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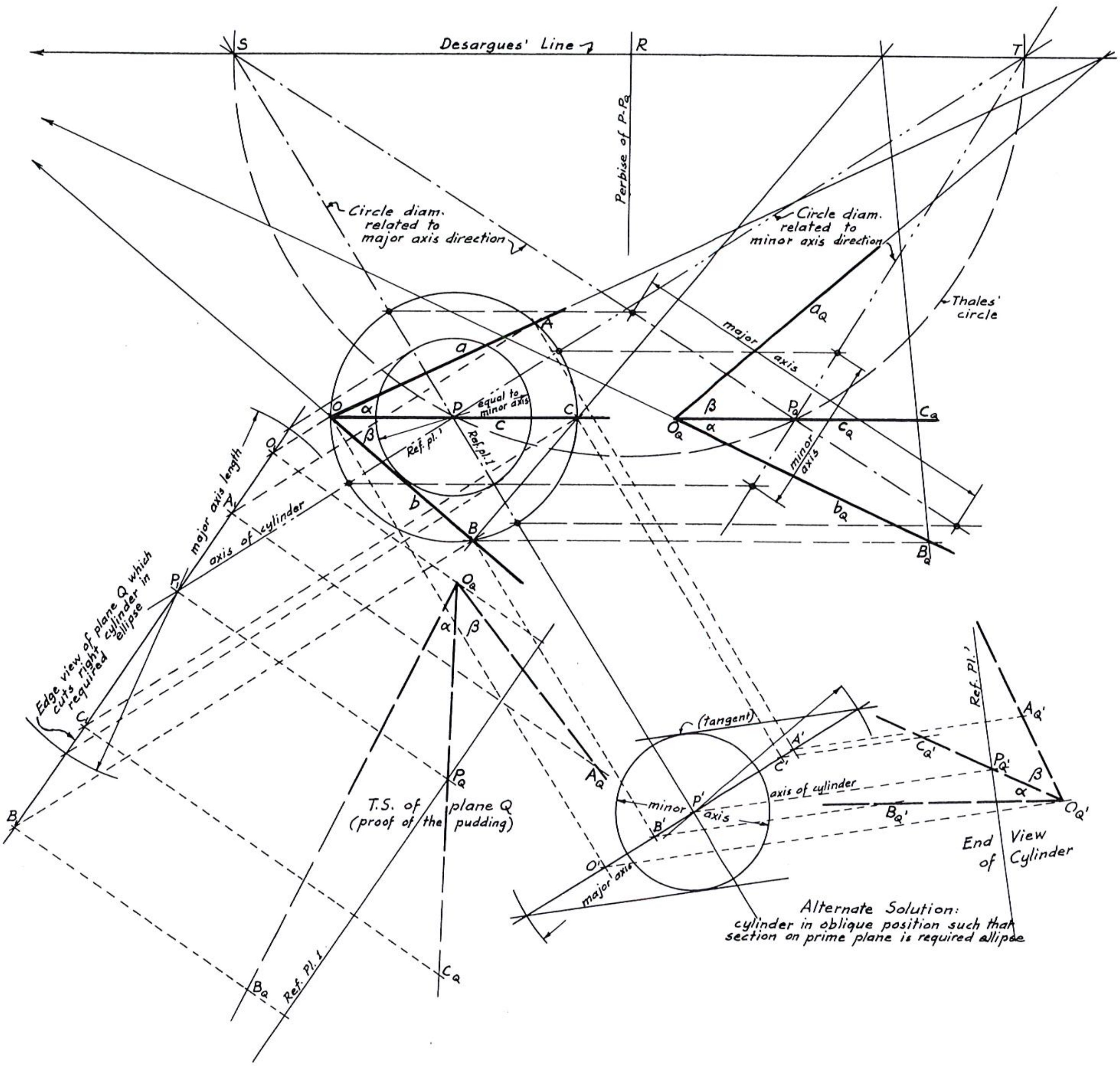

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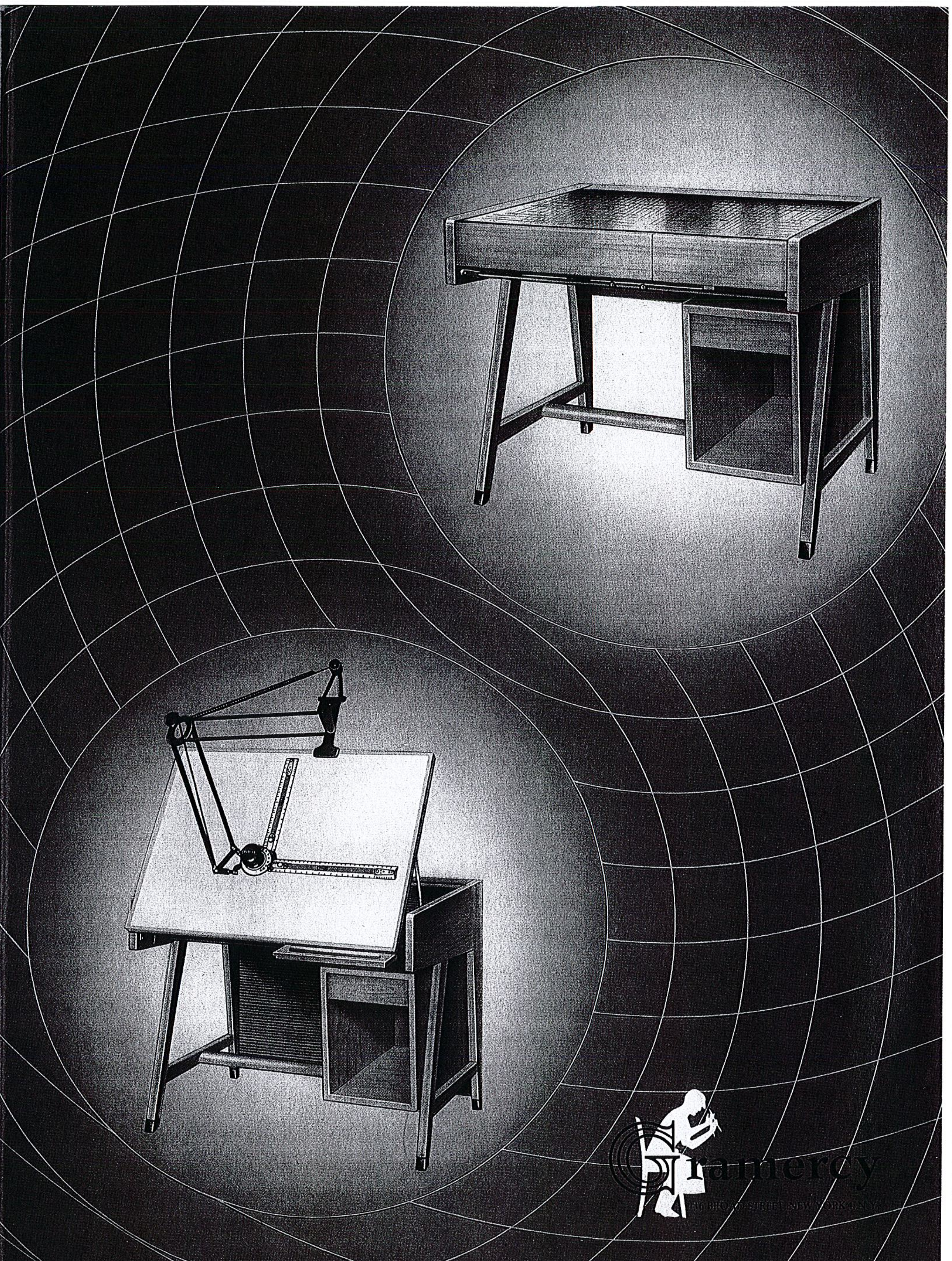
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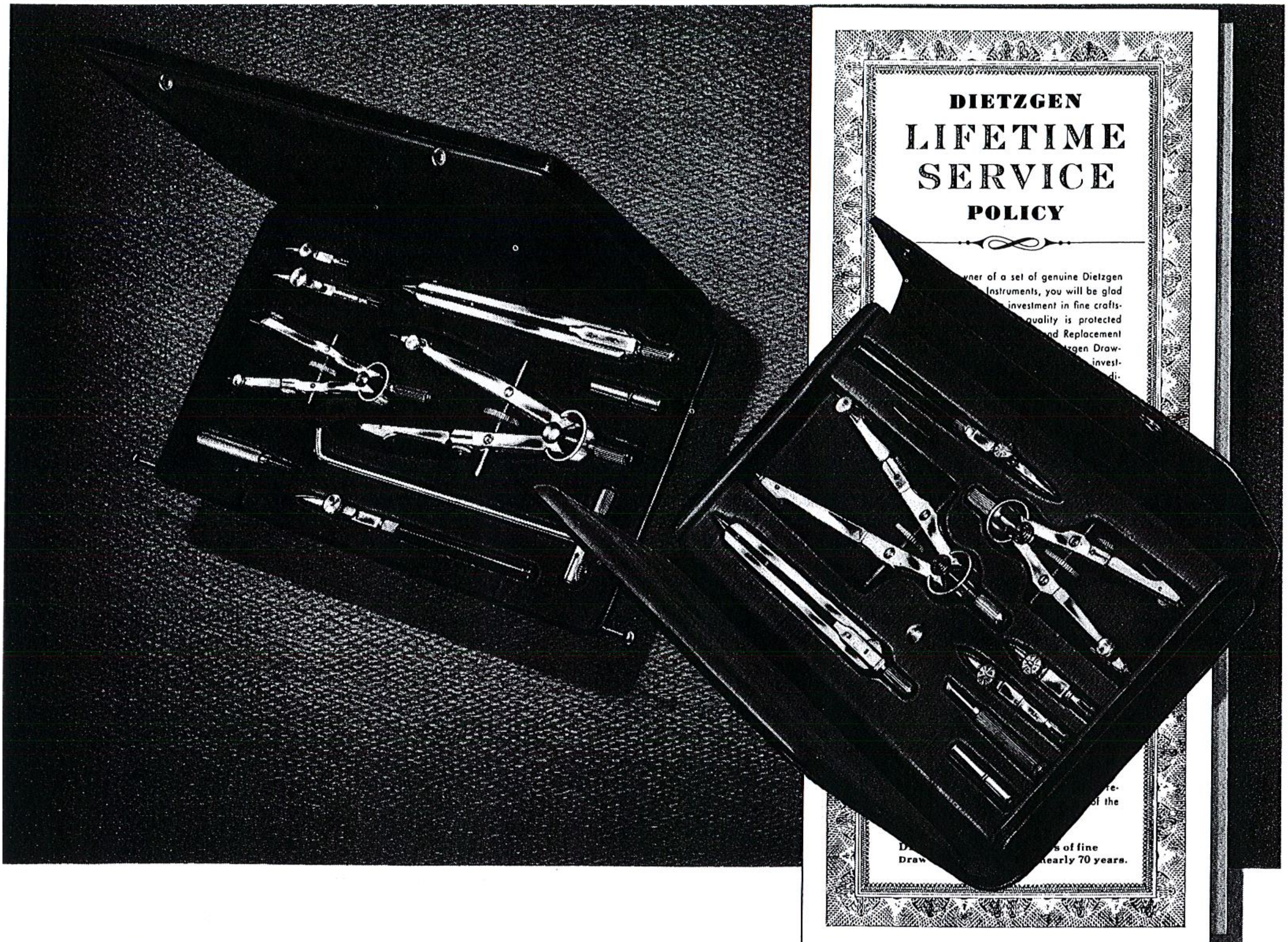

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by

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This integrated text has been completely rewritten and incorporates many improvements suggested by students and others who used the previous edition. This book is now ready in its new second edition. The basic principles of communication drawings are presented in a logical and integrated manner so that the student can readily grasp the fundamentals. Each unit of study includes practice problems designed to illustrate the principles discussed.

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The topics are presented in a sequence that promotes easy progress in the study of the graphical language. The text emphasizes subject material and methods of solution which provide a good foundation in graphical reading and writing, and in the logical analysis and visualization required for orderly solution of engineering problems. It is intended that the written material be as brief as possible, consistent with clear explanations. Designed for beginners, the text follows a self-teaching approach which guides the student through the basic principles of graphical communication.

Sketching, both orthographic and pictorial, is introduced early. It is felt that freehand work should be stressed continuously wherever rapid and reasonable results can be obtained or where methods for problem solution can be demonstrated.

Innovations in this integrated course include the initial introduction of orthographic or multiview projection by the study of a Point and its spatial location. Experience shows that the student can more readily visualize the principles of projection of a point in space rather than the projections of a solid object with the complications offered by invisible edges and surfaces. The next logical step joins two points to form a Line, with succeeding steps to the Plane and finally the Solid. Problems of interest concerning points, lines, planes, and solids are introduced in the order of their complication.

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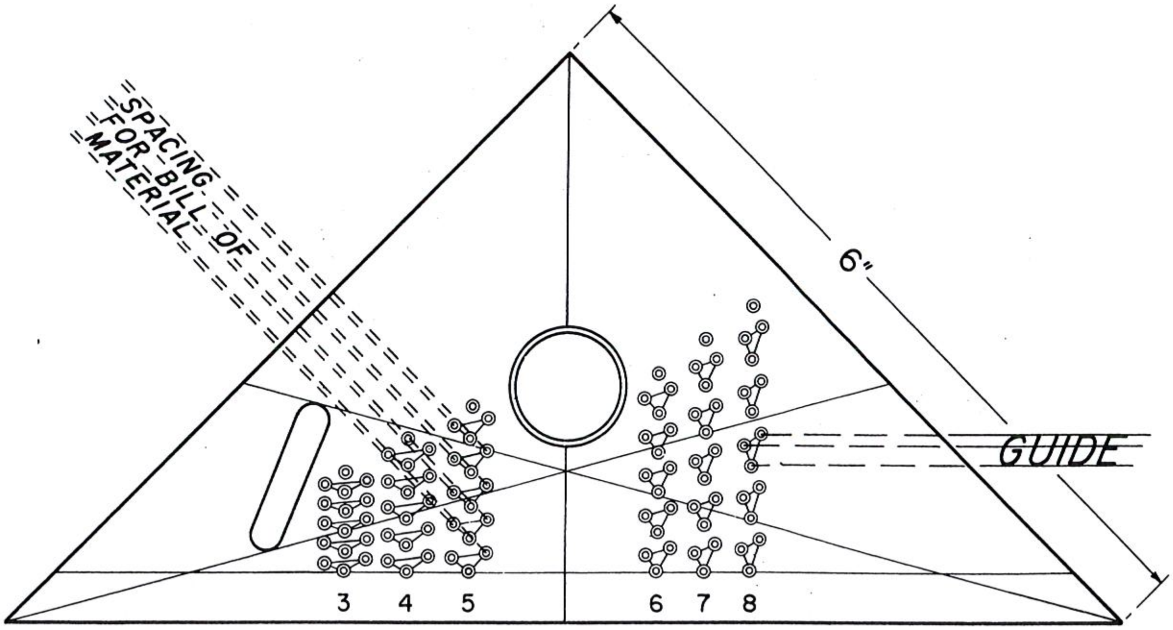

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T- SQUARES

You, like many other teachers, may have experienced within the last few years difficulties with T-squares. Of course, loosening of the joint between the wooden head and the arm has been a problem of such long standing as to have become almost "a necessary evil," and provision of various supplemental screw or bolt fastenings seeking to reinforce the joint has been going on for years.

However, excessive nicking of the guiding edges, breakage of the plastic corners at the end of the arm, usually followed by separation of the plastic edges from the wooden arm, thus making the T-square virtually unusable, have appeared to many as a very annoying but inexplicable failure of a proven construction.

There is a simple explanation for these difficulties. The familiar T-square construction including a wooden head and a wooden arm with transparent plastic lined edges was developed by trial and error over a period of many years with the use of "celluloid," i.e. cellulose nitrate, an exceedingly tough and virtually shatter-proof plastic material. With "celluloid," that construction served very well. However, the susceptibility of cellulose nitrate to attack by apparently contagious fungus disease which causes its unsightly discoloration and disintegration, reached alarming proportions in recent years. This and other important reasons accelerated acceptance of new plastic materials for drafting instrument applications.

Properly used, the new materials provide opportunities for important advances in this field. However, it should be fully appreciated that properties of the new materials are not the same as those of celluloid. Particularly, their increased hardness and brittleness has to be kept constantly in mind in designing. Unfortunately, in the case of T-squares the new materials were, in many instances, merely substituted for the old celluloid into virtually the same dimensional and constructional specifications not fully suited for the new materials. Similar "substitution of materials" has resulted in serious failures in many other fields of engineering design, and it proved to be very embarrassing in this instance as well, bringing about the difficulties which you have probably observed.

Working with the new materials, our engineers developed an improved T-square, basing its design on the purpose or function of the instrument and properties of the materials best suited for its construction. We avoided the temptation of following accustomed design by inertia. We also thought that an improved design need not necessarily look like the old wooden T-square.

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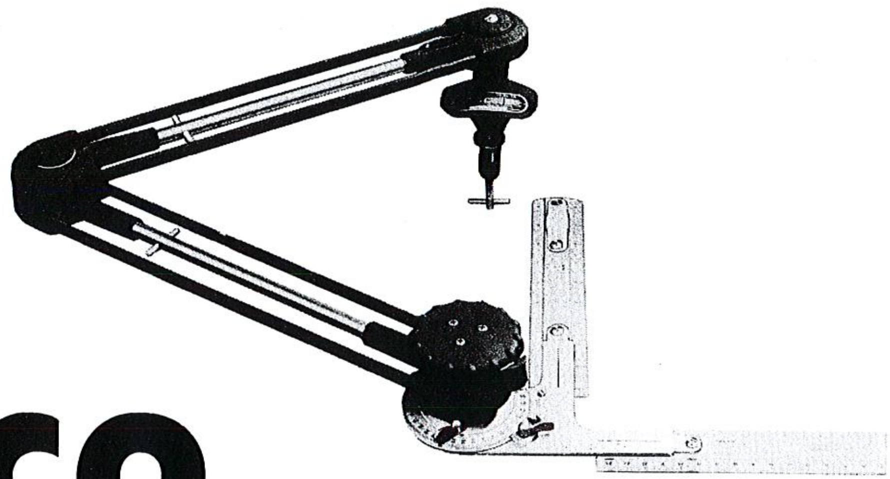

CONTENTS

EDITORIAL PAGE

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AXONOMETRY

Axonometry is an old science. In this issue is a translation of an article on the subject by Professor L. Eckhart of Vienna, originally published in VDI Zeitschrift, 1938.

Briefly, Professor Eckhart states: Place two orthographic views in any position and project in any direction from those views; the resultant intersections of projection form a valid, axonometric view. Except by extraordinary accident, this axonometric view will be non-orthogonal (as we say, oblique). Further, the axonometric may be grossly distorted in appearance. Eckhart shows examples of non-orthogonal axonometric projections which have acceptable three-dimensional appearance.

Some years ago, the origination of orthogonal axonometry was mistakenly attributed to Eckhart. Such an interpretation might be gathered from a study of the illustrations only, without an exact translation of the text of his article. Eckhart's non-orthogonal deviation is but a minor element in the whole science. He refers to the work of Professor Theodor Schmid in axonometry, and other references show previous study of the subject. The presentation by Schmid of orthogonal axonometry in Darstellende Geometrie, Volume I is thorough and well illustrated. Professor Halasz also referred to Schmid in his article on a new perspective method, May, 1956, Journal of Engineering Drawing.

Professor Krzywoblocki, who translated the article, is in the Aeronautical Engineering Department at the University of Illinois. He was born and educated in Poland. The German Department was called for clarification of a few words. At the moment of the call, Professor H. H. Korst of the Mechanical Engineering Department was there. He was quite helpful--twenty-five years ago he was a student of Professor Eckhart!

Korst asserted that axonometry was quite old, that he had studied the subject in technical high school and in college. His pre-college education consisted of five years of grammar school and eight years of technical high school. In each of the eight years, he studied mathematics, science, languages, and descriptive geometry as major courses. Eight years of descriptive geometry! There was more rigorous exposure to the subject in college. He went on to solve six major design problems, including full working drawings suitable for production, and axonometric views of the designs with shades and shadows.

Professor Korst believes that this was too much drawing. Is too much drawing better than too little or almost none? In Korst's opinion, descriptive geometry has such a high place in German engineering education because it provides competence in geometric statement, analysis and solution of engineering problems, and more importantly develops reasoning ability in a rigorous and logical system.

These values of descriptive geometry have been subdued in contemporary U.S. engineering since most of our engineering students receive a limited exposure to the subject. We suspect that these values have not been lost in the German and Russian engineer. Exact information on the current role of descriptive geometry and drawing in European engineering education would be welcome.

Axonometry, as part of descriptive geometry, was only recently introduced in our drawing texts. Though an old topic in Europe, axonometry was relatively unknown to our learned men in graphics. Today, how many teachers of drawing know axonometry? How many engineering students solve an elementary problem in axonometric projection? How long is the list of topics in drawing and descriptive geometry which are given superficial study?

Professor Krzywoblocki comments on our engineers' weakness in graphics: "We say we will beat the Russians. What with, sticks?"

APPRECIATION

The retired Circulation Manager and Treasurer of the Journal of Engineering Graphics would like to thank The Cooper Union for providing secretarial assistance and encouragement without which the job would have been far more difficult. He would also like to thank Professors Mary Blade and Joseph Pizzirusso for their assistance in mailing the Journal. It was their willingness to pitch in and help that put the Journal into the mail on time. Special thanks is due Professor Kenneth E. Lofgren for his help in checking the circulation list, finding mistakes in the Treasurer's books, and in mailing.

It has been a pleasure to serve the Engineering Graphics Division as Circulation Manager and Treasurer for seven years. It has been work, but it has had many rewards. Not the least of these rewards have been the many friends that I have made at the Division meetings and by correspondence from all parts of the country.

I am sure that our new Circulation Manager and Treasurer will receive the same wholehearted support of the Division that I have had. Good luck to him and may the Journal of Engineering Graphics continue to grow in prestige and in number of subscribers.

Edward M. Griswold

* * * *

To Correspondents (From THE ENGINEER, London, December 9, 1859)

Anti-Decimal--Your views may be well-founded, but you will have to put them in a very different shape, and allude more respectfully to men of whom it is probable that even you may learn something, before your communications can appear in the columns of THE ENGINEER.*

Society of Engineering Draughtsmen--Mr. Joseph Willock, of 89 Chancery Lane, sends us a lengthy communication upon the desirability of organizing a Society of Engineering Draughtsmen. We cannot find space for more than the following portion of the letter:--" I sincerely trust that this will be the means of calling serious attention to the formation of a Society, and would advise its immediate commencement, let the support be ever so small. To prove my willingness to do all in my power, I will subscribe a guinea towards preliminary expenses for advertising, if three or four will do the same, which I should forward to your office and care, if your kindness might be so far trespassed upon. Should a few guineas be subscribed, I propose that a meeting be called, and the society formed at once. All details could be afterwards arranged." Whilst we have no doubt such a society might be successfully organized, we must decline acting as trustee of its funds. Let a meeting be called and a committee be appointed to receive and apply subscriptions.*

From Letters to the Editor (From THE ENGINEER, London, December 16, 1859)

(We do not hold ourselves responsible for the opinions of our Correspondents)

Sir:

The engineering draughtsmen of the metropolis have been, for some time past, discussing at intervals the propriety of establishing among themselves a society of a scientific and philanthropical character; but there appears, somehow, to be a want of cohesion in the body, which militates against so desirable a consummation. Last week a correspondent of yours came manfully forward with the offer of a guinea towards the preliminary expenses of organising such an institution, and it remains to be seen whether his brethren of the pencil and ink will nobly follow his example. If they should, there will be a prospect of success opened up, which may lead on to a realisation of it. If however, on the contrary, there should appear an apathetic indifference to the good cause, why then your worthy correspondent will take nothing but disappointment by his motion, "and there an end."

I am decidedly of opinion that there exist in London all the elements for the construction of a society of mechanical draughtsmen, and that it requires but determination to unite these elements. That determination, however, appears to be totally wanting. Of agitation there has been much--of newspaper correspondence much more--but as yet there are not tangible results--with the exception of Mr. Willock's guinea--from either agitation or correspondence.

What, then, are draughtsmen to do? I say--since they cannot apparently form a society of their own--let them join other societies of a nature similar to that they wish to create. There are at least three such societies at present in existence in London, and either of these would open its portals to receive them. Firstly, there is the Society of Engineers, next the Association of Foremen Engineers, and thirdly the Civil and Mechnical Engineers' Society.

Mechanical draughtsmen would, I feel convinced, be welcomed as members by all of these scientific bodies, whilst there exists also a congeniality of sentiment, arising from similarity of pursuit, which would make both engineers and draughtsmen feel "quite at home" in each others company. Possibly you will afford space, Sir, for this suggestion, which is thrown out con amore, and which I trust may have some weight with those to whom it is offered.

Tower-hill, December 13th, 1859 J. N.

---

* The above comments were printed in THE ENGINEER in answer to letters to the editor.

The Mechanical Draughtsmen (From THE ENGINEER, London, December 30, 1859)

Of mere copyists there are hundreds too many. Although mechanical drawing may be an art by itself, and although an excellent draughtsman may be always sure of employment, the demand for mere drawing is limited, and really excellent draughtsmen have always been scarce. The gentlemanly nature of the employment is attractive, no doubt, and it is to this circumstance that we must attribute the brisk trade of the drawing-instrument and water-colour dealers. Perseverance will do much, but if mere adventurers in drawing, who would be draughtsmen because they would like an easy, irresponsible employment, were to examine a portfolio of really first-class drawings--such as those of the Great Eastern* in Mr. Scott Russell's office--they might conclude they were missing their vocation, and determine upon looking up something else in which the probabilities of success would be more in their favour. A young man with only sufficient capacity to become a third-rate draughtsman should have very moderate wishes, for he can never command either the respect or salary which would satisfy a gentleman. But if there is more in him than a faculty for mere ink marking and colour daubing, let him develope himself by all means. Above all, let him devote himself to the design of mechanism in its simplest forms. The rough machinery and appliances of railway drainage and building contractors often requires more real skill and accurate knowledge of mechanical forces and proportion than would serve in designing machinery in which a surplus of material may cover up serious blunders. A PASSABLE KNOWLEDGE OF DYNAMICS, A HABIT OF ESTIMATING STRAINS, WEIGHTS, AND QUANTITIES, A LITTLE TACT IN ASCERTAINING THE PRICES OF WORK, TOGETHER WITH MODERATE POWERS OF OBSERVATION AND A FAIR JUDGMENT, WOULD ENABLE MANY A PLODDING DRAUGHTSMAN TO BECOME A SUCCESSFUL ENGINEER.

(The caps are mine. W.L.S.)

---

*Note: The Great Eastern was a steamship of the day which was still undergoing trials. She made 13 knots, and would require 40 days to travel to Australia from England. This ship laid the first transatlantic cable in 1866.

A LETTER FROM O. W. POTTER

University of Minnesota

Dear Colleagues:

My association with you in the Engineering Graphics Division of ASEE has been a highlight of my life. The mid-year and annual meetings were an opportunity to meet and discuss our mutual problems. I have derived pleasure and inspiration from them and will miss them in the future.

It has been a privilege to know such pioneers in the field of Graphics as French of Ohio, Giesecke of Texas A and M, McCulley of Carnegie Tech, Mann of Missouri, Jordan, Hoelscher and Porter of Illinois, Rising of Purdue, Svensen of Texas Tech, Rowe of Texas, Worsencroft of Wisconsin, Heacock of Princeton, Rule of MIT, and Kirchner of Minnesota.

My teaching experience of nearly fifty years included thirty-nine in Engineering Graphics. In 1953-54, I took a sabbatical to study "The Importance of Graphics in Engineering Training." Through the years it has been my privilege to visit many of the Engineering Schools throughout the country. I wish to share the impressions of these years with you.

Drafting Rooms

Drafting Rooms were often located in an older building, on the top floor or in an unfinished attic. Skylights provided extra natural light. Many drafting rooms were located in temporary buildings held over from World War I and World War II. In some of the larger schools, drafting rooms were scattered all through the building from basement to attic, or all over the campus in various buildings. Rooms were of different sizes, with few designed to be drafting rooms. At some schools, more than one class was being conducted in the same room at the same time.

The new building in our colleges has not been enough to meet increased enrollments. Graphics departments have profited from the remodeling of older buildings. In a few instances, drafting rooms, office, and lecture room are grouped together on the same floor--an ideal arrangement.

The worst condition is in lighting. Combination of natural and artificial light is generally poor. Low level of illumination and severe shadows make working conditions very difficult. Only in recent years has serious attention been given to lighting in college rooms. A modern drafting room in industry provides 100 foot-candles and no shadows. College drafting rooms seldom meet this standard. Consider the damage to the eyes of our students which has occurred over the years because of poor lighting. Now is the time to check with a light meter the lighting conditions in your instruction rooms.

Drafting Room Equipment

There are as many kinds of drafting tables as there are schools. Ideally, drawing teachers would get together and design a standard drafting table for mass production at low cost. Most drafting tables are old enough to be replaced. One school provides no stools, and the students stand to draw upon tables at an uncomfortable height. Draftsmen in industry would strike if presented with such working conditions.

Drafting lockers are a problem, especially in the larger schools. Most lockers are built into the drafting tables; some are separate. Many lockers are too small for drawing boards and T-squares, so that such equipment must be carried back and forth. Some schools have finished the table surface so that separate drawing boards are not needed; this practice should be furthered. Other schools have no lockers, and the students must carry all equipment between residence and classroom.

Office Facilities

Office accommodations are a hit-and-miss proposition, good and bad. Some teachers have only a desk in one of the drafting rooms; others are crowded together in the same room with no privacy for consultation or study. Poor ventilation and light, inadequate filing space and work space are common faults. Good teachers cannot be attracted or retained under such working conditions.

Teaching Aids

With the time allotment for Graphics cut drastically, the use of teaching aids is more important than ever. Charts, diagrams and models are effective in classroom use, and should be displayed in permanent cabinets. Facilities for making models, charts, slides, etc., are desirable. The department should have its own duplicating machinery for blueprinting, ozalid and other processes.

Teachers

Drawing teachers work hard and conscientiously to give students a good training in graphics in spite of poor facilities and equipment, and constant pressure to do the job with less and less time. The teacher is frequently overloaded, carrying as many as 30 class hours per week. In addition, he is expected to do considerable administrative work in counselling and registration of students, and in committees. Little time is left for advanced study, research or writing as is accorded members of other departments.

Graphics teachers have constantly tried to improve their teaching. They were the first to organize a separate division of ASEE; they were among the first to conduct summer schools for teachers, and have held five such sessions since 1930. They were also the first to set up their own publication, the Journal of Engineering Graphics (formerly, the Journal of Engineering Drawing). This has been the only publication devoted exclusively to Graphics.

Down through the years, the graphics teachers have been one of the mainstays of the ASEE. They have contributed to making that society into a strong national organization for improved engineering curricula, research and teaching, and for ECPD accreditation of engineering curricula in institutions all over America. I am proud to have been associated with such a group.

If Engineering Graphics is to be a part of the undergraduate curriculum, it should be allotted sufficient time to do a decent job of training, and it is entitled to adequate space and facilities.

Is Engineering Graphics really important in the training of the engineer and scientist? Graphics is not only important; it is indispensable. Without graphics, industry would collapse, and civilization would revert to the stone age. Graphics has made present day industrialization possible. This method of communication is essential to carry out all complicated procedures. There is an old saying, "An engineer without adequate training in graphics is professionally illiterate." The best and logical place to obtain this training is in the engineering college. Industry and the practicing engineer are aware of this fact, but college administrators have not recognized the importance of graphics. I have talked to many deans throughout the country who were lukewarm or even antagonistic towards graphics.

In 1955, I reported on a national survey in the Journal of Engineering Education and the Journal of Engineering Drawing, in articles entitled "How Important is Graphics to the Practicing Engineer?" and "Graphics in Engineering Practice". In these reports, the replies of 711 practicing engineers in more than 200 different industries were summarized. The report covered all kinds of industry, large and small, in many fields of engineering. The consensus of opinions from both executives and engineers was unaminous, graphics is very important. They also expressed concern and opposition to the present trend in the schools to deemphasize graphics.

This study and others have been casually ignored. I suspect that few college administrators have read these reports or respected the opinions of the practicing engineers so represented. More mathematics, science and humanities have been crowded into the curriculum at the expense of graphics and material processing courses.

Time for graphics instruction has been reduced. You must join with industry and practicing engineers in a flght to regain time to do an adequate job. School administrators must be convinced that improved facilities and equipment are more important than ever. Teachers of graphics should have adequate salaries and advancement opportunities, as do other undergraduate teachers. The use of graduate assistants for teaching can be overdone.

For those of us who have retired, activity on behalf of Graphics must diminish. I wish you all the best of everything for the future, and as one news commentator says, "Take care of yourselves, you are most important".

LULU SOLUTION TO LULU PROBLEM

By Andre Halsz

The City College of New York

1. The problem may be stated this way: The space projectors of the given orthographic view constitute a prism. We are looking for the angular position of a cutting plane such that its section will be the given normal view. We note immediately that the two figures are completely equivalent and interchangeable; it makes no difference which is regarded as which.
2. Now this looks like a formidable problem indeed. So let's try to set it up in a general form. It is always more fruitful to attack the general problem than to fret over the particular form in which it happens to appear. After all, this is what we are trying to get across to our students, isn't it?
3. Any two orthographic views of a plane figure, whether one of them is true shape or not, are projective transforms of one another; there is a one-to-one correspondence between them. A circle appearing in one of them, for instance, will have in the other a corresponding conic; one specific conic, corresponding to this circle.
4. Superimposing a circle on the given figure in plane Q above, the problem is reduced to the easy one of finding the cutting plane of a right circular cylinder, such that its section will be an ellipse of given shape. Since there is an infinity of such cutting planes (revolving around the cylinder), it is essential to find the specific pair of circle diameters which projectively correspond to the major-minor axes of the ellipse. The proper cutting plane will appear in edge view when sighted along the related minor axis--or, if you prefer the "Plane-of-projection" terminology: the cutting plane will project as a line upon a plane parallel to the major-axis-related diameter of the circle.

The actual construction may be carried out in many ways. For convenience I inverted the notation, as if the primary plane were the right-section plane of the cylinder, and plane Q the desired cutting plane. This was permissible because of the equivalence of the two figures, as pointed out in (1.) above.

STEP (1): Draw the two figures side by side. To simplify the construction, I made c and c_Q collinear. A desargues configuration is used, with the pole at infinity to the right and left; the Desargues line (axis of homology) will be parallel to c - c_Q, through the intersections of a with a_Q and b with b_Q. I chose a circle with center P on c and passing through 0; it cuts a, b, c, at points A, B, C, and the correspondence in the Q figure is readily found. I refrained from sketching in the ellipse as determined by A_Q, B_Q, C_Q, with P_Q as its center, because Dean Rule says "no faired curves".

STEP(2): Since the tangents at X and Y are parallel to the diameter c and will remain so in the transformation (being parallel to the Desargues line), it follows that C_Q - 0_Q and X_Q - Y_Q will be conjugate diameters. From a pair of conjugate diameters, the major and minor axes can be found by standard methods. I prefer the projective method (as given by me in "Ramsey and Sleeper: Architectural Graphic Standards, 5th Ed.) which consists of applying the good old Thales theorem to the projective configuration, as follows: Draw a circle with center R on the Desargues line, and passing through P and P_Q; this circle crosses Desargues' line in S and T; therefore SPT and SP_QT are right angles, which makes them the axes sought. We don't even need X and Y; I left them in just for illustration. To obtain the lengths of the ellipse axes, project over from the circle to the ellipse.

STEP (3): Draw the auxiliary view of the right circular cylinder, projected in the direction of the related minor axis, and fit the ellipse onto it. To do this, the ellipse must first be enlarged proportionally until its minor axis equals the cylinder diameter.

With the edge view of plane Q drawn, the problem is now solved.

We must of course satisfy our curiosity; project OABC, along cylinder elements, onto plane Q and find the true shape. This turns out as specified, and constitutes the proof of the pudding.

Alternatively, I might have drawn the right elliptical cylinder, based upon the ellipse of the Q figure, proportionally reduced until its major axis equalled the diameter of the circle. The auxiliary view would then be projected in the direction of the actual major axis, making the width of the cylinder appear equal to the (reduced) minor axis. The diameter of the circle fitted onto the auxiliary view of the cylinder will establish the edge view of the primary plane, and the relative position of the two planes will be exactly equal to that found on my drawing on Step 3.

SEE COVER FOR HALSZ' SOLUTION

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DISTINGUISHED SERVICE AWARD

To the Members of the Engineering Graphics Division:

The Special Awards Committee solicits your nomination for the Distinguished Service Award for 1960. The committee, composed of the three immediate past chairmen of the Division, determines the recipient of the award at the mid-winter meeting of the Division. Therefore, it will be necessary to mail your nomination not later than January 8, 1960.

To be eligible for the award, a candidate must have made clearly discernable contributions to teaching the art and science of graphics, contributed to the literature in his field; and rendered a distinct service to the Division. Kindly refer to page 27 of the May 1952 issue of the Journal of Engineering Drawing for a full statement of the requirements for the Distinguished Service Award. Also refer to a copy of the Constitution and By-laws of the Division as amended June, 1959.

The Distinguished Service Award has been given to the following:

- 1950 - Frederick G. Higbee
- 1951 - Frederick E. Giesecke
- 1952 - George J. Hood
- 1953 - Carl L. Svensen
- 1954 - Randolph P. Hoelscher
- 1955 - Justus Rising
- 1956 - Ralph S. Paffenbarger
- 1957 - Frank Heacock
- 1958 - H. Cecil Spencer
- 1959 - C. Elmer Rowe

Please send your nominations to the chairman of the committee singly or in groups. Your prompt cooperation will be greatly appreciated.

W. J. Luzadder
J. S. Rising
I. L. Hill, Chairman

DISTINGUISHED SERVICE AWARD
FOR 1959

CHARLES ELMER ROWE, the person to receive this award, is a graduate of the University of Colorado School of Mines. He has degrees in Civil Engineering and Mining Engineering and has been a college teacher and college administrator for fifty-four years.

A distinguished teacher, author, designer, professional engineer, and consultant in the field of engineering graphics, he first joined the faculty of The University of Texas as an instructor of Mining Engineering in 1905 and started teaching Drawing in 1911. By 1927 he had advanced to full Professor of Drawing and Chairman of the department and he was made Assistant Dean of Engineering and Professor of Drawing at the University of Texas in 1945. He has had broad experience as a designer and professional engineer. He pioneered in the development of a unique and outstanding collection of teaching aid models in Graphics.

The wide use of his books is evidence of their professional quality. He has written extensively in the graphics field and served the Graphics Division with distinction as Chairman of the 1938 National Drawing Competition Committee, member 1946 Drawing Summer School Faculty and as a member of the Executive Committee.

As a teacher, counselor, and professional engineer, he is held in high esteem by his students, colleagues and friends everywhere. He is admired for his competence, for his devotion and graciousness, and his allegiance to duty.

DIVISION OF ENGINEERING GRAPHICS
OF THE
AMERICAN SOCIETY
FOR
ENGINEERING EDUCATION

RESOLVED:

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

CHARLES ELMER ROWE

THROUGH THE YEARS 1935-1959

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

PRESENTED THIS SIXTEENTH DAY OF JUNE IN THE YEAR OF OUR LORD NINETEEN HUNDRED FIFTY-NINE.

Chairman of the Division

Irwin Wladaver
Secretary of the Division

RESPONSE TO THE AWARD CITATION

By Professor Charles E. Rowe

Mr. Chairman, Members of the Division of Engineering Graphics, Ladies and Gentlemen:

I never thought for one moment that I would ever be so highly honored. I am deeply grateful to Dr. Street for his generous remarks and to the Awards Committee for their kind consideration and decision. Of course, I am very happy, but I accept the Award with humility in the presence of so many of the top men of our profession.

For nearly half a century I have enjoyed the privilege of teaching graphics. When I began, no textbook in drawing was used at the University of Texas, and there were no quizzes or examinations. Our present day students would regard this as a little bit of Paradise. This condition was changed immediately, and Dean Taylor was surprised to learn that quizzes and examinations could be given in this subject. In the years that followed many excellent textbooks have been published on both drawing and descriptive geometry, the needs of Industry have been considered, American standards have been established, the requirements of the engineering profession have been studied and met, and the teaching of Graphics has been greatly improved through the efforts and influence of the Division of Engineering Graphics. We had reached the point where in six semester hours we were able to give the freshman student his first contacts with engineering by solving many interesting problems graphically, and we had time to teach him the graphical language in a satisfactory manner. We were working in the Golden Age of Graphics.

Then came the Grinter Report which seemed to imply that we were teaching a skill. This was an unfortunate interpretation because it gave to semester-hour-hungry degree-granting departments a hunting license to go out and bag a few precious hours from our field. In many cases the time allowed for graphics has been reduced to 3 or 4 semester hours, and in some cases to none. How can any man be called an engineer if he does not understand the universal language of graphics? At present, there seems to be a tendency to minimize the importance of graphics.

I believe that a major objective of the Division of Engineering Graphics should be to correct this attitude. Each and everyone of us should do everything possible to educate other faculty members in the importance of modern graphics.

INSTRUCTION IN GRAPHICS BY CLOSED-CIRCUIT TELEVISION

By

Oliver M. Stone and John R. Martin
Case Institute of Technology

Introduction

Educational television has made great strides during the past decade and now assumes an important role in adult education programs and in an ever-increasing number of educational institutions throughout the country. There are now thirty open-circuit educational broadcasting stations financed by foundations, educational institutions, corporations, and individuals that serve an audience of an estimated 20 to 30 million persons per week. The closed-circuit installations provide class instruction ranging from first grade through college postgraduate work and cover a wide diversity of subject matter. An estimated 8 million students now receive up to one hour of instruction daily by this means.

The July 1958 Joint Council on Education Television Report lists 119 educational institutions and 21 military installations where closed-circuit television is being used. The Hagerstown, Maryland system embraces twenty-three schools with a total of 12,000 pupils. All forty-eight schools in Washington County, comprising 18,000 pupils, are expected to be included in this system during the present school year. The report shows a wide use of the medium at all levels for the teaching of science subjects. Among the many institutions of higher education, teaching basic science subjects by this medium, ten are listed as also teaching engineering subjects. The list also includes eleven medical and fourteen dental schools.

There is at present a shortage of qualified teachers at all educational levels, particularily in the science subjects, which is likely to become more acute in the future. This has led to a number of sponsored research projects in certain educational institutions attempting to determine the relative effectiveness of this medium as compared with conventional teaching methods where an instructor has more intimate contact with a relatively small group of students in a classroom. The Case project was conducted under the direction of Professor J. R. Martin of the Electrical Engineering Department. These studies seem to indicate that where the alternative is a large lecture room situation, necessitating an instructor talking and demonstrating to a large number of students, then certain advantages obtain in the televised procedure. When the same number of students are divided into smaller groups among several classrooms having large screen receivers, a greater sense of identification of the student with the instructor seems to be obtained. There is less distraction and the instructor appears to be talking more directly to each individual student. Also, since the camera is capable of producing an overall or magnified close-up view, demonstrations of scientific phenomena and equipment can be seen more advantageously in a television screen.

Certain valid criticisms of closed-circuit television, as generally conducted, may also be made. If the instructor lectures from a studio with no audience present, he is unable to observe the reactions of interest, understanding, or puzzlement which are indications as to the effectiveness of his presentation. There is a lack of reciprocal identification of the instructor with the student and limited or no opportunity for the student to ask questions. This situation is alleviated in some installations by providing additional circuits, whereby a student may signal his intent to establish two-way audio contact with the instructor, using a hand microphone that is passed among the students. The limitations of this method are obvious and conditions simulating a classroom situation can only be obtained by providing a two-way audio-visual system.

The television equipment and the operating procedures at Case were designed and developed so as to overcome some of the objections and limitations of closed-circuit television as a teaching medium: (a) By enabling the instructor to operate as normally as possible under simulated conventional classroom situations; (b) By providing two-way audio-visual contact between the students in the remote rooms and the instructor. An effort has been made to develop presentation techniques and facilities for a more effective utilization of television in teaching, and to study the economic aspects as well as student and faculty reactions.

The Two-Way Audio-Visual Television System at Case

In the most generally used method of closed-circuit television, the image is transmitted to the remote receivers at video frequency and the sound is transmitted over additional audio circuits. In order to provide two-way visual communication between an instructor and a remote classroom, it is necessary to provide additional video lines to each classroom.

The new Wickenden Electrical Engineering

Building, completed in 1955, uses radio rather than video frequency distribution for transmitting the image. This provides a more flexible operation. The video output of the camera amplitude modulates a radio frequency carrier which also carries frequency modulated sound and is then transmitted over a coaxial cable distribution system. In this installation twenty-seven camera input positions are connected by a single coaxial line to a central radio frequency amplifier which consists of four amplifying strips. The output of the central amplifier is then transmitted over a second coaxial cable system to thirty-eight receiver positions. Four independent cameras are able to operate simultaneously over the system, together with sound originating at each camera position. Standard commercial receivers can be tuned to any of the four channels now available, with sound added through an audio-video mixer. A monitor receiver for each remote classroom is located directly in front of the instructor, together with a block diagram which gives the names and the prearranged seating position of each student. In this manner the instructor is at all times in direct audio and video contact with the students in the remote rooms as well as those in the classroom where the live presentation is being conducted. The additional equipment in the program-originating room, besides the cameras, is a control booth at the rear which also houses an electronic projector. One of the cameras carries a three-lens turret fitted with 1", 2", and 3" lenses, while the other used a 2" to 4" zoom-type lens. There is also a receiver located at the rear of the room through which the instructor can view his own presentation. The instructor usually uses a lavalier microphone, although floor and desk mounted types are sometimes used.

In the remote rooms the 27" receiver and the camera are mounted together in a large mobile cabinet. The room microphone is usually placed to one side of the cabinet. There are two types of cameras used. In one type, a single $\frac{1}{2}$", f/1.5 lens is used to cover the entire classroom. The second type is equipped with a four-lens turret carrying $\frac{1}{2}$", 1", 2", and 4" lenses. Lens size, pan, tilt, and optical focus are controlled for close-ups, medium or long shots by a proctor stationed at a control console at the rear of the room. The proctor can control the room receiver for brightness, contrast, and audio level from this position and also see the image from the room camera in a monitor located in the control console.

The Graphics Program

The use of closed-circuit television seems to offer a solution for some of the problems encountered in the teaching of engineering drawing on the college level.

Most college curricula require a basic course in drawing for all engineering students, usually in the freshman year. The instructional pattern generally followed consists of a one-hour lecture, followed by from two to four hours of drafting room practice or problem-solving on each of several topics.

Such an instructional method may produce an administrative problem in the maintenance of a competent teaching staff. Adequate engineering training is a necessary qualification for instructors; but limited opportunity for advanced study in engineering drawing, as such, and therefore for academic recognition, makes the field unattractive as a teaching career. A rapid staff turn-over is apt to result, with instructors often remaining only until they are able to find employment in the field of their major professional interest.

It would seem desirable to maintain a comparatively small permanent teaching department staffed by members with primary interests in design, architecture, and other forms of the graphic arts. Since advanced study is possible in these fields, the opportunity for academic advancement would be considerably increased. Such a staff could then have the primary responsibility for course content and the presentation of lecture material, while the more routine supervision of laboratory exercises in skills and the solution of graphical problems could be carried out by temporary or part-time instructors, or graduate students. However, the large number of students to be given the lecture material may still require a fairly large permanent staff unless a better utilization of teaching resources can be realized.

Recent developments in the use of educational closed-circuit television suggests that this form of instruction may offer a solution to some of the administrative problems outlined above. Television would seem to be well-adapted to the lecture presentations since the material is mostly graphical and therefore visual in nature. Frequent use of models, special instruments, and drafting techniques during a lecture presentation is also desirable but, as a rule, ineffective when presented to large instructional groups. By the use of closed-circuit television, a single instructor can present a lecture to a large number of students simultaneously, the only limitation being the number of receiving positions available or the degree of student-to-instructor feed-back considered desirable. In addition to materially reducing the numerical requirements of a permanent staff, there are a number of ancillary benefits to be derived from this instructional method. Not only is the monotony of repeated presentations of identical material reduced, but instructors can be assigned to lectures in their particular field of interest or specialization. Thus, all students receive the same instructional material from the best talent in the department, while staff members not participating in a particular topic are released for more productive professional activities. Much more careful preparation and presentations result, since highly refined instructional material can be developed and used repeatedly by the methods of a well-planned television presentation.

Experiments in educational closed-circuit television sponsored by the Committee on the Utilization of College Teaching Resources of the Fund for the Advancement of Education provided an opportunity to investigate these instructional possibilities at Case Institute of Technology and to develop improved methods in the use of the medium. The first experimental studies were carried out during the spring semester of 1957. Results of these studies were sufficiently encouraging to justify continuation of the experiment during the fall semester of 1957 and the spring of 1958.

Objectives

This report describes the development of methods for the presentation of lecture material in engineering drawing over a closed-circuit television system. The objectives were: studies of the limitations of the medium, methods for overcoming these limitations, and the development of instructional material and techniques which would not only be of superior educational value but would also improve student acceptance of televised instruction.

Reports of many investigations comparing televised with conventional teaching have seemed to prove that there is little significant difference between the educational achievements of the two methods. Verification of these conclusions have therefore not been considered as the primary concern of the present study. However, during the course of the investigation, comparisons have been made of the grades of the students taught by television with those having conventional instruction. The results of these comparisons have been summarized in a separate report (1) and will not be considered here; particularly since no significant difference was observed.

Instructional Conditions

The first course in which televised instruction was used was Graphics I, given to entering mid-year freshmen during the spring semester of 1957. This was regarded as a pilot run to establish proper operating conditions for the televised system. Although environmental conditions were far from ideal, the course was valuable in that it provided experience to the instructors and also indicated what modifications in techniques of presentation were necessary for an effective presentation of this type of material.

Unfavorable classroom conditions were corrected during the summer of 1957, and six sections of Graphics I and Graphics II were taught by closed-circuit television during the fall and spring terms of 1957-58. Two groups of three sections each were taught during each semester. One section was present with the instructor during each lecture and the other two sections observed the presentation in remote viewing rooms. The classroom position of the sections was rotated every week so that each group had two weeks of experience in televised instruction and one week of experience in live instruction for each three-week interval throughout the term. Two-way video and audio was provided so that the instructor would be able to see the remote groups in classroom monitors and be in direct auditory contact with the class at all times. (2) Four hours of drawing room exercises and problems on the material presented followed each lecture. The lectures were given by the various members of the staff in rotation so that each instructor obtained the same experience in the use of the medium and in the modification of teaching techniques necessary for an effective presentation. Whenever possible, the lecture assignment was along the line of the instructor's major interest. For example; nomograms and graphical calculus, principles of design, freehand sketching, special drawing machines, etc., were all presented by instructors with particular interest in these aspects of graphical presentation. Not only was the material for these topics more carefully prepared than might have been done by another instructor, but all students were equally exposed to the instructor's enthusiasm and superior knowledge of his major field of interest.

Development of Instructional Methods

Chalkboards

Presentation of graphical material on conventionally-used chalkboards was found to be unsatisfactory for good televised images. White chalk on green boards gave poor contrast; and although white chalk on blackboards was somewhat better, any erasures produced further reduction in contrast. Since most chalkboard work is freehand, with little opportunity for advance layout, there is a tendency for poor draftsmanship with frequent erasures. It is also evident that such material has no permanent value to the class since it is completely removed from the board at the end of the class period.

Alternative Methods of Presentation

A number of alternative methods for presenting written and graphical material were tried; the first being the use of paper sheets taped to the board with drawings made upon these sheets. Various weights, colors, and surfaces of paper were tried with several types of markers. A paper known in the printing trade as "Becket cover, short grain, antique finish" was found to be most suitable for this work. A gray shade corresponding to 3, on a 1 to 10 logarithmic gray scale, was used with a black felt pen and gave the greatest contrast with the least degree of glare. Sheets measured 48" x 36" to maintain the same 4 to 3 aspect ratio as used in all television image systems. Sheets were usually taped directly to the chalkboard, although in some cases it was found advantageous to attach them to stiff masonite boards.

This method of presentation has two important educational advantages. One is that prior to the lecture the instructor can prepare the drawings in light pencil; this will be invisible to the camera but can be traced in during the development of the problem. A skillful presentation is then possible even by an inexperienced instructor. A second advantage is that the sheets can be removed at the end of the lecture and posted in the drawing rooms for examination and further discussion by the student.

In the case of very complex drawings, however, the method had one serious difficulty. This was the fact that once the drawing had been filled in, it was unsuitable for further use. It was therefore necessary to make up one set of three or four complex drawings for each televised program.

This problem was effectively solved by the use of a cellophane over-lay. Cellophane obtained in four foot widths was stretched tightly over the pencilled drawings, and the inked lines were made directly on the cellophane over-lay. In this way it was possible to use a single complex drawing repeatedly for any number of lectures and still have it available for use during the following term. A file of such drawings has been accumulated and is available for any future class use. It was initially feared that the cellophane would produce undesirable specular reflection, but careful adjustment of the chalkboard lighting unit, used to illuminate the drawings, produced a glare-free surface. With a little care it is possible to remove the original drawing layout from the filled-in over-lay, particularly if the sheets are mounted on stiff masonite. It is thus possible to preserve both the original layout and the finally-developed drawing for class discussion.

Use of Models

Television is especially effective for the showing of models and offers two decided advantages over conventional demonstrations. The first of these is the enlarging capabilities of the camera. Small parts such as gears, various types of bolts, etc., can be enlarged to the full screen diameter. Of perhaps greater importance is the fact that the same view of any three-dimensional model is seen by the entire class. Ordinarily, each member of a class observes a solid model from a different viewpoint, depending on his position relative to the model. With television, however, the instructor simply changes the orientation of the model until he obtains the desired view as observed on his room monitor. An identical view is then observed on all receivers connected to the system.

Considerable care must be observed, however, in the use of models as to material, color, and lighting. Improper lighting can completely destroy proper three-dimensional perspective effects. Since a monochromatic image is obtained from the camera, and since the vidicon tube does not have the same spectrum response as the eye, areas of different color easily discernable with direct vision may show no difference on a television screen. Highly polished surfaces give spectral reflections, and considerable experimenting with lighting may be necessary to avoid undesirable reflection effects. For example; a transparent plastic model to demonstrate orthographic projection was very effective for direct visual observation but presented some difficulties when shown by television. Very careful control of orientation and lighting was necessary to eliminate undesirable reflection and to maintain correct three-dimensional appearance. An excellent discussion of problems of color, shapes, and materials is given in a report from the Office of Naval Research(3) and will be found valuable in the construction of models to be used in televised instruction. Principles used in photographic lighting will be found to solve most ordinary lighting problems.

Facilities

Camera requirements are quite simple. If the system is to be used only for the teaching of engineering drawing, a relatively inexpensive industrial-type camera may be used. High resolution is not necessary since minute details are seldom involved. The industrial-type camera has a self-contained carrier oscillator which will permit the use of commercial television receivers for all viewing monitors. A single camera with a zoom-type lens is adequate for most purposes, although two cameras will permit a somewhat more sophisticated-type of program.

An inexpensive "electronic" projector, described in another report, (1) provides a simple method for the showing of lantern slides on the television system. Images are superior to those obtained by pick-up of an image projected on a screen and can be electrically varied as to contrast and brightness. The slide image can also be superimposed on the image from the live camera, thus permitting novel and effective presentations not possible by any other method. Lantern slides shown by either method should have high contrast and a minimum of fine detail in order to be effectively televised.

Since education and not entertainment is the objective, special studios are neither necessary nor desirable. An ordinary classroom, sufficiently large to accommodate a class and the camera with associated monitors, has been found more satisfactory for most instructional conditions than a central studio. The presence of a live class provides a familiar teaching environment for the instructor and an increased degree of personal contact with the students, particularly if the classes are periodically rotated between the live and the remote rooms. This room, however, should be provided with adequate screening and ventilation since outside lighting ordinarily produces non-uniform room illumination. Provision should also be made in the remote viewing rooms to eliminate reflections from outside windows and room-lighting luminaires.

Proper lighting of drawings is best obtained by the use of a commercial chalkboard lighting unit. However, if such a unit is mounted in a position directly above the surface to be lighted, uneven illumination of the area will result. The lighting unit should be mounted about thirty inches from the wall and the reflector angle varied until a uniform light distribution is obtained.

All receivers should be carefully adjusted for both horizontal and vertical linearity. It is evident that maladjustment of these receiver characteristics may distort line drawings to such an extent that the objectives of the presentation might be invalidated.

Student and Staff Reactions

Although experience has shown that there is no significant difference in student grades between conventional and televised instruction, student acceptance is an important factor in evaluating the success of this educational methodology. The problem has been discussed in some detail in a previous report but conclusions reached from the experimental studies at Case will be summarized here. Other things being equal; students prefer live instruction in small groups to a television lecture, particularly if there is no evident need for the use of the television medium. On the other hand, they recognize the advantages in the showing of models and of the more carefully prepared lectures on the part of the instructional staff. They generally would prefer a good instructor on television to conventional classes with a poor teacher.

Instructors also prefer live instruction for several reasons. They believe that the loss of personal contact, even with two-way video and sound, is a serious problem; although the presence of a live class and the rotation of sections between live and televised instruction tends to mitigate this difficulty. They also believe that allowance should be made on teaching loads to compensate for the increased time necessary for preparation and rehearsals.

Conclusion

Courses in engineering drawing are probably better suited for televised instruction than almost any other engineering subject. Line drawings are the simplest and most easily transmitted-type of visual material for a television system; and the enlarging ability of the camera, plus the elimination of parallax on the part of the observer, makes the viewing of models superior to direct observation.

Even though a favorable student-to-instructor ratio may make television unnecessary as an instructional medium, its use as a teaching aid (4) will greatly improve the quality of instruction. On the other hand, if there is an evident reason for its use as a teaching medium, and if both students and instructors recognize this need, it is a satisfactory and effective substitute for live instruction in the graphic arts.

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2. Two-Way Educational Closed-Circuit Television. J. R. Martin, Electrical Engineering, Vol. 76, No. 10, October 1957, pp. 921-924.
3. Visual Principles for Training by Television. Robert Jackson, Human Engineering Report SDC 20-TV-2. Office of Naval Research, Special Devices Center.
4. Closed Circuit Television as a Teaching Aid. Research Report No. 948-4. Case Institute of Technology, August 1, 1957.

Appendix I

Illustrations

1. (Figure 2) Equipment used at program originating point. Two light boards are also shown; the control for these lights is the console on the left side of the photograph. The electronic slide projector rests on the top of this and the second console. Other consoles are (left to right): video monitor for camera 1, main control console, video monitor for camera 2, and r.f. line monitor. The main control console carries the following (top to bottom): wave form monitor; elapsed time meters for each camera and video switch for electronic projector; camera control and switcher; audio mixer and intercom control; synchronizing generator; audio-video mixer.
2. (Figure 6) Live class at the instructor position. The instructors room monitor is at the rear of the classroom. The two monitors at the front show two remote classes.

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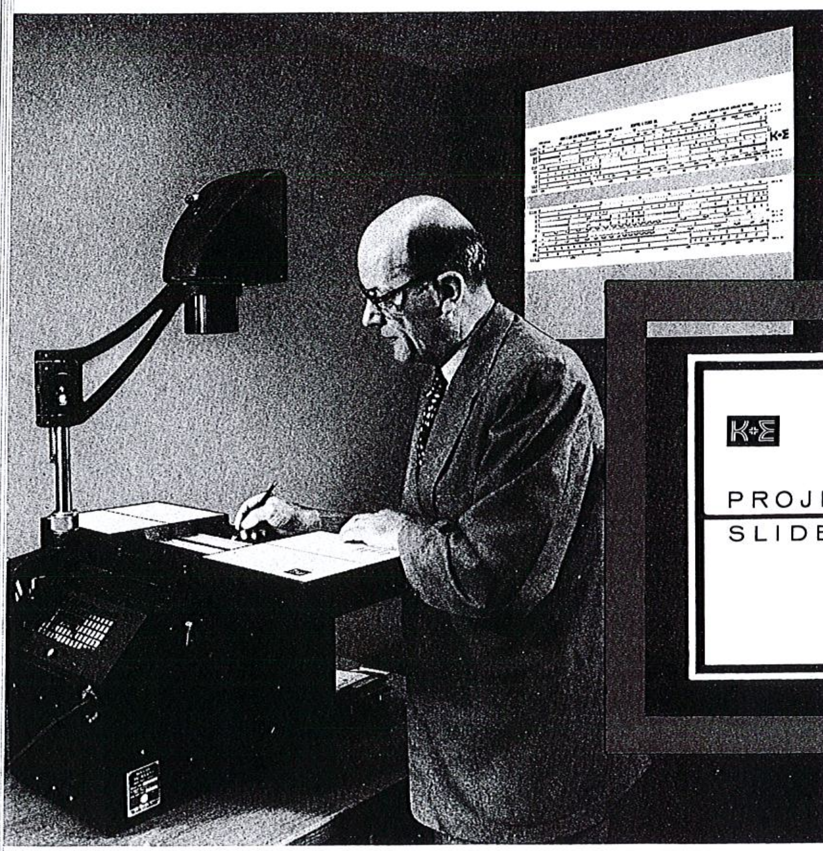

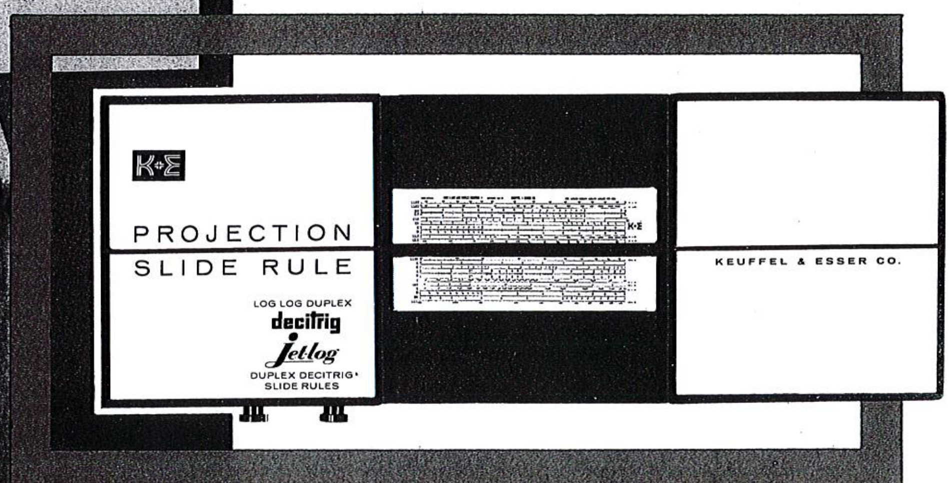

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Scales of the K&E Log Log Duplex DECITRIG® Slide Rule are accurately printed on tough, dimensionally stable STABILENE® Film made by K&E. Two knobs control all movements. One moves the slide, the other positions the indicator. The unit is designed for operation with standard overhead projectors. It projects a clear, accurate image of the scales onto a screen or wall. This image can be made to cover almost any screen size, without distortion. The durable, non-fading STABILENE film image retains its stability even after long exposure to heat and strong light.

A Versatile and *Consistent* Scale System is a well-known advantage of the K&E Log Log Duplex DECITRIG and JET-LOG T.M. Duplex DECITRIG® Slide Rules. Every scale relates – without exception – to the basic C and D scales. There's a dual-purpose D scale and three LL scales, to cover a log log range of 1.00 . . . to 22,000. The A-B scales are arranged so that square-root derivations can be made quickly – without stopping to reset. Scales included are: LL02, LL03, DF, CF, CIF, CI, C, D, LL3, LL2, LL01, L, K, A, B, T, SRT, S, DI & LL1.

As used by Dr. Harvey E. White, Professor of Physics, University of California, on *Continental Classroom*, the NBC-TV network course for college credit.

"I FIND THIS DRAFTING MACHINE AN INDISPENSABLE TOOL in my preparation of daily lectures and visual sequences," says Dr. White of the Paragon *Auto-Flow* – made exclusively by K&E.

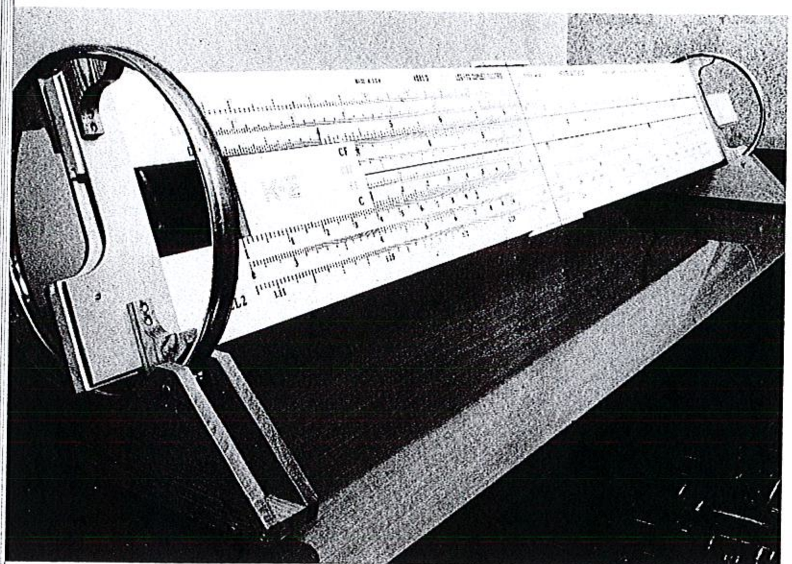
The *Auto-Flow* combines the functions of T-square or straightedge, triangles, scales and protractor in *one* convenient unit, controlled entirely by the left hand. Thus, the right hand is left free for drawing – without annoying interruptions or waste effort.

Specially developed by K&E for blackboard use, the *Auto-Flow* permits accurate efficient work with chalk, and can be furnished with top and vertical rails in any desired length. The 25-inch rule is boldly marked, and numbered at 5-inch intervals. Precision stainless steel construction, built-in balance, feather-touch controls and locking scales that eliminate "drift" are important K&E features – the same as those found on standard K&E drawing-board models.

Paragon® Auto-Flow™ Drafting Machine

specially adapted for blackboard use . . . saves effort, improves accuracy of classroom illustrations

Trundle-Mounted Demonstration Slide Rule



This is an 8-foot enlargement of the K&E Log Log Duplex DECITRIG,® with working slides and indicator. It can be turned 360° to demonstrate scales and slide operation on either side. Trundles have unique wheel and axle construction, with grooved wheels turning freely on revolving ball supports for rapid changes from front to back of the rule.

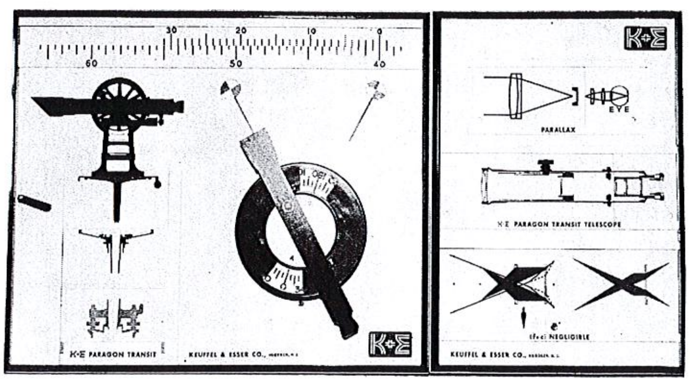
The original trundle unit was developed by K&E for the Mathematics Department of the United States Military Academy, and others have been used on Sunrise Semester, the educational television program sponsored jointly by New York University and the Columbia Broadcasting System.

Wall-Mounted Demonstration Slide Rules

100 Mannheim Type recommended for use with Mannheim POLYPHASE® and BEGINNERS'T.M. No. N4058W Slide Rules. Approximately 7 feet long. Front face shows the A, B, CI, C, D and K scales; reverse side displays the S, L, and T scales. Furnished with indicator and two screw eyes for suspending.

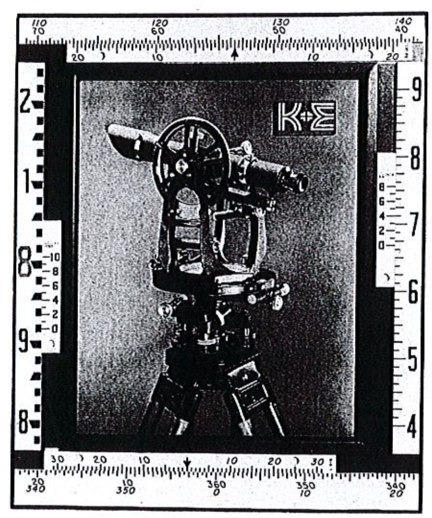
N105 Log Log Duplex DECITRIG.® Same size as the trundle-mounted unit described above (8 feet), but designed for wall display. Complete with indicator and device for suspending and turning over.

Transit Demonstration Panels



For simple, clear demonstration of the construction and operation of a transit and the optics of a transit telescope. Details are easily visible in the classroom at 30 feet or more. Furnished as two separate panels with moving parts of clear, heavy plastic. Equipped for hanging on a wall or easel, side by side or separately. Combined measurement is 95 inches wide by 49 inches high.

Vernier Demonstration Board



Size 31 x 37 inches. Four scales with verniers as follows: transit graduated to 20 minutes, reading to 30 seconds; leveling rod graduated to 1/100th of a foot, reading to 1000ths of a foot; inch scale graduated to 16ths, reading to 64ths. Board is furnished with fixtures for hanging.

For further information and prices, write to

KEUFFEL & ESSER CO.

Hoboken, N. J.

39163

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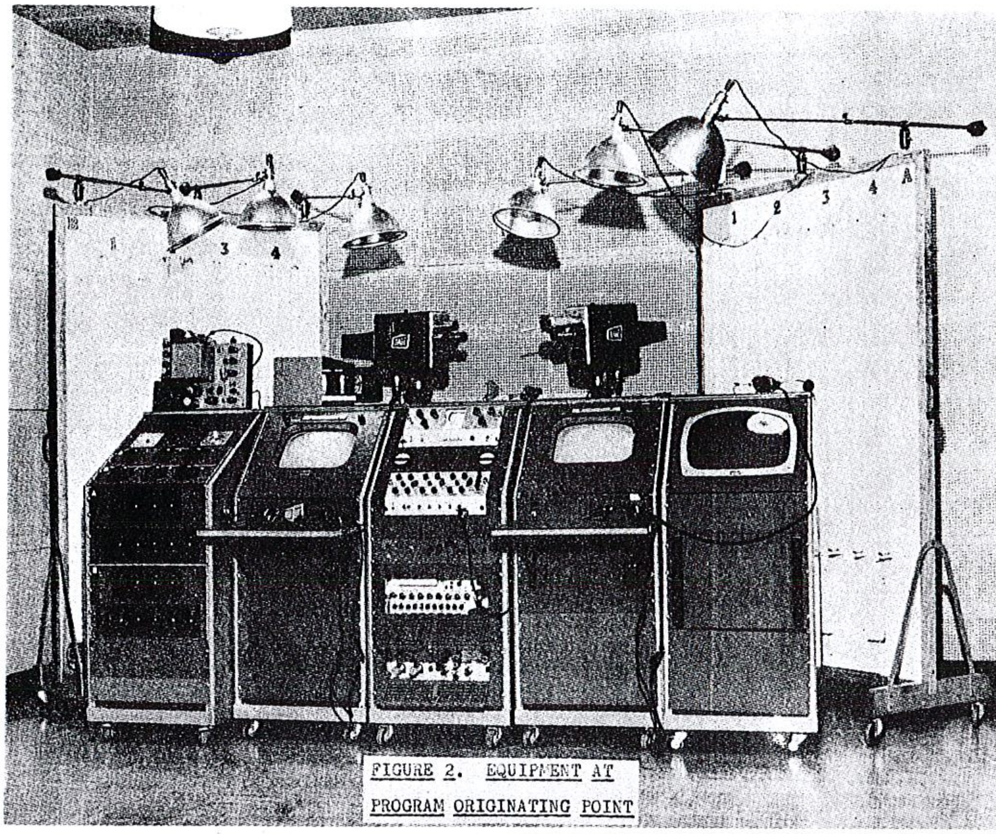


FIGURE 2. EQUIPMENT AT PROGRAM ORIGINATING POINT

FIGURE 6. LIVE CLASS AT INSTRUCTOR POSITION

Annual Meeting

ENGINEERING GRAPHICS DIVISION, ASEE

June 17, 1959

Row 1: J. S. Rising, W. E. Street, C. E. Rowe, W. L. Collins, I. Wladaver, A. Jorgensen.
Row 2: Mrs. Arnold, S. G. Hall, Barbara Billings, Amogene Devaney.
Row 3: S. Coons, J. E. Pearson, J. S. Dobrovolny, F. A. Heacock, J. Lenhart, A. P. McDonald, H. C. Nelson, J. A. Anderson, J. Plant, M C. Hawk.
Row 4: L. M. Sahag, E. Pare, D. P. Adams, H. G. Kinner.
Row 5: J. N. Wood, P. H. Riedel, J. N. Arnold, N. D. Thomas, Mrs. Thomas, F. Binns, W. Luzadder, E. M. Griswold, J. H. Porsch, H. B. Howe.
Row 6: R. F. Pray, W. B. Rogers, R. W. Grant, A. Halasz, E. Petty, H. W. Shippling, R. A. Celaschi.
Row 7: R. J. Cooper, E. D. Ebert, I. Hill, L. G. Skubic, E. Mochel, W. M. Christman, L. C. Christianson, J. L. Blackman, E. D. Black, R. L. Elkins, K. R. Gulden.
Row 8: H. W. Vreeland, R. O. Loving, B. L. Wellman, R. S. Paffenbarger, C. I. Carlson, H. L. Aldrich, H. C. Spencer, Mrs. Aldrich, D. Schiller.
Row 9: E. Jacunski, R. B. Thornhill, C. Buck, H. Nelson, M. G. Mochel, D. Roberge, A. L. Hoag, R. P. Hoelscher, S. E. Shapiro, W. L. Shick, J. Rising, C. H. Springer, F. A. Smutz, M. McNeary.

(Sorry--a couple of names missing. J.S.R.)

MID-WINTER MEETING

Division of Engineering Graphics, A.S.E.E.
January 20-22, 1960
Missouri School of Mines and Metallurgy, Rolla, Missouri

Lloyd C. Christianson, Program Chairman

Theme: Modern Graphics

WEDNESDAY, JANUARY 20,

6:30 p.m. Executive Committee Dinner - Student Union (For Executive Committee Members)
Presiding: Albert Jorgenson, University of Pennsylvania

THURSDAY MORNING, JANUARY 21

8:00 - 9:45 Registration and Coffee Hour - Student Union
10:00 - 12:00 Technical Session--Chemistry Lecture Room
Theme: Teaching Techniques
Presiding: Irwin Wladaver, New York University
Welcome: Leon Hershkowitz, Assistant Dean Missouri School of Mines and Metallurgy

1. Illustrated Lecture on Electrical Drawings
   Charles E. Baer, University of Kansas

2. Methods of Teaching Engineering Drawing
   Earl D. Black, General Motors Institute

THURSDAY AFTERNOON, JANUARY 21

12:15 - 2:00 Luncheon - Student Union
Speaker: C. V. Mann, Missouri School of Mines and Metallurgy, Retired.
Presiding: R. S. Paffenbarger, The Ohio State University
(Picture taken following this luncheon.)

2:15 - 5:00 Technical Session-- Chemistry Lecture Room
Theme: Effective Programs in Engineering Graphics. How Shall They be Taught?
Presiding: L. C. Christianson

1. A. E. Messenheimer, Kansas State University.

2. James McGarath, Texas A and M. College.

Panel: James Rising, Iowa State College
Paul Machovina, The Ohio State University
Edward Knoblock, University of Wisconsin
Albert Palmerlee, Kansas University

THURSDAY EVENING, JANUARY 21

6:30 Mid-Winter Banquet Main Dining Room Student Union
Presiding: Albert Jorgenson
Invocation: William E. Street Texas A and M College
Entertainment: M.S.M. Glee Club
Speaker: Dr. Curtis L. Wilson, Dean Missouri School of Mines and Metallurgy

FRIDAY MORNING, JANUARY 22

8:00 - 9:30 Coffee Hour - Student Union
9:30 - 11:30 Technical Session Chemistry Lecture Room
Theme: Graphics in Industry
Presiding: A. P. McDonald The Rice Institute

1. Missouri State Highway Department
2. McDonnel Aircraft
3. Westinghouse at Kansas City
4. Discussion from the floor

FRIDAY AFTERNOON, JANUARY 22

12:00 - 2:00 Business Meeting and Luncheon
Presiding: Albert Jorgenson
2:15 - 4:30 Tour - U.S. Geological Survey or U. S. Bureau of Mines
4:30 - 5:30 Tour of Drawing Department (Second Floor, Mining Building)

6:00 Adjournment

TENTATIVE SLATE OF CANDIDATES FOR OFFICES OF THE DIVISION, 1960-61

RULES

(a) The Nominating Committee to be appointed in June at the annual meeting shall be composed of five persons, three of whom shall be the last three past Chairmen of the Division who are present at the annual meeting (not including the retiring chairman) and two others, who are present, to be appointed by the Vice-Chairman in office with the approval of the Executive Committee. The latter two appointees shall not hold any office at the time of their appointment. The senior past Chairman of the Division shall act as Chairman.

(b) The Nominating Committee shall prepare a slate containing, for each office to be filled, two names of eligible candidates who have expressed a willingness to accept nomination and to serve if elected. The slate as prepared by the Nominating Committee shall be published in the November issue of the Journal.

(c) A properly prepared petition nominating a member for any office that bears ten (10) signatures of members of the Division and Society shall require the Nominating Committee to place the name on the ballot.

(d) The nomination period must be considered as being closed at the end of the last conference session of the mid-winter meeting. A petition for nomination received after the close of the mid-winter meeting cannot be accepted. A conference session is herein defined as a regularly scheduled meeting at which papers are presented for discussion.

(e) On March 1, and returnable before April 1, the Secretary shall mail to each member of the Division an election ballot bearing the slate prepared by the Nominating Committee.

(f) Any holder of an elective office whose term extends beyond the current year shall not be eligible for nomination to another office.

NOMINATIONS

The Nominating Committee of the Engineering Graphics Division met at Pittsburgh, Pennsylvania and selected the following candidates for the office indicated.

VICE-CHAIRMAN:
- Edward M. Groswold, The Cooper Union
- A. P. McDonald, The Rice Institute

SECRETARY:
- Carson P. Buck, Syracuse University
- Webster M. Christman, Jr., University of Wisconsin, Milwaukee

FIVE-YEAR DIRECTOR:
- James S. Blackman, University of Nebraska
- Eugene F. Pare', Washington State University

ADVERTISING MANAGER, JOURNAL OF ENGINEERING GRAPHICS:
- Robert H. Hammond, U. S. Military Academy
- Ernest R. Weidhaas, Pennsylvania State University

GRAPHIC SCIENCE PAGE OF THE ASEE JOURNAL:
- Edwin W. Jacunski, University of Florida
- H. Dale Walraven, University of Illinois, Chicago

COUNCIL MEMBER:
- Jasper J. Gerardi, University of Detroit
- James S. Rising, Iowa State University

Additional candidates may be nominated by petition. A petition should be signed by ten members of the Engineering Graphics Division. The candidate must have expressed his willingness to accept office if elected. Such petitions for nominations should reach William E. Street, A. and M. College of Texas, College Station, by the opening of the Mid-Winter Meeting in January 1960.

Nominating Committee
Glenn E. Cramer
Amogene F. DeVaney
Ivan L. Hill
Warren J. Luzadder
William E. Street, Chairman

DEVELOPING CREATIVITY AND CREATIVE THINKING IN ENGINEERING GRAPHICS

By Jack H. Anderson, General Motors Corporation

In recent years, almost every technical magazine has explored the field of creative thinking. The articles published have pointed out the need for ideas in our race for international supremacy. The seemingly magical accomplishments of Edison, Einstein, and Kettering are illustrated. Suggestions are given for bringing about greater creative activity. When one finishes these articles, he is greatly impressed by past creative achievements, but is uncertain whether he can benefit personally. After reading these publications, two thoughts develop: (1) everyone is interested in developing creativity, but (2) no one yet has a fool-proof method.

What is Creative Thinking

Before we delve into the means of becoming more creative, let us review for a moment what we mean by creative thinking. This is not a simple phrase to define. Creative thinking does not lend itself to an engineering-like formula--or even to a technical description. We know most about creativity by observing its after effects. Thus when Archimedes leaped out of his bathtub and shouted "Eureka!", we know that he had just thought creatively. Since the process is so intangible and even borders on the mystic, we must pause before we attempt to describe it as concrete terms. In order to somewhat limit our discussion today let us consider on-the-job applications only. Of all descriptions I have seen, the one which covers this situation best is that creative thinking is the capacity to add something to the job by idea, invention, or unique problem solving. Creative results may come about through a combination of two or more old ideas or by coming out with an original suggestion. The suggestion, to be beneficial to industry, should apply to the job situation. Thus an improvement in the methods of preparing frozen foods is unlikely to have application in manufacture of automotive instruments. This morning we are primarily interested in on-the-job applications.

What is a Creative Problem?

One more ground rule must be established at this point. A creative problem differs in how it is worded and in method of solution from the more conventional analytical problem. This difference must be clearly understood, or our conception of what we are trying to achieve will not be correct.

The analytical problem, first of all is solved by a direct logical approach. It lends itself to "plugging" values into a formula or following an established procedure. There is usually only one correct answer or result. This type of problem is well known to students and may be assigned to routine industrial workers. Examples of this type of problem might be:

1) "Install a new set of spark plugs in my car", a request given to a service station attendant. A problem of this nature may present difficulties in a modern car, but there is nothing essentially creative required in solving it. One answer is all that is asked for.

2) Solve this problem : "My husband's age", remarked a lady the other day, "is represented by the figures of my own age reversed. He is my senior and the difference inour ages is one-eleventh of their sum". This, of course, is a typical puzzle problem which takes effort to solve, but requires little creativity in method of solution.

The characteristics of an analytical problem are that:

(1) its statement suggests the means of solution, and

(2) there is usually only one right answer.

A creative problem, in contrast, is multi-solutional; it has many and varied answers. The statement of the problem does not tend to narrow the approach or limit the number of results. Most often there is no well marked path to follow. Examples of creative problems could be:

1) Devise a bed which will never squeak.

2) Develop a quick and efficient fruit peeler for use in hotels and institutions.

3) Develop a bullet proof insulator for telegraph poles.

There could be many answers to these problems, some much better than others. Thus they lend themselves to a creative problem solving method.

The Importance of the Individual

The question which all of us would like to have answered is how to instill creative thinking in the designer or draftsman. After all, he is the practitioner of engineering graphics. Let us imagine for a moment the engineering department in a large manufacturing company. It is an expansive room in which many designers are at their boards facing impressive looking drawings. In this room are two people who attract our interest. Each has a similar design problem. Each is going to be baffled by the problem he faces. One will work hard and fail to find an answer; one will work a little harder and succeed.

As supervisors and instructors, we wonder why the first man falls short while the second man comes through. There may be many things involved but one could be lack of understanding of the creative process.

The individual designer is a very important man. His decisions on many small items can determine whether a product is acceptable to all who must handle it, or whether little flaws will make continuous problems. The use of a group or a committee to replace one good idea-designer is seldom successful. The committee or brainstorm approach to problem solving has been deplored by many people. One commentator recently stated that a camel is a horse that was designed by a committee. A problem solving or brainstorm group works best in areas of limited scope. How then, can we improve the situation of a designer so that he can become more of an idea man?

The Individual and His Environment

When we examine the designer in a work situation, it helps to separate the individual from the external factors which may influence him. As an individual, certain things can be done to promote greater creativity. We will discuss those. The outside influences exerted by society and management over which the individual has little control, play an important part and will also be discussed.

Personal Characteristics Required

The magical power of creative thinking can turn a drawing board into a kind of magic slate. The technique can be used by anyone who knows some of its principles and who sincerely wants to think creatively. There are several basic concepts which the student of creativity must recognize.

1. Everyone has creative ability to a greater or smaller extent. The time of greatest creativity in most individuals is as a child of pre-school age. While children must obey the rules established by their parents, they have not yet learned from society what they can not do. As a child enters school, he learns a set of rules which requires him to conform to the group. Some of the spark of originality is lost. We have cause to be concerned when this becomes so well ingrained that a conscious attempt is made by the adult to be exactly like his co-workers. By the time a person enters an industrial position, his habits may be so well established that much "un-training" is required to recapture some of that youthful vision. Individuals who sincerely wish to improve creative achievements can do so through properly applied effort. The first step in the program toward greater creativity is for the individual to realize that he has creative ability.

2. While everyone has a top limit on his inherited creative ability, most people can become more proficient in using it. The fears, and hesitations which we may have about our idea potential can be dispelled when we realize that everyone has uncertain moments. To gain confidence in solving problems, successful past experience helps. The analytical problem in the form of puzzles of reasonable complexity, can be a valuable exerciser of the mental muscles. When we say that there are some bad influences because of schooling, we must also say that one of the valuable things gained is problem solving experience.

A problem posed by one of our engineers, recently, was the question of finding the counterfeit coin hidden in a group of eleven good coins. It could only be detected by weight difference. We were not told whether the false coin was lighter or heavier than the genuine coins. In three balancings, one should be able to discover the counterfeit and whether it was lighter or heavier than the genuine coins.

Solving a problem of this nature takes a great deal of ingenuity. A practice of seeking and solving these problems can help us to become more proficient in using our creative abilities

3. Creative ability goes hand in hand with a well rounded background. A wide range of interests combined with good technical knowledge serve as irreplaceable tools in scouting for ideas. Too much knowledge can be bad, but a good minimum is required. For example, a person with too much knowledge is apt to set up his own stumbling blocks. The story is told about an electrical engineer who informed Kettering that a wire couldn't possibly carry the current required to start a car. He had the formulae to prove it too!

In connection with developing a good background creative hobbies are beneficial. They may help build up knowledge in seemingly unrelated fields, as well as serve as a challenge to the imagination. Hobbies which fall into this category include model making, critical reading, writing, or photography. One design engineer in my group belongs to a model railroad club. He has half of the basement in his new home devoted to an extensive layout. As he installs relays, controls, and other gadgets to automate his line, he is becoming familiar with a complex of knowledge as well as exercising his imagination in the attempt to out-strip other members of his club.

A well rounded background combined with a wide range of interests definitely aids creativity.

4. Persistence is required when creativity is sought. An obstacle to routine workers should merely be a challenge to idea workers. When an idea has just been born, it is very fragile. Unless the creative worker pushes, the idea will never live through its infancy. A popular cigarette advertisement declares that "They say it couldn't be done". The ad goes on to show that by persistence and effort the particular folly became a practical reality. Without discussing the merits of the product involved, the advertising statement illustrates a typical block encountered by creative people. A new or unique idea is almost always met by scoffing or ridicule.

5. Creativity is difficult. If a person is going to be creative he must expect to work hard. In walking through a design group, one can not help but notice the difference in effort applied by workers. Some always see you approach and have a ready greeting or question by the time you reach them. Others are so immersed in their hunt for ideas that they may work for some time

before they are aware that someone wishes to speak to them. This latter group is usually among the more creative. They realize that concentration and effort are required to shake loose ideas.

How can an individual become aware of all of these facts? At AC Spark Plug, we have conducted classes in creative engineering for a number of years. In these sessions, we have studied and used the creative processes. A class problem is usually assigned in which an actual plant problem must be solved. We don't pretend that our people are on their way to replace Edison, but those who complete our courses have a better understanding of the creative process. The next time they meet a challenge on the job, they try harder to overcome it. The course in creative engineering has given many workers in the engineering area a more open mind as well as a greater willingness to tackle tough problems.

It should be recognized that the idea seeking process can be learned before a worker enters industry. A planned program is now offered at General Motors Institute in Flint. Some colleges and universities also have a creative engineering program. Our adult education program in Flint provides a creative thinking course of value to the noncollege student. There is little doubt that use of such courses prepare the idea worker for the time he enters industry.

Environmental Factors

The actual creative accomplishment of an individual, however inherently gifted he may be, is greatly influenced by the external influences of his work situation. Management in industry can do a great deal to control work environment. Without the backing of top supervision, a creative thinking program may never survive long enough to show its value. In what ways will environment stimulate or stifle creativity? Let us look:

1. Idea workers need encouragement. They are more sensitive than routine workers. Supervision should show enthusiasm for the project being worked on. When discovering an error in concept on a job, the supervisor should teach rather than resort to caustic comment. Quick or sarcastic criticism of a proposal may bury a good idea. Supervision must maintain an active interest in a project without taking it over. Recently one design engineer at AC was working on a long range development project. Supervision seemed to have little interest in what he was doing and so he lost interest himself. The project bogged down and eventually had to be dropped when a competitor developed a satisfactory design and got the business. He felt concerned because he was responsible for the project, but I heard him say that the boss wasn't pushing it, so why should he? In dealing with idea workers, credit and recognition for a good job pay rich rewards. Creative workers need encouragement.

2. Environmental block, real or imagined will slow down the best idea worker. These blocks are brought about and shown by the attitude of some supervisors. The worker who wishes to please his superior is most affected by these attitudes. Some of these include:

a) Supervision's reluctance to deviate from established practices. We sometimes hear the remark, "It has always been done that way". This is the clue that someone is playing it safe and is unwilling to take the risk which is necessitated by using a new idea.

b) Supervision's lack of faith in idea seeking methods. When this occurs a hard driving boss may give little encouragement to that employee who tries to come up with something new through use of idea seeking methods.

c) The distrust of someone who is somewhat different. Sometimes creative people refuse to conform to the group. At a recent meeting I attended, my attention was drawn to a character wearing a beret, a checkered vest, a cowboy style string tie, and a set of round lensed safety glasses. Everyone else at the meeting was dressed in conservative business suits. The character, of whom I speak, has a growing list of patents as well as a doctorate in physics. I wonder if the men in business suits could say that they had similar accomplishments? I wonder what our reaction would be if the character came up to us to interview for a job?

The attitudes which supervision may have about their creative workers can influence their end accomplishments. Whether they will admit it or not, supervisors attitudes are detected. Group leaders may fail to recognize and appreciate ideas of others. This is especially true when pet personal theories are involved. The story told by a former dean of a large mid-western university illustrates this.

It seems that one professor tried to encourage originality in his students. One of his students, a school teacher, concerned about getting a high grade took verbatim notes. Her term paper, according to the story, consisted of stringing together her transcribed lecture notes. The professor's pet ideas were given prominent play. When the paper was returned, it was marked with a large "A", together with the comment, "This is one of the most original papers I have ever read!"

3. Supervision must allow time for indulging in fantasy. There is a very normal feeling that if a worker isn't visibly doing something continuously, that he is wasting time. The Reader's Digest published the account of John D. Rockefeller being approached by one of his executives who complained that a colleague was

being paid $50,000 a year and yet spent most of his time looking out of the window. Rockefeller answered: "If you will look out of the window and think the kind of thoughts he is thinking I'll pay you $50,000, too".

Idea workers need time to muse. A far away look isn't necessarily the result of disinterest in a job.

4. A stimulating work atmosphere must be developed. The armed forces refer to this attitude as high morale. An enthusiastic supervisor of creative people will encourage workers to be enthusiastic. We all recall those dormitory bull sessions which lasted most of the night. Sometimes as politics, religion, or the opposite sex served as the topic of conversation, the air would become quite heated. Various opinions were offered by the participants. The air seemed to breathe opinions and ideas. This attitude is what we want to obtain in industry when ideas are sought. A lively stimulating work atmosphere is a definite benefit.

One way to build this atmosphere is to place workers carefully. A creative individual in a group of routine workers is like a rose in a corn field. Placing creative people together provides for mutual stimulation.

How can the leaders of creative workers improve the work environment? Some suggestions have been given in our discussion and should be followed if idea results are really sought. However, of greatest benefit to group leaders and intermediate supervision is the help of top management. The real push for a creative thinking program must come from the top. Without stimulus from there, then only a short lived program is expected. At AC, we are fortunate in that the greatest promoter of the whole idea program is our general manager, Mr. J. A. Anderson. Supervision on down the line reflects his attitude. Although I don't want to oversell the organization for which I work, it is safe to say that it is a rare person at AC who will scoff at a new idea. That is why our division has succeeded as well as it has in corporation wide suggestion contests. This has been achieved because top supervision has actively backed the program and saw that an idea-receptive atmosphere was built.

Summary and Conclusion

Fundamentally, there are only a few basic facts about creativity which we should remember. Everyone is inherently creative. The reason that this is not exhibited is two-fold. First, the individual may not know the facts of idea gathering. Secondly, the environment in which he works may not encourage creativity. Management influence can provide instructive courses and supervisory attitude which will encourage ideas.

Successful promotion of creativity will bring a richer life for all those who work with it. It will bring a better world tomorrow for those outside our area because of what we accomplish. The prime responsibility for the success of the program rests with management in industry. In the classroom, much could be done to prepare the idea worker to enter the industrial environment.

NEW MEMBERS OF THE DIVISION OF ENGINEERING GRAPHICS

The following new members of the American Society for Engineering Education have expressed their interest in the Division of Engineering Graphics. We welcome them, and we invite them to join us in all our activities.

We encourage subscription to the journal, as so many new members have already done. We hope that both old and new members will give as well as receive contributions to engineering graphics by communication in the journal.

Robert O. Butler, Iowa State College
Harold C. Cunningham, Wayne State University
Ralph L. Drumwright, Kensington Junior High School,
Francis J. Dupuis, University of Alabama
Charles J. Firth, Villanova University
Loring W. Hulick, Orange County Community College
Frank W. Klement, University of Florida
Richard T. Kombrink, California Polytechnic College
Glennon Mapes, Mississippi State University
Thomas J. Minter, Tri-State College
David Petty, University of Alabama
Erwin J. Rainer, Fairleigh Dickinson University
Alvin R. Reinhart, Trinity College
Benedict J. Roberts, Saint Bernard College
Donald E. Schech, University of Illinois
Wells Thompson, University of Washington
Harold W. Tuckett, Flint Community College
Earle H. Watts, University of Florida
Edward M. Wray, Ohio College of Applied Science
Herbert W. Yankee, Worcester Polytechnic Institute

Members of the Engineering Graphics Division are members of the American Society for Engineering Education who have named engineering drawing, graphics or descriptive geometry as one of their two fields of academic or professional activity. New members of A.S.E.E. should notify our secretary, E. M. Griswold, The Cooper Union, of their interest in this division. All members of the division: Please advise the secretary of change of address.

A NEW SYSTEM OF AXONOMETRIC PROJECTION

By L. Eckhart

Originally published in VDI Zeitschrift, April 9, 1938

An English Translation by M. Z. v. Krzywoblocki and Wayne L. Shick

A method will be described which enables a very simple axonometric presentation correlated with the production of regular orthographic views. In spite of its simplicity, the procedure is theoretically justified. The fundamental ideas of the method can be used as well in freehand drawing.

To represent a visual picture of a technical object given in orthographic projection, axonometric drawing is commonly used. In this kind of drawing, representation is referenced to an orthogonal straight linear system of X-Y-Z axes correlated with the object. The traces of the axes can be arbitrarily assumed, as well as the location of the axes in the axonometric. However, in axonometric projection, rather than in axonometric drawing, axes must first be constructed. In traditional procedures, for each axial direction a certain scale is employed, and in addition various angular relationships must be used to determine the ratios of reduction so that correct lengths can be transferred for the segments parallel to corresponding axes. The fundamental matrix of the spatial axes usually is correlated with the orthographic planes of projection.

In this paper, a very simple procedure is explained for the projection of axonometric views which avoids all these auxiliary drawing procedures and measurement-transfers, and consequently is much more adaptable. Moreover, it leads much faster to the goal of obtaining an axonometric view, and is theoretically fully justified.

Explanation of the Procedure:

The method of operation for this proposed system is shown in figure 1. Two simple views, in this case the horizontal projection and the vertical projection, are positioned arbitrarily. We shall refer to them as auxiliary views. Next, we shall choose for each of these auxiliary views, a direction of projection, which is marked by arrows. Through each point of each auxiliary view, we project lines parallel to the chosen direction, and we find the points of intersection. This drawing of parallel lines and finding of points of intersection we shall call projection-intersection. Employing projection-intersection to all the important points, we obtain an axonometric picture of the object. Strictly speaking it is an oblique projection of an object, which object is similar to the one given by an auxiliary view--but this for practical purposes is meaningless. Thus, we have the following Theorem: Given two orthographic views of an object located in an arbitrary way in the plane of projection for the axonometric view, and choosing for each orthographic view an arbitrary straight line direction of projection, we can always derive through this projection-intersection procedure an axonometric drawing representing the object.

To prove our theorem, let us choose a cartesian coordinate system with the unit directional vectors, OX, OY, and OZ, in the simplest possible way in the horizontal and vertical directions, where any point P is described by the two projections P' and P" jointly with its projections to the coordinate planes Q' and Q", see figure 2. O'Q' and O"Q" for example, are the projections of the Y-coordinates. The projections of each point are located on parallel lines, the so-called ordinates. Next, we separate the two views, and we place them in an arbitrary way in the projection plane for our drawing, considering them to be the auxiliary views, see figure 3. When we prolong for each auxiliary view the previously common ordinates, it is easy to see that they will always intersect on a straight line "a", which we will call a "mitering line" or "transfer line". It is clear that using this mitering line, we can solve all the problems of projection between views with the same accuracy with which we can solve the problem in the original plane of figure 2, the only difference being that instead of straight line ordinates, they appear broken or "bent".

If a mitering line is not too convenient, or it is not located in the area of the drawing paper, we can still operate without it, observing that in the drawing, figure 2, that the ordinates are parallel to O'X' or O"A" and that they have the same distance from those lines. This means, for example, that the distance O'Q' is equal to O"Q"; thus, instead of the mitering line we can use dividers to transfer measurements.

We choose for each auxiliary view in figure 3, a direction e' and e", and applying the projection-intersection procedure above in the chosen directions, we obtain a drawing whose points are constructed directly, automatically. One thing we immediately see from this projection-intersection is that from an orthographic view of a straight line, we obtain a straight line in the axonometric view. Considering the line OZ, this is immediately clear, since the auxiliary view of this line is a point. Taking the Y axis, the parallel lines projected through O'Q'Y' and O"Q"Y" intersect in points which again must lie on a straight line. For parallel lines in space, one obtains through this projection-intersection, parallel projection lines. The resulting picture thus has the properties of a parallel projection. Following the theorem of Pohlke, OXYZ is the projection of a definite cubical corner whose unit lengths are not immediately known, but which in general do not coincide with the unit lengths of the original cubical corner. The coordinates of a point P appear on the axis in the proper ratio to the corresponding unit length. The new picture is obviously the projection of an object which is similar to that one given by the auxiliary views. When the orthographic views are moved out along the projection lines, the point P results as an element of intersection of the entire axonometric procedure.

This purely planimetric procedure is not only a graphic approximative approach, but is in spite of its simplicity fully theoretically justified. If we require any construction or change of configuration we can develop it first of all in the orthographic views and then directly project into the axonometric views. The lengths of segments are definitively presented in the orthographic views.

Ovbiously the described procedure can be applied to sketching. A sketch is here considered to be more or less a freehand reproduction of an exact draft.

The Choice of a Particular Layout:

In practice, we usually wish to have the projection of an axis to be vertical, so that the direction of the projection e' is determined. The position of the auxiliary projection and the choice of e" is still free (Note that parallel shifting is unessential). This means that the draftsman has an extraordinarily large freedom of choice, inside which he can obtain an arbitrary projection of the object. Obviously, it may happen that in choosing some layout the projection will come out to be very poor. Thus, before one draws a projective picture of a large object, it is a good idea to make a projection of a cube to find out whether its projective picture is most appropriate. In figures 4 to 8 are shown some examples of this procedure.

Example:

In figures 9 are shown the projections of a simple technical object, namely that of a pipe connection. The orthographic projections chosen are the simplest possible. In order to represent the circle, one chooses the orthographic projections of two perpendicular diameters OA and OB from which one obtains two conjugate axes of the corresponding ellipse. Next, one may investigate the procedure of obtaining a point P on the intersection curve, using simply straight line projections.

Relation to Regular Axonometry:

It may happen during the projection process that a particular positioning of the orthographic views gives a normal projection which is nothing other than the well-known procedure of orthogonal axonometry. Suppose there is given the projection of the intersecting axes Oxyz, figure 10. Moreover, there may be drawn a triangle ABC such that these axes are the altitudes of this triangle. Let us now rotate the xy-plane around AB; then the origin O rotates to Position O_o and the axes to O_oA and O_oB. Here the horizontal projection appears in its actual, true shape. In this position the horizontal projection lies within the area of the axonometric view. However, we can shift this rotated system parallel and downward, and obtain the auxiliary horizontal projection O'x'y' with the direction of projection to the axonometric in the a-direction. Obviously, one can also obtain an auxiliary projection O"y"z" with the direction x or an auxiliary projection of the coordinate system x"y"z". The latter does not differ from a non-orthogonal projection procedure.

Thus non-orthogonal and orthogonal axonometric possess common fundamentals and procedure. In general, one can always use a non-orthogonal procedure. Only when spheres or objects of rotation are handled is it more appropriate to use for their projective representation a normal (orthogonal) axonometric representation.

For a presentation of orthogonal axonometric projection, the author referred to the work of Professor Theodor Schmid, Darstellende Geometrie, 1922.

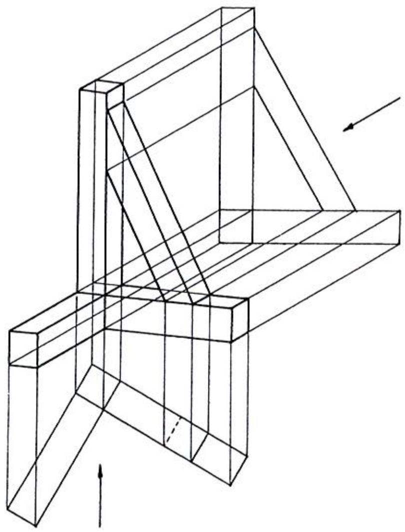


Fig. 1

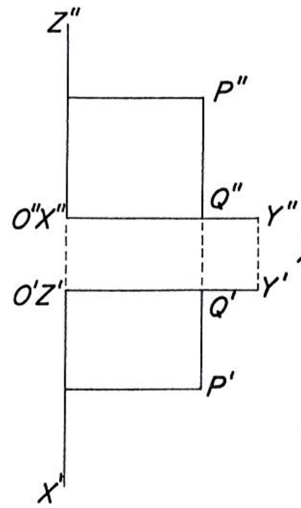


Fig. 2

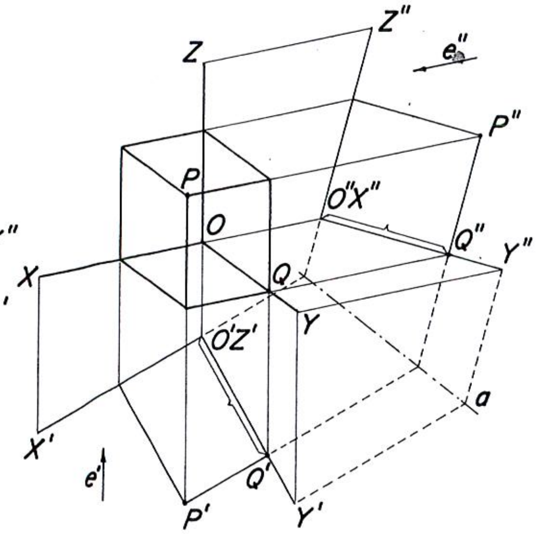


Fig. 3

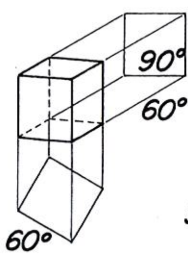


Fig. 4

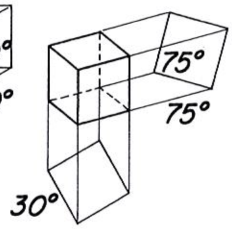


Fig. 5

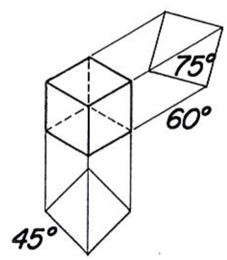


Fig. 6

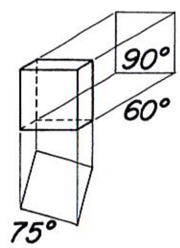


Fig. 7

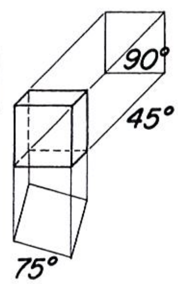


Fig. 8

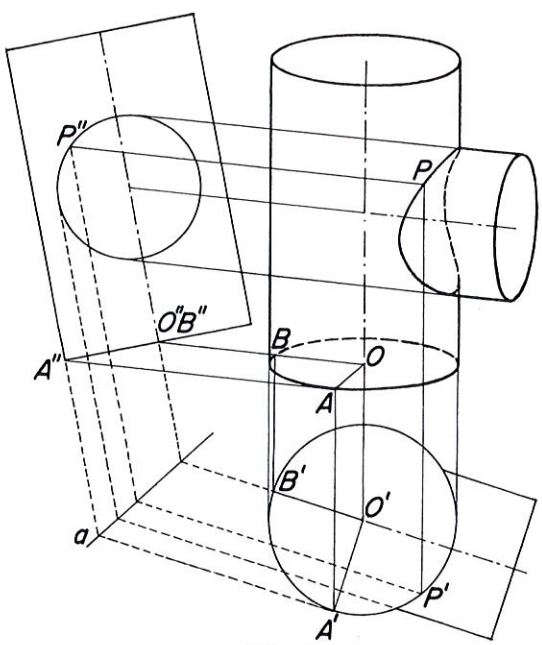


Fig. 9

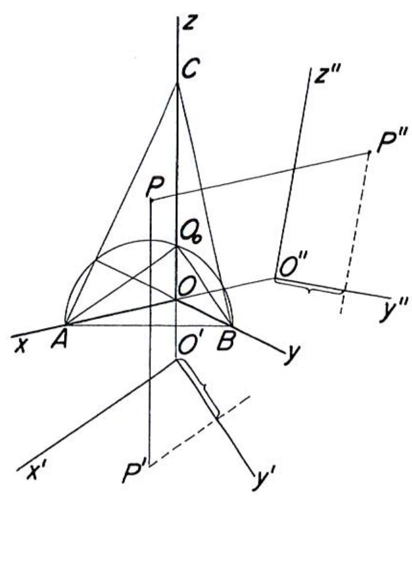


Fig. 10

QUALITY CONTROL SPECIFICATIONS AND THEIR EFFECT ON DRAWINGS

By Marvin Fuller

International Harvester Company

During the last two decades the impact of quality control and statistical methods has brought about both immediate and fundamental advantages. Acceptance of these advantages has led to the adoption of new techniques, new materials and equipment, and most important of all a new way of thinking in the field of engineering and engineering drawings.

Once the possibilities of quality control have been understood a chain reaction follows. Products begin to tell what is happening in a manufacturing process. Equipment is changed to meet requirements. Requirements are revised to meet equipment capabilities and these capabilities are in turn translated into new specifications. These new specifications, based on functional requirements and process capabilities assure the desired results when introduced into the manufacturing flow.

The effective development and application of specifications requires a basic knowledge of variability. Since it is a known fact that variation does exist in all manufactured materials it is not too difficult to accept the general concept of tolerances. Economic manufacture and the application of modern acceptance inspection methods depend on specifications that allow for some variation in the manufactured product. It is inherent in a manufacturing process that its output varies from item to item. A product may be said to be uniform, but in reality no two units will be exactly alike. All we need are instruments fine enough to detect the difference and it becomes apparent that the output is not the same, but does vary from piece to piece. Differences from piece to piece, within specifications are to be expected.

As long as all machinery and the resulting manufactured parts have some inherent degree of variation it is to our advantage to use this information as a guide to more application specifications. The fact that the output of a process does have inherent variation should no longer be a detriment to practical design tolerances. The design engineer, when supplied with the tolerances or the method of determining tolerances that available equipment can attain, has a sound basis for the tolerances on his piece-part drawings.

The numerous causes of variation in a process combine in a random manner to produce a normal distribution, or bell shaped curve of the results when work pieces are measured for a given characteristic and plotted in the form of frequency distribution. (Figure 1.)

This distribution of measurements indicates the central tendency or average measurement obtained from the process, and more important the amount of fluctuation in measurement, or the variation, that can normally be expected from the process.

The term tolerance indicates the amount of variation that can be allowed between one piece and another when all pieces are being made to a single specification.

The extent of this tolerance is governed by two factors:

(a) The requirements of the design in which the part is to be used.

(b) The extent to which the production process can be held within prescribed limits. In other words, with what degree of accuracy can a given job be done with the equipment available.

Quality control techniques have given a reliable means of determining the accuracy that can be expected from a process through the use of the frequency distribution. The concept of the normal curve has also provided the base for bilateral tolerances which in themselves provide a nominal dimension plus and minus a specified amount of variation. Knowing that a normal process will tend to produce an average measurement and a normal curve of variation about this average, the design engineer is in reality simulating the normal curve in his specification when he calls for a nominal dimension plus or minus a given tolerance. (Figure 2)

As an illustration of the trend in specifications brought about by our increasing reliance on the concept of variation and the normal curve, consider a shaft and bored hole where the specifications are stated in the older conventional manner as:

Shaft	O. D.	0.499"	+ .000"	- .001"
Bore	I. D.	0.500"	+ .001"	- .000"

From the shaft specifications as written we would normally conclude:

(1) The most desirable diameter in 0.499". This has been referred to as the nominal dimension and the one most desired by the design engineer.

(2) The diameters may vary only .001". Making the minimum diameter 0.498", the maximum diameter is 0.499" which coincides with the nominal dimension as specified.

The experienced workman would further interpret this type of tolerance as "favoring the high side". His interpretation no doubt is based on the location of the so-called nominal dimension and the direction of tolerance. This type of tolerance also leads the workman to work close to the prescribed nominal dimensions which call for maximum metal and allow stock for rework of rejected O.D's and I.D's rather than scrap due to favoring the limits of minimum metal.

Prior to the advent of quality control it was common practice to specify unilateral, or one-direction tolerances in the case of mating parts. However, since the more common acceptance of the normal distribution theory, two-direction or bilateral tolerances have become more accepted in industry.

Consider the comparison of the two methods of specification. (Figure 3)

Unilateral

Shaft O.D. 0.499" + .000" - .001"
Bore I.D. 0.500" + .001" - .000"

Bilateral

Shaft O.D. 0.4985" ± .0005"
Bore I.D. 0.5005" ± .0005"

(1) The diameters in both cases may vary only .001"

(2) The most desirable diameter of the bilateral method is the mean or truly nominal diameter.

(3) The minimum and maximum diameters are unchanged. But, the workman is striving for the nominal diameter can depend on the normal variation in the process to provide acceptable parts all within specifications.

(4) Rework due to favoring the maximum metal theory is radically reduced.

Realization that the ability of a process to maintain tolerance is determined by the variation within the process has had its affect on the individual parts drawings. But what about the assembly that is made up of different parts all of which have variation within themselves?

With knowledge of the inherent variability of the components it appears logical that we should be able to determine the limits of resulting variation in the assembled product. This line of thinking has led to the formation of a new aspect in determining the tolerances of assemblies and their components.

In general, our present tolerances for parts and related assemblies have been established on the premise that the tolerance of the overall assembly should be equal to the arithmetic sum of the tolerances of the parts that make up the assembly. (Figure 4)

Here again quality control has turned to the theory of random dispersal of parts coming from a controlled process, and introduced a new concept of tolerances for assemblies and related parts. Based on a well established law of probability we now know that the overall tolerance of a group of mating parts equals the square root of the sum of the squares of the individual parts tolerances.

$$T_t = \sqrt{T_1^2 + T_2^2 + T_3^2 \ldots\ldots T_n^2}$$

where T_t = overall tolerance

T_1, T_2, etc., = tolerances of the individual mating parts.

The expected variation, when controlled can be of great value to the engineer. Consider the design problem of four adjacent parts, all with finished surfaces operating between the fixed surfaces of a machined gear case.

If all parts become excessively small or large in themselves, there is a possibility of interference or sloppy fits.

There are two alternatives in the situation of mating parts, (a) Selective assembly of parts that match each other, (b) Statistical control of the components.

There are four disadvantages to selective assemblies:

(1) High inspection or sorting cost.

(2) Stock inventory becomes large when storing parts to be matched.

(3) Shortages may result when the bulk of the product being produced is to either extreme of its tolerance.

(4) Lack of interchangeability when stock parts are assembled in the field.

The most satisfactory method is to establish all specifications as bilateral and adjust the process to aim at the nominal.

With this in mind, what should be the nominal dimension and the tolerance for the milled area within which the four parts must fit?

The conventional method would be:

Part No.	Nominal Dimension	Individual Tolerance
(1)	1.750"	.004"
(2)	1.125"	.004"
(3)	.800"	.002"
(4)	1.250"	.004"
	4.925"	.014"

Milled Slot = 4.925" ± .007"

Using the statistical method we can determine the stack up of the tolerances in the following manner:

$$T_t = \sqrt{T_1^2 + T_2^2 + T_3^2 + T_4^2}$$

$$T_t = \sqrt{4^2 + 4^2 + 2^2 + 4^2} \qquad T_t = 7.21 \text{ or } .00721"$$

$$T_t = \sqrt{16 + 16 + 4 + 16} \qquad T_t = \pm .0036"$$

$$T_t = \sqrt{52}$$

The nominal dimension remains unchanged, but the tolerance of the milled slot as determined by the statistical method is about one-half the tolerance determined by the conventional method.

If it is desirable to accept the milled slot tolerance at ± .007" then we can broaden the individual tolerance. In most cases the individual tolerances can be approximately doubled.

If upon examination of the individual parts processes we learn that one of the components cannot be economically held within prescribed tolerance, we can often accept the inherent variation in the particular process and revise one or more of the remaining parts tolerances without noticeably affecting the overall assembly tolerance.

Let us consider an actual case where the statistical approach to tolerances of mating parts was used to advantage in a manufacturing process.

The problem concerned the excessive amount of rejected parts from milling operations on automotive connecting rod components. (Figure 5)

Blueprint tolerances for width of the milled slots and corresponding lugs had been established in the customary manner callint for clearances between lugs and slots to be held within .0005" to .0025".

Individual parts tolerances were determined as follows:

(1) Determine the average clearance
(.0005" + .0025")/2 = .0015".

(2) Make the difference in nominal dimensions of Slot and Lug .0015"

Nominal Slot Width	=	.2515"
$\bar{X}$ Avg. Clearance	=	.0015"
Nominal Lug Width	=	.2500"

(3) Establish tolerances of $\pm$ .0005" for slot and lug to provide minimum clearance of .0005" and maximum clearance of .0025".

Width of Slot		Width of Lug	
.2515"	.2515"	.2500"	.2500"
+.0005"	-.0005"	+.0005"	-.0005"
.2520" Max.	.2510" Min.	.2505" Max.	.2495" Min.

Min. Slot	.2510"	Max. Slot	.2520"
Max. Lug	.2505"	Min. Lug	.2495"
Min. Clearance	.0005"	Max. Clearance	.0025"

(See Figure 6.)

On investigation it was determined that the available milling equipment could not maintain an overall variation of .001" but could maintain an overall variation slightly in excess of .0015".

Could the statistical approach to tolerances be of any aid in this situation?

The statistical approach in this case is based on the theory that the variation in the clearances is dependent on the variation in the lug and slot sizes according to formula.

$$\sigma c = \sqrt{\sigma L^2 + \sigma s^2}$$

where σc = Standard deviation of the clearances.
σL = Standard deviation of lug widths.
σs = Standard deviation of slot widths.

In a normal distribution the range of $\pm\ 2\sigma$ will contain 95% of the expected observations. Hence, the range of $\pm\ 2\sigma$ is equal to the range of clearances desired in this case (.0025" - .0005") or .0020".

Therefore $\pm\ 2\sigma_c$ or $4\sigma_c$ = .002"

and σc = .002/4 = .0005"

this in turn means that

$$\sqrt{\sigma L^2 + \sigma s^2} = .0005''$$

assuming as before equal tolerances for slot and lug.

$$\sigma s = \sigma L$$

Combining $\sqrt{2\sigma s^2}$ = .0005"

$$1.414\sigma s = .0005''$$

$$\sigma s = .0005/1.414$$

$$\sigma s = .00035''$$

$$3\sigma s = .00105''$$

Tolerance on slot and/or lug = $\pm$ .001".
(See Figure 7)

There is no trick to the tolerances we have developed. In plain language the idea is that the law of probabilities will not let extremes come together very often. A maximum lug and a minimum slot can in themselves occur, but for both to be randomly selected at the same time is not very probable. In theory, 100% control of parts to arithmetic tolerances will produce 100% good assemblies - poor assemblies are impossible.

In our example statistical control of the process will allow for normal fluctuation of parts within the revised tolerances and piece parts previously considered rejects are in reality acceptable parts.

Under the statistical solution poor assemblies are "improbable". If we reduce the probability to a very low value (as in our example) there is little difference numerically between the impossible and the improbable. However, the ease of making parts within acceptable specifications improves to a great extent.

There are many advantages to be gained by acceptance of quality control techniques, and the more forward organizations are putting these advantages to work with very good results. The skeptics of course will have to be shown, but in the meantime the estimating, arguing and confusion between manufacturing and engineering will continue.

To quote one of our more progressive gage manufacturers: "The effort against progressive inspection and quality control techniques may reasonably be regarded as an admission of sub-quality product resulting from lack of progress in inspection methods, manufacturing and design methods and equipment, and general operational defects. It would be well to remember the well known adage, you can't compete successfully for Today's or Tomorrow's business with yesterday's tools and methods."

SEE YOU AT ROLLA !

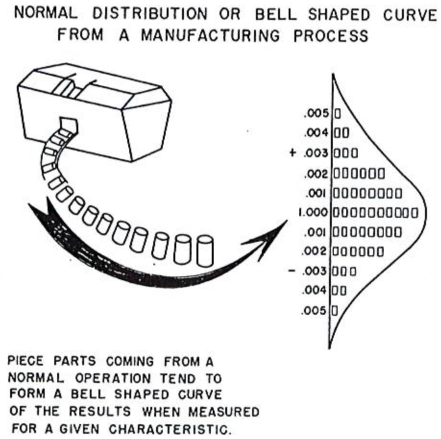


Figure 1

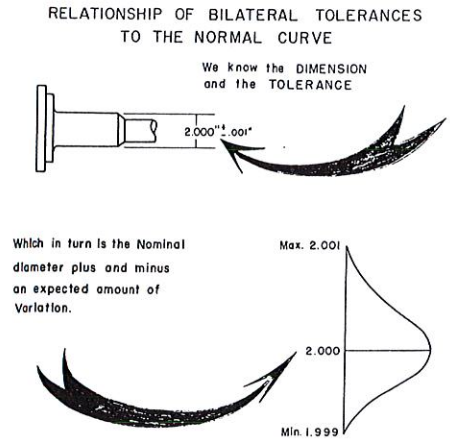


Figure 2

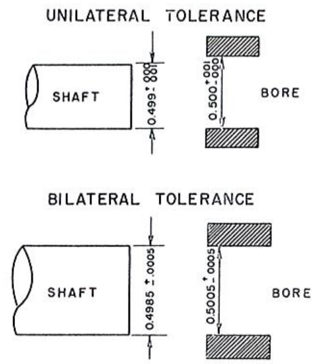
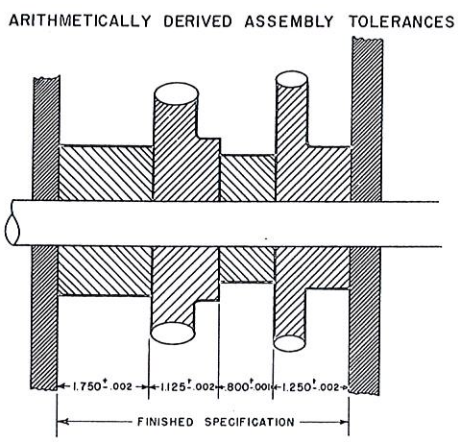


Figure 3



	MIN.	MAX.	TOL.
A	1.748	1.752	.004
B	1.123	1.127	.004
C	0.799	0.801	.002
D	1.248	1.252	.004
FIN. SPEC.	4.918	4.932	.014

Figure 4

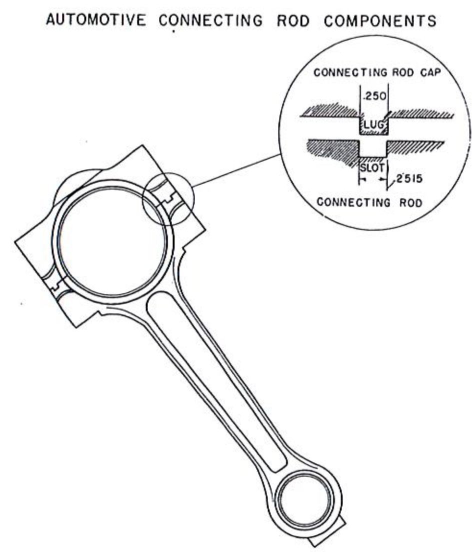


Figure 5

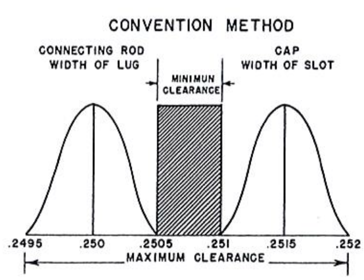


Figure 6

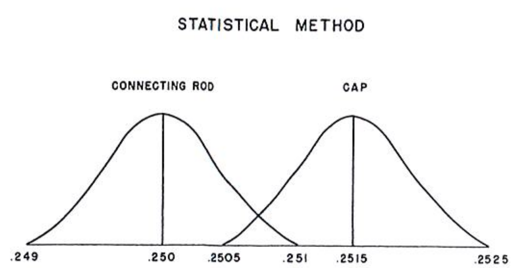
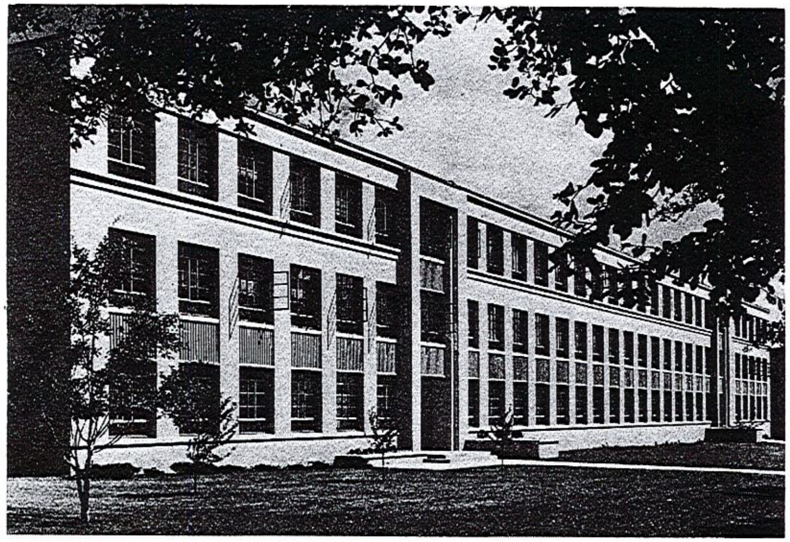


Figure 7



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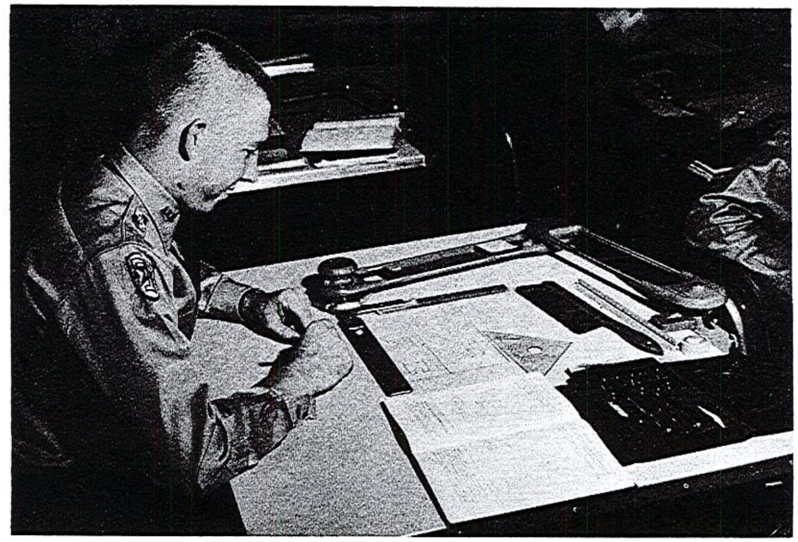
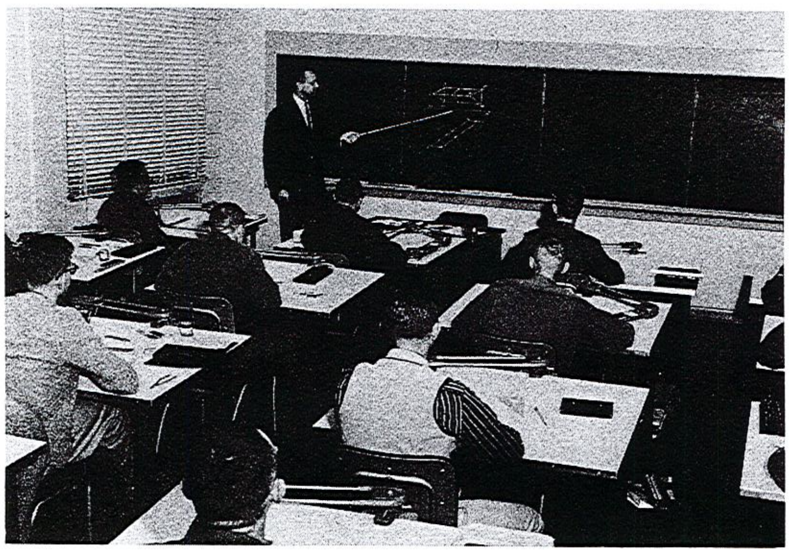


EACH ENGINEERING DRAWING STUDENT HAS ACCESS TO THE FINEST DRAFTING MACHINES AND TABLES. 3

2 THE CLASSROOMS ARE WELL EQUIPPED.



DRAWINGS ARE REPRODUCED IN ALL THE MEDIUMS USED BY INDUSTRY. 4

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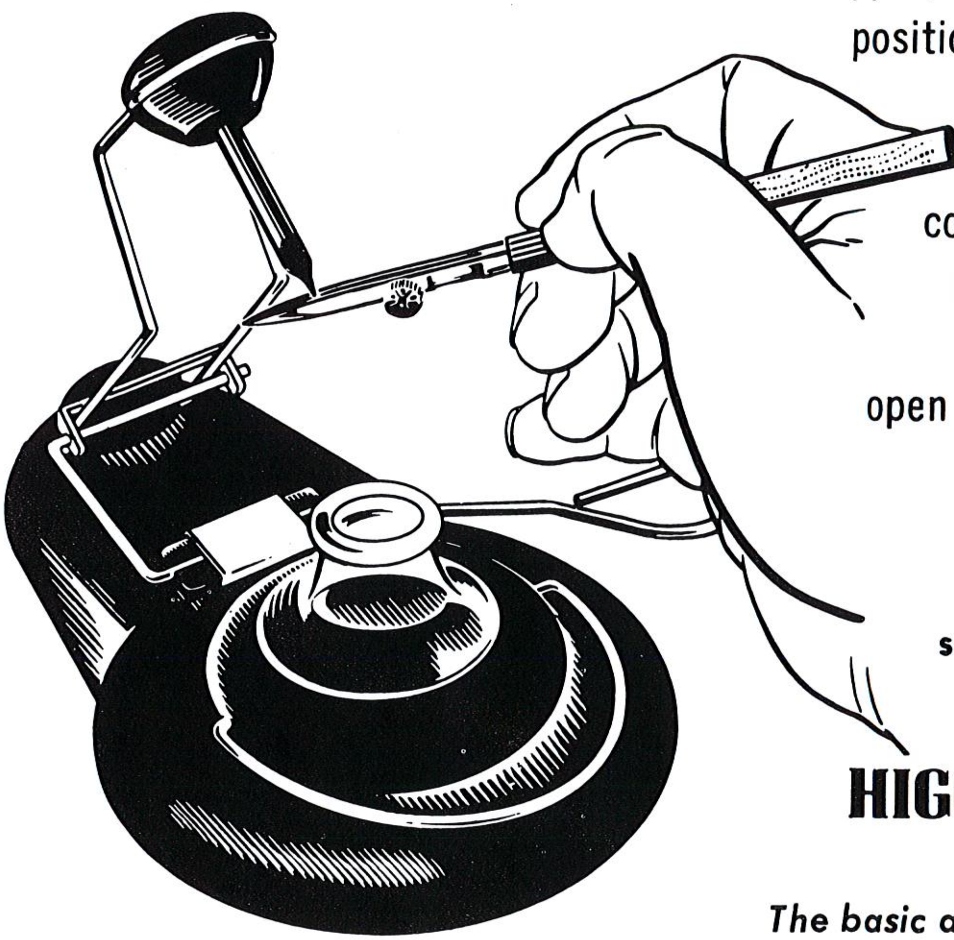

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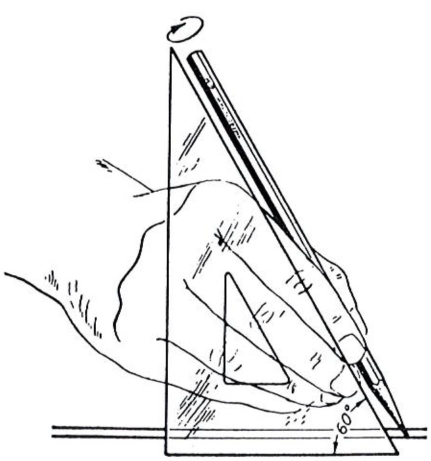

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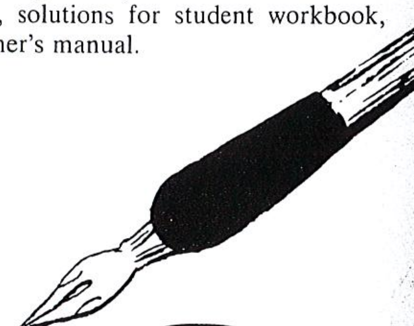

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