THE JOURNAL OF
ENGINEERING DRAWING

CONTENTS

Analysis
Synthesis
Communication

Vol. 22, No. 2 **MAY, 1958** **Series No. 65**

Published by the
DIVISION OF ENGINEERING DRAWING AND DESCRIPTIVE GEOMETRY
of the American Society for Engineering Education

TECHNICAL DESCRIPTIVE GEOMETRY

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

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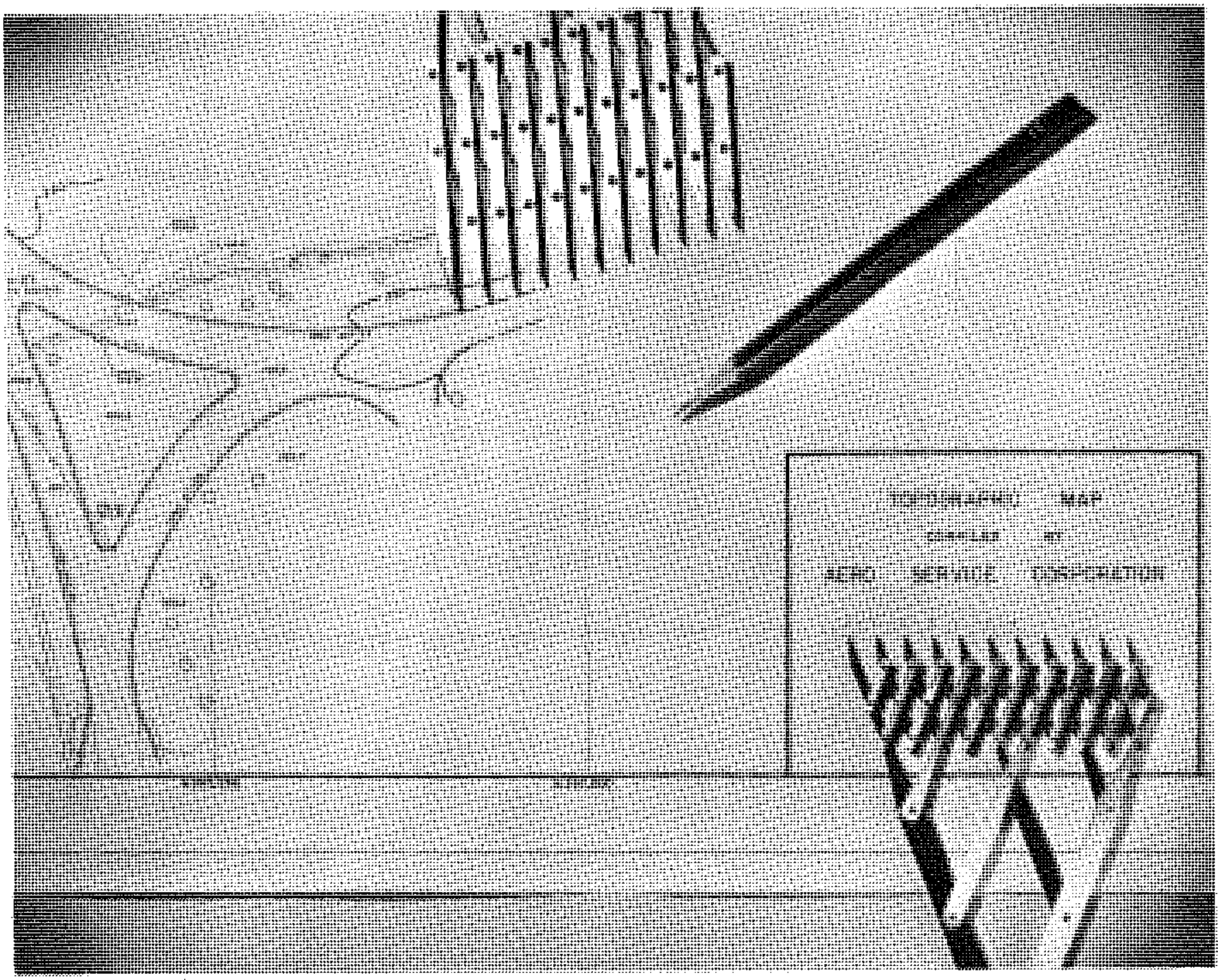

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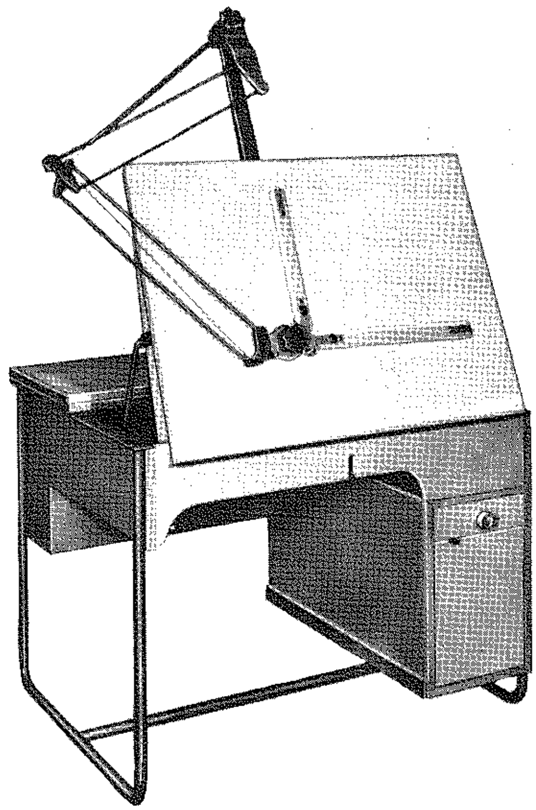

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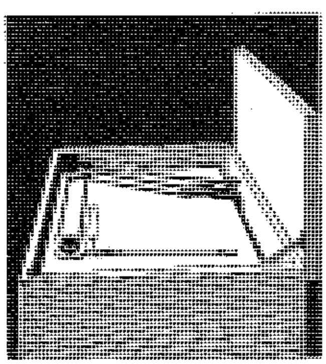

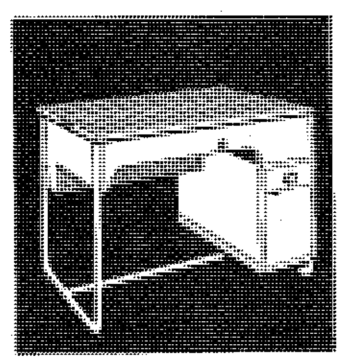

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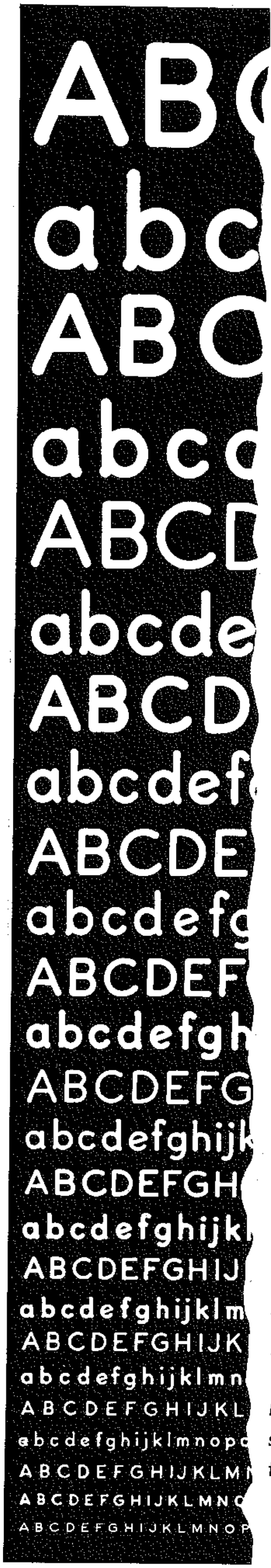

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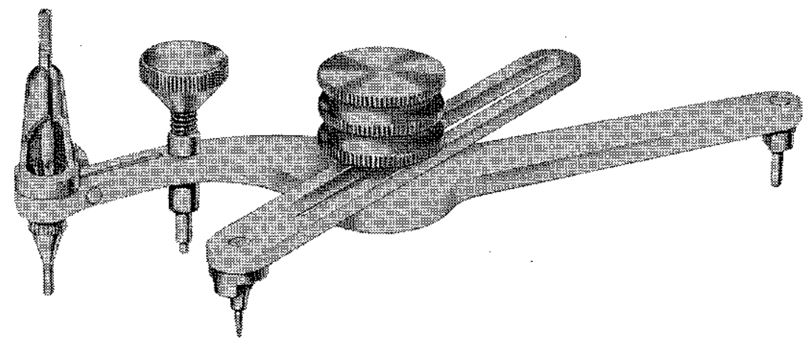

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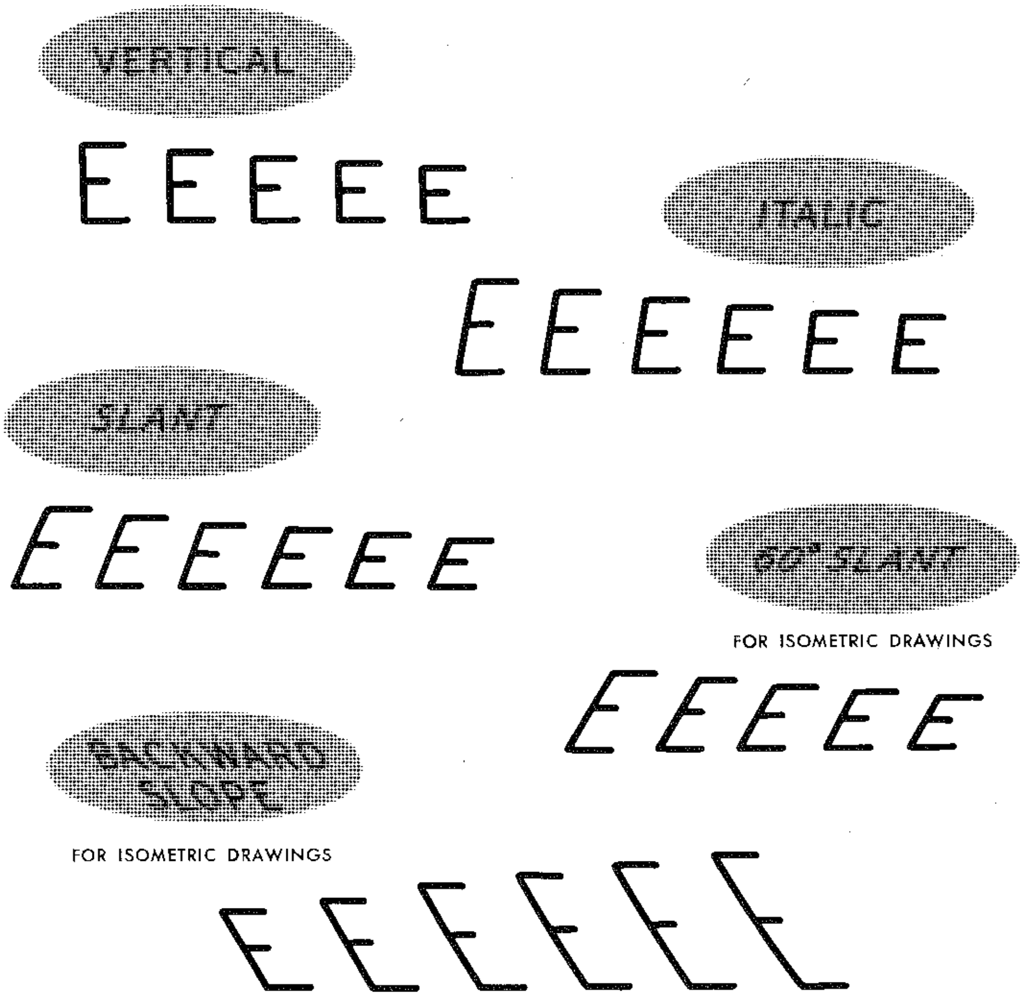

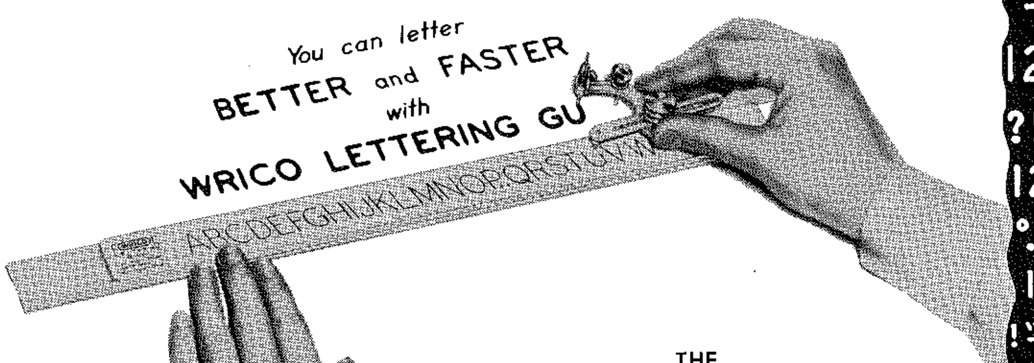

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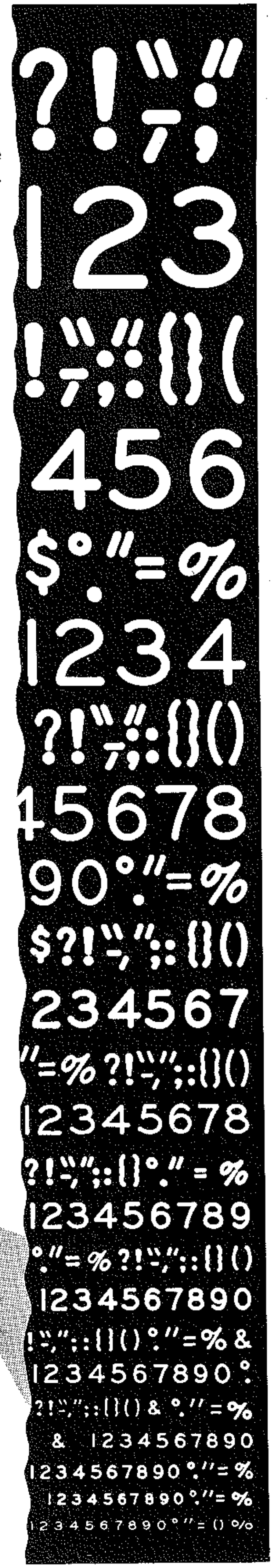

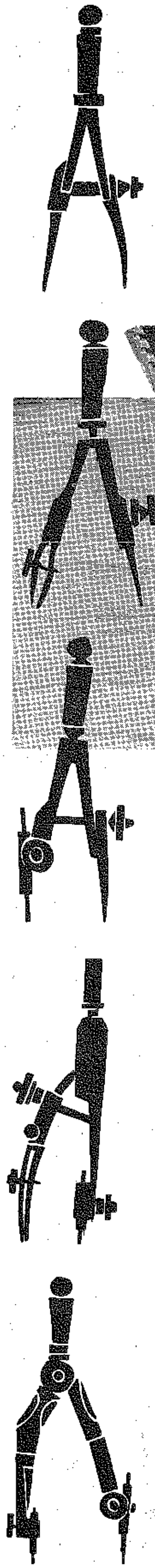

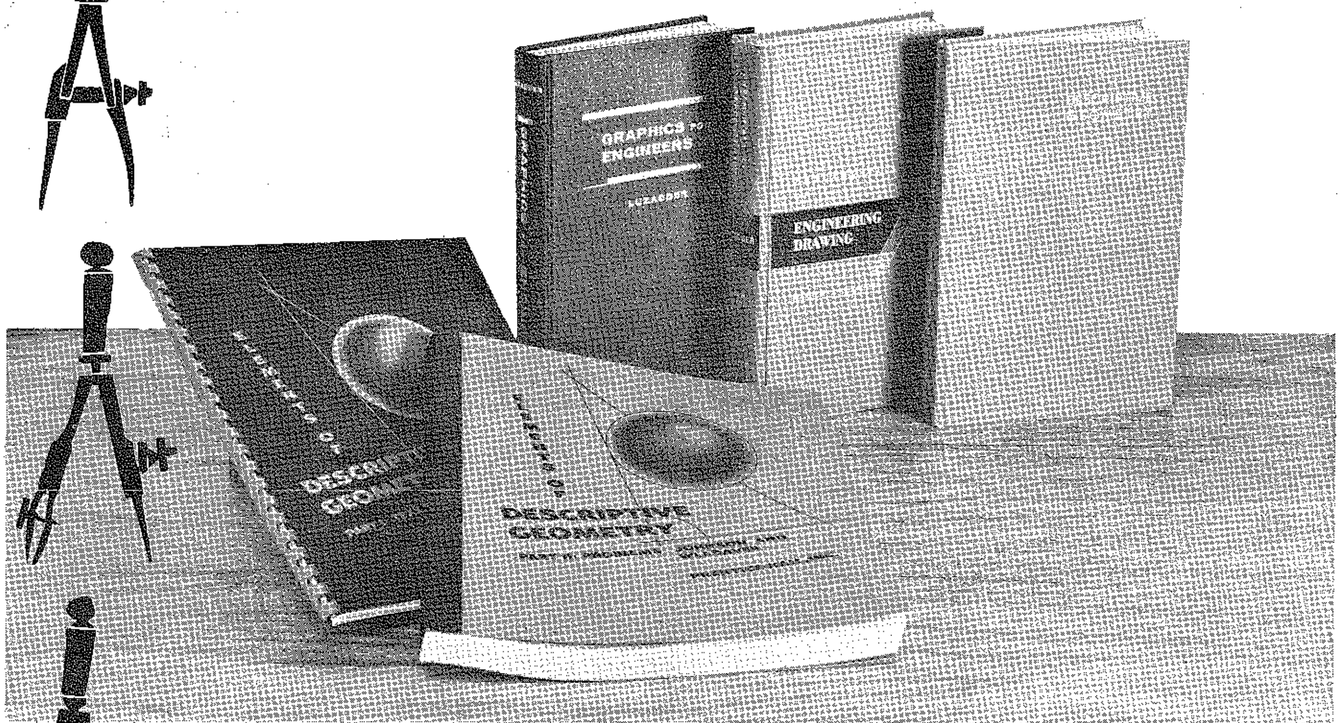

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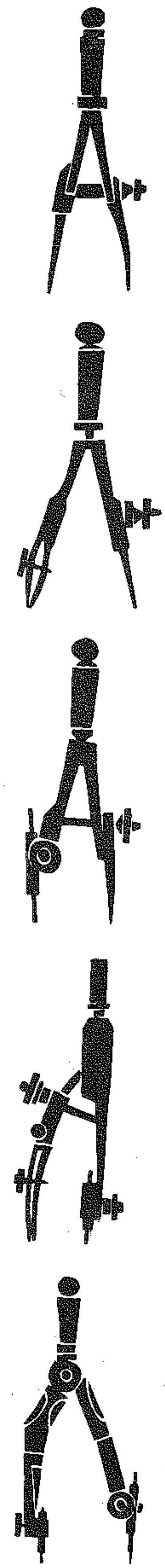

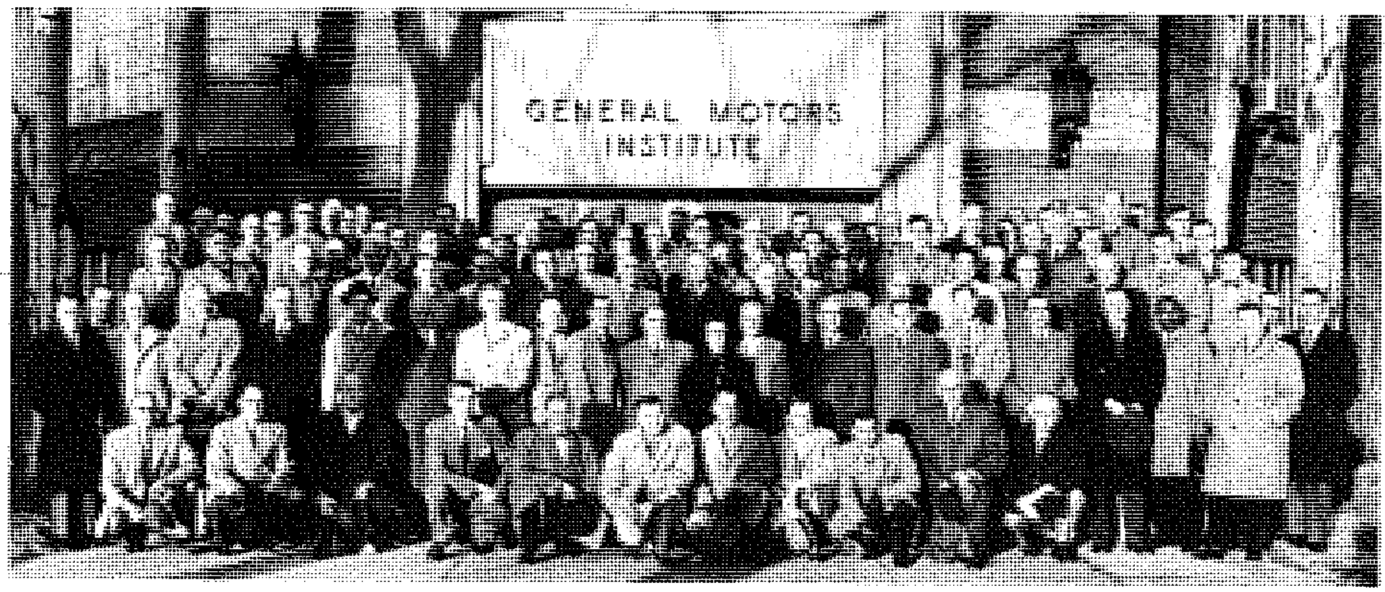

ASEE ENGINEERING DRAWING DIVISION

Mid-Winter Group Picture

General Motors Institute, Flint, Michigan

January, 1958

(The following list is incomplete)

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Editorial Page

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There is fairly substantial agreement, we believe, that the name of our Division no longer fully reflects what we are doing in our classrooms toward the education of young engineers. Should we change the name?

The members of the Executive Committee have debated the matter at great length and have reached only one conclusion: That such an important step must not be taken lightly. The decision was to submit the subject to the membership at large for the guidance of the Executive Committee.

This is not just lip-service to democratic action. Your opinion is not only wanted; it is needed. Please let the Executive Committee know your feelings about whether or not the name of the Division should be changed and, if so, what the new name ought to be.

We earnestly hope that everyone who has opinions will speak up while there is still a chance to say yes or no.

THE MID-WINTER MEETING AT GENERAL MOTORS INSTITUTE

Congratulations to Earl D. Black and his staff at the General Motors Institute, Flint, Michigan, for one of the finest meetings in Division history. It was a record-breaking event in size of registration: there were 206 persons registered, not counting General Motors personnel.

But size alone is relatively unimportant. Speaking for himself, the editor confesses he had a wonderful time because of old friends he met again after an interval, somehow always too long; and because of new friends, somehow always too few. And you know, sometimes a fellow even learns something at a Division meeting.

Now, we have nothing against GM Institute, but we hope that the next mid-winter meeting, at Wayne State, Detroit 1959, breaks the new GMI record into at least 207 pieces.

BERKELEY, JUNE 1958

If we had printed everything Professor A. S. Levens sent us about the University of California at Berkeley, there would have been nothing else in this issue.

Let's all go to Berkeley and see for ourselves.

THE HIGH SCHOOLS HAVE SOMETHING TO SAY

Instead of ranting against the high schools for their omissions, as some of us have done, we might spend more time listening to what high school teachers say.

Several attended the Flint meeting and spoke up, we are glad to say. Several have contributed to the JOURNAL. We hope this continues, for we all stand to gain.

SWAN SONG

Editing the JOURNAL OF ENGINEERING DRAWING has been quite an experience. Fools rush in, they say . . . Well, since this editor is no angel, draw your own conclusions. Every editor (until now, that is) has added something good to the magazine. Nor is there much doubt that each has made a few mistakes. Of mistakes, this editor has had a full share. In fact you might even say his cup runneth over.

But try to imagine what might have happened without good people to keep him in check, good people like Professors Harold Howe, A. P. McDonald, and Ed Griswold. To each of these redoubtables, our sincerest thanks. Our gratitude also to Professors R. C. Carpenter, O. M. Stone, and Frank Zozzora, whose artistry speaks for itself, and to the writers who delivered copy on request.

To the new editor, whoever he may be, congratulations and the best of luck. His education is about to begin.

The Development of Graphical Representation*

By Frederic G. Higbee
The State University of Iowa

Just when man became conscious of a need for some means other than spoken and written language to express ideas is not known. In the very nature of things it would appear that drawings of some kind must have been used to guide the ancient builders, for drawings are now, and must have always been the necessary accompaniment of constructive endeavor. To contemplate the work of earliest times is to appreciate the fact that there must have been a carefully thought out plan to guide the work. In just what form this plan was presented, there is, of course, no record. It may have been but a crude sketch pictorially representing the idea, and leaving much to the initiative and imagination of the builders; it may have been an artistic rendering dealing largely with appearances and meagerly with details; it may have been a cryptic expression based on a system of description now lost like the languages of the ancient tribes. These representations served and functioned, nevertheless, much as do modern drawings, if results may be used as a measure.

It seems not unreasonable to believe that when Tubal-Cain—who is alleged to have been the first teacher of shop work according to Genesis 4:22—set up his forge on the plains of Mesopotamia and began his lessons in the working of brass and iron, he must have used some means of representation to convey his ideas. These may have been no more than crude diagrams in the sand, yet they served a purpose. Nor does an examination of some of the archaeological discoveries from the biblical cities of Palestine leave one in doubt about the ability of an ancient people living as early as 2000 B.C. to portray a story in pictorial form. Meager as such evidence is concerning the beginnings of a science which is now a controlling force in human enterprise, it is all that remains to show that even in those early days the spoken and written language needed to be supplemented.

In this very connection, it may not be too farfetched to speculate on the possibility that in the building of the Tower of Babel a "confusion of tongues" may have meant inadequate direction and that failure was due to a lack of blue prints!

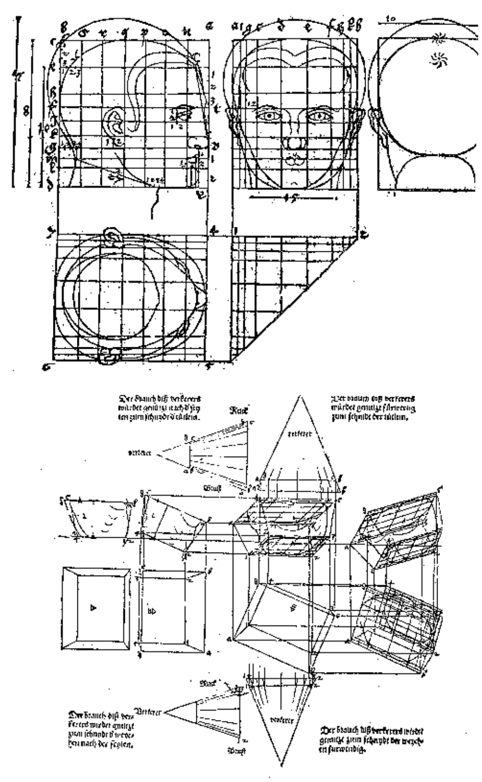
Early evidence, which definitely establishes the fact that drawings were used to guide constructive undertakings, is found in the writings of Vitruvius (63 B.C.—A.D. 14) who states—"The architect must be skillful with the pencil and have knowledge of drawing so that he readily can make the drawings required to show the appearance of the work he proposes to construct,. . ."

Other references in Vitruvius establish the fact that draftsmanship was recognized and that drawings were the method used to convey structural ideas.

In about 100 B.C. Frontinus, who became "Curator Aquarum," relates how he had plans made of the Roman aqueducts.

In commenting upon these facts, Professor Alexander P. Gest states: "I have no doubt that there must have been at least a practical knowledge of drafting among the Greek and Roman engineers, and it is hard to imagine the Greek geometers without some sort of Descriptive Geometry."

But just when the geometry of description had its origins, and its applications to the transfer of constructive information, is still unknown. Engineers have not been too interested in origins, and to those who are the facts are only to be had in languages such as early Italian and German, most difficult to read. Pioneer artists and writers such as Ghiberti, Alberti, Pierro, Viator, Durer were concerned primarily with the geometry of converging visual rays, the graphical mathematics of the proportions a picture should have in relation to the object, and the proportions within that



Projection drawings
Albrecht Durer (1471-1528)

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picture due to its varying distances from the artist's eye. Even as they developed and systematized the graphical science of perspective, these artists and writers were aware that a one-view drawing had its limitations in presenting true conditions. Pierro della Francesca (1410–1492) used three-view drawings made by orthogonal projection methods, and in Albrecht Durer's "Vier Buchen von Menschlicher Proportion" published in 1528, nearly a century later, illustrations clearly show that he understood and used three-view drawings made by recognized projection methods.

Of Leonardo da Vinci more is known. Not only was he a great artist, but he was also a great engineer. His treatise on painting, which included an exposition of the theory of perspective, doubtless exercised a great influence on the art and artists who were his contemporaries; and his vast collection of sketch books are filled with sketches of assembled machines and their details. Whatever may some day be discovered about the mechanical proficiency of Leonardo's time, this great collection of ideas so marvelously expressed in graphical language, forecast the mechanical development of the years which followed.

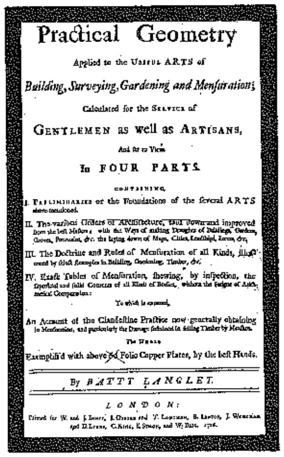
In "The History of Mechanical Inventions" by Usher, reference is made to a "selection from the mechanical drawings" in Leonardo's various manuscripts, and relates how these passed from one owner to another, from Italy to Spain, to England and back at last to the Ambrosian library at Milan in 1636, where they remained until the invasion of Napoleon. "They were then brought to Paris and many of them never returned." Whether the "mechanical drawing" referred to here means graphical representation of the type now called orthographic representation, or whether "mechanical drawing" in connection with Leonardo's work means graphic representation by the method of scenographic projection made with mechanical aids, is not clear.

It is not so important to establish in this record the type of graphic representation used at this period, as it is to establish the very important fact that during da Vinci's active life—from 1475 to 1516—he practiced and taught a method of graphical description which had for its direct purpose the recording and conveying of ideas on mechanical subjects.

Passing now to the period which followed da Vinci some evidence is to be found showing that drawings were commonly used in constructive work. While most of the structural activity of that period centered around public buildings and civil engineering works of a public character, there is reason to believe that graphical representation was the common source of information used to guide the work.

There was in existence a few years ago, a set of drawing instruments bearing the date 1701, and which in many details bears a striking resemblance to our modern high-grade sets. In workmanship alone, here is testimony concerning the age of drawing of a striking character; for these tools obviously were the product of many years of use and development, both in the art of instrument-making and in the art of draftsmanship for which they were designed.

In 1715 Brook Taylor published the first book in the English language on perspective which was entitled: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Batty Langley's book,
1726.

"New Principles of Linear Perspective, or the art of designing on a plane the representations of all sorts of objects in a simpler method than has yet been done."

In 1726 Batty Langley published the first book on what has developed into Engineering Drawing. The book, a beautiful example of printing—hand-set type, and hand-made paper—is called "Practical Geometry, Applied to the useful arts of Building, Surveying, Gardening and Mensuration."

Commenting upon the forces which gave rise to the discovery of the science called descriptive geometry, Alexander W. Cunningham in his "Notes on the History, Methods and Technological Importance of Descriptive Geometry" states: "Architecture and stone masonry have always necessitated the study of geometrical drawing. I am aware that Mr. Fergusson in his History of Architecture (page 665) ignores the idea of any great attention having been paid to graphical designs in the erection of the early Gothic Cathedrals. But it appears to me that Mr. Fergusson, in maintaining (what is probably quite correct) that the nomadic masons were not the architects of these Cathedrals, but that the Bishops, abbots, and accomplished laymen, 'not specially educated' to the profession of architecture, and qualified only by 'talent and good taste,' fulfilled this office, goes too far when he says that 'without making drawings,' guided only 'by general directions as to the plan and dimensions, the masons might proceed with the work.'

"Mr. Fergusson, however, referring to Masonry itself, says (page 666), 'When freemasonry became so powerful as to usurp the designing as well as the execution of churches, there was an end of all art, though accompanied by some of the most wonderful specimens of stone-cutting and constructive skill that ever were produced.' Now this art of stone-cutting deserves to be particularly mentioned as having given birth to many ingenious, graphical, and constructive operations, more especially as, for obvious reasons, it was practically associated with the art of dialling. Geometrical methods, both graphical and constructive, which in the middle ages and early modern times had been cherished as secrets pertaining to the masonic craft, were in the seventeenth and eighteenth centuries expounded in treatises on the art of stone-cutting.

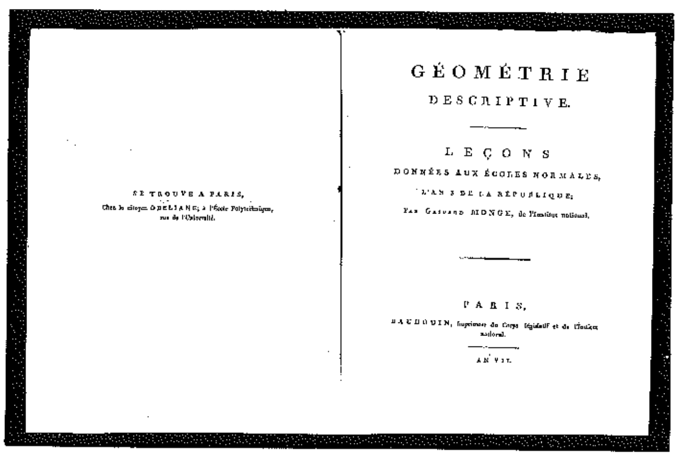
"I regret that it is impossible for me at present to notice the development of graphical geometry with respect to Shipbuilding, an art especially dependent on scientific means of graphical representation. I pass on to Fortification....

"...Accordingly, towards the close of last century, the French mathematician Monge was led, from the consideration of certain problems, in fortification, to

Gaspard Monge
(1746-1818)

generalize all the isolated method hitherto employed, not merely in fortification, but in perspective, dialling, stone-cutting, etc., into a theoretical code, which he termed la Géométrie Descriptive, and which was designed to supply the means of—(1st) preparing on uniform principles the working drawings necessary in the various arts; and of (2nd) graphically solving problems in solid geometry, by general methods, capable of the most extensive practical application.

"Gaspard Monge was born at Beaume in 1746, having early given evidence of distinguished mathematical talents, both as a student and teacher in the College at Lyons, he obtained an appointment as draughtsman in the military school at Mezieres. Here he distinguished himself by his geometrical solutions of questions in Defilade (Defilement), a term given to the general problem of securing in the design of a work of defence, thrown up on an irregular site, the utmost amount of cover compatible with a certain moderate 'relief' or height. 'By applying,' says Dupin, 'his mathematical talents successively to different questions of an analogous character, and generalizing in every instance his modes of conception and operation, he succeeded at last in establishing a code of doctrine—his Descriptive Geometry....But how many



SE TROUVE A PARIS,

GÉOMÉTRIE
DESCRIPTIVE.

LEÇONS
DONNÉES AUX ÉCOLES NORMALES,
L'AN 3 DE LA RÉPUBLIQUE;

PARIS,

AN VII.

First pages Monge's Descriptive Geometry, 1st Ed.
"An VII" means the 7th year after the French Revolution.

obstacles had he to overcome before he could overthrow the scaffolding of a mass of incoherent practices, and substitute for them a simple and general method, which left no longer a vantage-ground for charlatanism, or an asylum for the mysteries of empiricism!"

Coincident with the development of the science of orthographic projection, came the beginnings of "the interchangeable system of manufacturing," and the establishment of technical education in the United States.

Even while Monge was pleading for the study of descriptive geometry, as means of stimulating manufacturing in France, Thomas Jefferson, then Minister to France, in 1785 wrote in describing the manufacturing of guns: "...it consists of the making of every part of them so exactly alike that what belongs to any one may be used for every other...."

In another letter written later to President James Monroe, Jefferson stated that Le Blanc, a French mechanic, had extended his system and that he, Jefferson, was hoping to get him to come to the United States. That Jefferson grasped the advantages of this system of manufacturing is evident from these early letters; that his interest continued is shown by a quotation from a letter he wrote in 1801 about Eli Whitney: "He has invented molds and machines for making all the pieces of his locks, so exactly equal that take one hundred locks to pieces, and mingle their parts, and the one hundred locks may be put together by taking the pieces which come to hand."

In England during the period just preceding and following Monge's discovery, such men as Sir Christopher Wren, Smeaton, and Telford were making use of the empirical knowledge of their times in graphically describing cathedrals, light houses, and public works. Smeaton is known to have taken down the interior walls of a cooperage in order to lay out on the floor his design for the Eddystone Light which he began in 1757. Telford lived long enough after the publication of Monge's work to have been influenced by it, for in connection with some of his work in 1821 a three-view drawing was printed. During this period, there seems to be abundant record to show that drawings were used in connection with public work of an architectural and civil engineering character, but we should credit James Nasmyth (1808-1890) for his influence in applying this new language to the description of machinery.

The story of the steam hammer that Nasmyth sketched in 1839, is now a classic, but of his ability as a draftsman the following is of interest: "James Nasmyth was the tenth in a family of eleven children. Like all of his brothers and sisters, he inherited his father's artistic tastes. If he had not become an engineer he would probably have become distinguished as an artist. To the end of his life his skill with his pencil was a constant source of pleasure and convenience. The notebook in which the late record of his mechanical ideas is contained, is crowded with funny little sketches, landscapes, little devils and whimsical figures running in and out among the calculations...."

In France and in Germany, Monge's descriptive geometry became very quickly a part of the national education plan, and in 1816 Claude Crozet introduced the subject into the educational scheme of the United States at West Point. After graduating at the Polytechnic School in Paris, Crozet had been an artillery officer under Napoleon. From 1816 to 1817 he was assistant professor in engineering at the Academy, and from 1817 to 1823 full professor. E. D. Mansfield has given us some interesting recollections of Crozet's earliest teaching at West Point.

The junior class of 1817-18 was the first class which commenced thoroughly the severe and complete course of studies at the Academy. Of Professor Crozet, Mansfield says that he was to teach engineering, but when he met the class he found that he would have to teach mathematics first, as not one of them had had the necessary preliminary training in pure mathematics for a course in engineering. "The surprise of the French engineer, instructed in the Polytechnique, may well be imagined when he commenced giving his class certain problems and instructions which not one of them could comprehend and perform." "We doubt," says E. D. Mansfield, "whether at that time more than a dozen or two professors of science in this country knew there was such a thing (descriptive geometry): certainly they never taught it, and equally certain there was no textbook in the English language."

This science, founded by Monge, was then scarcely thirty years old. Crozet meant to begin by teaching this branch, but a new difficulty arose. Just then he had no textbook on the subject, and geometry could not be taught orally. What was to be done? "It was here, at this precise time, that Crozet, by aid of the carpenter and a painter, introduced the blackboard and chalk.[1] To him, as far as we know, is due the introduction of this simple machine. He found it in the Polytechnic of France."

In 1821 Crozet published his "Treatise on Descriptive Geometry," for the use of cadets of the United States Military Academy at West Point, thus antedating all but the original books on the subject. The first eighty-seven pages were given to the elementary principles, and the next sixty-three pages to the application of descriptive geometry to spherics and conic sections. This is, according to our information, the first English work of any importance on descriptive geometry, and the first book published in this country.

Even before descriptive geometry was introduced into the curriculum at the Academy, Christian Zoeller was made instructor of drawing in 1807. Later he was made professor and is doubtless the first teacher of drawing in our first school of engineering. Probably on the walls of West Point is a more complete record of the stages through which graphical representation has passed, than exists anywhere in this country. Although it is recorded that Christian Zoeller was an instructor of drawing at West Point in 1807, it must be remembered that painting and other forms of graphical expression were then taught to the embryo soldiers and among these records on the walls of West Point is a sketch by Whistler, who was once a cadet.

During the years 1802—1824, the United States Military Academy established the beginnings of engineering education in this country. At the same time in New England the technique of interchangeable manufacturing applied to guns and locks by such men as Whitney, North, Jerome, and Colt was creating a demand for scientific knowledge. This demand was amplified by conditions following the War of 1812: The exhaustion of the soil by unscientific methods of agriculture, the demands for better systems, the trend toward new lands in the West, all tended to focus attention on the need for scientifically trained leaders.

Commenting upon this situation, Dr. Charles R. Mann, in Bulletin 11, on "A Study of Engineering Education" states: "In spite of the widespread recognition of the need, the Rensselaer Polytechnic Institute remained for twenty-three years the only school of its kind. Union College offered courses in engineering in 1845, and Brown University in 1849. In 1847, through private benefactions, the Lawrence Scientific School was established at Harvard and the Sheffield Scientific School at Yale. The University of Michigan also voted that same year to offer a course in civil engineering. These were the only engineering schools opened before the Civil War, and they had a hard struggle for existence because their aims seemed dangerous to academic traditions.

"During the Civil War, Congress passed the Morrill Act (1862) granting federal aid to the several states for founding colleges of agriculture and mechanic arts. State legislatures that had for years been deaf to all appeals now quickly accepted the federal grants and voted to create the new type of school. Established colleges caught the spirit and added departments of engineering. The four schools of 1860 increased to seventeen by 1870, to forty-one by 1871, to seventy by 1872, and to eighty-five by 1880."

The importance of drawing and descriptive geometry in these pioneer civil educational institutions was early recognized and in 1849 the revised curriculum of Rensselaer devoted four courses scattered throughout the three year curriculum to drawing and descriptive geometry; in 1865 the Massachusetts Institute gave two courses in drawing and two courses in descriptive geometry; in 1867 drawing was mentioned in the curriculum of the University of Illinois twice, descriptive geometry and shades, shadows, and perspective once. Among "the qualifications requisite for a candidate for the degree Civil Engineer" the Rensselaer school stated: ". . .he must be perfectly familiar with plotting and business drafting."

1. While Crozet may certainly be credited with the introduction of the blackboard into West Point, historical records show that one Reverend Francis Xavier Brosius of Boston antedated him: ". . . in the winter of 1813-14, during my first college vacations, I attended a mathematical school kept in Boston by the Rev. Francis Xavier Brosius, a Catholic priest who had fled to this country from persecution in France. He was a man of much learning and of unaffected, cheerful piety. On entering his room, we were struck at the appearance of ample 'Blackboard' suspended on the wall, with lumps of chalk on a ledge below, and cloths hanging at either side. I had never heard of such a thing before. There it was–forty-two years ago–that I first saw what now I trust is considered indispensable in every school–the blackboard–and there that I first witnessed the processes of analytical and inductive teachings." From Barnard's Journal of Education, 1866.

Of the teaching of descriptive geometry, at these institutions and of the ideals and objectives of the pioneer teachers: Crozet, Davies, Church, and Warren, fortunately there is adequate record in the prefaces of their valuable books on descriptive geometry. Of the teaching of mechanical drawing, as it was beginning to be called, very little is known until the middle of the nineteenth century.

In 1834, T. Sopwith, an Englishman who described himself as a "Mine and Land Surveyor," published a treatise on "Isometrical Drawing," which method of representation he advocated as applicable to "...perspective views and working plans of buildings and machinery." In this excellent book the author clearly demonstrated his knowledge of orthographic projection, and advocated isometric drawing in preference to isometric projection, and that he favored isometric representation as "many peculiar advantages which cannot be obtained by any other method." While we are not now concerned with Sopwith's championship of isometric drawing, we are enlightened thereby because his thesis no doubt was the outgrowth of a need for a better method of graphic representation than was commonly used. And this we may infer from the following: "For Plans and Elevations of Buildings, and for working details of Machinery, Isometrical Drawing possessed such decided advantages, that a more extended knowledge of its principles cannot fail to ensure its almost universal application, in preference to every other mode of perspective drawing."

That a need for text books existed at this time, is voiced by William Minifie who published one of the earliest books on drawing which might be called a text book. In 1849, Minifie states in his "Geometrical Drawing": "...having been for several years engaged in teaching Architectural and Mechanical drawing, both in the High School of Baltimore and to private classes, I have endeavored without success, to procure a book that I could introduce as a text book: works on Geometry generally contain too much theory for the purpose, with an insufficient amount of practical problems; and books on Architecture and Machinery are mostly too voluminous and costly, containing much that is entirely unnecessary for the purpose. Under these circumstances, I collected most of the useful practical problems in geometry from a variety of sources, simplified them and drew them on cards for the use of the classes, arranging them from the most easy to the more difficult, thus leading the students gradually forward; this was followed by the drawing plans, sections, elevations and details of Buildings and Machinery then followed Isometrical drawing, and the course was closed by the study of Linear perspective and shadows; the whole being illustrated by a series of short lectures to the classes.... In conclusion, I must warn my readers against an idea that I am sorry to find too prevalent, viz: that drawing requires but little time or study for its attainment, that it may be imbibed involuntarily as one would fragrance in a flower garden, with little or no exertion on the part of the recipient, not that the idea is expressed in so many words, but it is frequently manifested by their dissatisfaction at not being able to make a drawing in a few lessons as well as their teacher, even before they have had sufficient practice to have obtained a free use of the instruments."

With the single exception of a slight reference to T-square and drawing board in Langley's book on "Practical Geometry" published in 1726, Minifie is one of the first writers to give any extensive discussion of drawing tools or of how to use them, and so far as I can learn this text bears to the subject of drawing in the United States about the same relation as does Crozet's to descriptive geometry.

The first half of the nineteenth century might well be called a formative period in the development of graphic language; the science of orthographic projection was discovered and knowledge of it was disseminated; text books on drawing and on descriptive geometry were written; schools were established and technical education was founded; and even more important for the future a pressing need for technically trained leaders and a growing demand for increased production focused attention upon the new sciences by means of which these ever increasing needs for expansion were to be satisfied.

The second half of this century was a period of growth, of change, of development, and of expansion so colossal and so fascinating that it deserves thoughtful study by every engineer. This era of national adolescence has been referred to vaguely and even wistfully by some as "the good old days." May I pause to point out just a few of the very highlights and very deep shadows of this epochal time?

Socially we were a people of little culture, a people of great wealth and of no knowledge of how effectively to use it. Our educational opportunities were at what would be called now a low high school level. Our ethical standards of conducting business were founded on bribery and corruption.

Even as early as 1865 we were a large manufacturing nation and the enormous expansion of industry which followed the Civil War has never ceased.

Agriculture in 1870 was passing through a crisis which threatened the political stability of the country. Our national life was thrusting westward toward new land, new resources and new problems.

There was a calamitous panic, an upheaval of labor, and an industrial revolution.

Couple all this, if you will, with the tremendous effect of new inventions in steel making, in the development and application of power, in the national transportation systems, with the discovery of vast reservoirs of national wealth in coal, iron, oil, water power, and new agricultural areas, and with the benefits which were being reaped from advances in sciences, both pure and applied, and you have the situation which made the United States what it is today.

Perhaps the growth, the change, the development which is here just hinted at may be more strikingly brought into the true relation it bears to the colossal economic change which was the product of this fifty years by the statement: "During the years from 1870 to 1895 the occupation of a large majority of persons employed in the production, the transportation, the marketing of almost every article in common use, was more or less modified."

During the period from 1850-1900 the whole scheme of graphic representation underwent the same colossal change which was common in all lines of endeavor. Military and Civil Engineering ceased to be designations sufficient to indicate the character of constructive undertakings, and engineering and engineering education became divided into branches. With each of these branches of engineering there arose a need for a kind and style of drawing in keeping with the nature of the undertaking, and thus came the day of specialization.

Along with, and stimulated by these developments and changes in the art of graphic representation, came improvements in drafting materials and instruments, the establishment in this country in 1850 of the pioneer American factory for manufacturing drafting instruments by the Alteneder family, the discovery about 1840, and the introduction to the engineers of this country in 1878 of the blueprint process of reproduction. During the first part of the nineteenth century "Draughtsmanship" was an art expressing itself in fine lines, shading both by lines and by washes, ornate borders, fancy lettering and the use of colors, but with the introduction of the blue print process, all this was changed.

With this epoch-making event, modern drafting came into being. The demands of the high-speed industrial organizations, of which the drafting room found itself a part, became so great that shading, fancy borders, and ornamental lettering could no longer justify the time required to execute them; drawings became plainer and even severely plain until now only that drawing which tells a complete story in the fewest lines is considered acceptable. Even the name which describes the making of a drawing had suffered from this process of pruning; the art of draughting has been completely lost, but the business of drafting has been discovered! This change is not to be deplored; the function of drawing is to produce and record results, and since the results obtained by the use of modern drawings are unquestionably superior to those of earlier times, it is fair to assume that a part at least of this improvement is due to the change in drawing, while at the same time it can be admitted candidly that the greater part is due to improvements in manufacturing processes. Drafting and manufacturing are so interdependent that development in the one is always accompanied by development in the other.

It was about this time that it became recognized that a drawing could accomplish what formerly had been considered, if not indeed impossible, at least impracticable–that is, infallibly to convey information to a workman; and with this fact established, model-making as an element in production became one of the lost arts.

The fact must not be overlooked that once established as the dependable means of conveying facts, drawing played an important role in establishing our present scheme of production, and as the demand upon the drafting rooms grew, it must be recorded that draftsmen faced challenges at that time as stupendous as those thrown down before any group of workmen engaged in keeping pace with the colossal demands of production. More and more it was expected that information from the drafting room would be reliable, complete, and not ambiguous. More and more were draftsmen called upon to demonstrate that the so-called "unproductive" drafting room was worth what it cost. Caught as it were, between the pressure of demands for results, and the problem of securing results in the face of lowering standards among the craftsmen who were responsible for the construction, the modern drafting rooms passed through a formative period which was revolutionary.

Thus it was that in the late nineties the modern drafting room came into being as a part of the national industrial organization, and came to be accepted as an integral element in the scheme of production. And as a result of all this, draftsmen became conscious of themselves and of their profession.

One might almost be permitted to call this period between 1890 and 1900, the "humorous" or even "literary" period in the development of graphic language because of the pages and pages of words which were published in all seriousness about matters which now seem so unimportant. It must be recalled, however, that at this time the "college-trained" draftsman was making his first bow in the industrial world, and that he was being received by his "hard-boiled" shop trained contemporaries with snorts of derision and a contempt born of a vague alarm that here indeed might be a new menace!

Be it also remembered that these college-trained draftsmen were far from the type we are now so proud of. These men had been trained to make drawings wonderful in appearance, they could shrink paper on the board, they could use water color and India ink wash, but when it came to making a drawing which described the shape and size of an object informing the workman simply and directly what he needed to know about finish, material, and other pertinent items, they should not be compared with that class of veterans who had earned their places in the drawing rooms by virtue of sheer merit and long experience.

Remember, too, that the texbooks of those days were written by "college men" or "professors" and no amount of quotation marks in this manuscript could convey the contempt with which their efforts were viewed by the "practical" draftsmen. Nor were these men among themselves in agreement, nor were their views always practical. Following in large measure the traditions of earlier works such books dealt generously with geometrical construction, practical descriptive geometry, exercises in the use of instruments, and meagerly, if indeed at all, with the application of such knowledge to graphical description. These "old timers" even resented somewhat new ideas as may be inferred from this comment by MacCord about drawing ink: "The best is of Chinese manufacture and comes in sticks or cakes of various sizes and forms; this is to be simply rubbed up with water to any desired density. The labor of preparation slight as it is, is to some persons a great bugbear; and in response to their demands various 'liquid India Inks' are offered for sale; the bottles, when properly cleaned, are good; which is more than can be said of the contents."

In those days, draftsmen and professors alike were still arguing about the proper form of delineation, about the proper arrangement of views. This period was about the turning point of that fine old war between those who favored the first quadrant against those who favored the third quadrant method of representation. To quote one author: "By this plan the horizontal and vertical projections are made with the object at rest on the horizontal plane. To illustrate, a brick will do. First, plan, brick lying down flat, view from top shows it eight inches long, four inches wide. Second, side elevation,board shoved behind brick, and figure of brick marked on it, two inches high, eight inches long. Third, end elevation, board raised on the right and figure of brick drawn on it, two inches high, four inches wide. This is the same effect as though the draftsman marked around the brick as it lay flat, then turned it up, directly on the side from him, scratched around it again. This scheme discountenanced acrobatism and all manner of inebriated posturing in the object and conserved for it a respectable representation ...."

Commenting somewhat tartly upon articles similar to the foregoing on projective drawing, Oberlin Smith wrote in 1875: "The writers of the recent essays upon the above seem to dwell particularly upon the doctrines of descriptive geometry, although some of them ring the changes upon other imaginative methods of conceiving what a drawing means, such as walking around the object represented, or climbing up on top of it, or burrowing underneath it, or looking at it through transparent paper, or through glass, or having its various sides depicted upon paper which may be supposed to be wrapped around it, and which afterwards may be peeled off, after the manner of skinning an onion, etc.

"The imagination required to see things in mid-air, where they do not exist, is a very desirable quality which is possessed as a gift of the gods by many inventors, by chess players who can conduct several games at once with their eyes blindfolded, and in a lesser degree, by ordinary geometricians, by well-trained draftsmen, by good whist players and also (shall I say it?) sometimes, perhaps, by theologians and commercial travelers.

"It seems to me, therefore, that if we desire a simplicity adapted to untortured, if not untutored, imaginations we must totally abandon for practical work the complexity of two ideal planes and their four ideal angles, with the conception of the object seen beneath the paper instead of above it, etc. If, further, we abandon the still more puzzling ideas of walking around or climbing over the object, or unfolding its skin, we will probably come down to the simple conception of the subject, or model thereof, of the proper size, lying upon the paper. To get additional views, we must either revolve it directly by merely rolling it over, or, by the method last described, we must both roll it over and slide it to a considerable distance from its original position. It does not appear to me, as probably it does not to the great army of my fellow believers that there can be two answers to the question as to which is the simplest and therefore the best of these two methods.

".... In some recent articles upon this subject, it has been stated that the majority of our best shops are now using the third-angle, or indirect method. If it be the fact that the first-angle, or direct method, has been gradually dying out, the melancholy probabilities are that it will die still more. When its disease becomes absolutely mortal, it will be only the proper thing for the army of 'direct' people to gracefully surrender to the larger army of 'indirect,' learning the habits of a lifetime over again, that a common practice (even if not so good as is something else, in the eyes of some of us) may obtain throughout the earth. Such uniformity is certainly of great importance, not only as a mater of convenience, but of actual saving of expense in the avoidance of mistakes, etc., and should undoubtedly be aimed at by all of us as early in the future as is possible.

"This question of which way to project cannot in the nature of things be of such very great importance in itself, like theology, or so many good people would not differ regarding it. Let us then all strive to come to a common practice in the matter and meet upon common ground of direct revolution if we can or indirect if we must. Let us remember, however, that America is all the time becoming less provincial and that this common ground should be international, rather than merely occidental."

Thus, even so early as 1895, is found a far-sighted plea for standardization and for uniformity. Amusing as many of these ideas of graphic representation now may seem, yet out of the unrest and dissatisfaction here expressed, gradually evolved a new period in the development of graphic representation, and a greater stability in the art of graphic expression.

Among the most significant and far-reaching influences in the development of graphic representation was the acceptance, early in the twentieth century, both by teachers and draftsmen, of the third angle method of representation. With the moot question of how views should be arranged disposed of, and settled for all time, theorists and practitioners alike, turned their energies in the years which followed, to the refinement and improvement of drawing as a language. As a natural result, more and better literature on graphical representation was published both in the form of text books and in magazine articles during the first quarter of the twentieth century than had appeared in any similar period throughout the entire history of the subject.

Books on descriptive geometry designed to make the subject easy to understand, to illustrate the applications of descriptive geometry and presenting the subject from the standpoint of the third angle appeared with almost clocklike regularity. But aside from the improvement in presentation, and in the study of applications, no great advances were evident in subject matter. The pioneer Monge had covered the field and one hundred and thirty-five years of scrutiny and research has added but little to his extraordinary and comprehensive achievement.

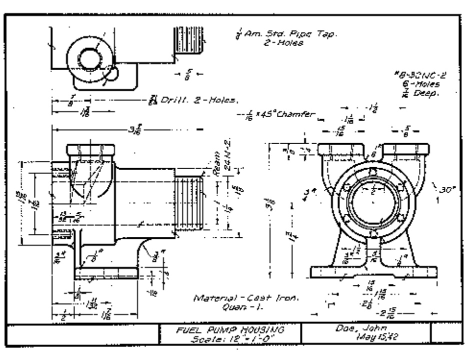
In the text books on drawing, however, great and noteworthy advances were made during this period. Technical education was passing out of its preliminary adolescent stages and the application of science to industry was becoming an actuality and not merely a dream.

Not only as a result of this but also because of the recognition industry was bestowing upon education in general, college trained draftsmen were finding a place in the industrial world and their influence was being felt in the literature of graphical representation. Indeed many of the teachers of engineering subjects were drafted from industry and after having learned the limitations of their own college training began a new era in technical teaching. For the first time, the whole subject of graphical representation: the theory of projection, the application of this theory to shape description, size description, and the application of shape and size description to general field of graphic description was joined to the old pedantic routine of geometrical drawing and the manipulation of drawing tools to make a comprehensive and adequate treatment of graphic representation.

Men like Anthony, the Reid brothers, Jamison, Fellows, and French, published books on drawing which explored the field as never before, and which adequately covered the subject in all its phases. Along with this development in drawing literature other books than texts on "mechanical drawing" appeared, and the literature of graphics began to make its appearance in books covering the fields of structural, architectural, topographic, machine drawing and later, an even newer branch covering the subject of the technic of presenting statistical and technical data in graphical form.

For a number of years both teachers and practitioners had been feeling a mild dissatisfaction with the inherited and misleading name "mechanical drawing" and with the more evident divisions of graphics into specialized branches it was inevitable that new names should appear. Professor Anthony's designation of "graphics" and Professor French's name of "engineering drawing" were both attempts – and successful attempts – to establish a fact known but never properly presented, that drawing of whatever kind, is a graphic language, and to each of these pioneer leaders, the profession owes great acknowledgment.

No sooner had the idea of a graphic language been established, than dissatisfaction with the disapproval of the lack of standards, the absence of uniformity, and the freedom with which ideas were conventionalized began to be published, and at once received endorsement. Like the weather, a great deal was said about it and nothing at all was done until under the impetus of the "simplified practice" movement, the American Standards Association, with the Society for the Promotion of Engineering Education and the American Society of Mechanical Engineers as sponsors, organized a committee to establish standards for drafting and to bring such standards into agreement. This committee has been at work now since 1926 and is ready to present in final form a recommendation for uniformity which in the end will make drawing what it should be – a truly uniform graphic language.



"Drafting" of the current era: A Modern Engineering Drawing.

Reviewing very briefly the development outlined here, four rather outstanding periods are evident: The first, antedating 1750 and reaching back into early times, reveals little but a conviction that even in this early day the value and use of a graphic means of conveying ideas were appreciated. The second, one hundred years in length is more productive. Monge discovered the science of orthographic projection, early engineers began to use methods commonly used today, engineering education was established, and teaching the graphic language began.

The third period, from 1850-1900, witnessed the establishment of drafting as an integral part of the materials of representation.

The fourth and final period, that in which we now find ourselves, is more significant than any. The science of graphical representation definitely is moving toward standardization, its literature is well-founded, and well-defined, its teaching is on a firm basis; its value is recognized, and its use in engineering and associated lines of activity is established.

Great improvements have been made in drafting equipment, drafting room furniture, lighting, and arrangement. New media upon which to draw and to reproduce drawings are constantly appearing and finding a place for themselves. New devices for increasing the output of the drafting room and the use of photography indicate that many minds are at work on problems of recording and conveying ideas with greater efficiency and economy.

Among the more significant of these recent developments has been the introduction of so-called production illustration. The principles of pictorial illustration are, of course, among the oldest known graphical methods, and have been in use since ancient times. The recent application of these to production drawings and to the making of "exploded" assembly drawings, and to "cut-away" views to reveal hidden interiors has been a direct result of recent wartime conditions. Forced to find methods for directing inexperienced and untrained workers who could not read an engineering drawing, the war industries of England found pictorial drawings an effective means for bridging the gap between the untrained worker and the complications of his job. The importance and worth of this development can be measured by the rapidity with which it was taken up in this country and its widening use in industry in peace time. Now it appears to be accepted not only as a useful descriptive device for workers, but as a designer's means for study and checking as well.

Thus, as we review the 500 years in the history of graphical representation covered by this discussion, we discover that drawing as a means of recording and conveying ideas has made a complete cycle. Pietro, Durer, and Leonardo—artists and draftsmen of notable ability—recognized the limitations of their methods of 1450; draftsmen and industrialists of our time also recognized the inadequacy of the engineering drawing of 1940. And so at the end of the 500 year cycle we find these two methods combined, each reenforcing the other.

Teachers of engineering drawing naturally are interested in the future; they have a lively curiosity about the developments in graphical representation which may take place in the period just ahead. As a teacher of engineering drawing I share both this interest and curiosity, but as a historian of graphical representation—admittedly of very amateur standing—I frankly do not know how I should conclude this discussion.

Shall I, as a teacher, now remind you that since its introduction into the engineering curriculum, engineering drawing has steadily been robbed of its allotted time, and that now a new raid is being organized by deans and administrators to provide room for a twenty per cent allotment of social-humanistic studies? Shall I suggest that in the near future engineering drawing may be taught by the art department because draftsmen of the future will be illustrators who know how to read engineering drawings? Shall I invite you to consider a possibility that photography combined with electronic science may be developed to a point where entirely new methods of recording and conveying ideas may by devised?

Or shall I, as a pseudo-historian, ask why it is that so many new ideas and methods, and devices and systems for representation by graphical methods come from without rather than from within the teaching profession? What were the reasons, asks the historian, why engineering drawing teachers failed to point out to industrialists the advantages available by the uses of pictorials? Why do practical men have an attitude about drawing teachers perhaps expressed by the phrase: "An awfully nice chap, but he is a professor"?

We all recall the plea for draftsmen at the beginning of World War II, and yet in the recent discussions of universal military training what voice has been raised for universal training? Is it true that engineers are indifferent to or unconscious of social-humanistic responsibilities? Surely reflects a historian, every boy and girl in this country should in return for his education prepare himself for some element of national defense; certainly experience has taught us that the manual of arms with a T-square is as important in the prosecution of a war as the manual of arms with a rifle.

Questions such as these are food for thought; it is no part of my purpose here to answer them. Nor do I propose to make predictions about the future. Viewed from the vantage point of long experience I can repeat with assurance what I have stated earlier: Graphical representation is moving toward international standardization; engineering drawing has a well-recognized literature, its value is proven, its use in engineering and associated lines of activity is established. Today, it can be stated without fear of contradiction, engineering drawing is better taught, and in less time, than ever before.

As teachers of engineering graphics, we stand today on the threshold of a future rich in opportunity for usefulness; usefulness in engineering communication, engineering research, engineering computation, engineering education. If we have but the courage to cross this threshold, the wit to grasp our opportunity, the future of engineering graphics will be controlled and guided by the teachers in this room.

A Word from Your Chairman

I urge each one of you to make every effort to attend the Annual Meeting at Berkeley this coming June. You should be present to participate in the discussions that will follow the report of our Committee on the Aims and Scope of Engineering Graphics. This committee, that has worked so hard this past year, deserves the guidance of your thinking.

It is likely that those in attendance at this annual meeting will be called upon to render a decision as to whether or not the name of our Division should be changed. This action would be in line with a proposal made by the Committee on the Aims and Scope of Engineering Graphics to the Executive Committee at Flint in January. As you may already know, our By-Laws require that final action by the Division on any such matters can be taken only at our Annual Meeting.

We can promise that you will be pleased with our program for we have been able to obtain some outstanding speakers. This fact coupled with the opportunity to enjoy a vacation in the mountains and at the seashore should make you join with others in the cry "On to Berkeley."

I am personally looking forward to seeing each one of you at this meeting. May you and your family have a pleasant trip on the way out. Best wishes.

Warren J. Luzadder
Chairman of the
Division of Engineering Drawing

Some Methods of Shading Engineering Drawings for Publication

By Clifford H. Springer
and Richard W. Reynolds

University of Illinois, Urbana

When it is necessary to illustrate a paper or text for for publication, it is frequently best to dress up the drawing to make them easier to read.

The engineer has learned to work with line drawings and is able to understand them and visualize the object without additional aids. However, when the engineer's information must be made available to others who have not been trained in the reading of engineering drawings, it is sometimes necessary to improve these drawings so that they may be more easily understood. The architect has long recognized this and makes good use of shades and shadows in the elevations and pictorials. The shading of engineering drawings is usually confined to pictorials and it is the usual practice to omit all shadows since shadows tend to cover up some of the details. The purpose of the shading is to make the drawing appear more realistic and consequently easier to read.

SELECTION OF METHOD

There are many methods of shading available to the engineer, any one of which may be mastered with a little practice. The choice of method will depend upon several things such as the character of the object, the type of projection, the material to be represented, the kind of reproduction to be used, the time available and the purpose of the drawing.

Many people say that it is impossible for them to do this kind of work, but that is merely saying that they do not care to take the time to learn. With a little practice, almost all of the students are able to do a satisfactory job. They usually display considerable interest in the work so that grades tend to be a little higher than their general average.

CHOICE OF POSITION

According to an old saying, "There is a little bit of good in the worst of us and a little bit of bad in the best of us." If that philosophy is accepted, there must be a little bit of art in the shading of engineering drawings. However, for an engineer, it is well to think of this work as more of an application of the laws of physics than the practice of art.

In other words, by considering the direction of the light rays, the angle that these rays make with the surface of the object and the way the rays will be reflected from the object to the eye of the observer, the engineer can determine the relative amount of light falling on each surface and the location of the highlights as well. By his knowledge of materials and finish, the engineer can also make a good estimate of the amount of light that will be reflected from each surface.

The artist will usually set up the object to be drawn in the desired position, arrange the light to give the best effect and then make a copy of the set up as it appears to the eye. On the other hand, the engineer may not even have the object. It may exist only in his imagination or as a line drawing. He is not so much interested in making a pleasing picture as in showing the object to the best advantage. He, therefore, makes the pictorial so that it will give as much information about the object as is possible and selects a direction of light that will be most effective in molding the object without the use of shadows.

THEORY OF SHADING

There are certain ideas that must apply to both shaded engineering drawings and artistic drawings. Both the artist and the engineer must realize that lines do not exist in nature although they are frequently used, particularly in engineering drawings. Surfaces are molded by shades and differentiated by tones. The tone of a surface will depend on the amount of light, the angle of the light, the kind of material, the finish of the material and the color. In any case the greatest contrasts will be close to the observer and all colors tend to fade into grays in the distance. In other words, the blacks will be blackest and the whites whitest close to the observer. This tends to give sharp contrast between various surfaces in the foreground and soften the contrasts in the background. This fact gives a method for choosing the direction of light desired. It should usually be chosen so that there will be one dark face, one light face and one intermediate face, which arrangement will provide a dark area adjacent to a light area to differentiate the various faces of the object. This is illustrated in the cube shown in Figure 1.

As a rule, curved surfaces are easier to mold than flat surfaces because they change gradually from dark to light and each surface has a distinct shape to its reflection area or highlight. Thus the highlight on a cylinder is always a rectangle and on a cone it is a triangle as shown in Figure 2. For a sphere, spheroid, torus or warped surface it is necessary to study the surface, and by inspection, determine the area on the surface that will reflect the rays of light toward the eye. Thus, on a sphere or spheroid there will be one spot or center of the reflection of a single point of light, but an area around that spot will show as a highlight. The size and shape of that highlight will be determined by the character of the light and by the shape and size of the surface.

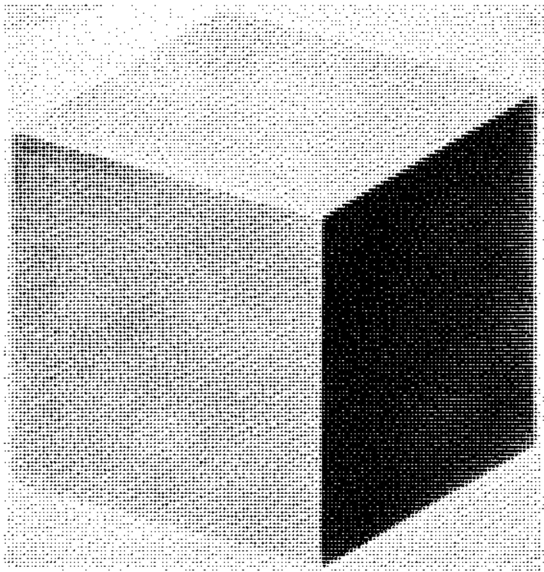


Figure 1. Shaded Cube by Sponge Method

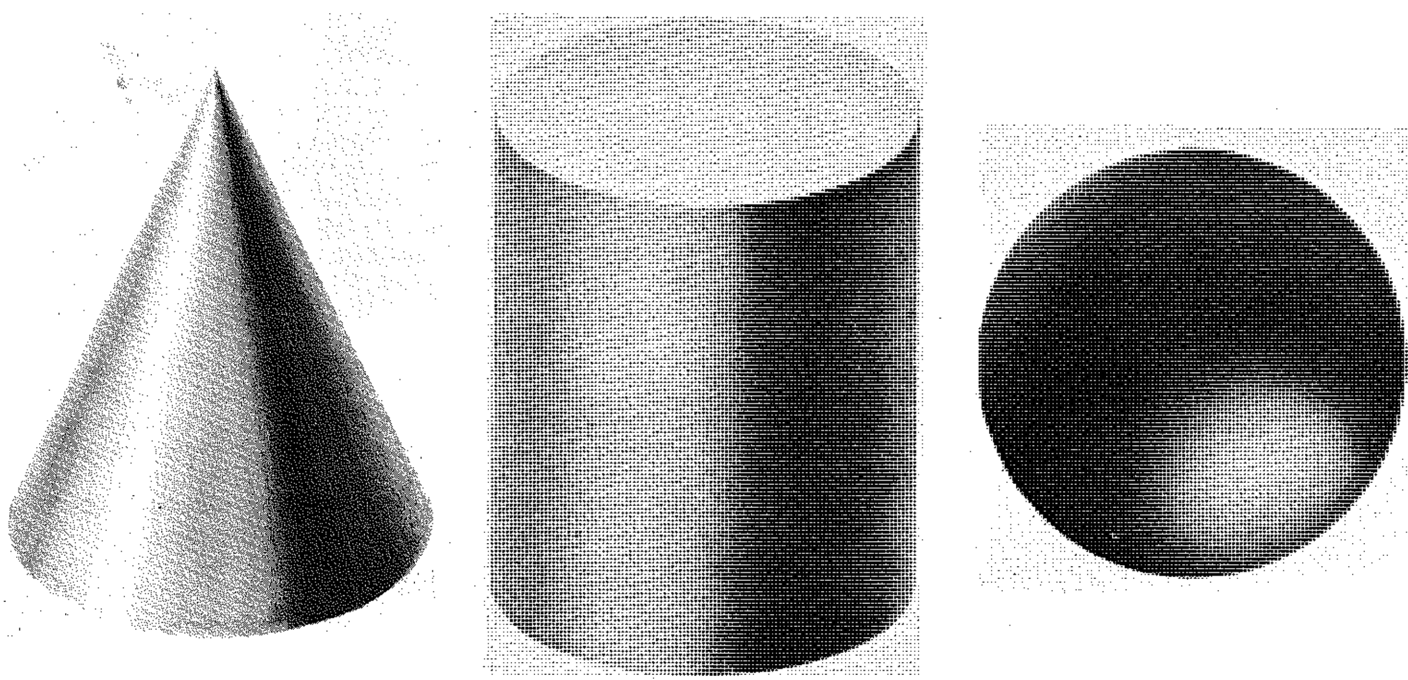
For overall shading such as airbrush, no lines are needed to make the drawing since each surface is molded by representing the tones of the area. Even when lines are used with some other kind of shading, the same principles of arranging the tones are followed.

METHODS OF SHADING

The following discussion will touch lightly on several methods of shading such as, airbrush, smudge, sponge, line, doubletone and Zip-A-Tone. Other popular methods include broad stroke, scratch board and grease pencil.

The airbrush is simply a spray gun that can be adjusted to give a line or a uniform overall tone. By proper manipulation a graded tone can be obtained. The first step in working with the airbrush is to learn to produce each of these patterns. See Figure 3. When using the airbrush, all of the drawing must be protected in some manner except the part that is being shaded. There are two methods of doing this: one, by means of a template which is a stiff piece of paper, cardboard, or metal with holes in it through which the spraying is done; and two, by means of frisket paper. This is merely thin paper or acetate with adhesive on one side that is placed over the whole drawing. All of the lines of the drawing are then cut through the frisket paper, after which any part of the drawing may be exposed by removing the frisket from that area. After that part has been shaded the frisket is replaced and another part uncovered. The greatest difficulty with this method is that the frisket becomes very black and it is difficult to know when the proper tone has been obtained. This can be remedied to some extent by making a chart on another piece of paper giving the desired dark, medium, and light tone for comparison.

The airbrush must always be started to one side of the drawing and then moved across the area to be shaded. Never start, stop or reverse the brush while it is on the drawing. In shading a cube as shown in Figure 1, the dark face is shaded first. Care must be taken to make the front part much darker than the rear part. The intermediate, or in this case the left face, is shaded next and this face is treated as a light face,



a. Cone-Pencil Shading b. Cylinder-Airbrush c. Sphere-Airbrush

Figure 2. Shape of Highlights

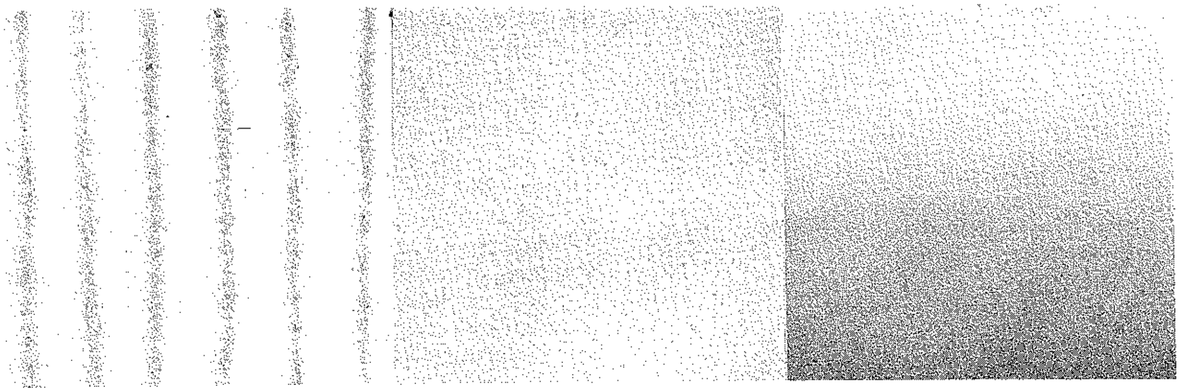


Figure 3. Airbrush Technique

in which the front part is lighter than the rear part. The darkest tone of this face is usually made a little lighter than the lightest tone of the dark face. By making this face light at the front, a very sharp contrast is provided with the dark part of the right side face, thus making a very definite edge for the front corner. The top or lightest face is shaded last and this face is frequently left pure white with just enough tone on the back of the face to define the rear lines of the cube. These same principles may be used for flat surfaces wherever they occur.

For a cylinder the surface to be shaded is exposed and the rest of the drawing protected either by a stencil or by frisket paper. The airbrush is started outside the part of the drawing to be shaded and moved parallel to the axis of the cylinder for the full length of the cylinder and beyond. With a slow steady motion the airbrush is moved back and forth until the dark part on the right is built up and a graded tone provided toward the highlight as shown in Figure 2. The dark tone on the right is made much broader than on the left so that the highlight will not fall in the center of the cylinder. The tone may be left a little lighter both on the extreme right and left to give the effect of reflected light.

The cone is treated in the same manner. In this case, care must be used to be sure that the highlight goes clear to the apex. There is usually a tendency for the strokes to be too broad where the surface becomes narrow and thus black out part of the highlight.

The airbrush is probably the best of the shading methods because it can be made to give the most natural appearance to the drawing. Figure 4 shows a drawing shaded by means of the airbrush. No lines are used and tones can be graded very readily. However, there is considerable expense in obtaining all of the necessary equipment. The cost of the airbrush may vary from $15.00 to $50.00 or more depending on the kind of brush desired. Then, if compressed air is not available, it is necessary to buy a compressor or use a tank. If the tank is used, a special valve is necessary to reduce the pressure to about 35 pounds per square inch. If many drawings are to be shaded, this expense can be justified; but if the engineer has only one or two drawings to be shaded, he should probably look for some other method.

In that case the sponge method should be considered. This is what is sometimes called the poor man's airbrush, since for a few cents all of the equipment needed can be obtained. For this method a rubber sponge should be purchased. A piece of glass with a small roller and a little printer's ink will complete the equipment.

A small amount of printer's ink is placed on the glass and rolled out to a thin film. The sponge should be squeezed or cut to a spherical shape and touched to the ink film. The ink is then transferred to the drawing by patting the drawing with the sponge. Printer's ink makes a good live drawing but is rather slow drying so care must be taken to prevent smearing. Stencils or frisket must be used for this method just as for the airbrush. The same principles apply as for any other shading. If a rubber sponge is not available, a piece of cloth can be rolled up to use as a dauber. Figure 5 shows a drawing shaded with the sponge.

Still another method of producing a similar result is

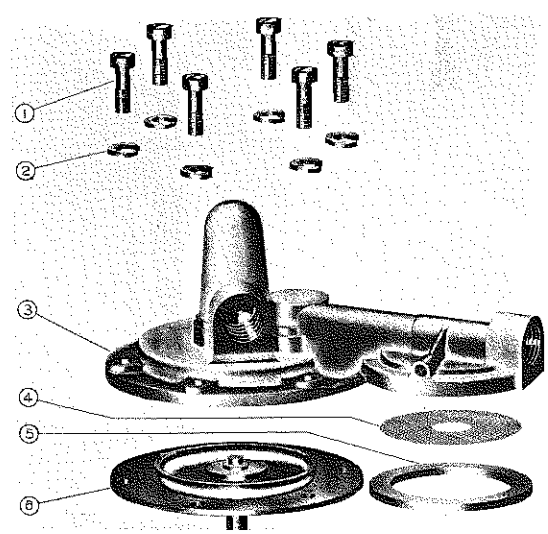


Figure 4. Airbrush Shading

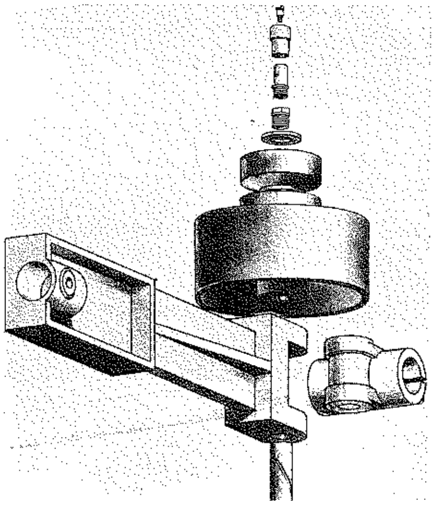


Figure 5. Sponge Shading

called smudge shading. In this method, the area to be shaded is covered with graphite by rubbing with the flat side of a soft pencil. This shaded area is then smoothed out by rubbing with a paper stump until all lines disappear. When dark tones are desired, very soft pencils may be used and lighter tones may be obtained by using harder pencils. This effect may also be obtained by using powdered graphite and transferring it directly to the drawing with the paper stump. To show a finished area with this method, the drawing must be on very heavy paper or it must be lying on a very smooth surface, as illustrated in Figure 6a. The rough surface shown in Figure 6b was obtained by using sandpaper as a backing. For reproduction purposes this is not as good a method as the others, because it is more difficult to get a good black tone. Unless fixed immediately this kind of drawing will smear badly.

One very convenient method of shading a drawing is by means of a commerical product in which various patterns have been printed on a clear acetate. This printed surface is coated with an adhesive by means of which the acetate can be made to adhere to the drawing. Several companies are now making the overlays with many patters from which a wide variety of texture can be obtained. The irregular patterns can be superimposed on one another to give a graded tone, but the regularly spaced dots will form a variety of patterns when superimposed on one another. This fact is important when it is desired to show patterns in cloth or draperies. For this reason the method is frequently used for making cartoons. It can also be obtained in colors. Another very important use for the material is for crosshatching drawings. It saves time and gives a perfect result, but a special kind of adhesive must be used for this purpose if the drawing is to be run through a blue print machine.

When using this method, a sheet of the overlay is placed over the drawing to be shaded and pressed down lightly with the hand. The overlay is then cut on the outline of the area to be shaded and the remainder of the sheet removed. The part that is to remain is then pressed down firmly with a smooth tool or piece of wood. A needle inserted in a piece of wood makes a good tool for cutting the acetate. Figure 7 shows a drawing shaded by this method.

Another very effective method of shading is by using a patented process known as doubletone, put out by the Craftint Company of Cleveland, Ohio. This paper has been printed with chemicals in the form of two sets of parallel lines. One kind of developer brings out only one set of these lines and a second developer brings out both sets of parallel lines. Thus, by the use of black ink, the white paper, single tone and doubletone, there are four tones available. By means of a judicious placing of these four tones, a very realistic shading can be obtained. However, it has the disadvantage that the original drawing should be inked to give the proper effect. It is also necessary

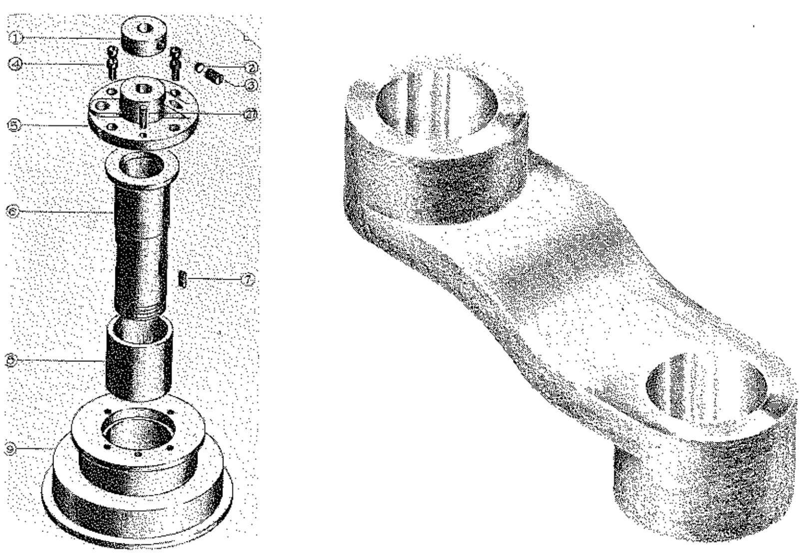


Figure 6. Smudge Shading

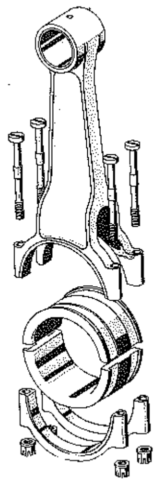


Figure 7. Shading by Overlays

to photograph the drawing immediately after shading since the doubletone tends to fade or turn brown in spots. It can be restored to almost its original color by redeveloping within a reasonable length of time. Figure 8 shows a drawing shaded by this method.

For industrial purposes, line shading is usally preferred. The reason for this is that by means of a few lines an effect can be created that will help mold the object, but the time required may be very small. On the other hand very elaborate drawings can be made by line shading. A drawing shaded by the line method is shown in Figure 9.

Shading by means of a series of dots is called stippling. This may be done freehand or by a semi-mechanical method in which ink is placed in a brush such as a tooth brush and a stiff cardboard moved across the brush. When this splatter method is used the drawing must be protected with frisket. See Figure 10.

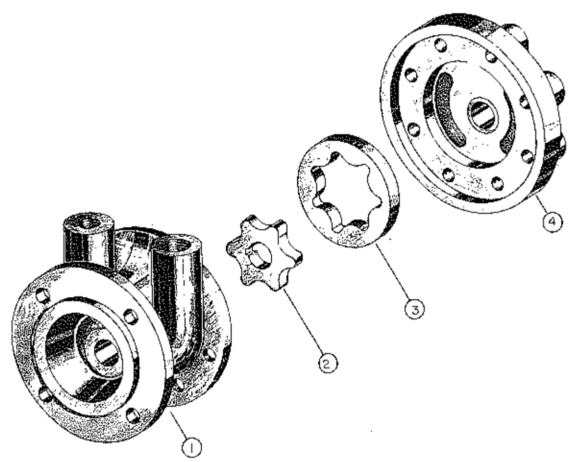


Figure 8. Double Tone

Special effects may be obtained by the use of overall pencil shading on very rough paper. The grain of the paper creates a pattern in the shading that may be very desirable as shown in Figure 11.

If the work is to be reproduced by the letter press method, it is usually preferable to use line shading, stippling, doubletone or Zip-A-Tone because these can be reproduced by means of a zinc etching. The overall shadings will require a half tone which is more expensive. However, if offset printing is to be used, there is very little difference in the cost of reproduction; so the overall shadings may be preferable because they appear more realistic.

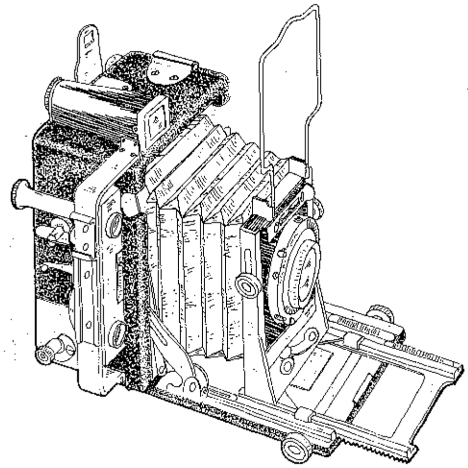


Figure 9. Line Shading and Stippling

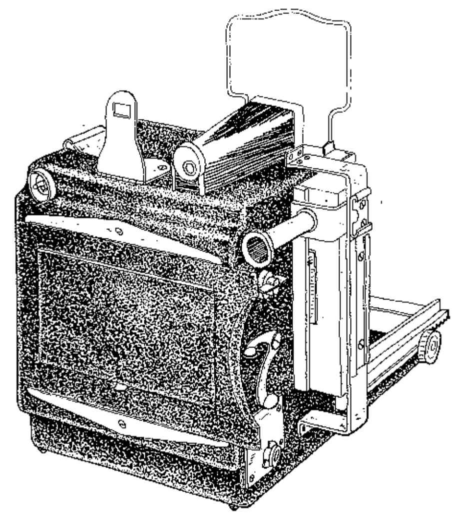


Figure 10. Stippling

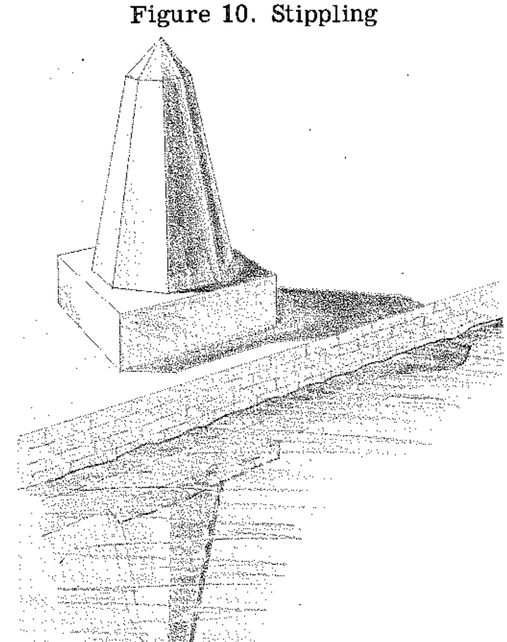


Figure 11. Pencil Shading on Rough Paper

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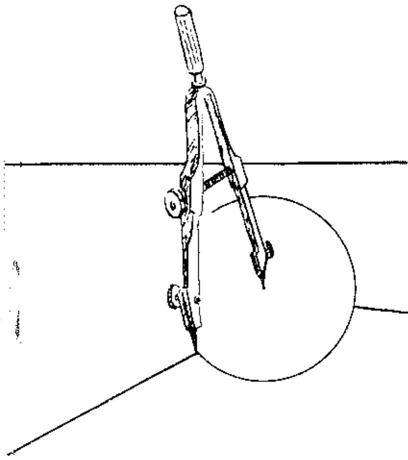

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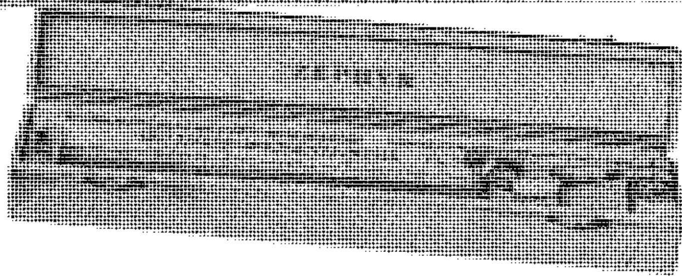

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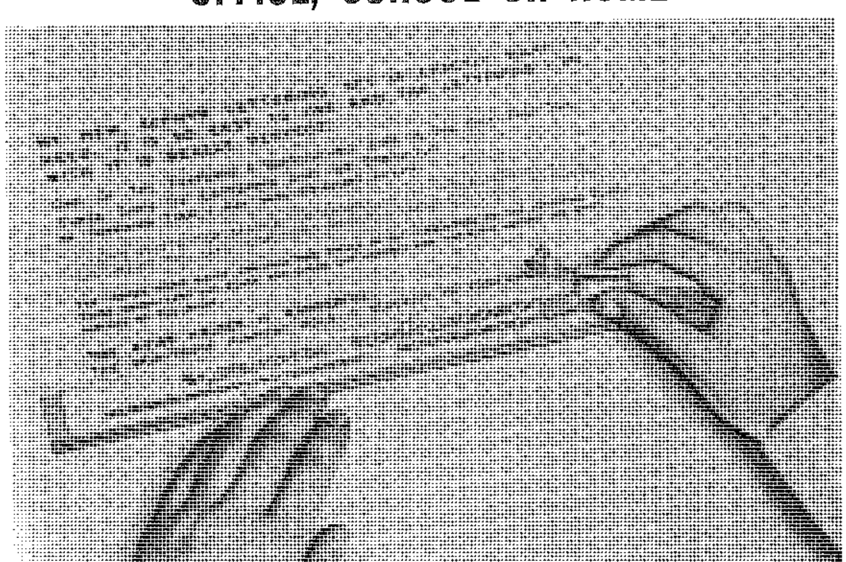

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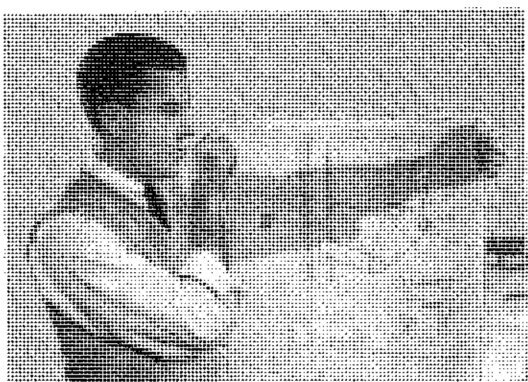

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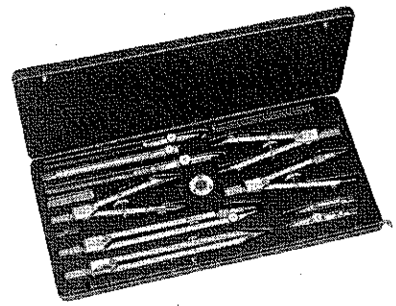

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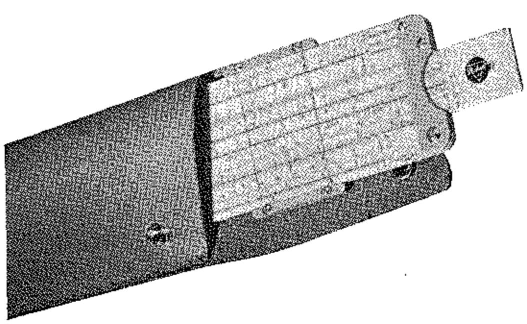

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Freehand Drawing—How to Teach It*

By Frank Burns

Newark College of Engineering

"Freehand Drawing—How to teach it," is a provocative title when its scope is considered. It brings up questions as to just what sort of freehand is to be dealt with; is it to be the freehand tracings industry is now tending to look upon so much more kindly than in the past, outline sketches based on isometric positioning, or true-to-life sketches having considerations for perspective outline and the applications of shades and shadows and of tones and textures?

Also, to whom is it to be taught? Draftsmen, deans, undergraduates, teachers, executives, salespeople for some engineering product, designers, or adult education groups? Each of these requires a different approach; but since most of you probably are concerned with engineering undergraduates, the following material is "slanted" in that direction.

The primary aim of this instruction should be to successfully train the students in methods for securing reasonably recognizable true-to-scale outlines and then, secondarily, in effective surface treatments. Any superior achievements in the latter should be regarded as pure profit.

"Nature abhors a straight line and rarely produces one." Engineers, on the other hand, tend to live quite close to the T-square and triangle although our modern designs indicate a tendency to move away into more pleasing outlines. Students, however, must begin with these two devices and use them until acquiring some sense of scale before attempting any serious sketching.

As the result of much experimentation over the years with when and how best to teach freehand we, at Newark, are now convinced that the finest results are to be obtained only after the student has finished his descriptive geometry. The sounder the sense of geometric proportions you can develop in your students, and the earlier you can do so, the better will be their sketch-products.

Capabilities of individual students vary widely and so will the results that are submitted when free choice is allowed or encouraged, the poorer students almost invariably coming up with some sort of weirdly symbolic or abstract design; hence it is much better to slightly limit the area. We ask for sketches of some devices commonly found about the home since these today are usually of a mechanical nature such as cameras, reels, mowers, shavers and other utilities, and are almost invariably composed of the geometric elements we supposedly have drilled into the students.

At the beginning a great deal of time, possibly even as much as one-half of the entire amount available for freehand instructions, should be spent on rigorous drill in these three basic techniques:

The production of reasonably straight lines.

The production of reasonably straight and parallel lines.

The production of reasonably straight and perpendicular lines.

There are innumerable subjects. A section of a brick wall, the flag, wiring diagrams, small steel details and, of course, the geometric designs which are to be found in almost all drawing texts (Fig. 1).**

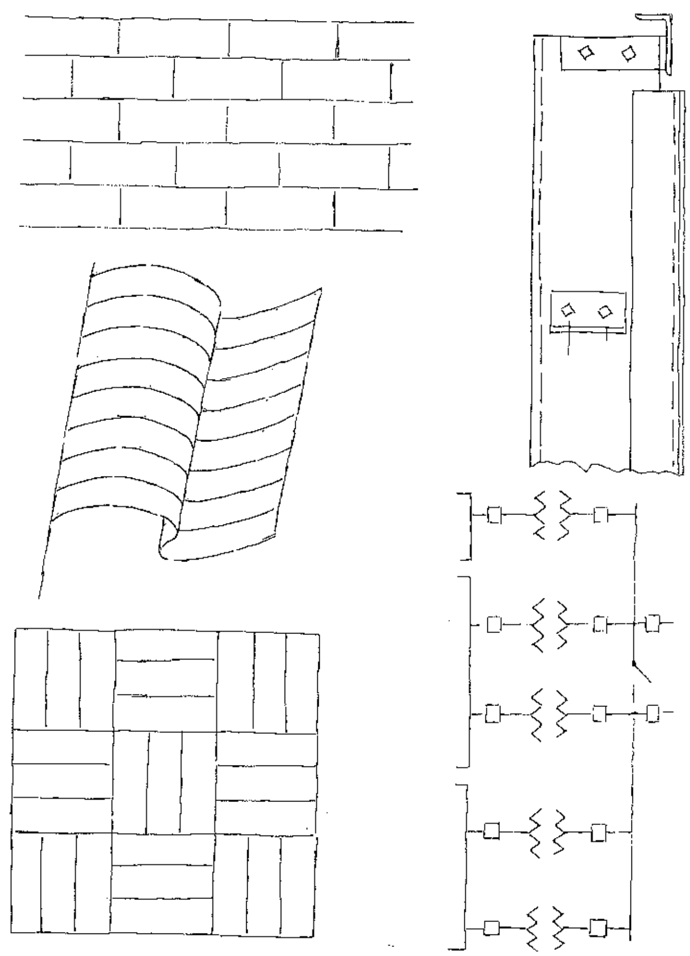


Figure 1

At this stage "works of art" should not be encouraged so much as a sense of geometry and of proportion should be, especially should you stress the ability to sketch a straight centerline and to equally

* Presented at the Annual Meeting, at Cornell University, June 1957.

** It was necessary to reduce several illustrations drawn by Professor Burns in the interest of saving space, with the result that injury may have resulted to certain line weights and tone values (Ed. note).

dispose about it certain outlines such as are found in surfaces of revolution.

Throughout the early part of the training and while the student is still exercising with parallel lines, it is also a good idea to introduce the idea of "scale." The student should memorize the size of some readily accessible object such as a coin, width of watch band, length of pen and so on. In my case the width of my first thumb-joint is just 1", a most convenient arrangement, for in looking at any object held in my hand I immediately have its scale.

Once past the preliminary training in straight line work, the use of carefully made "dittoes" of small details may be permissible to some small degree to accompany demonstrations in certain techniques. One reason for this is to overcome the tendency of students to make their earliest sketches too small and then to cram them with unrecognizable detail.

These small units or "thumbnails" have great value in training a student in seeing an object in its simplest geometric elements, and often they can be made to stimulate imagination strongly. James Thurber's characters are thus drawn; so is the profile of Alfred Hitchcock, shown at the start of his television shows (Fig. 2). Thumbnail sketches, so-called, are small ones that are quickly roughed out to "suggest" outlines only. They are valuable aids in giving general impressions of the form of an object or to ascertain how best to orient a more formal and complete sketch. If you have access to any of the illustrations in DaVinci's notebook you will find there are many thumbnail sketches.

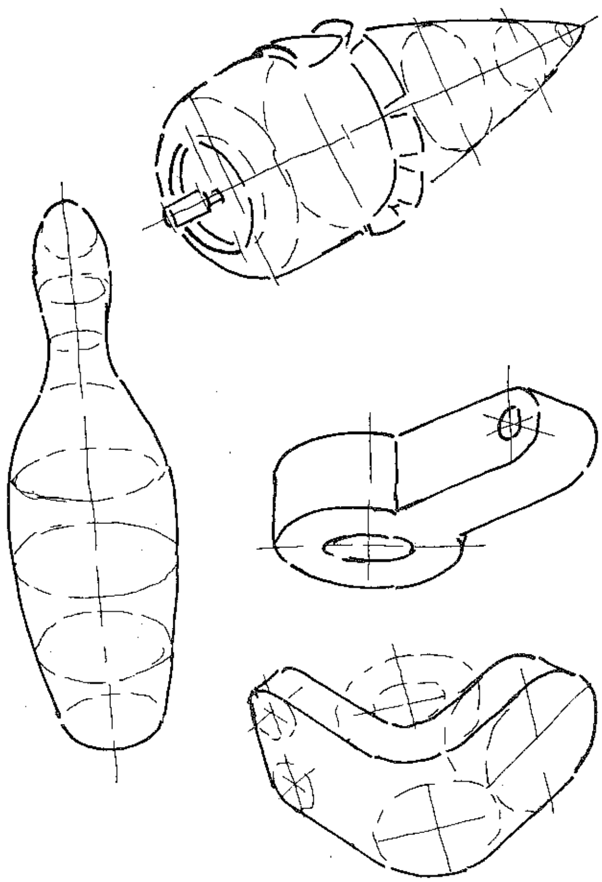


Figure 2

Comprehension of tone values can be developed through construction of a "tone-scale." The student lightly sketches a 5" × 5" grid of 1" squares making alternate outlines light or dark (Fig. 3). Although this

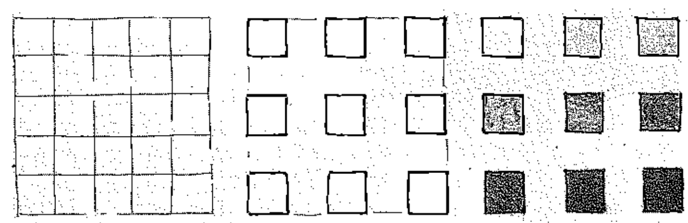


Figure 3

device is to teach things having to do with tone, note how, in its construction, it is possible to stress accuracies in the three primary disciplines; namely, how to sketch straight lines, parallel lines, carefully equispaced lines.

Place some paper beneath to act as a platen and, on the grid of 9 squares, bear down with a soft pencil and make the lower right square as black as you can get it. The upper left square is to be left clear. The central square is now to be given a "tone" of grey that has a "value" midway between the corner two. Consider the result carefully then proceed to so treat the remainder of the squares that, as you read from left to right and down, there will be no two that are alike and each will have a difference of tone from the adjacent ones that is readily discernible.

In applying tone values the rule is that the strongest dark areas are nearest you as are the strongest light ones.

Cylinders require special treatment as the ellipses which represent their ends seem to offer an unreasonable amount of trouble for the beginning student. You have to "spell it out" here.

By far the greater number of cylindrical objects with which we deal are relatively small ones. Ashcans, food tins, garbage pails, cosmetic and drug containers usually found about the home and material examples of such items are always readily at hand for use as models.

Drill in sketching such cylinders needs emphasis. One needs to have the students sketch a rather long thin ellipse which is to represent the top of a cylinder (Fig. 4). Explain how the cylinder sides and axis must always remain parallel to each other and perpendicular to the ellipse major axis. Have them construct the ellipse for the other end and show how minor axis dimensions increase at sections removed from the narrow nearer end ellipse. As was done in the case of the tone scale a drill in relative values is possible here by making minor diameters in proportion to their stations between the ends. It is through painstaking

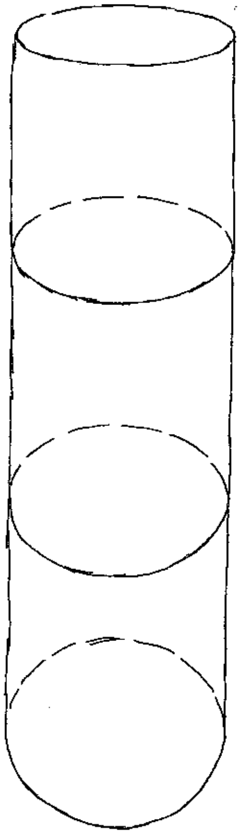


Figure 4

drill in these picayune details that the best work is finally obtained.

It is difficult for beginners, and some oldsters, to directly sketch a well-faired ellipse. Some "gimmick" is indicated. For this the use of a light enclosing rectangle seems to give best results. In it the two small end arcs are first sketched to a diameter approximately one-half that of the ellipse minor diameter and checked carefully and adjusted for equality of curvature. The larger, flatter connecting arcs then seem to offer no difficulty (Fig. 5).

When the major diameter is known and its scale must be maintained, consider how a circle, boxed in a square, passes just inside of the 3/4 marks (from the center out) of each of the square's diagonals (Fig. 6). When the square is distorted to a parallelogram the circle distorts to an ellipse but still passes through these points on the diagonals.

Please pardon the recurrent use of the name gimmick, but another fruitful one is the use of what we call the "cascade" in locating detail radially and angularly. The student cannot be counted upon to "see" the relation of the orthographic plan to his pictorial for a while and should be made to place these orthographics above his sketches and to project from them until you feel that he can accomplish quite complicated ones without their use. They can be sketched faintly and later removed if he so desires. (Prof. Walters, President of the Institution of Engineering Draftsmen and Designers of London, England, first wrote of this method here in 1947.)

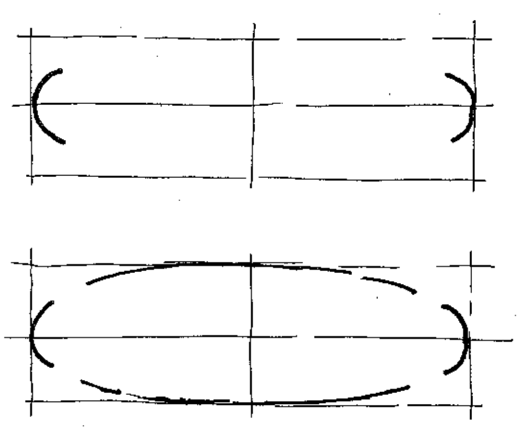


Figure 5

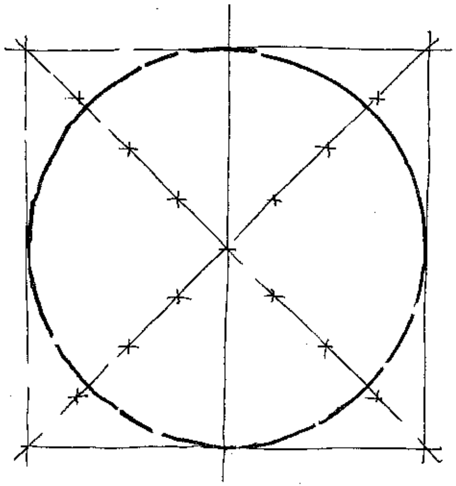


Figure 6

Parallel line drill carries over, together with the estimation of scale, to the sketching of isometrics within carefully plotted grids or frameworks of grids.

"Scumbling" is a word we borrow from painters who use it to describe the overlaying of large dark masses with lighter variegated patterns to break up their bulk. We use it in our type freehand to impart a sense of "roundness" or depth by denoting differences in lighting effects through the use of broad strokes of varying shades and densities. Note that most students will tend to overdo this technique. It is better underdone than over. Also note that because pencil leads are very weak in tension, scumbling should be done by forcing the pencil along with its point toward you in a direction which is also toward you (Fig. 7).

"Secondary detail" is of great value in enhancing detail which might otherwise appear very dull as does the cylinder shown herewith (Fig. 8a). Addition of scumbling to its surface brings out some sense of its roundness but not much.

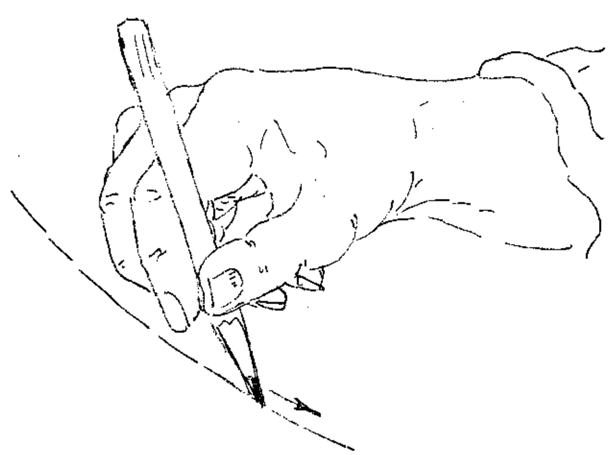
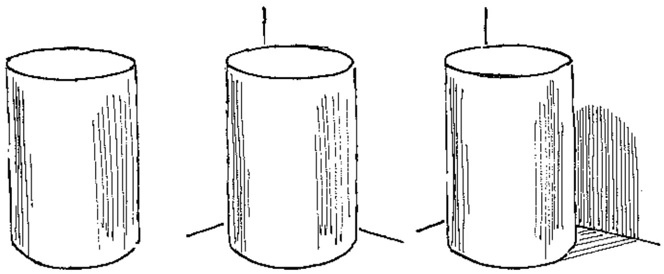


Figure 7



8a 8b 8c

Figure 8

The addition of three directional lines in the background, as secondary detail, suggests that the cylinder is standing on the floor, in a corner, and by implying there is something back of the cylinder give a three dimensional effect by illusion (Fig. 8b). Addition of shade and shadow and others heighten the illusion (Fig. 8c).

Freehand techniques are loaded with tricks, and the following is a particularly good one for helping the student to avoid badly warped constructions. It has to do with locating the approximate position of what we call the "cross-axis" of an object. To illustrate, suppose we use a section of corrugated material, as shown, the construction of which is basically a series of continuous right cylinders (Fig 9a).

The direction for the long axis of the cylinders is first selected and sketched out at some low and pleasing angle (Fig. 9b). The end of the first elliptic end is then sketched making certain that the major axis is perpendicular to the cylinder axis (Fig. 9c). The scale

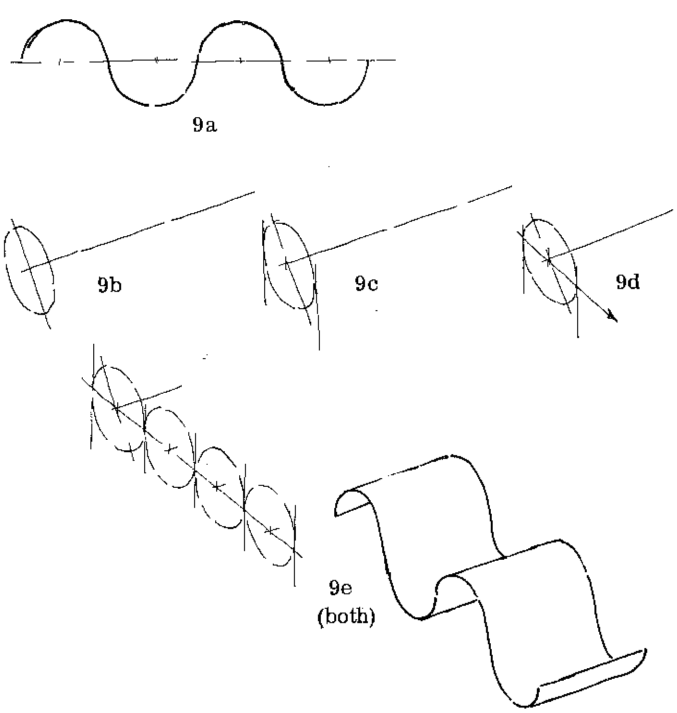


Figure 9

of the sketch has now been set and so have the directions of two of the three dimensional axes. It is in the placement of the next axis, the line that runs through the ends of all the cylinder ends that the beginner usually gets into difficulties. The "gimmick" here is to sketch a pair of light lines that are vertical and tangent to the sides of the first ellipse then to run this cross-axis through the tangency points and center of the ellipse and to construct the following ellipses along this line (Fig. 9d). Not perfect Schwarzian geometry, perhaps, but it works wonderfully well (Fig. 9e).

The torus is perhaps the most difficult of the geometric forms to sketch, and the best method I have found for this form is to first sketch the elliptic center-line and then to carefully construct on this a series of spheres all of which are of the same size (Fig. 10). The envelope of all these spheres, which is

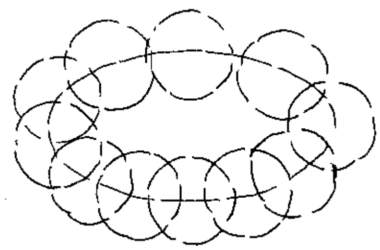


Figure 10

an oval and not an ellipse, is next sketched about the outside of the spheres and offers no problem. The outline of the hole, however, is where the problem does lie. It should not be shown as a continuing oval line but as two overlapping ones. That is, the internal corners are sharp rather than rounded (Fig. 11). How far to carry the nearer line across the farther is a matter for experimentation and depends greatly upon the diameters involved and the degree of tilt.

Lines alone will not suffice for this figure; it needs the application of surface treatment and the best seems to be to show a highlight along the rear lower edge and above this and adjacent to this and, in fact, outlining it a strong dense tone value that is made crescent shaped in that it tapers to horns at the extremes. Additional surface treatments and shadows

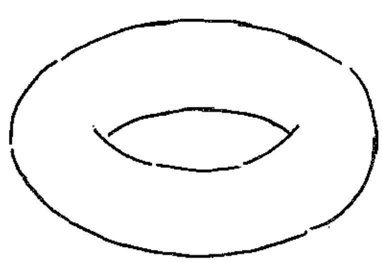


Figure 11

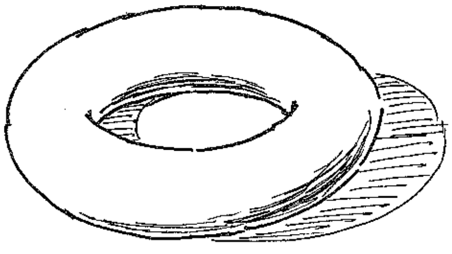


Figure 12

are possible in many variations but this seems to be necessary as a minimum (Fig. 12).

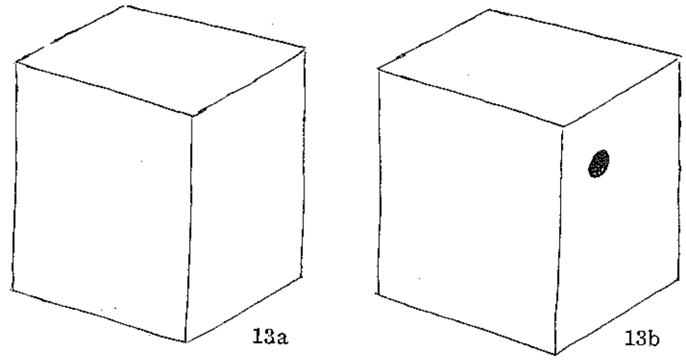
Various useful grids can be graved into the surfaces of your blackboards. We have one of a group of three panels graved with lines for isometrics, one with a rectangular or square pattern, and will soon have the third with a perspective grid similar to those set out on Lawson charts.

The one having the pattern of squares was subdivided into nine units for height so that we could readily plot descriptive geometry problems from standard texts and these, we found, gave good visibility from the rear of the lecture hall which is quite large. The other two, the isometric and perspective, are then made to the same scale so drawings on any pair will have some reasonable resemblance.

One suggestion: do not grave the grids with wide or deep lines as these tend to fill with chalk dust which, through a sort of halation effect, make them appear much wider than they are; and these then may become the center of interest with the student becoming subconsciously much more aware of the grid than they should. Such lines should be mere scratches that are barely visible to the instructor. They can be rescratched if they weaken with use.

The consideration, in relation to fine-line layout, which has to do with what our fine-arts colleagues refer to as "center of interest" is one which you may illustrate to your group by means of the light outlines of a cube. On inspection this will appear flat, dull, and unreal (Fig. 13a). Have the class close eyes or turn their heads for a moment while you perform a small operation. As they do so, place a conspicuous mark, in this case a large dot, somewhere on the figure and then recall the group to observation (Fig. 13b). Ask what catches the eye almost immediately and tends to hold it quite insistently. It will, of course, be the dot and this is what is meant by a center of interest. Too often, we let the construction lines for our sketches assume the role of such a center, and this is why it would be wise to take the time to sharpen a few pieces of chalk just before going to class and to make use of them for fine line construction work when there.

When one sketches on the board, as many of us do, using white chalk on the black board while the students are operating in exactly the reversed order of black and white, there is considerable call for the exercise



13a 13b

Figure 13

of imagination on the parts of teacher and student. Of course we teachers could use large white sheets of paper and black crayons, but these are expensive and have an annoying habit of not always being handy when we want them and, anyway, we are in the imagination-stirring-up business.

Your preliminary outline work should be so faint and thin that it is not discernible to any degree by the students. The younger men in my department have solved this problem by running some chalk pieces through the pencil sharpener just prior to going to class. Such sharp points are ideal for the desired fine lines of construction work.

Your final chalk outline should be made in bold and evenly wide lines which you can get by breaking the chalk stick in two and holding one piece almost perpendicular to the board. Resultant visibility is good from 10 to 80 feet.

In summation and conclusion, I believe that the value of good sketching, which has never been low, will tend to increase in the near future as the complexities of the engineering product increase; I believe that every department in the college or university where engineering students turn in reports that can be illustrated in any way through the use of sketches should insist that these be added.

The student should be required to look up DaVinci's sketchbook and see how he worked out his ideas in thumbnail sketches and the tie-in with this approach to design should be stressed.

Student sketches should be kept to small geometric elements as much as possible, and these as simple and forceful as they can be made. Sketches of large and complicated objects are to be avoided until he masters the smaller elements of which they are composed. Later he will be able to assemble these under his own steam.

It is to be hoped, as an aside, that some of these achievements on the parts of these students may eventually be reflected in an increased appreciation of fine arts illustrating and painting and even, perhaps, to stimulate their possible essays in that direction.

HAVE YOU RENEWED YOUR SUBSCRIPTION?

Modernization of Basic Drawing Courses

By Klaus E. Kroner
University of Massachusetts

At many ASEE meetings one can hear about some school or department dropping the drawing and/or descriptive geometry courses from their curricula. This in spite of the accepted and widespread opinion that drawing is an essential part of any engineer's education. Very often, however, the argument against keeping the drawing courses is the feeling that drawing is still taught, as it was twenty years ago, with endless hours spent on lettering exercises and the copying of fictitious machine parts. For how many schools this is true (or whether it is true at all) I would not venture to guess, but the fact is that the argument still faces the drawing staff.

At the recent annual meeting of the New England Section of ASEE, several teachers from various engineering disciplines separately stated they would not mind keeping drawing in their curricula, if only the course would serve their specific disciplines and contribute further by arousing interest in their fields. This is a challenge which must be met by the teaching staff of the basic engineering drawing courses.

A logical way to accomplish this would be to offer several types of freshmen drawing courses, each one putting emphasis on a different branch of engineering. At most institutions there would be four such courses: for chemical, civil, electrical, and mechanical (the traditional one) engineering. Architectural, mining, geological, and other sections might be added in others. This can easily be done without an increase in the number of classes, as more than a few drawing sections are taught concurrently at almost all engineering institutions.

It should be pointed out that this is hardly a new idea because a very limited number of schools are already offering such "field of interest" drawing courses. Nor is a radical revision in the basic drawing courses advocated here, but rather a more selective choice of problems.

Obviously technique, lettering, and basic theory must be presented to all students, but as soon as orthographic projection is taken up, different types of problems for the various sections should be used. Traditionally, mutilated blocks of various degrees of complexity and configuration are used. Would it not be more sensible to give a problem involving the three views of a tripod to prospective chemical engineers, a simple bridge for the civil engineering students, and a knife-switch for those interested in electrical engineering? Similarly, when working drawings are the topic, the chemicals may be asked to design a piping layout for a certain laboratory experiment, the civils might draw a complete cross-section of a highway roadbed, and the electricals could work on the assembly drawing of a motor.

In the case of charts and graphs: triangular charts, flow charts, and nomographs are almost a "must" for the chemical sections; the civil classes could draw charts showing hourly traffic loads; and this would not be a bad time to introduce the characteristic curves of motors to the electrical engineering students.

The reader can probably already think of many more problems suitable for use in the various drawing courses. This selective choice of problems could, of course, be carried into and continued in the subsequent descriptive geometry course.

The main point of these paragraphs is that drawing must be made more interesting and more beneficial to the individual student and as soon as possible get him acquainted with some of the equipment, machinery, charts, and processes with which he will soon be working. The increased value of such drawing courses to the upperclass programs of the different engineering departments is obvious.

In some schools certain administrative problems may arise, particularly in those where the freshmen are not required to indicate a choice as to the field of engineering in which they are interested. At registration, however, the students could be told: Drawing courses with emphasis on different fields of engineering are offered – pick the one you think will interest you most. This should in no way obligate the student to stick to his choice at a later date; and even if he did change his field of study after the freshman year, he would still have learned the basic principles of drawgin, how to draw, and how to read drawings. Furthermore, the student would thus be given his first contact with the type of engineering which he thinks he would like to pursue in the future. During the term he might or might not decide that this is what he wants to do. When the time comes when the school requires him to select a major, he will be able to make an intelligent choice based on a little, but real, experience. The probability that the student desires, at a later date, to switch majors, which usually results in a loss of credits to him and is somewhat of a nuisance to the departments involved, is thereby also minimized.

With this kind of a drawing course program, by which the student gets a preview of his subsequent work, the major departments would hardly be inclined to eliminate drawing from their curricula.

"The keenest tool in an engineer's kit is his imagination. This is the tool without which no great engineering or scientific accomplishment is ever consummated. Imagination—that characteristic which is beyond other human capabilities. Imagination—the first and greatest ingredient in all creative work. . . ."
—Edward B. Newill, Vice President of General Motors

Introduction to Nomography in Engineering Drawing

By Richard G. Huzarski
University of New Mexico

With the present trend of de-emphasizing the "drafting" aspects in teaching engineering drawing, and of stressing the "engineering" phase of the work, an instructor often has difficulty in finding appropriate teaching material. Such teaching material must indeed meet and satisfy several apparently unreconcilable conditions.

It is the instructor's basic job to prepare the student for the work in engineering design, grounded on the student's knowledge of the natural sciences, mathematics and technology. But at the educational level at which engineering drawing is taught an average student is normally still plodding through the lowermost reaches of mathematics and sciences, and knows virtually nothing about their technological applications.

This regrettable condition leads some of the instructors to hang on doggedly to teaching only the principles of mechanical drafting. Such a course of action is obviously inadequate for the students with the engineering aspirations. On the other hand, instructors stressing primarily the graphic aspects of engineering design often aim high above the students' heads, leaving all but the most gifted ones bewildered rather than taught. Nor should it be advocated that the courses in engineering drawing stress greatly the subject of graphic solutions to the mathematical problems and/or the technical sketching exercises, for the former may be best taught by the mathematicians and the latter by the artists and illustrators.

Confronted with these facts, an instructor finds himself burdened with a difficult problem. Once his students have learned to use their tools, developed a decent set of drawing habits, and learned the rules of orthographic projection—what should they be taught next?

The answers usually arrived at come from the realm of mechanical assemblies, building trades, etc. Some of the problems from these groups are quite good, but almost all of them have two common failings: thev rarely suit the interests of more than a fraction of the class, and they are much closer to a technician's and a tradesman's line of pursuits than to that of an engineer. There exists, however, a branch of graphic science which could provide us with drafting room problems admirably suited to our engineering drawing course.

The name of this science is "nomography." Its products, the nomograms (or nomographs), are known to and used by every practicing engineer, but their graphic construction is seldom included in our engineering curricula. These nomograms, if properly executed, represent tools which are of considerable value in engineering analysis and design. While in the process of production they offer a student much food for thought and serve to develop his accuracy and drawing technique.

By definition a nomogram is a graphic representation of numerical relations. Since all the mathematical formulas are also numerical relations, it follows that many formulas can be represented graphically, if their component factors can be located on properly calibrated and correctly placed scales. Thus, scales C and D of a common slide rule are a form of a nomogram devised for the purpose of multiplying and dividing numbers.

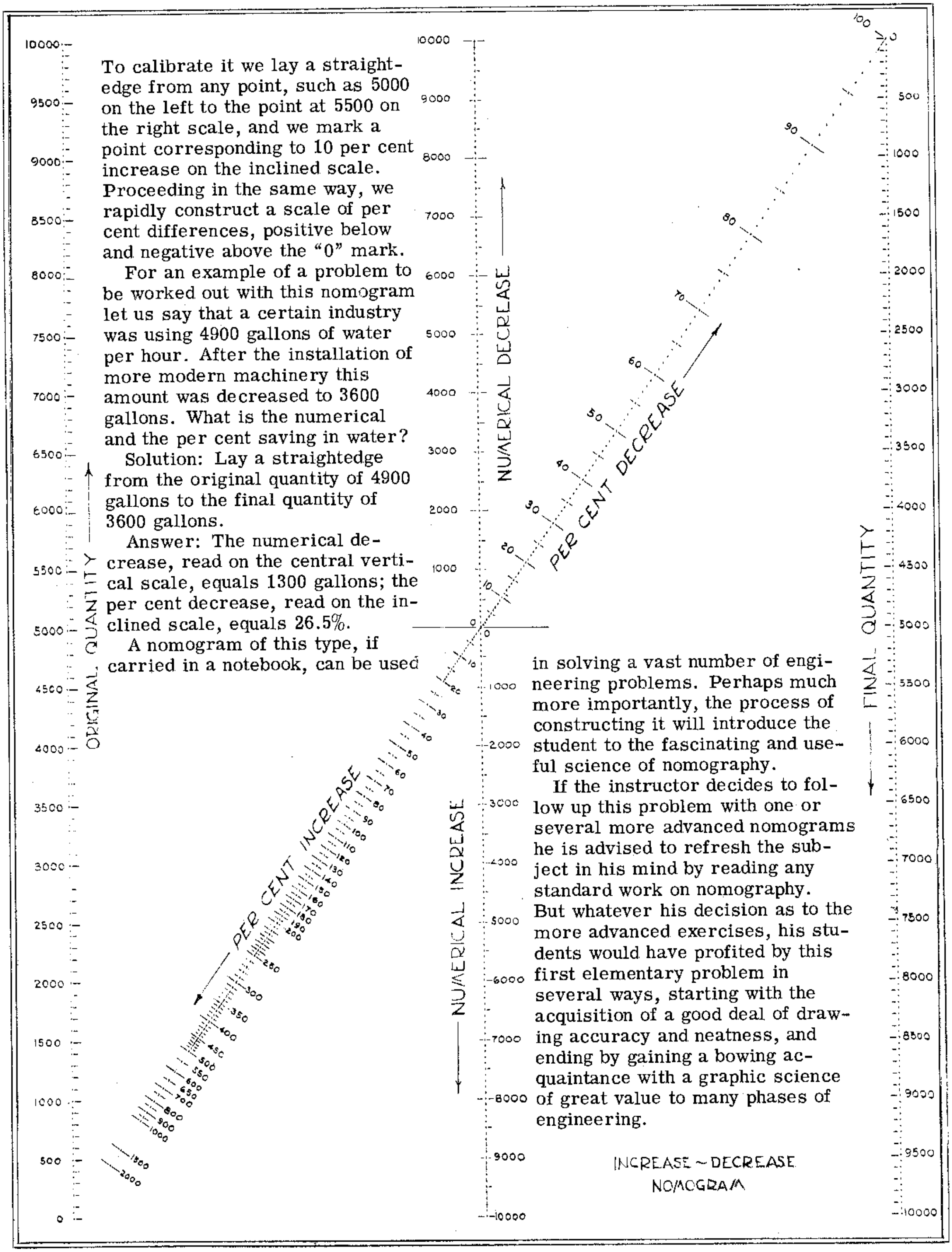
Nomograms may be extremely simple, involving only straight lines and uniform calibrations, or they can be highly complex, comprising parabolic, hyperbolic, and exponential curves, and may be used for solving equations of many constants. As an example of the latter type, a recent nomogram by this author contains six scales, some of them calibrated uniformly and some logarithmically. Its purpose is to facilitate work with bent aluminum sheet used in aircraft manufacturing.

The nomogram shown and explained in this article is of a much simpler type, but of a very broad range of applications. It has been tested by my friends and colleagues at and around the campus of the University of New Mexico on such divergent problems as stock market losses, increases of crops under varying conditions, changes of areas, volumes, strengths, elongations, and so on.

There are three vertical scales in this nomogram. Both of the outside ones are uniformly calibrated from 0 to 10,000 (the location of the decimal point is not important), and each division is again divided into ten equal parts. The right-side scale, however, is calibrated from top to bottom, or opposite to the left-side scale. The central vertical scale is located exactly half way between the two outside ones. It is of the same length as the other two, but it is divided by the "0" point into the upper and the lower halves. Each of these halves is so calibrated that the divisions are one-half as long as those of the two outside scales.

A straightedge laid from any point on the left scale (original quantity) to any point on the right scale (final quantity), will cross the central scale at a point corresponding to the numerical difference between the two quantities. If this difference is positive, it will be read below the "0" point, and if negative, above the "0" point.

The inclined scale, which is laid out to give the per cent differences between any two quantities, also passes through the "0" point. It is mathematically proper and graphically convenient to have it pass also through the "0" points of the two outside scales. This inclined scale is so calibrated graphically as to give the per cent differences between any two quantities.



To calibrate it we lay a straightedge from any point, such as 5000 on the left to the point at 5500 on the right scale, and we mark a point corresponding to 10 per cent increase on the inclined scale. Proceeding in the same way, we rapidly construct a scale of per cent differences, positive below and negative above the "0" mark.

For an example of a problem to be worked out with this nomogram let us say that a certain industry was using 4900 gallons of water per hour. After the installation of more modern machinery this amount was decreased to 3600 gallons. What is the numerical and the per cent saving in water?

Solution: Lay a straightedge from the original quantity of 4900 gallons to the final quantity of 3600 gallons.

Answer: The numerical decrease, read on the central vertical scale, equals 1300 gallons; the per cent decrease, read on the inclined scale, equals 26.5%.

A nomogram of this type, if carried in a notebook, can be used in solving a vast number of engineering problems. Perhaps much more importantly, the process of constructing it will introduce the student to the fascinating and useful science of nomography.

If the instructor decides to follow up this problem with one or several more advanced nomograms he is advised to refresh the subject in his mind by reading any standard work on nomography. But whatever his decision as to the more advanced exercises, his students would have profited by this first elementary problem in several ways, starting with the acquisition of a good deal of drawing accuracy and neatness, and ending by gaining a bowing acquaintance with a graphic science of great value to many phases of engineering.

INCREASE ~ DECREASE NOMOGRAM

An Aid in Perspective Drawing

By Gerald W. Walsh, Jr.
and Paul E. Keicher

Syracuse University

One of the unique service courses offered by the Drawing Department of Syracuse University's College of Engineering is a basic course for Interior Design students. These students are enrolled in a program developed to train them in all phases of interior design work – both for commercial and private types of construction. They take this course while they are in the lower division, that is, at the freshman-sophomore level. Because of their close working alliance with the professions of architecture and engineering, the fine arts advisors for these students felt the need for some training in mechanical drawing as a part of their program.

This was to serve three purposes. First, to familiarize them with the graphic language of the architect and engineer; a language with which they must be well versed. Secondly, it would enable them to better understand production drawings of new equipment and furniture as supplied by the manufactures. And finally, the course would serve as a discipline in a field where free hand expression is dominant. While to a practicing engineer this last objective may seem minor, the advisors considered this alone as sufficient justification for the course.

As would be naturally expected, one important phase of such a course is the study of pictorial representation, particularly perspective. Interior Design students make extensive use of perspective representation in their work. Usually their perspectives are rendered with the aid of the commercially available "perspective charts" or underlays.

Joint discussions between the advisors in Fine Arts and our own staff brought about the fact that these students usually entered the program with a lack of understanding of basic perspective principles. It was felt that our course was the proper place for their indoctrination into the theory of perspective for use in subsequent course work. Further discussions with students in the upper level (junior and senior) revealed that the commercial charts often did not meet their specific needs for representing interiors, and that they desired more flexibility.

With this background we set out to formulate sequence of study in perspective. It is not our purpose in this paper to review the teaching techniques for the basic principles of perspective as presented to the students. This follows the basic pattern found in most drawing texts. But rather our purpose here is to demonstrate how, by using these principles, we provide the students with a method for developing their own guides to replace the commercial charts. In this way they can set up interior guides to meet specific demands.

In the subsequent paragraphs we shall first present the analysis for grid construction as presented to the students. Then we shall discuss what these mean to the students.

A typical procedure for constructing an angular perspective grid for use in drawing interiors is as follows. This discussion describes a composite perspective construction – both a top and front view combined together. First a ground line A-B is established at a convenient location on the paper as part of the front view. A good location for most drawings is about one-third of the way from the bottom of the sheet (Fig. 1). Next a line perpendicular to the ground line is erected at a point O. This line C-O will represent the corner, or intersection of two walls in the final drawing.

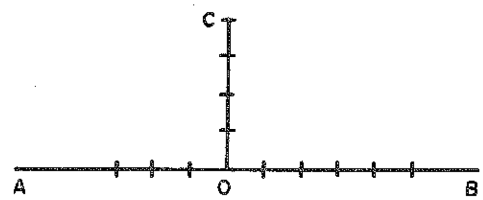


Figure 1

The location of this perpendicular will depend upon the relative areas of the two walls to be viewed. If it is desired to see an equal amount of both walls in the final drawing, then this perpendicular is erected approximately in the center of the sheet. If it is desirable to see more of one wall than the other, the line C-O is located somewhat to the right or left of center. With the position of the line established, it becomes a vertical axis or measuring line along which a suitable scale is laid off. Scale divisions represent height measurements in the final grid, and are labeled to measure feet or any other convenient scale of measurement. Since, in the construction of the grid, the ground line A-B and this measuring line C-O lie in the same vertical plane, the ground line can be used as a horizontal measuring line along which similar scales are laid out in each direction from O. These scales provide the means for horizontal measurements along each wall in the final grid.

The next step, as shown in Fig. 2, is the establishment of a horizontal line, D-E, which for convenience serves a dual purpose: first, as a horizon in the front view; and second as an edge view of the picture plane in the top view. This line is drawn at some convenient distance above the ground line, usually at a height considered to be normal eye level for the average person. This location is decided with reference to the previously established vertical measuring scale. Then a station point SP is established in line with the center of interest for the final drawing. Following the basic rules for perspective, this station point should be located far enough away from the picture

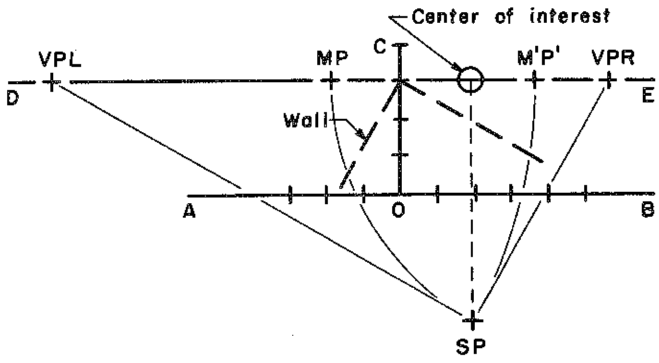


Figure 2

plane so as to avoid any distortion in the final grid. Next it is decided at what angle the walls will be positioned with respect to the picture plane. These are sketched on the drawing in dashed lines for reference. Then with the aid of the line D-E and the station point SP, right and left vanishing points VPL and VPR, and measuring points MP and M'P' are established in the usual manner.

Referring to Fig. 3, lines are now drawn from the two vanishing points to the point of intersection O and extended to form the line of intersections between walls and floor in the final grid. By drawing lines

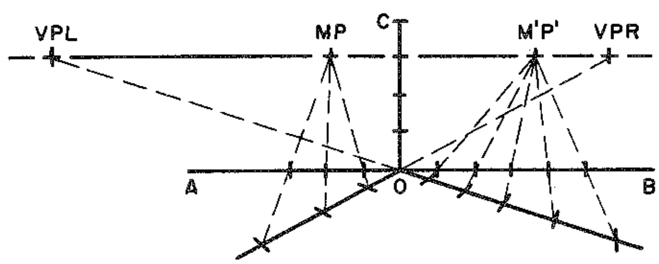


Figure 3

from the measuring points to the scale divisions along the ground line A-B and extending them, these scales can be transferred to the lines of intersection between floor and walls where they now appear in perspective.

To complete the grid as shown in Fig. 4, lines are drawn from the vanishing points to the graduations along the line of intersection between the walls and the floor and extended to produce a perspective grid on the floor. Also lines are drawn from the vanishing points to the graduations along the vertical measuring line C-O and extended to establish horizontal reference lines for the two walls. Finally, vertical lines are drawn from the graduations along the lines of intersection of walls and floor to produce the completed perspective grid on the walls. If desired a ceiling grid could be constructed in the same manner as that on the floor.

Due to space limitations there is considerable distortion in the previous figures. In actual practice, however, the vanishing points are usually selected off

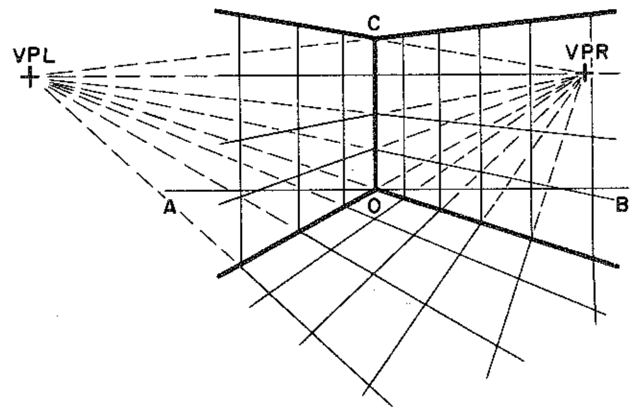


Figure 4

the limits of the paper in order to show a greater portion of the interior before inherent distortion becomes evident. In practice the grid constructed by this technique supplies the underlay or background for an interior layout. While some portions of actual drawings rendered by Interior Design students are instrumental, a great proportion of them are free hand. The grid provides the students with a perspective coordinate system which is invaluable in positioning interior details, and in keeping the relative proportions between the various parts of an interior study. Fig. 5 shows

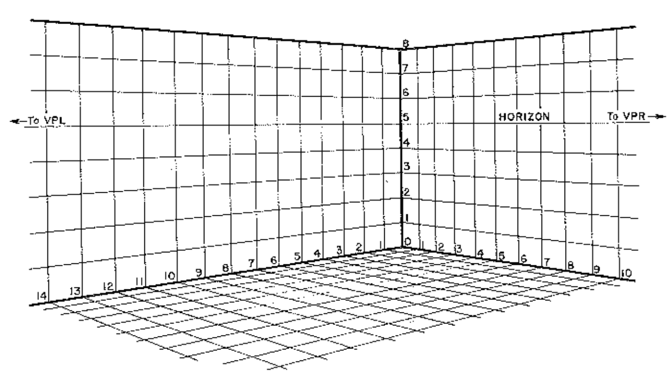


Figure 5

an actual grid constructed by a student in the classroom while Fig. 6 shows a simple interior, drawn using the grid.

This approach, as a followup to the regular perspective lectures, has been well received by the students. First, it provides the student a better appreciation for the commercial charts and their use. Then, as the abilities and imagination of the students are developed, they begin to set up their own grids. Using this approach they are released from the constraints of the commercial grids, and have complete freedom in the orientation of their presentation. They can orient their interiors in any manner and shift the center of interest to any location desired.

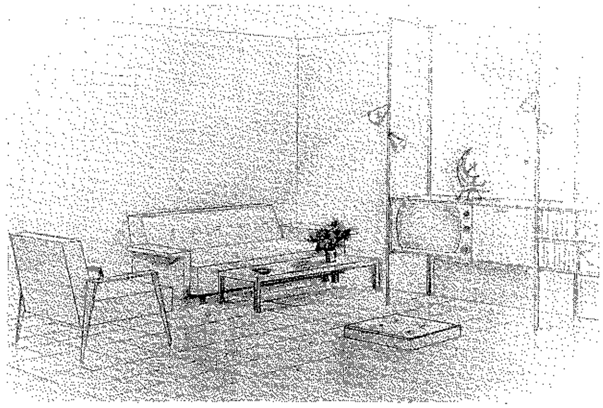


Figure 6

In presenting this material we fully appreciate that it does not present any new development in the field of perspective drawing. It merely illustrates how ideas may be regrouped to meet the specific needs of certain specialized groups. Although developed primarily for the fine artist, it should be noted that the technique could also be quite useful to the engineer and architect. In fact with minor modification it could be utilized in any graphics course where an emphasis is placed on perspective since it is applicable to exterior views of objects and structures as well as room interiors.

Experience with our Interior Design students has shown that this additional perspective training has given them a much better appreciation of perspective, both from a theoretical and practical standpoint. The short period of time during which this approach has been presented does not permit a detailed evaluation of improvement in the students' abilities, but there already seems to be more freedom evident in the subsequent student work. While an average student may well continue to use the stereotyped forms available, the superior ones are breaking away from regimentation and proceeding on their own.

Too Large for A Beam Compass—Too Small for A Transit

By Robert M. Johnston
California State Polytechnic Institute

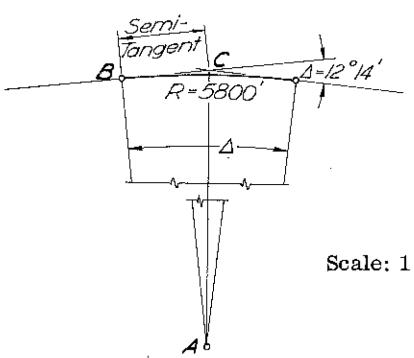
Have you ever wondered how to draw a circle arc whose radius is too large for a beam compass? Civil engineers, especially those in highway design, continually work with curves whose centers are inaccessible.

In the field, these curves are staked out by using a transit and setting off deflection angles. In the drafting room, they are drawn with the aid of celluloid curves, available in sizes ranging from $1\frac{1}{2}$" radius to 600" radius. The example following will illustrate.

It is required to draw a 5800' radius arc tangent to two intersecting straight lines. Let Δ be 12° 14', and the drawing scale be 1" = 20'.

In Fig. 1, the semi-tangent distance is found to be 618' by solving triangle ABC. Since the drawing is to a scale 1" = 20', $\frac{5800}{20}$ gives the curve radius, in inches, to be selected. Often the exact radius curve isn't available, in which case the next closest is used. A 300 inch radius curve would serve the purpose here.

To attain the greatest possible accuracy, tangent offsets may be computed for additional points on the curve, as shown in Fig. 2. This is absolutely necessary when the celluloid curve used isn't the correct radius, or when it isn't long enough to reach from beginning to end.



Scale: 1" = 20'

Figure 1

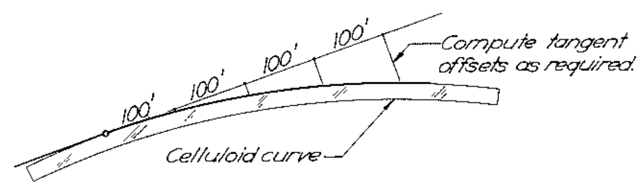


Figure 2

A New Pictorial Piping Method

By George K. Stegman
Davenport High School, Davenport, Iowa

and Robert K. Kemp
Stanley Engineering Company, Muscatine, Iowa

A piping diagram is in reality an assembly drawing. However, an assembly drawing is generally categorized as a multiview drawing. In depicting a complicated piping diagram, a multiview drawing may lead to confusion, particularly if the diagram is to be viewed by a person or a group of persons who are not thoroughly trained in reading drawings.

In some instances, a "one-line schematic" piping diagram is used, in which all piping runs are shown as single lines in one plane. This has the obvious drawback that not all of the pipes are shown in their true lengths and that not all the necessary fittings can be shown easily. Further, there is often no indication how the piping is to be routed through a structure.

Confusion may be avoided by representing the piping diagram in a pictorial view, either isometric or oblique. The pictorial will show clearly the directions and changes in level of pipe, and may be used alone or with an orthographic view of the diagram.

Pictorial piping drawings, however, sometimes have the unfortunate property of being optical illusions in that they appear to reverse themselves, the lines in the foreground appearing to be in the background, and vice-versa.

Greater clarity may be added to the pictorial piping diagram by utilizing various weights of lines to create a greater illusion of depth. This may be done by increasing the weights of the lines representing the pipes (either single or double) as they progress toward the viewer, so that the lines representing the pipes in the background are light and those in the foreground are heavy. (See Figure 1.) This technique helps simulate depth and eliminates any optical illusions.

The method illustrated has been used with success at the Stanley Engineering Company, Muscatine, Iowa and in the Machine Drawing classes at Davenport High School, Davenport, Iowa and has been favorably accepted by tradesmen.

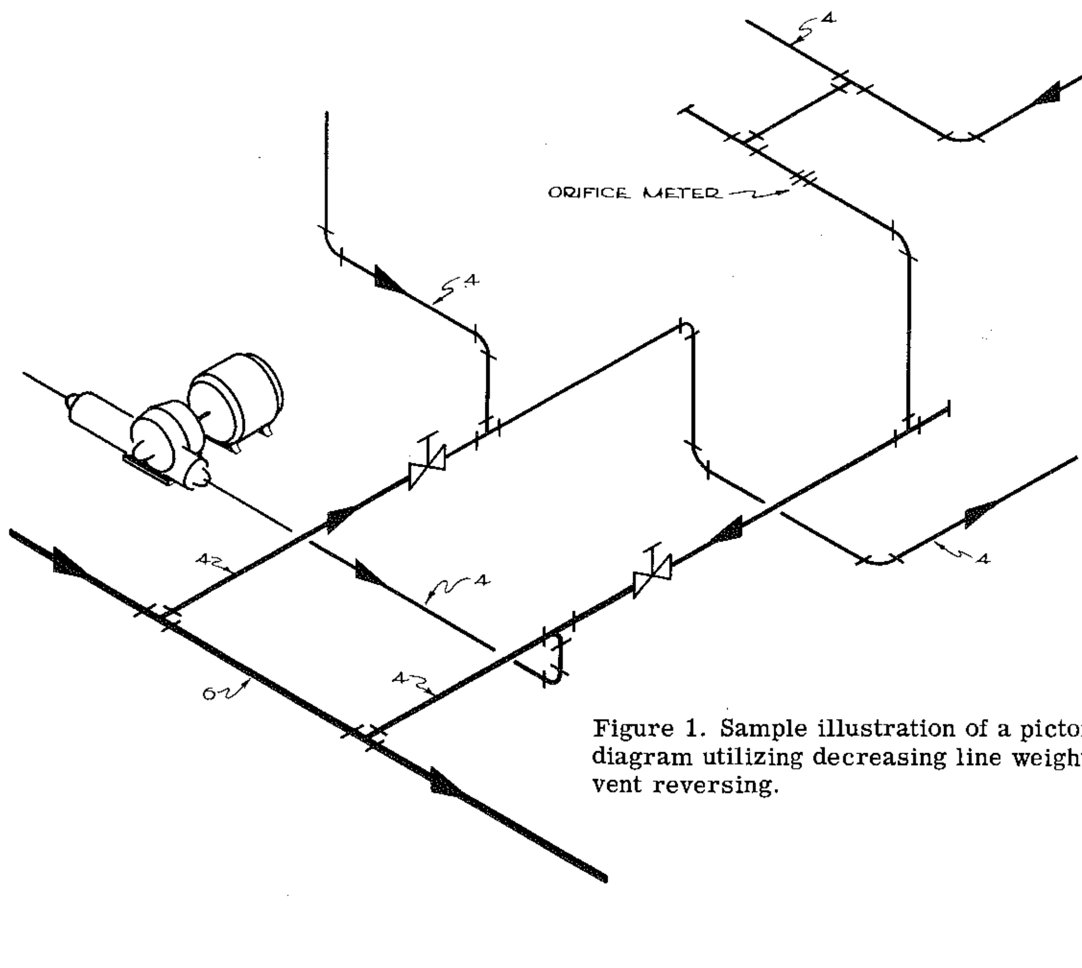


Figure 1. Sample illustration of a pictorial piping diagram utilizing decreasing line weights to prevent reversing.

A Change in Name for the Division *

By Matthew McNeary

University of Maine

Chairman, Committee on Aims and Scope

Regardless of Shakespeare's comment about a rose, there is some question about whether it would smell as sweet if it were called a cabbage. Names involuntarily call up associations of one kind or another that influence attitudes and actions. The time has come to give serious consideration to the appropriateness and association value of the name of the Engineering Drawing Division.

Prior to the end of the first decade of this century the accepted name for the subject our predecessors taught was "Mechanical Drawing." This term implied the making of drawings by instrumental or mechanical means rather than freehand, and, in view of the state of scientific knowledge and engineering practice at that time, it was reasonably adequate. With the publication in 1911 of "Engineering Drawing" by Thomas E. French a new name was introduced and widely accepted by colleges and universities throughout the country. Evidently Professor French thought that we were teaching more than the mechanical manipulation of instruments and that the adjective "engineering" was more descriptive of our work. Few of us would want to go back to the term "Mechanical Drawing."

Because of the rapid evolution of science and engineering since the two World Wars there is now considerable sentiment among members of the Engineering Drawing Division that the name "Engineering Drawing" no longer conveys to others a proper understanding of what we are teaching. This time it is the noun rather than the adjective that is in dispute. Does the word "drawing" lead others to think that we are teaching primarily manual skills? Do others understand that we are teaching graphic communication and problem-solving in all its aspects, freehand as well as instrumental? Are others aware that we are teaching our students to use the analytic power of graphic methods in meeting scientific problems and the indispensable synthetic power of graphic methods in the creation of new products? Many of us feel that a change of name would help create better understanding of our true objectives.

At the recent Mid-Winter Meeting of the Engineering Drawing Division of A.S.E.E. in Flint, Michigan, January 15-17, 1958, your Committee on Aims and Scope unanimously presented the following resolution to the Executive Committee:

Whereas, the term "Engineering Graphics" characterizes more accurately the scope of our work, which includes graphic analysis and problem solving as well as the description of objects for manufacture; therefore

We recommend that the name of the Engineering Drawing Division of the American Society for Engineering Education be changed to the Engineering Graphics Division of the American Society for Engineering Education.

After an extended and soul-searching discussion it was decided to refer the change of name problem to the entire Division in the form of an advisory ballot to determine grass-roots sentiment. It was also decided to place the matter on the agenda for action at the Annual Meeting this June in Berkeley, California. The only way the name can be changed constitutionally is by a two-thirds vote of the membership present at the Annual Meeting. The advisory ballot will offer an opportunity for every member, whether or not he attends the Annual Meeting, to express his sentiment for "Engineering Drawing," "Engineering Graphics," or for some other name he may devise that he considers more appropriate.

We commend this matter to you as an item of some importance. If you have an opinion that you would like to express at greater length than the ballot affords, please write to a member of the Executive Committee or the Committee on Aims and Scope. Their names are listed below.

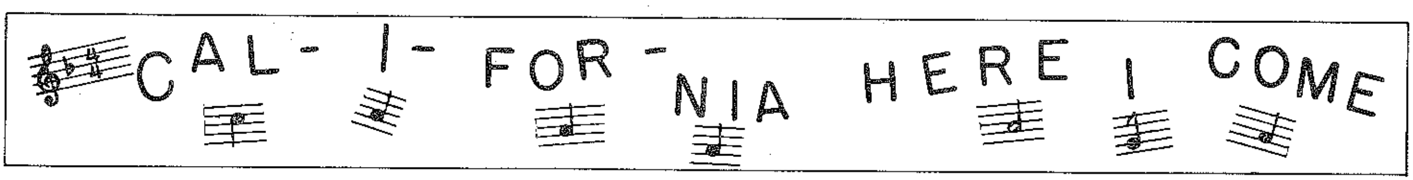
Executive Committee

W. J. Luzadder
J. S. Rising
J. S. Blackman
I. L. Hill
F. A. Heacock
C. H. Springer
C. J. Vierck
J. H. Porsch
M. McNeary
B. L. Wellman
A. P. McDonald
I. Wladaver
E. M. Griswold
E. G. Paré

Committee on Aims and Scope

C. P. Buck
J. Gerardi
R. H. Hammond
F. A. Heacock
A. Jorgensen
R. A. Kliphardt
M. McNeary
J. S. Rising
B. L. Wellman

* See also the editorial page of this issue



Workshop Reports of the Mid-Winter Meeting, January 1958 at General Motors Institute, Flint, Michigan*

Subject: Engineering Drawing and its Relation to Designing
Chairman: Frank H. Smith (University of Michigan)
Analyst : Albert Jorgensen (Univ. of Pennsylvania)
Recorder: Theodore Aakhus (University of Nebraska)

There were 26 men in attendance at the meeting and it is significant that 15 were representatives from industry. The following industries were represented: General Motors, International Harvester, John Deere & Company, Otis Elevator Company, Detroit Edison, Eastman Kodak, International Business Machines, Westinghouse and Goodyear Tire Company.

The meeting was opened by the chairman who introduced the analyst and recorder. The analyst outlined our objective. An informal atmosphere prevailed and the participation was gratifying.

It was emphasized by several speakers that engineering drawing was essential in all areas of design and that it was difficult to draw a sharp line of demarcation between them.

A good designer must have creative ability and it is desirable that he also have the ability to draw in order that he can translate the design into a useful product. It was pointed out that designers made extensive use of descriptive geometry.

The configuration and space requirements of a mechanism cannot be calculated in most cases but must be produced through the medium of drawing. Useful designs cannot be produced by calculation alone. All engineers must understand drawings even though they are not expert in making them. It was pointed out that persons in management have occasion to use engineering drawings to clarify their thinking and to transmit their thoughts to subordinates.

A rough survey of the industrial representatives indicated that about 50% of the men performing engineering functions worked in design.

Although there was not unanimous agreement, it was stated that in a large group of industries the greatest opportunity for a successful career in engineering is through experience related to design. Some industrial representatives complained of the increasing tendency on the part of engineering graduates to avoid design positions.

It was suggested that mid-winter meetings for the most part be held in industrial areas so that the Division could avail itself of the guidance and support of industrial people who are vitally concerned with our area of interest.

The academic representatives present at the workshop are highly appreciative of the sincere interest displayed by our industrial friends.

* The following reports have been prepared in each case by the Recorder of the committee.

Subject: Better Methods of Instruction in Engineering and Technical Drawing
Chairman: Kenneth E. Botkin (Purdue University)
Analyst : Harold Skamser (Michigan State University)
Recorder: Irwin Wladaver (New York University)

The keynote to the workshop on better methods of instruction was sounded formally by Dean Harold Skamser. He opened a veritable Pandora's Box of lively, current, controversial topics such as:

1. What are effective and efficient methods of teaching? a. Are we getting a maximum job done in the limited time that we have?
2. What are the responsibilities to the above average, average, below average student?
3. Is better instruction likely to be achieved through less or more personal contacts with the student or through types and contents of lab, tests, and homework? a. Are creative type problems more likely to motivate interest, develop visualizing abilities, and provide experiences in analysis and synthesis? b. Is closed circuit TV instruction better than the usual personal instruction? c. Can tests and quizzes be made to serve as teaching devices?
4. Can more responsibility be assumed by the student, thus requiring self-initiative in preparing lesson material? a. Can more home and less lab work be assigned to obtain better prepared students?
5. How can activities between experienced and inexperienced staff be utilized? a. Is this the situation under which TV could best be utilized?

Members of the workshop suggested that the following questions might be worthy of discussions:

6. How can we challenge the student to increase his interest in engineering in general and in drawing in particular?
7. How should quizzes and classroom (or lab) work be weighted in the final grade?
8. How can we determine a. whether we need better or different type of instruction, and b. whether we have done a better job?
9. What is the maximum percentage of failures compatible with good instruction?
10. What do you mean by "logical" class size?
11. "It's in your textbook: look it up."
12. What are the characteristics of an ideal teacher?
13. How about more visual aids for descriptive geometry?

It is pointless to try to reflect the enthusiasm and the spirit that became evident at once. It is true that the ever-present spectre of "reduced time" inevitably came into frequent view. Nevertheless virtually all the subjects offered to the workshop were dealt with or approached at various times and intervals during the afternoon and from widely divergent viewpoints.

Kessler (I. I. T.) stated his interest in the scarcity of visual aids for descriptive geometry. Knoblock

(Wisc.) suggested that the Vu-Graph position in the front of the room was advantageous for class-control and its usability in a lighted room was also to the good. Wladaver (N. Y. U.) mentioned the practicality of successive overlays in illustrating step-by-step solution. Ring (Kansas) elaborated on the wall charts available to supplement a certain textbook. Isbell (Valparaiso) brought up his experience in the use of contrasting colors to show step-by-step progress. Betterley (Iowa) felt that completed problems in textbooks were helpful to all students, of course, but especially so to slower students who could then mull over the work at their own paces.

Carlstrom (New Trier High School) told what could be (and is being) done at his school with models made of 1/8" and 3/16" wire, brazed and painted in different colors for progressive steps. Barnes (Rochester) brought up the usefulness of the overhead projector and the possibility of challenging the student to say what the next step in a solution should be. Grant (Wayne) asked about the pace at which the Vu-Graph and overhead projector demonstration should be conducted.

Felbarth (Detroit) asked us not to neglect blackboard techniques. He said that our allusions to unfamiliar geometrical forms like frustrated pyramids would fall on unavailing ears. He thought that the presence of models (he did not state their forms specifically) would serve to de-frustrate the students.

The debate continued with some heat when the touchy subject of faculty rating by students was broached. Felbarth, Besel (Wisc.) were the protagonists in this spirited duel, but no blood was shed.

Howe (R. P. I.) asked Holmes (Heald Machine) what he thought should be included in a one-semester course. Holmes said "Teach them how to read blueprints." Howe wanted to know how to do this and everything else in such limited time and Paffenbarger (Ohio State) said it was impossible within such prescribed limits.

Tappan (G. E.), Keith (Kent State), Potts (Mich.) and others joined in the controversy just as the bell ended the first round.

In the second round many of the other topics came up. In the rapid melee it was possible to note the names of only a few of the participants, among them: Watts, Clark, Blackman, Botkin, Schick, Sanders, Skamser, Hoelscher, Aldrich, Kessler. Particularly interesting were the attempts to get ideal teacher defined and to state the best ways to train new teachers before throwing them to the wolves. Only the sounding of the final bell saved us from going into overtime.

Apologies to those whose names were missed or who were misquoted. And thanks to Botkin and Skamser for their work in organizing the work. To Professor J. Howard Porsch goes our sympathy in the bereavement which befell him so grievously.

Subject: Problems in Graphical Analysis of Mechanisms
Chairman: Ralph T. Northrup (Wayne State University)
Analyst : Douglas P. Adams (Mass. Institute of Tech.)
Recorder: Frank A. Heacock (Princeton University)

INTRODUCTION:

To assure a common terminology and a foundation statement for general agreement, Adams provided a mimeographed definition of mechanism and machine with typical examples of each, and a statement that problems in the graphical synthesis of mechanisms are included along with those in the analysis of mechanisms. He also listed suggested questions for discussion in the following areas:

a. Use in industry of graphical analysis of mechanisms.
b. Teaching the graphical analysis of mechanisms.
c. Comparison of graphical and arithmetic methods.
d. Student interest.
e. Present opportunities.
f. A current graduate program in kinematics.

The discussion began with a question as to whether kinematics should be integrated with the teaching program in engineering drawing. It was suggested that kinematics now taught in the first semester of junior year might well be shifted to the second semester of sophomore year and made a final drawing course. In general, the course combines theory with drawing and basic design and is highly regarded by the students.

At the Cooper Union kinematics is taught in the sophomore year and the students like it. The ME Department teaches it, and engineering drawing is taught by the same department. At General Motors Institute the students consider kinematics as an essential part of their education.

In considering the integration of kinematics with the drawing program it was felt that it should be introduced in the freshman year because all available time is needed at that level for the basic elements of drawing courses, and there is no background material for kinematics. But a third course in drawing would be strengthened by combining kinematics with it. A show of hands indicated that the ME Department teaches kinematics at two-thirds of the colleges represented.

Although descriptive geometry applications do not always include mechanism applications, the basic principles and constructions taught in this course are helpful when applied to problems in vector graphics encountered later in kinematics. The fundamental principles of vector graphics taught in freshman descriptive geometry are generally approved by ME faculty members and by industry.

At the General Motors Institute kinematics is taught at three levels: (1) To machine repair men; (2) to technicians, and (3) to engineers as a complete high-level course. There is need for more kinematics instruction especially in the cooperative plan of study. Students appreciate its value. General Motors Institute is trying to get reports from industry to show exactly what is needed in the course.

A Cooper Union graduate working on switch gear used all the kinematics he had learned and that gained in eight months of further study to advantage in his work. By selecting specially qualified students who have had good high school instruction and can pass a proficiency exam, Cooper Union has divided the freshman taking drawing into two sections. The advance section is allowed to skip the elementary part of the course. This group had a high morale and their examinations showed superior performance. At Wayne State University an advanced drawing project was offered at the 3/4 point of the freshman drawing course. Fifty per cent of the students chose the project opportunity and did well on it.

As precise graphical work is necessary for kinematics, printed worksheets are usually too small, and students are encouraged to use larger paper and make large scale drawings for accurate results.

There is a growing interest in graphic analysis of mechanism which is stimulated by teachers who have had experience in European instruction. Many problems that cannot be solved by mathematics can be worked out satisfactorily and accurately by graphic analysis. Three-dimensional problems in mechanism are specially adapted to descriptive geometry solution.

In summary, this discussion showed that students and teaching methods vary considerably in different schools. Integration of kinematics with graphics programs is possible on a limited basis, because industry and students are interested in the project. There is some graduate study and some research active in this field of engineering education. Graphic analysis and synthesis of mechanisms promise to make the teaching of the graphics courses more useful and vital.

Subject: Course Development in Relation to an Engineering Curriculum and Future Needs of the Young Engineer
Chairman: Carson P. Buck (Syracuse University)
Analyst : Ivan L. Hill (Illinois Institute of Tech.)
Recorder: A. P. McDonald (Rice Institute)

Chairman Buck introduced the subject to the workshop stating that engineering drawing courses have been hacked away in many instances and that the feeling of this group (about 70 strong) should be taken relative to the contents of a basic engineering drawing course that has been cut to the irreducible minimum.

He pointed out that the group consisted of a fairly representative cross section of the U. S. A. and that the results of this work would be the basis of a paper to be delivered this summer at Berkeley by Vice-Chairman, Jim Rising.

Analyst Hill gave each member of the workshop a copy of a chart showing the alleged relation of graphical expression to the total education of an "Educated Individual." For the sake of classification, it was assumed that the graphical expression might be represented by a basic course in engineering drawing. The basic course was further defined as a one-semester course in engineering drawing or a two-semester course including descriptive geometry. It was pointed out that should the course be a two-semester course, topics listed under engineering drawing might be presented during the second semester while other topics listed under descriptive geometry could be given the first semester. Analyst Hill presented a group of possible topics under each heading and they were taken up one by one, discussed and a vote was taken which showed whether the majority of the group thought the topic should be omitted, receive limited treatment or major treatment. Having exhausted the topics thus supplied, the group was asked to suggest other topics and the same test was put to them. Below are the results:

Basic Engineering Drawing

O - Omit. L - Limited treatment - 1/2 week or less.
M - Major treatment - Over 1/2 week.

1. Lettering - L
2. Instruments and Materials - L
3. Sketching - M
4. Orthographic Projections - M
5. Applied Geometry - L
6. Charts and Graphs - L
7. Sectional Views - M
8. Primary Auxiliary Views - M
9. Isometric Drawing (Mechanical and Freehand) - L
10. Oblique Drawing - L
11. Dimensioning - M
12. Shop Processes - L
13. Detail Drawing - L
14. Ink work and Tracing - L (5% majority)
15. Threads and Fasteners - L
16. Cams and Gears - O
17. Structural Drawing - M
18. Assembly Drawing - L
19. Original Design and Analysis - O
20. Reprod. Processes - L
21. Piping Drawings - O
22. Blueprint Reading (The consensus was that this was covered by other topics.)
23. Welding and Welding Symbols - O
24. Electrical Diagram and Circuity in general - O
25. Axonometric Drawings (Only as an adjunct to Isometric Drawings)

Descriptive Geometry

1. Lines - M
2. Planes - M
3. Successive Auxiliary Views - M
4. Piercing Points - M
5. Intersection of Planes - M
6. Angle Between Planes - M
7. Parallelism - M
8. Perpendicularity - M
9. Angle Between Line and Oblique Plane - M
10. All applied problems, for example, Mining and Civil Engineering Problems-L
11. Revolution - L
12. Plane Tangencies - 50% L 50% O
13. Intersection of Solids - L
14. Developments - L
15. Intersection of Curved Surfaces - L
16. Perspective Representation - L
17. Spherical Triangle - O
18. Map Projection - O
19. Shades and Shadows - O
20. Conics - L
21. Cone Focus Problems - L
22. Warped Surfaces - L
23. Classification and Generation of All Surfaces - L

Question: "Should a basic engineering drawing course contain some graphical mathematics?"
Limited - 30; None - 27.

To those who thought it should contain this phase, the following breakdown was: Empirical Curves - 12 yes; Functional Scales - 10 yes; Nomographs - 15 yes; Graphical Calculus - 15 yes; Vectors (3 dimensional) - 28 yes.

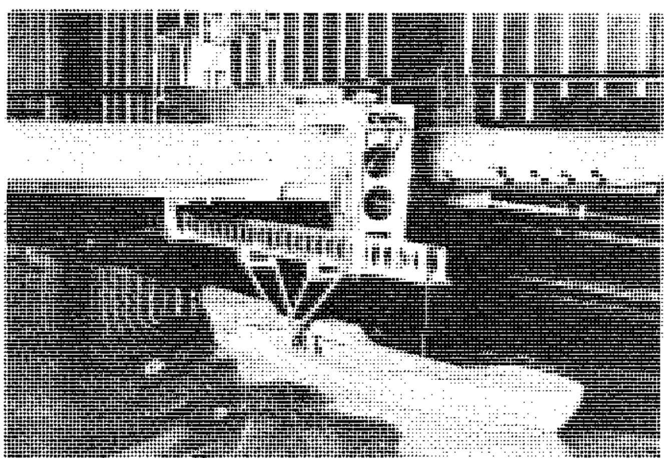
Question: "Should such graphic courses be taught to all engineering students, but in some course other than basic"? 30 - Yes.

At this point Professor Jim Rising pointed out that he would give quite a lot of thought to the results here in the preparation of his paper for the Berkeley Meeting "Recommended Course Content - Basic Graphics - Descriptive Geometry." He further invited any individual who had comments concerning this subject to transmit them to him: Professor James Rising, Iowa State College, Ames Iowa and to state whether or not he could use their name in connection with such comment. He pointed out that this invitation applied to all who should read this report whether or not they were members of this workshop.

University of California, Berkeley
A Few Interesting Items

NAVAL ARCHITECTURE

Naval architecture, a relative newcomer to the Institute of Engineering Research's program, first became a part of the University scene in 1952, when the U.S. Navy offered to support research and teaching at the University of California. Although three other institutions teach naval architecture, the University of California is the only university with a graduate program of research and study sponsored in this way. The program has resulted in stimulating student interest in naval architecture, as well as in providing for Government and industry a wealth of research information affecting the design of ships. Some of the projects under study include the motion of ships in a seaway, the thermal stresses on a ship, the parameters involved in towing a heavy cable or other body underneath the water by a surface ship, the reactions of two vessels on the surface, and the proper design of cargo holds.



Tow tank carriage and model for still water test

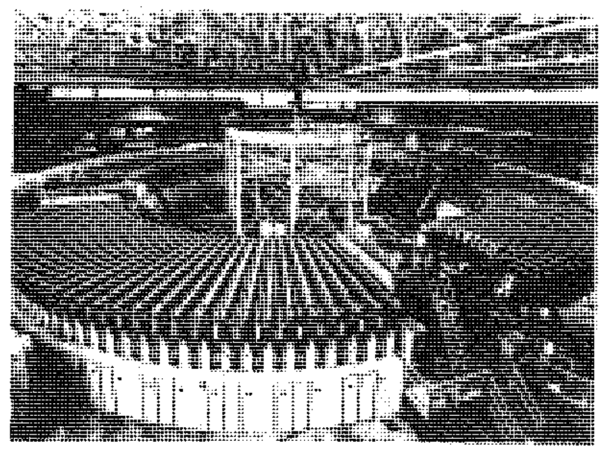
BEVATRON

Early research with the Bevatron will be devoted to the identification of nuclear particles generated when protons from the machine smash into target atoms.

In addition to the proton beam, a secondary beam of neutrons, ranging in energy up to 6.25 billion electron volts (Bev), is generated. These neutrons are dislodged when the protons strike target nuclei. The neutron beam can be used for special research bombardments.

Attention will be focused especially on mesons created by the collision of high energy protons with particles in target nuclei. The production of mesons is one of the chief missions of all modern high energy particle accelerators.

It is impossible to convey an adequate idea of the Bevatron—its purpose and its operation—in a paragraph or two. Come to Berkeley in June and you will get the whole fascinating story.



Bevatron

STRUCTURES AND MATERIALS

The Structures and Materials Group has undertaken many structural engineering studies, involving both static and dynamic behavior. In the course of these studies, the Group has contributed significantly to the design and construction of such large structures as Hoover Dam and the San Francisco Oakland Bay Bridge, as well as to the solution of the intricate biomechanical problems involved in developing efficient artificial limbs. Many members of the Group are experienced in the solution of structural problems related to aircraft.

In carrying out its work, the Structures and Materials staff has assembled an array of equipment not available elsewhere in the West. This equipment includes a 30-foot rotary kiln for studies of the material used in the manufacture of cement and special aggregates; a 13 x 10-foot furnace used in determining the fire safety of structural walls, and a 4,000,000-pound universal testing machine installed on campus for studies of materials under a wide range of temperatures and humidities. Significant too are many special instruments developed by the staff to solve particular problems and now used in structural engineering research.

The Group has studied the entire range of structural materials, including wood, masonry, concrete, steel, aluminum, and plastics. More recently, as a result of the spectacular growth of interest by the construction industry, the staff has focused special attention on the problems of prestressed concrete. Current studies emphasize the ultimate strength of concrete, the plastic design of steel structures, and the improvement of artificial limbs.

Program

Annual Meeting of the

Engineering Drawing Division of the ASEE

University of California, Berkeley, California

June 16-20, 1958

Monday—June 16

8:00 A;M.—Registration
2:00 P.M.—Conference
Presiding: A. P. McDonald, Rice Institute

1. Report of Committee on Aims and Scope of Engineering Graphics.—Matthew McNeary, University of Maine

2. Report—Evaluation of Engineering Graphics.—J. Gerardi, University of Detroit

3. Recommended Course Content—Basic Graphics-Descriptive Geometry.—James Rising, Iowa State College

4. Discussion: C. P. Buck, F. A. Heacock, R. T. Northrup, E. G. Paré

6:30 P.M.—Executive Committee Dinner and Business Meeting

Tuesday—June 17

9:30 A.M.—General Session
12:00 Noon—Division Luncheon and Business Meeting
Presiding: W. J. Luzadder, Purdue University

1. Reports and Recommendations of Committees

2:00 P.M.—Conference
Presiding: R. H. Hammond, United States Military Academy

1. Importance of Engineering Graphics to the Professional Engineer.—Andrew Macellan, Senior Dynamics Engineer, Convair, San Diego, California

2. The Engineering Orientation Values of the Drawing Courses.—Dean James McGivern, Dean of Engineering, Gonzaga University

3. What Engineering Departments Expect from the Drawing Courses.—Dean H. C. Hesse, Dean of Engineering, Valparaiso University

4. Discussion: E. D. Black, F. J. Burns, R. G. Huzarski, A. S. Palmerlee, H. P. Skamser

Tuesday—June 17 (Continued)

6:30 P.M.—Annual Division Dinner
Presiding: W. J. Luzadder
Toastmaster: A. S. Levens

1. Presentation of Distinguished Service Award
T. T. Aakhus, University of Nebraska

2. Presentation of Nomography Award
A. S. Levens, University of California, Berkeley

3. Address: The Engineer and Education for Business. Dr. Robert A. Gordon, Director, Study of Business Education, Ford Foundation, University of California, Berkeley

9:30 A.M.—General Session
12:00 Noon—Joint Luncheon—Divisions of Engineering Economy, Civil Engineering, Electrical Engineering, Mechanical Engineering, Mineral Engineering, etc.
2:00 P.M.—Conference
Presiding: D. P. Adams, Massachusetts Institute of Technology

1. Function of the Graphic and Illustrative Languages in the Communication Process.—Robert A. Spencer, Director, Special Communications Program, Rensselaer Polytechnic Institute

2. Use of Descriptive Geometry in Design.—Harry E. Parshall, North American Aviation Co.

3. Uses of Nomography in Modern Research.—Sanford Baum, Senior Research Investigator, U. S. Naval Radiological Defense Laboratory, San Francisco

4. Discussion: T. T. Aakhus, J. H. Porsch, R. W. Reynolds, W. E. Street

Thursday—June 19

9:30 A.M.—General Session
7:00 P.M.—Annual Banquet

Report of the Bibliography Committee

By S. E. Shapiro, Chairman

University of Illinois, Chicago

Books Published 1956 to 1958

AUTHORS	TITLE	PUBLISHER	ED.	YEAR	PP.	PRICE
M.W. Almfeldt, D.D. Glower	Engineering Graphics Prob. Book I	Wm. C. Brown	1	1957	74	3.00
M.W. Almfeldt, D.D. Glower	Engineering Graphics Prob. Book II	Wm. C. Brown	1	1957	88	3.00
J.N. Arnold	Introductory Graphics	McGraw-Hill	1	1958		
T.E. French, C.J.Vierck	Graphic Science: Eng. Drawing, Descriptive Geometry, and Graphics	McGraw-Hill	1	1958	650	
F.E. Giesecke, A. Mitchell, H.C. Spencer	Technical Drawing	Macmillan	4	1958		
H.R.Goppert, C.I. Carlson, G.E. Cramer, E.J. Caldario	Probs. in Eng. Geom., Series No. 3	Stipes	2	1956	88	2.75
H.E. Grant	Practical Descriptive Geometry (Alternate edition with problems) (Reviewed Dec. 1956*)	McGraw-Hill	1	1956	403	5.25
S.G. Hall, L.D. Walker, E.D. Ebert, A.G. Frederich	Probs. in Eng. Drawing, Series B	Stipes	2	1957	62	3.00
R.P. Hoelscher, C.H. Springer	Engineering Drawing & Geometry (Reviewed Apr. 1956*)	John Wiley & Sons	1	1956	520	8.00
R.P. Hoelscher, C.H. Springer, B.O. Larson, J.E. Pearson	Probs. in Eng. Geom., Series No. 1	Stipes	2	1956	84	2.75
R.P. Hoelscher, C.H. Springer, B.O. Larson, J.E. Pearson	Probs. in Eng. Geom., Series No. 2	Stipes	2	1957	84	2.75
R.P. Hoelscher, C.H. Springer, B.O. Larson, J.E. Pearson	Probs. in Eng. Draw. Series A	Stipes	2	1956	58	3.00
C.J.Hood	Geometry of Engineering Drawing	McGraw-Hill	4	1958	380	5.75
C.J.Hood, A. Palmerlee	Problem Sheets	McGraw-Hill	4	1958		3.75
L.O. Johnson, I. Wladaver	Engineering Drawing Probs.	Prentice-Hall	1	1956	66	5.00
W.J. Luzadder	Graphics for Engineers	Prentice-Hall	1	1957	608	6.50
M. McNeary, E.R. Weidhaas, E.A. Kelso	Creative Probs. for Basic Eng. Drawing	McGraw-Hill	1	1957	48	3.75
E.G. Paré	Engineering Drawing	Dryden	1	1958		
E.G. Paré, R.O. Loving, I.L. Hill	Engineering Graphics Prob. Book III	Wm. C. Brown	1	1957	86	3.75
J.S. Rising, D.D. Glower	Descriptive Geometry Worksheets, Series C	Macmillan	1	1957	152	3.25
S.E. Shapiro, D.M. Holladay, G. Wilson, W.L. Shick	Probs. in Geometry for Architects, Series A, Part I	Stipes	1	1956	61	3.00
S.E. Shapiro, D.M. Holladay, G. Wilson, W.L. Shick	Probs. in Geometry for Architects, Series B, Part II	Stipes	1	1958		3.00
W.L. Shick, G. Wilson, D.M. Holladay, S.E. Shapiro	Probs. in Geometry for Architects, Series A, Part II	Stipes	1	1956	56	3.00
W.L. Shick, G. Wilson, D.M. Holladay, S.E. Shapiro	Probs. in Geometry for Architects, Series B, Part I	Stipes	1	1957		3.00
H.W. Shupe, P. E. Machovina	Engineering Geometry and Graphics (Reviewed Dec. 1956*)	McGraw-Hill	1	1956	347	5.25
H.C. Spencer	Basic Technical Drawing	Macmillan	1	1956	370	4.32
H.D. Walraven, C.I. Carlson, E.J. Mysiak	Probs. in Eng. Drawing, Series C	Stipes	2	1956	64	3.00
B.L. Wellman	Technical Descriptive Geometry	McGraw-Hill	2	1957	620	5.75
F. Zozzora	Engineering Drawing	McGraw-Hill	2	1958	369	5.50

* Book was reviewed in the Technical Book Review Index, an independent periodical published by the Carnegie Library of Pittsburgh, which quotes from reviews that have been printed in professional journals.

Solve This One and Win Two Years of the JOURNAL

By John T. Rule
Massachusetts Institute of Technology

Professor Irwin Wladaver
Box 5, N.Y.U. Heights
New York 53, New York

Dear Vlad:

Here's a new one for you. I don't believe it has ever been presented before. I warn the avid problem solvers that it is a "lu-lu." I am enclosing my own strictly Euclidean solution in a sealed envelope.

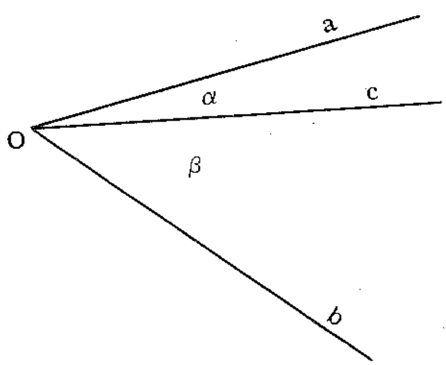
Just to make it more intriguing, I will offer a prize of two years' subscription to the JOURNAL OF ENGINEERING DRAWING for the first correct solution received by you--strictly Euclidean, no cut and try permitted, no faired curves.

PROBLEM:

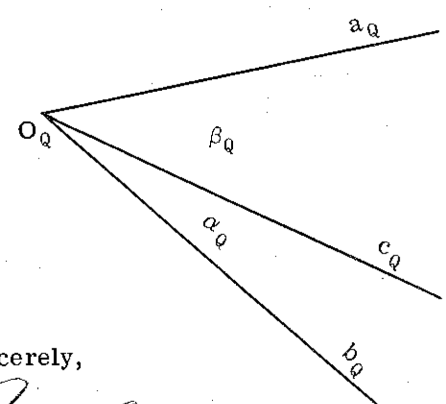
Given an angle formed by lines a and b divided into two unequal angles α and β by line c in the same plane. Find a projection plane such that the two angles will project orthographically in reverse size. That is, if the projection plane is Q, then

$$\alpha \rightarrow \beta_Q \quad (\alpha \text{ projects into } \beta_Q)$$
$$\beta \rightarrow \alpha_Q \quad (\beta \text{ projects into } \alpha_Q)$$

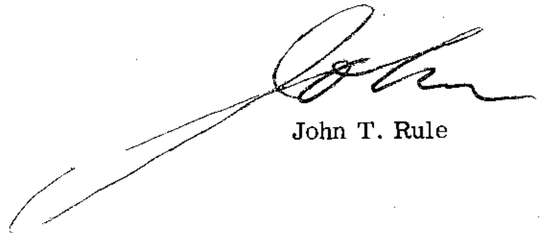
Pictorially: - Given the normal view:



Required: a projection plane Q, which will yield:



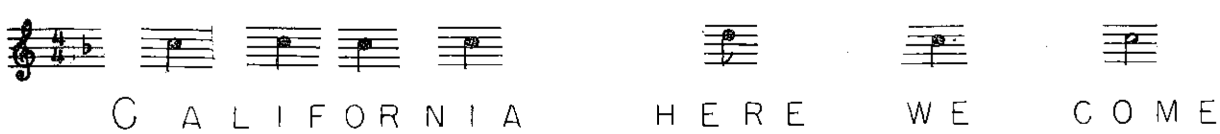
Sincerely,

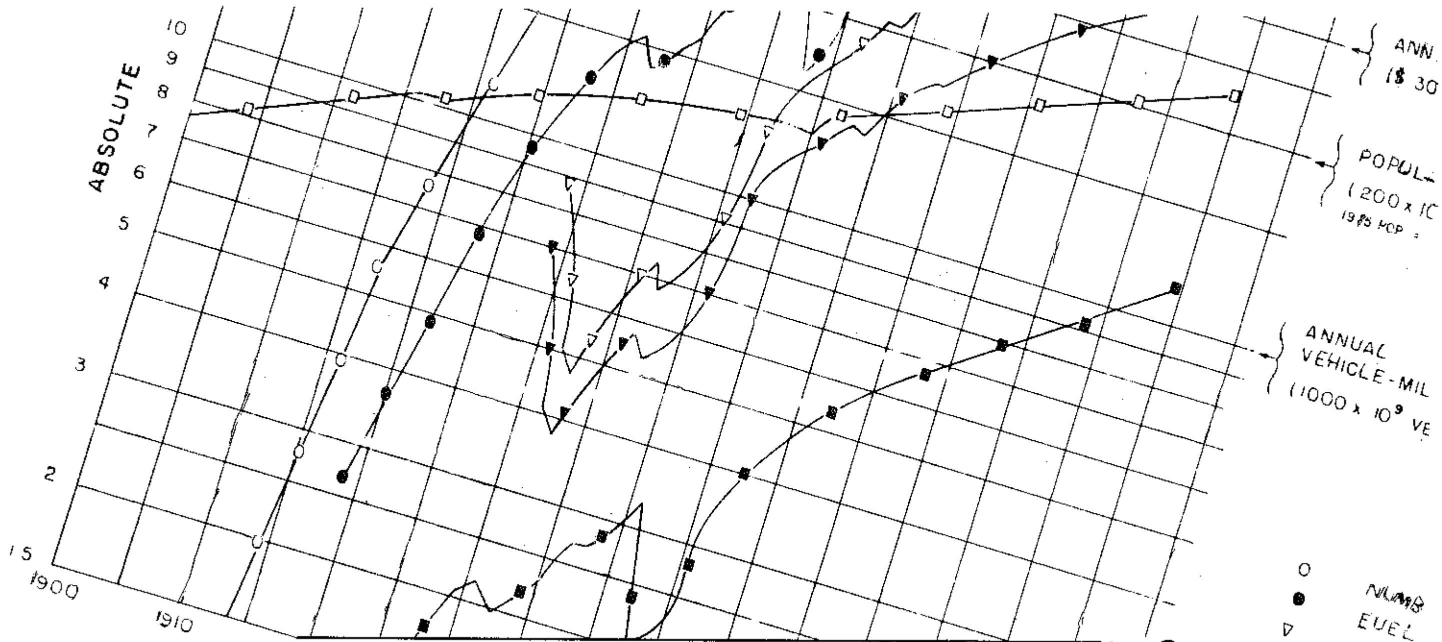


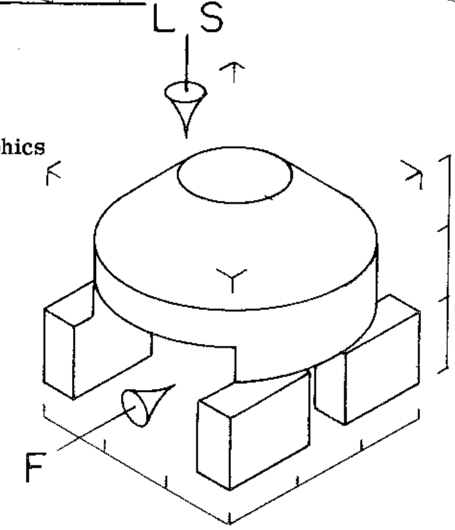
John T. Rule

N.B.:

The solution sent in by Dean Rule will remain in the sealed envelope until readers begin pouring in their solutions. (Ed. note)







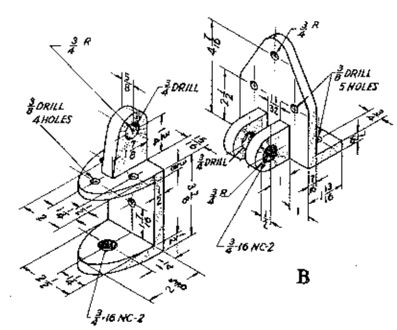
Balt Publishers present two workbooks to meet the requirements for basic courses in Engineering Graphics and in Engineering Drawing.

1. Worksheets for Introductory Graphics by J. N. Arnold, M. H. Bolds, S. B. Elrod, J. H. Porsch, and R. P. Thompson - members of the Engineering Graphics Staff, Purdue University. Published in 1958 at $4.00.

   The 100 problem sheets ($8\frac{1}{2}$" x 11") represent problems selected from the several fields of engineering. They provide an opportunity for meeting individual differences and for varying course content. They give the teacher an opportunity to present many engineering principles and devices to give the student orientation in engineering and to help him integrate his engineering graphics course with other courses in the engineering curriculum.

   The problem sheets include: geometric constructions (8), lettering (4), Multiview drawing (20), pictorial drawing (14), drawings for construction (10), representation of data (4), representation of equations (2), vectors (4), intersections (6), developments (4), space problems of angle and distance (8), empirical design (4), empirical equations (4), and graphical calculus (4).

   The problem sheets are designed to accompany Introductory Graphics by J. N. Arnold et al (published by McGraw-Hill Book Company, 1958). An instructor's manual includes references to standard texts and solutions to the problems.


A B

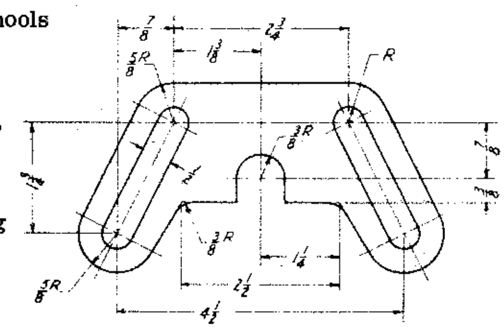
2. Problems in Engineering Drawing, Abridged by W. J. Luzadder and J. N. Arnold, Purdue University, and F. H. Thompson, Senior Technical Artist, Allison Division, General Motors Corporation. Now in 4th edition (1956) at $1.70.

   The 40 problem sheets ($8\frac{1}{2}$" x 11") represent problems selected from industry. They provide an opportunity for meeting the individual differences of students and for varying the course content.

   The several editions have been used with marked success in engineering schools and technical institutes since 1943.

   The problem sheets cover lettering exercises (4), use of instruments and geometric construction (5), free-hand sketching and multi-view drawing (11), auxiliary views (3), sectional views (5), detail drawings (10), assembly drawing (1), and a special problem (1).

   The problem sheets are designed to accompany standard texts in engineering drawing. Instructions to the instructor and students are included.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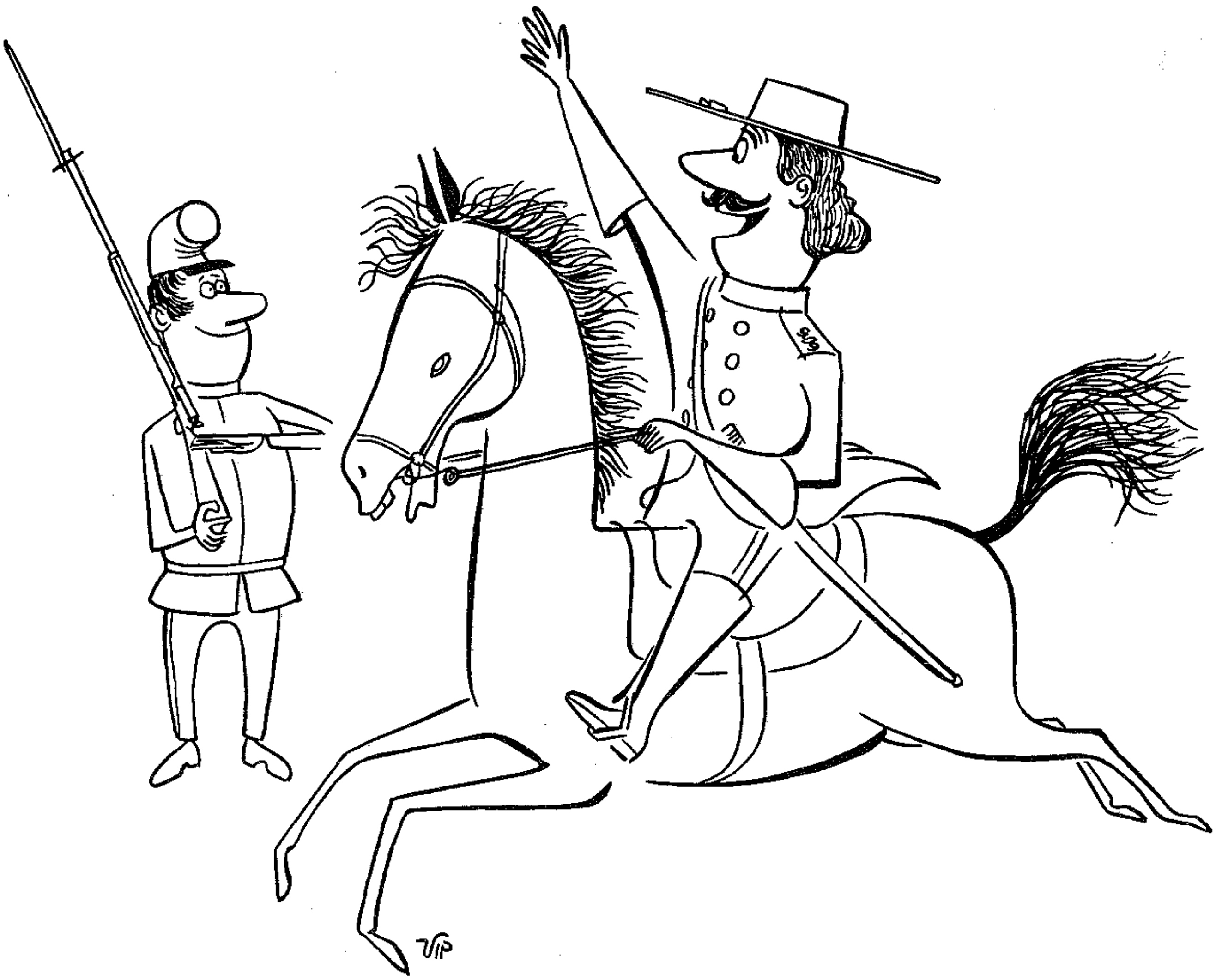
West Lafayette, Indiana



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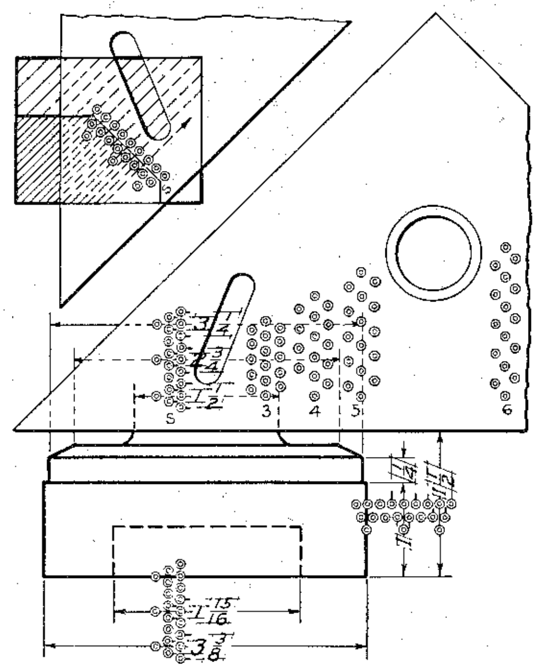
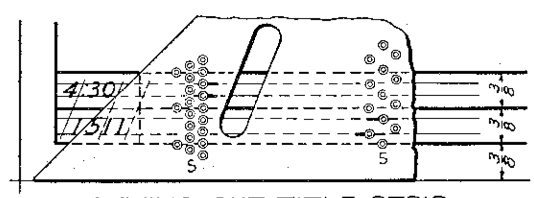


SYSTEMATIC DIMENSIONING



LAYING OUT TITLE STRIP

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4"-45
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7"-45
8"45

6"-45 Brd.-Rowe

8"-45 Style "C"

Style "B"

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