The Journal of Engineering Drawing

CONTENTS

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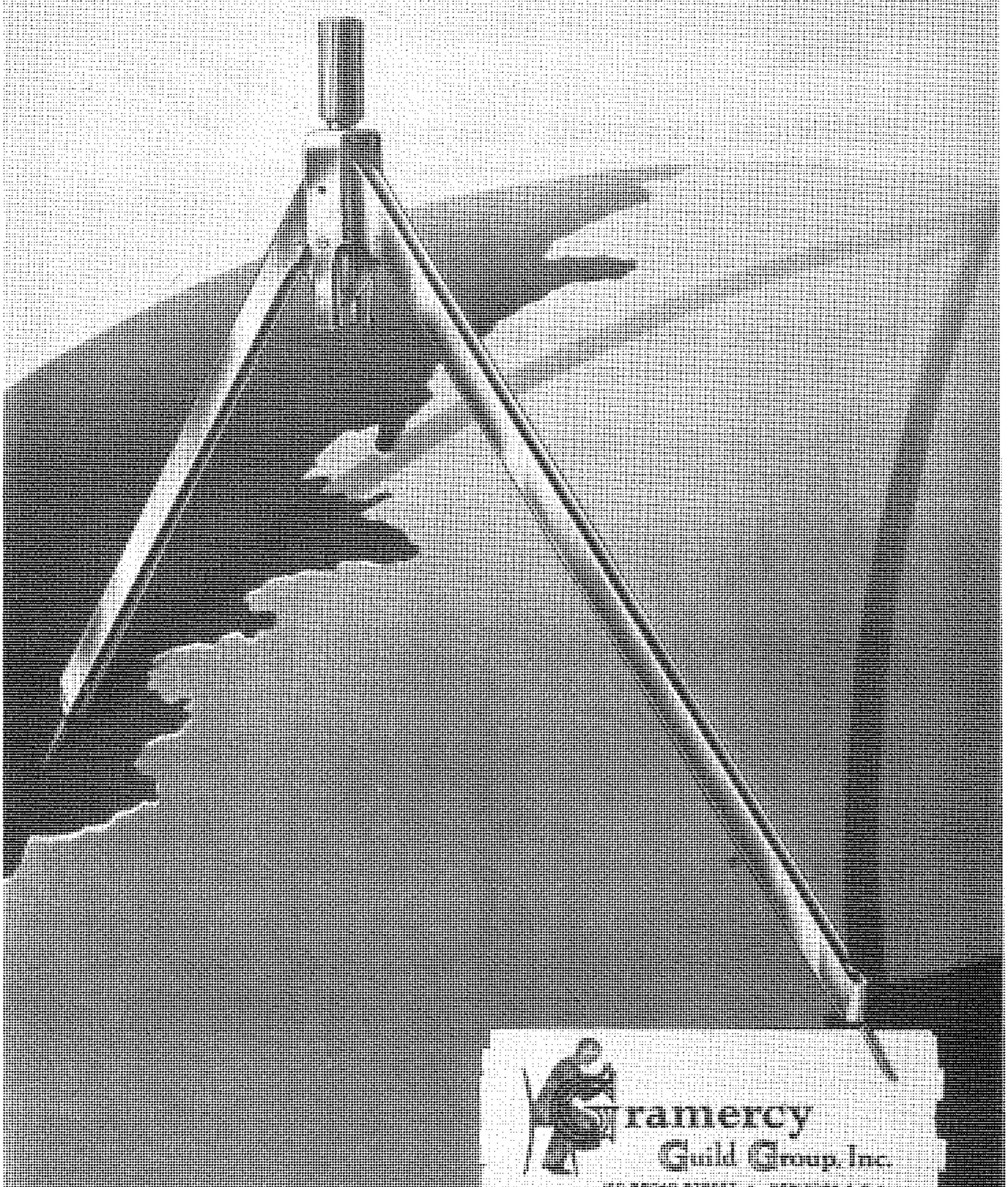

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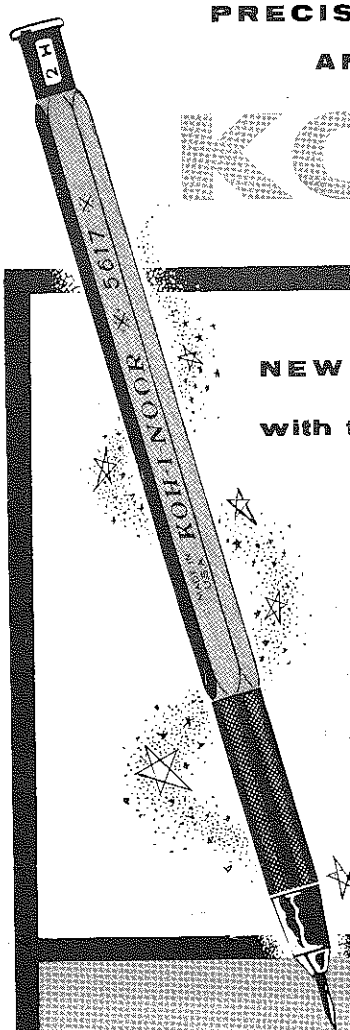

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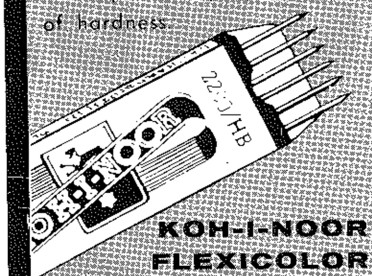

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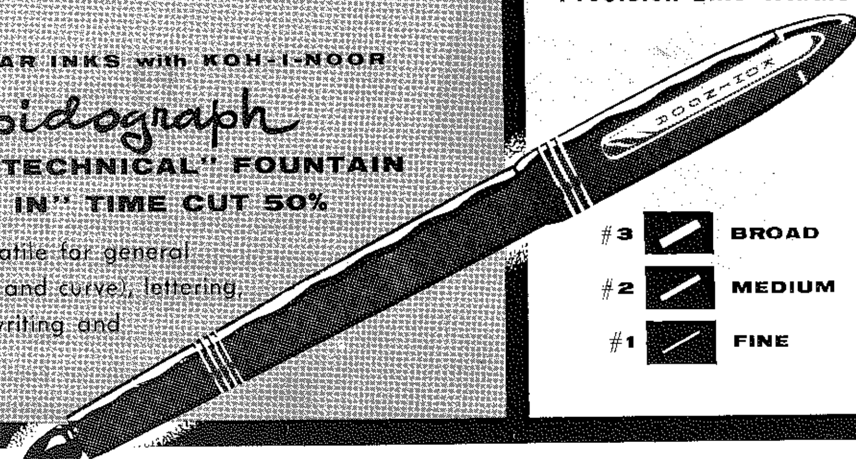

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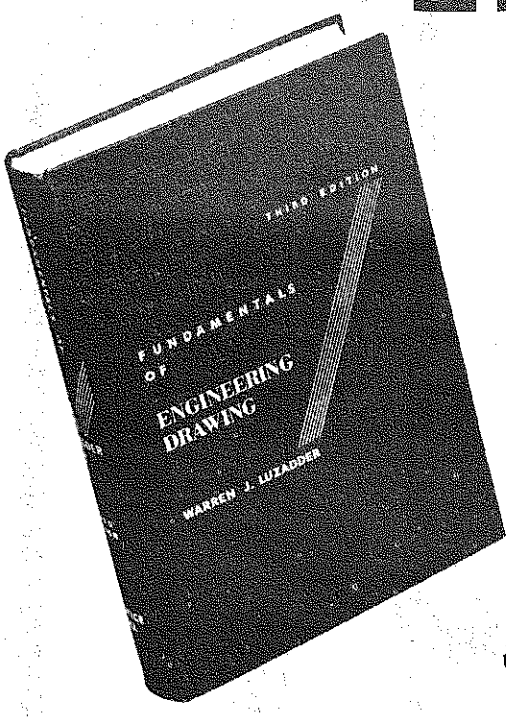

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by

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To be published Spring 1956

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By

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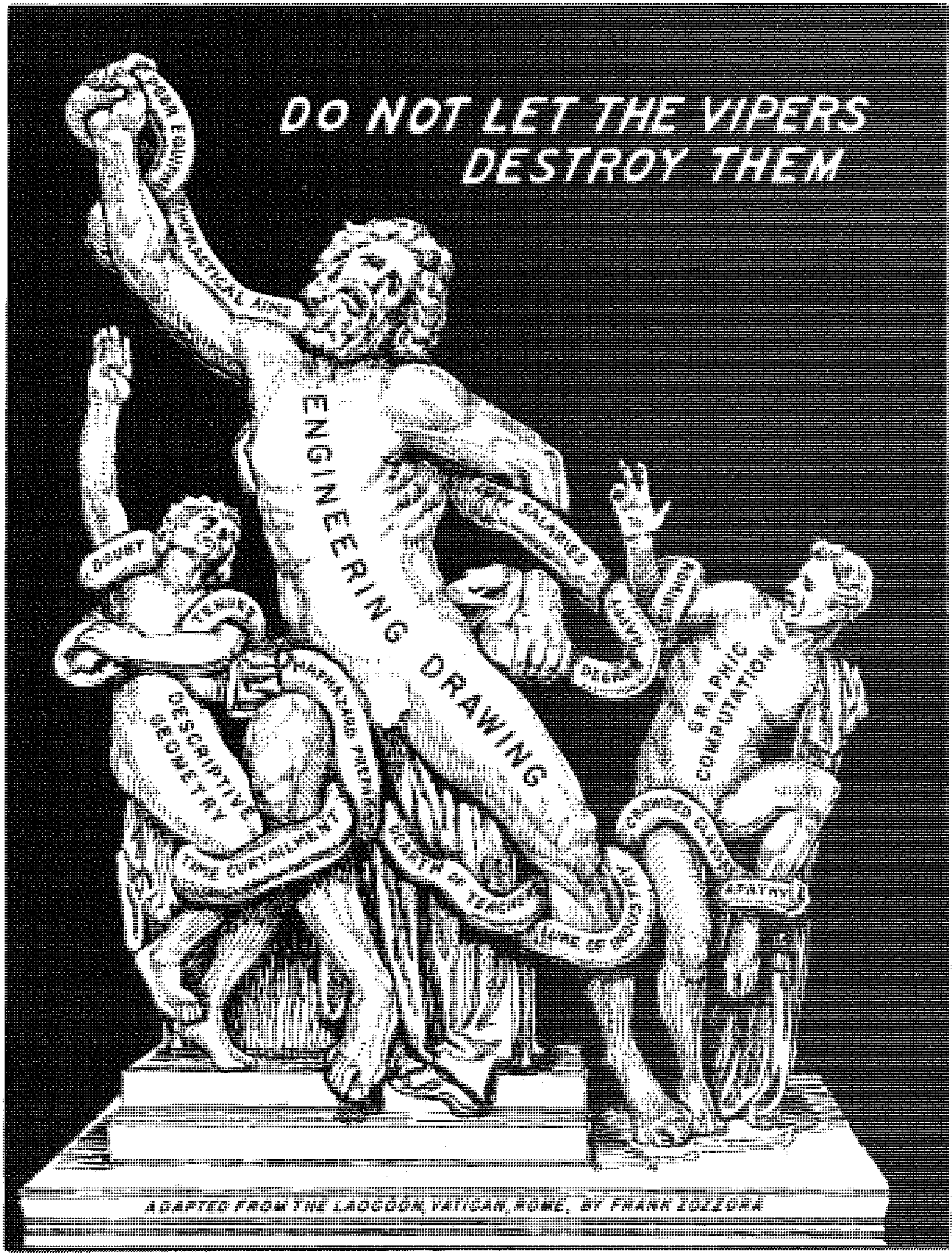
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EDITORIAL PAGE

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

SOLVE THIS ONE:

The sum of the angles Alpha, Beta, and Gamma, which a straight line makes respectively with the top, front, and profile planes varies between what limits?

This problem was sent to the JOURNAL by Professor Peter L. Tea, The City College, New York, N.Y. The prize for solving the problem would naturally be a non-euclidean plastic triangle, the sum of the angles of which is flexible.

Do you have a pet problem? Send it to the JOURNAL.

WHAT ABOUT STUDENT-QUALITY?

On page 32 of this issue of the JOURNAL, Mr. Herbert W. Zimdars gives his answers to nine questions set forth by the editor in the November, 1955, issue. The answers are sufficiently provocative and controversial, we may trust, to evoke comment from our readers. But the implications which we choose to draw from Mr. Zimdar's opening statement deserve careful consideration.

Many of use are afflicated with a malevolent and contagious occupational disease: A chronic complaint against the "poor quality of students being turned out by the high Schools." But what do we actually know about the problems that daily confront the secondary and vocational school teachers? Within what limitations and prescriptions must they work? Excessively large classes? Poor equipment? Authoritarian and unsympathetic administration? Constant discipline situations? But despite all this: Where do our many outstanding students come from? And aren't they coming in increasing numbers?

Clearly we ought to improve and multiply our contacts with the schools that send us our students. Some of us do keep in touch with our colleagues in secondary and preparatory schools, but others of us give hardly a passing thought to what those teachers are up against.

At worst, we work under a heavy handicap when we lack information about the background of our students. At best, the more we can learn about the problems and objectives of high school teachers, particularly drawing teachers, the more likely we shall be to solve some of our own problems and to reach the objectives we have set for own students.

DO WE ASSUME TOO MUCH?

Professor James D. McFarland put his stethoscope on a vital organ of our student body in his article beginning on Page 38. He said that approximately one-third of the students in one of his classes did not know "the meaning of a bulkhead or a bracket."

No one can doubt the validity of Professor Mc Farland's contention: that many students have not had the kinds of experience that we assume they have had. Nevertheless, we continue to press forward without realizing why certain reasonably bright students cannot hang on. There are many reasons, of course; but one important reason is that we are probably making untrue assumptions about their background.

It may very well be true that we must make these assumptions to make any progress whatever, and that there are engineering freshmen who would drop out under any circumstances. At any rate, the pages of the JOURNAL are open to anyone with ideas on this elusive matter.

NOMOGRAPHY

Have you noticed the number of articles on nomography in recent issues of the JOURNAL? This is no accident. It so happens that advocates of nomography are an active and prolific band. The do not overwhelm the editor with contributions, but they always are ready to respond to a call for help.

In the meantime, the announcement of a prize in nomography has apparently stirred up some action. Until the end of the contest, any nomogram that seems to rate a fighting chance will be cordially welcomed to these columns.

Do not let this statement discourage you if intended to send in an article on any topic in our field. Your contribution will be greeted with open arms and, we hope, with an open mind.

GRAPHICS APPLIED TO THE CRAFT OF BELLS AND CARILLONS

By

Arthur L. Bigelow
Princeton University

PART I

Ever since the first attempt at casting a bell to a particular musical note, founders have followed the rule of thumb. Oftentimes it has been necessary to recast a bell one or more times before the desired pitch was reached. As chimes and carillons developed, the series of bells composing them presented anything but a homogeneous aspect: there were bells of different proportions, different profiles, and even within the series their diameters did not present a gradual diminution from the lower bells to the higher. Anything went, as long as the bell occupied a fairly definite position in the musical scale.

When the carillon first developed into an instrument we could call truly musical, in the early 1600's, we find founders in Flanders and Holland paying attention to proportions and profiles to the extent that for the first time a series of bells could claim some tonal homogeneity.

Still it was the rule of thumb which governed the shape. Sometimes when a bell proved to have a pleasing tone, its profile was applied to others of the same part of the instrument. Oftentimes the hass bells possessed certain profiles and proportions, the mediums differed somewhat with the basses while the highest bells of the series often bore no resemblance at all to their bigger sisters.

It may be said that one single hell posseses as many as fifty variables. A series of strings, or a series of simple organ pipes, differ only as to length and diameter. (Of course the string may be tightened or loosened to raise or lower its pitch.) Nature has endowed the string and pipe with a series of harmonics which produce, accordingly as they are strong or weak, the timbre or quality of the tone. All of these harmonics, in the ratio of 1:2:3:4 etc., remain in exact ratio to the fundamental even though the length of the pipe be changed, or the string be changed as to length or tension.

Compared to string and pipe, the bell is an extremly complex instrument. Its size, diameter at the mouth, diameter at the shoulders, height from mouth to shoulder, may all vary considerably, not to speak of its differing thickness from shoulder to mouth. The shape of the lip may vary; it may either be curved or straight on the inside or outside. The curves in the bell's profile may vary infinitely. To these variables we must still add an almost unlimited variety of tones of different pitches, and different intensities, in every bell. It may easily be seen that it is a challenge to design one bell, let alone a whole series of them.

Once a series is cast, the bells must then be tuned. This means the exact pitching of five or six of the lowest partials in the bell, since nature does not regulate the overtones of a bell as she does those of a pipe and string. It is man himself who first had to determine what shape and proportion would embrace the most pleasing series of overtones - and then he had to learn to tune the bell so that these overtones were put into perfect relationship to the fundamental. These, then, are some of the difficulties which have confronted the conscientious bell and carillon founder.

In an attempt to reduce the great number of variables and arrive at a definite form which will allow a pleasing and acoustically balanced result throughout a series of bells, the author has applied graphics to the measurements of bells and carillons and to his research into the tonal analysis of such instruments, a research in which he has been interested for over a quarter of a century.

PART II

The design of an instrument of bells is divided into two operations: (a) determining the sizes of the bells themselves and (b) determining the proportions and profiles of the bells.

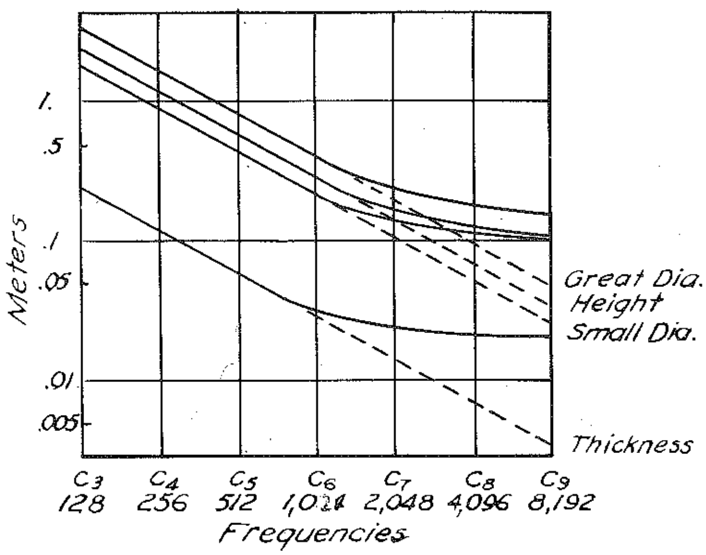
A. THE SIZES OF THE BELLS IN THE SERIES: <u>OPERATION A</u>

If we consider two organ pipes, one of them half the length of the other, the shorter will have double the frequency of the longer and will sound the octave of the longer. In other words, the length, or size, of the vibrating object is in inverse proportion to its frequency (pitch). This also holds true in hells, where the diameter, rather than the length is figured. Therefore,

$$\frac{\text{diameter bell 1}}{\text{diameter bell 2}} = \frac{\text{frequency bell 2}}{\text{frequency bell 1}}$$

By applying the equation $C = D_N F_N$ (where C = a constant, D = diameter, F = frequency, and N = a given bell), the diameters of all the bells of the series may be calculated once the diameter of one bell is determined. Graphically, this process is reduced to a single line on semi-log paper. This line is known as the line of Absolute Musical Proportion.

Together with this are plotted the lines representing the small diameter (diameter at the shoulder), the height (from mouth to shoulder), and even the thickness at the lip - after these measurements have been determined from the second operation.



OPERATION A

The establishment of lines of proportion

If this were all that was necessary to determine the proportionally diminishing diameters of bells, it would be a fairly simple matter. Unfortunately, however, bells do not act like the pipes of an organ, where each succeeding octave is one half the length of the preceeding. If nature's law were followed into the higher regions of a carillon of three or more octaves, we should soon find that we were dealing with bells only an inch or two in diameter and by no means capable of asserting themselves in company with their larger sisters to create a musically balanced impression throughout the range. Correction for this must therefore be sought.

Again this is an easy thing to do graphically, once that only one bell has been determined to establish by how much the line will deviate from the line of Absolute Musical Proportion. The diameter of the smallest bell is determined through experiment, checking its acoustical value (intensity, resonance) with the larger bells of the series. Its diameter is then plotted on the graph and an arc drawn from it tangent to the line of Absolute Musical Proportion at a point half way in the range of the instrument.

In like manner, the lines of deviation for the small diameter, the height, and the thickness may be plotted and drawn.

B. THE PROPORTIONS AND PROFILES OF THE BELLS: OPERATION B

This is the more involved operation of the two, since the proportion of the bell must necessarily be based on much actual experiment. Bell founders are reluctant to disclose the results of their own particular research in proportion and profile. This can well be understood when one reflects that the establishment of the profile of a bell, musically pleasing by itself and well able to take its place in a series, is sometimes the result of many decades of applied craftsmanship.

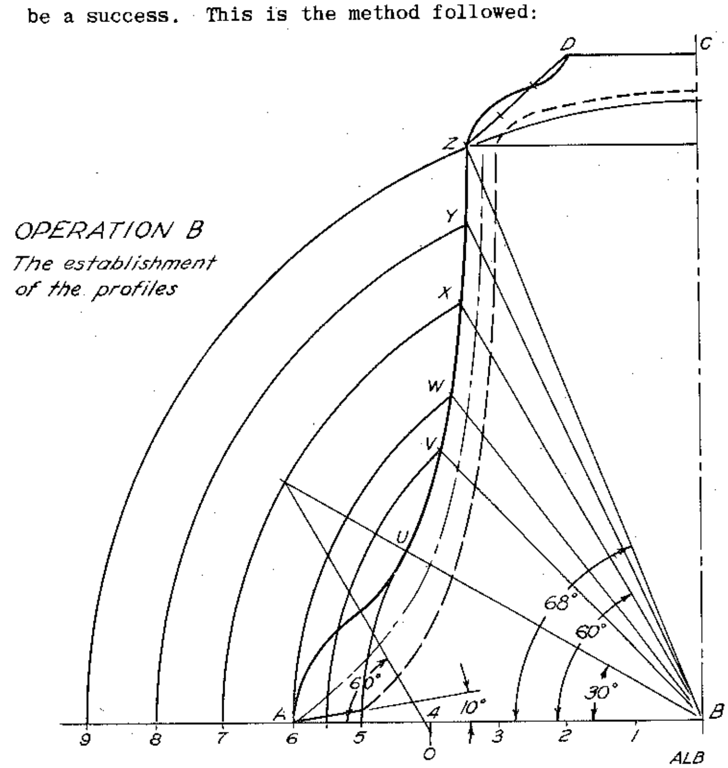
However, if one notes the successes and failures, understanding the tabulating each change made in the profile, constantly comparing the new profiles to the best of those that have gone before, one will arrive at a form which will possess a pleasing combination of partials of proportionate strength - in other words, a musical bell.

The basic partials in the traditional carillon bell are:

1. The Hum Tone, a full octave below the Strike Tone.
2. The Prime, in unison with Strike Tone.
3. The Strike Tone, or principal tone.
4. The Minor Third, a minor third above the Strike Tone.
5. The Fifth, a perfect fifth above the Strike Tone.
6. The Octave, an octave above the Strike Tone.
- etc.

The Ratio of Carillon bell partials is:	1:2:2:2.4:3:4:5:6: :8,etc.
The ratio of the natural harmonic series:	1:2: :3:4:5:6:7:8,etc.

In the author's research further to reduce the great number of variables which have confronted bell founders from the earliest times, he has devised a means by which a bell may be designed with every expectancy that it will be a success. This is the method followed:



1. The diameter is determined from the chart in Operation A. One half this diameter, AB, is laid off on a horizontal line and divided into six parts, numbered 1 to 6, with 6 at A. The horizontal line is extended and numbered further to 9. The distances between these numbers are the units of measure used here.

2. From the right end of the line, point B, a vertical center-line is drawn.

3. The outer lip of the bell, or "Sound Bow," is in an arc with a radius of "2." Its center is determined by swinging an arc of radius "7" from B as a center, until it meets a line from B making 30° with the horizontal. From this intersection of arc and line, a line is drawn at 60° with the horizontal until it crosses a vertical line dropped from 4. This is point O, and is the center of the arc describing the outer lip. The limits of the arc are the horizontal and the 60° line through O.

4. The remainder of the profile is parabolical and may be drawn in with a French curve or a ship's curve, once points on the curve are found. These points may be found in this wise:

From B as a center, arcs of radius 5, 5½, 6, 7, 8 and 9 are drawn.

Where radius	5	intersects the	30°	line from B,	find	U
"	5½	"	46°	"	"	V
"	6	"	52.5°	"	"	W
"	7	"	60°	"	"	
"	8	"	65°	"	"	
"	9	"	68°	"	"	Z

5. From Z draw a horizontal to the center-line. The vertical height of the bell is determined by adding, above the horizontal from Z, twice the distance between this horizontal and the point where radius 9 intersects the center-line.

6. The distance CD is not quite "2." The counter curve between Z and D may be drawn in fairly free, but with the lower curve tangent to the profile line.

The inner profile of the bell is less complicated to draw than the outer. It is, in general, the same curve as the outer profile, but carried down to the base line AB.

From A, a line of slope 10° is drawn until it intersects the inner profile. This determines the inner lip. Above Z, the inner profile is taken roughly parallel to the arc from 9, until it intersects the center-line. As the bell does not vibrate above Z, this is of small importance.

Of most importance is the thickness of the bell at the lip. This will be governed, again, by the lines established in Operation A. It will be noted that the thickness increases rapidly in proportion to the Great Diameter as the bells reach higher frequencies.

The inner profile is rarely trusted to "hit the tone." Rather, after it is calculated, the thickness is increased by a certain amount to be sure that the partial tones will be too high. They may then be tuned down to their correct pitch. If they were to come out too low in the casting, nothing could save the bell for the pitch desired.

However, if it were thick enough to stand the tuning operation, the bell could be turned and its tone reduced to a note an entire half-tone lower than the original. Even if the correct partials could be given to the bell, it would not have the strength that it would have had if it kept its original weight - and sounded the higher note!

Between the two profiles, there is what is termed the "neutral line." This line is half-way between the other two at all times. It should present a constant curve with no "fractures." If this neutral were to display any marked breaks, it would signify that the bell's inner proportions were at variance with the physical production of sound, and there would be undesirable elements in the overall tonal picture.

CONCLUSION

Two charts are here determined which will greatly reduce the number of variables which must be dealt with in the design of bells and carillons. The chart of lines of Absolute Musical Proportion determines the sizes of the bells, while the profile chart determines the shape of each bell.

In this manner empirical determination and guesswork are dispensed with. Bells designed according to the procedure herein outlined will embody the proportions a bell must have for its several partials to be in harmonious relationship. Their exact pitch depends on the knowledge and the skill of the tuner.

COMING ATTRACTIONS

Two interesting articles have been promised for the May issue. One will be on the "integration" of engineering drawing and descriptive geometry. The other will concern itself with the attitude of a giant industrial firm toward one aspect of engineering education, the aspect that touches us directly.

The first article is being prepared by a department chairman of an eastern university. He is a recognized authority, having taught under a system of integration and having co-authored a textbook in which drawing and descriptive geometry are integrated.

The second article is being prepared by the personnel coordinator of a large company that employes many new engineers every year. The title will be something like: "What my Company expects its newly employed engineers to know about drafting."

LIFE TEST NOMOGRAM

By

Edward C. Varnum
Barber-Colman Company, Rockford, Illinois

The theory of extreme values is concerned with the probability of encountering very large or very small values (1) (2). The application of this theory has been generally confined to hydrologic data for use in designing flood control systems, (3) but more recently the subject of life-testing (4) has been attached with this statistical tool. Although the precise general formulas for extreme-value distributions contain terms of the hypergeometric series (5), Mr. Harris of General Electric (4) has simplified these formulas by assuming that the number of items in the future lot is large so that Stirling's formula may be used to approximate the factorials appearing in the precise formulas.

The simplified formula evaluated by the present nomogram is

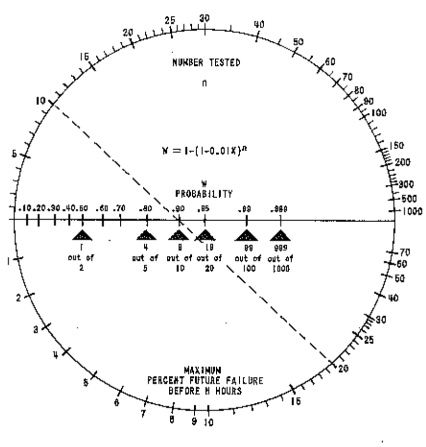
$$W = 1 - (1 - .01K)^n \qquad (1)$$

where W is the probability that no more than K% of a large future lot will fail sooner than the observed shortest life of a sample of n units tested. For numerical illustration, suppose that ten units are life-tested and that the first failure occurs after 1178 hours. Suppose also that we wish to know the probability that 20% of a large lot of future units will fail before 1178. Using equation (1), we may calculate

$$W = 1 - (1 - .20)^{10} = 1 - (.8)^{10} = .8926258176 \qquad (2)$$

LIFE TEST NOMOGRAM

Test n units. If the first failure occurs in H hours the probability (W) that no more than K% of a large future lot will fail before H hours is found by drawing a line from n-value to K-value and reading off the W-value



Example: Ten units are tested. First unit fails after 1178 hrs. The chances are 9 out of 10 that no more than 20% of a large lot of future units will fall before 1178 hrs. (n = 10, K = 20, Draw line to find W = .90)

Use of the nomogram by drawing the line as shown from 10 on the upper semicircle to 20 on the lower semicircle, gives a value of W on the diameter which is slightly less than .90.

The nomogram can also be used for finding how many items we should test in order to have a given probability assurance that the lives of a specified percent of a large future lot will exceed the minimum life of our test sample. Using the same numbers as above, we can imagine that a customer demands 90% assurance that at least 80% of our units will exceed 1100 hrs. By drawing from 20 on the lower semicircle through "9 out of 10" on the diameter, we find 10 on the upper semicircle and thus select 10 units at random for the life-test, which may be terminated as soon as the first unit fails.

The numbers chosen for the above examples are illustrative only and do not refer to actual lives of our products, actual numbers life-tested, or assurance levels required by our customers. These three numbers vary within plants and between plants. The circular nomogram provides a quick and sufficiently accurate method for finding any one of the three numbers when the other two are specified.

References:

(1) Fisher, R.A. and Tippett, L.H.C. "Limiting Forms of the Frequency Distribution of the Largest or Smallest Member of a Sample", Proceedings of the Cambridge Philosophical Society. Vol.24 (1928) p.180

(2)Gumbel, E.J.: "Les valeurs extrêmes des distributions statistiques," Ann. Inst. Henri Poincaré Vol. 5 (1936) p.115

(3) Grassberger, H., "Die Anwendung der Wahrscheinlichkeitsrechnung auf Hochwasserfragen" Deutsche Wasserwirtschaft, Nos. 9 und 10, Stuttgart 1936

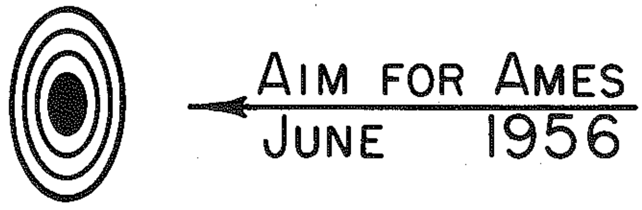
(4) Harris, L.B.: "On a Limiting Case for the Distribution of Exceedances, with an Application to Life-Testing," Annals of Mathematical Statistics. Vol. 23 (1952) p.295

(5) Gumbel, E.J. and Von Schelling, H.: "The Distribution of the Number of Exceedances," Annals of Mathematical Statistics Vol. 21 (1950) p.247

A NOMOGRAPHY PRIZE TO BE AWARDED IN JUNE, 1956

The Drawing Division Committee on Nomography is pleased to repeat the announcement of a prize in nomography. The David Gessner Company, Worcester, Mass., has contributed the sum of $100 for a prize in nomography and has requested the Committee to administer the competition.

The Committee would appreciate help in uncovering such nomograms as comply with the rules and conditions stated in the November, 1955 issue of the JOURNAL. Any such assistance by individuals will be acknowledged at the Annual Meeting at Ames, Iowa, in June, 1956. And at that time, the winner will be announced.



A SHORT TERMINAL COURSE IN TECHNOLOGY

By

Lyle E. Young
University of Nebraska

Our country is experiencing a grave shortage of technically trained men. This shortage is expecially serious at a time when our security as a nation is so dependent upon keeping abreast of the rest of the world in technical progress. The shortage does not appear to be temporary. None of the classes now enrolled in technical schools, including the generally larger class entering training last fall, will be adequate to supply the anticipated demand upon graduation. This would indicate a serious shortage of engineers and scientists for at least four years unless more efficient use can be made of those available. The shortage of other technicians is also acute, but a new supply can be made available in a shorter time. This would suggest an examiniation of technical training and needs at all levels.

The technical need for engineers would not be nearly as great if it were not for the large number of engineers in non-engineering and sub-professional work. Much of this work could be done by persons trained in a short terminal course in technology. These "technical aids" could relieve engineers of much of the routine allowing those engineers, with the ability, to work on higher technical pursuits. Many studies have indicated that a ratio of about three technical aids for one engineer could efficiently be used.

There are many men and women with technical ability who do not have the inclination or financial means to attend a four or five year course in engineering. If a shorter course were available locally, many of these people would he attracted by it.

The faculties of the engineering colleges share in the responsibility for alleviating the shortage. The state supported schools are especially obligated to provide trained personnel in line with the needs of their local industry. In those parts of the country, where a need for technical aids exists and where there are no adequate training facilities, the engineering colleges could provide this training.

The engineering colleges are well suited to train technical aids. The staff of engineers, in their contacts with men of industry, keep aware of the changing personnel needs of industry. They can then provide training programs coordinated to provide engineers and technical aids, who will be effective in complementary industry positions.

The inevitable contacts in and out of class between the technical aid student and engineering instructors and students provides an excellent atmosphere for mutual understanding and appreciation. This encourages an interchange of students into technical courses more comparable to their abilities and interests.

The physical facilities of most engineering colleges are adequate for a technical aid program without significant alteration.

The existing administrational facilities can be easily adjusted to take care of the technical aid student. It is desirahle to provide a man to direct and coordinate the program, but otherwise it is not necessary nor advisable to set up an independent technical aid department.

The placement service of an engineering college has the contacts with employers of technical men to effectively place the technical aid graduate.

The initiation of technical aid training in an engineering college requires no major adjustments in teaching or administrational staffs or physical plant. If a school can better provide for the personnel needs of its local industry with a short terminal course in technology, it should consider doing so.

If a technical aid program is to serve the purpose of relieving the engineering shortage the course must be based on the results of surveys and studies of the needs of local industry and existing training facilities. The course should be of college level if the technical aid is to effectively aid the engineer.

A program for training the technical aid should not be merely the first year or two of an engineering curriculum. The first two years of an engineering curriculum are devoted in large part to providing the student with a basis for the courses to follow. An effective technical aid curriculum must be concieved so that each course or series of courses are entities in themselves. Contents of the curriculum should come out of a careful consideration of the unique objectives and needs of technical aids.

The curriculum probably should have a specialty such as drafting, tool designing, surveying, and so on. With no specialty, the graduate might have some trouble in obtaining his first job.

Each of the specific courses should receive special consideration to be sure it best fills the needs of the trainees. These needs are not the same as those of the engineering student. For example, in a course in drawing or graphics, the engineering student is given a tool for the graphical representation of designs, data, and mathematical concepts with limited concentration on developing drafting techniques. But the technical aids need the techniques. Engineering math should prepare for advanced courses. For technical aids, the practical is needed.

One of the greatest problems of giving a technical aid course in an engineering college is in providing a staff with the proper attitudes for effective teaching. Basic to effective teaching at any level is a conviction of the importance of the course and an enthusiasm for teaching it. Many men on an engineering college staff do not have these attitudes for teaching technical aid or even undergraduate courses. This may be due in part to the lack of recognition and compensation by their administrations for those who teach courses of the lower technical levels.

The technical aid program serves well as a period of orientation and adjustment for students without entrance requirements for engineering, or those undecided as to what they want to take. Many students will use the technical aid training for these purposes and then enter a course in engineering or architecture. This brings up the question of allowable credit transfers. Obviously the two years of a technical aid course could not be allowed as a substitute for the first two years of an engineering course. The credits allowed, however, will probably be comparable to the transferable credits accurued in any other non-engineering course. The non-transferable credits taken in a technical aid course will be more applicable to engineering needs than other non-directional periods of study.

The University with which I was then associated, with the encouragement of the Veterans' Administration, started ten technical aid curricula at the end of the war. These ten curricula were generally parallel to the branches of engineering. It was the intention of the Veterans' Administration to screen the veteran student into courses in engineering or the shorter technical aid courses comparable to his ability, eligibility, time. After the courses were set up, however, the Veterans' Administration found that it did not have this power to screen the veteran student. The course were run nevertheless, but there were too many curricula for the limited number of students. These technical aid courses were soon dropped.

With the encouragement of industry, two technical aid courses were started in the fall of 1949. A course for training industrial technicians attracted only a few students and only one class was graduated. A second two-year terminal course in drafting has been much better received. The present enrollment is at a high with 22 second-year men and 71 first-year students.

The entrance requirements are somewhat lower than those for the engineering students. A high school education including two years of mathematics is required but no specific grade averages are necessary.

The technical aid student is expected to maintain the same honor point average as the engineering student. He must achieve a reasonable proficiency in order to receive the certificate of graduation.

In every respect the technical aid student has the opportunity to share the activities and privileges of the other students. He therefore can enter into the social and cultural life of the university, an important part of a college education. He is a college student of good standing.

The curriculum of the Technical Aid (Engineering Drafting) includes:

1. 6 quarters, 15 hours per week of drafting including: mechanical drafting, descriptive geometry, structural detailing, architectural drawing, and production illustration.
2. 6 quarters, 10 hours per week of mathematics including: practical arithmetic and geometry, college algebra, trigonomery, and analytical geometry.
3. 4 quarters, 6 hours per week of shop including: machine tools, metal processing, machine shop, etc.
4. 4 quarters, 3 hours per week of English including: technical writing, composition, and speech.
5. 2 quarters, 2 hours per week of materials (building and metals).
6. Miscellaneous courses in alphabets, slide rule and use of handbooks.

Each of these courses is given in its respective department of the engineering college. The staff that teaches the courses is not employed full time teaching technical aid students, but usually teach regular engineering courses too.

The Technical Aid Program has a supervisor to direct and coordinate the work in the various departments. He also serves as a student adviser in academic and job placement problems.

The fifty-nine technical aid graduates in the two classes to graduate to date, 1953, were placed in industry with no difficulty. There were many more job offers than men available. As far as I can tell at this time, all graduates have accepted employment with local firms although a considerable number of offers from other parts of the country were made. The starting salary has ranged from $240.00 to $265.00 per month, and perhaps more by now. It is significant that several firms that hired graduates from the first class hired additional men the next year. At least, sixteen of the graduates have transferred to other technical fields and are probably still in school. Most of these students are in mechancial engineering and architecture.

Changes in the curriculum and the content of the individual courses have been made and others are being considered. Inclusion of basic courses in chemistry and physic have been planned. When more complete reports are available from employers, other changes will undoubtedly become necessary.

Reports from firms that have hired technical aids, have revealed that in general the graduates are performing very satisfactory work in the capacities for which they were trained. However, the program is yet somewhat young to make specific conclusions as to the program's effectiveness.

SUMMARY

The shortage of engineers can in part be relieved by training technical aids with short terminal courses in technology. In parts of the country where industry indicates a need for persons with such training, and where existing facilities are inadequate, the state supported engineering colleges have a clear obligation to provide such courses. An engineering college can effectively give technical aid training without significant alteration of staff, physical facilities, or administrational structure.

The experience with short courses at the University has indicated that only a limited number of courses should be attempted. If the courses are based on needs indicated by industry, the trainees will have no trouble entering into and being successful in industry.

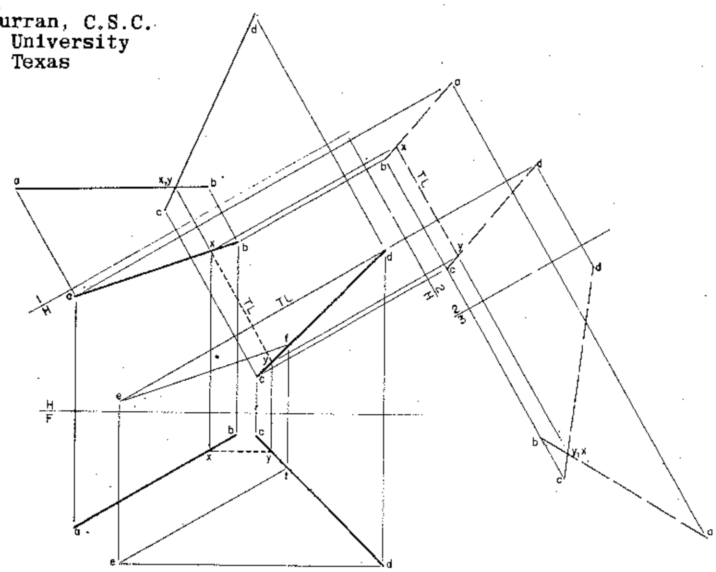
A NOTE ON THE SHORTEST HORIZONTAL DISTANCE BETWEEN TWO SKEW LINES

By

Brother Henry Curran, C.S.C.
St. Edward's University
Austin, Texas

Given the H and F views of the two skew lines AB and CD, and required to find the shortest horizontal distance between them. The method of solving this problem usually given in descriptive geometry textbooks is shown by the broken-line successive auxiliary views at the left of the figure. The plan DEF is established parallel to AB in the H and F views, the line DE being a horizontal line. The primary elevation, View 2, with line of sight parallel to DE, gives parallel projections of AB and CD. The secondary auxiliary elevation, View 3, then locates the end view of the shortest horizontal distances XY at the apparent intersection of AB and CD.

A more direct solution is obtainable by the use of primary auxiliary elevation, View 1, which is easily seen to be equivalent to View 3. As shown in the figure, this is simply obtained by using a line of sight normal to the H view of the horizontal line DE.



THE SHORTEST HORIZONTAL DISTANCE BETWEEN TWO SKEW LINES.

NOMOGRAMS FOR VAN DER WAALS' EQUATION FOR REAL GASES AND FOR THE CORRESPONDING EQUATION FOR IDEAL GASES

By

Peter L. Tea
The City College, New York, N.Y.

Fig. 1 shows the nomogram for Van Der Waals' approximate equation for all real gases, in units of critical pressure, volume, and temperature, and also the nomogram for the corresponding ideal gases, eqs. 1 and 2,

$$\left(p + \frac{3}{v^2}\right)(3v - 1) = 8\ T \qquad (1)$$

$$3\ pv = 8\ T$$

The surface of eq. 1 approaches the surface of eq. 2 tangentially as v and T increase, for p constant. The surface of eq. 2 is to the surface of eq. 1 like the asymptote is to the hyperbola.

A straight edge accross the scales of Fig. 1 gives a set of values of p, v, T for the ideal gases, and for the same p and T, one, two or three different values of v, for the real gases. Eq. 1 is a cubic equation in v, for any value of p and T, and there may be three real roots, or one real and two imaginary roots. For T = 0.8 and p positive there is a small range of p yielding roots, from the extreme of p = 0.53 and v = 2, and v = 0.51 where the straight edge is tangent to the v scale at v = 2, and hence v is a double root, corresponding to the maximum value of p on the isothermol for T = 0.8 on Fig. 2. The other extreme position of the straight edge for T = 0.8 yields p = —3.75 and v = 0.65, a double root for v, corresponding to the minimum value of p on the isothermal for T = 0.8. The third root is negative for v and would be found on the v curve plotted for negative values, which would have no apparent interest in physics, and there is no interest in v for negative temperatures either; but negative pressures do appear for Van Der Waals' gases.

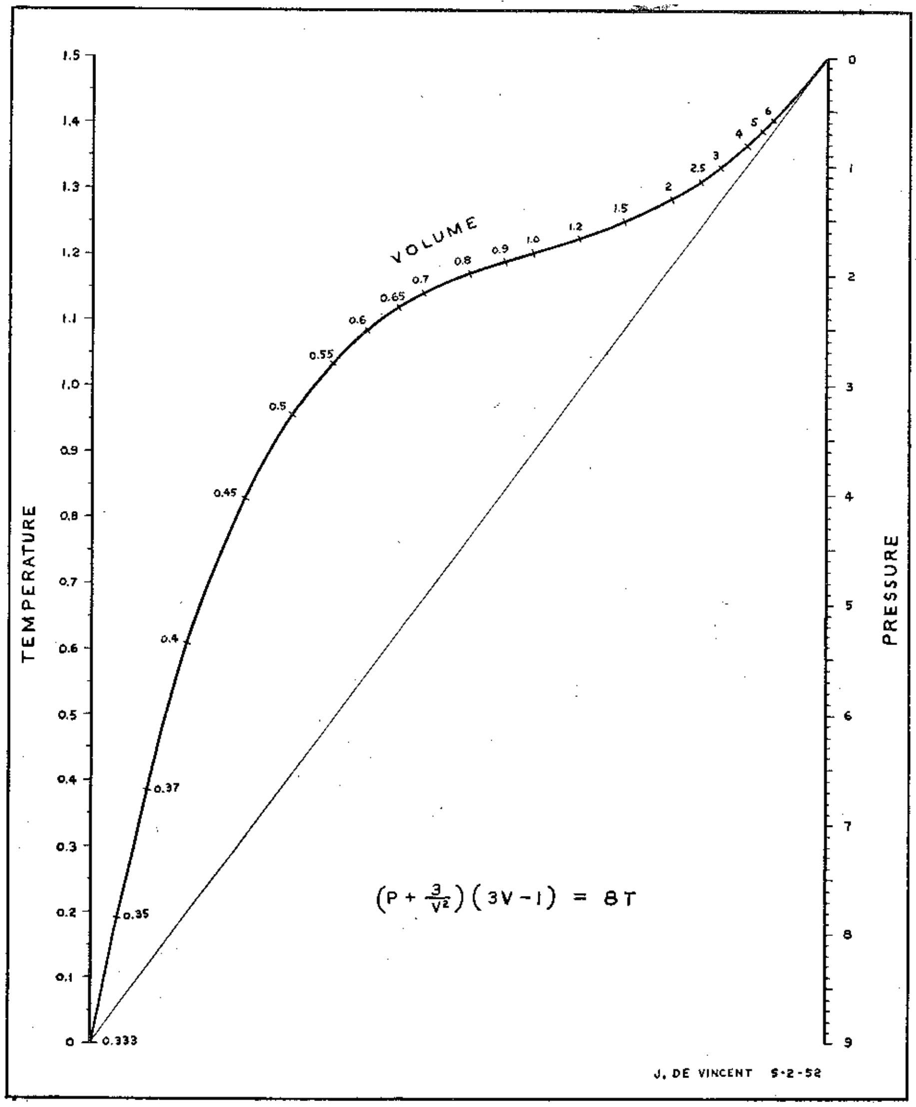


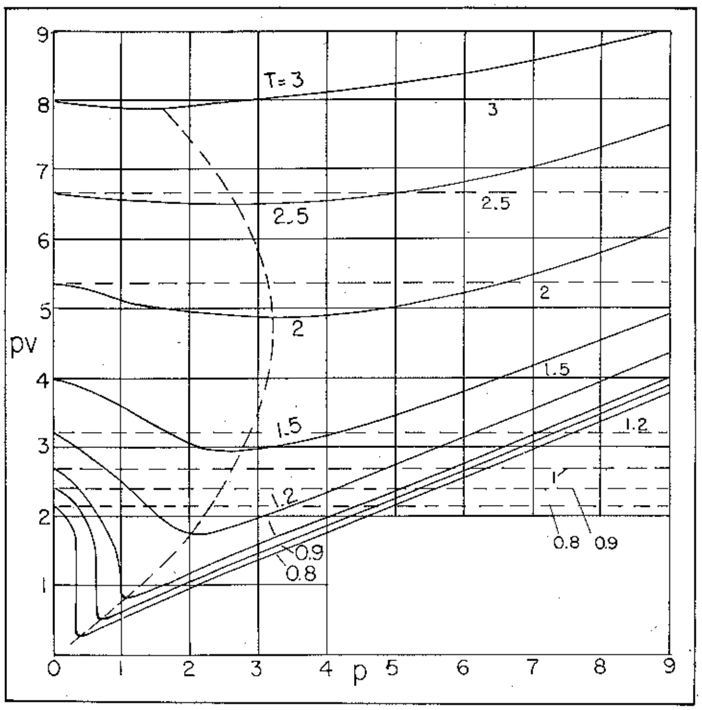
Figure I—Nomogram for Van der Waals' equation, equation (I).

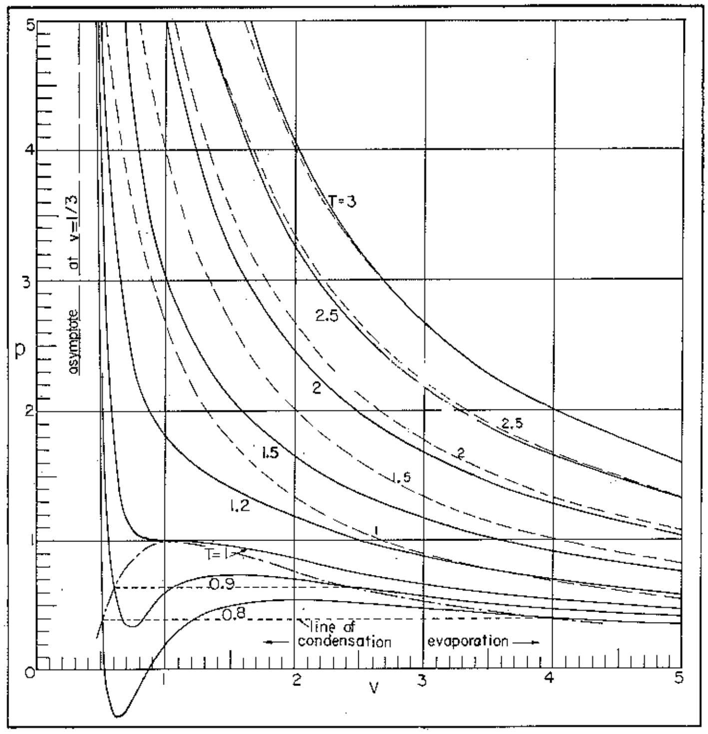
After this nomogram was designed and drawn with scales to show up the Van Der Waals' domain to advantage, the author had occasion to use it to draw all the isothermals for T = 0.8 to 3, of Fig. 2 and 3.* The T scale was extended to T = 2 on a photostatic copy. All the necessary points for the isothermals for Figs. 2 and 3, including T = 2 were obtained from Fig. 1 extended; for T = 2.5 and 3 the isothermals were calculated.

It is interesting to point out that Fig. 1 contains two uniform scales, p and T, and only one scale, the curved scale for v, was calculated. From Fig. 1 the isothermals for any value of T within the range of the T scale can be read off point by point and any number of isothermals for Figs. 2 and 3 obtained with little calculation for Fig. 3.

It is to be noted that in obtaining points for Fig. 3 in the region of the loops in Fig. 2, the constant pressure lines of condensation and evaporation were used,

* Van Der Waals' Equation; The Liquefaction of Gases, Peter L. Tea, Vector, January 1953, The City College, New York, N.Y.





as these correspond better to real gases than the loops.

It would be of interest to the student of nomography to draw the two nomograms for higher temperature ranges, say for T = 2 to T = 10, and T = 10 to T = 100 to see how the hump in the Van Der Waals' curve becomes less and less significant, and the v curve approaches the ideal gas straight line for v.

NEW NOMINATING PROCEDURE

A new procedure for nominating candidates for the offices of the Division of Engineering Drawing has been adopted by The Executive Committee of the Division.

The new procedure as recorded in the minutes of the Executive Committee is as follows:

"That a nominating committee be formed to be composed of five persons, three of whom shall be the last three chairmen of the Division who are present at the June Meeting, and not including the retiring chairman, and two others, to be elected by the Executive Committee and who are present at the Meeting. These two shall not hold any office at the time of their appointment. This committee shall be appointed at the time of the June Meeting. The senior past chairman of the Division shall act as chairman.

This committee shall present a slate of two names for each office.

A petition having 10 signatures of members of the Division nominating any member for any office shall require the nominating committee to place that name on the ballot also.

As many names as necessary may be placed on the ballot for each office.

All nominations must be closed at the time of the Mid-winter Meeting.

The ballots shall be sent out and the votes counted in the same manner as presently specified."

The nominating committee in 1955 was composed of F.C. Bragg, A.P. McDonald, Jasper Gerardi, Ralph Northrup, and C.H. Springer, Chairman.

The slate as presented by this committee is as follows:

Vice-Chairman--H.P. Skamser, W.J. Luzadder.
Secretary--A. Jorgensen, J.E. Pearsón.
Editor T-square page--R.H. Hammond, N.J. Arnold.
Circulation Manager--F.H. Smith, E.D. Black.
Member of Executive Committee--D.P. Adams, M. McNeary.
Member of Council--J.T. Rule, F.A. Heacock.

NEW SAE DIMENSIONING STANDARDS *

By

Col. C.M. Buhl, Budd Co.
Jasper Gerardi, University of Detroit
G.L. McCain, Chrysler Corp.

Expansion of industry, our Department of Defense, and the correlation of engineering work in the mechanical industries have focused critical attention on the necessity of standardizing the dimensioning of detail drawings.

Three new sections of the SAE Automotive Drafting Standards, which have recently been published, explain principles and methods for specifying geometric and positional tolerancing. They include fundamental principles of dimensioning, application of size tolerances, decimal dimensioning, choice of datum, and methods of specifying permissible limits of flatness, straightness, augularity, symmetry, concentricity, and combinations of these variations. Methods of dimensioning common features are illustrated so that the standard may be used directly by all draftsmen and engineers. In order to illustrate some of these principles, a few examples are discussed in the following article with an introduction to the recommendations included in the new standard.

GEOMETRIC TOLERANCING

Geometric Tolerancing includes the control of form, such as roundness, squareness, flatness, and symmetry. The term "geometric" implies in one case the control of roundness and concentricity and combinations of these characteristics. A perfectly cylindrical shaft might fit into a perfectly cylindrical hole of the same size, but since neither one can be produced, we always allow some clearance. If both shaft and hole are elliptical, they might go together in one place; but if there must be relative motion between them, the largest dimension of the shaft must be less than the smallest dimension of the hole or bearing. If a cylinder, representing the largest permissible shaft, will go inside a cylindrical hole, representing the smallest permissible size, each of these cylindrical shapes may be used as limits for tolerance zones. Fig. 1 shows a shaft with its tolerance zone.

Within this tolerance zone, there may occur out-of-roundness, out-of-straightness (if the shaft has appreciable length), and a sort of waviness which might be defined as an out-of-roundness. However, none of these variations may be permitted when the shaft is at maximum diameter, as any variation would cause the surface to exceed the limits of the tolerance zone. If the shaft is everywhere at minimum diameter, it cannot vary from a true cylindrical form; hence all variations must be between the high and low limits of the features as shown in Fig. 1. It can be said that a maximum diameter (maximum material) there cannot be any tolerance of form, but that away from maximum diameter, errors of form may be permissible until they reach minimum diameter.

This same principle also applies to the internal cylindrical form,because at its minimum diameter it is in the maximum material condition.

Therefore, a feature at its maximum material condition as defined by its dimensions, may not vary in form. And the geometrical tolerance may be referred to as zero. However, when the feature is away from maximum material condition of size, then geometric variations may be permitted within the zone defined by maximum and minimum limits of size.

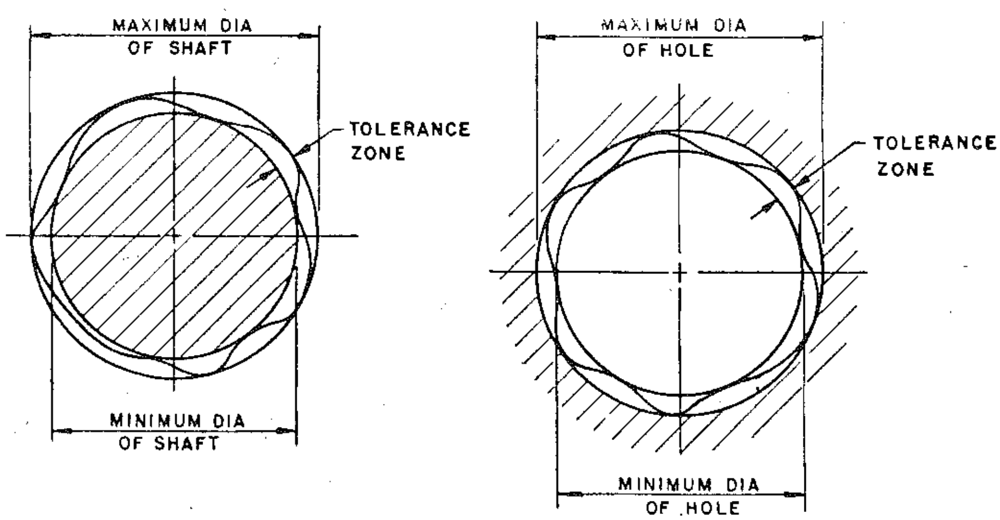


Fig. 1—Within the tolerance zones of a shaft (left) and a hole (right) there may occur "out-of-roundness" and "out-of-straightness." At maximum material, that is maximum diameter for the shaft and minimum diameter for the hole, there cannot be any tolerance of form

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POSITIONAL TOLERANCE WITH DIRECTLY TOLERANCED FEATURES

A simple example of positional tolerancing of a feature is shown in A of Fig. 2. The position tolerance allows the center distance to become maximum, as at B, or minimum, as at C. Since both conditions are acceptable, the inspection gage must be made as at D, so that the pins in the gage set on 2.00 in. center distance will just contact the inside edges of the feature with maximum center distance and the outside edges of the feature at minimum center distance. The sketch at D shows the diameter of gage pins which will accept a part whose holes are at minimum diameter and center distances are at maximum and minimum. If the holes are both at maximum diameter, then the same gage, as at E, would accept the part even though the center distance was greater, or less, than the limits specified on the drawing as shown at E.

It is not uncommon practice to make inspection gages in this manner, and the gage is usually the means of inspecting the part. It may be expected that all parts which are accepted by the gage are then usable.

If there is no restriction on the drawing, and if parts will function as required, this extra available tolerance, which in the above case amounts to one-half the hole size tolerance, may be used to advantage, fewer parts would be scrapped, cost reduced, efficiency and interchangeability increased.

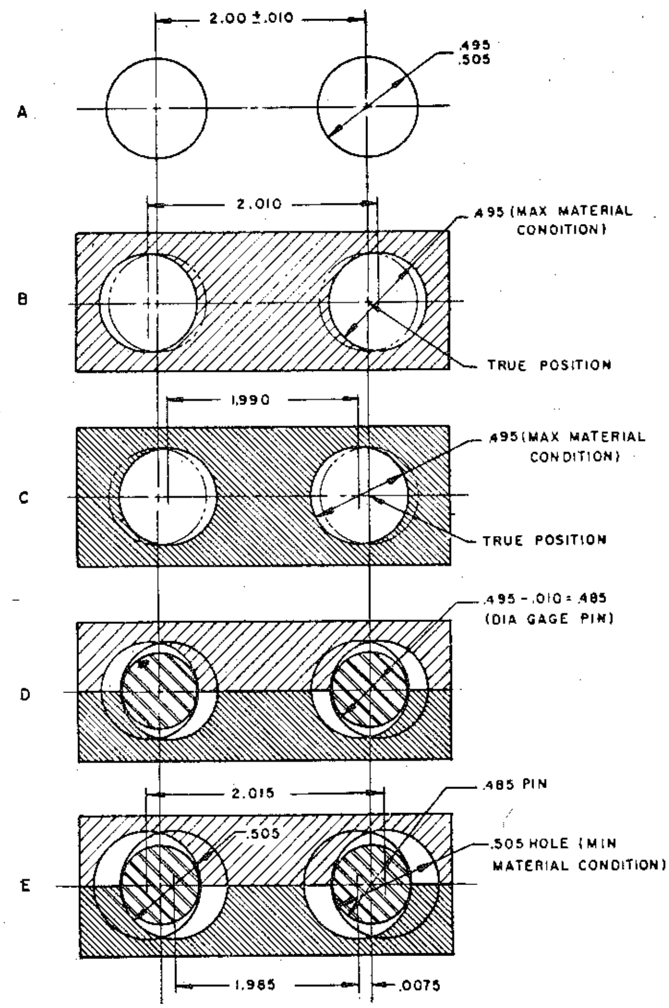

Fig. 2—An example of positional tolerancing

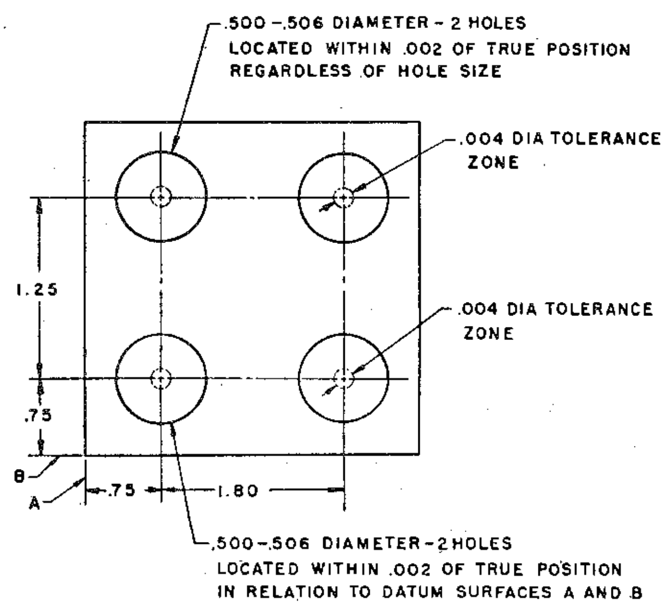

Fig. 3—The two upper holes must be held on centers whose maximum distance is 1.804 in. and minimum distance is 1.796 in.; while the lower holes may exceed these limits and could vary from 1.810 to 1.790 in.

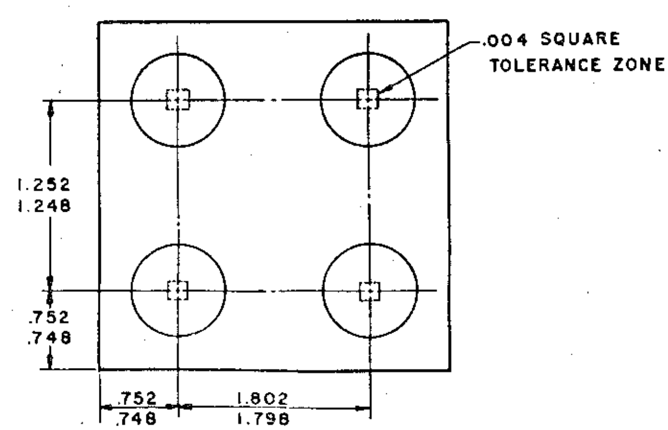

Fig. 4—Direct tolerances allow variation in the direction indicated by the dimension lines resulting in square tolerance zones whose corners are farther away from the desired position than with the true position method with circular tolerance zone

Tolerances are usually selected to apply at maximum material condition, but may be increased when the part is away from maximum material condition, unless restrictions are noted on the drawing. If the center distance must be held to the tolerance specifield, it should not be subject to an extra tolerance because of hole size

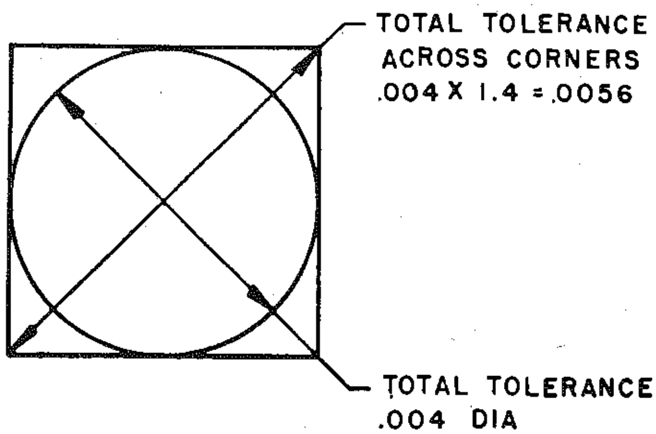

Fig. 5—A maximum variation in excess of the intended tolerance may occur at 45 deg from horizontal or vertical direction in which the tolerances have been indicated

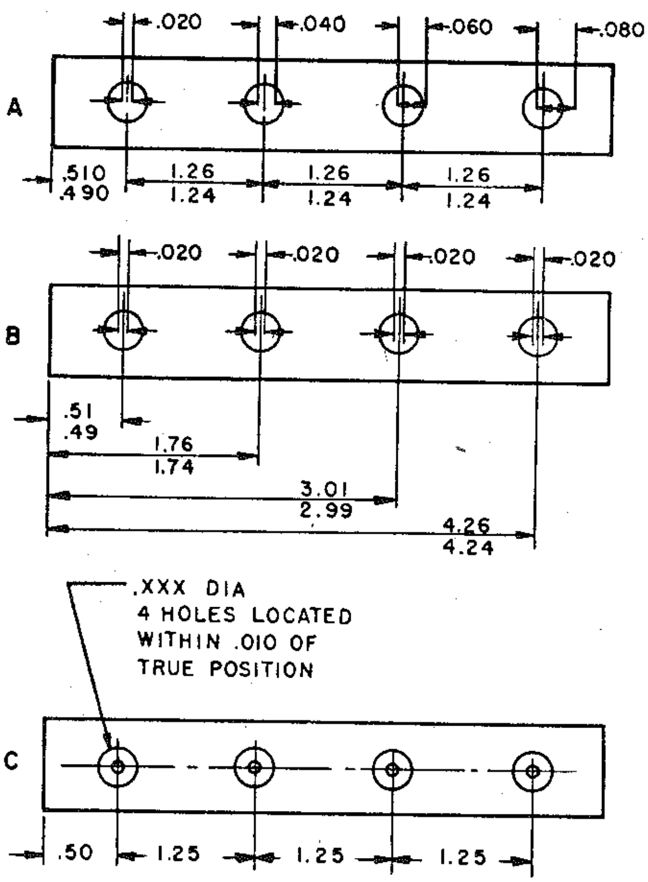

Fig. 6—Types of dimensioning: (A) successive, (B) progressive (C) true positioning

variation. In such cases the drawing may state "regardless of feature size," and when this restriction is necessary, an appropriate type of gage must be used.

The two conditions just described illustrate the two importance interpretations of positional tolerancing, termed the "liberal" and the "restricted" applications. Since the restricted application is used only where required, particular case should be exercised to make the requirements clear on the drawing by wording the tolerance notes so as to avoid any possible misunderstanding. See Fig. 3. This conveys the information that position must be controlled independently of any other variation by tools and gages made to enforce the restricted limits. The two upper holes must be held on centers whose maximum distance is 1.804 in. and minimum distance is 1.796 in., while the lower holes may exceed these limits and could vary from 1.810 to 1.790 in.

True position tolerancing is just as simple as any method of dimensioning can be made, for the permissible variation is in all cases included in the circle which defines the tolerance zone as shown in Fig. 3. On the other hand, direct tolerances, as shown in Fig. 4, allow variation in tbe direction indicated by the dimension lines,which would result in square tolerance zones whose corners are farther away from the desired position than in the case of the true positioning method with the circular tolerance zone.

When variation may occur anywhere within the square shown in Fig. 5, a maximum in excess of the intended tolerance may occur at 45 deg. from horizontal or vertical direction in which the tolerances bave been indicated; hence, more accuracy may be expected where a circular tolerance zone is used in place of a square one.

When tolerances are applied to coordinate dimensions and are not uniform, the tolerance pattern will be in the form of rectangles, and where such tolerances are required, true positional tolerances cannot be used. True positional tolerancing can be used only where the required tolerances are uniform in all directions.

We have learned by experience the difference between continuous (or cbain) dimensioning and progressive (or step) dimensioning. Fig. 6 illustrates the two methods. It shows the successive type at "A," the progressive at "B," and the true positioning at "C." In the case of "A," the tolerances accumulate with eacb hole in line. In the case of "B," each hole is controlled from the same base line, preventing tolerance accumulation. In the case of "C" the net result will be the same as that in "B," because the individual tolerances for each hole are the same, regardless of the method of dimensioning.

WHY NEW STANDARDS WERE SET UP

Two of American's industries, the automotive and the aeronautical, representing 20 billion dollars of our national productive income, depend on mass production to supply markets all over the world with air and ground vehicles of all kinds. Although these industries are highly competitive, they have a common general objective: high production, and excellence in performance of the product at least cost.

The complexity of modern mass production, on both national and international levels, has increased demand for interchangeability and for more efficient performance and durability. Also, during periods of high stress, it has been found difficult for a manufacturer to make parts from another manufacturer's drawing.

To avoid unnecessary cost, complete information must be included on drawings, concisely expressed in terms which are understood by all concerned. The emphasis for cutting costs has shifted from the shop to the engineering and design office. Add to this the fact that the scientific development of most equipment today calls for a high degree of precision in a large number of parts and we find that cost must be reduced if the product is to survive in a competitive market.

Precision parts having toleranced features are expensive. Cost can be reduced if an attempt is made to create better understanding between the design engineer, whose primary object is to create, and the gage or tool engineer, whose responsibility it is to meet the proper functional requirements as set forth by the designer.

Each of these personalities has a different approach to a project. The designer creates, he builds--both in his mind and on paper. The very nature of his work causes his mental processes to become essentially inductive. While it is not implied that he is casual or careless about the importance of tolerances in the proper functioning of parts, it is true that the design of the components usually constitute his primary interest and responsibility. A designer or engineer is likely to be more aware of such factors as chemical and physical properties of materials, stresses, performance, fabrication, costs, and servicing. He recognizes that appropriate tolerancing is a factor in all these elements, but often assumes that the gage engineers will cooperate to assure proper functioning of the product he designs.

The gage engineer is a deductive-minded fellow. Experience has taught him that in many cases the tolerances shown on a drawing do not necessarily mean what they say and he may assume that the design engineer depends on his services to assure the intended or required degree of functional quality. A competent gage engineer first analyzes the new drawing to visualize proper functioning of the part, the quality of work required, and economy in materials and fabrication. This analysis by the gage specialist is extremely important. As a corollary to this analysis he determines whether accumulations of size, positional, or form tolerances are consonant with functional requirements of the part or combination of parts.

Rejection and scrapping of parts which are not in accordance with drawing requirements have always been problems. The inspector has gages which are made to accept or reject a part on the basis of its dimensions or functions. Other inspectors may reject the part because of structural defects or surface imperfections. Sometimes, a chief inspector may override the part inspector and decide that in spite of such imperfections the part is usable. This he may do because he knows the functioning requirements of the part and applies a liberal interpretation to the tolerances as stated on the drawing. For reasons of economy, reduction of scrap loss, and facility of manufacture, the gage is normally designed to accept the broadest or coarsest tolerances which permit ready interchangeability and proper functioning.

Let it again be emphasized that the designer is not considered to be oblivious of limits to which work must be held to assure proper functioning of the part. He could be the most tolerance conscious person imaginable - but under the present dimensioning systems may lack the means whereby he can indicate whether or not an accumulation of size and positional tolerances is permissible. This leaves the interpretation of tolerances open to both the gage engineer and the tool engineer--and unfortunately their respective interpretations, too often, remain uncoordinated.

In order to eliminate these shortcomings, and to reduce costs which result from misinterpretation in our present drawing practices, the Society of Automotive Engineers revised the portion of the Drafting Standard which deals with tolerances.

YET CONFERENCE — AN INVITATION

All members of the ASEE are invited to attend the North Midwest Section YET "Conference on Teaching" on April 19, 20, and 21, 1956, at the State University of Iowa. Notable speakers from industry and teaching will discuss teaching problems and the professional development of the YET. Discussion groups will be organized to stimulate the ideas of those attending. Additional information may be obtained from the North Midwest Section Sub-Chairman, William Streib, Department of Engineering Drawing, State University of Iowa, Iowa City, Iowa.


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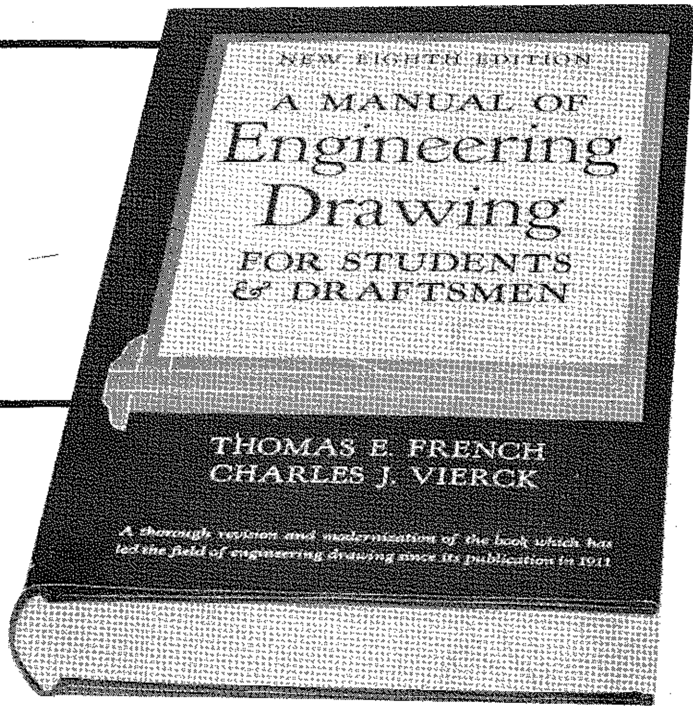

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THREE-DIMENSIONAL NOMOGRAMS

By

Douglas P. Adams
Massachusetts Institute of Technology

The method used to construct two-dimensional "alignment" charts, or nomograms, can be extended with the aid of descriptive geometry to provide a practical construction for three-dimensional "coplanar" diagrams. The theories for the two types of charts are parallel, Table I. In the former, three scales are so arranged that values of the three variables satisfying the given equation always lie on a straight line. In the latter, four scales are so arranged that the values of four variables always lie in a plane. If the equation for which the chart is made is F(U,V,W,T) = 0, values of any three parameters, such as U,V, and W, on their respective scales will determine a plane and the value of the fourth variable, which in this instance is T, is found at the point where this plane intersects the T-scale.

Space diagrams of this type have been suggested in the past, and even drawn pictorially, but they have not been used because of the difficulty of handling space distributions on the two-dimensional page. This can be overcome, however, with the aid of such descriptive geometry techniques as the following:

1. *Auxiliary Line and Parallel Join.* This technique can be used effectively when the four variables have straight, vertical scales as shown in Fig. 1. Although the equation for this illustration is comparatively simple, U + V + W = T, more difficult problems can also be solved, as will be demonstrated in a later section.

Considering first an equation that can be solved with a two-dimensional diagram, it can be shown by expansion that U + V = W, can be expressed in determinant form as follows:

$$\begin{vmatrix} 0 & uU & 1 \\ B & vV & 1 \\ \frac{uB}{u+v} & \frac{uvW}{u+v} & 1 \end{vmatrix} = 0$$

Coordinate Interpretation: X, Y

where u, v, and B are constants.

As indicated in Table I, the first column of this determinant can be interpreted as the X-coordinate of the respective U, V or W curve and the second column as the Y-coordinate.

In similar manner, the equation of Fig. 1, U + V + W = T, can be put in determinant form and given a coordinate interpretation.

Table I—Theory of Two- and Three-Dimensional Nomograms

Three points are in alignment when:	Four points are coplanar when:
$\begin{vmatrix} x_1 & y_1 & 1 \\ x_2 & y_2 & 1 \\ x_3 & y_3 & 1 \end{vmatrix} = 0$	$\begin{vmatrix} x_1 & y_1 & z_1 & 1 \\ x_2 & y_2 & z_2 & 1 \\ x_3 & y_3 & z_3 & 1 \\ x_4 & y_4 & z_4 & 1 \end{vmatrix} = 0$
Assume that a function $F(U, V, W) = 0$ can be put in the form	Assume that a function $F(U, V, W, T) = 0$ can be put in the form
$\begin{vmatrix} U_1 & U_2 & 1 \\ V_1 & V_2 & 1 \\ W_1 & W_2 & 1 \end{vmatrix} = 0$	$\begin{vmatrix} U_1 & U_2 & U_3 & 1 \\ V_1 & V_2 & V_3 & 1 \\ W_1 & W_2 & W_3 & 1 \\ T_1 & T_2 & T_3 & 1 \end{vmatrix} = 0$
where U_1, U_2 are functions of U only, and similarly for V and W. Interpret U_1, U_2 as the X and Y coordinates of a plane curve. Then the curve can be plotted on X, Y axes and calibrated in U. Similarly for V and W. Values of U, V and W which satisfy the original equation also satisfy the determinant and hence, are "aligned."	where U_1, U_2, U_3 are functions of U only, and similarly for V, W, and T. Interpret U_1, U_2, U_3 as the X, Y and Z coordinates of a space curve. Then the curve can be plotted on X, Y, Z axes and calibrated in U. Similarly for V, W and T. Values of U, V, W and T which satisfy the original equation satisfy the determinant and hence, are "coplanar."

$$\begin{vmatrix} 0 & 0 & uU & 1 \\ G & 0 & vV & 1 \\ 0 & K & wW & 1 \\ \frac{uwG}{uv+vw+wu} & \frac{uvK}{uv+vw+wu} & \frac{uvwT}{uv+vw+wu} & 1 \end{vmatrix} = 0$$

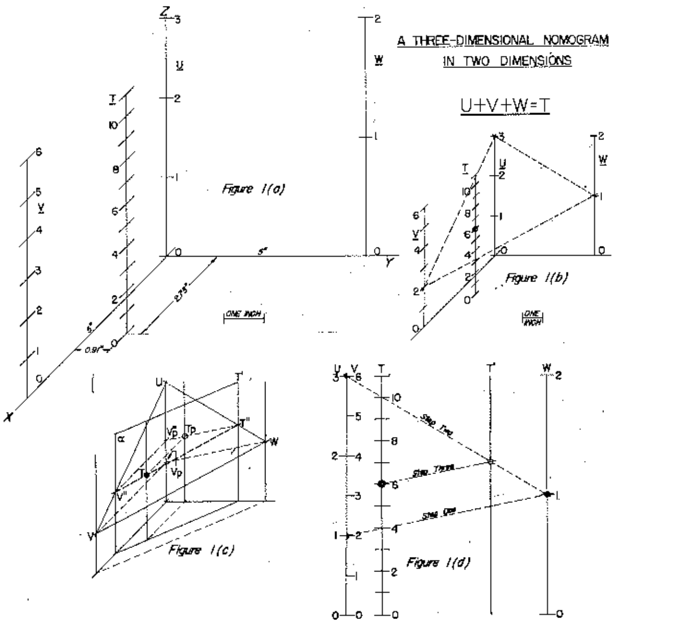
Coordinate Interpretation: X, Y, Z

where u, v, w, G and K are constants.

A space nomogram for this determinant appears in Fig. 1 (a), for u = 2, v = 1, w = 3, G = 5, and K = 5. The T-scale is located at X = 2.73; Y = 0.91 and the scale factor of the T-scale is 0.546. In Fig. 1 (b), a solution plane is shown for U = 3, V = 2, and W = 1. Pictorially, it appears that this plane cuts the T-scale at T = 6. Fig. 1 (c) shows pictorially a descriptive geometry "cutting plane" device for finding precisely the intersection of the T-scale with such a plane. The cutting plane α has been passed through the T-scale parallel to the plane of the V and W scales, cutting the UW plane (Y,Z plane) in the vertical line T'. The ortho-

* Reprinted from the August, 1955 issue of PRODUCT ENGINEERING by special permission.

graphic projection of the entire figure onto the U, W, (Y, Z) plane is now used. Here the line $T'' V''_p$ is parallel to the known line Wv_p, also $\bar{V}_p = \bar{V}$ and the projected figure



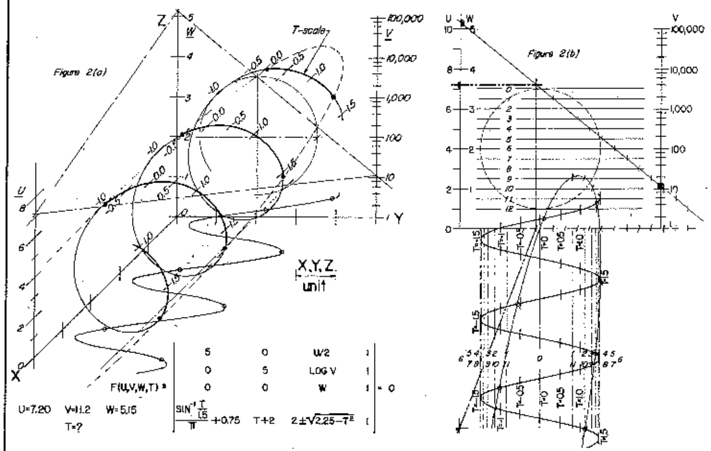
takes the form shown in Fig. 1 (d). A conventional double-alignment diagram could also solve this particular equation, but the method shown here will be useful later.

2. *Method of Numbered Line Pairs.*: Fig. 2(a) shows pictorially a three-dimensional nomogram for a function of U, V, W and T where the U, V and W scales are vertical, straight lines at three corners of a rectangle and the T-scale is a helix with a horizontal axis, and component projections on the two coordinate planes are as shown.

The projection on the YZ plane is defined by the combined behavior of the Y and Z T-functions in the determinant form of the equation. Since $Y = T + 2$, $T = Y - 2$, $(Y - 2)^2 + (Z - 2)^2 = (1.5)^2$ and the YZ projection is a circle, center at 2, 2, radius 1.5. In the X, Y plane, $Y = T + 2$, $T = Y - 2$, $\bar{Y} - 2 = 1.5 \sin (X - 0.75)\pi$ and the X, Y projection is a sine curve of period two units, amplitude 1.5 units, zero point (0.75,2). Graduations of T will appear on this curve according to the equation $T = Y - 2$.

Values of U, V and W could be assigned such that the plane determined by them would not cut the T-helix at all, indicating there is no solution in T for these values of U, V, W. Or, a plane cutting the helix and lying parallel to its axis could determine an infinite number of solutions.

In. Fig. 2(A), the values of U = 7.20, V = 11.20, W = 5.15 are shown as determining a solution plane. This plane cuts the helix cylinder in an ellipse, helix and ellipse meeting at points where the plane cuts the



helix-at values of T which are solutions. The bold-line portions of the helix lie above the plane and end at the ellipse--at these very T-values. Calibrations have been shown only for these bold portions of the T-curve. There are some fourteen intersections, seven of which are shown. They certainly could not be found readily by trail and error.

With descriptive geometry, it is possible to represent this space diagram and effect its solution by establishing the projection of the ellipse in Fig. 2 (b). This shows the two projections of the T-curve previously discussed and also twelve numbered section planes seen on edge in the circular view. Their lines of intersection with the cylinder are shown in the lower view, numbered correspondingly. A horizontal plane through U = 7.20 will cut a horizontal masterline from the U, V, W plane shown by its two projections in Fig. 2(b). Each of the twelve horizontal section planes cuts lines parallel to this from the U, V, W plane which can be drawn in the lower view and numbered as soon as the masterline has been established. Then in the lower view, a line from the cylinder and a line from the plane with the same number are coplanar and determine a point common to both the U,V,W plane and the cylinder--namely one on the desired ellipse. The projected ellipse cuts the projected T-curve at values of T which are solutions of the given equation.

3. *Method of Doubly-Indexed Scales.* The third descriptive geometry technique involves calibrating each scale in a given orthographic view both in the value of its variable and also (along the other side of the scale stem) in its space coordinate perpendicular to the plane of that view. Let an equation be given by

$$\begin{vmatrix} U & 5 + \frac{1}{5}(U-5)^2 & U & 1 \\ V+1 & V & 2V & 1 \\ W-1 & 10 - \frac{1}{10}(W-10)^2 & W & 1 \\ 10-T & T & T & 1 \end{vmatrix} = 0$$

Coordinate Interpretation

X Y Z

In Fig. 3, two views are given of U, V, W and T curves for the above equation. V and T have straight scales, the other two are curves. In the upper view (YZ), a

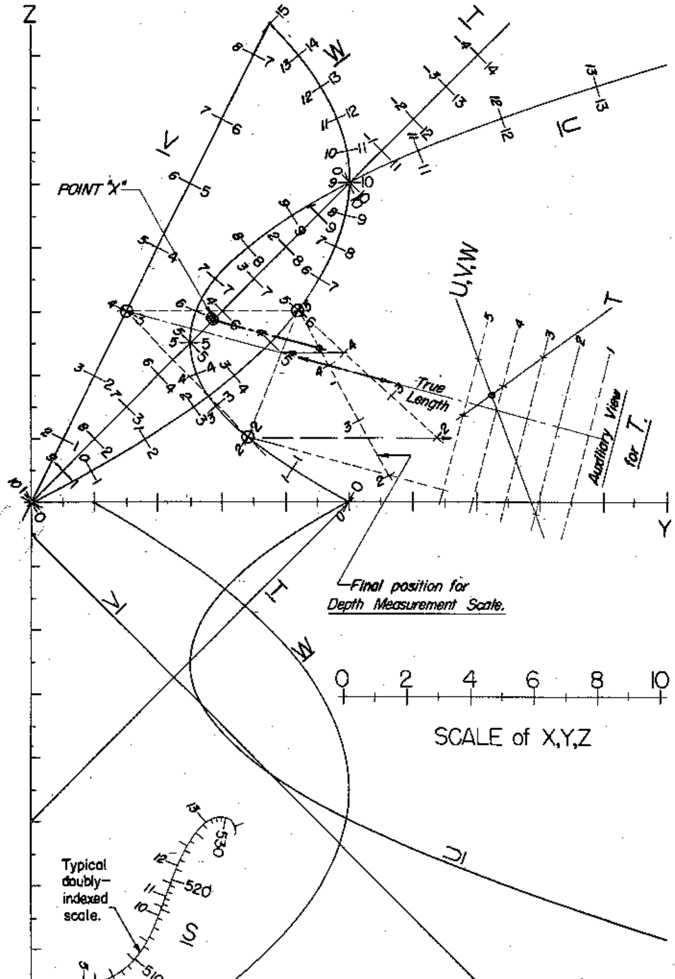


Figure 3

vertical calibration is the value of the variable at that point, the inclined calibration is the X-coordinate of the curve at that point. Now the X- Y view can be discarded. Values U = 2, V = 3, W = 6 have been circled and joined to indicate a solution plane. Several methods are available for determining the value of T where the T-scale is cut by the plane. For example, an "auxiliary view" which shows the plane on edge will show it cutting the T-scale at this value. Such a view could be found in the direction of "constant X-value" of the solution plane because this direction is parallel to the Y, Z plane. Thus for instance, for V = 3, X = 4; U = 2, X = 2; W = 6, X = 5, one finds by proportional division the point on line U = 2, W = 6 such that X = 4. When joined with V = 3, X = 4, the direction of the strategic edge view is indicated. In the auxiliary view taken in the direction of the double arrow the "levels" represent values of X and can be chosen to any convenient scale. In this view, the U, V, W plane is seen on edge cutting the T-curve at the answer-value of T, point "X."

Applications

To illustrate the application of the first technique consider the following fifth degree equation

$$x^5 + A''x^4 + A'x^3 + B'x^2 + C'x + D' = 0$$

This can have the fourth power of x removed by reduction of the roots by a real value, when it becomes

$$x^5 + Ax^3 + Bx^2 + Cx + D = 0$$

This can be put in the canonical nomographic form

$$\begin{vmatrix} 0 & 0 & -A & 1 \\ 15 & 0 & -B & 1 \\ 0 & 15 & -C & 1 \\ \frac{15x^2}{x^3+x^2+x} & \frac{15x}{x^3+x^2+x} & \frac{(D+x^5)}{x^3+x^2+x} & 1 \end{vmatrix} = 0$$

Coordinate Interpretation
X *Y* *Z*

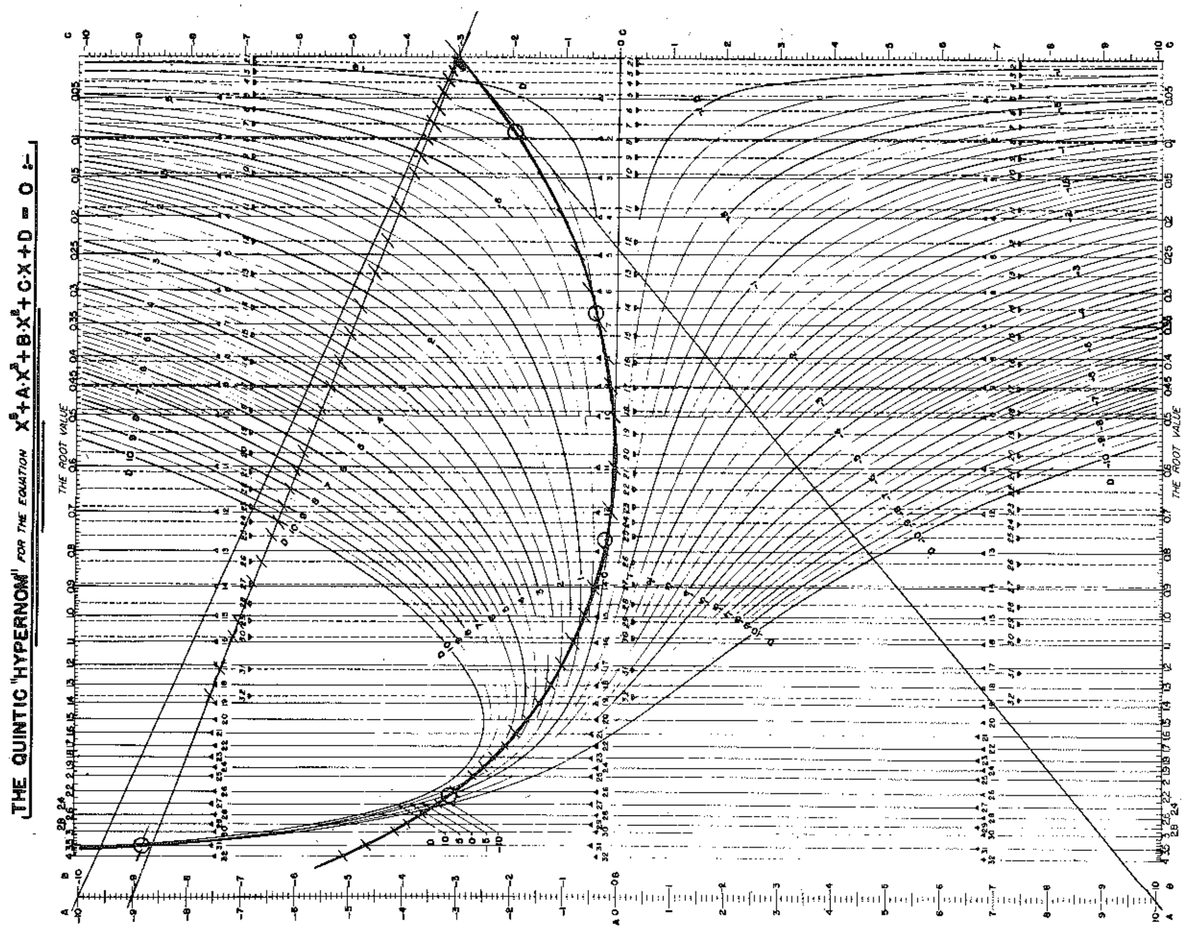
where A,B, C range from -10 to 10 and the chart is 15 units wide and 20 units high. The determinant should be checked by expansion to show that it does represent the equation. The A, B, C scales are uniform and lie upon straight, vertical lines. For constant x, D enters only into Z, so constant x-value is represented by a vertical line with known X, Y coordinates and graduated uniformly in D. Taken together, these x-lines trace a vertical cylindrical surface whose X, Y projection has the equation

$$X = \frac{15x^2}{x^3 + x^2 + x}; \quad Y = \frac{15x}{x^3 + x^2 + x}$$

Within the chart area, this is a smooth, convex curve. Curves of constant D wind in space over this cylindrical surface. When values of A, B, C and D are specified and x sought, a plane in space is determined by the first three which cuts the cylindrical surface in a smooth curve. The intersection of the latter with the D-curve lies on the vertical x answer-line.

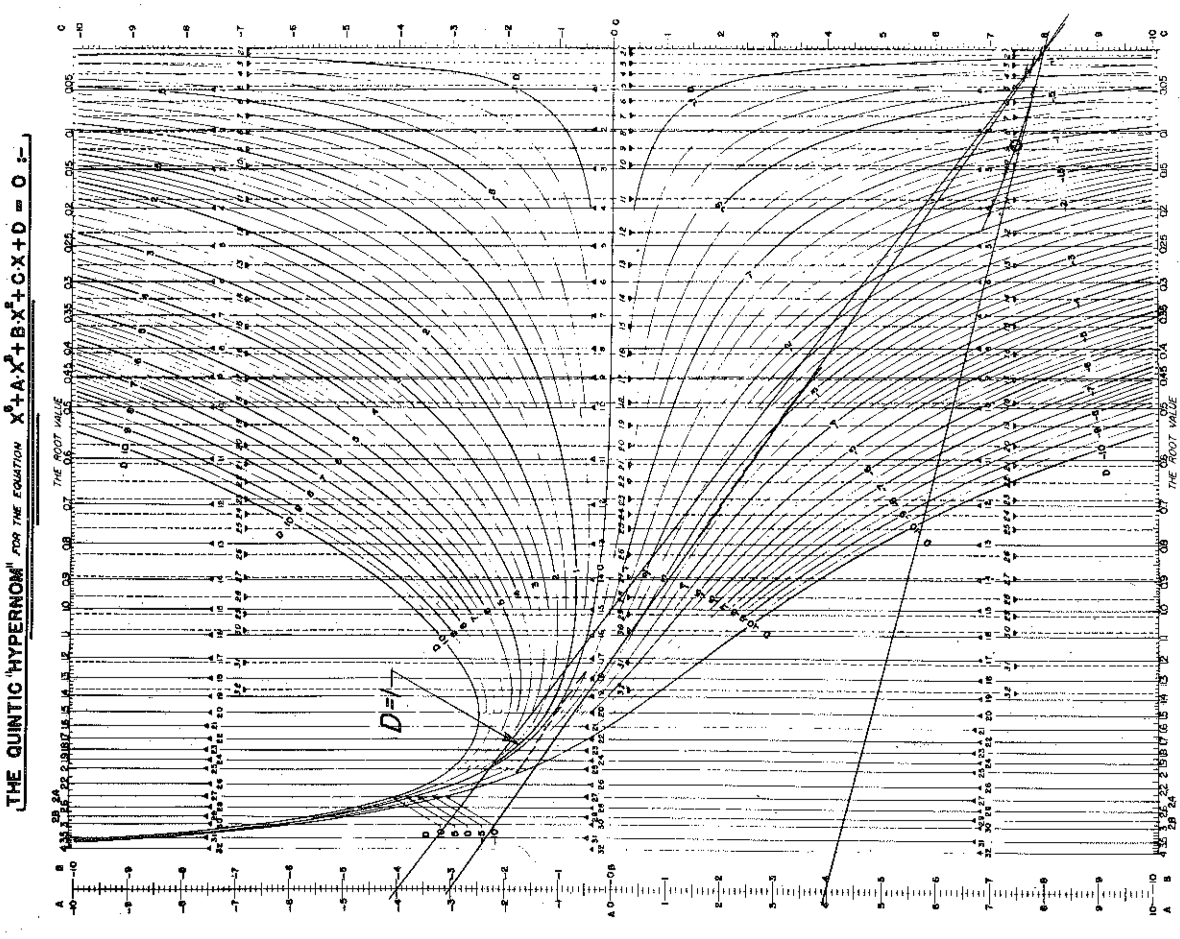
Fig. 4 shows the two-dimensional representation and use of this nomogram. It is based on Fig. 1(d) which was: (1) a projection of the space configuration onto the UW plane, plus (2) a T' line derived from the T line by a section plane $\measuredangle$ parallel to the VW plane. Correspondingly, in the present case: (1) the entire space configuration is projected onto the AC (Y,Z) plane, and (2) each x-line is carried into an x'-line by a section plane passing through it and parallel to the plane of scales B and C.

The graduations of the x-scales are given by the passage of D-curves across them. Each pair of x (solid) and x' (dotted) lines is correlated by being given the same serial numbers (vertical and inclined respectively), and is then used exactly as theT and T' lines were in Fig. 1; A of Fig. 1 corresponds to U, Fig. 4, B to V, C to W, and x to T. Each solution on an x-scale gives one point of a curve. This is the curve of intersection of the x, D cylinder and the A,B,C plane as projected on the AC plane (YZ-plane). Wherever this projected curve



$X^5-9X^3+10X^2-3X+0.2=0$

Figure 4(b)



$X^5-3X^3+4X^2+8X-1=0$

Figure 4(a)

cuts the given projected D curve, there lies a vertical solution line in x. In the working nomogram, the projected curve of the intersection always lies within the sector ACB, passing from C to A and arching toward B.

Practical use of the chart is quite rapid because the only portion of the projected intersection curve which needs to be drawn is that which stands some chance of cutting the D-curve. This portion can be identified by inspection. The chart is made for positive roots of the quintic but yields negative roots on reversal of the signs of B and D. Multiple roots are indicated by tangency of the intersection curve with the D-line. Horner's or Newton's methods are natural complements of the chart, deriving their basic roots from it before refining them.

If a fourth degree equation has the third power missing, it can be multiplied by x = 0 to become a reduced fifth degree equation in which D = 0 and the chart is applicable. For example, consider equation

$$x^5 - 3x^3 + 4x^2 + 8x - 1 = 0$$

On establishing lines AC and BC, it is clear from the path of D = - 1 that there will be only one real, positive root. Two or three points establish the curve and root x = 0.13 (refined value x = 0.1294).

Reversing signs of B and D, the AC line remains the same and curve D = + 1 cuts through a limited portion of the new sector. A few points show that the projection of the intersection curve will not cut D = + 1. Hence there are no negative roots.

TENTATIVE PROGRAM: ANNUAL MEETING AND 1956 SUMMER SCHOOL

Iowa State College, Ames, Iowa

Professor W.E. Street, Chairman of the Division, has sent to the JOURNAL the tentative program for the 1956 Annual Meeting and Summer School to be held at Ames, Iowa. Professor Street emphasizes that there may be some changes and a few additional items on the agenda. In fact, he has stated that suggestions are still very much in order and that he will be glad to receive them at any time.

TENTATIVE PROGRAM:

Wednesday, June 20:

4-6 PM Registration
7:30 PM Informal Meeting

Thursday, June 21:

8-9 AM Registration
9-12 AM Opening Session; J.S. Rising, Presiding:
Welcome - J. Downie Smith
Response - W.E. Street
Objectives of Engineering Drawing in Engineering Education
Correlation of Engineering Drawing Courses
Drawing for Tomorrow
Panel discussion

2-5 PM Second Session:
Motivation Needed in Teaching Engineering Drawing
Creative Problems for Basic Engineering Drawing
Drawing and Descriptive Geometry Courses Which Comply with the ASEE Evaluation Report for 1952-55
Panel Discussion

7-10 PM Third Session:
To be arranged

Friday, June 22:

8:30 AM Group Picture

9-11 AM Fourth Session:
Should the Content of Drawing Courses be Influenced by Requirements of Government and Industry?
How does Unionization Affect the Teaching of Drawing?

11-12 AM Graphics and John Deere Cotton Picker Spindle Des Moines Works

1-5 PM Inspection Trip - John Deere

7-10 PM Dinner (ladies included)
How is Pictorial Drawing Taught at________?
A Surprise
Tour of Exhibits

Saturday, June 23:

9-12 AM Fifth Session:
Simplified Drafting - A Curse or a Blessing?
Simplified Drafting as Practiced by the Bureau of Ships
How to Teach Tolerance Dimensioning to Freshmen
Dimensioning - True Position, etc.
Panel Discussion

2-5 PM Sixth Session:
Teaching Drawing Freehand
How to Make and Use Teaching Aids
Changes in 1946 Drawing Standards
Should Drawing Standards be included in Freshman Drawing?
Panel Discussion

6 PM Executive Committee Dinner

Sunday, June 24:

3-6 PM Reception at the Home of J.S. Rising

Monday, June 25:

9-12 AM Seventh Session:
To be Arranged

2-5 PM Eighth Session:
Elementary Nomography
Movable Scale Nomographs
Lecture Demonstration with Audience Participation on Nomograms for Beginners
Advanced Nomograph Problems with Audience Participation

Tuesday, June 26:

2-5 PM Joint Conference with English
Theme: Esthetic Functions of our Disciplines.
To be Arranged

6 PM Dinner
Awards; Speaker

Wednesday, June 27:

12 Noon Luncheon - Business Meeting, Etc.

2-5 PM Joint Conference with Mathematics
Graphical Approach in the Study of Calculus
An Operational Symbolism for Graphical Processes
Graphical Analogies of Mathematical Processes

The "Final" program will be announced in the May JOURNAL. The Ladies' program is in process of arrangement,

ANSWERS TO SOME QUESTIONS

By

Herbert W. Zimdars
Madison Vocational and Adult School
Madison, Wisconsin

Apparently the JOURNAL OF ENGINEERING DRAWING is published primarily for Engineering Drawing Divisions of Colleges. However, from the point of view of a good many Secondary and Vocational School teachers, as well as those people engaged in the field of drawing in industry, this should not be. As an entering wedge for a broader approach to problems relating to drawing, I am submitting the following answers to the questions on page 39 of the November, 1955 issue of the Journal.

1. *How do you challenge the interest of exceptionally good students?*

Since in our Vocational School curriculum most of the instruction is on an individual basis, it is easy to offer new and advanced material to students who are ready for it. This material may be in the field of descriptive geometry, advanced machine drawing, architectural drawing or information relating to these fields.

2. *How do you boost - or blast - simplified drawing*

Simplified drawing is not new. It is almost twenty years since the writer encountered this idea in industry. An attempt was made to simplify dimensioning of more or less standard shaft items by using prepared prints which required only the writing in of the proper dimensions. This attempt was not successful, and in most cases it will be found that the application of this ides will be very, very limited and that the engineering work will he hindered rather than helped.

3. *How do you feel about nomography in your courses?*

Many excellent nomographs can be obtained from current engineering or industrial publications. If it is desired to give instruction in this field, suitable material can undoubtedly be found. However, this instruction should be brief.

4. *Should we concern ourselves with the "needs of industry" or with the "needs of the student" or are they one and the same?*

If the answer to this one is straightened out and presented in its proper sequence, the paradox disappears. The student is the first consideration. He needs instruction and training which must be at his own level. Consequently much of the material and many of the teaching devices used will have immediate value only, but in the larger sense, unless his training is directed into channels preparing him for absorption into industry, both he and the school will have failed.

5. *Why teach descriptive geometry?*

Picture a drafting room in industry. Here are many draftsmen and some engineers all well trained in the simpler phases of engineering drawing, but only the head man, we'll say, knows anything about descriptive geometry. Some engineering department. Eh, what!

6. *What are your theories about "integration"?*

De-emphasize integration of subject matter in drawing courses. Give as many full time drawing courses as possible, and include as much material as can be fit into the courses.

7. *How do you "integrate" engineering drawing and descriptive geometry in your school?*

Since I am writing about a Vocational School, this question does not apply to us. As a suggestion I would offer the idea that the term "functional" should be kept very prominently in mind. Where integration is unavoidable the basic principles should be emphasized and the curriculum should be designed to attain that goal.

8. *Should high school drawing be required of entering freshmen engineers?*

Yes, but an introductory course should be offered to those requesting it.

As a teacher of drawing on the secondary level, I am in a position to see the results of training in the drawing room. I can't conceive a situation where a boy without any drawing or any idea of drawing can readily fit into a college class in engineering drawing. I am thinking, of course, of the demands that a professional school makes of its students, of the pressure under which a boy labors when he is in the process of making an adjustment from a secondary to a college level; and I am also aware that with the brief time allotted to it the engineering drawing class must work at an accelerated speed. Consequently, in justice to all concerned, guide the pre-engineering student into mechanical drawing in his high school days and avoid the rigors of the initial breaking-in period.

9. *If so, how do we judge the quality of the high school work?*

A year of drawing in any high school should be accepted. During a year of high school drawing any boy should become acquainted with the basic tools of drafting and the techniques related to their use and also acquire a foundation in orthographic projection and the dimensioning of views. Any additional knowledge would, of course, be welcome but not essential.

POWER THREADS — A TEACHING-AID BOOKLET

By

Hiram E. Grant
Washington University

The following four pages of illustrations comprise a booklet which is used to supplement our lectures in engineering drawing.

Figs. 2 to 13 are the sequence of steps recommended for laying out a multiple R.H. acme thread.

Figs. 6 and 9 stress the use of the lead and L/2 to establish the slope of the crest lines.

Figs. 12 and 13 stress the visible portion of the back crest line.

Buttress and square thread problems are assigned. The student is expected to apply the basic steps (omitting the pitch diameter) of the acme thread in laying out these two threads. This is done quite readily by the student without further explanation.

Except for Figs. 17 and 31, Figs. 16 to 33 give various practical considerations for the use of these threads.

Fig. 16 calls attention to the use of the split nut for quick return mechanisms. Attention is also called in lecture to the use of the national standard thread in split nuts in shop dividers and the Vemco quick adjusting large bow drafting compass.

Figs. 18 and 19 feature the engaging button which makes it easier to engage the external thread with its mating thread. Fig. 19 calls attention to the use of a relief to obtain only good threads.

Figs. 20 to 30 deal with the thin or relatively thin edge run-outs to the three types of threads illustrated and what may be done to strengthen them.

Figs. 21, 22 and 24 show how the run-outs may be strengthened by an end mill or milling cutter. Fig. 27 shows cross-sections of the run-outs created by the squared off end of a threaded shaft or hole.

The run-outs may also be strengthened by a 45° chamfer of the end of the shaft and hole. The cross-sections of these threads as they are increased in cross-section are shown in Fig. 28.

Fig. 20 calls attention to the method of counting of the thread multiple or starts, a term frequently used in industry.

Fig. 31 gives the basic dimensions of the new American and British standard form of buttress thread.

Fig. 32 features the conventional thread representation of a helix, and explains how the helix angle is obtained and where it is used in industry.

Fig. 33 calls attention to the effect of load of the various threads on the thread of a nut by the various threads, explains why one thread is preferred to another and the difficulty of machining the square side or sides of threads.

We have found booklets of this type helpful in this and other phases of the course for they make it easier for the student to read the large illustrations. They are also a good means of presenting practical aspects to supplement theory. The practical aspects create greater interest in the course; this in turn speeds up the course, making it possible to include more material.

Similar booklets may be printed quite inexpensively by offset printing. The typed material in this booklet was typed on an IBM executive model typewriter. The type is a little larger than pica. All illustrations and typing have been reduced one-half.

Each illustration may be drawn on a separate sheet of paper and the captions may be typed on still different paper. The illustrations may be trimmed with a pair of shears to within 1/8" of the lines of type though a 1/4" space is preferred. The illustrations may then be rubber cemented to a large single sheet in the desired arrangement. If any of the edges of paper about the illustrations should show on the negative, the lithographer will opaque them out. Rubber cement is preferred to glue because it does not shrink and wrinkle the paper. White drawing paper is preferred to tracing cloth. Mistakes may be covered up (of course none is ever made by drawing teachers) by painting over the mistakes with Opacitone which incidently may be thinned with water. Typing will reproduce best when typed on white enamel (coated) paper which any paper wholesaler can furnish. The illustrations and captions for the following four pages were prepared on over 100 separate pieces of paper of varying sizes. All were rubber cemented to four sheets to form four pages but none of the edges of the separate pieces of paper shows in the printing.

Note the finer visible lines of Fig. 14 compared to several of the more "open" illustrations like the following one. Lines close together should be finer than those used in Fig. 15. The visible lines of Fig. 15 are between 1/30 and 1/40 of an inch.

POWER THREADS

(ACME, SQUARE & BUTTRESS)

PAGE I

TYPICAL THREAD NOTES

$1\frac{1}{2}$" - $\frac{1}{2}$" PITCH-TRIPLE ACME
$1\frac{1}{2}$" - $1\frac{1}{2}$" LEAD-TRIPLE ACME
$1\frac{1}{2}$" - $\frac{1}{2}$" PITCH - $1\frac{1}{2}$ LEAD ACME
$1\frac{1}{2}$" - $\frac{1}{2}$" PITCH - 3 START - ACME

FORMULA

Lead = Pitch x Multiple
$L = P \times M$

$P = \frac{L}{M}$ $M = \frac{L}{P}$

Pitch Diameter = Outside Diameter $- \frac{P}{2}$

$P.D = O.D. - \frac{P}{2}$

Note: If Pitch, Lead or Multiple is unknown, use formulas listed above.

EXAMPLE of COMPUTATION of THREAD DATA

(See thread note.)
$L = P \times M$
$L = \frac{1}{2}" \times 3 = 1\frac{1}{2}"$
$P.D. = O.D. - \frac{P}{2}$

$P.D. = 1\frac{1}{2}" - \frac{\frac{1}{2}"}{2} = 1\frac{1}{4}"$

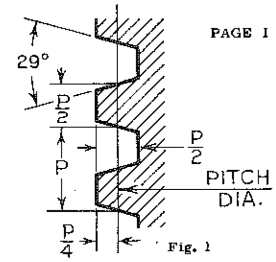


Fig. 1
ACME TOOTH DIMENSIONS

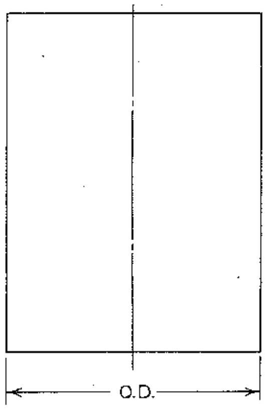


Fig. 2
LAYING OUT the OUTSIDE DIAMETER (O.D.)

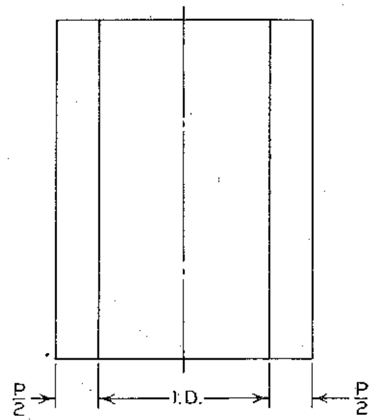


Fig. 3
LAYING OUT the INSIDE DIAMETER (I.D.)

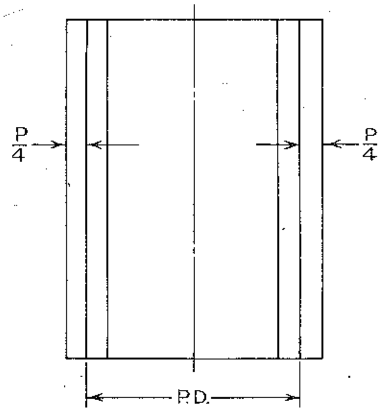


Fig. 4
LAYING OUT the PITCH DIAMETER (P.D.)

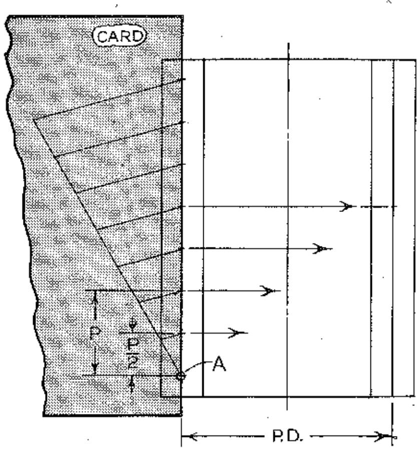


Fig. 5
LAYING OUT TOOTH SPACES (P and P/2)

Layout a number of P/2 values on the edge of a card by the parallel line method. Project P/2 marks to opposite side as shown.

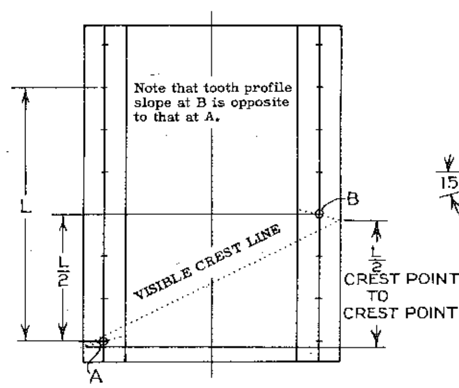


Fig. 6
ESTABLISHING ONE SIDE OF TOOTH PROFILE ON OPPOSITE SIDES OF DRAWING

Slope at B must be in the direction which will give the crest line an advancement of $\frac{L}{2}$.

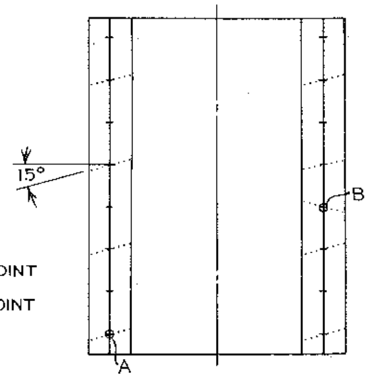


Fig. 7
STARTING the TOOTH PROFILE

Alternate thread profile slopes will be in the same direction. Conventionally use 15° for the slope of the profile.

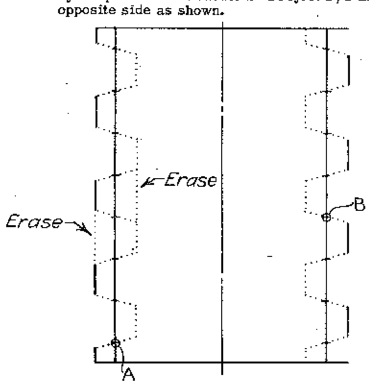


Fig. 8
OUTLINING of TOOTH PROFILE COMPLETED

Erase indicated construction lines.

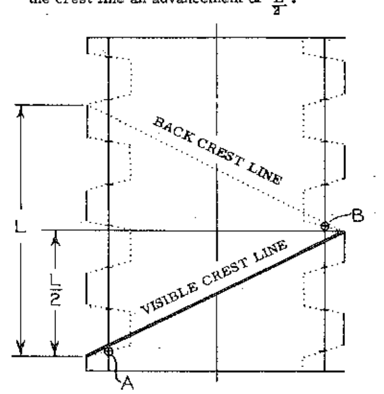


Fig. 9
CONNECTING CREST LINES for R.H. THREADS

Note use of the lead L and $\frac{L}{2}$ in establishing the slope of the crest lines.

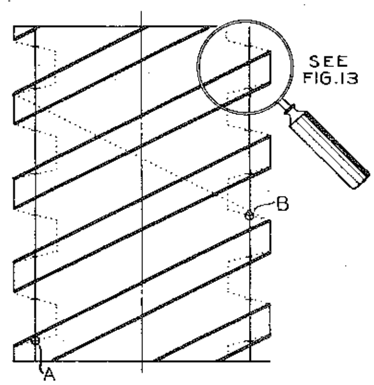


Fig. 10
DRAWING VISIBLE CREST LINES

All crest lines are parallel.

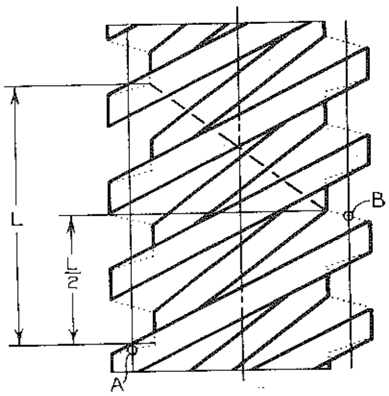


Fig. 11

CONNECTING ROOT LINES for R. H. THREADS

The root lines also must have their slope based on $\frac{L}{2}$. Connect root corners as indicated. Note that the crest covers one of the sides of a tooth profile and part of a root line.

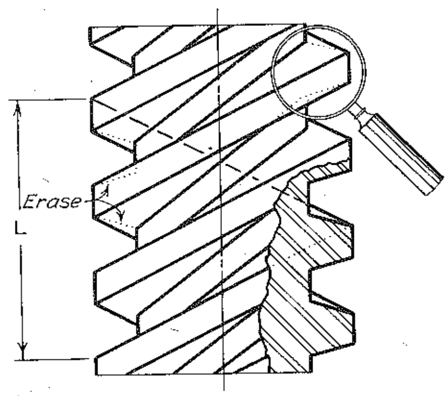


Fig. 12

DRAWING VISIBLE BACK CREST LINES

Whenever the helix angle is greater than $14\frac{1}{2}°$ a portion of each back crest line will show. Using the lead L as shown establish the slope of the back crest line. Tooth profile lines locate the root corners but are later erased.

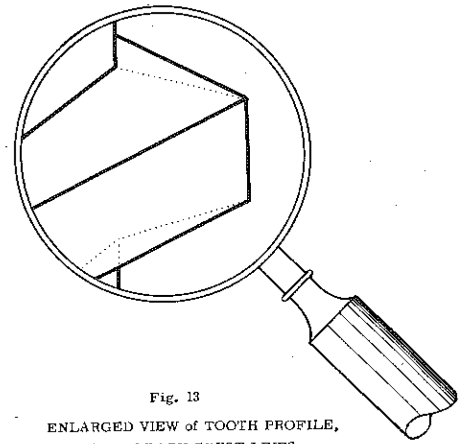


Fig. 13

ENLARGED VIEW of TOOTH PROFILE, CREST and BACK CREST LINES.

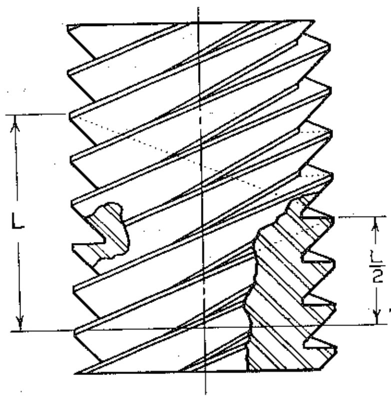


Fig. 14

OLD STYLE QUINTUPLE BUTTRESS THREAD

Note use of L and L/2 to establish crest lines. Next lay out tooth profiles then proceed according to laying out of acme threads. Omit pitch diameter. Depth of thread is 3/4 P. Width of crest is 1/8 P. Slope of inclined side of tooth profile is 45°.

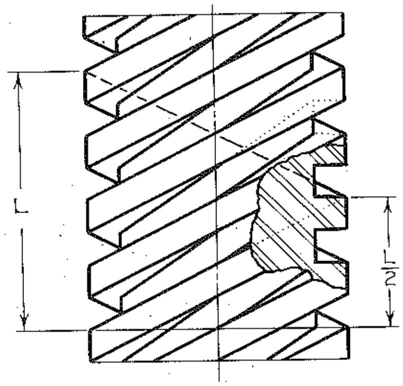


Fig. 15

QUADRUPLE (4 start) SQUARE THREADS

Note use of L and $\frac{L}{2}$ to establish crest lines. Next lay out tooth profiles then proceed according to laying out of acme threads. Omit pitch diameter. Width and depth of square thread is $\frac{P}{2}$.

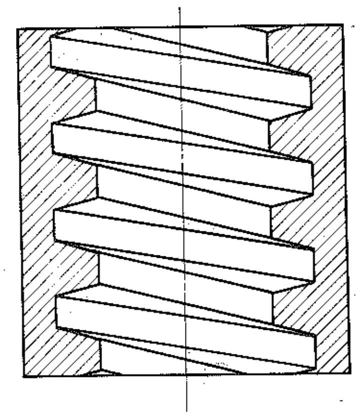


Fig. 16

SINGLE INTERNAL R. H. ACME IN SECTION SPLIT NUTS

The internal single acme is sometimes split lengthwise to form two half-nuts. The two half-nuts may be readily disengaged from the threaded shaft for quick returns. This eliminates the unscrewing of a nut from a long threaded shaft on lathes and other machines.

The helix angle must be less than $14\frac{1}{2}°$ before a nut may be split and used effectively.

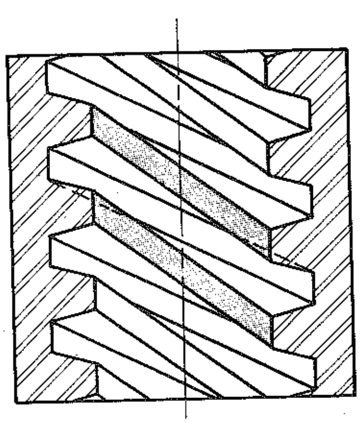


Fig. 17

TRIPLE INTERNAL ACME IN SECTION

Use L/2 to establish the slope of crest and root lines. Root lines show full as indicated by the shaded areas. When the crest lines exceed $14\frac{1}{2}°$ the root lines overlap them making a portion of the crest invisible. When this occurs the thread can not be used in a split nut.

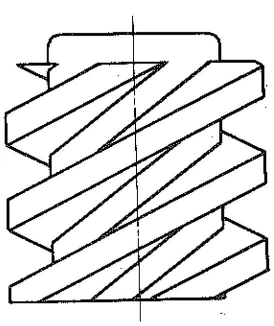


Fig. 18

ENGAGING BUTTON

This button makes it easier to engage the thread with a threaded hole. A chamfer on national standard threads is used for similar purpose.

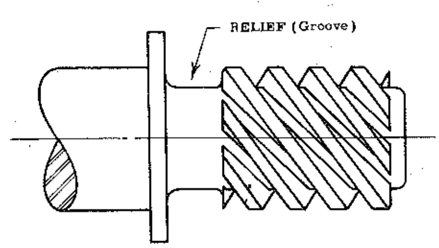


Fig. 19

EXTERNAL RELIEF

The relief (groove) at the shoulder is for the purpose of allowing the threading tool to produce full, perfect threads. The small fillets are to relieve stress concentration thus reduce breakage.

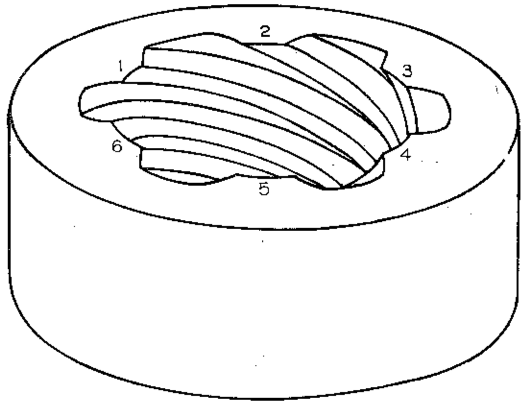


Fig. 20

SEXTUPLE (6 start) R.H. ACME

Note the start of the 6 separate threads, also those on Fig. 22.

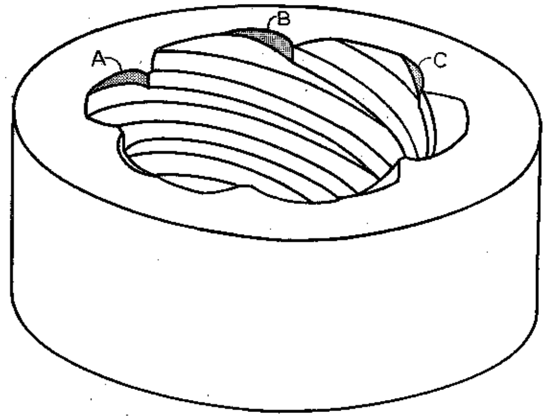


Fig. 21

SEXTUPLE (6 start) R.H. ACME WITH ENDS OF THREADS ENDMILL RELIEVED TO REDUCE DAMAGE TO THREAD ENDS.

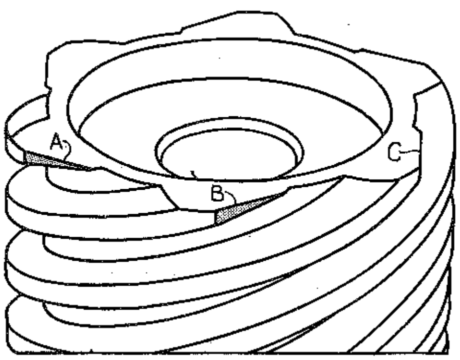


Fig. 22

SEXTUPLE (6 start) R.H. ACME WITH ENDS OF THREADS STRAIGHT RELIEVED TO REDUCE DAMAGE TO THREAD ENDS.
Horizontal line at bottom represents edge of photo from which this drawing was made.

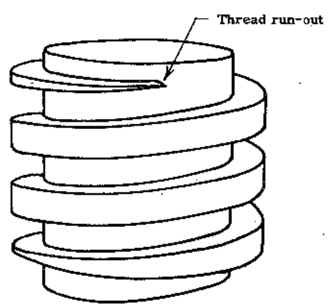


Fig. 23

SINGLE R.H. SQUARE

Note sharp run-out at end of thread.

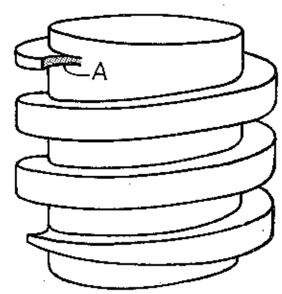


Fig. 24

SINGLE R.H. SQUARE

Run-out of thread end relieved by end-mill to reduce damage to thread ends.

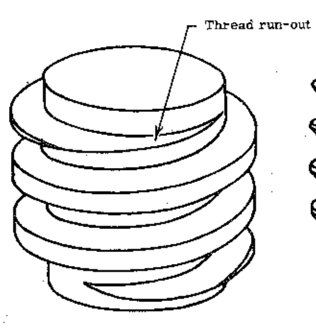


Fig. 25

SINGLE R.H. ACME

Note sharpness of run-out of end of thread.

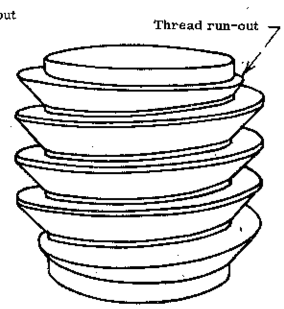
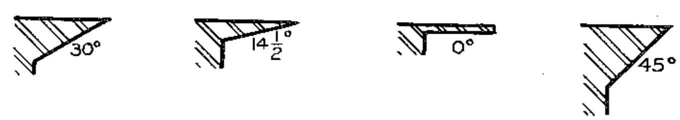


Fig. 26

SINGLE R.H. (old style) BUTTRESS

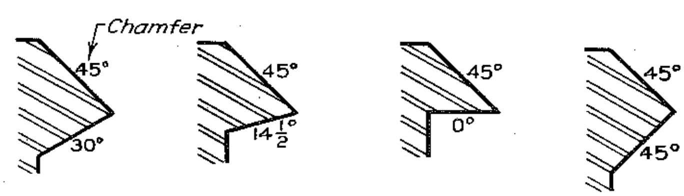
Note the run-out of thread end.



NATIONAL STANDARD — ACME — SQUARE — OLD & NEW BUTTRESS

Fig. 27

CROSS SECTIONS OF THREAD END RUN-OUTS. (See Figs. 20, 23, 25, 26)



NATIONAL STANDARD — ACME — SQUARE — OLD & NEW BUTTRESS

Fig. 28

CROSS-SECTIONS OF THREAD END RUN-OUTS WHICH HAVE BEEN STRENGTHENED BY 45° CHAMFERING OF END OF SHAFT AND HOLE.

The above pictorials are line drawing tracings of photographs. Line drawing pictorials of machines are frequently made by this method. The tracing is made over a "light" table.

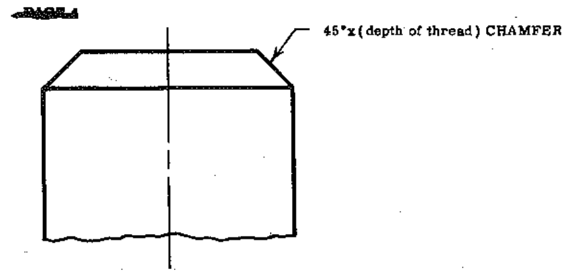


Fig. 29

45° CHAMFERING OF END OF SHAFT TO REDUCE DAMAGE TO THREAD ENDS.

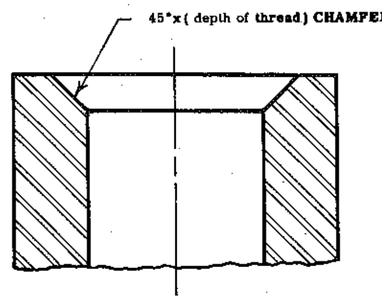


Fig. 30

45° CHAMFERING OF END OF HOLE TO REDUCE DAMAGE TO THREAD ENDS.

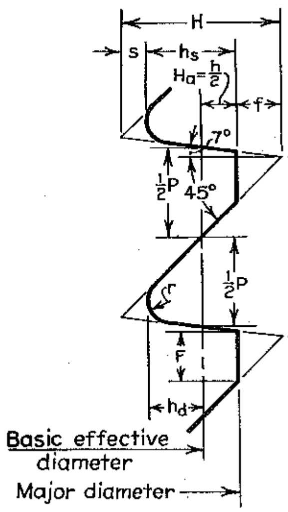


Fig. 31

NEW AMERICAN AND BRITISH STANDARD FORM OF BUTTRESS THREAD.

P = Pitch	r = .12055 P	F = .27544 P
H = .89064 P	h_s = .50586 P	h = .4 P
f = .24532 P	h_d = .30586 P	s = .13946 P

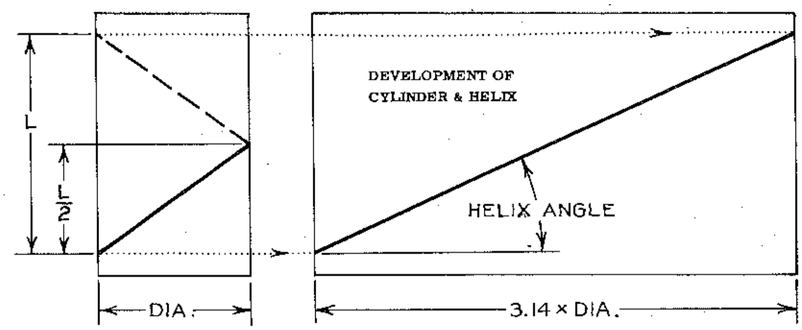
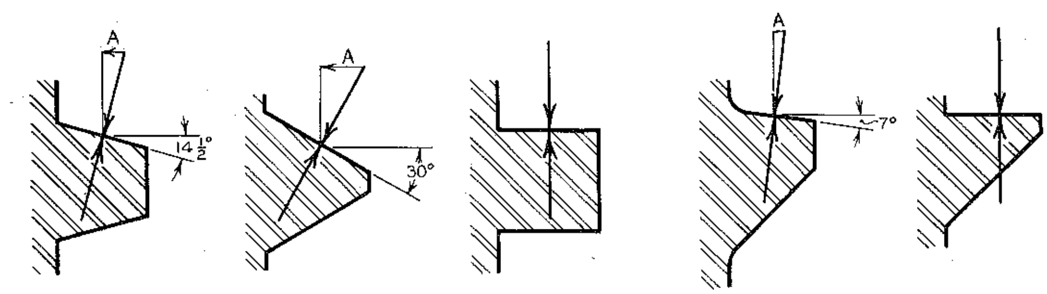


Fig. 32

HELIX ANGLE

The helix angle is obtained graphically as shown above. Mathematically it is the angle of the natural tangent of lead over circumference of the major diameter.

The helix angle is an important angle in the obtaining of precision threads and in the design and manufacture of gears.



ACME | NATIONAL STANDARD | SQUARE | NEW BUTTRESS | OLD BUTTRESS

Fig. 33

EFFECT OF LOAD ON THREAD OF A NUT

Whenever there is a load on the thread of a shaft there is an equal and opposite reaction by the thread of the nut. The forces created by the load on a threaded shaft upon the mating threads is perpendicular to the sides of the threads which are indicated above by large arrows. These forces may be resolved into two components with one component parallel to the axis of the mating threads and the other perpendicular to it. The components labelled A above represent the force tending to burst the nut. Since the component A of the national standard thread is so large it is not suitable for heavy loads.

The acme is very commonly used as a power thread because it is relatively easy to machine and has only a small component A tending to burst the nut.

The square thread is ideal for power threads because it has no component A tending to burst the nut. It is however very difficult to machine and is becoming less and less commonly used.

The old buttress thread likewise has no component A but is considerably easier to machine than the square thread. The square side is however difficult to machine.

The new buttress thread has only a very small component A tending to burst the nut due to the 7° angle as compared with the 14½° of the acme. The 7° angle considerably reduces the difficulties of machining the thread.

The buttress thread is replacing the square thread in such fields as aircraft, plastic moulding machinery and large screw jacks.

OBJECTIONS TO THE PROJECT METHOD OF TEACHING ENGINEERING DRAWING

By

James D. McFarland
The University of Texas

Today we hear a great deal about the shortage of engineers and the efforts being made by various groups of individuals to stimulate the interest of high school graduates in the study of engineering. As is well known, an appreciable percentage of these young men who undertake the study of engineering will never finish the training. It is our job as teachers to guide them into the field of endeavor in which their abilities and interests will enable them to make the greatest contribution.

Drawing teachers are in a favorable position to help a large number of these students to render a useful service to the engineering profession. Among those who do not have the aptitude or potential to become engineers, and who either drop out of school or pursue some other form of training, there will be a goodly number who will profit from their experiences with us. Many will have gone far enough in their studies to learn the fundamentals of the engineering approach to problems, and will be able to find employment profitable to themselves and to society.

It has been said that one of the objectives of engineering education is to develop in the student the ability to solve problems by efficient methods based on fundamental laws or principles. It is thought by some that the "project method" of teaching is the best for accomplishing this objective. I think the evidence is pretty strong that this is probably true in some courses, but it is equally false for others. This is especially so for basic courses of the freshman and sophomore level.

Let us define "project method." I believe that among educators the most common interpretation of it is the practice of assigning to individual students, or small groups of students, specific problems or projects. These problems are of a more comprehensive scope than those of the usual type employed in the course and are designed to tax the ingenuity and resourcefulness of the student. It is intended that he draw upon his past training, seek out needed source material, and carry out the solution of the project with a minimum of assistance. The student plans and executes the solution largely on his own initiative.

It follows, then, that the "project method" of teaching might be sucessfully employed in classes in which the students have had the necessary basic background material, and know how to obtain needed information from books and other sources to enable them to successfully complete the project.

Let us see how this method would apply to the teaching of engineering drawing. I am talking now of the basic course in engineering drawing and descriptive geometry given in every recognized engineering school in the country, and required for most engineering degrees. These are the courses we all teach, and which are constantly in danger of being crowded out of the engineering curriculum to make room for courses which some people think are more important. These are the courses which apparently some people believe should be taught by the "project method." At the college level, drawing is a course based on geometrical principles, and requires the study of a good textbook in addition to the patient and skillful guidance of the teacher. In fact, it requires more study then most of the students are prepared to give without considerable guidance. Our students are largely freshmen, most of whom come to use with poorly developed study habits, if any, and are incapable of intelligently reading technical literature. This does not mean that they will never become engineers, but it does mean that they are not ready for the "project method." Some will have had a little technical drawing in high school, often taught by the football coach and rarely ever by an engineering graduate. All will have had plane geometry. Our experience has been that very few of them have received or retained enough learning to enable them to locate accurately the center of a circle tangent to two lines. It is pure delusion to think these people would make any progress if assigned a project requiring any independent thinking or research and left to their own resources to do it.

In the case of students at my school we begin with the fundamentals, and by means of regularly scheduled lecture-recitation and laboratory periods, follow a planned schedule of work which leads to a fairly satisfactory conclusion at the end of the semester. The majority of the students emerge with a workable knowledge of the course, and a few are pretty good; but there are no geniuses. They have improved in their ability to learn from the printed page, learned how to make and read drawings, have become familiar with the idioms and conventional treatments and symbols peculiar to the graphical language, and now have the necessary background material for an elementary design project. As they increase in knowledge of shop work, machanics, strength of materials, and cost determinations, they will be fitted for more intriguing problems; but it is doubtful if more than a few are yet ready to assume the responsibility of undertaking a project requiring very much learning. After all, what is wrong with giving the student a thorough grounding in the fundamentals of drawing? It is the basis of all other forms of graphics, which are agreed to be the best method for recording and communicating information indispensable to the engineer. Does not the engineer of today, and throughout his profession, have to make drawings, approve drawings, or approve bids based on drawings? As a very minimum, he should have a thorough training in the fundamentals of this important subject.

When we look around us we see examples of the successful teaching of other basic courses analogous to drawing. English, mathematics, chemistry, physics, engineering mechanics, and strength of materials are all basic engineering course in which at least a year of training in fundamentals is necessary before a student can embark on any sort of project in which they are involved.

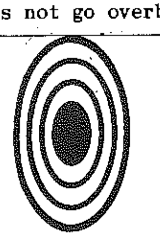
The project method of teaching is not new. The idea of applying it to basic courses probably is new. The undergraduate thesis represents one form of it which has been in use for many years. It has also been employed successfully in machine design courses. A number of laboratory courses in the various branches of engineering have used it to advantage. Its greatest use, however, has been in senior and graduate courses, and to my mind that is where it should be used. I have a feeling that most teachers use it in a simplified form when there is an opportunity, but call it another name. It has long been known that a student's interest in a course will be enhanced if he can see how the problems he solves will fit into his future work. We call these "engineering problems" or "practical problems." They are not projects. If they sound like engineering applications he is inspired to work harder on their solution than if they do not. It is a fairly easy matter to present interesting problems of this type in descriptive geometry and in some parts of the drawing course, but in the time allotted to drawing in most of our schools, the best we can do is give the student the best training possible in the fundamentals of the subject. If he learns this he can master all other forms of drawing.

It is generally agreed among drawing teachers, that effective teaching cannot result when the students of a class are engaged in widely different phases of the work. Group instruction and planned class work are impossible under such conditions. We have classes of from 20 to 40 students, and it is quite likely that this condition prevails in most engineering schools. As the project method is applicable only to small classes it is quite evident that if it were employed in the teaching of several hundred students the outlay for equipment, teachers, room space, and other facilities would become prohibitive. It contributes to both the cost of teaching, and the coverage of less subject matter. The importance of the latter is debatable in a good many courses, but maybe not too much so in the case of drawing. Most of us are allowed little enough time as it is. The cost of teaching, of course, is generally considered important.

At a recent Mid-winter Meeting of the Drawing Division of the A.S.E.E., one speaker made the following statement in favor of the "project method": "We are learning that a mucb more fruitful procedure is to immerse the student in bits of an unknown world and allow his mind to struggle to make the proper mental associations and the proper judgements, pulling him out of the morass when he goes too far wrong, and stimulating the proper associations by indirect suggestion in the middle of his struggle rather than always presenting them to him in a lecture prior to the problem." I maintain that the bulk of our students are already immersed in bits of an unknown world so far as engineering is concerned, when they first come to us, and if we hope to eliminate a lot of floundering around and enable them to get out, it will be necessary to guide and instruct them in building a firm foundation, and a ladder that will enable them to climb out. Engineering drawing is one of the rungs of this ladder.

In conclusion it seems, therefore, that we can say that for small classes there is considerable merit in the project method of teaching when used for upper level courses for whicb the student has the necessary background; but that it is unsuitable for courses of freshman or sophomore rank which are largely basic courses. Some of the teachers of senior and graduate courses who advocate the teaching of engineering drawing by the project method have forgotten that probably 75 per cent of our students never get them. I am afraid that too many of them are just vaguely familiar with the type of students with whom we work. Recently, I gave a problem on a descriptive geometry quiz in which it was required to locate and find the length of a brace supporting a bulk-head and fastened to a given point on the floor with a 45-degree bracket. Approximately one-third of the students did not know the meaning of either a bulkhead or a bracket.

Engineering drawing and descriptive geometry are the backbone of graphics, the common language of engineers in every country, and are just as basic and important in the training of an engineer today as they have ever been. Let us keep trying to improve our methods of teaching the fundamentals of the subject, but let's not go overboard for the "project method."



STATUS OF THE ASA Y-14 DRAWING AND DRAFTING PRACTICE STANDARDS

By

Ralph S. Paffenbarger
The Ohio State University

The ASA Y-14 Committee, jointly sponsored by ASME and ASEE, was reorganized November 30, 1948, and since that time has been busy organizing and producing drafting standards under several subcommittees. The scope of Y-14 was recently revised to read as follows:

The development of standards of recognized practices in engineering drafting including the following items but excluding architectural drawing practices and graphical symbols.

1. Size and format of drawings including border lines, title blocks, parts lists, revision lists, zoning and folding.
2. Classification of drawings including diagrams and pictorial representation and nomenclature used thereon.
3. Representation of objects for most effective interpretation.
4. Dimensioning, tolerancing and notation as required in production for various materials and processes.

The names and numbers assigned to the various subcommittees of this standard, together with their chairmen, are as follows:

1. Size and Format
   A.H. Rau, Executive Dept.
   Building #2, Room 457
   General Electric Company
   Schenectady 5, New York
2. Line Conventions, Lettering and Sectioning
   Professor H.C. Spencer
   Illinois Institute of Technology
   3300 South Federal Street
   Chicago 16, Illinois
3. Projections
   Professor C.J. Vierck
   Dept. of Engineering Drawing
   Ohio State University
   Columbus 10, Ohio
4. Pictorial Presentation
   Professor C.H. Springer
   Dept. of General Engineering
   University of Illinois
   Urbana, Illinois
5. Dimensioning and Notes
   Norman E. Brown
   Chief Designing Engineer
   The Taft-Pierce Mfg. Co.
   Woonsocket, Rhode Island
6. Screw Threads
   Prof. Warren J. Luzadder
   Dept. of Engineering Drawing
   Purdue University
   West Lafayette, Indiana
7. Gears, Splines and Serrations
   Harry H. Gotberg
   Vice Pres. & Chief Engineer
   Colonial Broach Company
   Box 37, Harper Station
   Detroit 13, Michigan
8. Castings
   Vacant
9. Forgings
   Charles M. McMabon, Chief Draftman
   Bay State Abrasive Products Co.
   Westboro, Massachusetts
10. Metal Stampings
    D.O. Hannan
    Western Electric Company, Inc.
    333 Sibley Street
    St. Paul 1, Minnesota
11. Plastics
    Herman Minneman
    Delco-Remy Division
    General Motors Corp.
    Anderson, Indiana
12. Die Casting
    J.N. Smith
    Alcoa Aluminum Co.
13. Springs, Helical and Flat
    Otto R. Hills, Chief Engineer
    The William D. Gibson Co.
    1800 Clybourn Avenue
    Chicago 14, Illinois
14. Structural Drafting
    R.P. Delano, Jr.
    E.I. du Pont de Nemours
    Wilmington, Delaware
15. Electrical Diagrams
    D.C. Bowen, RCA Victor Div.
    Camden, New Jersey
16. Tools, Dies and Gears
    Vacant
17. Hydraulic Diagrams
    Kenneth Court
    Hydraulic Circuit Supervisor
    Vickers Incorporated
    1400 Oakman Blvd.
    Detroit 32, Michigan
18. Extruded Products
    Vacant

The chart below gives the progress of the various committees to date. As noted, several are essentially completed but by action of the Executive Committee of the Sectional Committee none is to be released until the first five are completed. Subcommittee #5 is at present resolving their differences dealing with tolerancing and dimensioning. It is the sincere hope of all who are connected with this project that this may soon be accomplished. If and when Subcommittee #5 report is finished the first five will be made available. Subsequent committee reports will then be released when finished and all the reports will then constitute the American Standards Drafting Manual.

Y 14 SUBCOMMITTEE PROGRESS REPORT
As of October 18, 1955

Committee Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Project Assigned to Subcommittee	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Subcommittee Report	X	X	X	X	X	X	X		X	X	X	X	X				X	
Circulation of Subcomm. Rep.	X	X	X	X	X	X	X		X		X		X				X	
Final Technical Revision	X	X	X	X			X		X		X		X				X	
Sectional Committee Approval	X	X	X	X			X				X						X	
Editing	X	X	X	X							X		X					
Final Revision																		

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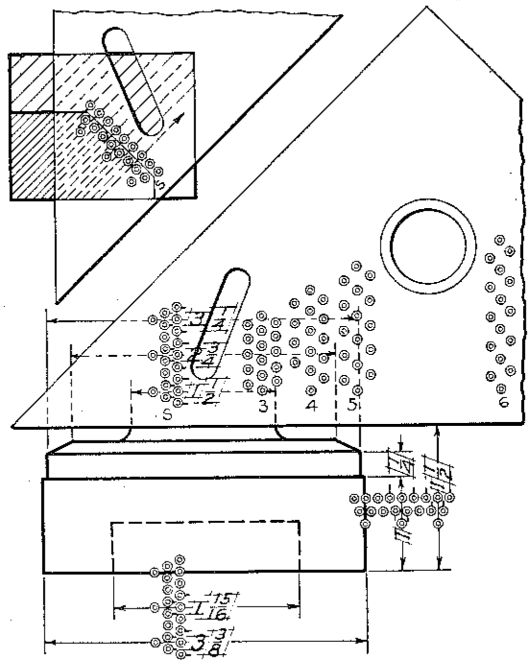

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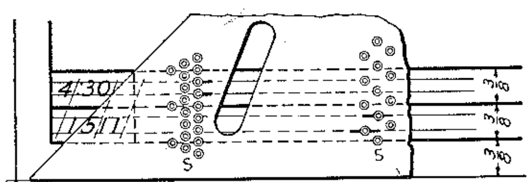

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6"-60
7"-60
8"-60
9"-60
4"-45
5"-45
6"-45
7"-45
8"45

6"-45 Brd.-Rowe

8"-45 Style "C"

Style "B"

5"-60
6"-60
7"-60
8"-60
9"-60
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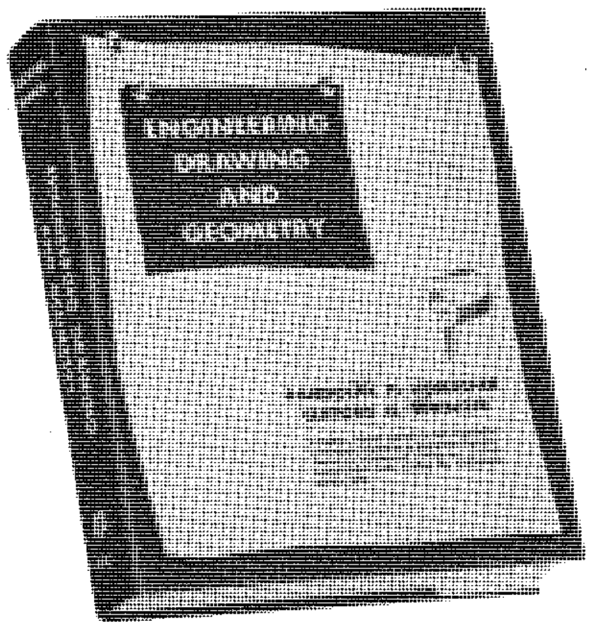

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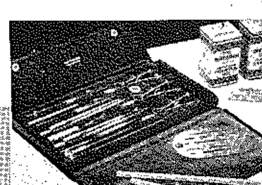

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