JOURNAL OF ENGINEERING DRAWING

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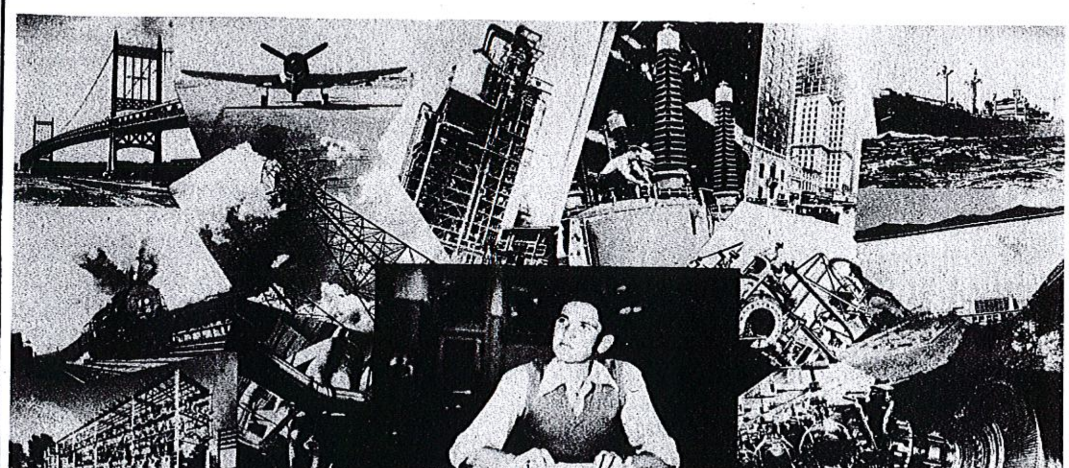

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A S E E

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CONTENTS

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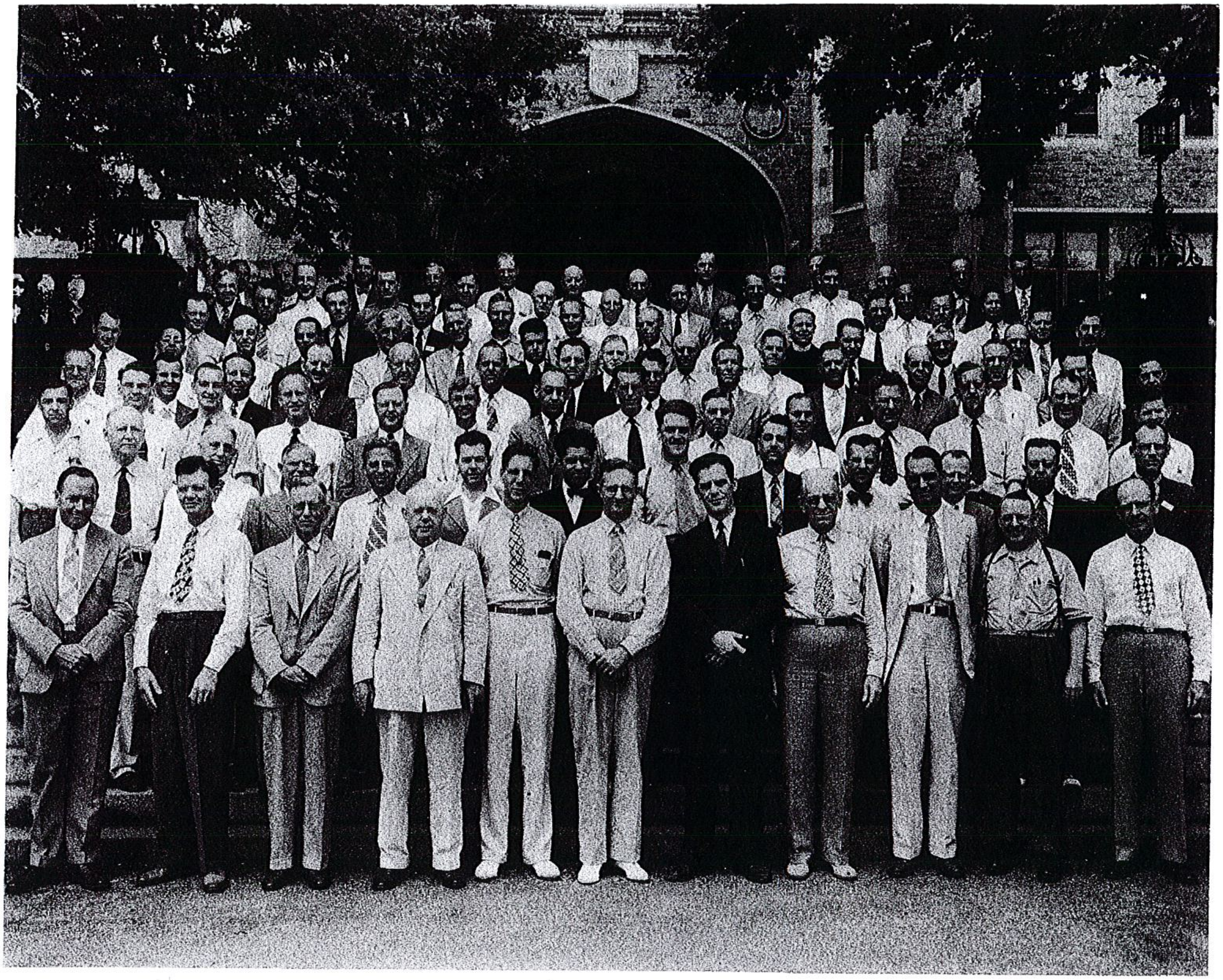

DRAWING DIVISION SUMMER SCHOOL
AMERICAN SOCIETY FOR ENGINEERING EDUCATION
WASHINGTON UNIVERSITY - ST. LOUIS, MO. JUNE 1946

(READ FROM LEFT TO RIGHT)

ROW 1. RUSS, AAKHUS, HIGBEE, McCULLY, HILL, HOELSCHER, BOCKHORST, J. RISING, RULE, NORTHRUP, PAFFENBARGER.

ROW 2. MANN, WARNER, ROWE, GERARDI, LARSON, HRACHOVSKY, MAGNUSON, LOVING, CAMBRE, ADAMS, HOWES, STREET.

ROW 3. BULLEN, PRESTON, VIDETO, RADFORD, STONE, JENKINS, J. S. RISING, N. THOMAS, WORSENCROFT, EUVRARD, LEE, ALLEN, BOERLIN, CHRISTMAN.

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ROW 5. IRWIN, BETTENCOURT, ROBERTSON, VIERCK, HUGHES, A. L. THOMAS, FREDERICK, FENWICK, ORTH, OLSON, DAINES, TURNER, WEBB, BUCK.

ROW 6. RIEBETH, RANSDELL, DEVINE, VOJTA, HEINKE, ENBURG, KNEBLE, GORMAN, VRANA, DIXON, THOMPSON, HALES.

ROW 7. BRATTIN, HEBRANK, SISSON, PALMERLEE, RUSSELL, GRISWOLD, SHIGLEY, BRUNO, SWANNER, H. HARRIS, McGUIRE.

ROW 8. WOOD, POTTER, HOPPE, FULLER, CHAPP, CLEARY, CLEMENT, M. HARRIS, B. L. BROWN, BRAGG, FARNHAM, STEWART, McTYRE.

THE SUMMER SCHOOL FOR ENGINEERING DRAWING TEACHERS
June 18-28, 1946

by

PROFESSOR R. W. BOCKHORST
Secretary of the Summer School

The 1946 Summer School of the Drawing Division of the S.P.E.E. held at Washington University in St. Louis was attended by 131 men representing 77 schools from 32 States. Two men came from Canada and one from Finland.

The school sessions were held for two days prior to the S.P.E.E. Convention and for five days following it. During the Convention the Drawing Division held joint meetings with other Divisions of the S.P.E.E. where areas of mutual interest were investigated and discussed.

During the Convention inspection trips were made to the McDonnell Aircraft Corp., to the Krey Packing Co., and to the Knapp Monarch Manufacturing Co. These trips made it possible to observe various machine operations, production methods and the movement of products through stages of processing.

The school sessions were ably directed by Professor Hoelscher, Chairman of the Faculty, who arranged the schedule of speakers and encouraged valued discussion following each paper. Eight committees were formed to sum up the papers and discussions and to report on them at an appropriate time. Each man in attendance served on at least one committee.

The writer was deeply impressed by the completeness of the program of the school and with the seriousness and tenacity with which it was conducted. The program thoroughly covered all matters of interest to a teacher of Engineering Drawing and Descriptive Geometry, from Administrative Organization and Physical Equipment to Course Content and Methods of Teaching. The papers while in themselves inherently factual, were in no small part an inspiration.

Emphasis was given to the necessity of enlarging, beyond the freshman level, the services offered by the Departments of Engineering Drawing. Since graphic solutions are well within the limits of accuracy required in engineering practice, the graphic language as an engineering medium is susceptible to wider use and application. Professor Levens gave a technical review of the work done in California where descriptive geometry proved valuable in the solution of certain problems arising in the design of prosthetic devices. Professor Adams reviewed the application of the graphic medium to nomography and Professor Warner stressed the value of further training in graphics through its application to advanced engineering problems. Professor Rule gave a tentative outline of a course of study in graphics covering four years.

There were three exhibits; visual aids, student work and foreign drawings. The visual aids exhibit under Professor Ransdell as Chairman gave us an excellent opportunity to see the nature and extent of suitable films available to Departments of Engineering Drawing. Professor Rising of Purdue offered considerable help in this connection. The models, particularly those of Professor Rowe and those from Pennsylvania State College illustrated the usefulness of this medium. The student work exhibit under Professor P. Paffenbarger as Chairman revealed the course content and laboratory work of 63 schools. The stereoscopic drawings and slides of Professor Rule showed the possibilities of these as an aid to visualization. The foreign drawings collected and exhibited by Professor Grant were of especial interest. One could not avoid being impressed by the high quality of the work done abroad.

While the days were largely given to the serious consideration of matters which concern a teacher of drawing, the time spent in St. Louis was not without relaxation, recreation and good fellowship. In this connection Professor Bragg merits mention and commendation. Professor Bragg possesses without doubt the highest in tonsorial art, the envy of all who would so aspire. In recognition of this the Drawing Division gave the gentleman from Georgia an award which was conspicuous at least for its size. It is improbable that the award will be treasured for very long.

The highlight of the Summer School was the inspiring address by Professor Higbee at the Farewell Dinner at the Chase Hotel. Professor Higbee emphasized the importance that graphics held in the development of engineering practice and stressed the need of continued study and research in the graphic field.

The men most responsible for the very real success of this Summer School are Professors Hoelscher from the University of Illinois, Rising from Purdue and McCully from the Carnegie Institute of Technology. It is to these three we owe a full measure of appreciation.

The entire proceedings are now being edited by Professor McCully and when this is done the proceedings will be published by McGraw Hill and made available at a nominal fee.

R. W. Bockhorst
Secretary Summer School

AN APPLICATION OF TECHNICAL SKETCHING IN INDUSTRY

by

H. H. Katz
Engineer, Republic Aviation Corp.

INTRODUCTION

In the design and building of any large complicated machine or structure a system of production flexible enough to allow for frequent changes in design and techniques is the natural and necessary result. This is especially true today as the rapid strides of technological development find industrial applications.

Changes introducing new materials, methods, design details, etc., are generally proposed and initiated by the engineering department of an industrial organization, or if proposed by any other source, the change must pass and be sanctioned by engineering.

The practical means used to pass this information along from the point of origin--perhaps in the field of operation, the assembly line, the laboratory, or from the drawing board of the engineer, is generally on an especially prepared and authorized engineering form.

These forms are also used to rectify engineering errors, to expedite the rapid release of information to sub-contractors and vendors, to eliminate the "marking up" of production blueprints, and to do away with the undesirable practice of issuing notes and verbal orders against drawings.

In the aircraft industry, the greatest strides have been made in the successful use of these forms, termed: "ENGINEERING ORDER" or "ENGINEERING ADVANCE INFORMATION", but commonly referred to as "E.O." or "E.A.I." The forms are essentially the same except for minor variations. In this discussion the abbreviation "E.A.I." will refer to the general engineering form.

The EAI is approximately $8\frac{1}{2}$" x 11" in size. The heading area contains printed blocks pertaining to manufacturing and record information and the "body" area is blank for sketch presentation. A number of sheets may comprise one form. Basically, the sketch is drawn on the top sheet called the "ditto original" which is backed by a special carbon-like sheet. Thus, lines drawn on the front side of the top sheet pick up carbon impressions on the back side thus creating a master from which additional copies are printed. The copies are routed to the various departments concerned and the original filed in the engineering department.

A change might be incorporated directly on the tracing of the drawing concerned, it would then be blueprinted and released to the shop. However, in large engineering departments, the process of sending a drawing through the "release system" is not only slow, but complicated and expensive. An EAI, on the other hand, may be routed quickly at a minimum of cost. Eventually, when a number of EAIs are "outstanding" against a drawing, they will be incorporated on the drawing (bringing the drawing up to date) and the tracing will then be re-released.

The change or other information is described in the body of the EAI in the form of an orthographic sketch generally executed without the aid of instruments.

VALUE OF TECHNICAL SKETCHING IN E.A.I.s

The mechanics of technical sketching are an integral, although sometimes neglected, part of the science of engineering drawing. However, there has always been a school of thought that proposes to present the information on the sketch "any old way", on the ground that sketches represent rough, speedily executed work, wherein errors are to be looked upon lightly. The writer wishes to assert that the only justification for speed is to minimize drafting and engineering costs, and although a rapidly and haphazardly drawn sketch might leave the draftsman with a slight time charge, an abundance of other time charges accumulate through time consumed in attempts to read and decipher the sketch in the shop: in allied engineering departments such as Stress, Weights, Planning, and Methods; in expensive telephone and telegram messages from vendors and subcontractors, and ironically enough, in other design engineering groups (often the originating group) that might find reason to use the sketch.

It is not uncommon for a group of approximately 300 engineers to issue well over 5,000 EAIs in a project lasting somewhat over one year. This percentage is not only true of aircraft, but applies to other industries as well. Furthermore, from a cost viewpoint, the average record cost alone for a single EAI is well over twenty dollars. Hence, we find the correct application of technical sketching manifesting itself to a very serious degree in industrial engineering drawing.

PLANNING THE SKETCH

The time taken to actually draw lines in the sketch is negligible. The time consuming element is in determining where the line is to go. In a larger sense, a mental picture should be formed first wherein the entire content of the proposed subject matter is visualized on the EAI. (That is, the general arrangement and grouping of the views, detail, notes, etc.).

Experienced engineers stop and consider the essentials of the information that is to be proposed in the sketch, mentally determine the views or parts of views required, then proceed to lightly block-in the subject. It is in this blocking-in or planning stage that the descriptive matter (in absence of detail) may be regrouped and properly arranged before actual drawing is begun. This process requires very little time and erasures are not necessary. As previously described, the EAI forms contain a top sheet backed by carbon-like

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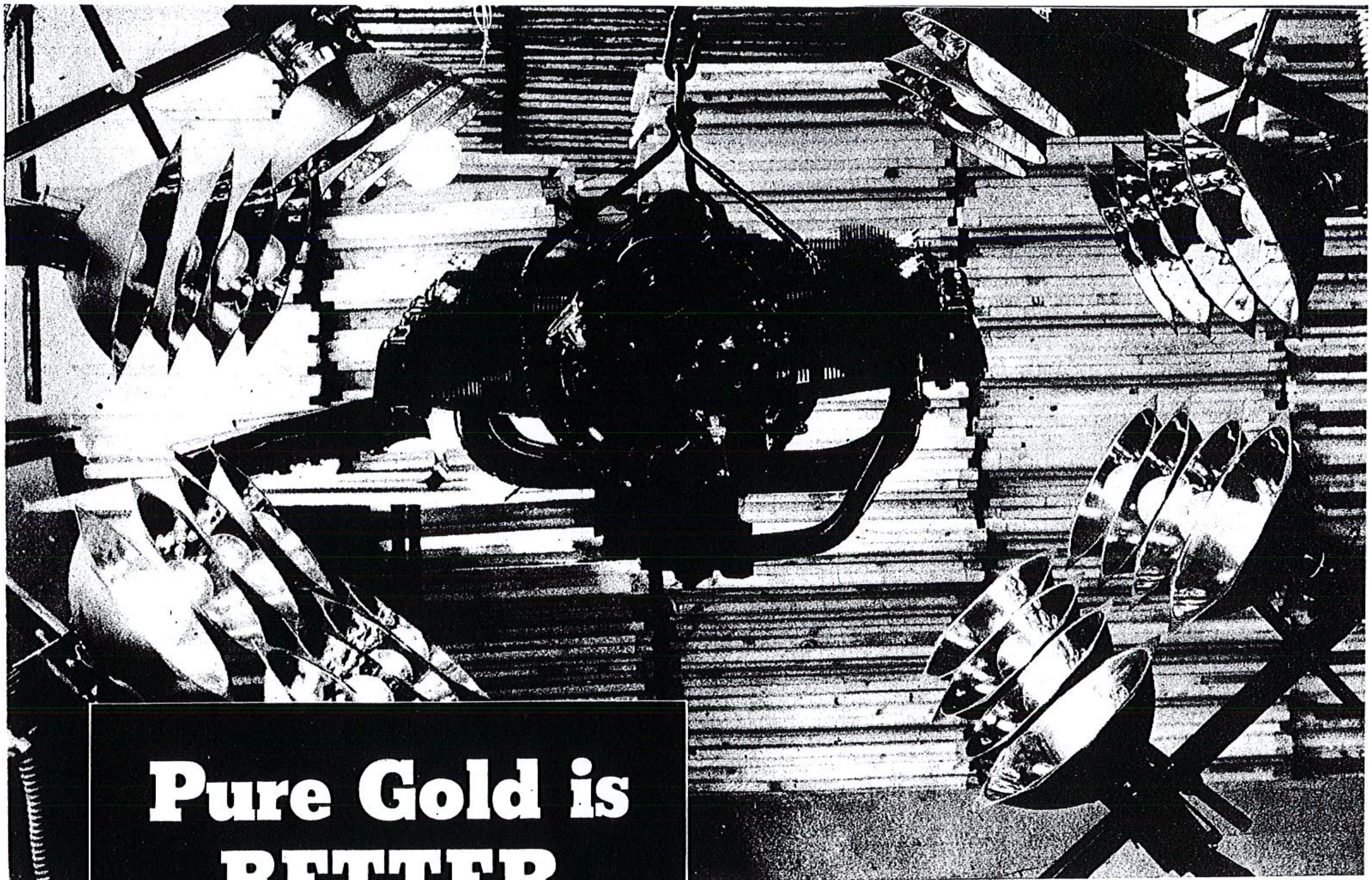


Pure Gold is BETTER

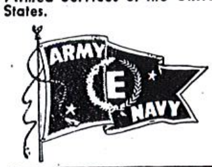
PHOTO COURTESY: FOSTORIA PRESSED STEEL CORPORATIOI

It would seem as if there were never a lack of energy for all the multitudinous jobs that mankind must perform, all the manifold problems that man must solve. What is so often lacking, what is so often needed, is the means of mobilizing, directing and applying energy available. For example, since man has solved the problem of collecting and directing the waves of infra-red energy he has been able to turn this energy to invaluable uses in industrial heating, drying and baking. Not only that, it has been found that pure gold is better than any of the baser metals in plating the reflectors that collect and direct these energy waves.

The same problem confronts the educator too . . . of collecting and directing the energy of the lads in his classroom . . . of mobilizing and directing their interest . . . of firing their imagination and their ambition so not only that the lad performs creditable classroom work but that he *acquires the habit of doing creditable work.* Together with aroused ambition and a sound set of standards, this is all the equipment a boy needs to make his way in life.

Here too in this important task, instructors have found that "pure gold" is better. Instructors in mechanical drafting are well aware of the value of *fine* drawing instruments in setting the level of all the work that confronts a boy when he first comes to class. These self-same instructors know only too well how cheaply made, carelessly selected instruments can cheapen the worth of all the fledgling is about to undertake. These instructors know how closely akin are pride of possession, pride of craftsmanship and that especial personal pride that prevents a boy from stooping to the snide, the mediocre, the cheap. Knowing all this the competent and intelligent instructor will not permit the slightly higher cost of fine instruments to stand in the way of their selection. He also knows that this slightly higher cost is the real investment and that it will return itself a thousand-fold to the boy who pays it.

Army-Navy "E" Production Award for Excellence in Manufacturing, Drafting and Surveying Instruments and Supplies for the Armed Services of the United States.



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paper, thus, in this initial sketching, a paper blank may be placed between the top sheet and the carbon so that these first impressions will not print when the finished sketch is duplicated on the ditto machine. Of course, the engineer must remember to remove this paper blank when the sketch is darkened.

It has been the writer's experience to observe innumerable cases where the lack of the above planning procedure resulted in discouraging attempts and considerable loss of time. A condition that is quite typical is the disregard for correct approximation of space, where the draftsman finds that he is "forced off the paper" in an attempt to include the necessary subject matter---the sketch is thrown in the basket and a new one begun. Often the draftsman discovers the need for more drawing area in the process of sketching, and to keep from making a new drawing, he will crowd and distort the remaining details to a degree that renders the sketch worthless.

THE NEW DRAWING TYPE SKETCH (Fig. 1)

Cases arise when it is desirable to have the shop fabricate a part or assembly immediately and time cannot be allowed to prepare and release a conventional production drawing. The subject may be sketched on an EAI form as a "New Drawing" and routed to the shop....production of the part is well on its way by the time that the actual production drawing is prepared, released by engineering and finally received by the shop.

The need for this type of drawing usually arises with the liaison engineer when he finds that an existing part is inadequate and that it cannot be successfully reworked. Design engineering may also find that a part of an assembly in process of fabrication must be replaced with a new part due to a design error or customer request.

The replacement part may be needed to keep an entire assembly or installation from being ~~retained~~ beyond production schedule, thus the necessity of supplying the shop with immediate design information and manufacturing authorization.

A sketch of this type must contain all the characteristics of a production drawing in regard to drawing number, bill of materials information and all the instructions necessary for manufacture.

It is not often that the engineer is called upon to draw and dimension a part for manufacture without the aid of instruments. But, although it is not common, cases do arise, and it is here that the greatest sketching dexterity may be displayed by supplying correct dimensions and etaining a reasonable sense of proportion. These characteristics are desirable and beneficial to creator and reader of the sketch, but of equal importance is the engineering reasoning that must accompany the drawing process. Hence, the bearing area about the 3/4 diameter hole in Figure 1 is determined by mentally subtracting the 3/8 radius from the 1-1/8 radius, and although the notation "3 EQ. SP." conveniently eliminates an accurate dimensioning procedure, the edge distance accumulation (3/4) is subtracted from the overall length (1-1/4) to give somewhat over 1 inch spacing between rivets and holes. This is necessary from the structural viewpoint, so that enough fasteners are called for to take the shear load, and sufficient bearing area is allowed in the sheet stock. Again, the rivet edge of the pilot-drilled holes which are later to take rivets or bolts should be carefully considered for rivet and bolt head clearances from adjacent walls.

This necessary reasoning in manufacturing sketches is, of course, limited to designs of moderate detail. Involved designs, requiring the determining of variable clearances and/or unusual or irregular contour demands too much pondering and defeats the purpose of the sketch as a means of rapid transmittal of information.

Some engineers carry a small portable drawing board. It is 10 x 12 inches in size and has a T square and two triangles, one 45 degrees and the other 30 x 60 degrees, secured to the back. This may serve as a valuable aid in the preparation of scaled sketches,

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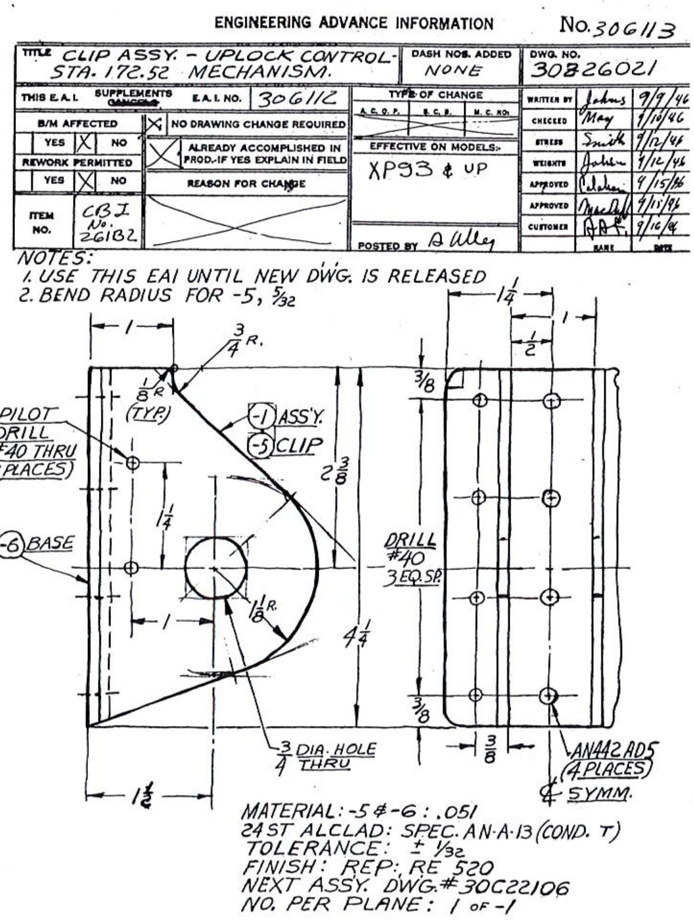

Fig. 1. New Drawing Type of EAI

Fig. 1 NEW DRAWING TYPE OF EAI

"The time has come" the Walrus said, "to talk of many things"
"Of shoes, and ships, and sealing wax –" "Of cabbages, and kings –"

The WALRUS and the CARPENTER

1. Professor R. P. Hoelscher of the Engineering Drawing Department of the University of Illinois is responsible for the organization of the Engineering Division at a branch of the University of Illinois at Chicago. It is anticipated that this division will enroll about 1300 or more students in the first two years of engineering. The organization of staff and teaching facilities for classes in Drawing, Physics, Mathematics and other subjects for the first two years of an Engineering curriculum in a relatively short time is a herculean task. Our confident best wishes go with Professor Hoelscher in his new assignment.

* * *

2. Eight promotions in rank in the Department of Engineering Drawing of the Agricultural and Mechanical College of Texas, are announced by Professor W. E. Street, Head of the Department.

John P. Oliver	Assistant	to	Associate	Professor
C. H. Ransdell	"	"	"	"
B. F. K. Mullins	"	"	"	"
G. H. Brock	"	"	"	"
R. L. Barton	Instructor	to	Assistant	Professor
B. H. Gallaway	"	"	"	"
Charles T. Hatchett	"	"	"	"
L. E. Stark	"	"	"	"

* * *

3. A hurried count of the paid up subscriptions for the May issue of the Journal showed that just under 650 copies were sent out. In seven years the "baby" has consistently grown and gained in weight. The effectiveness of the journal may be measured by the renewals of present subscribers as well as by new subcriptions.

* ***

4. Professor T. C. Brown of the Department of Engineering Drawing of North Carolina State College has, in his own words, been "flat on his back" for nine weeks. His note of September 5 indicated that the doctor was permitting him to sit up for a few more minutes each day as he gained back his strength. Always one to find some good in any situation, Professor Brown further states that his enforced rest has given him time to collect his wits from the pressure and hurry of present day living.

* * *

5. Mr. Roy E. Bolles, Instructor of Tool and Die design at Wilbur Wright Vocational School, Detroit, Michigan, writes in part, "It is a pleasure for me to be included in your family of subscribers, and I look forward to the issues. I enclose my check for one dollar.- Without seeing any issue, I would like to be bold enough to ask if your magazine has carried any articles on visual aids in teaching of drafting. I am in the midst of writing my masters thesis on the subject of 'Visual Aids in the Teaching of Drafting.'".....

* * *

6. "To increase the skills of people is to increase their income and lift their standard of living." This quotation is taken from the front of a new folder advertising the Topeka Trade School. The folder is illustrated throughout with excellent action pictures showing work being done by students attending the school, and with a picture of the school. P. W. Chamness, director of vocational education, and Dr. Kenneth McFarland, superintendent of schools, are responsible for the pamphlet, and are to be congratulated upon this fine piece of work. It is an excellent way to call the attention of the public to the Trade School.

* * *

7. Professor H. E. Grant of the University of Wisconsin, has been appointed Chairman of the Engineering Drawing Department at Washington University.

* * *

8. Acknowledgement of credit for preparation of the new heading for this page is made to J. S. Blackman, Instructor in Engineering Drawing at the University of Nebraska. If you are wondering where you have heard the little couplet about the Walrus and the Carpenter, ----it is from Alice in Wonderland-----and your childhood.

* * *

9. The banquet held near the close of the Engineering Drawing School in St. Louis was one of the high points in the less serious part of the school program. Professor T. C. Brown of the Department of Engineering Drawing at North Carolina State College of Agriculture and Engineering has composed a peom that recounts the pranks and exposes the personalities of the individuals who participated in the school and its activities. Professor Brown's story of the School is printed on page 30, and will recall the St. Louis experience for those of us who attended, and will make those who could not attend wish they had.

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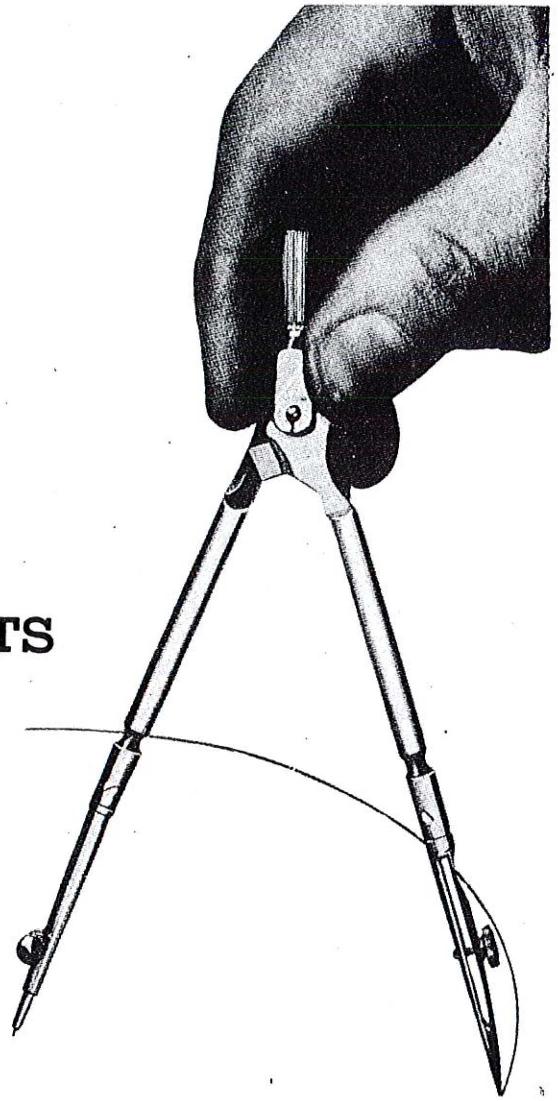

DRAWING INSTRUMENTS IN SETS

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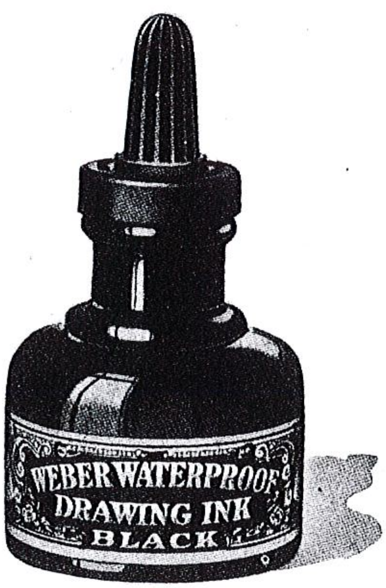

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but the engineer that develops his sketching and reasoning powers possess the most security and can cope with a greater range of contingencies.

The combination of technical sketching and engineering reasoning, as incorporated in the new drawing type EAI, lends itself to interesting and practical engineering training problems. The writer has included this type of problem in various aircraft engineering training programs. Some of the problems and conclusions are noted here.

Problem 1: Given-Circular Frame...40 inch radius... outside contour...3 inch channel, 3/4 inch flanges facing forward...gage of frame, .064.
Given-Pulley...for 1/8 inch steel cable... load on pulley- 2,000 pounds.
Plane of pulley (aft side of frame) 75 degrees down from plane of station...plane of pulley intersecting 45 degree radial of frame station (left, top radial)...center of pulley 3.25 inches from station on plane of pulley...and 2 inches ↓ from contour on plane of pulley.
To draw: Pulley bracket installation in dimensioned technical sketch.

Problem 2: Given- Fuselage Frame as in Problem 1... standard bend radius.
Given- Top skin or covering on frame, .032 gage.
At vertical center line, the frame must be spliced, the connection to take 3,000 pounds in tension...The aft side of frame (station plane) to be in same plane...no third splicing member may be used.
To draw: Frame splice in dimensioned technical sketch.

Problem 3: Given- Fuselage Frame as in Problem 1.
Given- Extruded Channel, $3\frac{1}{2}$ inches high... flanges 1 inch...thickness .125...fillet radii .125.
Center line of extruded section located on 30 degree bottom left frame radial, the back of channel flush with contour, and butting aft side of frame.
There is a design load of 15,000 pounds on the channel-frame connection.
To draw: A dimensioned technical sketch of the channel-frame connection using a machined fitting.

This type of problem trains the engineer to <u>think</u> rather than to only draw with the aid of a pencil. Only too often the approach to the problem is to sit down at the drawing board and begin mechanical drawing with the hope or intention that the solution will develop from out of the projected lines. A successful solution will unquestionably result when careful engineering thought accompanies the mechanical drawing in process of development. But the sketching medium is flexible and rapid, and the <u>essentials</u> of the solution may thus be obtained, discussed, revised and the subsequent production hastened.

Invariably, the most impressive answers to these technical sketching problems marked the engineers that faired best in production. Some of the sketches were so well executed that they could adequately serve as production drawings, and as in the case of the "new drawing" type of EAI, this condition is actual.

DESIGN CHANGE TYPE OF SKETCH (Fig. 2)

Of all the many types of sketches drawn on EAI forms, the design change type is by far the most common. The subject for this type of sketch is a change in the existing design, usually due to some discrepancy discovered by the shop in the process of fabrication, assembly or installation. The design engineering department may also wish to issue engineering sketches to rectify errors or make additions to the production drawings after they have been released to the shop.

The design change type of sketch basically differs from the new drawing type in that the change is made in an existing part or assembly. Generally, the change is already determined and the work possibly accomplished in the shop, hence, the draftsman may feel more secure in presenting correct information. This is generally true, but not always the case. For example, it may be known that regular nuts securing a duct flange must be replaced due to the inaccessible position of the nuts in installation. Nutplates may indiscriminately be called for on the sketch to replace the nuts, without consideration for the added flange area and edge distance required to install the nutplates, and often, because of their greater size, less nutplates can be installed in the area originally taken by the nuts. A good rule to follow is: "think carefully before sketching rapidly".

Only the information that directly concerns the change should be drawn on the sketch. However it is important that adjacent structure or parts are included when it is necessary to help locate and associate the change in a large complicated assembly or installation. This becomes quite obvious when a few dimensions are changed in a drawing comprising one hundred or more detail parts. The description of adjacent parts should be stripped to its basic essentials, and often a simple reference or center line will suffice as a locating and associating source for the change. In any event, the location of the change in relation to the assembly is an important initial consideration.

One of the most convenient means of obtaining this location information on long complicated drawings is through the "zoning" method. All drawings longer than 66 inches generally provide horizontal and vertical zoning by alphabetical entry in the left and right hand borders and numerical entry in the upper and lower borders. Each part appearing in this type drawing is located by zone in the "zone" column of the Bill of Materials block of the drawing. Zones measure 11 inches horizontally, starting from the outside of the right hand border and are numbered in order, from right to left. The zone number or letter appears in the center of the space within the border. Zones measure $8\frac{1}{2}$ inches vertically and are designated by letter A, B, C, etc., reading up. The zones extend from outside to outside of borders. In referring to zones, the number is given first, followed by a dash, and then the letter, for example, 7-C, 3-A, etc.

Parts may be located on the sketch by referring to conventional reference planes or lines that exist on the drawing subjected to change. For example, a notation under the sketch may read...."at Station 23-Waterline-17.375" or "..32.125 from horizontal centerline".

It is good practice to note the specific detail, section or view that is affected by the change, and in aircraft and shipbuilding, the direction from which the object is viewed. For example, "...View Looking Outboard-Right Hand Side" or "... in Plan View-Section A-A".

Reference may be made to the predominate details or sub-assemblies adjacent to the part affected. It is indispensable of course, to make reference to the name and detail or dash drawing number of the actual part affected.

Often a combination of the methods described above may be required to adequately locate the change. The degree of locating information necessary is dependent on the length and complexity of the drawing, and it is not practical to set down definite rules since every drawing and its change matter contains its own peculiar characteristics.

The engineer sketching the change is usually so familiar with the condition of the design that he is likely to neglect the importance of accurate locating information. This invariably brings grievances from the shop and complaints from management on the accumulation of costs due to the time expended in attempts to analyze the engineering order.

A number of EAIs are eventually grouped together and incorporated on the drawing (producing tracing). It is likely that the draftsman called upon to bring the tracing up-to-date is not familiar with the design, and if any great effort is required to interpret or find the location of the change, engineering then received a taste of the difficulty that confronts the shop by inadequately prepared engineering orders.

DIMENSIONING

Dimensions on EAI sketches, as in all types of technical sketches, are assumed to be out of scale. However, a good sense of proportion facilitates the logical placing of dimensions and presents a more professional appearance. The dimensions on the sketch are the predominate instructions and they should be given with the greatest clarity and accuracy. Due to the limited area of the EAI form as compared to the production drawing tracing, notations and dimensions are often placed closer to the picture subject matter of the sketch than that called for in orthodox drafting practice. In every case, the dimensioning instructions should be given priority over picture. For example, a "break" may be placed in object or center lines to make room for clear numeral presentation.

Conventional dimensioning practices should be called for whenever feasible, but to minimize dimensioning on the face of the sketch as far as possible, general notations may be given. Thus, when the majority of rivet, bolt and/or hole edge distances are the same, dimensioning space may be saved by adding the notation, "....EDGE DISTANCES ARE 2D (TWO DIAMETERS) UNLESS OTHERWISE NOTED". Likewise, the notation, "RIVETS ARE EQUALLY SPACED BETWEEN KNOWN POINTS UNLESS OTHERWISE NOTED." may provide added area in the sketch for other dimensioning and description. Similar notes pertaining to rivet types, bolt types and size standard relief and bend radii, etc., may be used to practical advantage.

Existing dimensions on the production drawing associated with the change, should be shown on the sketch when it is felt necessary to clarify and help follow the new instructions. These dimensions should be marked "(REF.)" on the sketch.

Place the word "(ADD)" beside dimensions on the design change sketch which are added to the drawing as a result of the EAI.

When replacing an existing dimension on the drawing with a new one authorized by the EAI, show the new dimension on the sketch and beside it, place the old one in parenthesis, for example, $\frac{3}{4}$(WAS$\frac{1}{4}$).

These notations, (REF), (ADD) and (--WAS), may also be applied to other information incorporated on the sketch such as basic reference lines, part numbers, notations, etc. Nothing should be left to the imagination of the reader of the sketch, and every assistance should be presented for clear, immediate and single interpretation.

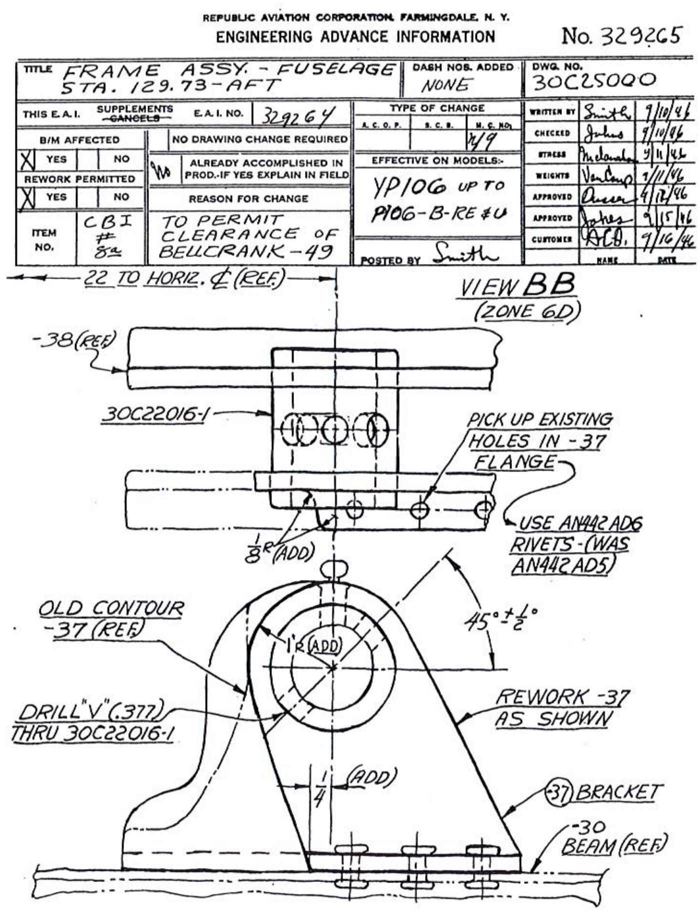

Fig. 2 DESIGN, CHANGE TYPE OF EAI

SCREW THREADS FOR FASTENERS

by

W. C. Stewart*

In considering screw threads for fasteners such as bolts, screws, and nuts, it might be well to glance at the historical development of this highly useful invention. Probably no one knows the date of the first invention of screw threads, but it is known that they were devised independently by many primitive peoples. They probably were made of bone or wood by holding the cutting edge of a knife against the piece at a helix angle and then rotating it. Thus a spiral groove was cut along the piece with a relatively constant progression. Further carving along these guiding marks shaped the thread for use as a means of holding spear heads or for other purposes, such as tapered threaded plugs for closing flesh wounds. This crude method can be contrasted with today's production of bolts, nuts, and screws in this country. Two million tons of steel are cut up into some fifty billion threaded pieces per year, and of marvelous accuracy considering the complex surface shape of a screw thread which must mate well and interchangeably with a complimentary threaded piece.

It probably is not necessary to go into the detail of production of threads in metal by cutting. This is a familiar process except that high-speed, automatic means have been developed for rapid production in tremendous quantity. There is a relatively new process of producing external threads, however, which is not so familiar; that is, by cold rolling (Fig. 1). In this process an accurate, round blank is prepared of a diameter equal to about the average diameter of the thread contour. Generally this blank is rolled under

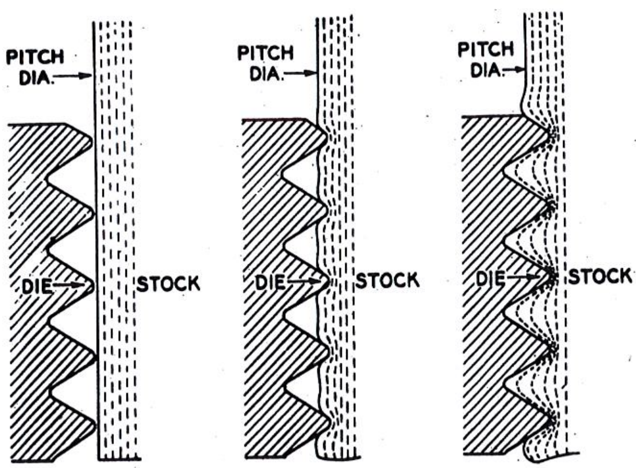

Fig. 1 ROLL THREADING ILLUSTRATED

pressure between two flat dies having grooves of the proper spacing and form, such as a pencil might be rolled between the hands. The result is that the blank metal is pressed inward to form the valley of the thread and is extruded outward into the die grooves to form the hill-tops of the thread. This is a rapid, economical method of producing the highest quality of thread. The process is adaptable also to the production of a variety of types of threads and circular grooves in machine parts in almost any malleable material.

One of the metallurgical advantages of rolled threads is that the metal is pressed into the shape of the thread and the grain flow follows the thread contour rather than being severed by cutting (Fig. 2). This produces the continuity and density of metal characteristics of all forgings. The thread surface is smooth and burnished, and the metal is work-hardened.

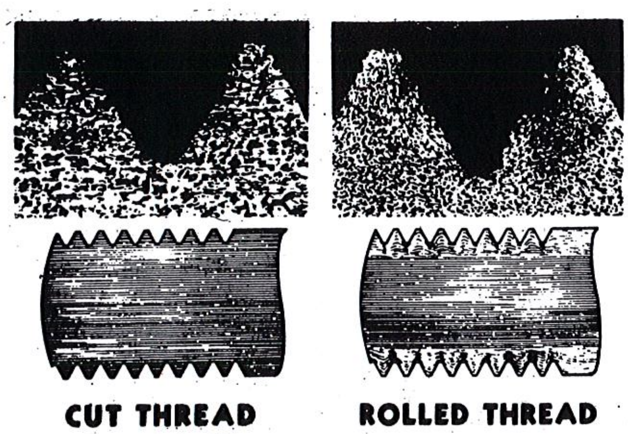

Fig. 2 PHOTOMICROGRAPH--ROLLED AND CUT THREADS

thereby increasing its strength. If not subsequently relieved by heat treatment, the metal surface at the roots of the thread is hardened and is in compression, which substantially increases the endurance limit of the part under dynamic stresses,

In order that terminology of screw threads may be clear, Fig. 3 is included showing the standard dimensions and terms used.

Threads for fastening devices are produced in two series of pitches known as course threads and fine threads. The pitch of fine threads is substantially less than that of coarse threads, and the threads are correspondingly shallower in relation to the bolt diameter. Coarse threads are in greatest use for general engineering while fine threads have found their principal application in automotive and aircraft work.

Since mass produced parts cannot be made exactly alike, some provision of tolerance from basic dimensions must be allowed to account for tolerances in the

* Technical Adviser, American Institute of Bolt, Nut and Rivet Manufacturers.

manufacture of tools, economical tool wear, chance variations in production process, and tolerance and wear of inspection gages. Such product tolerances have been established in several classes by the American Standards Association from Class 1 to Class 5. Class 1 is a loose fit not ordinarily used in fastening devices

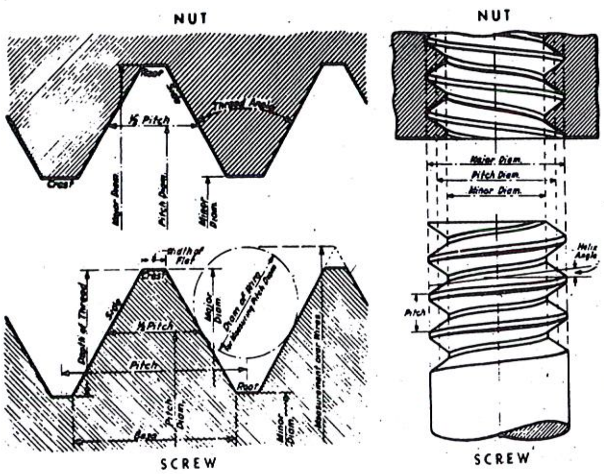

Fig. 3 SCREW THREAD NOTATION

except for small screws, stove bolts, and nuts. Class 4 is a very close fit resulting in some interference between parts and will be wrench tight in a certain proportion of cases. It is little used for fasteners. Class 5 is designed as a special wrench-tight fit in all cases and is used for tap-end studs and other tight thread assemblies. The remaining Classes 2 and 3 are most generally used for bolts and nuts and will be considered in some detail.

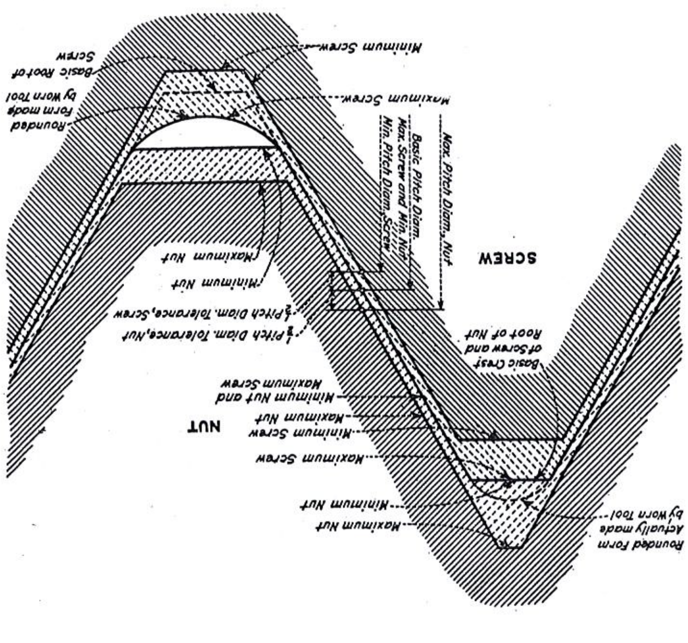

Fig. 4 ILLUSTRATION OF CLASSES 2 AND 3 TOLERANCES

In Classes 2 and 3 fits, the maximum-metal limits of both internal and external threads have the same basic dimensions, and there is metal-to-metal contact (Fig. 4). The tolerances are plus for internal threads and minus for external threads, resulting in a certain looseness in the minimum-metal condition. The amount of this tolerance for Class 3 is 2/3 that of Class 2. The resulting fit of both classes varies from a metal-to-metal fit to a somewhat free condition, but the maximum looseness of Class 2 is 50 percent greater than that of Class 3. The actual amount of tolerance in both classes of fit varies with diameter, being proportionately larger in the smaller sizes. The only difference, therefore, between Class 2 and Class 3 is the amount of looseness permitted in the minimum-metal condition.

Gaging of threads commercially is done with "go" and "not-go" gages. For internal threads these gages are threaded plugs, the "go" gage being made to the minimum limit of the tapped hole and the "not-go" gage to the maximum limit of the hole. A similar set of ring gages is used for external threads. The difference in pitch diameter of "go" and "not-go" gages is the so-called pitch-diameter tolerance of the product. The actual errors in the threads, however, in addition to diameter errors may be in angle or lead which absorb a certain amount of "pitch-diameter" tolerance (Fig. 5). In reality, therefore, this so-called "pitch-diameter" tolerance is the difference in pitch diameter of the

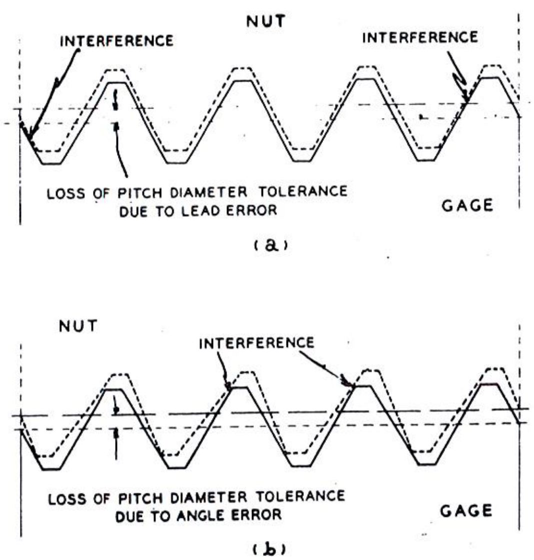

Fig. 5 LEAD AND ANGLE ERRORS ABSORB PITCH-DIAMETER TOLERANCE

gages which determines the maximum and minimum contour for the thread. The actual product thread contour may be in error in pitch diameter, lead, angle, etc.; but as long as the combined effect of these errors does not result in a thread outside the limiting contours, the thread is acceptable (Fig. 6). It is important in some cases, however, to distinguish between these different types of errors for they have different effects on the functioning of a fastener thread.

Angle error is not particularly important. It may determine the exact point of initial contact of mating threads. However, when full load is applied, the threads bend and seat themselves in the proper manner provided one member is sufficiently malleable to withstand this slight deformation.

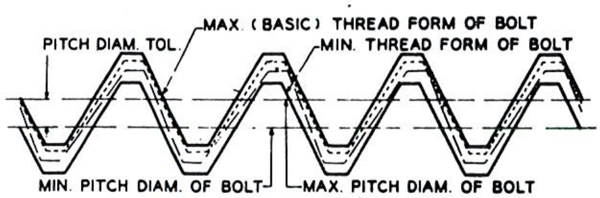

Fig. 6 PITCH-DIAMETER TOLERANCE OF THREAD INCLUDES EFFECT OF ALL ERRORS

True diameter errors are of no importance in any case within the standard limits of threads. It is true that a bolt with undersize threads is technically weaker, but the decrease in strength within the limits of the various classes of threads is only a matter of two or three percent, which is less than the chance variation in strength of the metal and much closer than could be considered in any design of bolted connections.

Error in lead is possibly the most important error to control in certain applications. If we study the distribution of load on successive threads within a loaded nut, we find that the load generally is not uniformly distributed (Fig. 7). It will be noted that there is a higher load on the threads near the base of the nut than there is near the top. The reason for

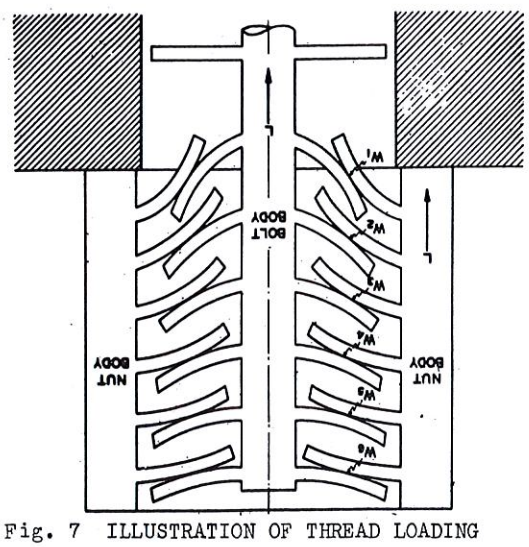

Fig. 7 ILLUSTRATION OF THREAD LOADING

this is that under load the bolt stretches within the nut, thereby tending to lengthen the load of the bolt thread. On the other hand, the nut is under compression and its lead tends to contract. The mating threads, however, must remain in contact and the result is that threads near the base of the nut are deflected more than others in order to maintain contact, and this results in uneven load distribution. If the lead of both bolt and nut were perfect before loading, several investigators have shown mathematically and by photo-elasticity that the distribution of load after loading is approximately as given in Fig. 8.

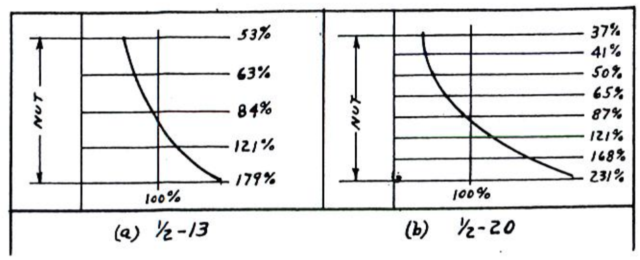

Fig. 8 CALCULATED LOAD DISTRIBUTION ON THREADS--PERFECT LEAD

If the excessive deflection of threads near the nut base is anticipated by introducing a deliberate lead error in the system by lengthening the lead in the nut or shortening the lead of the bolt, the load distribution tends to become more uniform. If the error is in the opposite direction, however, the nonuniformity is even more pronounced than in threads of perfect lead. (Fig. 9).

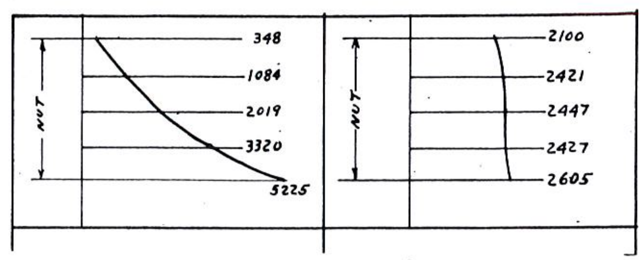

Fig. 9 CALCULATED LOAD DISTRIBUTION ON THREADS--PLUS AND MINUS LEAD ERRORS ON BOLT

The above non-uniform load distribution does not harm the load carrying capacity if one of the mating parts is of a metal soft enough that it can deform plastically. The highly loaded threads then merely shift plastically into a slightly different position when the load exceeds the yield point of the metal. If materials of both parts are relatively brittle, however, this adjustment cannot occur without fracture of the metal. Also, even in softer metals the stress concentration on the bottom threads, though insufficient to cause static failure, may be a factor in producing fatigue failure in dynamic loading. This effect may be accentuated if there are angle errors present also. It is important, therefore, that lead and angle errors be controlled where threaded parts are brittle or where severe cyclic loading is present. It is apparent that with Class 3 tolerances, the lead and angle errors cannot be as great as is permitted by Class 2. This is the principal reason for specifying Class 3, which is useful only in hard materials and in severe dynamic loading. Class 2 tolerance is just as suitable as Class 3 for all general applications.

In both Class 2 and Class 3 fits if mating parts are in their tightest condition, there is metal-to-metal contact with theoretically no freedom. Often this is an undesirable condition since it promotes difficult assembly, seizure in high-cycle power wrenching and seizure in high temperature service, and provides no room for electroplating even though the plating is only one and a half ten-thousandths of an inch. A small

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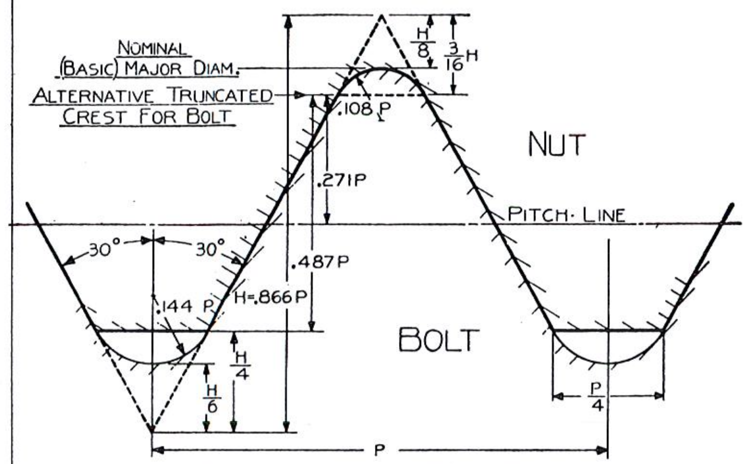
allowance under tightest conditions will help to avoid these difficulties and have no effect on the strength and other characteristics of the threaded connection. This is becoming increasingly realized among engineers, and there is a movement under way at the moment to establish a new class of fit having a definite minimum allowance. In establishing this new class of fit, it may be possible to kill two birds with one stone, that is, to provide an allowance fit which should serve practically all purposes for fasteners and to establish a single fit for these purposes in place of the present Classes 2 and 3. This will avoid the present difficulties in choosing between two classes of fit, the difference in which is important only in special cases.

The static load carrying capacity of threaded joints is an important consideration in most applications. If both parts are of the same material, the nut is considerably stronger than the bolt. In other words, failure of the connection will be by tensile break of the bolt in the threaded section. The breaking load will, of course, depend upon the unit tensile strength of the bolt material and upon some effective area of the threaded section. It has been commonly assumed that the area to use is the area at the root diameter of the bolt thread. This area, however, is too small and in conjunction with the unit tensile strength will give a load less than actual breaking load of the bolt. There is no rational way of determining the proper area to use, but it has been found that the area at a diameter halfway between the root diameter and the pitch diameter is more nearly correct. This is called the "mean area" of the thread section and is becoming more generally used.

If a common nut is used with higher strength bolts, the bolts will still break in tension until a bolt steel of about 100,000 PSI tensile strength is used. Bolts stronger than this ordinarily will not be broken by a common nut; instead, the threads of the nut will be stripped out by shearing. It is fortunate that nuts are so designed, for it permits using a soft steel nut on a harder bolt; thereby realizing a more uniform distribution of load on engaged threads and avoiding the stress concentration discussed previously.

Dynamic loading of threaded connections presents different problems. J. O. Almen of General Motors Research Laboratories has shown that if a bolted connection is preloaded by tightening the nut to a bolt tension exceeding the peak value of applied service loads, and if the bolted parts are rigid, then the bolt and nut will experience only the static preload stress. Dynamic loads applied to the joint will not cause a variation in bolt stress. Under these conditions the bolt cannot fail by fatigue (Fig. 10). Further, there is no need of the usual refinements of design common to machine parts that must withstand varying stress.

In actual practice the foregoing "ideal" conditions are not possible in the strictest sense, for all bolted parts have some degree of elasticity. As a matter of fact, in some designs a flexible gasket must be used. However, if the design is carefully made so as to avoid flexibility as much as possible, the resulting stress variation in the bolt will be minimized and be only a fraction of the range of applied loads. The resulting stress range in the bolt then will not exceed the endurance limit of the ordinary bolt without resorting to unusual specifications of fillets and surface smoothness to get additional fatigue strength.



Proposed Basic Screw Thread Form

Fig. 10 PROPOSED AMERICAN-BRITISH-CANADIAN THREAD FORM

There are special application where it is impossible to provide sufficient rigidity of bolted parts, and the resulting stress range in the bolt may be severe. In these special cases larger bolts must be used to reduce the unit stress; or the bolts must be carefully designed by providing fillets, high degree of surface smoothness, and surface compressive stresses, such as by peening in order to develop the highest resistance to severe fluctuating stresses.

In discussing design details to improve the fatigue strength of threaded connections, mention might be made of studies now going on to change the thread form of the American National thread. In Britain the standard thread is the Whitworth thread having rounded roots and rounded crests. During the war there was a great deal of material made in this country to British standards, and likewise a great deal of material made in England to American standards for servicing overseas American equipment. The resulting confusion of using two standards of thread cost millions of dollars and considerable delay. Consequently, there have been discussions recently between Canada, England, and the United States to adopt a single standard; and at a recent conference such a standard was recommended. It is not known whether this proposal will be acceptable, but any final standard agreed upon probably will have to conform to the Whitworth Standard, at least to the extent of providing some degree of rounding of roots of external threads. Such rounding will improve the endurance limit of threaded connections and will be useful, particularly in those dynamically loaded connections where large stress range in the bolt cannot be avoided in design.

It is apparent from the foregoing that it is desirable to establish high bolt tension in joints subject to dynamic loads. Tension is also necessary in joints holding gas or fluid pressure to avoid leaks and in other structural joints where slippage is to be avoided. Such tension is ordinarily produced by torquing the nut with a wrench. This torque, through the mechanical advantage of the thread helix, produces tension in the bolt. As a mechanism, however, this operation is only about five percent efficient because of friction on the bearing surface of the nut and on contacting flanks of the threads. It is important to know what tension is produced in the bolt, but this cannot be determined with accuracy by measuring applied torque. Where precision is not too necessary, however, a torque-measuring wrench may be used and the bolt tension thereby determined. A rough relation between torque and tension is 200 lb-in of torque per inch of bolt diameter per 1000 lb tension, regardless of whether fine or coarse threads are used.

Where precise knowledge of bolt tension is required, torque wrenches are not suitable. Resort then must be made to measurement of elastic extension of the bolt which is accurately correlated with the tensile stress established, depending upon the dimensions of the bolt and the Young's modulus of the material.

Examination of the bolt tension produced in a bolt by available torque as applied by hand power to ordinary standard wrenches, shows that there is a certain "critical size of bolt" (Fig. 11). For common steel this critical size is about 1/2 inch and for a

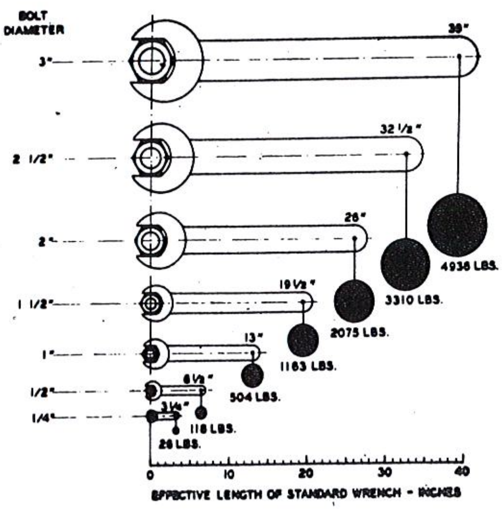


Fig. 11 PULL ON STANDARD WRENCH TO PRODUCE 60,000 PSI BOLT TENSION

heat treated, medium-carbon steel bolt is about 5/16 inch. These critical-size bolts can be fully loaded with standard wrenches by hand effort. Smaller bolts are apt to be broken if full effort is used. Larger bolts cannot be loaded fully by hand effort on standard wrenches.

Where large bolts are used in applications requiring high preloading, resort must be made to other means of tightening than hand effort on standard wrenches. It is possible to use longer than standard wrenches to multiply hand effort. Power wrenches can be used to give unlimited effort, or the bolt can be assembled in a heated condition permitting it to contract thermally and produce tension.

In torquing a nut to produce tension, it is desirable to produce a tension of nearly the yield strength in order to get maximum efficiency from the bolt. The yield point of the bolt in torquing, however, is not the same as that in direct tension. As the nut is torqued, it induces a torsional shear stress in the bolt shank because of frictional drag on the thread surfaces. As a result, the maximum tension clamping force that the bolt can provide is somewhat reduced and is only about 3/4 of the breaking strength in direct tension.

Much consideration has been given recently to the prevention of loosening of nuts, and many locking devices have been invented. In view of the realization that maintenance of tension in the bolt is of prime need in many applications, the problem of preventing loosening is growing in importance. So far there has not been a clearly established theory as to why nuts come loose. Certainly there is little if any effect from classes of thread fit except in cases where a wrench-tight fit is used. Standard Class 2 and Class 3 fit both provide a certain amount of looseness because of the necessary tolerances allowed. As far as loosening goes, there is little choice between them.

Ordinarily, it is considered that nuts cannot loosen, providing elastic tension is maintained in the bolt shank. A nut rests on bolt threads through a sloping spiral surface much as a block on an inclined plane surface. If the tangent of angle of slope is smaller than the coefficient of friction, the block does not slide down the plane. Similarly, the nut under pressure should not rotate and "slide" down the helical thread surface since the tangent of this helical angle is only about 1/4 of the coefficient of friction. A small loosening torque is present, but it is opposed by frictional torque several times as great.

A recent paper* has discussed the theory of nut rotation under load which may account for looseness. According to this new theory, another factor is present when the bolt and nut are subjected to varying tension. As tension increases, the nut expands radially because of the wedge action of the thread angle. Also, the bolt contracts under tension in accordance with Poisson's ratio. As bolt tension decreases, the reverse radial motion occurs, therefore, under varying tension there is a continual breathing action consisting of radial skidding between bolt and nut threads. This motion, if rapid, absorbs practically all of the friction force available on the thread surfaces. Tangential motion on these surfaces (rotation of nut) can then take place slowly with little frictional resistance. According to this theory, therefore, the small unscrewing torque, which is always present because of the thread helix

(Continued on page 20)

* "Loosening by Vibration of Threaded Fastenings" by J. N. Goodier and R. J. Sweeney, Mechanical Engineering, December, 1945.

(Continued from page 19)

angle, may cause a slow rotation or unloosening of the nut, unless it is counteracted by some locking means.

While the above theory has been put into mathematical form and certain experimental work indicates that nut rotation occurs, there still has not been enough work done to determine the practical effect.

The theory presupposes a radial breathing motion between bolt and nut threads which occurs only when there is varying bolt tension. There probably is some threshold value of tension variation below which radial skidding does not occur because of the high static coefficient of friction. It would appear, therefore, that the variation of bolt tension must exceed some limiting value before nut loosening may occur.

THE REPORT OF CIRCULATION MANAGER AND TREASURER OF THE JOURNAL OF ENGINEERING DRAWING AS OF JUNE 10, 1946

FINANCIAL REPORT:

Cash Received

On hand June 25, 1945	$ 162.29
Received from advertising	343.10
Received from subscriptions	731.07
Total	$ 1,236.46

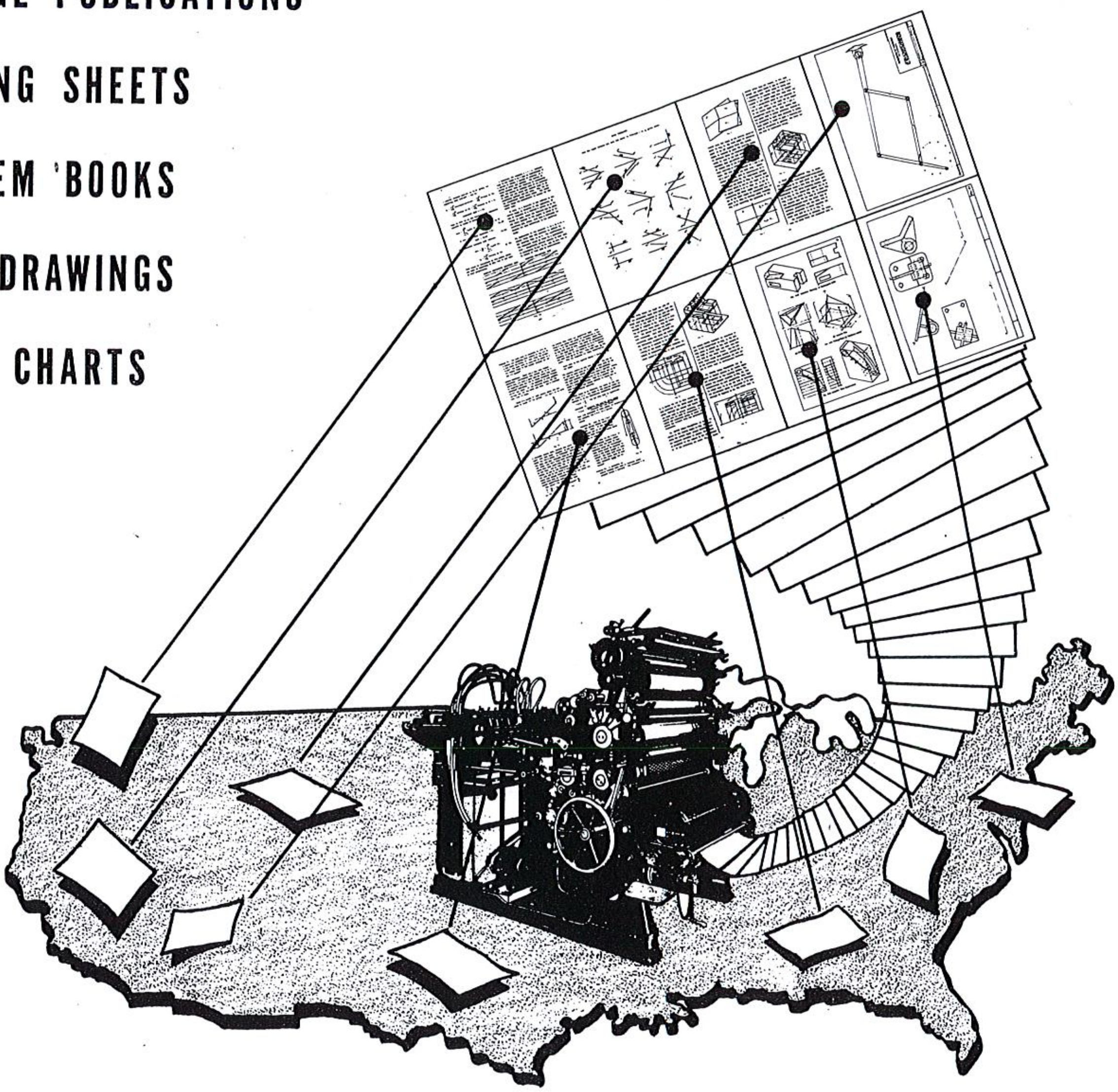
Disbursements

Printing and Supplies	$ 567.75
Postage, express and telephone charges	182.12
Typing charges	33.20
Bank charges	1.37
Total	$ 784.44

Cash on hand June 10, 1946	452.02
Accounts outstanding for May advertising	50.00
Cash Received and Receivable	$ 1,286.46
Cash Expended	784.44
Net Balance	$ 502.02

J. N. Wood

J. N. Wood
Circulation Manager and Treasurer



NEW LIGHTING DEVELOPMENTS AND THEIR APPLICATION TO DRAFTING ROOMS

by

Russell C. Putnam
Associate Professor, Case School of
Applied Science
and
Consultant, Engineering Division,
Lamp Department, General Electric Company

Under the stimulus of war significant advances have been made in light sources, in lighting equipment, in knowledge of the basic principles of efficient and comfortable seeing, and of the application of all of these to the lighting of drafting rooms. War production, with its long hours of operation, resulted in an increased dependence on artificial lighting. Good lighting installations proved their worth; poor ones soon revealed their weaknesses.

The lessons learned from this wartime experience can be converted to peacetime practices. This reconversion is particularly direct in the case of drafting. The visual tasks and the general conditions are much the same in the industrial and the college drafting rooms. What applies to one is equally applicable to the other.

The four main factors of seeing are generally considered to be: (1) the size of the object; (2) its brightness; (3) the contrast between the object and its immediate surroundings; and (4) the time available for seeing. All of these factors can be improved by more light of the correct quality. The quality and the quantity of the lighting are both important.

The college or university drafting rooms present conditions requiring accurate visual work involving fine discrimination over sustained periods of time; visual requirements which are not exceeded, if indeed equalled, in any other department. Small details must be seen accurately, often under conditions of poor contrast (as when a hard pencil is used on white or manila paper). There are few places where the help of good lighting is needed as much as in the drafting room.

There are few situations also in colleges where the tendency to eyestrain and fatigue is as pronounced. A rather common comment of engineering students is to the effect that they have received definite and sometimes permanent eyestrain in the college drafting rooms, and, unfortunately, there is all too often some justification of their feeling.

Much has been learned in the last few years concerning the role of good lighting on eye conservation and the reduction of fatigue. Researches and publications of Dr. M. Luckiesh, Dr. Charles Sheard, Dr. R. J. Lythgoe and others in this country and abroad give proof of the effect of lighting and accompanying visual conditions on the consumption of human energy as well as on the ease and comfort of seeing. One quotation from Dr. Charles Sheard, Division of Physics and Biophysical Research, The Mayo Foundation, Rochester, Minnesota, may be quoted here. In a paper published in the American Journal of Optometry in July, 1936, he says, in part, "Even under adequate lighting, with normal vision and adequate reserves of accommodation and convergence, it has been estimated that there is a consumption of a quarter of the bodily energy in the processes of distinct binocular single vision. The ease of seeing, when vision is normal and the powers of accommodation and convergence are adequate, is controlled almost entirely by sufficient and proper lighting. When the lighting is inadequate and improper and when poor vision and ocular insufficiencies are present, the consumption of bodily energy is increased, for various reasons, above the normally necessary amount. For vision which is poor, either because of the need of proper optical assistance or on account of insufficient light, causes uncertainty, tension, annoyance, and distraction. These unfavorable reactions and results, produced by increased expenditures of energy, contribute to ocular discomfort and to other trains of symptoms exhibited by abused eyes."

Present recommendations for lighting levels in drafting rooms call for a minimum maintained value of 50 foot candles, with many industrial installations using considerably higher levels. There is rather general recognition that drafting work requires an adequate lighting level, but it is not always appreciated that the quality of lighting must be good also for efficient and comfortable seeing. In the drafting room, there must be a sufficient amount of light with proper distribution, absence of glare, and correct brightness control.

Proper distribution involves well-diffused light with a minimum of shadows. This question of shadow is particularly important in drafting work as a shadow along the edge of a triangle or T-square may contribute to inaccuracy and be definitely annoying. Indirect lighting systems used with matte white ceilings are effective in reducing shadows, as the ceiling itself acts as a large area, low-brightness light source. The resultant illumination on the drafting table is soft, evenly distributed, and of high quality.

At the higher lighting levels, however, the ceiling may get uncomfortable bright with indirect lighting systems, especially in large rooms. This may be helped by the use of ceiling beams to break up the large ceiling area in the visual field, or by the use of semi-direct or direct fluorescent systems.

Although either the incandescent filament or the fluorescent lamp can be used successfully in indirect lighting installations, only the fluorescent lamp has a low enough brightness to be used with semi-direct or direct lighting equipment in a drafting room, and even it should be well shielded so that the lamp itself cannot be seen at ordinary viewing angles. The high efficiency and low radiant heat emission of the fluorescent lamp allow the higher lighting levels to be reached at reasonable consumptions of electrical energy and with physical comfort.

When drafting boards are used in the horizontal position, the shadows under indirect lighting are very soft and almost non-existent, but with direct or semi-direct fluorescent systems, the shadows of straight edges when parallel to the lines of lamps may be annoying. This annoying sharpness of shadows can be reduced by moving either the lamps or the straightedge until they are no longer parallel, but are at an appreciable angle. The feathering out of the shadow edge is noticeable at about a 15° divergence between axes of straightedge and lamps. For ease in installation, however, the lines of fluorescent lighting units are often mounted at a 45 angle to the axis of the board. This is satisfactory in reducing shadows in all positions of T-square and triangle but one - that is, at the 45° angle where the triangle edge is parallel to the lamps. As this position represents but a small fraction of a draftsman's work, the 45° orientation of the lighting units is often used.

Many industrial drafting rooms are using the vertical board with drafting machines. When the board is vertical or nearly so, it is not necessary to use the 45° mounting with direct or semi-direct types of lighting as the angle of the board eliminates the shadows. It also largely eliminates reflected glare as the reflected brightness now is away from the draftsman's eyes and the vertical position also reduces direct glare by shielding the brightnesses of lighting units and ceiling in front of the draftsman. (Fig. 1 and 2.)

Glare can be defined as any brightness in the field of view which causes annoyance, discomfort, eye fatigue, or interference with vision. It is rather complex, as it depends on the brightness of the glare source, its size, the position in the visual field, the surrounding brightness, and the length of time of viewing. Glare can be either direct or reflected, and care must be taken to control both. This is especially important in the drafting room because of the specular finishes of triangles and drawing instruments as well as the critical seeing tasks encountered there.

The problems of glare and distribution have been recognized for a long while. The control of brightnesses represents a recent trend, however. In December 1944, the Committee on Standards of Quality and Quantity for Interior Illumination of the Illuminating Engineering Society published a report on brightness of the visual task should not exceed three times that of its immediate surroundings. The same ratios are given for lighting units and their backgrounds although in the latter case practical considerations may increase the limiting ratio to about ten to one due to individual conditions of size and surroundings.

This is an important principle. It affects the type of lighting equipment and also the finishes of walls, ceiling, and floor. In offices and schoolrooms the finish of the desk tops would be controlled also, but in a drafting room the work generally covers the top of the drafting table. Reflection factors of 80 percent or better for ceilings, 50 to 60 percent for walls, approximately 35 percent for

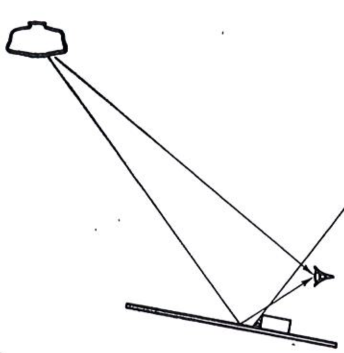


Figure 1

At or near a horizontal board position, direct and reflected glare may be produced by unshielded lighting, units in front of the draftsman. A lighting unit behind the draftsman may cause shadows.

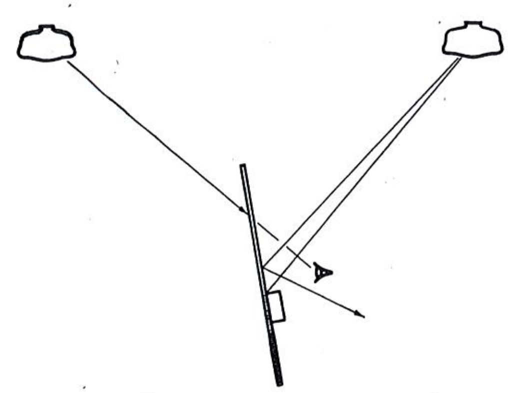


Figure 2

A more vertical board position reduces shadows and glare.

the trim (around chalkboards, tackboards, windows, etc.) and 35 to 50 percent for desk tops if they are used, seem to fulfill the specifications of good brightness ratios in a practical manner. All of these finishes should be matte or nearly so; at least they should definitely not be shiny for visual comfort. Color is important from a psychological sense, and color preferences vary with different individuals. The illuminating engineer is primarily interested in brightness and the resultant brightness ratios in the field of view and does not care particularly what color is chosen so long as it meets the reflection factor specifications.

Progress has been made in light sources and in lighting equipment as well as in the principles of efficient and comfortable seeing.

The virtually shadowless quality of lighting that results from an overcast sky can be duplicated by indirect or luminous-indirect lighting units and a matte white ceiling. A variation of indirect lighting with the silvered-bowl incandescent filament lamp utilizes silvered-bowl lamps in a very efficient luminaire made of three concentric rings to shield the bright upper part of the bulb, the silvered-bowl of the lamp being the reflecting surface. The use of beams to reduce the amount of ceiling area in the visual field permits a good lighting level of excellent quality and comfortable brightness conditions in large rooms. For smaller drafting rooms where the cumulative effect of the ceiling is not as pronounced, the indirect units suspended from a flat ceiling gives an excellent combination of high efficiency incandescent filament lighting and good quality. Two of the advantages of the silvered-bowl lamp are the ease with which it is kept clean and the fact that a new reflecting surface is automatically provided every time a lamp is replaced.

The standard inside-frost filament lamp can also give excellent results for drafting when used in a plastic or glass luminous-indirect unit. These units do collect dirt, but they are translucent enough so that the presence of dirt and other extraneous objects shows from below and gives and unmistakable indication of when they should be cleaned. The brightness ratio of this type of lighting unit with the ceiling is also good.

With indirect systems, the reflection factor of the ceiling must be kept high in addition to keeping the lighting equipment clean, as the ceiling is the secondary light source. The ceiling darkens slowly and may possibly not be noticed until there has been a severe decrease in lighting level. A yearly cleaning schedule with refinishing when necessary will prevent the deterioration of ceiling reflection factors that is all too prevalent.

With the development of the highly efficient fluorescent lamp, it was natural that this new lamp should be applied to drafting room lighting in a similar way to that found good for the incandescent filament lamp; that is, in indirect or luminous-indirect lighting equipment.

As the appearance and the quality of the artificial lighting systems approximated skylight conditions, it was a natural step to design fluorescent lighting installations for drafting rooms that were virtually skylights with fluorescent lamps above the glass. In these types of installations, an almost complete ceiling of glass acts as a diffusing medium for the fluorescent lamps which are mounted above the glass plates.

Advantage can be taken of the comparatively low brightness of the fluorescent lamp to design equipment with higher efficiency and easier maintenance than the previous examples. Although the brightness of this lamp is higher than one would care to have in the normal field of view for prolonged periods, it is judged to be tolerable from the standpoint of reflected glare for the majority of drafting room uses if the lighting level is 50 footcandles or more and the lamps are distributed over the ceiling. This has led to the design of semi-direct and direct units which have proved very satisfactory when used in accordance with the principles of efficient and comfortable seeing.

Since direct and semi-direct luminaires do not shield the lamp from the work, although they do shield the lamp from the eyes of the draftsman, the question of the best angle between the lamp and drawing board for greatest reduction of shadows is important. Research and trial led to the selection of 45 degrees as the most practical solution of the problem as mentioned previously. One of the very first such installations (probably the first in an educational institution) was made at the Case School of Applied Science before the war (Fig. 3). Here, in a drafting room on the top floor of an old building, the lighting level was raised from an average of 14 footcandles with the old filament indirect units to about 50 footcandles maintained with approximately the same total wattage in both cases. These continuous rows of units are equipped with louvers to shield the lamps from the eyes of the students. Somewhat similar installations in industrial drafting rooms also utilize the 45° mounting at lighting levels ranging from 60 to 100 footcandles. In the latter installations, the lighting units are so designed that some light is spread over the ceiling as well as on the work in order to keep the brightness ratios comfortable.

In new construction, a trend in present practice is to the use of fluorescent lamps in recessed troffers, generally used with an acoustical ceiling. Now that aluminum has become available, the most comfortable conditions result from troffers which use lightly etched aluminum as the reflecting surface. Since the trend in industry seems also to be to the vertical drafting board, a combination of recessed troffers and vertical boards may be

(Continued on page 26)

MINUTES OF SPECIAL MEETING OF DIVISION OF ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY

June 28, 1946

Immediately following the adjournment of the 1946 Summer School for Drawing Teachers, Professor John T. Rule, newly elected chairman of the Division, called to order the first meeting of 1946-47, under the new name of the parent society. The purpose was to formally adopt, as action of the Division, the recommendations made by the various Summer School Committees.

These were all unanimously accepted and are as follows:

1. That the 1946 Summer School recommended to the Drawing Division of the American Society for Engineering Education that a committee be appointed to study the matter of minimum standards for basic courses in Engineering Drawing, including course content and time allotment, this committee to report at the next annual meeting of the Drawing Division.

2. That the Division ascertain whether more suitable visual aids in the form of slides or strip films concerning shop processes and their specific relation to dimensioning in the drafting room, are or could be made. It is suggested that industries such as General Motors, thru its institute, or the Society for Visual Education or others might be asked if they have these aids. In the event none is available, it is suggested that some educational foundation be approached, thru the Council of ASEE, to see if such aids could be developed. Most present shop process films are of the "How to run a lathe" type and are not well adapted to the specific needs of the engineering drawing teacher. A commercial development of the ideas presented by Professor McGuire is recommended.

3. That the problem of granting drawing credit for previous drafting experience be referred to an appropriate committee for preparation of unit examinations covering all subjects treated in basic drawing courses. These units could then be combined to meet the needs for any particular course of a college or University.

4. That a committee be appointed to study the projectional material presently on the market and to establish a list of these offerings together with a suggested list for future production.

   That a committee be appointed to offer technical advice to those companies desiring to produce projectional material and offer reviewing service after the material is completed.

5. That a committee be appointed to compile information concerning new methods of graphics and specific examples of war projects on which graphics proved of unusual value.

   That a committee be appointed to survey the field of advanced graphics with the purpose of suggesting subject matter for courses and material and textbooks now available for study in this field.

No other item of business being considered, the meeting was adjourned to June 1947.

Respectfully submitted,

J. Lawrence Hill, Jr.
Secretary

ATTENTION: TEACHERS OF ENGINEERING DRAWING

The Journal of Engineering Drawing serves as a vital means for the exchange of information, new ideas, new methods of teaching Engineering Drawing and Descriptive Geometry, and news of the activities of our group. If it is to continue to perform these functions, it is necessary that many workers in the field of Engineering Drawing contribute articles and information in form ready for publication.

There are many new men, who, I am sure, could make some real contributions to our field of endeavor. There are also many older teachers from whom we have never heard. Chairmen of Engineering Drawing Departments might well assign topics to members of their staff to be written up in form ready for publication in the Journal.

I solicit the cooperation of all for contributions to our magazine.

-------The Editor

(Continued from page 24)

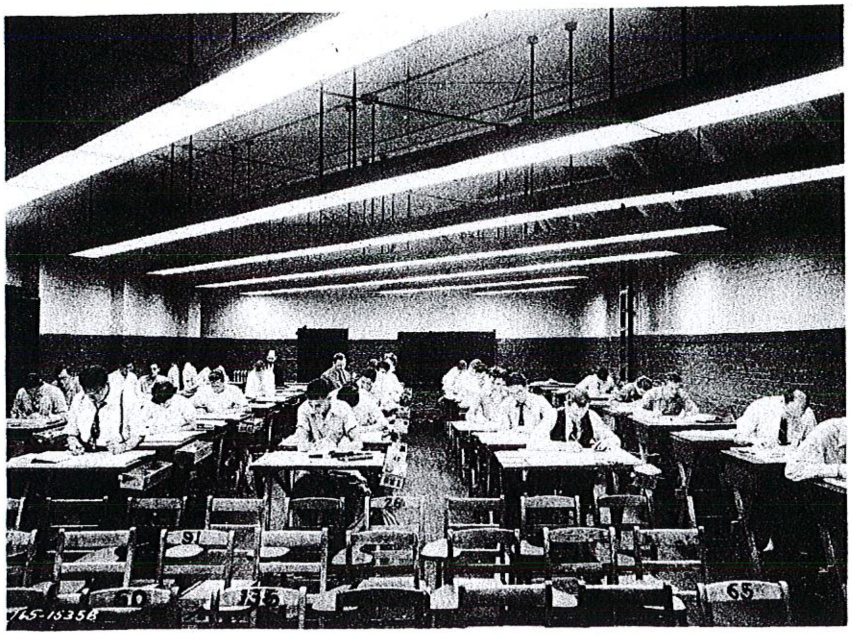


Figure 3

Louvered fluorescent units in continuous rows with 45° mounting tripled the lighting level for the same connected wattage in this converted drafting room at Case School of Applied Science.

considered as typical of the best present practice.

The need for relighting drafting rooms in colleges and universities is much more pressing than the lighting of new buildings. Professors have been conscious of the advances in the drafting room lighting in industry; many of them have worked under some of the new installations. They are interested in the possibility of replacing their present inadequate lighting systems. What is the answer to their problem?

Local conditions may influence the choice of equipment, but in the great majority of cases the choice will rest between an indirect system (filament or fluorescent) or a semi-direct system (fluorescent). Several of the installations which have been discussed are relighting projects which have taken the place of less satisfactory equipment. Some new fluorescent designs have recently been announced which are excellent for light control, efficiency, and maintenance. Some of these are so new that the first installations are just being made and pictures are not yet available. An installation in a classroom of the Oxford School, Cleveland Heights, Ohio gives a maintained lighting level of nearly 50 foot-candles with efficiency, good maintenance, and comfort. This is typical of some of the newest developments which are equally applicable to drafting rooms.

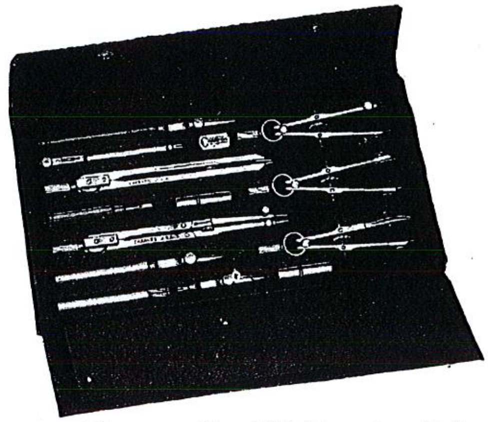
Tracing presents a difficult lighting problem, especially where the visibility of the original is low. A trans-illuminated tracing table which projects light through the original, silhouetting the lines on the drawing, makes the job of tracing a great deal easier. The use of such tracing tables was retarded for many years by the difficulty of using thumb tacks and by the problem of heat from the filament lamps. Now the availability of easily removable adhesive tape makes it possible to work on even the smallest drawing at any convenient location on the transmitting glass surface, while the fluorescent lamp supplies adequate light with relatively little heating. These also can be tilted toward the vertical if desired, since the use of the fluorescent lamp permits compact construction.

In fluorescent lamps and control there are also interesting recent advances. A new color has been added; in addition to the standard 3500° white lamp and the daylight lamp, there is now available a 4500° white lamp which is midway in color quality between the two and incorporates many of the advantages of each. Fluorescent lamps may also be started instantly if desired, without the slight delay of the standard pre-heat start.

A very new lamp so new that the first installations are just now being made offers great promise for drafting room work in connection with recessed troffers or semi-direct equipment. It is the low-brightness 40-watt fluorescent lamp, which has twice the area and hence approximately half the brightness of the standard 40-watt lamp, thus reducing reflected glare. It is furnished for instant starting, and it is made in the new 4500° color.

Good drafting room lighting can be obtained from either filament or fluorescent lamps, if used intelligently. Very uncomfortable, annoying, and unsatisfactory installations can result from either light source also if the rules of good lighting and seeing are not followed. Competent engineering advice should be secured, as the exacting visual tasks and close application over long periods of time required in drafting makes the highest quality lighting a necessity. The trend definitely is to fluorescent lamps for drafting room installations because of their high efficiency and low radiant heat emission; but whatever light source is used, care should be taken that the installation incorporates the accumulated knowledge of what constitutes good seeing and good lighting practice. Electrical engineering, through its sub-division of illuminating engineering, is in a position to make significant and valuable contributions to engineering drawing through recent advances in basic knowledge and in lighting technique.

NEW-POST WAR CHARVOS PRECISION DRAWING SETS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SOLUTION OF DESCRIPTIVE GEOMETRY PROBLEM

PROFESSOR J. AMARL DE MATTOS
Escola National deEngenharia
Rio de Janeiro, Brazil

THE PROBLEM:

Given: A right elliptical cone of known base and altitude.

Required: To determine a plane whose intersection with the cone is a circle of specified diameter.

Contributed by F. M. Porter, University of Illinois.

Let (v, v') be the vertex and (aba_1b_1, $a'b'a_1'b_1'$) be the right section of the conical surface.

To find the directions Δ_1 and Δ_2 of the circular sections consider the cutting planes passing by the major axis (aa_1, $a'a_1'$) of the ellipse. Those planes are perpendicular to the V plane, and we must examine only the directions of the V traces.

za, in the horizontal projection, is the true length of the distance from the circle of the circular section projected in fa'e to the point (z,z'). Then, we have to determine a'e and a'f so that

$$(a'e) \times (a'f) = (za)^2.$$

1)- Draw kl parallel to v'f. With the center a' and the radius a'k = za determine points k and l on this parallel. Circle ka'l, whose center is o, gives points e and h on v'h. ea'f and ga'h are the two solutions relating to Δ_1 and Δ_2.

Let "d" be the given diameter of the required circular section.

Draw in the vertical projection p'q' and $p_1'q_1'$, with length "d", respectively parallel to fe and hg.

p'q' and $p_1'q_1'$ are the vertical projections of the two solutions of the problem.

The horizontal projections are easily found as the two small ellipses of the figure, and the true size of one of the half-sections is shown revolved on the V plane in p'sq'.

Justification:-

1)- In circle ka'l, triangles a'ek and a'mh are similar because angle a'ek = angle a'mh, and angle eka' = angle mha'. (In true a'k and a'm are isogonals to the sides of angle ea'h)
We have

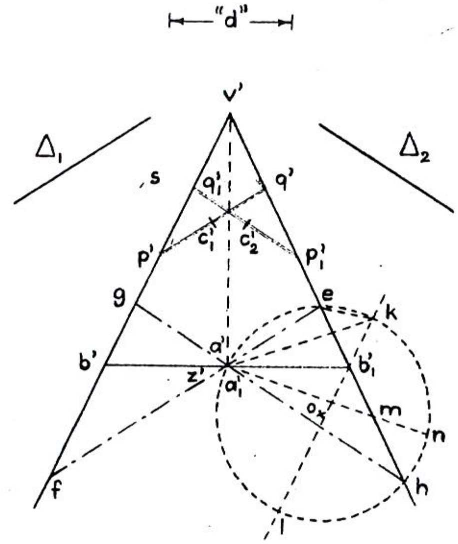
$$\frac{a'e}{a'm} = \frac{a'k}{a'h} \quad \text{or} \quad \frac{a'e}{za} = \frac{za}{a'h'}$$

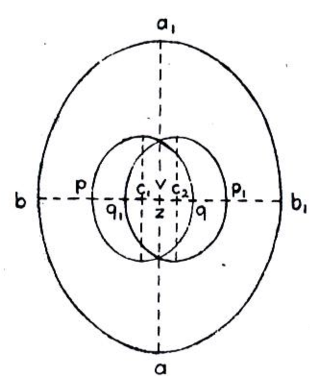
therefore

$$(a'e) \times (a'h) = (za)^2.$$

As a'e = a'g, and a'f = a'h, we have

$$(a'e) \times (a'f) = (za)^2$$
$$(a'g) \times (a'h) = (za)^2.$$





1st Angle Projection

Remarks:-

I) - Determination of circular sections direction's is treated by "F. G.-M., Exercices de Géométrie Descriptive, Vve. Ch. Poussielgue (Libraire), Paris".

II) - As observed by the referred author, two sections, one of the system Δ_1 and one of the system Δ_2, are antiparallel, and are sections of the same sphere.

III) - Δ_1 and Δ_2 are the two cyclic directions of the conical surface.

SOLUTION FOR PROFESSOR PORTER'S CONE PROBLEM

by

JACK LENHART
Assistant Professor of Drawing
University of Texas

GIVEN: A right elliptical cone of known altitude and base.

REQUIRED: To determine a plane whose intersection with the cone is a circle of specified diameter.

SOLUTION:

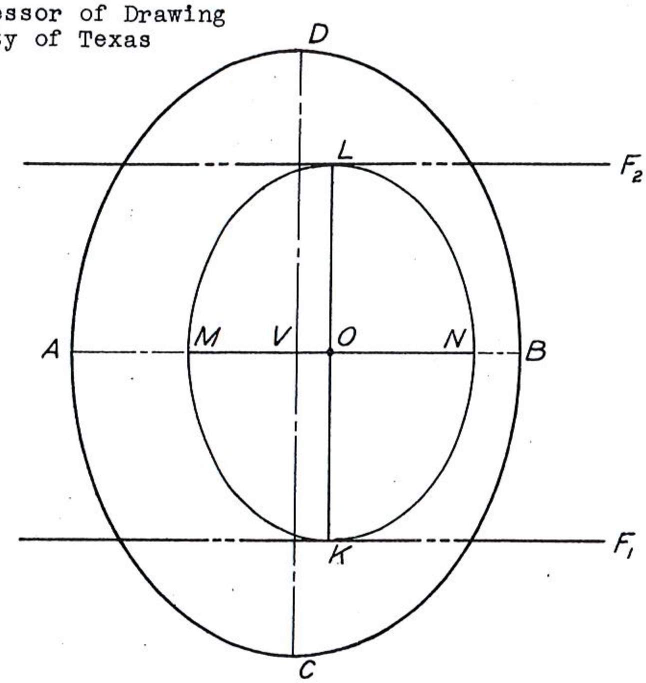
The diameter KL of the required circle will be parallel to CD and the diameter MN which is perpendicular to LK will be inclined to the base and will have its ends on the elements VA and VB of the cone. A locus line for the midpoint of each of these diameters can be found. The intersection of these loci will locate the center of the required circle.

First locus line:-
Plot the locus of the midpoint of the inclined diameter MN by placing it in various positions as shown by 1, 2, 3, and 4. This locus line, which is in the plane AVB, is the curve S-S.

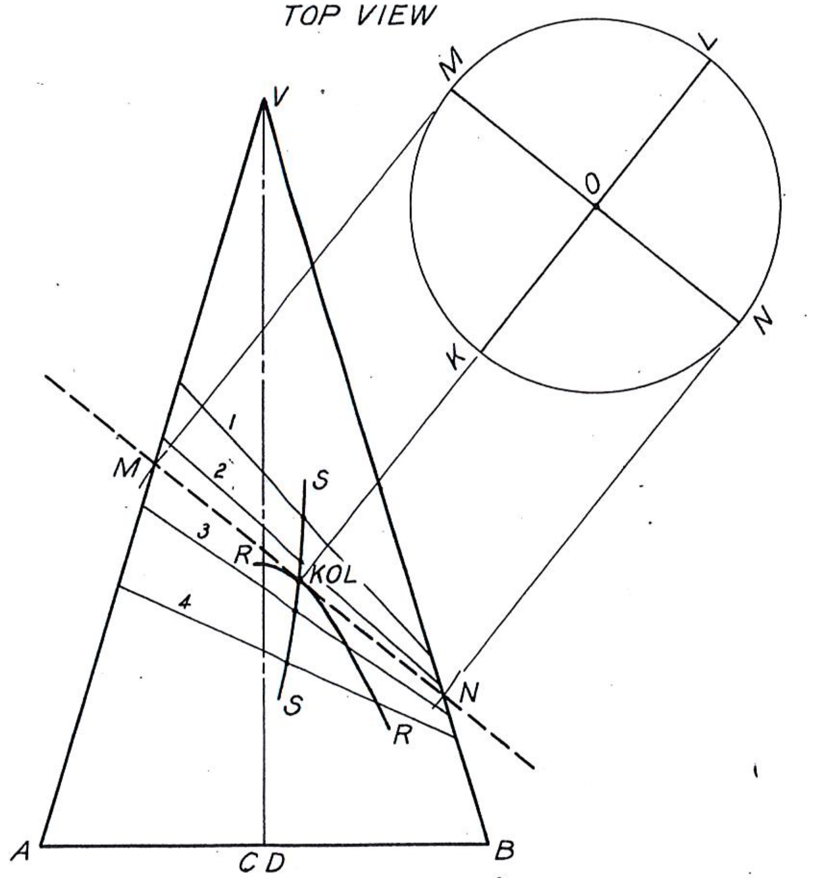
Second locus line:-
The diameter KL will have its ends K and L in the frontal planes F_1 and F_2 which is perpendicular to CD as shown in the top view. The points K and L will also be on the surface of the cone. Draw in the front view the hyperbolic curve which represents the intersection of these planes and the cone. The locus line for the midpoint of KL is identical with this curve and has the same front view, R-R, although it is in the plane AVB.

The point O where the locus lines S-S and R-R intersect is the center of the required circle. Its slope is found by striking arcs of the proper radius to intersect elements VA and VB at points M and N.

Of course there is a second solution giving a circle symmetrically placed on the other side of the cone.



TOP VIEW



FRONT VIEW

NOTES ON THE SUMMER DRAWING SCHOOL

by

T. C. Brown

Twas June 18th when we here assembled
And Hoelscher like a Dean resembled

And called us to order as a summer drawing school
To learn more of drawings as an engineering tool

Dean Langsdrof led off with a welcome address
Rising responded with his usual finesse

Wednesday provided interesting factors
With Engineer Burk from Caterpillar Tractors

The discussion was given by an interesting cuss
A gentleman from Iowa by the name of Russ

G. E. was represented by a man named Linn
Who told us the predicament industry is in

Wagner Electric sent a very able engineer
Named Waters who described the electrical career

Salveter and Greenfelder, two construction men,
Told of conditions with which they must conten'

Said one great weakness with which they reckon
Is graduates who cannot do freehand sketchin'

Rogan of Beech Aircraft spoke to SPEE
Recommended we give more Advanced D. G.

Hoelscher announced a dinner at Candlelight Inn
Where a delightful affair was about to begin

'Twas evident, from the menu, meat was stricken
And in its place, a wee bit of chicken

Dean Hammond related conditions at Penn State
How he had farmed out freshmen of late

And production engineering needed mention
The Louis-Conn fight then gained attention

Thursday some went to the Hotel Jefferson
To sit in on the lengthy general session

Others went on a trip of inspection
To see helicopters and jet propulsion

In the afternoon, a man by the name of Wetzel
Turned the audience almost into a pretzel

On drawing and descriptive he gave his view
Bockhurst and Porter did really stew

That night at the dinner, Potter did speak
And John Ruhle read a paper, far from weak

Officers were elected for the drawing division
Men of forethought and long-range vision

Believe me, next day the boys got their fill
Visiting the Krey Packers where they kill

Cattle and sheep and hogs and by-product
Since then they've been eating most poultry and duck

In the afternoon, a trip to a large concern
Knapp Monarch is the title of the firm

Where they make electrical stoves and roasters
Fans and mixers and heaters and toasters

Prof. Washburn says the company of Knapp
Should furnish all visitors with a road map

Henry Spencer seemed all in a whirl
When he passed a certain redheaded girl

Christman said, she may be on an assembly line
But she can hang her hat under his roof any time

Thompson said he really could not boast
But he would like to go out with the girl testing toast

Tomorrow we hear from Prof. Frank Warner
Cambre to Turner says "Well, I'll Swanner"

Our men are from all over the nation
They seem to be of odd creation

Dixon of L S U is very quiet
Francis Porter is always watching his diet

Jim Robertson got lost in a local zoo
Found Jenkins in a cage there too

The moustache of Bragg is something to behold!
'Twould make A Boo Ben Adam sit up more BOLD!!

Geradi of Detroit says quizzes need a rest
Worsencroft suggested he try the Mann Test

Prof. Claire Mann is not a pest
He's just an authority on a drawing test

Someone said Clement is an awful pill
But they don't know his name is "Wild Bill"

Graney spoke on the word seductivity
In connection with examination productivity

Schuck tried to make a contribution
To grades and grade distribution

While Hoelscher asked for discussion-not a peep
Four Georgia Tech men were sound asleep

Stone of Case leaned forward with a lurch
When Levens stirrred us with some real research

Fenwick of Louisville does not fear
When his boys bring in a keg of Beer

Joe Doak as a teacher must go some to beat
The gentleman from Texas named W. E. Street

While another Texan named Rans Dell
Showed slides and movies, and did so well

Willey of Oregon visited some lodges
While Moore rambled with shots and hodgepodges

A grand discussion by Engineer Hesse
Outlined the program for the shop processes

The story isn't complete lest we mention
Engineer Kuck who talked on dimension

Henry read a paper showing he really did know
Twas complimented by the Texan, Prof. Rowe

For an appetite we nominate Prof. Lee
For dignity we nominate Allen's goatee

For freehand sketches we commend McGuire
For cool looking clothes, Jud Rising's attire

For lettering we commend F. W. Slantz
And Thomas for the ideal drawing plants

An excellent paper was presented by Aahkus
But the snoring House sure did knock us

Adams paper was very good
Twas over my head, says Prof. Wood

Brown of Georgia has a big bay
Prof. Brittan has little to say

Wheels have a rim and certainly a hub
We have odd ones, including Prof. Bulb

Bookkeepers use files and big ledgers
We have Heacock and a fellow named Eggers

Skanzer of Michigan is always pulling
For a Minnesota teacher named Bulling

Someone replied Harris was on a mission
But he was located by Colonel Sisson

This task was thrust on me, but I know it
I can hear you say, He's no poet

With all this junk, you must be in pain
But let's have a summer school--again.

PROCEEDINGS OF ENGINEERING DRAWING SUMMER SCHOOL

Washington University
St. Louis, Missouri
June 1946

By

Professor H. M. McCully
Carnegie Institute of Technology
Editor of Summer School Proceedings

My dear Mr. Editor:*

In reply to your inquiry concerning the present status of the Proceedings of the Engineering Drawing Summer School held in St. Louis, the good word is that the material is in the hands of the publishers. I sincerely hope that the resulting volume will be fully worthy of the untiring efforts of Director Langsdorf, Chairman Rising of the Drawing Division, Chairman Hoelscher of the faculty of the Summer School, and our worthy secretary, Professor Bockhorst.

Members of the Engineering Drawing Division should immediately make reservations with the publishers, the McGraw-Hill Book Company, 330 West 42nd Street, New York, to reserve one or more copies of these Proceedings. It will be found to be a most comprehensive survey of the present status and future outlook of the drawing field. When the teaching group has the privilege of quietly reading over this material again and particularly those who were so unfortunate as to have missed this outstanding experience, they will be greatly pleased by the conscientious preparation which the various authors have put into the presentation of the various phases assigned to them. This will be, of course, the first instance of the Proceedings of any of the many summer engineering schools promoted by the Society appearing as a bound volume. Each paper was presented by an outstanding specialist in each particular phase of our work, and it would have been presumptuous on my part to have pretended to do any great amount of editorial work on these papers after the careful preparation which had been given them. There, of course, has been considerable labor in properly co-ordinating them into a coherent reading text.

Many of these papers are profusely illustrated with very carefully prepared drawings. The intelligent use of illustration which has been accomplished is an outstanding demonstration of the value and validity of the subject we teach to our engineering students.

A number of these papers literally are gems of reading. All of us who were privileged to hear Cecil Spencer read his paper on "So You Are Going To Be A Teacher" will relish again the privilege of re-reading this splendid paper. Fred Higbee's paper should be in the library of every college and secondary school in which any form of engineering drawing is taught. The group of papers dealing with course content will be found invaluable by those younger, newer teachers who are just entering our teaching group. The older group who are looking forward to a broader and promising future development and expansion of our field will find the papers of Herman C. Hesse, Douglas P. Adams, A. S. Levens, and of our new chairman, John T. Rule a source of inspiration to that continued effort for which the Drawing Division has been justly famous in the past. Space limits only prevent a complete listing of the many papers.

Just a word about circulation. It is highly desirable that we get as wide a circulation of this volume as possible. Of course a considerable number of those present at the Summer School enrolled themselves for from one to five volumes. However, I am hopeful that you will be able to promote the sale of this particular volume and that those of our teaching group will make every effort to attempt to spread its sale in the secondary schools and other institutions. There will be a limited printing, and there will be only one printing as far as I know.

I feel that the tremendous effort which has been put into the Summer School by the organizing group, consisting of the officers previously mentioned and the executive committee of the Division, merit all possible co-operation and help on our part. Let us look forward to a wide distribution of the Proceedings of the Summer School for engineering drawing and descriptive geometry, held at St. Louis in June.

* I am publishing, with minor deletions, Professor McCully's letter to me on the Proceedings of the Engineering Drawing Summer School. I add my personal endorsement for the widest possible circulation of these proceedings.

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