The Journal of Engineering Drawing

CONTENTS

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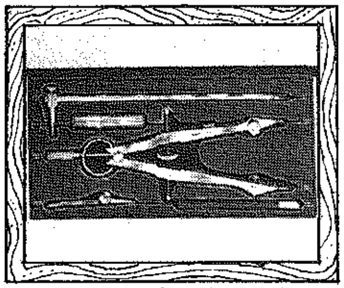

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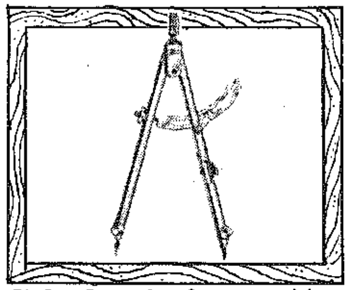

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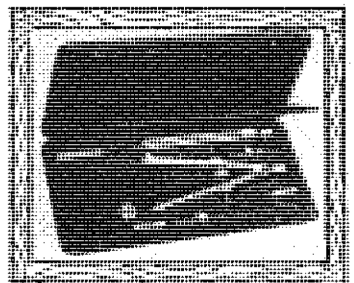

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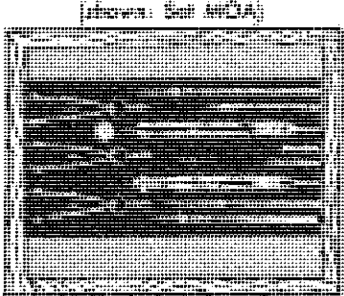

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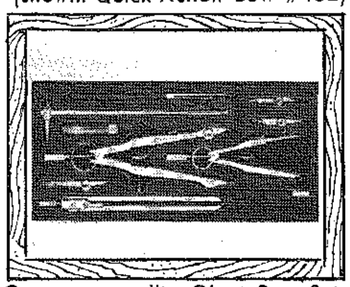

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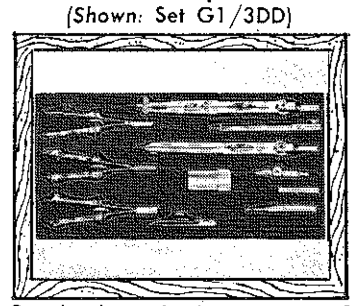

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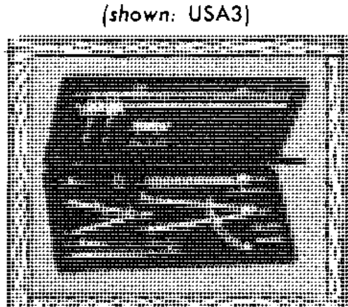

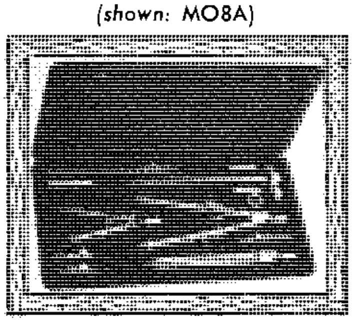

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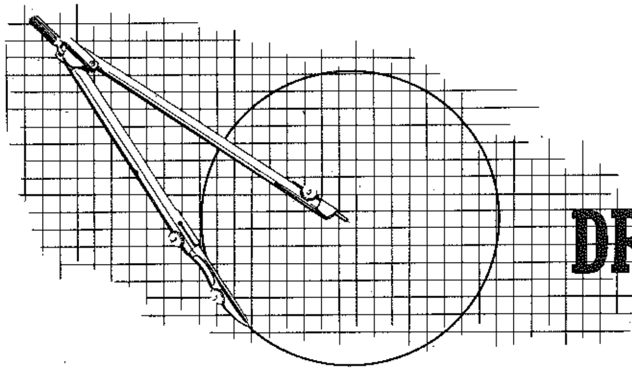


THE NEW LOOK IN ENGINEERING EDUCATION

by
H.C. Spencer
Illinois Institute of Technology

I think it was Voltaire who returned a manuscript to a young writer with the notation: "There are some things in here that are true and some that are new, but the new things are not true, and the true things are not new." I hope that my remarks, if not new, will at least be true.

The ASEE, or the old SPEE, was organized at the Columbian Exposition in Chicago in 1893. Since then a number of committees have made studies to determine the course of engineering education. From the beginning, these reports have emphasized two objectives of engineering education - the technological and the social. Hence, the current interest in the humanistic-social studies is not new and is here to stay.

Also, the idea of the 4-year undergraduate curriculum has been accepted from the beginning, and although pressures have increased in recent years to extend the program to 5 years, the 4-year curriculum is strongly entrenched, and the majority of institutions appear to favor its continuance.

In 1952 the Committee on Evaluation of Engineering Education was formed with Dr. Grinter as Chairman. The procedure adopted was to obtain opinions from local committees in accredited institutions, and then to prepare a final report. Some 122 such local committees responded, and the Preliminary Report was issued in 1953. This report pointed out that engineering education was not keeping abreast of developments in the physical sciences, and that more emphasis should be placed on chemistry, physics, and mathematics, and upon the engineering sciences. And, the importance of the humanistic-social studies was again affirmed.

Two types of curricula were suggested: the "professional-general" (roughly the typical program of today), and the "professional-scientific." The difference between the two was thought to be so great that "bifurcation" was suggested - that is, separate curricula for the two objectives.

The Preliminary Report also recommended that "those curricula which meet criteria substantially above the minima" by virtue of a distinguished faculty should be singled out for special recognition and designation.

The various Divisions of ASEE were asked at the outset to submit their ideas, and the Engineering Drawing Division, through our Committee headed by W.E. Street, submitted a very fine statement of our objectives. Nevertheless, one has to look carefully in the Grinter Committee Preliminary Report to find the brief paragraph about drawing - but it is there, under the subheading, "Non-Departmental Engineering Courses." More about this later.

After the Preliminary Report was studied and criticised by the 122 local committees, the Grinter Committee issued, in June 1954, a revision called the "Interim Report," and this is now under study by the local committees.

In general, this "Interim Report" retained the ideas of the Preliminary Report, except two which were almost unanimously rejected by the local committees: (1) The idea of "bifurcation" of curricula, and (2) the idea of singling out highly-approved curricula for special distinction.

The main thought of the Grinter Committee, in both reports, has been than "the evaluation of engineering curricula has been characterized by a continuous invasion of new scientific and technical knowledge," and that the young engineer must be equipped to understand the "new science as it develops." Outstanding in its influence, of course, have been the developments in nuclear physics.

Inevitably the Report gets around to the topic "Making Room for New Curricular Material" - the same old story of how to crowd more material into the 4-year curriculum. More time must be found for basic and engineering science, according to the Report, which went on to say "there is considerable doubt as to whether there is any margin of student time left." How is that for an understatement?

Four methods for crowding in the new material were suggested:

1. Raise entrance requirements. It was conceded that we cannot expect substantial gains in high school preparation in the forseeable future. It was also admitted that higher selectivity of students would be impractical now because it would reduce the number of students at the very time we have a shortage of engineering graduates. So, that eliminates suggestion No. 1.

2. Increase efficiency of instruction. The Report admitted that this effort has been under continuous study for a long time and goes on to suggest that an "alert faculty" can simplify things and maybe save some time. This reminds me of the signs which we often see with the single word "THINK." The boss puts up these signs in a moment of self-admiration, but I doubt if they cause anyone to think. Anyway, I doubt if we will save much time by increasing the "efficiency of instruction." Actually, it may take more time to put across increased emphasis on scientific fundamentals. So, that cancels suggestion No. 2.

3. Extend the curriculum beyond 4 years. In the Preliminary Report, 4 years was thought to be enough for "professional-general" curricula, but not enough for the "professional-scientific" curricula. The "bifurcation" of "professional-general" and "professional-scientific" curricula has now been dropped in favor of one "scientifically-oriented" curriculum. The Committee did not officially urge the 4-year program, but thought the unified curriculum could be practically carried out in 4 years, roughly as follows:

Humanistic - Social	21 sem. hrs.
Math and Basic Science (about equal)	36 " "
Engineering Science	36 " "
Required Technology (Drawing?)	7 " "
	100 " "
Major Sequence: Engineering Analysis, Design and Engineering Systems	21 " "
Options or Electives	17 " "
Total for 4 years	138 sem. hrs.

Obviously the Committee is not thinking in terms of a 5-year program. So that eliminates suggestion No. 3.

4. Eliminate some material from the curricula. According to the Report, "Elimination of material now in the curriculum . . . . is an accepted practice . . ." Well, of the four suggestions, this appears to be the only practical way to find time for the new scientific material. The curriculum-makers don't want to reduce time for social studies, and they insist on increasing time for basic and engineering science. Therefore, it appears that additional time inevitably will have to come from the professional courses - much of which will have to be pushed up into the graduate school level. If I am correct in this, the change is drastic, and I shall be interested in watching developments. Whether or not industry will regard graduates of the new "scientifically-oriented" curricula as satisfactory for immediate employment at the end of 4 years is the question. The Committee stated that it relied upon the advice of "seven of the largest employers of engineers," who said they preferred the new curricula. The smaller employers have not been heard from, but the Committee expressed the belief that they would undoubtedly approve. This remains to be seen. As one of my colleagues put it: "What are we going to do with all of these young Einsteins?"

Another question which has been raised is whether the new "scientifically-oriented" curricula will result in too many failures - in other words, too many "flunk-outs" at a time when we need more engineers. The Committee thought not, but I think this also is doubtful.

In both the "Preliminary Report" and the "Interim Report," practically the same references to drawing were made. In the words of the "Interim Report," these were:

"Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful, for these purposes, is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, the ability to convey ideas, especially by freehand sketching."

I do not suppose that this brief statement is intended as a detailed specification, yet it is disappointing to find so little space given to graphical expression. Certainly drawing should be clearly identified and not simply classified as "Required Technology." Above all, it is really an engineering science, and should be classified as such. Obviously, we have a selling job to do.

Nevertheless the statement, brief as it is, actually affirms what most of us are doing already. Thomas E. French said, many years ago, "The whole energy should be directed toward training in constructive imagination, the perceptive ability which enables one to think in three dimensions, to visualize quickly and accurately, to build up a clear mental image, a requirement absolutely necessary for the designer who is to represent his thoughts on paper." Without this accomplishment, of course, there can be no "analysis and synthesis."

The "new look in engineering education" means, for some of us, a stronger emphasis on basic theory, and at a higher level of difficulty. The level of difficulty should be equivalent to that of the other courses taken by the students at the same time. This is already the case in every progressive drawing department, and I object to the statement in the "Interim Report," referring to drawing, that "Its value as a skill alone does not justify its inclusion in a curriculum," precisely as I would object if they said that we should not beat our grandmothers.

But notice that "its value as a skill alone" means that the development of skill is admissible, but not alone. We have become so self-conscious on this point that one seldom hears even the mention of lettering or any kind of technique any more. I suggest that we be realistic and quit worrying about intellectual prestige, which shows that as a Division we have an inferiority complex - and think more about what you and I know that the student needs in his work as a professional engineer. To my knowledge, no one is interested primarily in the development of skill or in training draftsmen. On the other hand, drawing is a graphical subject. It is by nature manipulative. We have a quite respectable body of scientific graphical theory, but somebody has got to draw. In the past we have made much of the excellent training we give in orderly thinking, neatness, and accuracy, and I suggest that these are still worth our time and the student's time. The increased emphasis on fundamental theory does not imply or necessitate sloppy or careless work.

Also, the aim mentioned in the report, to develop "experience in creative thinking," deserves comment. I doubt if some of our students will achieve "creative thinking" as long as they live, regardless of what we do. On the other hand there are undoubtedly some who might develop into "creative thinkers" if handled properly.

It would appear that "creative thinking" may occur, if it occurs at all, after the student has acquired certain basic tools with which to work. It isn't to be expected that the student will do a lot of "creative thinking" while learning the A B C's. For example, in chemistry, I imagine that the teacher must be preoccupied mainly with the basic principles and that there will be little time and scant opportunity for developing real "creative thinking." On the other hand, I can conceive of a teacher of machine design, after his students have had all of the basic scientific courses, including technical drawing, encouraging the development of originality or even "creative thinking" on the part of the students. It would appear that the best contribution the drawing teacher could possibly make would be to see to it that his students really understand the subject and can use it. Then later on, in the junior year, senior year, or after graduation, our young engineer may be able to do some "synthesizing" on his own.

However, it is easy to underestimate the creative potential in our immature students. And it is easy for the unimaginative or dull teacher to fall into a rigidity of instruction that would dampen the spirits of a Newton or a Faraday. What can we do? We can make some direct contributions, even in our basic courses, by getting away from the rut we were in last year - away from the rigid problems which admit of only one procedure to get one answer and not calling on the ingenuity or resourcefulness of the student. We may develop at least the ability to think graphically and resourcefully, if not "creatively." In our drawing courses, we can give more attention to developing "thought problems" which will challenge the students to use constructive imagination and ingenuity along with the basic principles of drawing - problems which require good drafting, but which particularly call for original thinking. Such problems will come toward the end of a period, perhaps of a semester, after the student has acquired some graphic tools with which to work. In descriptive geometry the possibilities, as Prof. Kliphart has shown, are endless if the teacher is imaginative and resourceful. The main idea is to encourage the student to have an inquiring attitude of mind - to question everything - to realize that "what the book says" or even what you say, may not necessarily be the last word - to know that the stupendous technical achievements of today are mostly the result of little improvements from day to day by people who are not satisfied with things as they are.

However, I repeat that our main job is to provide our students with sound graphic fundamentals. Then later on we can hope that the student will develop some new ideas and use graphic principles in the process. So much for "creative thinking."

There are some mistaken notions about freehand sketching that I hope I can clear up. The Grinter Committee, with my hearty approval, stressed "the ability to convey ideas, especially by freehand sketching." Could the Committee possibly feel that we are over emphasizing the development of mechanical drawing skills and neglecting freehand sketching? Let's take a brief look at these two techniques.

No one will deny, or wants to deny, that freehand sketching is a valuable tool in the hands of the engineer We agree that every engineering student should, if possible, be provided with this skill. For, of course, it is a skill - in most cases a skill that is more time-consuming to learn or perform than mechanical drawing. If you doubt this, draw a circle with a compass and then draw one freehand. Compare the results and also compare the required times. Actually, the ability to sketch depends more on native aptitude than does mechanical drawing. In fact, T-squares, triangles, drawing instruments, drafting machines, ellipsographs, etc., were invented precisely as crutches for the wavering hand.

I suspect that the Committee is thinking of freehand sketching as a simple technique that can be quickly and easily acquired - a sort of valuable shorthand for the super-scientific engineer of the future who would not soil his hands witb a T-square. Actually, freehand sketching is a skill that requires time and much practice to develop. When curriculum-makers suggest that we de-emphasize skill and increase emphasis on freehand sketching, I wonder if they are aware of the contradiction. What is really needed by the average engineering student is at least one full course devoted entirely to freehand sketching. If tbe curriculum-makers expect really adequate training in freehand sketching, they should provide additional time for it.

We have recognized for a long time, of course, that reasonable ability in freehand sketching is an important objective in our existing courses, and progressive drawing departments are already doing more along this line that the Committee appears to realize. As I see it, our job is to teach the fundamental theory of the graphic language, and to carry this out through two equally-important techniques - accurate workmanlike mechanical drafting and reasonably skilled freehand sketching. Each technique should be used in the roll for which it is best suited. In general, freehand sketching can be used advantageously in the beginning stages of multiview drawing, pictorial drawing, and working drawings. As Harold Howe has shown, freehand sketching can be used to great advantage as a means of promoting visualization even in descriptive geometry. Wherever possible we should present problems which require "idea sketches." The last statement in such a problem may well be "Show what you mean by a freehand sketch." Actually, if freehand techniques are used throughout our courses at appropriate places, much can be accomplished.

The Committee did not mention advanced graphics, or nomography, or graphical calculus, or any other mathematical topics, but did suggest that "graphical expression is both a form of communication and a means of analysis and synthesis," which I presume may be interpreted to include these phases. Many menbers of our Division have made outstanding contributions along these lines, and we may hope that the curriculum-makers will soon recognize the value of such training. And by "recognize" I do not mean just a pleasant affirmation, but concrete curricular changes with actual time alloted for the purpose. If we cannot convince our colleagues in degree-granting departments of the value of training in these areas to the extent that they will permit such courses to be offered and at least encourage their students to take them as technical electives, then it is obvious that they are not really interested in that training. Certainly it would be a mistake, in these circumstances, for us to push aside important basic material in our required courses to make room for these topics. The result is very likely to be to weaken our basic courses while gaining only a smattering of the new material.

Furthermore, if we do omit fundamentals of projection, or if we compress or water down our basic courses in order to find time for such topics, while at the same time we continue to complain that we are not allowed enough time, we involve ourselves in a basic contradiction which may logically result in the embarrassing suggestion that we already have too much time.

Nor do I think we can find room in our regular courses for such material by pushing down into high school certain elementary parts of our work. Maybe this can be done to some extent in some localities, but I can say that in Chicago, although a very high percentage of our entering students have had high school drawing, they do not have enough knowledge or skill to enable them to skip any part of our courses. A few years make a lot of difference in a boy, and there is a great deal of difference between high school and college work - not only in drawing, but in chemistry, Englisb, and mathematics as well. The boy who has had high school training in drawing may have an advantage for a month of two, but after that the brightest boys are in the lead, regardless of whether they had previous training or not.

In this connection, it is interesting to note, in the Interim Report, that "not more than 2 of the 16 units for entrance should be considered for drawing, shop or other vocational work." Tbus, it appears that the trend is away from the encouragement of high school drawing as a substitute for any part of our work.

The "new look in engineering education" means, for the whole curriculum, a stronger emphasis on the basic sciences and the engineering sciences. Technical drawing is really an engineering science, and we must redouble our efforts to obtain its recognition as such. In the meantime, in line with the new trends in engineering education, we must think first of the fundamentals of projection - which are no less important today than they were 30 years ago - and at the same time develop such skills as we can in mechanical drafting and freehand sketching in the meagre time available in our basic courses. Finally, when we are tempted to add additional topics in our already crowded courses, we should consider carefully what must be omitted in order to find the required time.

A GRAPHICAL METHOD OF PLOTTING ELECTRON TRAJECTORIES IN CROSSED ELECTRIC AND MAGNETIC FIELDS

by
Ray Kinslow
Tennessee Polytechnic Institute

Many practical electronic devices (i.e., the magnetron, cyclotron, electron multiplier, mass spectrometer, electron microscope, and certain type television tubes) utilize crossed electrostatic and magnetic fields, but only the very simplest of cases may be solved by analytical methods. There is, therefore, a need for a graphical method by which electron paths may be approximated. The method described here consists of computing the instantaneous radii of curvature of the path and plotting the trajectories as a series of joined circular segments.

When electrostatic and magnetic fields simultaneously influence the motion of an electron, the net force acting may be expressed as

$$F_x = m\ddot{x} = e\,(\epsilon_x - B_y\dot{z} + B_z\dot{y})$$

$$F_y = m\ddot{y} = e\,(\epsilon_y - B_z\dot{x} + B_x\dot{z})$$

$$F_z = m\ddot{z} = e\,(\epsilon_z - B_x\dot{y} + B_y\dot{x})$$

where F_x, F_y, F_z are components of the force exerted by the fields; m and e are charge and mass of an electron, respectively; ϵ_x, ϵ_y, ϵ_z are components of the electric field intensity; B_x, B_y, B_z are components of the magnetic flux density; $\dot{x}$, $\dot{y}$, $\dot{z}$ are components of velocity; and $\ddot{x}$, $\ddot{y}$, $\ddot{z}$ are components of acceleration.

Considering a constant magnetic field and choosing the coordinate axes so that the magnetic field is directed along the -z axis, the force equations become

$$F_x = m\ddot{x} = e\,(\epsilon_x + B\dot{y})$$

$$F_y = m\ddot{y} = e\,(\epsilon_y + B\dot{x})$$

$$F_z = m\ddot{z} = e\,(\epsilon_z)$$

If $\epsilon_z = 0$, $F_z = 0$, the electron will remain in the x-y plane, and the problem is one of two dimensions.

The component of force normal to the electron path at any instant is

$$F_n = e\,(\epsilon_n \pm B\,v)$$

where ϵ_n is the normal component of electric field intensity and v is the velocity of the electron. This normal force (F_n) must equal the centrifugal force ($m\,v^2/R$) acting on the particle, where R is the instantaneous radius of curvature of the electron path. Assuming negligible initial velocity, the kinetic energy gained by the electron ($m\,v^2/2$) must equal the potential energy lost (e E). E is the potential through which the electron has been accelerated. Substituting these relations in the equation for F_n and solving for R:

$$R = \frac{2\,E}{\epsilon_n \pm B\,\sqrt{2\,E\,(e/m)}}$$

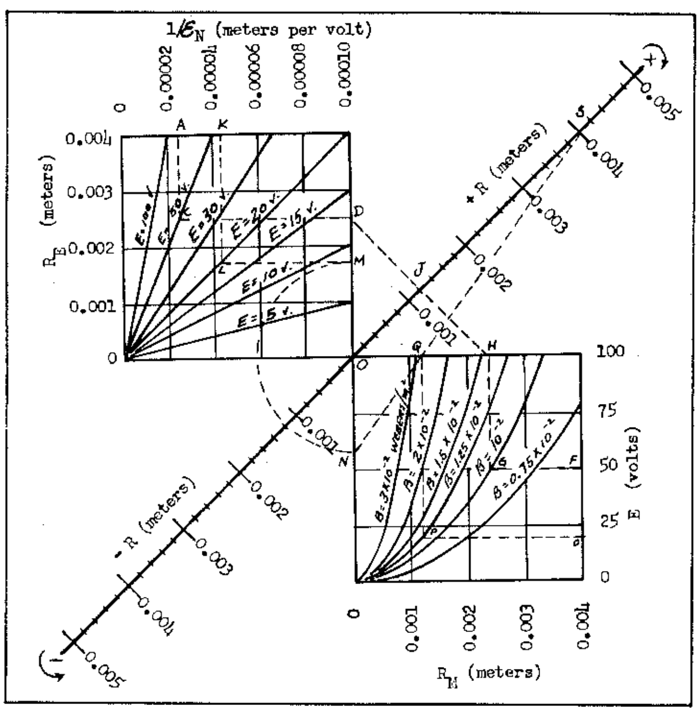
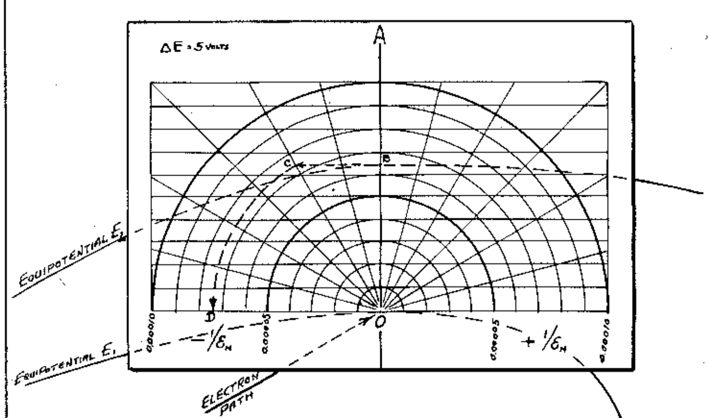


Figure 1

NOMOGRAPH FOR FINDING INSTANTANEOUS RADIUS OF CURVATURE OF ELECTRON PATH



Directions: Place templet on plot of potential distribution with point O at position of electron and OA normal to equipotential line. Note point B where next equipotential line intersects OA. Follow horizontal line to point of intersection with line which is normal to electron path (C). The distance OC is the value of $1/\mathcal{E}$ and may be transferred by dividers to the nomograph (Figure 1). To determine values of $1/\mathcal{E}_N$, follow circle to point D and read value in meters per volt.

Figure 2

TEMPLET FOR DETERMINING $1/\epsilon_N$

$1/R = 1/R_E + 1/R_M = \epsilon_n/2E \pm B/\sqrt{2E\,(m/e)}$, which is the reciprocal of the preceding value of R. R_E is the radius of curvature of an electron path when influenced by an electric field only, and R_M is the radius when only a magnetic field is present.

Figure 1 is a nomograph giving the radius of curvature, R, in meters, when E is expressed in volts, ϵ in volts per meter, B in Webers per square meter, e is 1.6×10^{-19} coulombs, and m is 9.1×10^{-31} kilograms.

The value of $1/\epsilon_n$ may be determined by using a transparent templet marked so as to give this value directly when placed over a plot of the potential field. The templet is shown in Figure 2. It is not necessary that any values be marked on the templet if the $1/\epsilon_n$-scale on the nomograph corresponds to the scale of the potential field. Values of $1/\epsilon_n$ may be transferred from the templet to the graph by the use of dividers. The graph may also be drawn so that the R-scale is the same as that of the potential field, eliminating the necessity of reading the values of R, but enabling one to set his compass to the proper radius directly from the graph.

Figure 3 shows the graphical method of plotting the electron path. The path may be computed analytically for the uniform field shown. This gives a check on the accuracy of the graphical method. Figures 4 and 5 show the electron paths in a type 45 electron tube in the presence of a uniform magnetic field.

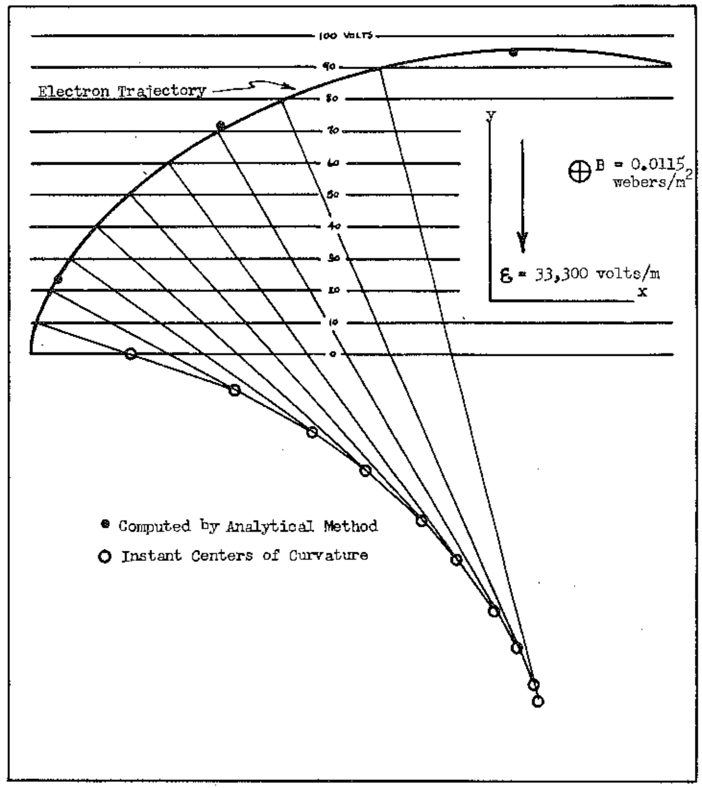


Figure 3
GRAPHICAL METHOD OF DETERMINING ELECTRON PATH

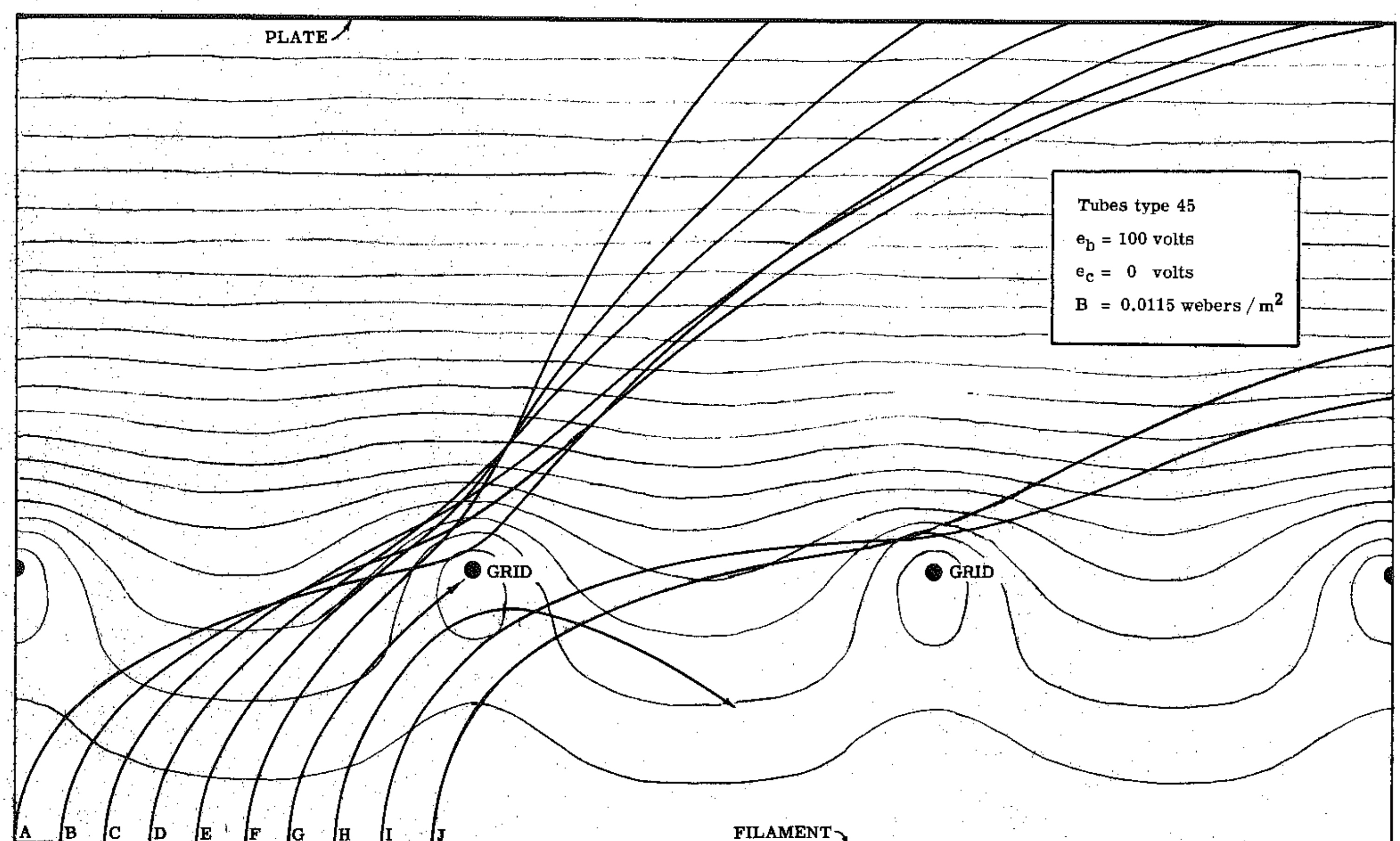


Figure 4
ELECTRON TRAJECTORIES WITH GRID POTENTIAL ZERO

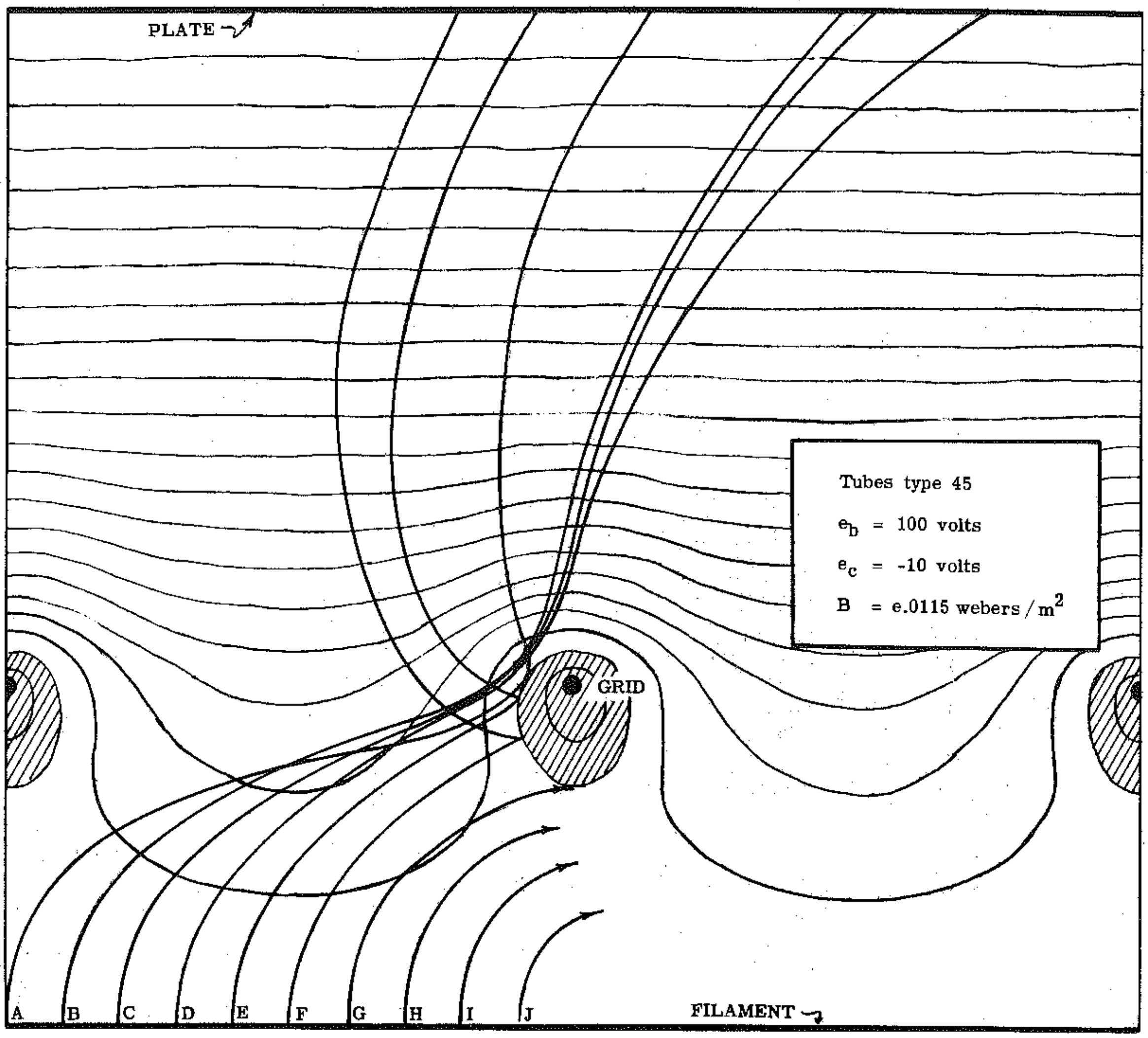


Figure 5
ELECTRON TRAJECTORIES WITH GRID POTENTIAL OF -10 VOLTS

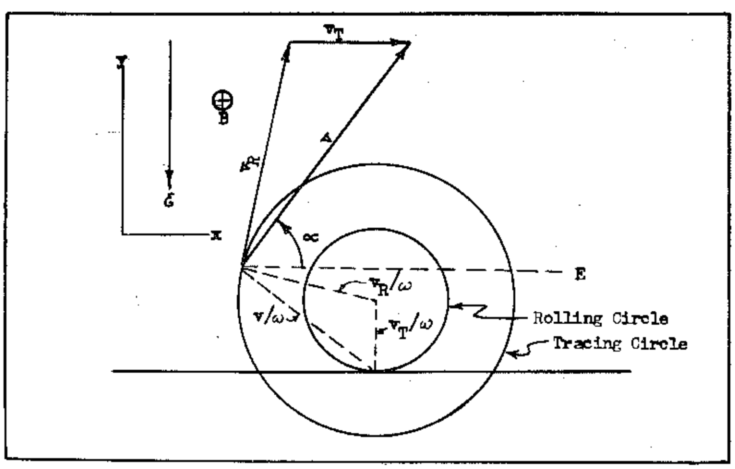


Figure 6
ROLLING SURFACES WHICH GENERATE TROCHOIDAL MOTION

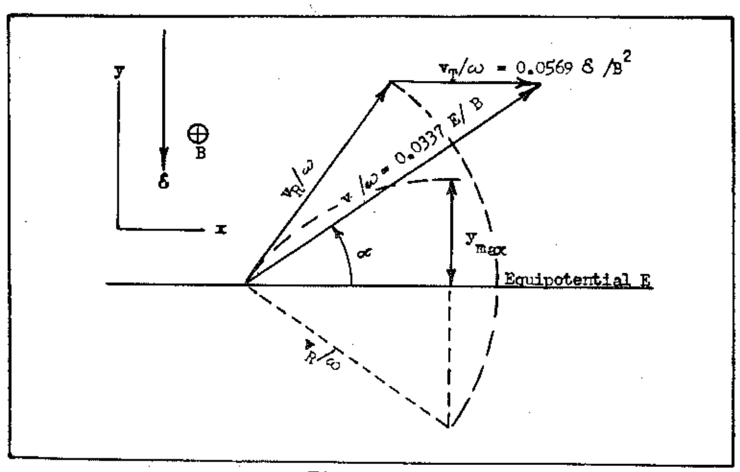


Figure 7
GRAPHICAL DETERMINATION OF MAXIMUM DISPLACEMENT OF ELECTRON IN y-DIRECTION

If the electric field is uniform (as is approximately true in the case of a plane-electrode diode or the region near the plate of a multiple-element tube) the force equations are: $F_x = m\ddot{x} = eB\dot{y}$ and $F_y = m\ddot{y} = e(\epsilon - B\dot{x})$. Substituting $\omega = eB/m$ and $a = e\,\epsilon/m$ gives $\ddot{x} = \omega\dot{y}$ and $\ddot{y} = a - \omega\dot{x}$. The solutions of these equations are

$$x = (v_o \sin a/\omega)(1 - \cos \omega t) + at/\omega + (v_o \cos a/\omega - a/\omega^2) \sin \omega t$$

$$y = (v_o \sin a/\omega) \sin \omega t + (a/\omega^2 - v_o \cos a/\omega)(1 - \cos \omega t).$$

(Concluded on page 40)

LIFE'S MESSY MOMENT

"I'm sure you'll recall Crawley that you're not one of us since the Reynolds job...."

SOLUTIONS OF DESCRIPTIVE GEOMETRY PROBLEMS BY ROTATIONS ABOUT NORMAL LINES AS AXES

by
Albert Jorgensen
University of Pennsylvania

The purpose of this article is to call the attention of those, to whom it may not have occurred, that the method of rotation about normal lines as axes, may be used to accomplish the same results as those obtained by the auxiliary plane method.

The solutions of numerous problems in descriptive geometry involve finding one or more of the following:

1. The true length (TL) of a line.*
2. The point view (PV) of a line.
3. The edge view (EV) of a plane.
4. The true size (TS) of a plane.

These views are logically considered in the sequence indicated since each of the first three views leads to the one following. This is true when the auxiliary plane method is used and also true when the method outlined here is followed.

In applying the auxiliary plane method, solutions to problems are obtained by making projections on inclined and oblique planes. In the method presented here, problems are reoriented in space so that new principal views, which lead to solutions, are obtained.

The method of rotation is dependent upon the fact that the essential relations between geometric magnitudes in space remain unchanged if all points are rotated through the <u>same angle</u> and in the <u>same direction</u> (clockwise or counter-clockwise) about <u>any fixed axis.</u>

By using several lines, which are perpendicular to several different principal planes, as axes of rotation, a problem may be given any desired orientation. Also, since the axes of rotation may be placed anywhere and since either of two supplementary angles may be used in a given rotation, the revolved views may be thrown into almost any location thus making it possible to avoid overlapping views.

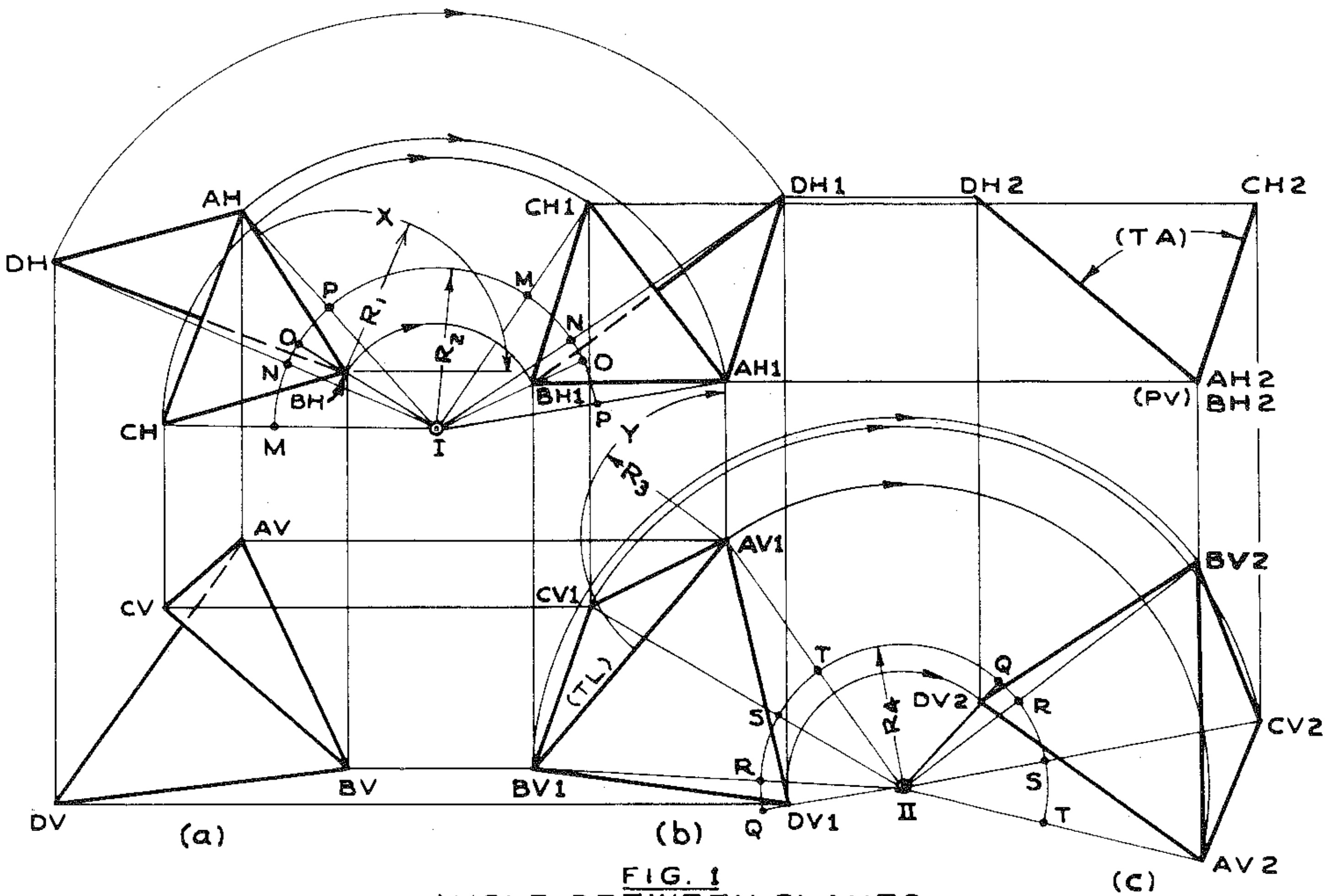


FIG. 1
ANGLE BETWEEN PLANES
(ARC METHOD)

* Refer to the appendix for an explanation of the terminology and notation.

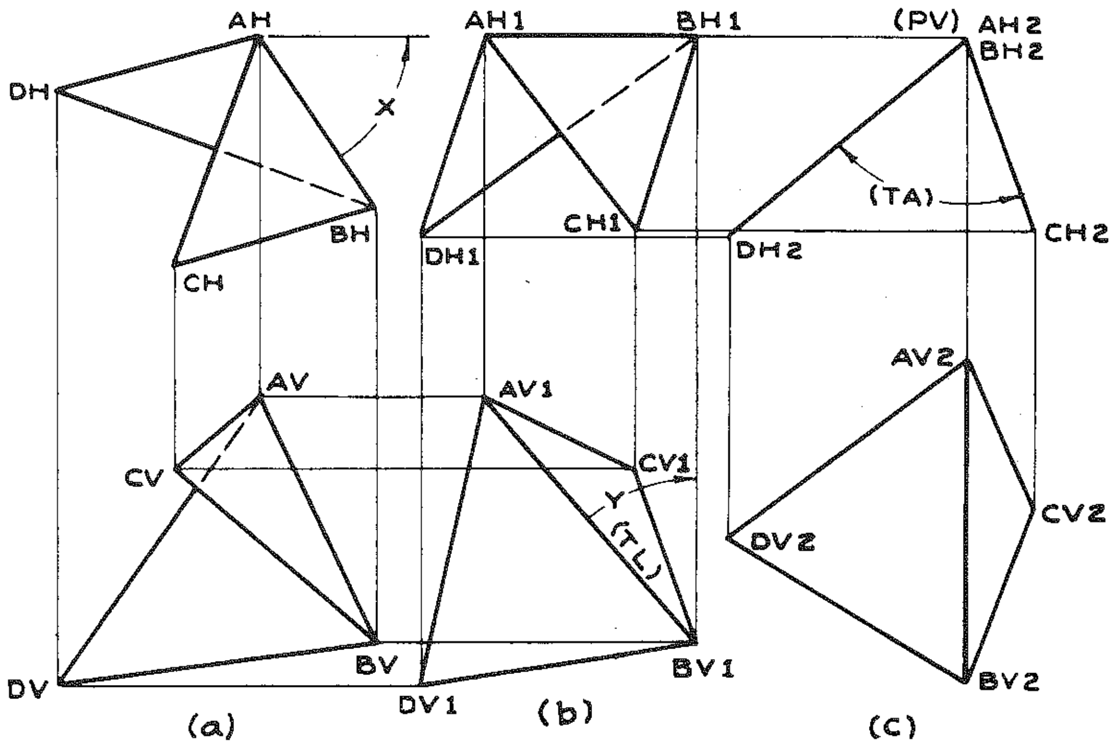


FIG. 2
ANGLE BETWEEN PLANES
(TRANSFER METHOD)

DISCUSSION OF ILLUSTRATIONS

In each of the illustrations presented herein, the solution progresses from left to right. Thus, the problem as given is designated (a) and appears at the left. The first step in the solution is designated (b) and is shown to the right of (a). The second step in the solution is designated (c) and is shown to the right of (b), etc.

The discussions of Figures 1 and 2 are quite complete. It is suggested that these discussions be read carefully since the discussions of the succeeding figures are less detailed.

In Figure 1, tbe method is applied to the problem of finding the angle between two intersecting planes, by finding a view in which the line of intersection of the planes appears as a point. In this instance, the line of intersection (AB) is an oblique line. Two rotations are required to obtain a point view of this line.

Referring to Figure 1(a), it may be noted that if line AB were rotated clockwise through angle X, about an axis which appears as a point at BH, the line would be parallel to the V plane and its true length would show in the front view. To obtain a separation of views, an axis which appears as a point at I (instead of at BH) was used. All points were rotated through angles equal to X to give Figure 1(b) in which AV1 - BV1 shows the true length of the line AB. The fact that the axis of rotation may be located at will, as just illustrated, provided the angle of rotation and the direction of rotation (clockwise or counter-clockwise) remain the same, may be checked graphically or proved by Euclidian methods. (Alternative axes, of course, must be parallel). $R_2 = R_1$ and arcs MM, NN, OO and PP all equal arc X.

The second axis of rotation appears as a point at II and all points were rotated clockwise through angles equal to Y so that line AB appears as a point in the top view, thus giving the angle desired. $R_4 = R_3$ and arcs QQ, RR, SS and TT all equal arc Y.

Acute angles which are supplements of the obtuse angles X and Y might have been used to give equivalent results. In this case the rotations would have been reversed in direction, i.e., counter-clockwise. In general, if acute angles are used, the arcs must have longer radii to produce a separation of views.

Referring back to Figure 1, the top views AH-BH-CH-DH and AH1-BH1-CH1-CH1 are found to be identical except for position and orientation. The same is true of the front views AV1-BV1-CV1-DV1 and AV2-BV2-CV2-DV2. This suggests that tbe rotated views may be transferred to the new locations using some trick of drafting less tedious than drawing arcs and constructing angles. Using a piece of tracing paper and the "pricking" method is suggested.

In Figure 2, the same problem is solved as that treated in Figure 1. Views AH1-BH1-CH1-DH1 and AV2-BV2-CV2-DV2 are relocations and reorientations of views AH-BH-CH-DH and AV1-BV1-CV1-DV1, respectively. Even though the arcs are not drawn, the process is still one of rotation because it is possible to locate axes about which rotations, through angles X and Y, could be made to give tbe results shown. In this case, the first rotation is counter-clockwise through angle X and the second rotation is clockwise through angle Y.

Hereinafter, the term "arc method" will be applied to the construction where the arcs are drawn and the designation "transfer method" will be applied to the construction where the rotation was accomplished by relocation and reorientation without drawing arcs.

In Figures 3 and 4, the same problem is solved, namely, that of finding first the edge view and then the true size of an oblique plane. In Figure 3, the arc method was used and in Figure 4, the transfer method was used. First, the inclined line DB was drawn in Figures 3(a) and 4(a). The first rotation produced Figures 3(b) and 4(b) in which line DB appears as a point and plane ABC is shown edgewise. The second rotation gave Figures 3(c) and 4(c) in which the true size of plane ABC is shown.

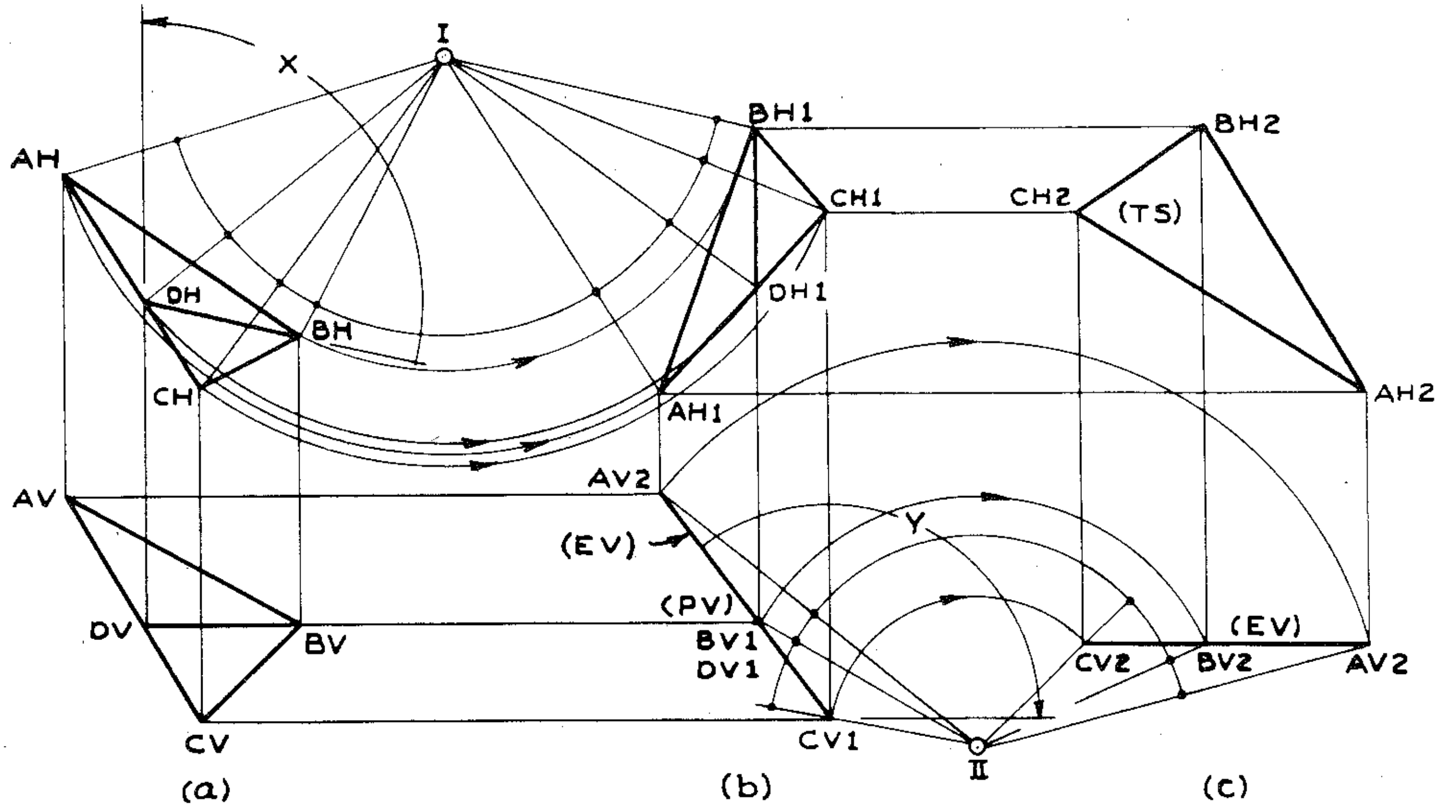


FIG. 3
EDGE VIEW & TRUE SIZE OF AN OBLIQUE PLANE
(ARC METHOD)

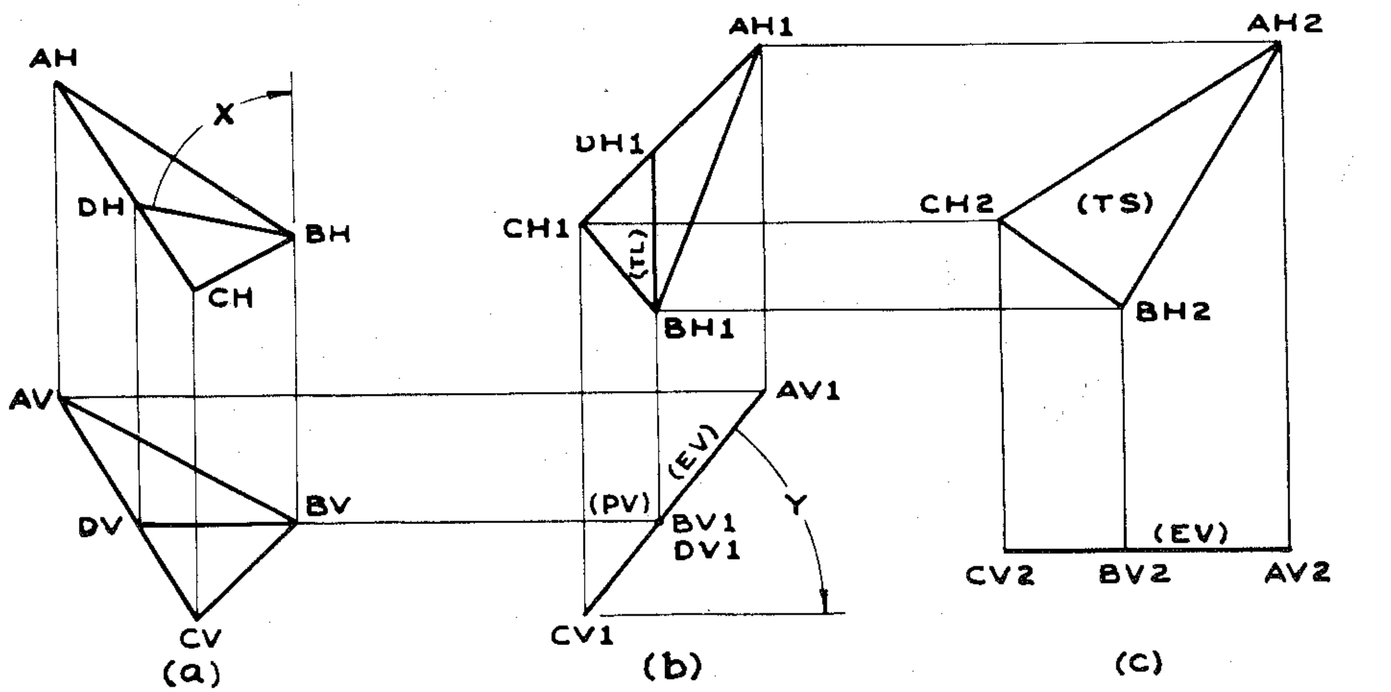


FIG. 4
EDGE VIEW & TRUE SIZE OF AN OBLIQUE PLANE
(TRANSFER METHOD)

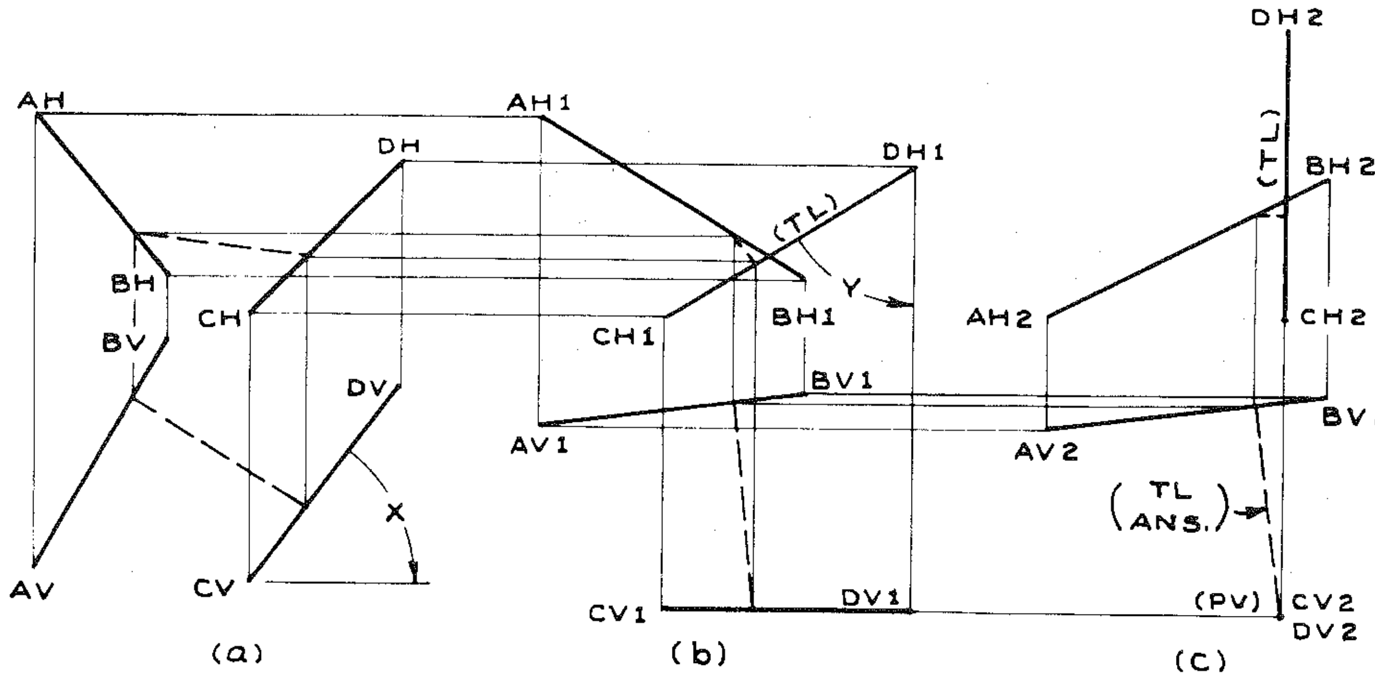


FIG. 5
COMMON PERPENDICULAR TO TWO OBLIQUE SKEW LINES
(TRANSFER METHOD)

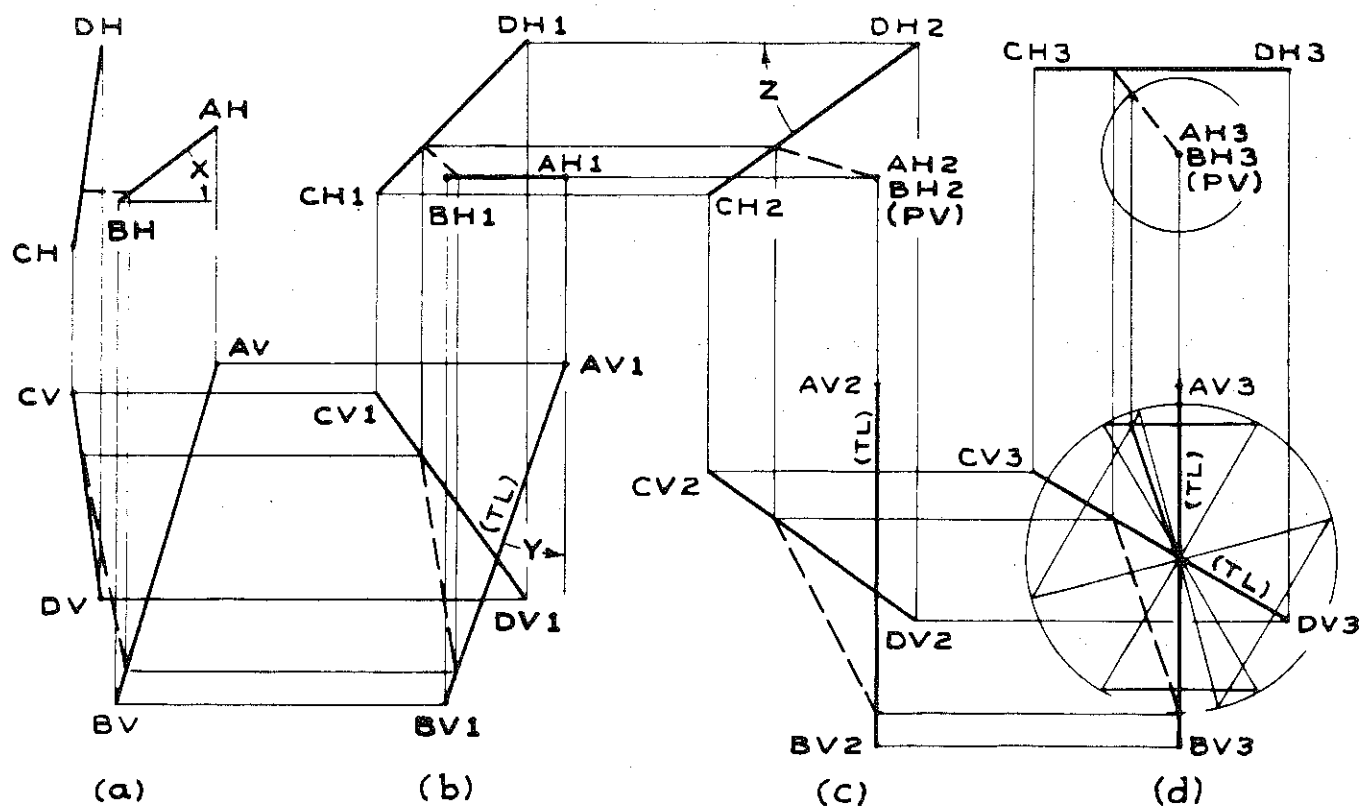


FIG. 6
LINE MAKING SPECIFIED ANGLES WITH TWO OBLIQUE SKEW LINES
(30° WITH AB & 45° WITH CD)
(TRANSFER METHOD)

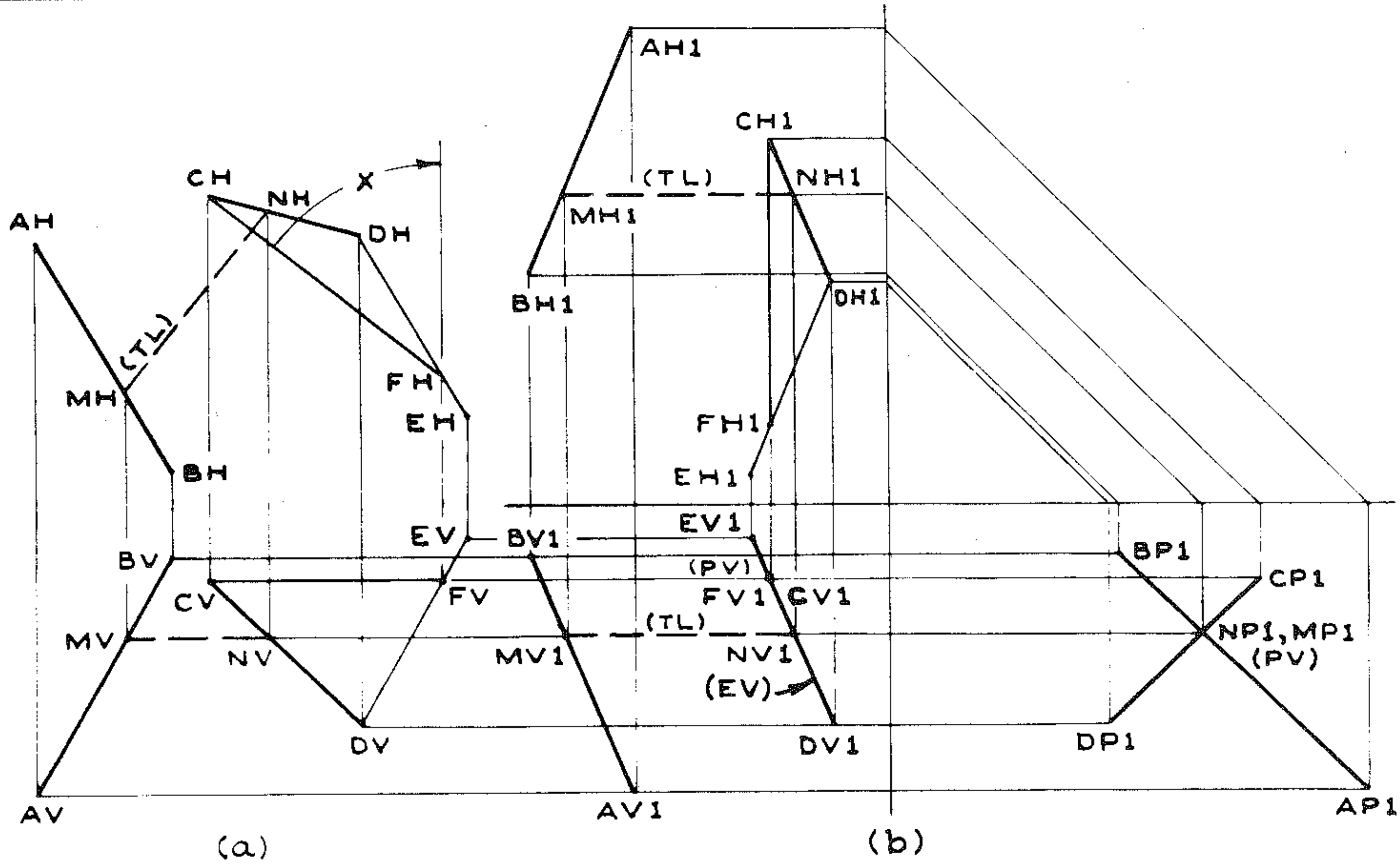


FIG. 7
SHORTEST HORIZONTAL LINE CONNECTING TWO OBLIQUE SKEW LINES (TRANSFER METHOD)

In Figure 5, the true length and projections of the common perpendicular to two oblique, skew lines are found. The transfer method was used. Rotations were made to give first the true length of line CD in Figure 5(b) and then the point view of CD in Figure 5(c). The common perpendicular, represented by dashes, was first drawn in Figure 5(c) and then projected to the other views.

In Figure 6, the problem of drawing a line which makes specified angles with two oblique, skew lines is solved. The transfer method was used. The successive rotations produced Figure 6(d) wherein the point view of line AB is shown in the top view and the true lengths of both lines are shown in the front view. In Figure 6(d), the usual cone construction was used to draw the required line, which is represented by dashes. Only one of the two possible solutions is shown.

Figure 7 shows the construction necessary for drawing the shortest horizontal line intersecting two oblique, skew lines. Since the required line must be parallel to the H plane, the relations between the given lines and the H plane must remain unchanged. Therefore, the only permissible rotation is one about an axis which is perpendicular to the H plane.

AB and CD are the given oblique, skew lines. In Figure 7(a), line DE was drawn parallel to line AB to form plane CDE which is parallel to line AB. Inclined line CF was drawn parallel to the H plane and in plane CDE.

The first rotation, about an axis perpendicular to the H plane, produced Figure 7(b) in the front view of which, a point view of line CF, an edge view of plane CDE and parallel views of lines AB and CD appear. The profile view in Figure 7(b) was drawn for the purpose of finding a point view of the required line MN. This point view of MN is located where the projections AP1 - BP1 and CP1 - DP1 cross. The other views of MN were located by projecting from MP1 - NP1. Only one rotation was necessary.

If, instead of the shortest horizontal line, the shortest grade line making, say 15°, with the horizontal were desired, the solution could be obtained by rotating the front view 15° in Figure 7(b) before drawing the profile view in which the required line would appear as a point. This second rotation would necessitate drawing a third figure, 7(c), in which the required line would appear horizontal. Whether the 15° rotation would be clockwise or counter-clockwise would depend on whether the required line is to slope down from AB to CD or vice versa.

Figure 8 shows the construction for finding the angle between an oblique plane (ABC) and an oblique line (DE). The first rotation produced Figure 8(b), in which an edge view of plane ABC appears. The second rotation made plane ABC horizontal in Figure 8(c). The top view of plane ABC was not drawn in Figure 8(c) because it was not needed. Line DE was then rotated through angle Z in Figure 8(c) to make it parallel to the V plane, so that the desired angle shows in the front view as indicated.

CONCLUSION

By way of comparing the method of rotation about normal lines with the auxiliary plane method, the author presents the following statements.

The method of rotation about normal lines:

1. Requires more construction.
2. Requires more time.
3. Cannot be expected to replace the auxiliary plane method as a means of delineation in the drafting room.
4. Is sufficiently interesting as a topic of geometry to be worthy of our consideration.
5. May be demonstrated by models of simple construction.
6. Involves only principal views and for this reason is probably more easily understood.

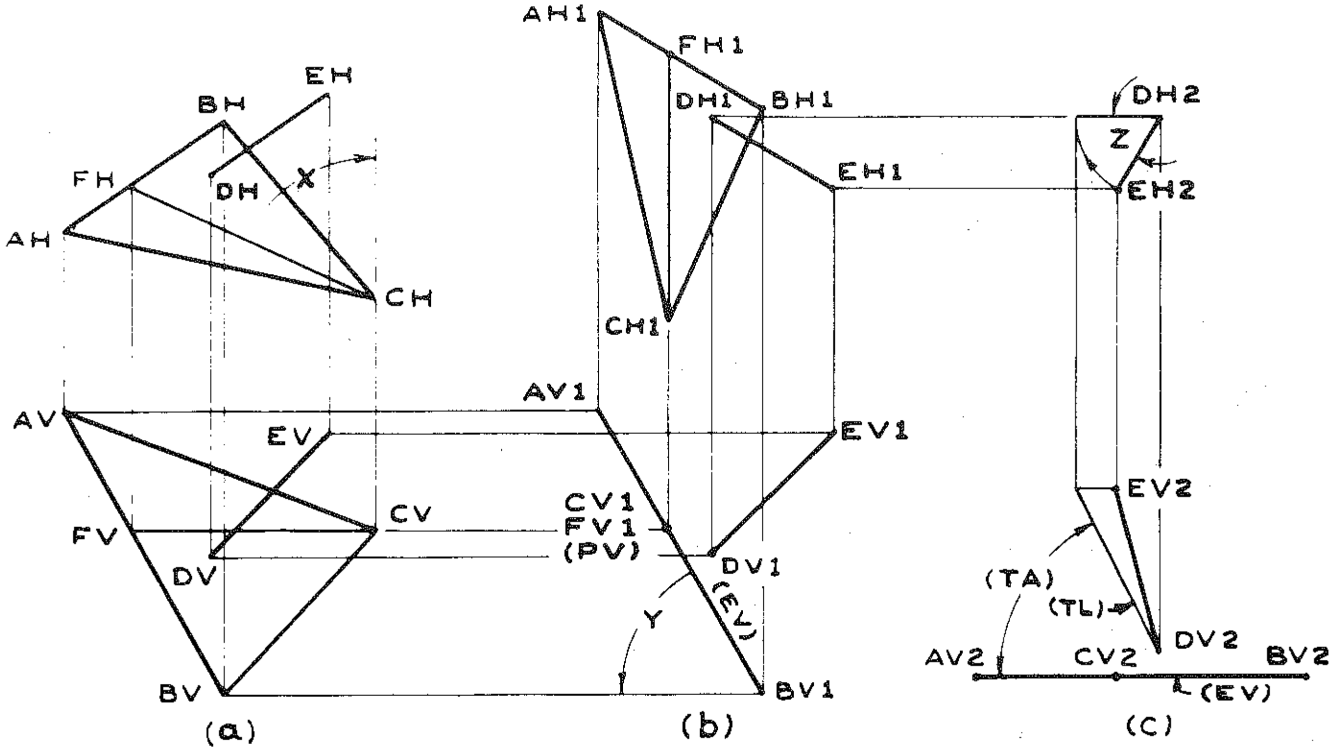


FIG. 8
ANGLE BETWEEN A LINE AND AN OBLIQUE PLANE
(TRANSFER METHOD)

APPENDIX

DEFINITIONS AND NOTATIONS

H, V and P represent the horizontal, vertical and profile planes on which the top, front and side views, respectively, are projected. These three planes are mutually perpendicular and are designated as the principal planes. Views projected on these planes are referred to as the principal views.

Letters are used to designate projections of points. These letters are followed by H, V or P to indicate projections on those planes. These second letters are followed by 1, 2 or 3 to indicate the first, second and third rotated positions, respectively. Thus, BH, BV and BP indicate principal views of point B as given. BH1, BV1 and BP1 indicate the principal views of point B in the first rotated position. BH2, BV2 and BP2 indicate the principal views of point B in the second rotated position, etc.

A small circle marked I indicates the point view of the first axis of rotation and a small circle marked II indicates the point view of the second axis of rotation, etc.

X, Y and Z indicate the first, second and third angles of rotation, respectively.

A normal line is one which is perpendicular to one of the principal planes.

An inclined line is one which is parallel to only one of the principal planes.

An oblique line is one which is oblique to each of the three principal planes.

A normal plane is one which is parallel to one of the principal planes.

An inclined plane is one which is perpendicular to only one of the principal planes.

An oblique plane is one which is oblique to each of the principal planes.

TL indicates the true length of a line.

PV indicates the point view of a line.

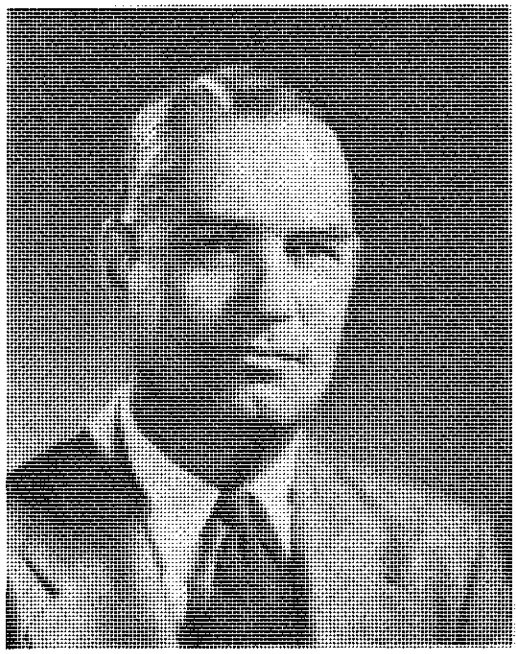
EV indicates the edge view of a plane.

TS indicates the true size of a plane.

TA indicates the true size of an angle.

PERSONALITY SKETCH
PROFESSOR JOHN T. RULE

by
Douglas P. Adams



Professor John T. Rule, "Jack" to anyone who has known him more than six minutes, is Head of the Section of Graphics at M.I.T., Chairman of the Course in General Science and General Engineering, and Professor of Engineering Graphics.

He was born in St. Louis in 1900, one of four children of the late Judge Virgil Rule and Estelle (Johnson) Rule of that city, and prepared for college at the public schools there. He received the Bachelor of Science degree from M.I.T. in 1921, specializing in Business and Engineering Administration. He was a member of the Theta Chi Fraternity, of the Chemical Engineering Society for three years, and Associate Editor of VOO-DOO (the M.I.T. funnybone). During college years he acquired the nickname of "Slide". On leaving M.I.T. he did special graduate work at Harvard for a year.

Until 1924 Professor Rule worked with the Scullin Steel Company, then served as consulting engineer for five years, and in 1929 became industrial engineer in charge of construction at the St. Louis plant of the Curtis Wright Corporation. In 1931 he was appointed Head of the Science and Mathematics Department at the Taylor School in St. Louis, and in 1936 he joined the M.I.T. staff as an Assistant Professor of Drawing. Two years later he was promoted to Associate Professor of Drawing and Descriptive Geometry and placed in charge of the Division of Drawing, which, in 1939, was renamed the Section of Graphics. He was promoted to full Professor in 1947, in 1950 was placed in charge of the Course in General Science and General Engineering, and in 1951 was named Professor of Engineering Graphics.

Jack Rule is widely known for his research and development in various phases of three-dimensional vision, including stereoscopic drawings, photography, motion pictures, and general stereoscopic theory. Beginning in 1941 he devoted most of his time to war research with the Polaroid Corporation and was in charge of the development of the Mark I macbine gun trainer for the United States Navy. In this device, he applied stereoscopic techniques to simulate combat conditions encountered in actual aerial warfare. He was also associated with other research projects, chiefly with the Bureau of Ordnance. During some of this period he spent part of his time with the Polaroid Corporation on special war projects. He is mentioned in Who's Who in America and Who's Who in Engineering.

All this biographical material certainly shows a personality blessed with a diversity of talents. Let's add, for instance, that Jack has been on just about all the M.I.T. Committees there are, or at least, the important ones - they just rotate him. The ASEE Drawing Division, of which he was the proud Chairman for 1946-47, has found in him an able expositor of the view that the grapbical method - "graphics" - was definable, teachable, and comprehensively valuable. He never misses a meeting, for here is a subject near and dear to his heart. He loves graphics and, above all, he loves teaching. He is the author of Engineering Graphics and Descriptive Geometry with E.F. Watts. His association with bright youngsters in the formative period of their lives gives him, he feels, one of his finest opportunities and keenest pleasures. He enjoys working out with them the well-known kind of solution he has repeatedly sent into the JOURNAL. And how the students love it!

Jack is a member of the American Association for the Advancement of Science, the Optical Society of America, the American Association of University Professors, the Newcomen Society, and the St. Botolph Club of Boston. He and Bobby (Helen Whiting) Rule have three sons, John, Clinton, and Stephen, who are all now taller than Dad.

Confidentially, if you ever happen to be out in a group with Jack when a meal is being prepared, let him toss the salad - mmm, MMMM!

KNOW YOUR COMMITTEES

by
T.T. Aakhus
Chairman, Division of Engineering Drawing
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A BRIEF SURVEY OF REPRODUCTION PROCESSES

Part II

by
H.P. Skamser and R.L. Paul

INTRODUCTION

This portion of the article is a follow-up on Part I which covered a general summary of common processes, costs of materials and equipment, a tabulation of the simplicity, and versatility of various processes, as well as practical quantity ranges. Particular emphasis was placed on the new developments which are sweeping across the business and industrial world.

The function of the second part of this article is, to give a more detailed description of specific processes and to indicate their chief uses. These processes are grouped as: (1) large quantity, (2) intermediate-producing (second originals), (3) limited quantity methods. In each group, the name of the process, some common trade names, the appearance of the print, the principal uses, a more detailed description, and some advantages and disadvantages are presented. Trade names and company names used in this article are representative and are not intended to be a complete listing.

A family tree of the common process follows:

(Continued on page 26)

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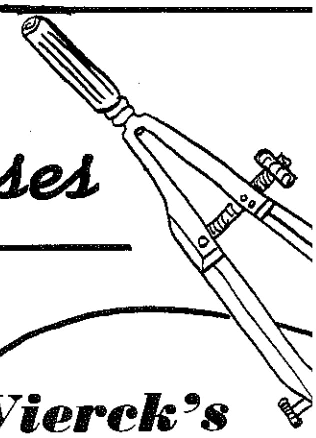

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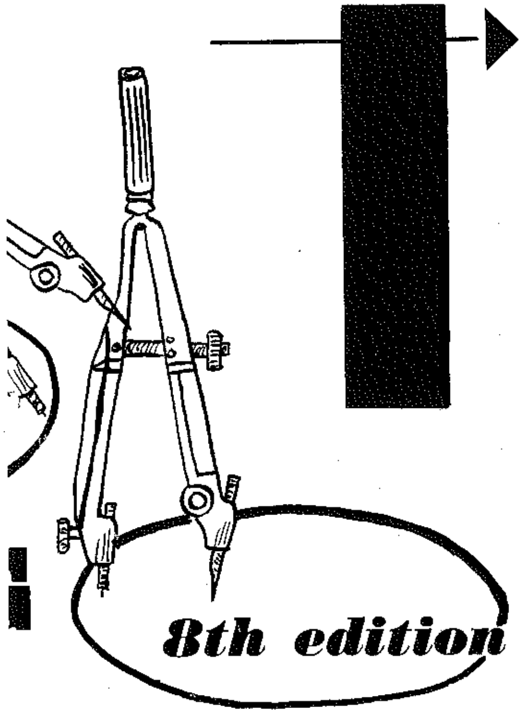

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Designed primarily to be used in conjunction with French and Vierck's *Engineering Drawing,* Eighth edition, this workbook has been expanded to cover the basic phase of engineering drawing normally taught in a one or two semester course. Since it includes more material than generally covered, it allows an adaptation to the particular scope of the individual course; i. e. complete coverage of necessary elements, or more extensive, but less thorough, coverage of each element.

ENGINEERING DRAWING BASIC PROBLEMS, Series A

By CHARLES J. VIERCK, CHARLES D. COOPER, and PAUL E. MACHOVINA, The Ohio State University. 8½ x 11, $3.50

This problem book is a briefer edition of *Series II,* designed for use in a one semester or quarter course. It covers all elementary phases of the subject, but omits some of the more difficult problems which are covered in the larger book.

Send for copies on approval

330 West 42nd Street, New York 36, N. Y.

(Continued from page 23)

REPRODUCTION PROCESSES

- MECHANICAL
  - DUPLICATING
    - Typewriter
    - Mimeograph
    - Hectograph
  - PRINTING
    - Letterpress
    - Gravure
    - Lithography
- PHOTOCHEMICAL
  - TRANSMITTED LIGHT (Contact)
    - Blueprint
    - Van Dyke
    - Diazo, Dry
    - Diazo, Moist
    - Photographic Contact Print
  - REFLECTED LIGHT (Projection)
    - Photostat
    - Microfilm
    - Photographic Reflex Print
- RECENT DEVELOPMENTS
  - NEW PRINCIPLES
    - Thermo-Fax (Heat & Plastic)
    - Xerography (Electro-plastic)
    - Photo-copy - (Transfer) (1 Step Developing)
    - Reflex film (Diazo)

PROCESSES GENERALLY USED FOR LARGER QUANTITIES

Name of Process with Trade Names	Appearance of Print	Principal Uses	Description of Process	Advantages	Disadvantages
Letterpress	Multicolored on any color background.	Large amount of commercial printing. Newspapers from flat bed or cylindrical presses.	Type or halftones laid out and placed in a printing press. A plastic, wax or lead mold is thinly electro-plated with copper or nickel and curved to fit the press cylinder and backed with a soft metal. Prints from raised surfaces.	Letterpress is most stable. Accurate reproduction of lines and letters. Unexcelled stability, sharpness and, uniformity of color in all of printing field.	Expensive to make up plates and adjust for good register (alignment). Requires a large amount of special equipment.
Gravure	Multicolored on any color background.	Commercial printing of picture sections in magazines and catalogs.	Type or illustrations are transferred, (using a transparent film proof and a photographic gelatin paper copy) to gravure plate which is etched. Photo-engraved cylindrical plate is placed in printing press and copies printed therefrom. Prints from depressed surfaces.	Gravure has widest tonal range. Accurate reproduction of lines and letters. Four-color roto-gravure printing on cheap papers. Little "make-ready" time required.	Good set of engraved plates difficult to make and are expensive. Requires large amount of special equipment.
Lithography or Offset Printing Planograph Multilith Photolith	Black or colored colored lines on any background.	Workbook drawings, problems and printed material. Patent drawings. Maps. Commercial printing.	A master is produced (by one of 14 manual or photographic methods) on paper or treated aluminum or zinc sheets. This master is mounted in a rotary lithograph and run much as in mimeograph. Ink is transferred to a rubber roller from the image on the master (ink adheres only to image due to a repellant on background) and thence to the final copy.	Offset is economical. Accurate reproduction of fine lines. Lowest cost color reproduction. Softer color tones than letterpress. Less expensive plates and make-up time than letterpress.	Difficult to predict number of impressions obtainable. Requires special equipment.

Mimeograph A.B. Dick	Multicolored on any color background.	Tests, instruction sheets, problems, small drawings, bulletins, maps, charts and general purpose.	Ink is transferred through master stencil to paper. Stencil may be typed, drawn or die cut (maps, forms, etc.). A photo sensitive stencil is also available.	Inexpensive, permanent and rapid. Quality varies with method of making stencil, choice of ink, and paper.	Dimensional accuracy is not dependable. Colors other than black fade.
Hectograph A.B. Dick Ditto Spirit - Fluid	Purple line on white background. Other colors also available.	Small drawings and instruction sheets when few are required. General purpose notes.	Aniline dye from Ditto "carbon" is transferred to underside of master by pressure from pencil or typewriter. Working (dye) side of master is negative reading. A right reading proof of master appears on front. Aniline dye is transferred from master to spirit moistened paper to produce copy.	Very cheap and rapid.	Smaller quantities and poorer contrast than mimeograph. Some smudging of copy when moistened. Master is messy to handle in preparation.
Blueprint Post, Dietzgen, Bruning, Pease, Paragon-Revolute.	White line on blue background. Blue line on white background when Van Dyke is used as an intermediate.	Bulk of commercial and manufacturing prints.	Wet, contact process: 1. Expose to light. 2. Wash in water. 3. Fixed with potassium dichromate solution. 4. Rinse in water. 5. Dry.	Cheap and permanent. Good contrast unimpaired by shop handling. Widely used. Equipment may be used for Van Dykes, "Auto-positive", etc.	Washing and drying equipment required. Difficult to mark up. Distortion due to shrinkage.
Diazo, Dry (Ammonia vapor) Ozalid, Pease, Peck & Harvey, Paragon-Revolute, Comet, Technifax, Post-Vapopapers, Dietzgen-Driprint.	Black, blue and maroon line. Several colored papers.	Positive prints and reproducible master drawings.	Dry, contact process: 1. Expose to light. 2. Develop in ammonia fumes.	No paper shrinkage. Positive prints. Versatile, Convenient and rapid. High production can be obtained with cut sheets or rolls. No drying.	Exhaust required for ammonia fumes.
Diazo, Moist (Fluid developer) Technifax, Post-Blacline, Dietzgen-Directo, Bruning-Copyflex & Whiteprint, Peck & Harvey.	Black line on white background.	Positive prints and check prints.	Dry, contact process: 1. Expose to light. 2. Bring in contact with special liquid developer.	No paper shrinkage. Positive prints. Easy to mark up. Rapid. High production can be obtained with cut sheets or rolls. No dryer needed.	May fade.

INTERMEDIATES (2nd ORIGINALS), REVISIONS

General Uses:

1. Extra originals to speed up quantity production
2. To save wear and tear on original.
3. Variations of an original while keeping original intact.
4. Permit production of a print at more than one location.

Name of Process with Trade Names	Appearance of Print	Principal Uses	Description of Process	Advantages	Disadvantages
Van Dyke (Brownline)	Light line on dark brown background.	Use as a negative for making brown-print and blue line prints.	Wet, contact process: 1. Expose to light. 2. Wash in water. 3. Develop in hyposulphite of soda. 4. Rinse well in water. 5. Dry.	Good contrast. Permanent. Widely used. Prints may be altered by use of eradicators and redrawing portions. Made on blueprint equipment.	Difficult to mark up. Reversed print. Distortion due to shrinkage. Washing and drying equipment required.
Photographic Print Photact Peerless Paper Kodagraph Dinoc.	Dark line on light background.	Reproduction, or upgrading of pencil tracings to be used as secondary reproducibles. Restoration of old drawings.	Wet, projection process: 1. Make intermediate (negative) by contact or by large camera. 2. Develop. 3. Fix paper negative & dry. 4. Print negative on sensitized cloth. 5. Develop. 6. Fix cloth and dry.	Good contrast. Positive prints. Enlargements or reductions. Permanent. Prints may be altered by eradicator, overlay, masking or cutout.	Special equipment required. Expensive.
Diazos Dry and Moist	Sepia & black lines on variety of papers, cloths and films, including reflex film to copy opaques.	Reproducibles.	Same as for regular dry and moist diazo.	To save wear and tear on originals. Changes may be made by use of correction fluid. Cheaper than photo processes.	
Microfoil by Technifax	Same as microfilm.	Duplication of photographic microfilm for dual storage or intermediates.	Same as Dry Diazo.	Saves original microfilm.	
PROCESSES GENERALLY USED FOR LIMITED NUMBER OF COPIES FROM ORIGINAL					
Photocopy (transfer-dry) Dristat, Apeco, Contoura, Exact photo-copy, Duplomat, Instant Copier, Portagraph, Photorapid, Co-Pease, Transcopy.	Dark line on light background. May use preprinted forms and also tinted papers.	Copying any printed or drawn material either direct or reflex (for 2-sided original). Some equipment will copy from open book.	1. Expose negative paper. 2. Process negative paper in contact with positive paper. Separate negative and positive (negative is discarded or may be used as a reverse reading file copy). Usually only one positive is obtainable from a positive.	Some models are portable for research work in libraries, etc. No special preparation of original.	Time and cost per copy remain approximately constant so there is no economic advantage for multiple copies. Limited to legal paper size.

Heat Sensitive Plastics Thermo-fax by Minnesota Mining & Mfg. Company.	Black on amber or light surface.	Copying of letters, forms, drawings, (small), etc.	Expose original & plastic-coated sheet to infra-red light, then peel apart.	Copies transparent or opaque originals. One of the most rapid processes in this group. With use of camera, 50% to 150% size can be accomplished.	Equipment not portable. Lacks sharp detail. Limited to legal paper size.
Electro-static Xerography-Haloid	Dark image on light background with shading and half-tones.	Paper masters for lithography.	"Electrostatic-electro photographic" 1. Positive charged plate. 2. Expose to light. 3. Apply negative powder. 4. Transfer, powder image. 5. Heat to fuse plastic powder.	Medium print cost. Quick reproduction. Plates can be reused. Prints on almost any surface. Requires no fussy chemical solutions.	Lacks sharp detail. Fair graduation of tonal qualities. Requires heavy use to warrant rental charges.
Photostat	Positive reading prints. Usually light image on dark background. Dark image on light background is available.	Reproduction of documents.	Wet, projection process: 1. Expose to light. 2. Develop in photographic developer. 3. Fix in hyposulphite of soda. 4. Wash. 5. Dry.	Permanent. Enlargements or reductions. Widely used. Legally acceptable same as original.	Difficult to mark up. Costly equipment required. Relatively expensive.
Microfilm Photorecord, Photostat-Microtronics, Kodagraph	Dark line on light background.	Reproduction of drawings and records for permanent storage.	Wet, projection process: 1. Photograph with small camera. 2. Develop. 3. Fix film. 4. Store film; or for copies enlarge on sensitized cloth or paper. 5. Develop. 6. Fix copy.	Small bulk for economical storage. May be used in projection readers. Micro size or enlarged copies may be made. Available in 3 sizes: 16mm, 35mm and 70mm.	Special equipment required. Expensive copies.
Reflex Prints Photocopy (transfer), processes, Bruning's Reflex-film; and Standard photo processes.	Dark line on light background.	Direct copying of drawings, illustrations and reports from opaque originals.	Wet, contact process: 1. Copy and film exposed to light. 2. Film developed. 3. Make contact print of film by any of several other processes.	Direct contact copy of opaque sheets. Can copy material from both sides of a sheet.	Some skill required and cost high.

(Continued on page 32)

(Continued from page 29)

Excellent (partially pictorial) charts describing many of these processes are obtainable from the following sources.

1. "Major Types of Reproduction Materials", John Berchin, Keuffel & Esser Co., Adams & Third Streets, Hoboken, New Jersey.
2. "Eight Major Reproduction Processes", Eugene Dietzgen Co., 2425 Sheffield Ave., Chicago 14, Illinois.
3. "Office Reproduction and Imprinting Methods" by Irvin A. Hermann, a reprint from the April 1951 issue of "The Office" magazine, 270 Madison Avenue, New York 16, New York.
4. "Eastman Intermediate Selection Chart" (Kodagraph Reproduction Materials), Eastman Kodak Company Industrial Photographic Division, Rochester 4, New York.

The authors have corresponded with 41 suppliers and have the names and addresses of these companies on file.

CONCLUSION

In this two-part article the authors have attempted to accumulate useable information from the vast amount of sales literature presented by many companies. In undertaking this work it is hoped first, that a better understanding of the various processes will result, secondly that new and unique uses will be suggested to engineering educators, and thirdly, a more satisfactory choice may be made when new equipment is to be purchased.

The authors will be happy to suggest sources of additional information.

PROGRAM ANNUAL MEETING of the ENGINEERING DRAWING DIVISION OF THE ASEE

Pennsylvania State College, State College, Pennsylvania
June 20-24, 1955

Monday, June 20:

2:00 p.m. — Chairman; William E. Street, Professor & Head of Drawing, Vice-Chairman of Drawing Division ASEE, Texas A.& M. College, College Station, Texas

Technical Papers--

(a) "Engineering Drawing and Scholarship," James Houghton, Unversity of Notre Dame.

(b) "Errors in Graphics," John Bossenga, Northwestern University.

(c) "Sound Motion Pictures and Television for Improving Instruction," Dr. C.R. Carpenter, Penn State College.

6:30 p.m. — Executive Committee Meeting, Division of Engineering Drawing.
Chairman: T.T. Aakhus, Chairman, Division of Engineering Drawing, University of Nebraska.

Tuesday, June 21:

2:00 p.m. — Chairman: John T. Rule, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Technical Papers--

(a) "Freehand Sketching & Pictorial Drawing in the Engineering Drawing Curriculum," Frank Zozzora, University of Delaware.

(b) "Developments for Surface Finish," Roy Trowbridge, General Motors Engineering Standards.

(c) "The Trend of Drafting in Industry Versus the Trend of Drafting in the Engineering Curriculum," E.H. Brock, Texas A.& M. College.

6:30 p.m. — Drawing Division Annual Banquet
Chairman: T.T. Aakhus, Chairman, Drawing Division ASEE, University of Nebraska.

(a) Presentation of distinguished service award, Clifford Springer, University of Illinois.

(b) "Great Possibilities of Expansion That This Country Has in the Foreseeable Future," Raymond O. Bell, Representative of the Transformer & Switchgear Dept. of the Allis-Chalmers Mfg. Company.

Wednesday, June 22:

12:00 noon — Business Meeting and Committee Reports
Chairman: Professor T.T. Aakhus, Chairman Division of Engineering Drawing, University of Neb.

Technical Papers--

(a) "Status of the ASA Engineering Drawing Standards," R.P. Hoelscher, University of Ill.

2:00 p.m. — Chairman: James S. Rising, Iowa State College.

Technical Papers:

(a) "The Value of the Circular Nomogram to an Industrial Firm," Edward C. Varnum, Barber-Coleman Company.

(b) "Graphical Methods for the Design of Bells and Carillons," Arthur Bigelow, Princeton University.

(c) "Graphics--The Cursive Writing of Science," Douglas Adams, Massachusetts Institute of Technology.

GRAPHICS IN ENGINEERING PRACTICE

by
Orrin W. Potter
University of Minnesota

INTRODUCTION

This is a study of Graphics as it relates to the undergraduate curriculum of the engineer and its importance to the practicing engineer and industry. This work was carried on during 1953 and 1954. The study consisted of personal interviews with Drafting-Design departments of industry, draftsmen, and practicing engineers, heads of drawing departments and drawing teachers of engineering schools. In addition, about 3,000 questionnaires were distributed among the following:

1. Heads of Drafting-Design departments of industry
2. Draftsmen
3. Practicing engineers
4. Heads of drawing departments of engineering colleges
5. Drawing teachers in engineering colleges

First, let's define graphics: According to "Webster's New International Dictionary," Graphics: Art or science of Drawing, esp., according to mathematical rules, as in perspective, projection and the like; specifically, calculations as of stresses in engineering, by the use of geometrical constructions.

Every effort was made to get as representative a sampling as possible. The objective was to get an unbiased opinion as to the importance of graphics in industry and to the practicing engineer. It was hoped that this would reveal (1) How important graphics is to the practicing engineer and industry, and (2) what the schools were doing to meet this need.

Approximately 3,000 questionnaires were distributed, and the returns were as follows:

1. Heads of the Drawing Departments in the Colleges	(No. returned)	50
2. Teachers of Drawing.	(No. returned)	232
3. Heads of Drafting-Design Departments of Industry	(No. returned)	124
4. Draftsmen.	(No. returned)	687
5. Graduate Engineers (excluding teachers).	(No. returned)	711
TOTAL		1804

COMPANIES RETURNING QUESTIONNAIRE "HEADS OF DRAFTING-DESIGN DEPARTMENTS"
117 Separate Plants----22 States

(•) No. of Companies

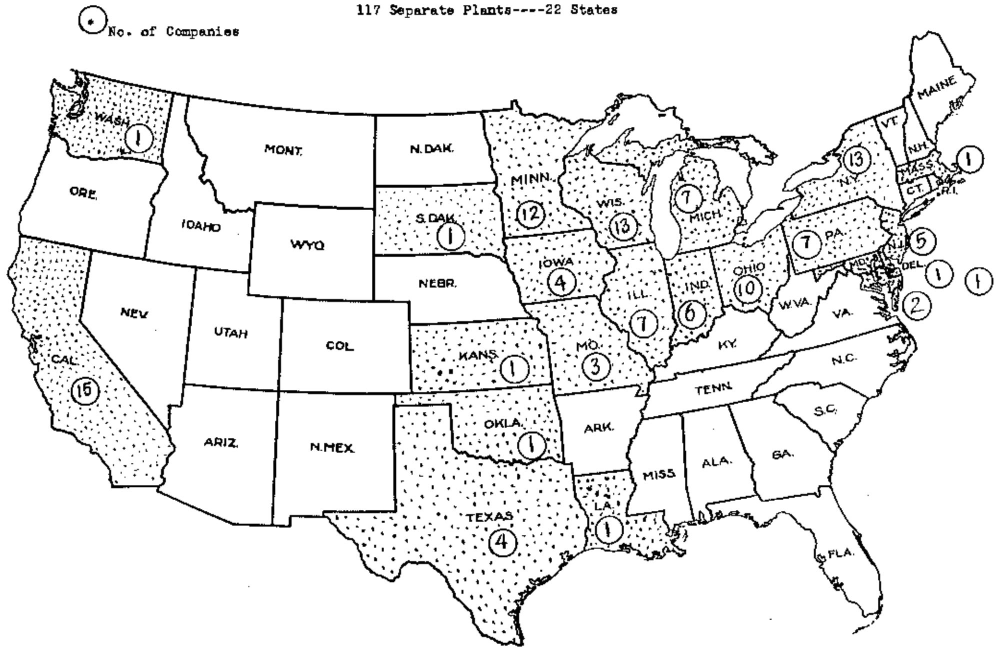

FIG. 1

SUMMARY OF QUESTIONNAIRES

I. HEADS OF DRAFTING-DESIGN DEPARTMENTS OF INDUSTRY

Fig. I shows the geographical distribution of the industrial companies that participated in this study. This comprised 112 separate plants, 124 separate departments located in 22 states. The figures in the circles are the number of companies in that particular state.

#1. "How many draftsmen are employed?" (Note: Some questions were not answered, so it is impossible to always reconcile the figures.)

These returns show the number of draftsmen employed at approximately 11,000. It is estimated that these same companies employed approximately 20,000 engineers.

#2. "What is the source of your draftsman?"

High Schools	58%
Engineers	18%
Company Training Program	13%
All others	11%
TOTAL	100%

#5. "Do you feel that drawings are as necessary as in former years?"

Yes - 96
More so - 28
No - 0

#6. "How important are drawings in your industry?"

1. Very important	55
2. Impossible to operate without them	55
3. All manufacturing is done from drawings	7
4. 100% important	5
5. Their importance cannot be stressed too strongly	1
6. Military requirements make drawings necessary	1
TOTAL	124

#7. "Do drawings carry more or less information than formerly?"

More	103
About the same	10
Less	7
No answer	4
TOTAL	124

#9. "Approximately what per cent of drawings are inked?"

100%	1
90-95%	6
80%	7
50-75%	5
10-35%	8
5-10%	25
Very little or none	72
TOTAL	124

#10. "What per cent of drawings are made in pencil, directly on vellum?"

95-100%	65
90-95%	35
80-90%	4
50-80%	7
10-20%	6
Very little	3
TOTAL	120

#11. "How much freehand sketching is used?"

None or very little	82
Approximately 5%	6
Approximately 10-15%	10
Considerable	18
TOTAL	116

#12. "How much pictorial drawing is used?"

None or very little	107
Some for instruction of advertising, publications, etc.	11
Considerable	1
TOTAL	119

#13. "Do you have occasion to construct graphs, charts, and nomograms?"

Frequently	84
Very little	40
TOTAL	124

SOME GENERAL COMMENTS FROM HEADS OF DRAFTING-DESIGN DEPARTMENTS AND PERSONNAL DIRECTORS OF INDUSTRY:

1. The importance of graphics in its broadest sense in Engineering cannot be stressed too strongly. (Large manufacturing company)

2. In my opinion, schools do not stress enough the importance of drawing, shop, and manufacturing processes to future designers. (Metal processing company)

3. It may well be that drawings are more necessary now, in that the information is more critical and complicated because of the nature of scientific discoveries and engineering advances in the field of Communications. The preparation of good drawings is one of the essential factors in the various phases of the job of furnishing improved communication services. (Telephone company)

4. In the aircraft industry, the greatest opportunities in terms of numbers of positions and level of work exists in the design-drafting field. It is also true that it is the most difficult field to sell to the graduating engineer. (Aircraft company)

5. I think it would be a fair opinion of many of our engineers that training in graphics is very desirable. I think it is extremely important. (Chemical industry)

6. Our company has emphasized the importance of graphics throughout the years. We feel that graphics provide a means of representation necessary to effective engineering. (Public utility)

7. Drafting is of considerable importance in the training of an engineer. The relationship of drafting to the engineer is not that of a full-time occupation, but drafting is a necessary, if not mandatory, tool for the design engineer. (Aircraft company)

8. Based on the rather considerable experience that we have had, we have integrated a great deal of our engineering activity with the preparation of the drawing. Because of this, we believe that more rather than less attention should be given to drawing and the entire field of engineering graphics. (Chemical industry)

9. Being able to interpret mechanical drawings is a definite requirement for any engineer, and the proper place to receive this training is in the college courses. For designers in particular, this training is absolutely essential. Even if engineers engaged in design and development work do no actual drawing, they supervise drafting work to a large extent, and to do this, they must have a very thorough knowledge of drafting. (Manufacturing company)

10. We feel that graphics is essential to engineering work. Almost all of our graduate engineers, while they start in drafting work, move into design activities. (Manufacturer of farm implements)

11. I deplore the lack of graphic skills found in the average graduate today, and worse still, his lack of interest and appreciation of these skills. I believe that too little emphasis has been placed on the drafting and its associated skills in recent years. Technical eyes are apparently blinded by the glamour of analogue computers and atomic reactors; while courting these developments, let us still remember to develop the basic tools with which we will work the rest of our lives. It occurs to me that the engineer with a weak background in graphics is like the writer who has a very weak vocabulary; he just doesn't have the necessary tools to do the job properly. (Manufacturing company)

12. We are glad to cooperate in this study because we feel that more emphasis should be placed on graphics by the engineering schools for the benefit of the engineering graduates as well as industry. (Manufacturing company)

EMPLOYERS OF GRADUATE ENGINEERS
200 Companies in 33 States and Canada

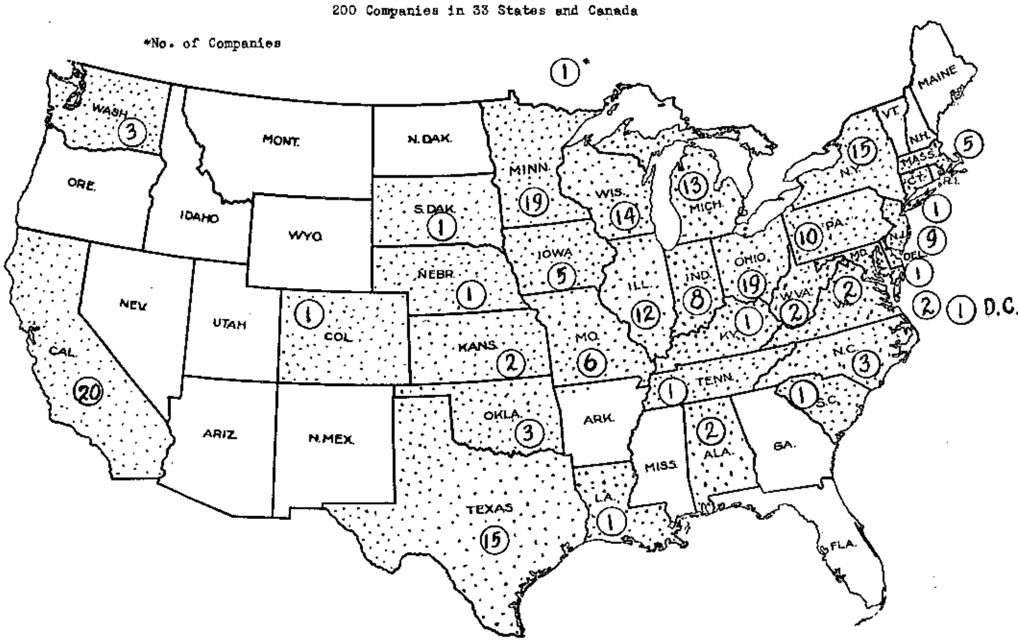

FIG. 2

13. We are concerned with the recent trend to drastically reduce the amount of drawing in the undergraduate curriculum of Engineering Colleges. It is difficult for us to accept any philosophy which tends to de-emphasize the importance of drawing, because engineering drawings constitute the authority for manufacturing a product. This current trend is particularly disconcerting to those companies such as ours, who have been forced by necessity to supplement the education with the "new starters." We feel that the current trend, if it were intended to coincide with industry's requirements, should place <u>more emphasis</u> on the basic requirements of drawing. (Aircraft company)

14. To sum up my total thinking and experience, I would certainly desire a greater emphasis at the undergraduate level for graphic expression in every respect. (Glass manufacturer)

15. I am somewhat surprised that there is any question as to the importance of drawing in engineering. It is one of the most essential means of communication; anything that will improve the communication skills of the young engineers is to be desired. (Chemical company)

16. In talking with our graduate engineers, it is safe to say that they all believe engineering drawing is a vital subject in preparation of an engineer and is most valuable when it is an aid in developing the ability to visualize and think creatively. It is least valuable when it is used solely as a means for developing mechanical skill. (Manufacturing company)

17. Engineering Drawing is the language of engineers, designers, and technicians in the industrial world and should be treated as importantly as in teacbing any course. (U.S. Air Force)

SCHOOLS OF GRADUATE ENGINEERS -- 144
(6 are not located, 2 Foreign Countries)
43 States and Canada

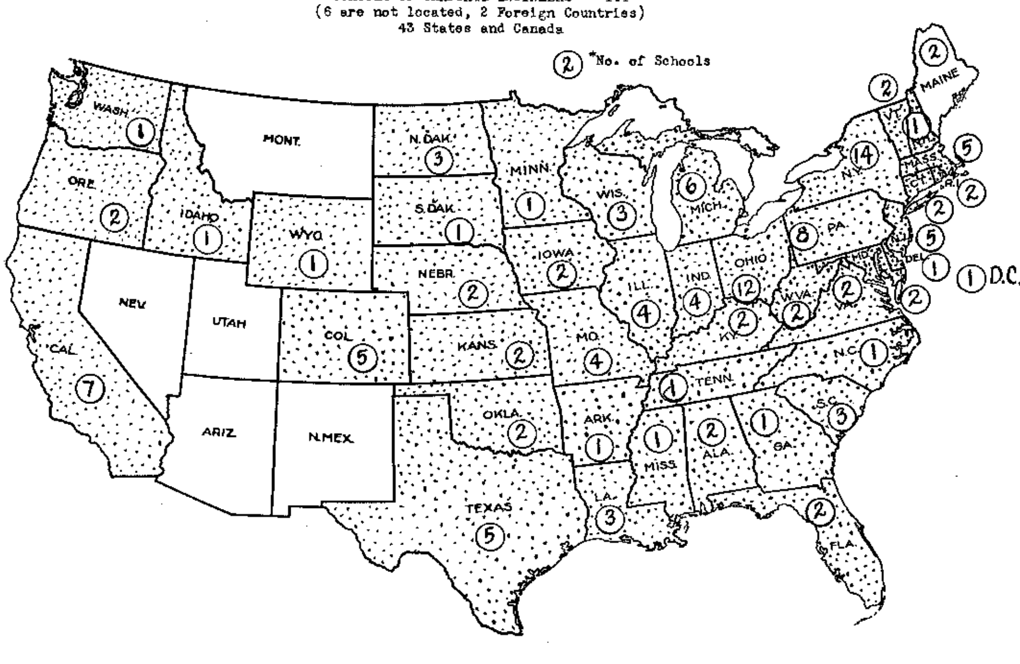

FIG. 3

GENERAL COMMENTS:

1. These returns came from a wide variety of industries, representing a reasonably fair sampling of the various types of industries employing draftsmen and engineers. They are distributed among 22 states and represent a reasonable sampling of the industrial areas of the country. The small company is probably not very well represented.

2. Engineers are not being used as career draftsmen except in the design field. The designer is more concerned with actual designing, calculations and consulting with other designers, shop men, and any who may help in the development of the design problems. He makes only the necessary sketches and layouts that will convey the design to the detail draftsmen who works out the drawings that are required for manufacture and construction. To do this kind of work, the designer must understand all phases of graphics thoroughly.

3. Drawings are considered not only important, but absolutely essential, to the conduct of their business. Not a single one inferred in any way that drawings were less important than they used to be. It was the other way around; drawings are considered more important and carry more information than formerly.

4. There is very much less inking being done; pencil work directly on vellum or similar paper is the common practice. More graphs and charts are being used now.

5. The general comments of the drafting room heads seem to indicate they consider drawing very important to the company and the engineer alike. Even though the engineer does not actually make as many complete drawings as formerly, he must be able to make intelligent sketches and layouts that can be turned over to the detail draftsmen for completion. If these sketches are not clear, complete, and accurate in necessary detail so that the draftsmen can readily go ahead, it causes serious delay and expense. The engineer must also be able to read and check the finished drawings before they are sent to the shop for manufacture. Manufacturing cannot proceed until the drawings are completed. They also serve as necessary permanent records of all manufacturing transactions.

II. GRADUATE ENGINEERS: Number of replies received, 711.

Figure 2 shows geographical distribution of the employers of the engineers returning questionnaires. These 200 separate companies are distributed among 33 states and Canada, and one foreign country. The numbers in the circles denote the number of companies in the different states.

1. Range of ages: from 22 to 69.

In the 20's	22%
In the 30's	50%
In the 40's	17%
50 or over	11%
TOTAL	100%

2. Employment titles. The engineers work under many different titles, too numerous to mention.

3. Degrees of graduate engineers. Many indicates more than one degree. The Bachelors Degrees shown were distributed as follows:

BSME	265	B Phys	7
BS	132	BAArch	5
BSEE	121	BAInd.E	3
BSCE	85	BSMines	3
BSAE	44	BSText.E	2
BSChE	32	BSCeramic	1
BA or AB	10	BSCommercial	1
TOTAL			711

Figure 3. This shows the geographical distribution of the engineering schools from which these engineers obtained their degrees. The figures in the circles are the number of different schools in this state. This comprised 144 schools in 43 states, Canada, and 2 foreign countries.

4. Has Drawing been useful to you in your engineering practice?

Yes	705
No	6

Those who stated "No" comprised 4EE, 1ME, and 1 ChemE.

5. Do you think drawing is important to the practicing engineer?

Yes	705
No	6

(Those who stated "No" same ones as in #4.)

6. Do you think Drawing is a necessary part of the undergraduate program for engineers?

Yes	707
No	4

7. How do you feel about the amount of drawing in your undergraduate program?

1. More would be desirable	154
2. Satisfactory	130
3. Less would be desirable	34
4. No reply	393
TOTAL	711

8. What phase of drawing do you feel should be stressed more. In order of emphasis they are as follows:

*1. Freehand sketching
*2. Descriptive geometry and applications
*3. Pictorial drawing (all forms: perspective., axonometric, and oblique)
*4. Reading problems and exercises in visualization
*5. Dimensioning, including tolerances, limits, etc.
*6. Layout and Design sketches
*7. Graphs, charts, nomograms, and graphical calculations
*8. Mechanical drafting and detailing
9. Lettering
10. Neatness, accuracy, and clarity
11. More attention to simplified forms, symbols, etc.
12. Fundamentals and basic principles and drafting standards
13. More machine design, creative design, and applications
14. Piping, wiring, flow-sheets, etc.
15. Relation of drawings to processing, casting, forging, machining, welding, etc.
16. More specialization in the different fields
17. More practical application and less theory
18. The use and purpose of drawings
19. Intersections and developments

(*These received major emphasis)

Many others were mentioned, such as checking, assembly drawings, use of special equipment, mapping, sections, auxiliary views, and lofting. More models and visual aids were also suggested.

9. What phases of drawing do you feel should be stressed less? In order of emphasis they are as follows:

1. Inking and tracing
2. Lettering
3. Technique and line work
4. Descriptive geometry
5. Too much detailing
6. Pictorial drawing (Production illustration, perspective, etc.)

7. Charts, graphs, nomography, etc.
8. Machine drawings
9. Threads, gears, cams, etc.
10. Freehand sketching

Also, 62 stated no phase of drawing should be stressed less.

10. Are Drawings more or less important in your work now as compared to some years back?

About the same	285
More important	276
Less important	103
No answer	47
TOTAL	711

A number of those indicating "less important" stated this was due to executive type work they were now doing.

11. How do you rate the teaching of drawing in your college work?

Excellent	99
Good	154
Average	84
Fair	79
Poor	56
TOTAL	472

Most schools will find themselves listed under all the above categories. This indicates that there is considerable room for improvement for all of us.

12. What suggestions have you to offer to improve the drawing program in tbe undergraduate curriculum?

Only about half the total number offered suggestions. They were many and varied. In order of emphasis the more importan' ones are as follows:

1. Offer more freehand sketching.
2. Emphasize the kind of drawing needed for manufacturing, fabrication and construction. Bring out the problems involved in the shop processes, e.g., casting, machining, forging, welding, etc. Give close attention to dimensioning, tolerances, limits, and finishes.
3. Impress on the student the importance of drawing in all engineering undertakings. Drawings are a means of communication. Every engineer must be able to read and make a drawing if he is to advance in his profession.
4. Emphasize the ASA drafting standards and other recognized standards. Emphasize how important it is to show everything that is necessary clearly so otbers can understand what the drawing is supposed to show. Bring out the importance of accuracy, neatness, and speed. Stress how to read and use a drawing.
5. Use more problems that require the student to think for himself. Require more planning and designing by the student--more freehand layouts.
6. Teachers of drawing should bave engineering and drafting experience.
7. More training in visualization, reading, and in checking a drawing. Work with more complicated industrial drawings. To many of the problems are too simple; there is no challenge to the student.
8. More descriptive geometry for everyone.
9. Better planning and coordination of the various graphics courses and other engineering subjects. So plan the courses that the student will get a reasonable understanding of the graphics the engineer needs in his work. The primary objective should not be to make expert draftsmen.
10. More practice in the use of handbooks, catalogs, etc., for standard parts bolts, screws, and other fastenings, bearings, gears, piping, etc.
11. Offer a course in junior or senior year to use mathematics and engineering acquired since taking drawing. Also to review fundamentals.

GENERAL COMMENTS:

1. The employers of these engineers are 206 (6 with no address) in number, scattered throughout 34 states and Canada and one foreign country. This list includes every type of industry, with few exceptions, that employ engineers. It appears to be a very representative sampling of industry.

2. Looking at the age range of tbe engineers reporting, it covers all ages with a decided majority in the 30's. This would seem to be a good sampling of the engineers of the country with reference to age.

3. It is interesting to see tbe distribution of degrees amoung these engineers. There has been some inference from various sources that electrical engineers were in favor of reducing the amount of drawing in the undergraduate program. This survey does not support that. The number of electrical engineers participating in this study are in fair proportion to the rest, yet only 4 out of 121 indicated that less drawing would be advisable. Many of the EE's indicated that they considered Drawing important to the engineer and recommended more emphasis on the graphics courses. The electrical electronics industries are well represented, with such companies as Bell Telephone, Western Union, International Business Macbines, Consolidated Engineers, and a number of electrical public utilities. Another interesting thing to note is the number who have degrees other than in engineering. The number designating a BS degree didn't specify the field, and I bave an idea that a number of them were not degrees in engineering. In other words, college graduates outside of engineering find tbeir way into engineering work and apparently do all right. Apparently, college training in any field prepares the person so that he can fit into other fields than his major in college.

4. It is apparent that, as an engineer progresses in his work throughout the years, he invariably gets into executive type of work. In such work, he does less drawing and more supervisory type of work. However, he still indicates that he thinks graphics is very important in any engineering undertaking.

5. The number of items on which more emphasis was suggested far outweighs the items recommended for de-emphasis; twice as many want more emphasis than wanted less emphasis. This would seem to indicate that the practicing engineer wants more emphasis on graphics rather than less.

6. Tbe things which were suggested for more and less emphasis is worthy of careful study. In the first place, practically all engineers want more freehand sketching and descriptive geometry. It is also quite apparent tbat inking, general technique, and lettering should be de-emphasized. This does not necessarily mean that they tolerate a sloppy, carelessly made drawing but they recommend less time being spent on getting perfection in line work, inking and lettering.

7. The rating given by these men of their college drawing courses will bear consideration also. This means that all the schools can well take stock and see what kind of a job they are doing now in the teaching of the present drawing courses. There has been a lot of discussion in recent years in regards to good teaching. I am afraid there has been more talk than action. Rewards for good teaching are little more than personal satisfaction and pride; increased pay and promotion are more often obtained as a result of things other than good teaching. This is a condition that should be remedied in all fields, not only in drawing.

DRAFTSMEN'S QUESTIONNAIRES

1. Number returned: 687.

2. Draftsmen received their training in graphics as follows:*

High School and vocational schools	762
**College	250
Night school	231
Company training programs	93
All others	71

This clearly shows that the main sources for career draftsmen are the secondary schools. Very few graduate engineers become draftsmen except in the field of design.

Question #5. Approximately what portion of your time is spent on the following:

1. Actual drawing:	Ranges from 5 to 90%,	Average. . .70%
2. Calculations:	" " 0 to 55%,	Average. . .15%
3. Consultation:	" " 0 to 30%,	Average. . .10%
4. Checking:	" " 0 to 30%,	Average. . . 5%

The young, inexperienced draftsmen spend most of their time drawing. As they gain experience, they are given more work which involves calculations, planning, consultation, and checking. The design engineers spend only approximately 25% of their time drawing, the major part of the time is spent on calculations, consulting with other designers in the shop, and checking. There is no definite mark of division between just pure drafting and design; all draftsmen, except for a short time at the very beginning of their service, are concerned with design prohlems.

Designing and supervisory work are handled almost exclusively by graduate engineers.

The resume of the questionnaires from the "Heads of Drawing Departments" and "Drawing Teachers" is not included in this report.

GENERAL OBSERVATIONS OF THE SCHOOLS VISITED

1. The schools were all very cooperative in the conducting of this study. I was privileged to interview deans, heads of drawing departments and drawing teachers.

2. Drafting Rooms: Drafting rooms are all sizes and shapes. The size of classes range from 6 to 100 approximately, two or more instructors are assigned to the larger classes. A few schools have the drafting rooms all on one floor and close to the staff offices, which is the most desirable arrangement. This is found only in those schools which have attained new quarters in a new or remodeled buildings, recently. The most common arrangement is for the drafting rooms to be in the same building but on different floors, usually on the upper floors. Several schools had their drafting rooms scattered in different buildings, which is the poorest arrangement. The lighting generally was rather poor in all the school drafting rooms; only in those with the newest accommodations was the lighting comparable with that in the drafting rooms of industry. Much of the equipment in the drafting rooms was old and antiquated. The drafting tables were every conceivable shape and size, and locker accommodations for the students were generally not too good.

It would seem that, with little expense to the schools, the drafting rooms could be made more attractive and useful. Lighting should be improved and ample accommodations furnished for hats and coats, books and lockers for drafting equipment. A raised lecture platform and ample blackboard space should be available in every drafting room. Display cabinets for drawings and models helps to get the interest of the student; some schools have such display cabinets. It would seem that someone ought to be able to design a good convenient drawing table just large enough to accommodate the largest drawing required in our courses with an adjustable top and made of material that can serve as a drawing surface and eliminate the use of drawing boards. They should be made so that the janitors can get around them or move them easily for cleaning. I have yet to see what I call a good drafting table for schools. Comfortable stools should be provided for all students so that they can maintain a decent posture while working.

3. Office Accommodations: A few of the staff offices were roomy and pleasant, and equipped with ample files and working space for the staff, but on the whole the office accommodations were rather poor. Good office facilities certainly are a factor in keeping up the morale of the teaching staff. This office condition is no doubt not confined to the drawing staff.

4. Staff Load. The staff load varies with every institution and runs from 12 to 30 contact hours. Drawing teachers, like teachers in any field, should have time for preparation, correcting papers, and quizzes, reading, study, and research; certainly, 30 contact hours per week doesn't leave much time for these other things. This is certainly not conductive to building up staff morale. I am quite sure that the staff turnover at such an institution is high and the teaching under such conditions is not the best.

5. Staff Morale: Teachers of drawing everywhere, in general, are making an honest effort to do a good job, but are confronted with a number of obstacles. It seemed to be the general feeling at most schools that drawing teachers were underpaid and not being given the same consideration as teachers in other departments. This is certainly not a healthy condition and should be remedied. If graphics is considered a necessary part of the engineers' undergraduate program, the teaching of such courses should not be considered inferior or secondary. Practically every school is looking for drawing teachers.

6. Time Allotted to Drawing Courses: The time allotted to the drawing courses varies considerably. Practically every school has lost some time in recent years. Every school is confronted with the possibility of further curtailment. The most disturbing factor is the fact that this reduction is being made without giving the drawing departments and teachers a chance to be heard on the subject. This has been going on for many years, and it is time something constructive is done about this situation. This problem gets to the student and is no doubt one of the factors that has given the young engineering student the idea that drawing is not too important to the practicing engineer.

* Many received training from more than one source.

** Most of these did not have engineering degrees.

7. Course Material: There is no standardization of course content in the various schools and it is probably just as well. Each school sets up its own course to fit the time allotment it has, and emphasizes what they think is important. We can all well examine our objectives and look over our course material to see if it is in harmony with all the advances in engineering. There is room for improvement.

8. Athletic Facilities: I could not help but notice that at most schools the athletic facilities are much better than the classroom and laboratory facilities. This is a sad commentary on American education.

GENERAL OBSERVATIONS FROM INDUSTRIES VISITED

1. Industry was very cooperative in every way in the conducting of this study. I had the opportunity of talking with personnel men, executives in the engineering departments, heads of drafting-design departments, draftsmen, and engineers. I was free to interview anyone I desired. I was also permitted to visit any place in the various plants, with the exception of one, which was engaged in secret government work.

2. Everyone interviewed expressed themselves freely and without reservations that drawings were very important to their business, and they considered graphics a very important part of an engineering training, regardless of what kind of work the engineer is engaged in.

3. The drafting rooms were generally well lighted, and most of them had individual lights for each drafting table in addition to good natural and artificial light in the room. All the drafting tables had adjustable tops, and work was usually done in an inclined position. An exception was in the making of very large drawings; then the drawing surface was either horizontal or nearly vertical. Draftsmen and graduate engineers worked together in the same room. The drafting room heads, senior draftsmen, and designers were almost all graduate engineers. The career draftsmen and detailers were almost all high school graduates who have worked up in the plant. They have to train their own draftsmen. The only source of competent draftsmen, other than in their own training program, is to hire them away from some other company. It is hard to get the recent graduate engineer to work on the board but many companies still like to break the young engineer in on the board. There is no attempt to keep them there, however. Several chief draftsmen stated that a young engineer who does well on the board was looked upon with favor when considered for advancement.

CONCLUSIONS

Every effort was made in conducting this study to get as representative an opinion as possible; no attempt was made to select the participants who might be inclined favorably towards graphics. The returns show a reasonable sampling as to the age of the participants, the schools where their training was obtained, and the industries where they are employed as to type and geographical location.

The overall opinion is almost unanimous in expressing that "graphics is very important to the practicing engineer and industry."

Industry, of course, wants to get engineers with the best training possible in all fields. They want individuals well grounded in fundamentals and humanities who can work and get along with other people, and who have developed the habit of thinking for themselves, and be able to carry a project through from beginning to end. Nothing should be emphasized at the expense of something else. This study shows that the individual engineer and industry both consider graphics as an important part of the engineering undergraduate curriculum.

The reduction of time allotted to drawing in recent years and the threat of further cuts is looked upon with considerable disfavor by both industry and the individual engineer.

Why is drawing being curtailed? There are several factors that enter into this problem, as follows:

1. A generation ago, too much time was allotted to drawing.

2. The engineering courses are still nominal 4-year courses, the same as for the past 75 years or more, in all but a very few schools where they have extended it to 5 years. It is the only one of the professional courses (Law, Medicine, Pharmacy, Dentistry, Divinity, Engineering) that has not lengthened its college training period since its beginning.

3. An attempt is being made to include all the advances and new tbings that have developed in the engineering field in the past 75 years or so.

4. The recent trend that engineers should have a certain amount of the so-called humanity courses to make them acceptable to society.

5. The competition with other departments for time.

The drawing departments and teachers are at a disadvantage in this competition for time, because they are usually considered as a service course or department. Only indirectly do they have much to say about the time allotted to drawing. It depends pretty much on the attitudes of the administration and the degree-giving departments as to how much time is going to be devoted to drawing. Many schools are attempting to be primarily senior colleges and graduate schools and depend on the liberal arts colleges and junior colleges around the country to do the screening in the first two years and furnish them with so-called "cream of the crop." They may specify a certain number of credits for entry, in mathematics, the sciences, and humanities, but no particular thought is given to drawing. They are not much considered with what they get in graphics or if they get any at all. It is no wonder that we hear from industry repeatedly that the engineer just out of college cannot make a drawing nor read one. During this study I ran into many such instances. If drawing is important to the engineer, the provision should be made in the colleges so that it can be handled properly.

This study also suggests that all drawing departments and teachers re-examine its objectives, course content, and methods of presentation in the light of the many advances and new things that have developed in the field of engineering in recent years. There is always room for improvement. Quoting from Mr. R.S. Sherwood's paper given at the 1952 meeting, "If engineering Drawing Departments are to prosper and grow to the fullest extent, it will be only by positive aggressive action on their part."

The attutide among students and recent young graduates that graphics is not important to him probably stems from the curtailment that has been taking place in recent years and the discouragement written on the faces of the drawing teachers. This was mentioned and deplored numerous times in this study. One graduate stated that he had had this attitude and wanted to state that he was wrong; after several years of practice, he stated that he now realizes that graphics is very important to the practicing engineer. Here is another instance of a personal interview. A chief engineer of an engineering division of one of our most progressive industries pointed out a certain engineer working on the board. He came with a very meager background in graphics and was assigned to a field job. He had so much difficulty reading drawings and making intelligent sketches that he was called into the drafting room for some training. The chief stated that if engineers were not so scarce this man would have been fired a long time ago.

There was nothing in this study that tried to determine what the minimum time is for doing a reasonable job of training in graphics for the engineer. The time now varies from practically nothing to two full years of graphics courses. Somewbere in between should be set which is an absolute minimum to do the job satisfactorily. A further study about this time could very well be made by a committee of the Drawing Division. Such a study was made some years ago and reported at the annual meeting of the ASEE at the University of Texas. For some unknown reason, this report was filed away, and nothing more has been heard of it.

The initiative must be taken by the drawing teachers. We must sell the school administrations and other departments on the importance of graphics to the engineer, work for adequate time to do a decent job, strive to get improved facilities and working conditions, and probably above all, do everything possible to improve the status of the drawing teacher and raise his morale. We must get away from being on the defensive all the time; first sell ourselves, and then get out and sell others.

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Published in the Interest of Teachers and Others
Interested in Engineering Graphics

HAVE YOU RENEWED YOUR SUBSCRIPTION?

(Continued from page 13)

These are the parametric equations of trochoidal motion. v_o is the initial velocity of an electron moving in the direction α. It may be seen that there is a constant x-component of velocity equal to a/ω which represents the translational velocity, v_T, of the circles that generate the trochoidal motion. The radius of the rolling circle must then be $v_T/\omega = a/\omega^2 = (m/e)\ (\epsilon/B^2)$. The radius of the tracing is v_R/ω, where v_R is the rotational velocity and is equal to $v \rightarrow v_T$. See Figure 6. When $v_R > v_T$, the path of the electron is a prolate cycloid; when $v_R < v_T$, the path is a curtate cycloid; and when $v_R = v_T$, tbe path is an ordinary cycloid. Having determined the radii of the rolling and tracing circles, the electron path may be plotted.

Often the actual electron path is not needed except to determine whether or not it reaches the anode and contributes to the plate current. In the case of a uniform electric field, the maximum displacement is given by the equation

$$y_{max} = (1/\omega)\left[(a/\omega) - v_o^2 \cos\alpha + \sqrt{v_o^2 - (2a/\omega)\ v_o \cos\alpha + (a/\omega)^2}\right]$$

Figure 7 illustrates a graphical method of determining this value. All vectors are divided by ω in order that they be the same scale as the radii of the circles. The vector representing the velocity is drawn $v/\omega = (0.0337/B)\sqrt{E}$ meters long in the direction α. The translational velocity vector is drawn $v_T/\omega = a/\omega^2 = 0.0569\ \epsilon/B^2$ meters long. The rotational velocity vector (v_R/ω) is now determined. A line drawn from the origin of this vector, perpendicular to it, and equal in length locates the center of the circles and the radius of the generating circle. By swinging the radius around in the y-direction, the value of y_{max} is determined.

REPORT OF THE BIBLIOGRAPHY COMMITTEE

by
Professor S.E. Shapiro, Chairman
University of Illinois

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AUTHOR	TITLE	ED.	PUBLISHER	YEAR	PAGES	PRICE
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French, T.E. & Vierck, C.J.	Manual of Engineering Drawing for Students and Draftsmen	8th	McGraw-Hill	1953	715	8.00
Giesecke, Mitchell & Spencer	Technical Drawing	4th	MacMillan Co.	1952	851	6.00
Grant, H.E.	Practical Descriptive Geometry	1st	McGraw-Hill	1952	253	4.25
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A STUDY OF DESIRABLE REQUIREMENTS FOR BEGINNING DRAFTSMEN

by
L.C. Christianson, Missouri School of Mines and Metallurgy, and
E.H. Woolrych, Chief Draftsman, Missouri Geological Survey

During the spring of 1953, the following questionnaire was sent to 575 engineering firms and industries employing draftsmen.

Gentlemen:

Enclosed is a list of topics usually covered in a college course in drawing. We may be stressing some and neglecting some that should be covered more throughly. Will you help us answer the question of professional training for beginning draftsmen by checking one of the columns to the right of each item that pertains particularly to your field of engineering?

Any suggestions or observations that you would like to make in regard to this problem will be appreciated.

PLEASE INDICATE BY A CHECKMARK IN THE PROPER COLUMN OPPOSITE EACH ITEM THE DEGREE OF KNOWLEDGE OR SKILL YOU WOULD LIKE FOR A BEGINNER TO HAVE WHEN ENTERING YOUR EMPLOYMENT.

THESE ARE THE TOPICS COVERED IN OUR FRESHMAN DRAWING COURSE.	NOT NEEDED FOR OUR WORK	WORKING KNOWLEDGE & FAIR SKILL NEEDED	HIGH DEGREE OF SKILL REQUIRED	REMARKS
Lettering - Vertical - Capitals				
Slope - Capitals				
Lower case letters				
Orthographic Projection - Using Instruments				
Orthographic Freehand Sketching				
Isometric Drawing - Using Instruments				
Isometric Freehand Drawing				
Inking - On Linen or Paper				
Sectional Views - Full Section				
- Half Section				
Dimensioning Drawings				
Auxiliary Views - Primary Views				
- Secondary Views				
Screw Threads				
Working Drawings - Showing Details				
- Showing Assembly				
Reproduction of Drawings				
Reproduction Machine Used - Black & White				
Ozalid				
Blue Print				
Van Dyke Prints				
Descriptive Geometry				

Of the 575 questionnaires sent out, 343 were returned. Although the number returned was not as large as we had hoped it would be, we feel that the results show some interesting trends in the requirements for beginning draftsmen.

Referring to the first graph showing the general or overall results, we would like to point out a few things that seem significant. The high percentage of skill desired in lettering was to be expected. However, the low percentage in both orthographic catagories seems odd, for in the working drawing catagories it is very high. It would seem that the word "orthographic" is not used in the drafting room, for working drawings are orthographic drawings. The large percentage indicating that both freehand orthographic and isometric drawings were not needed was rather surprising. This may be due to the fact that the beginning draftsman does not do much design work. The fact that almost one-fourth desire a high degree of skill in descriptive geometry is also very interesting.

The answers to the questions regarding reproduction processes were omitted in the graphs because of lack of space and we did not feel they were very significant. The general concession being that a knowledge of the processes might be desirable but not needed. A large number indicated they did not make their own reproductions.

We would like to call attention to the graphs showing the desires of civil and mechanical engineers. Some of the results simply confirm what we are doing, while others indicate some trends that probably need some consideration and further study. Note particularly the high degree of skill desired in auxiliary views. The civils are not as high in working drawings as others. The "O" indicates that the percentage was less than one for those classifications.

Perhaps it should be pointed out that the industries in the western part of the country, to which these questionnaires were sent, did not respond as well as those in the eastern and central part. Just how much this has effected the results is hard to tell, but we hope not too much.

The authors of work books for beginning students should note the large amount of skill desired in dimensioning and working drawings, two topics that are usually covered in the latter part of the work book. Since these are often given in the latter part of the course, they do not receive proper emphasis. It would seem desirable to give more space to the problems introducing the fundamental three views so that dimensioning could be included from the start. We also feel that a larger percentage of the problems in the work book should be on tracing paper so that reproduction can be stressed throughout the course. Two statements: "Have them make tracings that will reproduce", and, "Teach them to be neat", were common comments sent in by those returning the questionnaire. A working drawing made on tracing paper seems the best way to accomplish these results.

A few of the most common comments are listed below. We would suggest that you look over these quotations rather carefully:

Charles H. Becker, Structural Engineering, Austin, Texas

> "You will be amazed to find that now, as always the most important qualification, outside of good character, an engineer can have is ability to make good drawings.
>
> Engineering needs more men able to make drawings, not those merely able to calculate mathematics."

R.W. Schellkopf, Albany, New York

> "Teach your students to think and visualize in three dimensions."

Harrison-Walker Refractories Company, Pittsburgh, Pa.
R.P. Snyder, Chief Engineer

> "I am always enthusiastic to discover a university that is attempting to fit its prerequisites to what industry considers its requirements."

Wettlaufer Engineering Corporation, Detroit, Michigan

> "The lines may be perfect, but if the lettering and dimensions are not legible, the drawing is useless."

Adams United Company, Akron, Ohio

"Teach them to think about what they are doing."

International Harvestor Company

"Produce a good reproduceable pencil drawing."

Detroit Manufacturing Company

"Neat lettering and draftsmanship preferred."

R.L. Erickson, Mechanics, Austin, Texas

"Engineers are in need of much greater abilities in the art of presenting their ideas pictorially. Emphasis should be placed on ability to make freehand representations, etc."

Simmions Machine Tool Company, Albany, New York

"Most beginners weak in orthographic freehand sketching."

Ottenheimer, Albany, New York

"We can more clearly explain a pipe installation by an isometric drawing than with a thousand word explanation."

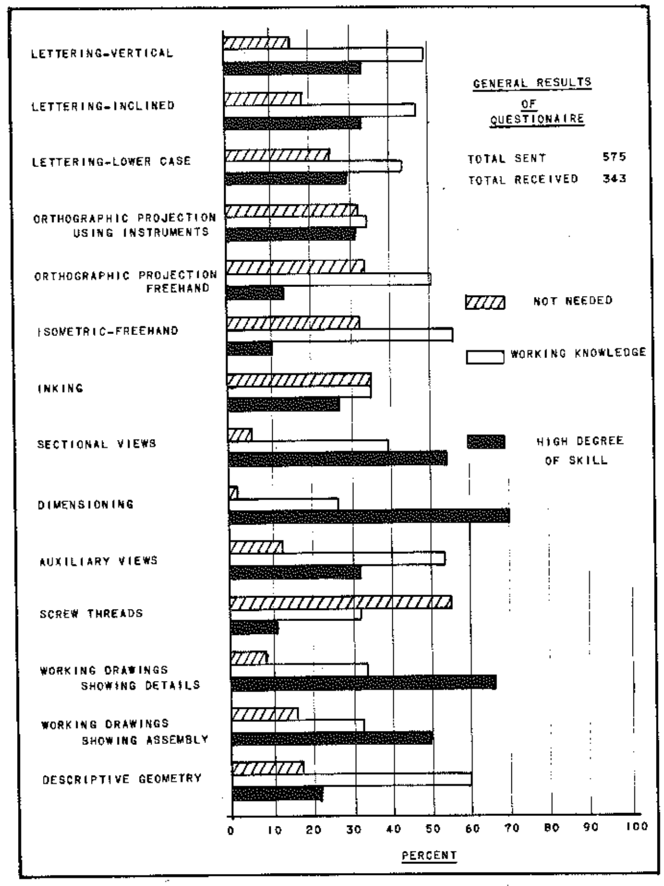
Myers and Noyes Associates, Corpus Christi, Texas

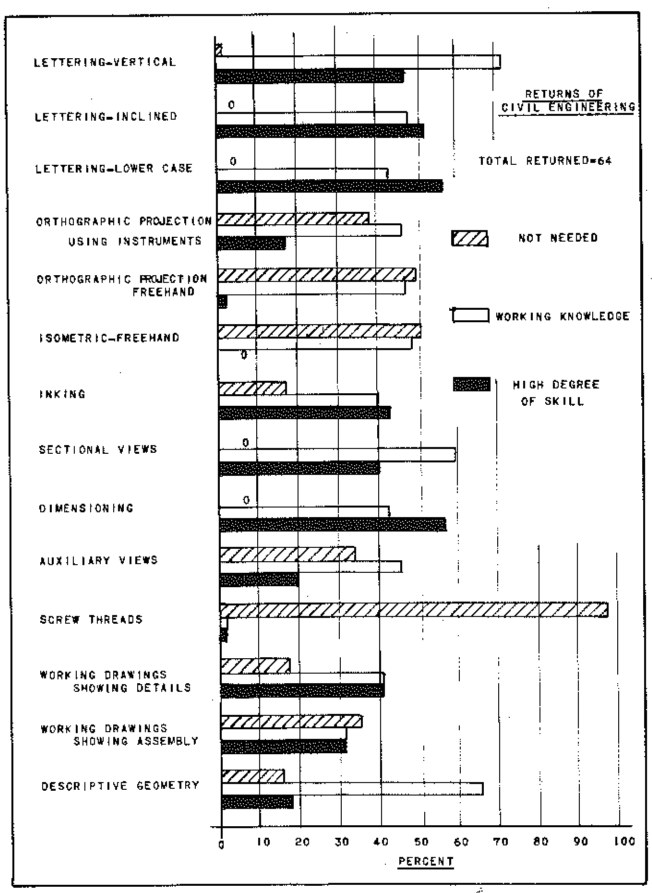
"A rough drawing with good lettering will look much better than a good drawing with sloppy lettering."

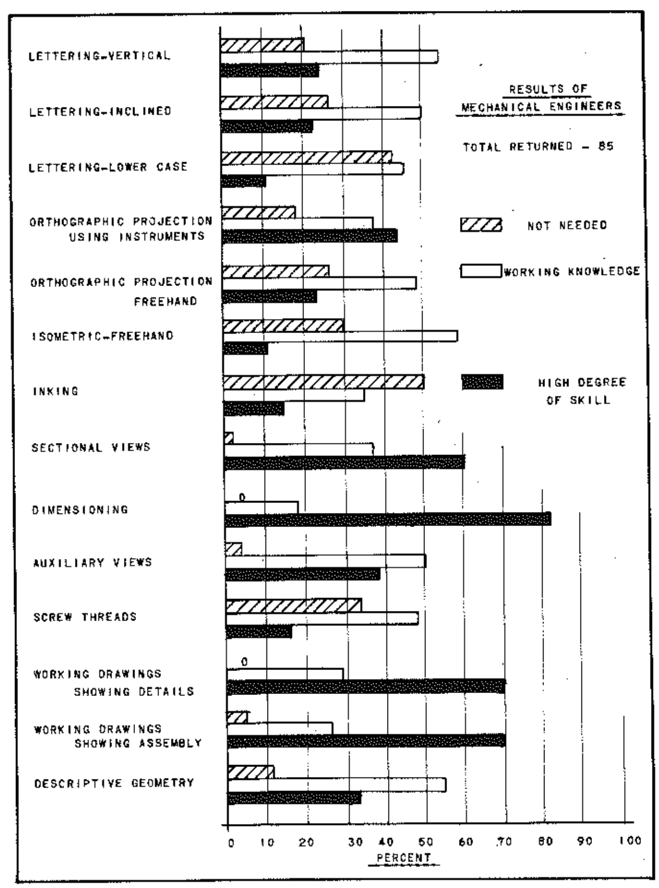
Missouri State Highway Commission, Jefferson City, Mo.

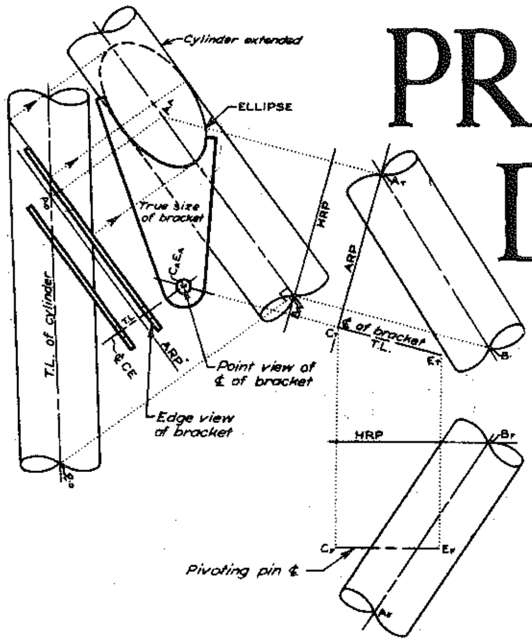
"We suggest that more emphasis be given to the importance of the drawing course in all engineering schools."

We realize that this study is not as complete as we would have liked to have made it. Perhaps some topics were not included that should have been, but it has given us some helpful information. We hope that after a thorough examination of the graphs, you will benefit as we have from the study. We were spending entirely too much time on screw threads, now we include them in our working drawings.









PRACTICAL DESCRIPTIVE GEOMETRY

HIRAM E. GRANT
Professor and Head
Department of Engineering Drawing
Washington University
St. Louis, Missouri

The "DIRECT METHOD" APPROACH

theory and practice correlated and integrated

SPECIAL FEATURES

- Reference plane used instead of reference or ground line as it orientates the student's spatial visualization much better.
- Careful, illustrated explanations of details usually troublesome to students.
- New methods to solve a number of fundamentals.
- Numerous practical applications.
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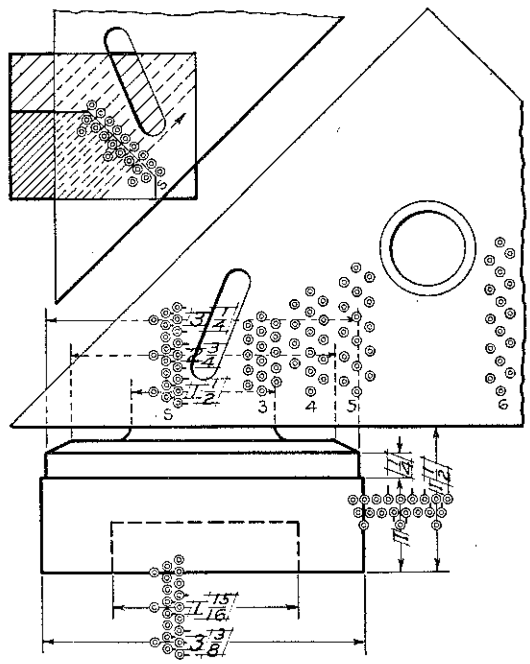

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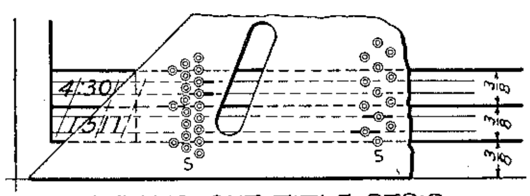

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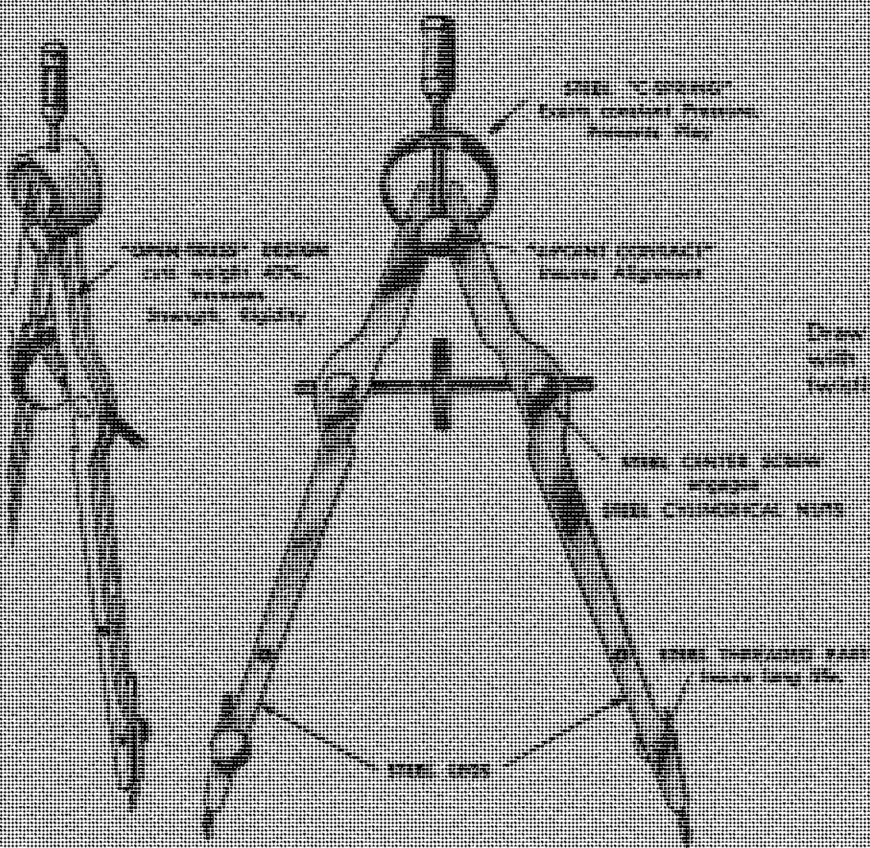

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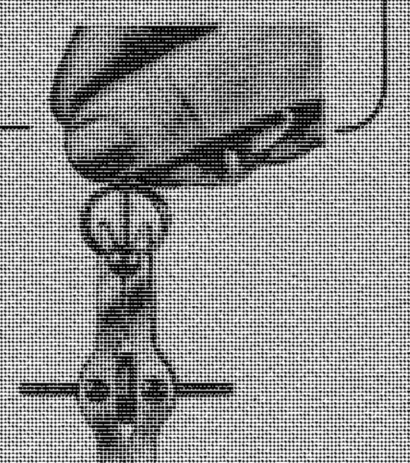

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