss like the original material. The best polishing machine is similar to a potter's wheel.

The wheel is a flat plate approximately 12" in diameter, covered with thick felt, and turns about 250 rpm. White rouge, a buffing compound used by optometrists, is worked into the felt with water. With the felt still damp, lightly press the joint against the turning wheel. Too much pressure or letting the felt get completely dry will burn the surface and hardened particles of felt will cause deep scratches.

FORMING LUCITE:

Lucite is a thermoplastic and can be formed at temperatures as low as 250 degrees Fahrenheit. Sketch 2 shows how the plastic is formed after being heated to a uniform temperature of 275 degrees. This forming operation is necessary to make a support for the machined part.

USE OF FINGERNAIL POLISH:

Red fingernail polish was selected for the lines on the Lucite because the solvent in the polish apparently reacts with the Lucite and forms very hard durable lines. The lines are soft for several hours but eventually harden enough to withstand the rough treatment of almost constant handling.

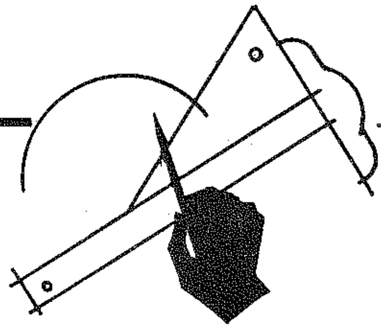
Any properly sharpened drawing instruments work well with the fingernail polish. It is advisable to add some thinner to the fingernail polish to make it flow more evenly. Any mistakes can be corrected with fingernail polish remover on a soft cloth.

CONCLUSION:

Lucite is so easily cut, machined and formed that making these models is a pleasant task. The possibilities are unlimited when one thinks of demonstrating the principles of auxiliary views, sectioning, intersections and developments, and problems in descriptive geometry.

The favorable comments and reactions of the students are enough to compel us to make more Lucite models for demonstrating the principles of projection.

OUTSTANDING AIDS for Engineering Drawing Students from the



Engineering Drawing — *7th Edition*

By the late Thomas E. French, the Ohio State University. Revised by Charles J. Vierck and associates of the Department of Engineering, The Ohio State University. 694 pages. $4.00

The value of a course in drawing lies in the selection, methods of presentation, and correlation of the problems with assigned study of the text. In this revision many of the favorite problems of the previous edition have been retained and many new ones representing current design have been added. The chapter on illustration and the complete rewriting of the chapter on perspective plus the expansion of the chapter on dimensioning into two chapters will be of tremendous value to the user of this text.

Engineering Drawing Problems

By Charles D. Cooper, Paul E. Machovina and Charles J. Vierck. All of the Ohio State University, arranged for and correlated with French's Engineering Drawing. Series I. $3.50

Practical, direct and thorough, this book presents a series of problems in the most logical and usable order for first-year classes in engineering drawing. In accordance with a recent survey made by the drawing division of the American Society for Engineering Education, the book includes exercises in all of the subjects usually covered in schools throughout the country.

Engineering Drawing Sheets—*Series F*

By Thomas E. French; and H. M. McCully, Late Professor and Head of the Department of Drawing and Descriptive Geometry, Carnegie Institute of Technology. $4.00

These sheets are designed to make the most economical use of time allowed for drawing courses. The careful arrangement of lesson sequence; the increased attention to reading drawings and technical sketching; the time-saving layouts of problems in projections; sections, dimensioning, lettering, working drawings; combine to make a course that compels student interest.

Problems in Engineering Drawing — *Series II*

By A. S. Levens and A. E. Edstrom. Both of the University of California. Keyed to the 7th Edition of French's Engineering Drawing. $3.00

This well-known and widely liked workbook has been carefully revised and enlarged from 62 to 72 worksheets. Its primary purpose is to provide, in a minimum number of plates, sufficient practice to enable the student to master the techniques of drawing in accordance with practice established by the American Standards Association.

Mechanical Drawing — *5th Edition*

By the late Thomas E. French. The Ohio State University; and Carl L. Svensen, Consulting Engineer. 437 pages. $2.80

This revision retains all the well-liked features of earlier editions but offers many improvements and much new material. New chapters have been added on aircraft drawing, production illustration, and welding drawing.

Workbook in Mechanical Drawing

An Introductory Course.

By Shriver L. Coover. Director, Industrial Arts Department, State Teachers College, California, Pennsylvania. 96 pages. $1.48

The unit structure of this workbook enables each member of the class to progress at his own speed with little help from the instructor. Drawing units are presented in logical order with each unit brief, but containing all the information necessary for understanding the principles involved. Special objective tests, pertinent to life situations and largely self-administering, are included with the various units. Written specifically to save time for both teacher and students, the book is as nearly self-teaching as it can be made.

Applied Descriptive Geometry

With Drafting-Room Problems — *Third Edition*

By Frank M. Warner, University of Washington. 252 pages. $2.75

Easy to teach, easy to understand, this widely used standard text is well liked because it emphasizes the direct view method; and because it includes a wealth of illustrative problems covering all branches of engineering with engineering settings and data as they occur in actual practice.

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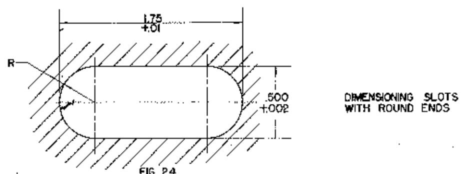


FIG. 24

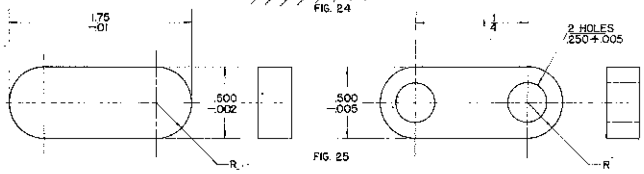


FIG. 25

DIMENSIONING EXTERNAL SURFACES WITH ROUND ENDS

most important dimensions, overall length and overall width, are given, but the value of the radius is omitted. Here again closer control can be accomplished without any "tightening up" of tolerances.

CURRENT SPECIALIZED SYSTEMS OF DIMENSIONING FOR INTERCHANGEABILITY

Several of the most interesting current systems being developed today differ only in the details of the notes or symbols employed and in their method of indicating tolerances and/or limits. To the best of my knowledge the beginning can be traced to the "True Position" note, and symbolic system of controlling eccentricity, squareness, etc., appearing in the Society of Automotive Engineers "Aircraft Engine Drafting Room Practice," which was published in 1941 as a result of the joint effort of a representative group of leading engine and accessory manufacturers and airline operators. The committee responsible for this manual was enlarged to include airframe manufacturers and a revised "SAE Aeronautical Drafting Manual" was issued as of June 1946. This revised manual goes still further into the "True position" method of dimensioning, but is still making what might be termed a "cautious and gradual transition", at least when compared to the efforts of several other agencies.

The next item to appear on the scene was "Drafting Room Practice in Relation to Interchangeable Components," by C.A. Gladman, Scientific Officer, National Physical Laboratory, England; published by the SAE in 1945. This excellent treatise, more commonly known in drafting circles as simply "The Gladman Paper" has stirred up quite a lot of controversy on at least two counts; it is not the easiest thing to read and digest, and furthermore, if one attempted to apply the practices contained in it a complete shop re-education might be required.

A third, and much more comprehensive, coverage is contained in the 132+ page "Ordnance Manual on Dimensioning and Tolerancing", prepared by the Inspection Gage Sub-Office, Office of the Chief of Ordnance, A.S.F. United States Army, and issued 1 August 1945. More detailed discussion and comparison of these three systems follows.

In reality all three of these items are merely different approaches to the locational tolerancing system. The underlying philosophy of this system is: remove all tolerances from location dimensions and allow variations to exist in the location of elements relative only to their theoretically exact location.

If all location dimensions are considered to be "Basic," without any tolerances, the effect acan be illustrated by the enlarged diagram in Fig. 66. (Ordnance Manual). The two intersecting centerlines

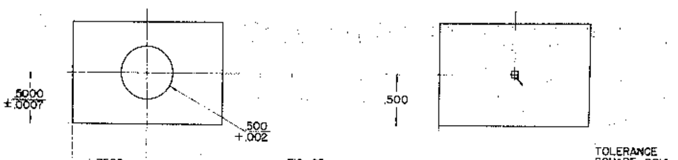


FIG. 65
DRAWING SPECIFICATION

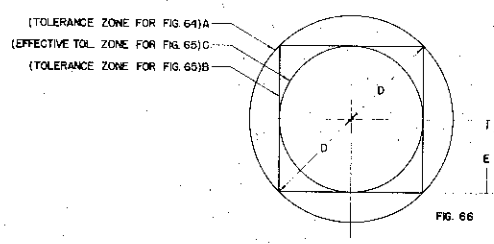


FIG. 66

represent the theoretical location of a hole (or pin, or other circular element).

If the design requirements allow the center of a particular hole or other element to vary from the calculated center by an amount D then the center may lie anywhere inside the area of the larger circle "A" of 2D diameter. If this same element were to be located by the conventional co-ordinate system the designer would be required to reduce this allowable variation to $E = \frac{D}{\sqrt{2}}$ = allowable tolerance on co-ordinate dimensions. This reduces the area of possible variation from πD^2 $2D^2$, or a reduction of 36.3% as shown by the inscribed square "B." When gages are made to check the location of this element it is necessary to further restrict the location of its center to the area of the smaller circle "C" inscribed within the square with a further reduction in area to $\frac{\pi D^2}{2}$ or a full 50% dreduction of the tolerance area. The opposite approach to this problem would be more impressive in that it can be shown that the change from the conventional method of co-ordinate location dimensions with tolerances to the locational tolerancing system gives us a 100% increase in the allowable area of variation.

This effect is purely one of production importance, however the effect on design is equally important. The design of universally interchangeable components when dimensioned conventionally is rather involved, the problem of tolerances, allowance, etc. is somewhat complicated by the introduction of the trigonometric relation between the holes. Where the parts are dimensioned by a locational tolerance system this problem becomes quite simple. For example, in the design of parts to be held together by three or more bolts the sum of the locational tolerances equals the allowance: specifically, if two parts have holes 1.010 min. dia, and are to be held by bolts of 1.000 dia, then the centers of the holes in each part may vary .005 from the theoretical center, or if the holes in one part are held to say .003 then the holes in the other part may vary .007, etc., regardless of the number of holes, or their relation to each other.

SAE AERONAUTICAL DRAFTING MANUAL

In Fig. 1 the pertinent dimensions of a sample part have been shown in conformance with the methods outlined in the SAE Aeronautical Drafting Manual. The practice of calling for "holes equally spaced" on a Bolt Circle is used here for simplicity only, a set of co-ordinate dimensions for their location would be required in many places. The diameter of the Bolt Circle in this drawing is marked "2.750 BASIC," which means exactly 2.750, with no variation allowed. The term "equally spaced" will then locate the theoretical centers of these holes with no error. Old timers are prone to give up at this point saying that it is impossible to locate anything with no error, which is, of course, quite true. However if we read the note carefully we should discover that "each hole within .002 of true position" gives us considerable leeway in that it is only necessary to locate the holes within that distance of the theoretical center; in other words that theoretical center is the center of a tolerance circle of .004 dia, and if we are successful in locating the holes in the part so that their centers lie within those circles then the part is acceptable and will function properly. It is not perfectly clear in this instance whether the 2.750 circle should be concentric with the axis of the part, or with some other physical feature of the part. This problem is being debated by the committee responsible for this manual and it is very likely that an early revision may contain a note such as this:--"each ohole located within .xxx of true position relative to this dia" (or other feature, as applicable).

The Roman letters A, with or without accompanying values, taken together with the typical note, control the trueness of some of the surfaces on the part. Surfaces marked A (no accompanying value) may be eccentric .005 FIR. (Full Indicator Reading) as indicated by the general note. The face of the flange, being marked A.002, must be square and true within .002 FIR, while the pilot diameter is allowed an eccentricity of only .0004 FIR. It may be noted that no indication is made of the preferred dimension in this system. All dimensions are given in the form of limits and production is allowed to make a choice of anything within those limits.

GLADMAN SYSTEM

Fig. 2 shows the same information as Fig. 1 expressed in terms of the Gladman proposal. This proposal covers other items, such as symbols for local interchangeability, jig boring, etc., with which we are not concerned. The note calling out the six holes in the flange is much more brief than the SAE note. The

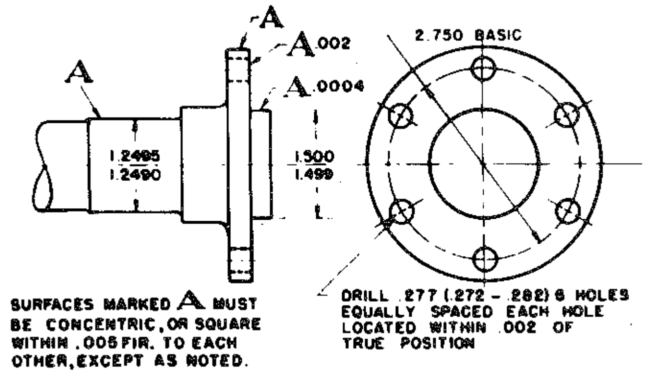


FIG. I SAE AERONAUTICAL DRAFTING MANUAL

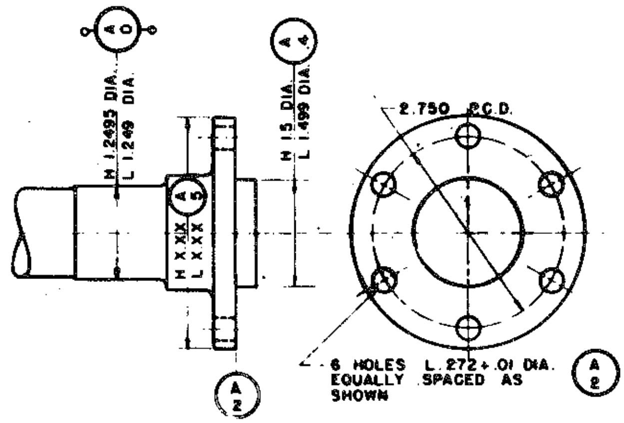


FIG. 2 GLADMAN SYSTEM (BRITISH)

symbol A over 2 inside the double circle is read as "each hole within .002 of true position with respect to datum surface A. Datum surface A is identified by the A over 0 in the circle with the dumbell. Except for the reference to a datum surface this is exactly the same as the SAE system, except that the word BASIC is omitted. Control of eccentricity, squareness, etc., is indicated by the same symbol. In case the datum is the axis, or some other feature not carrying a dimension line it can be indicated by the two small circles connected by a straight line, thus: O—O The method of indicating dimension and tolerance values is a bit involved. High and low limit dimensions are shown preceded by the letters H and L and the interpretation is exactly the same as our limit dimensions, i.e. the shop may choose any value between those limits. If any dimension is given as a basic dimension preceded by H or L, and followed by tolerance, then the basic dimension given is preferred and should be held whenever possible. For example, the low limit of the flange holes is given as .272, meaning that this is the diameter wanted, but that holes .01 larger would be accepted. This is a feature usually neglected in this country, and its value is controversial.

ORDNANCE MANUAL

Figure 3 shows the same part as Figs. 1 and 2 dimensioned according to the practices recommended by

(Continued on page 25)

(Continued from page 15)

PICTORIAL DRAWING

by

Professor John T. Rule,
Massachusetts Institute of Technology

There are two major objectives that determine the form of a drawing. The first of these is accurate size and shape description involving scalability and no possibility of ambiguity. This demands a one to one correspondence between the three dimensional space object and the two dimensional drawing surface.

Orthographic projection in two or more views yields the required one to one correspondence while proper orientation of the views yields scalability of every desired dimension. Thus, this type of drawing substantially achieves this first objective. It is, consequently, the most common form of engineering drawing.

The second major objective of a drawing is to achieve a pictorial correspondence to the space object, that is, to create a visual image which shall be as nearly as possible a duplicate of the visual image created by the object itself. From the engineering point of view such a drawing is particularly valuable for explanatory purposes when dealing with non-technical personnel such as untrained assembly workers.

Actual photography most nearly achieves this objective. A perspective drawing has only this purpose in view. It is consequently the best type if the only objective is a maximum of visual correspondence to the object. Thus, the architect chooses perspective when making a drawing of his proposed house.

We may now give a rather loose definition of a pictorial drawing. Any drawing in which the chief objective is visual correspondence to the space object is a "pictorial drawing." Let us investigate the various types in common use and analyze the reasons for their existence. There are two important objections to perspective drawing. First, it takes considerably longer to make a perspective than any other type of drawing. Second, a perspective drawing is substantially an unscalable drawing. It is frequently desirable to sacrifice some of the visual correspondence of perspective to obtain an increase in speed and some degree of scalability.

Let's examine the problem of scalability. Consider a straight line in space marked at various points. If we are to make a projection that is to be scalable, the ratios in which the line in space is divided by the marks must be maintained in the projection.

This condition is not fulfilled in perspective. In Fig. 1, if the space line APB is divided into the segments a and b by the point P and projected into A'P'B' the ratio a/b is not in general equal to to a'/b'. We say, therefore, that in perspective, ratio is not a projective invariant.

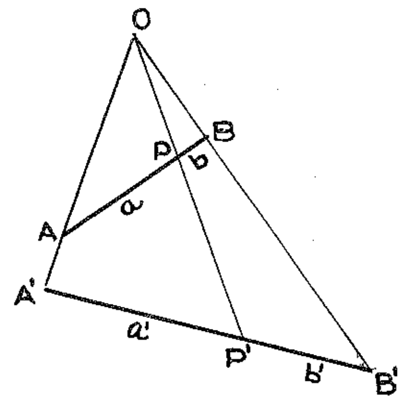


FIG. 1

If, however, we project the line APB by parallel projectors in any direction whatever (Fig. 2) the ratio a/b will equal the ratio a'/b'. Thus, under parallel projection ration is a projective invariant. Consequently, the divisions of any line are scalable in any parallel projection of the line, it being only necessary to know the size of the projected scale with respect to the space scale.

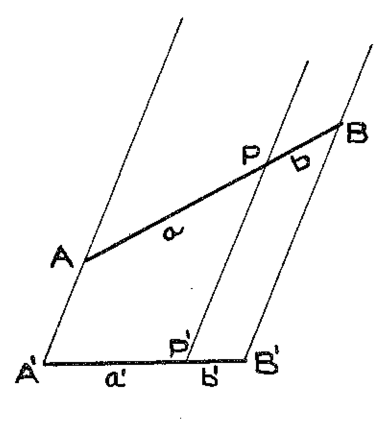


FIG. 2

Orthographic projection is a particular form of parallel projection. Furthermore, any oblique orthographic view of the usual predominantly rectalinear object taken so that all three major dimensions are foreshortened gives a reasonable visual correspondence to the object. Such views are thus classified as pictorial views. They fall into three classes: trimetric, dimetric and isometric, depending on whether three scales, two scales or one scale are necessary to measure along the three principal directions.

Consider the cube of unit edge in Fig. 3, two views of which are standard orthographic front and top views. If we insert an arrow in a random oblique direction and obtain an orthographic view looking in that direction, the three mutually perpendicular edges will in general each be foreshortened in a different ratio. Thus, three scales will be necessary to measure in the three principal direction. A line in any other direction will also be scalable if it is worth the trouble to determine the ratio of foreshortening for that direction.

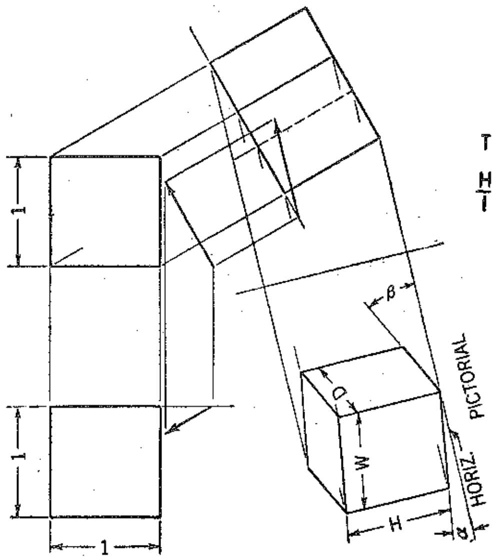


FIG. 3
TRIMETRIC
$\frac{H}{1} \neq \frac{W}{1} \neq \frac{D}{1}$

Such a drawing is a trimetric drawing. Various orientations of the base cube yield various sets of ratios. Groups of objects of roughly similar shapes seem pictorially most realistic with some favored set of ratios. The scale for any direction is equal to the full scale multiplied by the cosine of the angle the direction makes with the projection plane perpendicular to the line of sight.

If a fixed orientation is chosen, a set of three scales set at three angles with the horizontal can be constructed. Under such conditions trimetric drawings can be made very rapidly and are quite effective.

It is to be noted with all this class of pictorial drawings, since only one view is used, the drawing is never completely unambiguous. For instance, lines which appear as points are completely unscalable.

If we now reorient our line of sight so that it makes equal angles with any two of the principal directions, two of our three scales become exactly alike so that we need only two scales as shown in Fig. 4. The width and depth are generally chosen to be equal. This is a dimetric drawing. It is subject to the same limitations as trimetric.

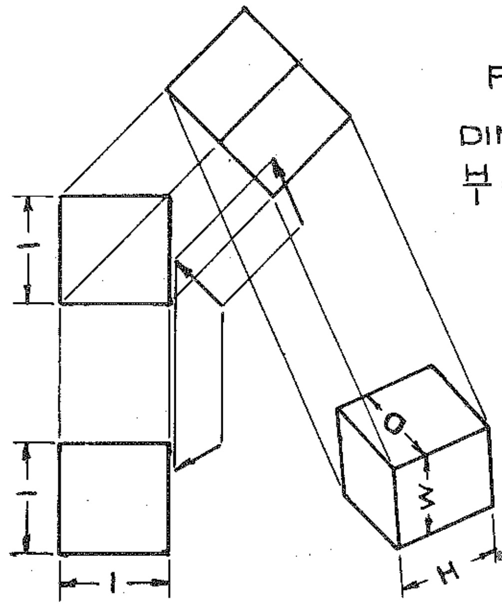
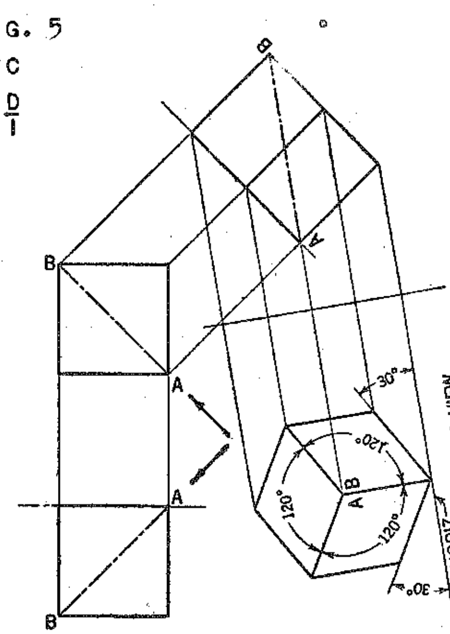


FIG. 4
DIMETRIC
$\frac{H}{1} \neq \frac{W}{1} = \frac{D}{1}$

If we now again reorient our arrow so that all three principal directions make equal angles with it, that is, if we make the arrow parallel to the long diagonal of the cube, all three directions will be equally foreshortened and we will need only one scale (about 81% full size) for all three dimensions (Fig. 5). This is obviously very convenient. Furthermore, as seen in Fig. 5, if the height is set vertical, the other two dimensions make angles of 30° with the horizontal. This is very convenient for T-Square and triangles. Such a drawing is called an "isometric projection."

FIG. 5
ISOMETRIC
$\frac{H}{1} = \frac{W}{1} = \frac{D}{1}$



Since the scales are all equal, it is customary to use a full scale rather than 81%. In this case the drawing is called an "isometric drawing."

Isometric drawings can be made very rapidly without resorting to the process of obtaining an isometric view from orthographic views by projection. Commercially isometric drawings are the most common if all forms of pictorial drawings.

In using parallel projection to preserve ratio, we do not need to confine ourselves to orthographic projection but may project at any angle with the projection plane that we may choose. This can yield good pictorial drawings, called oblique drawings.

Oblique drawings are generally used where one face of an object, (two dimensions) contains most of the detail, the third dimension being unimportant. The object can then be oriented so that this face is parallel to the projection plane. Thus, regardless of the angle chosen for the parallel projectors, this face will remain its true size and shape in the resultant drawing. The face may thus be scaled at full size in any direction. The third dimension will, of course, be scalable to another scale.

The most common form of oblique drawing uses projectors such that lines perpendicular to the projection plane appear at 45° to the horizontal in the drawing. The foreshortening of these lines might be anything. Full scale or half scale is generally arbitrarily chosen.

A COMMENTARY ON GRADING DRAWINGS

by

Dean J. Gerardi
University of Detroit

When Professor McNeill assigned this topic to me, I did my best to have it changed. I even went so far as to tell him that all I had to say on the subject could be said in two minutes and that this meeting would be more interesting if he assigned the topic to someone who was more scientific in his method of approach. In reply to my letter, Professor McNeill assured that some members of the division would be interested in non-scientific methods of grading papers, that those who disagree would start a discussion, and that all of us would profit from the exchange of ideas. Therefore, I submit my ideas not for what they are worth, but to promote a discussion which will give the younger teachers a few ideas to consider, before he sets up a grading system of his own.

The subject of grading drawings has been well presented at some of our meetings. It has also been well presented by contributors to the Engineering Drawing Journal and I am sure that Prof. Kirkpatrick will present some new ideas at our Wednesday meeting.

Most of these presentations have been quite scientific and based on much research and study. Others have been quite simple, as a matter of fact, one institution devised a machine for grading drawings. I do not mean that this is a poor way to grade drawings, nor do I advocate this method of grading drawings, but this particular drawing department had thousands of drawings to grade daily and were forced to design a grading machine in self defense. Some teachers use a check list for every problem sheet, each item to be checked is listed on this sheet with a particular drawing. In some cases master sheets are prepared. The master drawing is made on transparent material, placed over the students drawing, the student being penalized if his drawing does not agree with the master sheet. There are many other methods, but I have come to the conclusion that the method of grading depends a great deal on many factors. I shall mention a few:

1. The number of papers to be graded.

2. The practical and teaching experience of the instructor.

3. The practical and teaching experience of the director of the department.

4. The character and personality of the teacher.

5. The value which the instructor or department director places on the importance of engineering drawing in the engineering profession.

Now, much can be said about the effect of any of these items on the method of grading drawings, and since my time is limited, I should like to expand on the last item I mentioned, namely the value which the instructor places on the importance of engineering drawing in the engineering profession.

As most of you know, the engineering college of the University of Detroit is a co-operative school. That is, students go to school and to work at alternate periods. The first two years of the five year program are continuous and employment in industry begins in the Junior year. A study of the reports which I get from our industrial co-ordinator shows that 35% of our students begin their engineering careers at the drafting board. This means that normally approximately 250 students must be ready to accept jobs as draftsmen. Obviously our drawing department is forced to attach a great deal of importance to the subject of engineering drawing not only because we must service the professional department, but because we must serve the industries who employ our students.

Because of the large number of students and because of constant scrutiny of our students work by chief draftsmen and engineers, we are forced to grade drawings according to values which the industries may give to a drawing. In other words, if the completed drawing which is submitted for a grade would be acceptable to a chief draftsman for employment purposes, then the drawing would be given a grade of A or B. If the submitted drawing shows that with some improvement the student has possibilities of being hired, the grade on the drawing would be a "C". If the submitted drawing clearly indicates that the student would not be hired it would be graded "F".

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There is no doubt in my mind that all of you have had experience with students complaining about receiving low grades on their drawing. There is really one way to satisfy the complaining student. Simply ask him if he would show his work to a chief draftsman interviewing him for employment. As soon as that question is put to the student, he realizes that the value of his work is practically zero, and will agree that the grade given was that which he deserved.

I do not want to give the impression that a student passes or fails his drawing course on the basis of the grades which are put on the drawing plates. The final grade should be based not only on the student's drafting ability, but must also indicate the student's knowledge of the work he has put on paper. We must not forget that we are training engineers, not draftsmen, and in many cases, I have given a student a "B" grade in spite of the fact that his drawings were mostly graded "C" and occasional "F"s. I have also failed students who had beautiful work but quizzes and examinations proved that the student had no idea as to the meaning of the drawing he had produced.

It may be interesting to tell you of one of the rules which was adopted years ago in our drawing department. The rule may be stated as follows: If a drawing or a sketch is called for in a final examination, and the student places a view out of projection, the student fails the course, regardless of the grades he earned on his drawings or quizzes throughout the semester. This is tough on the students, but sometimes a person has to be given a good kick in the pants to be impressed by the importance and values of accepted practices.

Although this criteria for grading papers sounds simple, we must recognize the fact that the validity of the grade depends on the background and experience of the instructor. If the instructor's experience has been with draftsmen who were not interested in good lettering, line work, placement of dimensions, etc.; it stands to reason that he is going to grade his papers a lot different than a teacher who has worked under opposite conditions. Or if we consider the teacher who has no experience as a draftsman, I am sure that his estimate of the drawing's value is much different than that of a teacher with a variety of experience.

The inexperienced teacher who wishes to employ the system of grading I have proposed should not employ it blindly, but should estimate the grades and periodically consult the director of his department or with some one in the department who is familiar with the requirements of the industries.

In my opinion, the proof of the pudding is in the eating. If industries who employ our students to work in drafting rooms are satisfied with the men we have trained for them, then there can't be much wrong with the grading system or the course of instruction. On the other hand, if the industries are not satisfied with the product of our efforts, let's not worry about the grading system, but let us concern ourselves with the weakness in our courses and do all we can to correct them. A grading system to obtain desired results can then be devised.

DEVELOPMENT OF STUDENTS ABILITY TO THINK AND ANALYZE IN SPACE

by

Professor F. M. Warner
University of Washington

One of the most important assets of a professional engineer is his ability to think and analyze in three dimensions. Some students who are just beginning their engineering education have a natural ability along this line and others have very little. A definite effort must be made to develop this ability for all students if we are to give them the best preparation possible for an engineering career. The responsibility for teaching visualization falls squarely on the shoulders of drawing instructors because our subject deals entirely with three-dimensional objects. Since the student's first college contact with engineering is usually made through his drawing instructor, the degree of success we attain in teaching visualization may be a determining factor in arrousing his interest and assuring his ultimate success.

This degree of success attained in teaching is a direct function of effort and logical planning on our part. I assume that all of us are willing and anxious to put forth the maximum of effort. Therefore I am going to discuss logical planning by enumerating a few of the methods which may be used to try to develop ability to think and analyze in space. I am listing them in the approximate order I think they should be given to a class. No one method mentioned will do a complete job; but by trying one thing and then another, and by repetition, etc., the result may finally be attained.

1. The first fundamental step is to teach the proper relationship between orthographic views and between the object itself and its views. This may be done best by the use of folding planes with models or by actually making a simple three-view drawing and then folding the views into their proper space relationship. Both methods should be tried. From the start this concentrates the student's thinking on the object itself instead of on the flat drawing, which, after all, is only some view of the object from a particular direction. For the first few sessions lot of models should be used.

2. From the very first day emphasis should be made of the fact that a plan view, for example, of an example gives absolutely no idea of the height of that object and very little idea of its shape. Therefore a second and sometimes a third view are required to completely describe an object. Again this focuses attention on the object itself and what it must be like as fixed by the views. We follow this up by showing a set of models of six entirely different objects but which appear exactly alike in the side elevation. This forces the student to think of each object at a time as he proceeds to draw a third view of all six of them.

3. Completion-type problems are of great value in the gradual process of teaching visualization because

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UNIT TESTS IN ENGINEERING DRAWING READY MARCH 1, 1949

by

Ralph S. Paffenbarger, Ohio State University

The Educational Testing Service, 15 Amsterdam, New York, New York, wishes to announce that the series of sixteen Unit Tests in Engineering Drawing prepared by the Committee on Advanced Credits, Drawing Division, ASEE, headed by Professor Ralph Paffenbarger, will be ready for distribution on or about March 1, 1949. These tests have been in preparation since April, 1947. Experimental work was completed last spring.

The Unit Tests will be available in the following subjects:

Use of Instruments and Applied Geometry
Orthographic Projection I
Orthographic Projection II
Orthographic Projection III
Sections and Conventions
Auxiliary Views
Elementary Dimensioning
Screw Threads and Threaded Fastenings
Advanced Dimensioning
Working Drawings
Isometric Drawing
Oblique Drawing
Perspective Drawing
Charts, Graphs, and Diagrams
Intersections
Developed Surfaces

These tests can be used as quizzes, final examinations, or as informal teaching aids. They have been designed also to be used in the evaluation of the proficiency of transfer students who are applying for advanced credit.

All of the tests are completely objective in form. Scoring stencils will be available.

Each of the tests has been set up in two parts, folder of drawings and question sheets. The folders will be printed on heavy paper and may be used repeatedly for an indefinite period. The question sheets may be used only once. Specimen sets, one each of the folders and question sheets, will be available at a probable price of $2.00 for the complete set. Prices for the drawing folders and question sheets in regular quantities have not yet been set.

(Continued from page 9)

the given angles to the plane of the triangle, when taken in pairs, will intersect in three curves, the common point of which is the vertex of the required pyramid. In space, any point on one of these curves will be the common vertex of two right triangles having a common vertical leg, with the hypotenuse of each making a given angle to the plane of the given triangle. Under these conditions the horizontal legs of these two triangles will be in a constant ratio for all points on any one curve. The top views of the curves will, therefore, be dipolar circles. The ratio of the distances from the top views of the ends of the side of the given triangle to the top views of points on the curve may be determined from the elevations in which the sides of the given triangle show true length, by drawing lines, one from each end, at the given angles which the lateral edges of the pyramid make with the base and projecting their intersection onto the sides in top view. The top view of this point will be a top view of the point on the curve directly above the side of the given triangle. A second point on the curve may be determined by striking arcs from the ends of the side of the given triangle the lengths of which are in the ratio in which the side has been divided. A line joining the point of intersection of these arcs with the point found on the side is a chord of the circle representing the curve in the top view. A perpendicular bisector of this chord will intersect the side of the given triangle extended at the center of the circle. The three circles obtained by this method will intersect in two common points either of which may be taken as the vertex of the required pyramid.

Construction: Divide each side of the triangle ABC by drawing lines in the elevations from the ends of each side making the angles which the lateral edges are to make with the plane of the base and project their intersections onto the top view of the side. For example, in the side elevation lines are drawn at 45° and 50° with the base from a_1 and b_1 respectively. The intersection of these lines m_1 is projected to m in the top view thus dividing ab in the proper ratio for constructing the top view of the intersection of cones with vertices at A and B which is a dipolar circle of which m is one point. To locate the center of the circle thru m, first locate the point S on the circle by striking arcs from a and b with radii in the ratio of bm to am. These radii may be obtained from the line $b_1m_1x_1$ in the side view where $\frac{b_1m_1}{x_1m_1} = \frac{bm}{am}$. A perpendicular to the chord sm at its mid-point will pass thru the center of the circle O on ab extended. Similar constructions are made to locate the center U on line bc and T on line ac for circles passing thru p and n respectively. The common points V and W in which the three circles intersect give two possible positions for the vertex of the pyramid. In this construction the lateral edges are represented by lines from V to a, b and c in the top view. In the elevations, V_1 and V_2 are located by rotating the lateral edges until parallel to the picture plane of the view to determine their height above the base.

(Continued from page 31)

the object must definitely be visualized in order for the student to draw its correct views. There are many variations of these problems, such as to fill in a missing line, to find an error and correct it, etc. All of these are valuable and should be used. I have a very simple method which challenges the student. I put a pencil mark on one of the views of his drawing and ask him to bore a hole through the object at that point and tell me how long the hole would be. This makes him think about that third dimension in space.

4. However, his moves may be simply mechanical and he still may not really picture the object he has represented by views. I would, therefore, introduce sketching at this point, using isometric ruled paper. This sketching may be done free-hand or with a triangle, but with no scale measuring. He can very quickly draw sketches of the objects he has already drawn three views of. We find this to be a wonderful help to the student and he is happy to see how real that object is and that it really appears as his three views show.

5. The next emphasis should be placed on reading three-view drawings by using a system of numbering placed on the views. This is to find out whether the student knows exactly what every line on each view represents on the object and can locate it in any other view. To answer correctly he must have an absolutely accurate mental picture of the object shown by the three views. A series of these problems can be made up so they are graded from simple to most difficult. We find them most valuable from the standpoint of developing visualizing ability. Students who get low scores on the first problems will develop quickly and often write the perfect answers for the later and harder ones.

6. The drawing of orthographic views of an object given in sketch form or even from the actual object itself is good practice. On the model the lines and surfaces can actually be seen and handled. The student can actually look at the object to see how it would appear in any view. This definitely directs attention to the object.

7. The next method to use in teaching visualization is the making of sectional views. Now the student must not only visualize the object but he must see exactly how it will look when cut in two. I suggest that, for the first sectional view a student draws, the instructor actually have a model of the object which has been cut in half by the section plane and held together by dowel pins. After the student has worked out the sectional view pull the model apart and let the student see the part which was behind the cutting plane and check his own drawing of it. I believe this one thing will teach visualizing the object better than any amount of talking.

8. The reading of numbered views should be followed up by practice in reading commercial drawings obtained from industry. These drawings can be furnished to the student exactly as they were used on a job. After all, the final purpose of our effort in teaching visualization is to train a student so he can look at a drawing on the job and very quickly form a mental picture of the machine or structure which is to be built. We have quite a file of these drawings for student use with mimeographed questions to be answered which will challenge the students ability to read and visualize. These drawings would not be used just for tests but for study problems and for discussion and teaching purposes.

9. An entire paper could be written on visual aid material such as films, film strips and slides. There is some excellent material available, a list of which has just been prepared by your Committee on Visual Education. We use both films and slides and find them very much worth while. However, as stated before, any one idea will not do a complete job. The best teaching is done by the instructor who tries everything he can think of and repeats each idea many times, until even the poorest student has learned to visualize.

10. In the descriptive geometry part of the drawing course I believe the best way to teach how to think in space is to talk more about a line or a plane or an object in space and less about the views. If a student has two views of a line or a plane on his drawing, he should be able instantly to hold up his pencil or his triangle exactly the way they lie in space. Descriptive geometry is a combination of logical reasoning and visualizing ability, both of which must be taught. But the logical reasoning can be applied more effectively if the condition in space is clearly visualized. Practically all of my teaching in this course is done, not by working out problems on the board, but by holding a pencil or a triangle up in the air. This keeps the students mind off the paper and out into space where I can get good discussion and draw out their logical reasoning. This is especially true in the use of locus principles in solving problems. Our motto could well be "Off the paper and out into space".

In conclusion, there seems to be no one sure way of teaching space thinking. Many of the methods I have mentioned will be found helpful and I realize they are not new. It is mainly by concentrating a students attention on the object instead of the views, by using models, pictures and slides, by giving much practice in drawing views, sketches and sections, even at the risk of overlapping or repeating, that we finally can say that we really believe that we have taught our students to think in space. At least, as teachers of drawing, it is our responsibility to make the best effort we know how to train the student whose future is in our hands.

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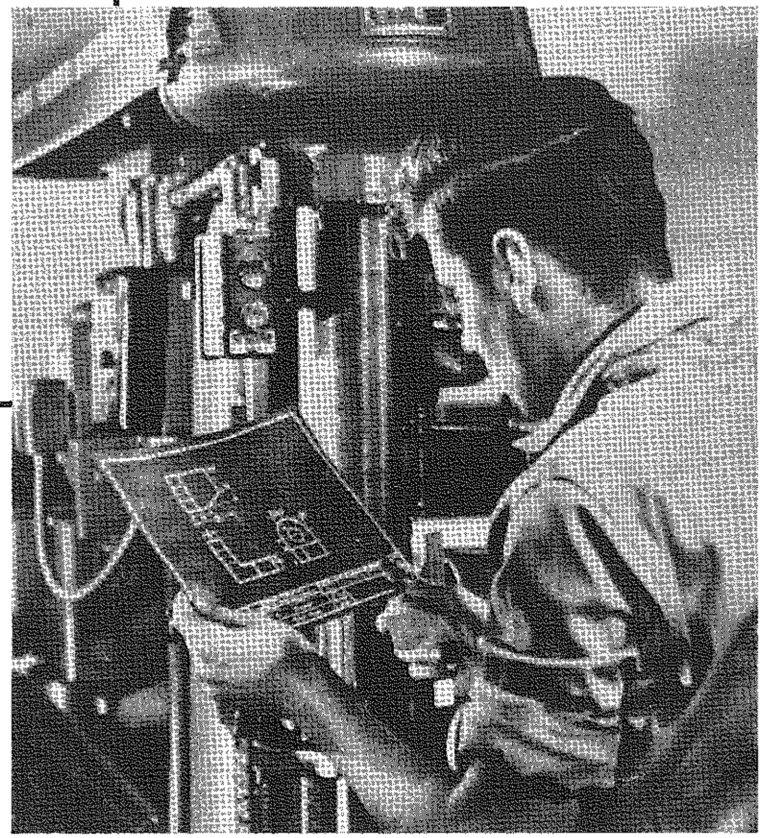

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