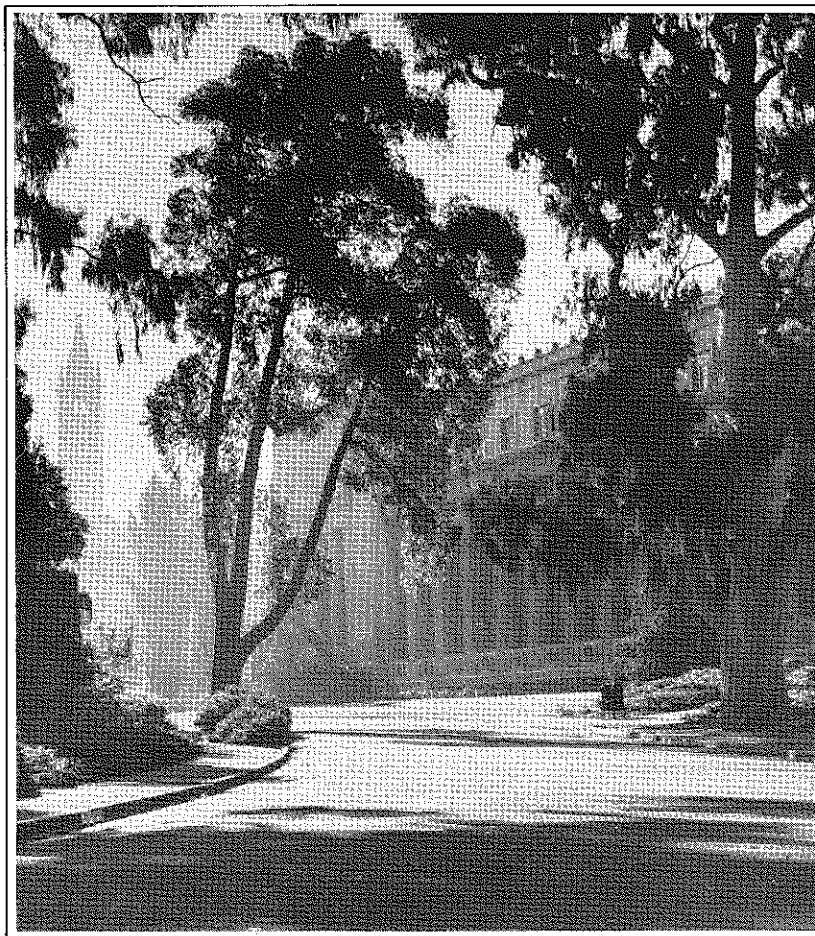
The Journal of Engineering Drawing



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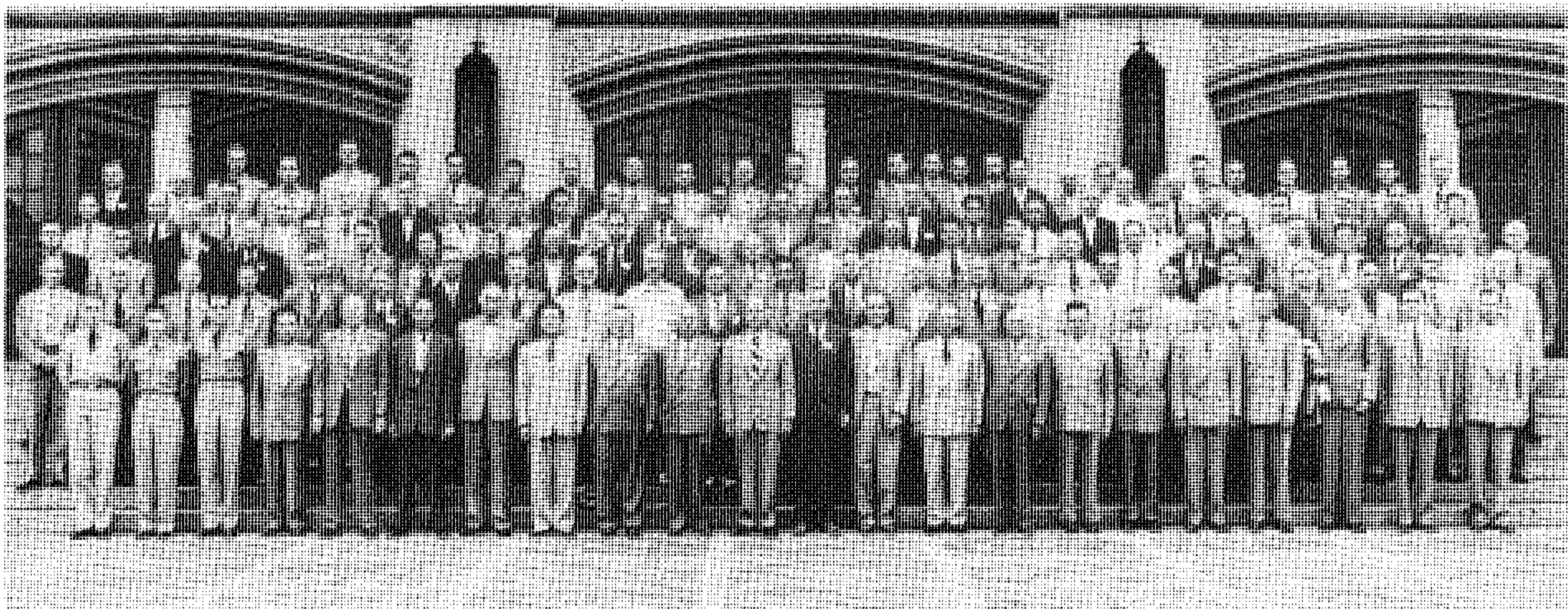

ENGINEERING DRAWING DIVISION SUMMER SCHOOL
AMERICAN SOCIETY FOR ENGINEERING EDUCATION
MICHIGAN STATE COLLEGE - EAST LANSING, MICH. JUNE 1951

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GENERAL EDUCATION THROUGH ENGINEERING DRAWING

by

Clifford H. Springer

Chairman Division of Engineering Drawing

As professional education has developed in this country, two somewhat opposing plans have come into general use. The legal and medical professions have chosen to add their professional work after the student has taken a more or less liberal or classical education. The engineering profession on the other hand has generally gone ahead on the theory that a liberal education can be obtained at the same time as a professional education. This method assumes that general education can be obtained through the medium of one course as well as another if the instruction is at a high enough level.

In recent years, there has been an increasing demand for the inclusion of more formal courses in the humanities and social studies. If engineering graduates are deficient in these respects, there seem to be only two conclusions; one, that the legal and medical professions chose the correct course, or that the teaching of engineering subjects has not been at a sufficiently high level. It does not seem logical to assume that the engineering profession can add a few courses here and there in an already overcrowded curriculum and thereby attain an education equivalent to the doctors or lawyers. The courses that can be added are necessarily the elementary courses that the other professions have used as a basis for their general education.

A few such courses may help, but if the engineering system is to be upheld, the "educational value of useful knowledge" and the idea of "learning by doing" as promoted by William Barton Rogers, founder of M.I.T., must be revitalized. To do this each engineering instructor must think in terms of education as well as subject matter.

A former teacher of logic who later taught descriptive geometry claims that he can teach logic through the medium of descriptive geometry as well as in a formalized course. Habits of concise, analytical and original thinking can be formed and developed through descriptive geometry if the instructor cares to make the effort. However, the course if taught by the Mongean method can very easily become a memory course, and if taught by the auxiliary plane method it may readily become one of manipulation. Drawing teachers, if they are to do their part in the education of the young engineer must be continually alert to these dangers. This would be a good time for each instructor to evaluate his work to see that he is giving the student all of the instruction that he deserves.

The Drawing Division of ASEE is a very live and effective organization in which many ideas for the good of engineering education are born and spread. The organization of the Division with its officers and committees for this year is listed below.

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PERSONALITY SKETCH OF PROFESSOR FREDERIC G. HIGBEE

by
John M. Russ
State University of Iowa

When our Editor asked me to write this personality sketch of Professor Higbee, I left a note on the Chief's desk asking for some personal data. The next day I found a note on my desk saying; "Well, whadda ya know? An obituary! And I'm not even sick yet." Of such salt has the relationship of all who know Fred been flavored.

I have never known a man who could with such an acute drouth of words, unleash such a flood of meaningful thinking. There are some of us who can remember a meeting of several, one of whom had just given a wordy exposition of his topic. "The Great Stone Face" lifted his eyes to the speaker and asked "When?" The meeting broke up then and there.

Professor French told me several times that he never knew a man whose mind was so intuitively right in matters politic or of delicate decision. Red herrings might cross the trails of thought. Contra matters might be introduced to confuse the issue. It was always Higbee who cut cleanly, sanely, and decisively to the sound and final conclusion.

As a teacher, his technique of presentation is flawlessly clear and masterful. His timing of saying and doing in blackboard demonstration is absolute perfection. Always, his chalk strikes the edge view of the plane at the instant he says "-------here". His interest in the growth and welfare of his students is deep and sincere. There is no one who will go further or fight harder for the good of the "forgotten man" (the freshman engineer) than F. G. Higbee.

There are four major contributions that the old master has made to the thinking and professional development of the brothers in the craft. They are these:

1. He is the author of the first work book or completion type of problem assignment. The publication date on his first edition is 1921. It was of course prefaced by some five years of tryout and experimentation in his own classes.

2. In June of 1928, a group of the old guard were sweating it out in the smoking room of the train on route to S.P.E.E. at Chapel Hill. It was too hot to sleep. Jordan and Mann were there, among others whose names do not respond to memory's call. Through the haze of tobacco smoke and the buzz of general conversation, came that quiet well loved voice; "I think this group should be recognized as such by the Society. It can be done as a Division under the constitution." So was born the first of the many Divisions of the Society that exist today. It was Higbee who introduced the resolution to the Council, and against no little resistance from some quarters there, promoted and obtained its passage.

3. In June of 1930, at the Montreal meeting, after the Drawing School at Carnegie Institute of Technology, the Division Fathers were relaxing one afternoon--when in spite of the bag pipes playing--or because of them--the talk turned to a medium for an exchange of ideas and news within the Division. It was Higbee who suggested using a special page in the S.P.E.E. Journal. French suggested the name of "The T-Square Page", and offered to design the original mast-head. Fred offered to be Editor for the first year, and served for six long cold winters.

4. In June of 1936, the group was sitting around a table one evening at the University of Wisconsin meeting. It was basically the usual gang - Higbee, French, Hood, McCully, Jordan, Rising, Porter, Kirchner, Farnham, Mann, Rowe, and probably others whose named presence escapes me now. I may have named some who were not there, but they would have been, had they known what was to happen. The talk was shop of course - who had said what about which that day in the Drawing School sessions. Out of the yak-yak came that Voice again:

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COLOR AS A TEACHING AID FOR ENGINEERING DRAWING

by
Rex W. Waymack
University of Notre Dame

I should like to begin this discussion by establishing one pertinent fact in your minds--namely, that I was formally trained for the teaching profession. The engineering experience which I have gained over the past fifteen years has been obtained the long hard way.

It is because of this formal teacher training however, that I am presumptious enough to appear before this group. I entertain the idea that it is because of this teacher training that I am being being paid to teach. It thus becomes mandatory for me to utilize my talents in the best possible way. If those talents are to be utilized to the fullest, there must be a constant vigil for new and improved techniques in teaching. It is because I think one of the most effective techniques is not being used that I am presenting my view to you here.

The medium to which I refer is "color" and its application to teaching. It is the purpose of this paper to indicate to you some of the uses of "Color As a Teaching Aid For Engineering Drawing."

The many definitions of color sometimes tend to confuse a layman. If you are a physicist, color means one thing; if you are a psychiatrist it means another; and if you are an ordinary individual it may mean something you find difficult to define. Ask some of your colleagues to give you their definition of white or black or color. I assure you, the responses will be neither immediate nor consistent.

The physicist would probably define white as a combination of all colors and black as the mere absence of light. The psychiatrist will probably classify black and white as colors, since each is perceived and each produces sensations.

These two views might be summarized something like this--color is light; without light we cannot observe color because there is actually no color present. An object appears white because it <u>reflects</u> all colors equally, while an object appears black because it <u>absorbs</u> all colors equally. In view of this there can be no true color classification for black or white.

It is obvious to everyone however, that black and white are something we experience every day. Common usage implies that the terms black and white are not interpreted as "color black" or "color white," but merely black and white.

There is no such thing as absence of color except where there is absence of light. It may be good color or bad color, but color nevertheless. All that is necessary to verify this is to merely look around you. A variation of practically every basic color is immediately observable. Since color is present everywhere then it must necessarily affect the daily lives of every individual.

Statistics show that more money is spent yearly on the aesthetic phase of the home than is spent on the physical phase. Perhaps that is as it should be since there is definite proof that various color combinations have a very profound psychological effect upon an individual. There are actual cases on record, where marriages which were headed for divorce were actually saved by a different color scheme in the interior decorating.

Everyone is aware of the theraputic studies made on a most rigid scientific basis. The hospitals, clinics and convalescent homes have largely discontinued the use of white pain in patient's rooms. The discontinuation was due to results of scientific studies which proved that color does have a great theraputic value.

Factories have found through intensive studies that the judicious use of color has played a major part in decreasing accidents, improving health and morale of the workers, lessened labor discontent and increased production. Motion and time studies have shown that certain colors lessen eyestrain and fatigue resulting in increased efficiency.

Advertising agencies have long since become aware of the use of color. How many roadside bill-boards do you observe that are not taking advantage of color combinations? Practically all displays of all types now utilize color.

Observe, if you will, the increased utilization of color in amature photography both in movies and stills. I am informed by dealers that the sale of color movie film comprise over 95% of the total, although the sales of still film are 75% black and white to 25% color. The lower ratio for still film can obviously be traced to the exorbitant price of color prints. The actual cost of color transparencies compared to black and white prints is much closer than most people realize.

If anyone doubts the affect color has upon the average individual, let him contrast the movie attendance to a good picture in technicolor with the same quality picture in black and white. Ask yourself which type leaves the most lasting impression on you.

It is likely that some of this audience have seen public demonstrations of color television. It has not been my good fortune to witness such a demonstration, but like million of others, I am looking forward to color television with a great deal of anticipation. The current raging battle of which company will first introduce it to the public is ample proof of its importance.

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Engineering departments of industrial plants are using color charts more and more. Experience has taught them that data can many times be shown to a much greater advantage with color than with black and white.

Many companies are training workmen the mechanics of the products they manufacture through the use of color diagrams, such as hydraulic systems, carburetors, etc.

Sales departments have long used charts and diagrams in color for regular departmental use. They have found that data can be presented quickly and more effectively with color.

Traffic engineering departments in many cities often lay out traffic flows of congested areas in color in order that the entire flow can be seen at practically a glance.

Tool design draftsmen use color constantly for construction hole locations and of course the part for which the particular jig or fixture is being designed is laid in with red lead.

Many of you may be familiar with body design layouts or "drafts" in the automatic industry which is similar in many respects to the aircraft and naval techniques. I shall remember forever the first day I went to work in the body drafting division of the Studebaker Corporation. The first look of a body draft is for only the courageous with a strong heart. The original official draft contains all views, sections, etc. on one large aluminum sheet. The top view overlapping the front view, section after section overlapping each other demands the use of color many times, especially for the detailer.

Some of you may doubt that it is possible to perceive color without an association of some past experience with it--in other words you might content that an individual has to be "educated" to color. In answer to this all that is necessary to do is to lay three balls on the floor by an infant, one white, one black and the other bright red. If the infant is a typical normal child you will find that there is a distinct preference for the red ball. Even very small infants recognize color in one form or another, which supports the contention that color is natural for humans. Color imparts qualities to an object that mere shape alone cannot do.

At this time I wish to ask you a question which may momentarily seem rather ridiculous, but I believe if you think about it a minute you will conclude that there may be food for thought after all. It is very probably that during the past ten years your wife has owned many dresses. It is also very likely that there is one particular dress she has owned during that period that stands out in your mind above all others. The question is. Gentlemen--what color was it? My guess would be that you remember that dress above all others because of its color. I would predict that less than 5% of the cases would involve a black or white dress, with the exception of a wedding gown. (It would be too much to expect color to compete with white on those occasions.)

The real question them becomes, why is the perception of color retained longer than the perception of black or white? I think the answer goes back to the fact that where--ever there is light there is color. The natural order of things is that of color--not of black and white.

What has all this to do with engineering drawing? Simply this--college life in general is complicated enough without teachers adding to the confusion by using techniques contrary to the natural scheme of things, and I am firmly convinced that black and white are contrary to that order. Everyone realizes that it is impossible to put everything used in teaching in color, but the situation can be greatly improved.

One process I have used to attempt to overcome this is the use of color overlays. These overlays which you are going to see are ones which I have actually used in classes. I have found that through the use of these, two distinct things have happened--first, the students have learned the principles more quickly than by any other method of presentation I have found, secondly, much less effort is required of me than by the conventional lecture method.

There is nothing new about the ideas of overlays. They have been used for years in some types of design work, but to my knowledge they have not been utilized to any great extent in the drawing field.

The principles and purposes of the overlays are quite evident. Through their use it is possible to show processes and fundamental steps in sequence more effectively than any other way I have yet found. As you can see, the steps are taken in order, emphasized by color while at the same time the preceding step is visible. What a far cry this is from a textbook explanation of a double auxiliary problem for example, where the complete solution is shown, not step by step, but complete in one drawing, resulting in a maze of lines which sometimes even challenges the author as soon as the lines get cold. Confusion is enhanced by the printed explanation of the solution continuing sometimes two or three pages beyond the solution itself. Even more complications are added by reducing the drawing itself down to half page size when the normal size of the problem would probably be at least three times the size of the cut shown.

Consider further the solution of a typical double auxiliary problem as it is found in most texts. In spite of the best anyone can do by labeling lines and points, it is practically impossible for anyone to limit his eye span to any exclusive feature of the drawing. In explaining the problem you may be talking about line AB in the book, but the students' eyes are seeing line AB plus XY, OZ, etc. If you doubt this in the least, pick up any text with the solution of a double auxiliary problem and try just seeing line AB. If you haven't tried it before you may be surprised to learn that you cannot just see line AB in a maze of other lines. The human eye just isn't constructed that way. With color overlays however you see step 1 layed out in red

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APPLICATION OF ADVANCED GRAPHICS

by

Frank A. Heacock
Professor of Graphics, Princeton University
Chairman, Committee on Advanced Graphics

The purpose of this paper is to describe briefly several graphic methods that have been usefully applied to the solution of important technical problems. Typical examples have been selected from three different fields of engineering in order to demonstrate the versatility of the graphic approach. In each case the graphic procedure is an essential part of the analysis and of the actual solution of the problem. Included in this discussion are the hydrograph, the psychometric chart, and the three-dimensional stereograph.

My first example, the hydrograph, is concerned with the flow of water. Many engineering problems call for aid from the science of hydrology which deals with the occurrence and flow of water upon and beneath the earth's surface. The hydrologist measures the flow of streams and ground water. He makes a systematic study of the behavior of rivers and the methods of developing water resources. On the basis of his measurements and analysis of rainfall and stream flow data; he makes accurate predictions of floods, droughts, and normal flow, and the effects of proposed improvements. Hydrology has important bearing on the structural design of bridges, dams, and culverts, water supply and irrigation projects, flood control, navigation, erosion control, and pollution abatement. In his studies of runoff data the hydrologist depends upon a simple analytical tool, the hydrograph.

A typical discharge hydrograph is shown in Fig. 1. All hydrographs are time-series charts, because their horizontal scale is always expressed in units of time. The vertical scale may be gage height, so that we have a stage hydrograph representing the rise and fall of water level at a given point on a stream. Or the vertical scale may measure discharge in cubic feet per second, commonly referred to as second-feet, which results in a discharge hydrograph. The area under a discharge hydrograph between any two points in time is equal to the volume of water that has passed the gage location during the time interval.

When rain falls upon the earth's surface, a part is lost by evaporation, another part

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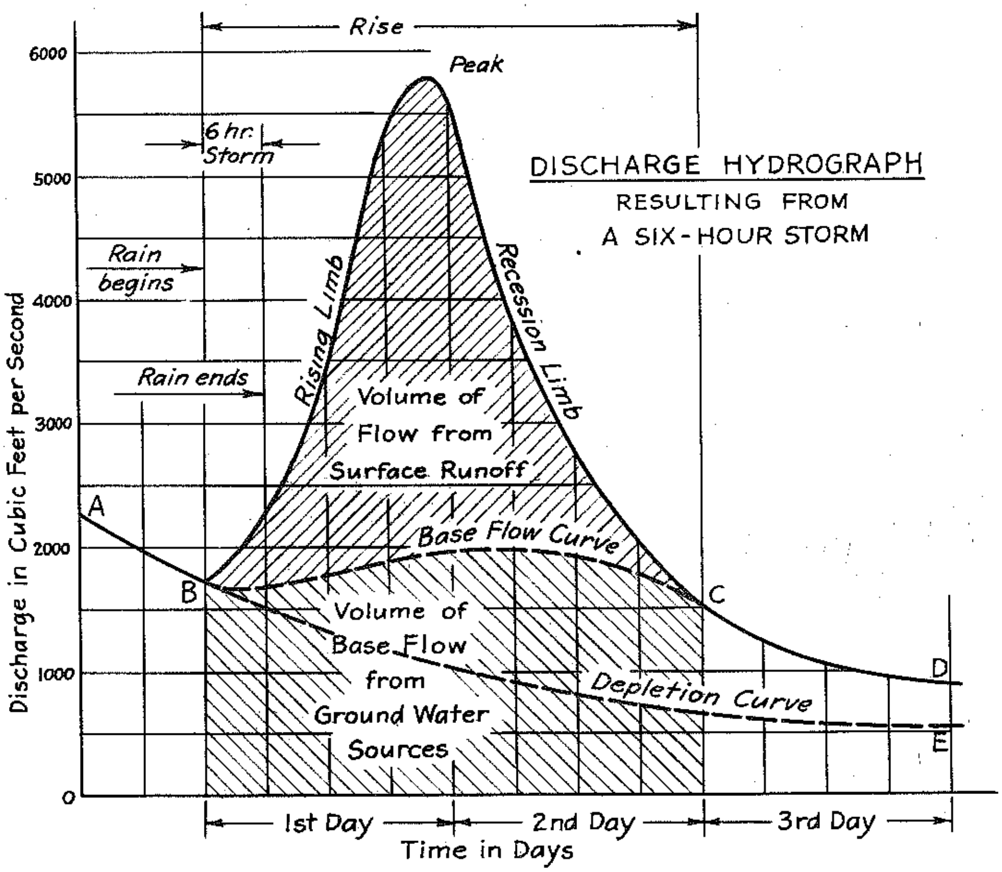


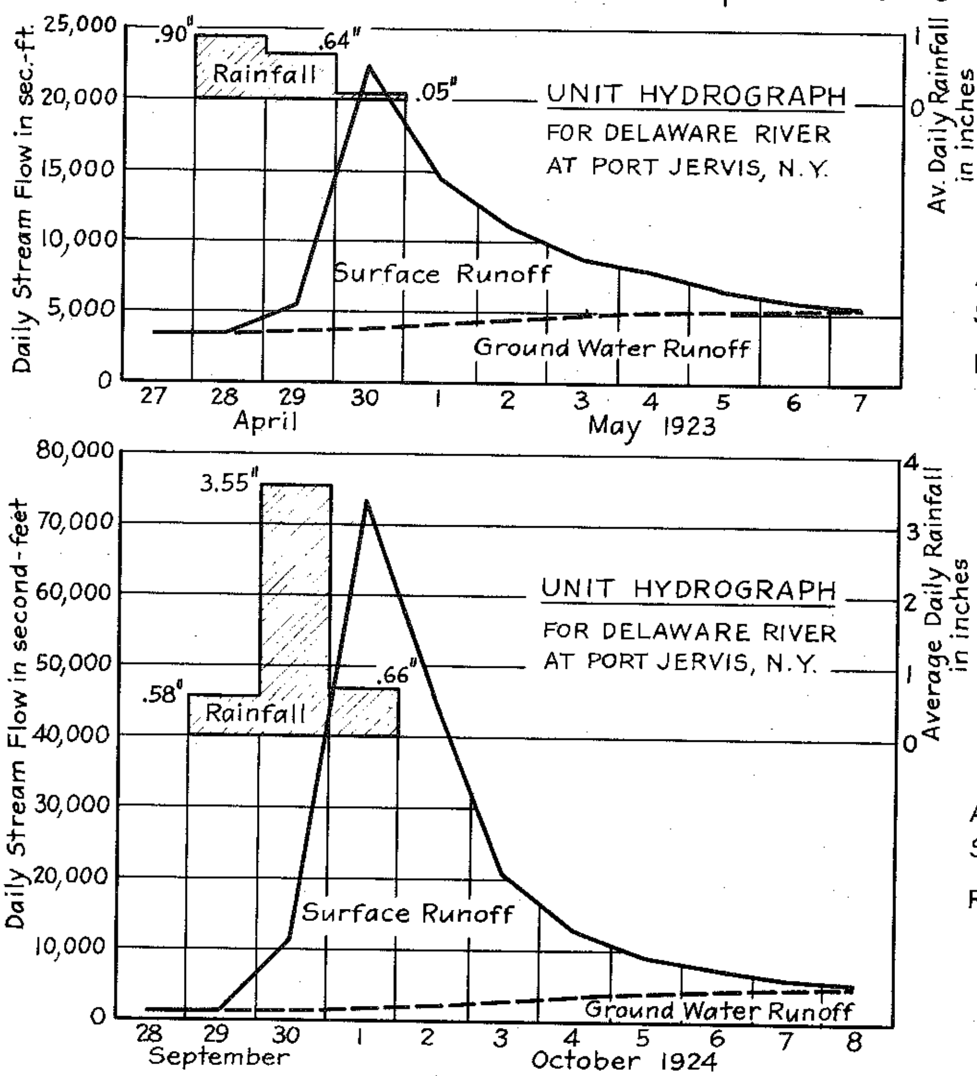
Fig. 1 The Hydrograph

(Continued from page 11)

is taken up by plant life and returned to the atmosphere by transpiration, and a portion infiltrates into the soil to become groundwater. The remaining storm water flows overland toward a stream as surface runoff. Stream flow is derived from surface runoff, channel storage and ground-water flow. A flood period hydrograph is, therefore, a hydrograph of surface runoff superimposed on a hydrograph of ground-water discharge.

In dry weather a stream derives its flow entirely from ground-water sources as represented by the depletion Curve AE in Fig. 1. The segment AB of the depletion curve is the hydrograph of the stream before the rain begins at point B. At this point the abrupt departure of the hydrograph from the depletion curve indicates the addition of surface runoff. After the rain ends six hours later the volume of stream flow continues to increase at a higher rate due to upstream runoff, as shown by the rising limb of the hydrograph. The rate of discharge reaches a maximum in this case about 16 hours after the rain ends and then the rate decreases along the recession limb of the hydrograph to point C, where the effect of surface runoff from this storm ceases. The high part of the curve from B to C is called a rise. Beyond point C the hydrograph follows a new segment of a depletion curve representing a higher rate of ground-water flow, because this storm has increased the supply of ground water.

The analysis and synthesis of the hydrograph is a fundamental problem in river hydrology. It is customary to develop a unitgraph, which is a hydrograph of unit volume of surface runoff resulting from rainfall of uniform intensity during a storm of unit length, such as a 1-day unitgraph, or a 6-hour unitgraph. The unitgraph method is used to estimate major floods, to predict a day or two in advance the flood stages that will be reached by a given river, and to fill in missing parts of a river-discharge record. The unitgraph procedure requires a satisfactory method of estimating net effective rainfall for the drainage basin. The unitgraph method is based on the hypothesie that in a given drainage basin the surface runoff from rainfall during a storm of unit length will produce hydrographs of approximately equal bases,



Average rainfall at stations = 1.54"
Surface runoff = .56"
Ratio $\frac{\text{surface runoff}}{\text{average rainfall}}$ = .36

Average rainfall at stations = 4.79"
Surface runoff = 2.01"
Ratio $\frac{\text{surface runoff}}{\text{average rainfall}}$ = .42

Fig. 2
Comparison of
Unit Hydrographs

(Continued on page 13)

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and the ordinates will vary according to the intensity of the net effective rainfall.

Fig. 2 shows a comparison of unit hydrographs for the Delaware River at Port Jervis, New York. These two graphs were selected from a group of nine unit-hydrographs constructed for typical unit storms in the Delaware Basin from 1917 to 1933 and published by the U.S. Geological Survey in a book entitled "Studies of Relations of Rainfall and Runoff in the United States." They illustrate the unit-hydrograph analysis of surface runoff and resulting stream flow. The drainage area of the Delaware River Basin above Port Jervis in 3020 square miles. Daily rainfall records are available from eight Weather Bureau stations within the Basin, and daily gage height measurements have been made at Port Jervis since 1904. These unit hydrographs are plotted in the customary manner, with straight lines joining points of mean daily discharge. They may be converted into unitgraphs by dividing their ordinates in second-feet by the total surface runoff in inches. The comparison of these unit-hydrographs at Port Jervis verifies the basic concept of the unit-hydrograph principle, that the base lengths are approximately equal and that corresponding ordinates are proportional to the total volumes of surface runoff.

With a proper knowledge of its capabilities and limitations, the hydrologist uses the hydrograph constantly in conjunction with other graphic aids in his analysis of rainfall, runoff, and stream flow relationships. He regards the hydrograph as a valuable part of his working equipment.

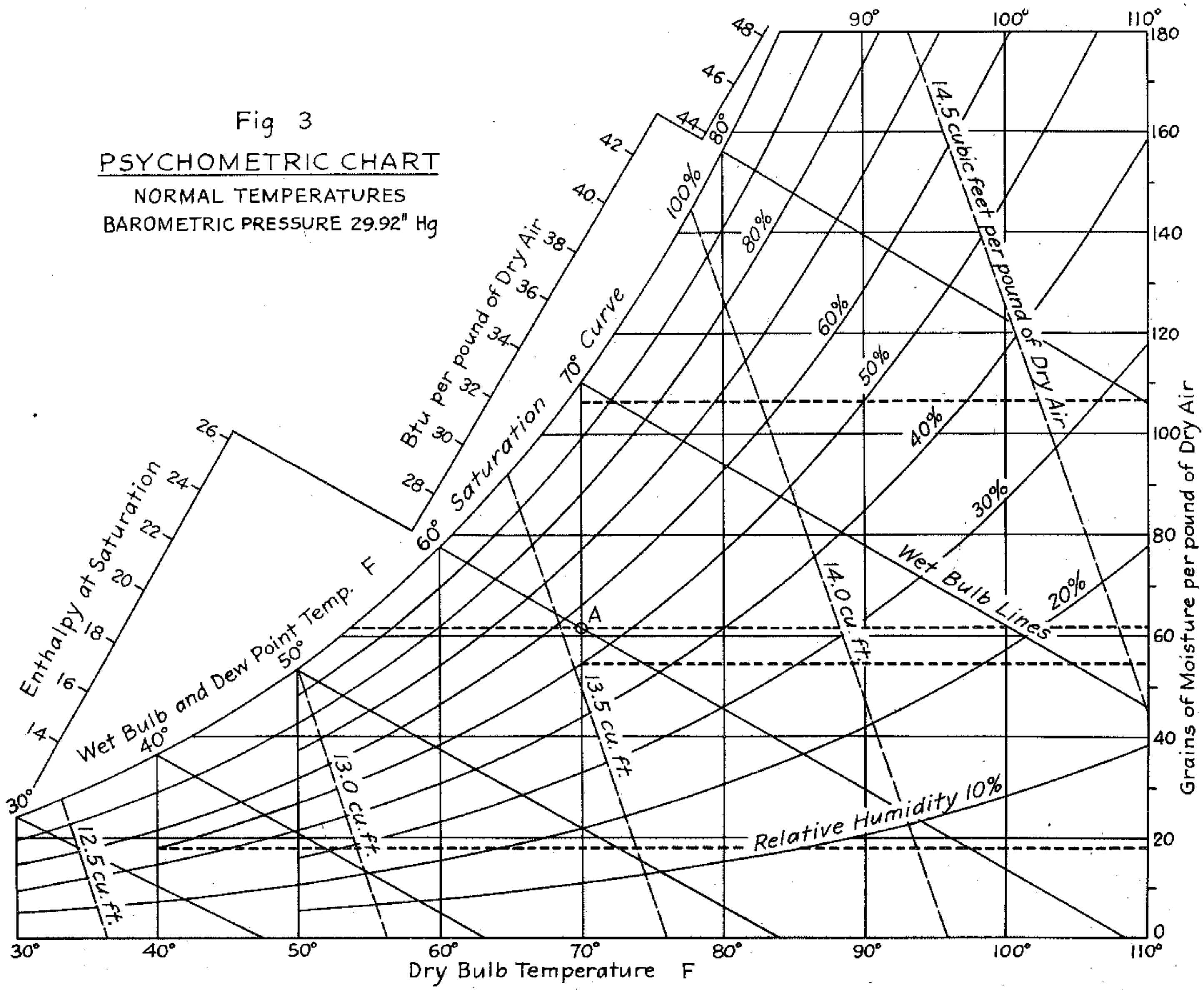
Now we turn to an entirely different graphic method. My second example is the psychometric

Fig 3

PSYCHOMETRIC CHART

NORMAL TEMPERATURES

BAROMETRIC PRESSURE 29.92" Hg



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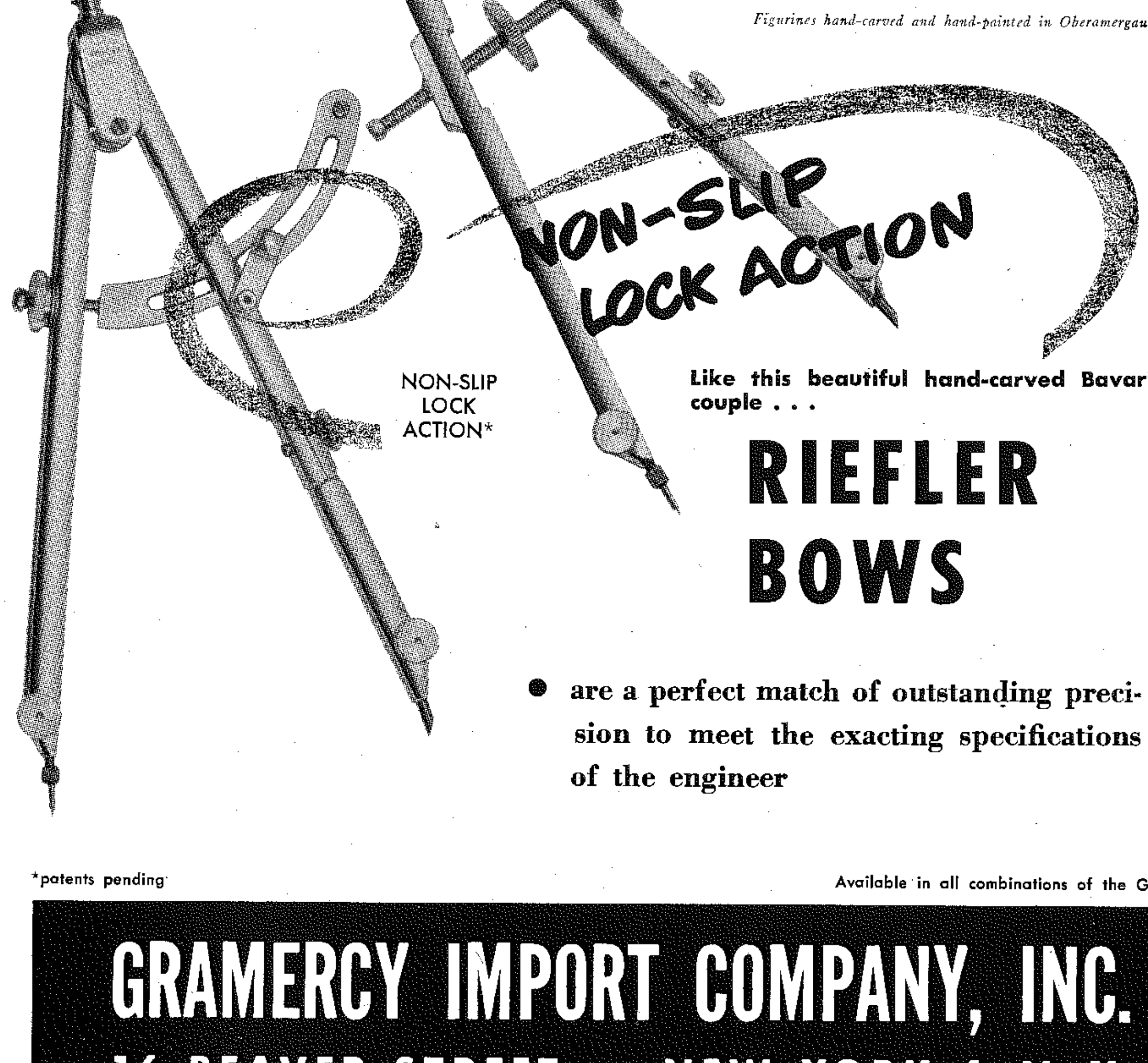

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INDUSTRIAL APPLICATION OF DRAFTING STANDARDS

by

Leon DeMause
Chairman General Motors Drafting Standards Committee

Mr. Chairman, members and guests of the Engineering Drawing Division of the American Society for Engineering Education.

After we were awakened this morning by the jingle of an alarm clock, from a specially constructed mattress, we switched on the lights and were served by the wizardry of modern plumbing.

Breakfast was being prepared with the magic of the mechanized kitchen and we were delivered to these halls on the miracles of wheeled transportation.

Between the productive realization of these comforts and necessities of our industrialized age and the original "gleams" in the engineer's eyes, are millions of pieces of paper called drawings made by thousands upon thousands of draftsmen.

The draftsman, that vitally important link between the Engineer and the Manufacturer, is responsible for the visual presentation of ideas and instructions that will finally materialize in the finished product. It is important that these drawings convey these ideas so as to give Planning, Purchasing and Production departments accurate and complete information for ordering and building the product.

These drawings have been aptly described by the teachers of engineering drawing as the "graphic language of the engineers," and like any language it should always provide a clear concept of its meaning.

And if I may go into politics for a moment, the unification of even a few of the world languages so that men could communicate clearly and understandably, would go far toward the solution of world problems.

The same is true concerning the solution of those problems in industry which depend for clarity upon drafting practice, the language of the engineer. Lack of definite and clear understanding caused by variances in drafting habits result in time wasting changes and corrections.

From a practical point of view, there is one outstanding criterion by which to judge a standard drafting practice and that is its economic effects.

More than ever before, the challenge to modern industry is to produce more with less effort. Industrial drafting must also meet this challenge and one of the tools that we can use to help meet this challenge is a Standardized Drafting Practice.

The idea of standardization is not new. Prompted by the demands of many individuals, notably teachers of mechanical drawing - the matter of a national standard for drawings was presented to the American Society of Mechanical Engineers Standards Committee in 1925. It is with warm regard that Industry appraises the efforts of Teachers of Engineering Drawing towards expanding the curriculum for Engineering Drawing. The student will become a better engineer with this fundamental grasp of the language of his profession.

Preparation of the General Motors Drafting Standards was undertaken in recognition of the obvious commercial advantages and the probable military expediency of a uniform practice. Convinced that national unification would sooner or later become necessary, General Motors endeavored to reconcile the view point and practices of the Divisions so as to permit more effective cooperation with the Society of Automotive Engineers in standardizing automotive practice, and subsequent cooperation with other industries and Government services in the development of a national standard.

General Motors, as a decentralized organization, recognizes the independence of Divisions in engineering and production matters. And I can personally tell you that this independence was voiced many a time in our committee meetings.

General Motors Divisions, never-the-less, through their close affiliation, are frequently dependent on one another for engineering information. Drawings are widely exchanged and engineering personnel are frequently transferred between Divisions.

These considerations render it obvious that uniformity of drafting practice is advantageous to General Motors aside from any broader objectives.

In developing this standard all available references, including standards of other companies and the government services, were examined and compared with divisional practice. Every Division and several other companies participated actively in the development. With national standardization as the ultimate goal, an effort was made to select and specify the practices that were best suited to the needs of all industry, regardless of conflict with current practices of General Motors Divisions. Differences in practices were reconciled on the basis of comparative merit rather than on opinion, preference or usage.

The Drafting Standards were prepared by the persons best qualified for that task by many years of experience in the drafting and engineering field.

Every General Motors Division has had an opportunity to study each subject included in these standards and to contribute to the improvement of every portions of them. (Con't on page 19)

DRAWING COURSES TECHNICAL INSTITUTE PROGRAM

by
Maurice Graney

I.

In discussing the plans of drawing in the technical institute it is appropriate to present first a brief statement of the objectives and philosophy of the technical institute itself. This is true for two reasons. First, the concept of the technical institute is not clearly understood by all college teachers. And, second, the drawing taught within the technical institute must be judged and interpreted against its proper background.

The term technical institute, as defined by E.C.P.D., defines a curriculum concept, not a school. Many colleges, junior colleges, and special schools have offered technical institute programs. Regular college facilities and faculties may be used. Or, if desirable, specialized facilities may be built and a particularly trained staff may be retained. In any event there are certain characteristics of curriculum and certain well-defined objectives which must be observed and followed. These characteristics and objectives give the technical institute its unique quality. What are they?

1. Entrance into a technical institute requires high school graduation, or some equivalent background of work experience.

2. Study is for a briefer period than commonly required for a bachelor degree. One year programs and two year programs are found most often.

3. Instruction is intense, specialized, and directed toward the preparation of individuals for employment in industry. The instruction is less theoretical then in engineering instruction, although frequently it is the same general fields. Emphasis is placed upon laboratory instruction and upon practical application to industrial problems.

4. Technical institute programs do not train skilled craftsmen, such as machinists, welders, masons, carpenters, and so forth.

5. Instruction must be based upon an understanding of theory. Rule of thumb practices are not adequate.

6. Graduates of technical institute programs are qualified to be employed as assistants to scientists and engineers, in various operating positions in production, in supervision, and in technical sales. They frequently perform jobs for which their unique qualifications in both the practical and theoretical fields make them excellent liaison employees. They bridge the gap between the theoretical designer on the one hand, and the skilled artisan on the other.

These six characteristics compose the basic definition of the technical institute. While this definition may be too brief, it helps to define the area, level, and scope. What, then, is the meaning of this to persons interested in in the subject matter field of drawing?

The answer to this question must include an examination of the specific objectives of the drawing courses in technical institute programs; it must include a discussion of teaching techniques; it must include an analysis of the type of teacher needed and the kind of student enrolled. The answer should define the differences between drawing as taught in the high schools, the engineering curricula, and the technical institute.

II.

The purpose of teaching drawing in the technical institute is twofold. Most technical institute programs include more than one specific curriculum. There are definite objectives for each. For example, a curriculum in metallurgical technology may have as its specific objective the training of metallurgical laboratory technicians. Curricula may be developed for production planning, petroleum technology, radio technology, or a host of other technical fields, each having its defined place in our industry. In programs such as these a course or two in drawing generally is included. The purpose of this inclusion is to round out the students' general theoretical background. The relationship of this purpose to the purpose of drawing courses in an engineering plan of study is quite close.

In addition to the above, however, specific drafting curricula are included in many technical institute programs. Such curricula are concerned with the machine-drawing field or the architectural-drawing field. For these, the specific objective of the drawing courses is quite different from the objective of the drawing courses in the previously mentioned fields. In these the purpose is to train draftsmen and junior designers.

The complete definition of this objective can be made most clearly by distinguishing it from the objectives of drawing courses in the engineering schools and in the secondary schools.

Drawing courses in engineering curricula do not have as their objective the preparation of professional draftsmen. It is true than many engineers start their professional careers in drafting departments. As a matter of fact, many of them never completely separate themselves from the drawing function. But the prime purpose of their drawing training is different. This training develops in them a knowledge of the graphical language. It helps develop their powers of visualization. It brings into sharp relief the methodical, orderly approach to the solution of an engineering problem, and develops a knowledge of machine parts, technical terms, and the conventional practices used in the

(Continued on page 18)

(Continued from page 17)

representation of objects and ideas. Some graphics courses attempt to achieve more abstract goals. In all of these objectives, however, the avowed purpose of preparing career draftsmen is not included.

The objectives of the drawing courses in high schools, on the other hand, also differ from those of the technical institute. On the high school level there appear to be two rather well defined goals. The one is that of appreciation. Students are taught to appreciate many fields of learning: art, music, poetry, the physical and biological sciences, technology, business, commerce, and so on. This is a part of their cultural development. And drawing is a part of the pattern. In addition to this objective there is the vocational objective of occupational competence. Selected students are drilled intensively in the techniques and practices of draftsmen and the skilled artisans in related fields. Many high school graduates enter industry as qualified tracers, detailers, and the like. Of these, however, only the rare exception understands the theory behind practice, or the basis for concept. The students' lack of maturity and their limited experience almost precludes such accomplishment.

In the technical institute program the attempt is to achieve an objective which includes, in part, that of the high school, and in part that of the engineering college. In addition, the objective has certain unique inclusions of its own.

The theoretical background supplied by the technical institute drafting curricula is more limited than that of the engineering college. In general, mathematics courses include only geometry, algebra and trigonometry. Thus, theoretical concepts requiring a background of calculus may not be taught. There are however, substantial courses in electricity, heat, applied mechanics, mechanisms, and machine design which can be taught on the non-calculus level. There are like courses in the architectural field. Such courses give the student an adequate background to work intelligently with the more theoretically trained engineer. Few vocational programs in high schools attempt instruction in theory to that extent.

In addition, technical institute curricula include offerings in such courses as tool design, jig and fixture design, die design, and give ample time in laboratory to insure the development of a high degree of skill. Few, if any, engineering programs permit as much time for such practical courses.

Frequently, technical institute drafting courses are administered as are industrial drafting departments. Classes are divided into squads. Squad leaders are appointed. Student achievement is adjudged satisfactory only if it meets high commercial standards. Practical laboratory courses constitute a significant part of the total instruction.

The qualifications of technical institute teachers are established by the requirements of the courses and programs. In most instances less emphasis is placed upon the academic credentials for technical institute teachers than for teachers in the colleges or in the high schools. The principle criterion to be met is the one concerned with the teacher's knowledge of and ability in his field. The drawing field is a typical example. A person selected to teach die design should have been a high grade die designer in industry. The fact that a substantial fraction of industrial die designers are not college men is relatively unimportant. It simply means that the chances are few that a technical institute teacher selected because of his industrial die design experience will be a college graduate. Obviously, most schools look for teachers who not only have practical experience, but also hold high academic credentials. But the primary emphasis is placed upon specific knowledge in the practical situation. As a consequence of this, a large number of technical institute instructors lack professional training in the art and science of teaching. This is a cause for real concern at the present time and much thought is being given to ways of remedying this deficiency.

What are the characteristics of the typical technical institute student? Perhaps no definition would fit all students very well, but the following comments will suggest a picture of an individual who is commonly found and who typifies at least one large group. He is a person who completed high school and took a job. In general, he took just any job that came along. Most frequently the job is in some industry. After a few years of work, he married and perhaps assumed the responsibilities of a family. As he approaches the age of 24 or 25 he realizes he has no specific training and that his chances of moving up in industry, of getting ahead, are limited. He is ambitious, and he looks around for a way out of his dilemma. The opportunity to go away for four years of college is closed to him because of the cost of such a move and because of his family responsibilities. He knows the kind of job he would like and is eager for the training needed. He wants a chance to keep his job and to go to school on a part-time basis so that in due time he may qualify for what he wants. He has an almost pathetic eagerness to learn. He makes an excellent student. Do not get confused about his ability. Frequently he has much more of it than the typical college sophomore. When a student such as this comes to the technical institute, he means business, he wants an education. The school would do well to give him training which is carefully conceived, and which is administered by competent people.

Still another type of student comes to the technical institute sponsored by the industry for which he works. Industry today is woefully short of workers who are well-trained technically. In order to correct such deficiency, industry is willing to send selected workers outside for special training and foot the bill itself. But industry wants training which will meet its needs. To assume that the standard high school or college curriculum supplies the training to meet the variety of needs of the many industries in our economy today is to ignore the facts to a most amazing degree. As a consequence, the industries are turning more

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Included under each subject is sufficient information to give even the least experienced user of these standards the necessary background to establish an understanding of the recommendations which are presented.

One of the first problems the General Motors Drafting Standards Committee was confronted with was not the number of subjects, but the scope of any particular subject. In generalities each subject was to embody the following features in the order listed.

1. General Statement: This should state the purpose of the subject.

2. Information. This should be devoted to a broad statement of methods, practices, and definition of terms.

3. Basic Rules and Applications: This should include detailed rules of procedure with specific examples of how they are applied under various conditions.

4. Composite Examples: This includes practical complete examples applying the methods and procedures previously outlined in detail.

The subject "Dimensioning" is a good example of the results attained, which I shall outline.

The General Statement was as follows:

"Dimensioning" may be defined as the art of imparting definition to a pictorial representation. It is, by far, the most important operation in producing a detail drawing, and should be given consideration even in the design stage.

The several external views on a drawing, together with the necessary sectional views, correctly placed and projected, tell the shape of the object. However, to specify its size definitely, dimensions must be added to the pictorial representation.

The major value of a mechanical drawing lies in its dimensions. In fact, the picture portion of most detail drawings serves no better purpose than to form a background to which the dimensions are applied.

Every detail drawing is expected to convey exact and positive information regarding every detail of the represented part, and to make engineering intent perfectly clear. Without the definite specifications expressed by dimensions it is practically impossible to accomplish these objectives.

Nearly every detail drawing bears some sort of admonition against scaling the drawing or prints made therefrom. This leaves only one course open to the drafting organization - to define the size, shape and proportions of every portion of the detail part completely and unmistakeably by means of dimensions and notes.

The foregoing "General Statement" might seem long but we felt that it was clear and explicit - the same as we expect the drawings to be.

Following our formula along, we then presented methods of dimensioning detail drawings, followed by basic rules and applications. In the basic rules and applications fifty-six illustrations were used. These illustrations not only clarified the rules, but made the presentation of them more interesting.

The dimensioning section was completed by the presentation of three practical examples illustrating a stamping, a forging and a casting.

The General Motors Drafting Standards "Table of Contents" will embrace the following:

Section A - Drafting Practice, will have the following subjects:

1. Drafting Technique
2. Drawing Mediums
3. Drawing Forms
4. Layout Forms
5. Line Conventions
6. Sectioning
7. Lettering
8. Symbols and Abbreviations
9. Projection and Descriptive Geometry
10. Dimensioning
11. Decimal Dimensioning
12. Limits and Tolerances
13. Notes
14. Drawing Revisions
15. Checking Practice
16. Drawing Reproductions
17. Layout Practice
18. Body Drafting Practice

Section B - Mechanical Design will have the following subjects:

1. Springs
2. Gears
3. Splines and Serrations
4. Bearings
5. Screw Threads
6. Hydraulics

Section C - Body Design will have:

1. Body Design

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)ST AIDS *DRAWING SHEETS • PROBLEMS*

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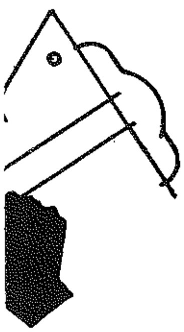

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(Continued from page 19)

2. Body and Sheet Metal Structure
3. Upholstery and Trim

Section D - Electrical Practice

Section E - Manufacturing Considerations will have the following subjects:

1. Stampings
2. Castings
3. Die Castings
4. Forgings
5. Powdered Metals
6. Plastics
7. Rubber
8. Machining Operations
9. Surface Finish
10. Plating
11. Painting
12. Welding, Brazing, Soldering

Section F - Metallurgical Considerations will have the following subjects:

1. Ferrous Metallurgy
2. Heat Treatment
3. Hardness Specifications
4. Non-Ferrous Metallurgy

Section G - Assembly Considerations will consist of the following subjects:

1. Fastening Methods
2. Assembly Operations
3. Clearance for Assembly Tools
4. Tubing Fittings

Section H - Legal Considerations------and a section on ready reference tables, formulae and contants.

These standards are intended to be used as reference material. It is believed that through constant use they will gradually become an integral part of each draftsman's technique. To accomplish this desirable condition, these standards should be the first source of information and reference whenever a question arises. It is not intended that they will be committed to memory by concentrated study, but rather that they will become part of every draftsman's "know-how" through constant association and use.

It is conceded that often there is more than one correct way to make and dimension drawings. These standards are expected to influence the decisions concerning practices and procedures that may be applicable, and to provide clear cut recommendations in each instance. They are not intended to stifle the draftsman's originality, but rather to furnish an authoritative guide in the mechanics of drafting so that his abilities may be applied to more important design considerations.

The success of these standards depends largely upon the checkers. These important critics of drawings can do much toward directing the draftsman in the application of these standards until familiarity has been thoroughly established.

Draftsmen who are trained to follow this standard drafting practice will make fewer mistakes and will produce more legible drawings with less effort.

Some of the time saving and cost reducing factors are:

a. Elimination of dis-agreements on how the drawing should be made or about the exast shade of meaning intended on the finished drawing.
b. Reduction of errors both in the drafting room and the shop because the presentation, dimensions, symbols, tolerances, etc. will be correctly interpreted by all.
c. Less work - the standard has the solution available at once. It is not necessary to go through a time wasting process to find the right interpretation each and every time the same problem arises.
d. Take less supervision - it is not necessary to guide the draftsman step-by-step in his drawing. He can refer to the manual of standards.

That the aims of General Motors were all met was demonstrated most dramatically last August of 1950. The Cadillac Motor Car Div. was given a contract to manufacture an Army tank for the Government.

There were thousands of production drawings to be made and draftsmen were borrowed from many Divisions of the Corporation for time ranges from three weeks to three months.

These men were able to produce drawings without costly and time consuming training because General Motors has standardized the drafting practices of the divisions.

At the peak of the program there were fifty-five draftsmen on loan to Cadillac from fifteen different divisions. As new help was procured these loaners were used to help train the additional new draftsmen before they were returned to their respective divisions.

With such cooperative effort, cadillac was able to do a better job for the Nation.

In conclusion, I have this to say. Every effort has been put forth to make these standards as comprehensive and informative as possible. They make available to every draftsman in the cooperation the best knowledge of General Motors authorities on the subjects covered.

June 23, 1951

Leon DeMause, Chairman
General Motors Drafting Standards Committee

IN MEMORIAM — PROFESSOR FRANCIS M. PORTER

University of Illincis

Professor Porter was active professionally during his entire career. He was one of the small group who organized the Engineering Drawing Division of the American Society of Engineering Education. He inspired both students and members of the staff by his thorough analysis of problems and the careful, accurate, graphic solution of them. His influence in the teaching of engineering drawing and descriptive geometry was nation-wide.

He was our friend and counselor.

(Continued from page 7)

"In my opinion, the Division has grown to where it could support a Journal of its own. I suggest we start one. I suggest we call it the Journal of Engineering Drawing." Thus it was that our Journal came to be. Our Journal that has since grown to its present stature and dignity. I might add that Fred served for one year as our first Editor.

Professor Higbee was born in Fremont, Ohio, "before Powhatan was a pup" as he puts it. After graduating from Kenyon Military Academy, he attended Case School of Applied Science under a tuition scholarship, and graduated with the degree of B.S. in 1903 and M.E. in 1908. After a year as instructor at Case, and a year as Assistant Engineer with the Osborn Engineering Company in Cleveland, Ohio, Fred came to the University of Iowa as Assistant Professor in 1909. He has been here ever since, serving with distinction in numerous capacities, on the campus, as a citizen in the Community, and on several National Committees.

Among these assignments, have been, or are now current: Professor and Head Department of Engineering Drawing, Director of Convocations, Chairman Campus Planning Committee, Member Athletic Board, Member Transit Board, Chairman Iowa City Zoning Commission, Chairman Iowa City Board of Adjustment, Secretary Alumni Association, Member Council and Vice President A.S.E.E., Member A.S.A., etc.

He is a member of A.S.E.E., Sigma Xi, Tau Beta Pi, Pi Tau Sigma, Engineers' Club, Triangle Fraternity, Iowa Academy of Science, Faculty Club, and is listed in Who's Who in America, Who's Who in Engineering and Who knows and what. As we all know, he was the first to receive the Engineering Drawing Award - June 1950.

He is the author of six published books and many papers and articles, all in or relative to the field of Engineering Drawing.

He married Beth Mather in 1912, and is the father of two sons. The elder, Frederic G. Jr. is a successful business man in Chicago, and Jay A. will soon receive his doctor's degree in Social Science at Syracuse University. Fred is four times a grandfather.

There are thousands of us nation wide - yes world round - who consider ourselves fortunate to have had the privilege and the opportunity to study or to work under, or to be associated with, Frederic Goodson Higbee.

(Continued from page 18)

more and more to the technical institute for in-service training to answer their needs. In such cases it is common practice for the school's educational experts to sit down with the industry's own representatives and work out a training program designed to do a job. Do not think for a moment that such training automatically becomes low grade. In some instances it constitutes the most effective education being carried on in our country today. In the drawing field the contributions which schools could make in this type of activity are almost limitless.

In addition to the two types of students described above there is the recent high school graduate type. He is the student who wants additional schooling immediately after high school graduation, but who is not attracted by by the regular college offering. He is interested in doing. Frequently his abilities lie in technical fields. He is not particularly verbal. He wants a job in industry when he feels he is sufficiently trained. On the scale which measures an individual's interest in ideas, things, or people, such a student would show a preference for things and people. In contrast with the engineer he is not interested in nor particularly able in dealing with ideas, abstractions, or symbols. To deny him further technical training because he does not fit the pattern established for the theoretical engineer is arrogant, undemocratio, and economically wasteful. He is a practical man and wants practical schooling. The technical institute tries to meet his needs.

III.

What does all of this mean for those designing content for drawing courses in a technical institute curriculum?

For one thing, it means that the person assigned the job should have an intimate knowledge of what he is trying to do. Course outlines have a way of being very deceptive. A basic drawing course in almost any situation will include such topics as use of instruments, applied geometry, theory of projection, auxiliary views, sections, dimensioning, working drawings, and so on. A technical institute course outline might look like this. Advanced courses in machine drawing, descriptive geometry, statics, dynamics, mechanism, machine design, all have their characteristic topics. A casual glance at course outlines selected from an engineering program and at outlines selected from a technical institute program would reveal that they were much alike in many instances. This might lead the superficial observer to conclude that the total programs would be the same. However, if the technical institute program is administered properly, it is significantly different from the engineering program. The type of teacher used, the type of student, the emphasis, the application and interpretation of many topics, all tend to orient the instruction. Anyone actively engaged in teaching can recognize easily the tremendous effect of these factors.

(Continued on page 39)


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GRAPHIC MULTIPLICATION

by
John F. Twigg
Section of Graphics
Massachusetts Institute of Technology

We are accustomed from our early educational background to think of mathematical problems in terms of symbolic notation. The geometric aspects are quite often neglected, or used only as a visual tool to the notational process. A great deal of time and labor in arithmetic computation can often be saved, and a clearer understanding of the results attained from a pure pictorial or geometric presentation and solution. Furthermore, many problems are known to be solvable through geometric means which are beyond the scope of analytic consideration. Addition and multiplication are basic in any mathematical system. Natural extentions of these basic operations lead to the more complex work of higher mathematics. It should follow that their development by graphical means will yield further possibilities for higher graphic solutions.

A geometric interpretation of our number system may be given by the following construction. Consider a straight line, and assume on it any point. (Fig. 1) This is the "0" or origin. From this point take any convenient length along the line to a second point which can be designated as "1." The unit segment is then the length of the line from "0" to "1." The positive and negative integers are then represented by lengths established by points along the line, positive to the right and negative to the left of "0."

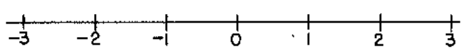


fig. 1

Any real number in our system may now be represented by an unique line segment from the origin to the point representing the number. No mathematical proof of this construction will be given. However, many interesting articles can be found in the literature concerning this seemingly simple geometric construction. It may be pointed out that this process is essentially that used when we establish the scales for a graphic plot.

The symbolic number has now been replaced with an equivalent geometric system. The natural question then arises as to the possibility of performing the equivalent of number operations (addition, subtraction, multiplication, etc.) with this geometric system. The answer to this question, strangely enough, has not been completely explored. However, many interesting applications can be demonstrated.

Addition in the geometric system consists merely of adding line segments. (Fig. 2)

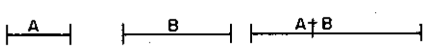


fig. 2

This construction appears rather trivial; however, it does have less trivial applications. For example: consider the sum of the curves

$$y_1 = r_1 \sin(\theta + \alpha_1) \quad y_2 = r_2 \sin(\theta + \alpha_2)$$

Note that no mention is made of number notation. However, due to the restrictions inherent in our language, some symbolism must be used to convey the problem.

By choosing any arbitrary units we may make the conventional set-up for representing these curves. (Fig. 3) Now to add these curves it is only necessary to add corresponding ordinates; in other words, adding line segments. The power of this elementary construction is made clear when we consider that any two or more curves, regardless of whether or not they can be represented analytically, may be added, and a sum curve obtained.

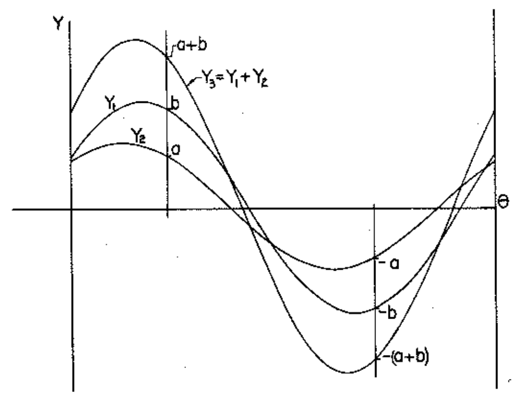


fig. 3

The process of subtraction follows immediately from the foregoing.

A more interesting and yet simple construction leads to graphic multiplication. Consider the similar triangles ABC and ADE. (Fig. 4).

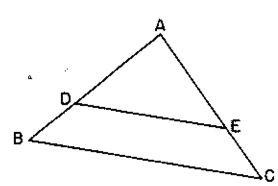


fig. 4

We may set up the relationship $\frac{AD}{AB} = \frac{AE}{AC}$

or $\overline{AB \cdot AE} = \overline{AD \cdot AC}$

(Continued on page 29)

(Continued from page 27)

If, now, we choose to make the length of $\overline{AE}$ a unit, we have $\overline{AB} = \overline{AD}.\overline{AC}$

or the length of the segment $\overline{AB}$ is equal to the product of the segments $\overline{AD}$ and $\overline{AC}$. We have now shifted our point of view from Euclidean geometry in which the multiplication of two line segments represents an area, to an entirely new outlook in which the multiplication produces a third segment.

The construction given, while in its basic form, is not the most convenient for use. Quite often it is necessary to multiply two or more line segments which are superimposed. For this we make use of a variation of our basic method.

Consider the line segments starting from "O" of length "a" and "o" on the line axis "y" (Fig. 5). Establish any convenient line OB through the origin "O." The unit point is located on the axis "y" and a perpendicular drawn to the axis from the unit point cutting the line OB at point P. To locate the point representing the product "ab," connect the extremity of segment "a" with point P. Through the extremity of segment "b" draw a perpendicular to the axis cutting line OB at point Q. From Q draw line QR parallel to line Pa, cutting the axis at point R. The line segment from O to R is the product segment "ab."

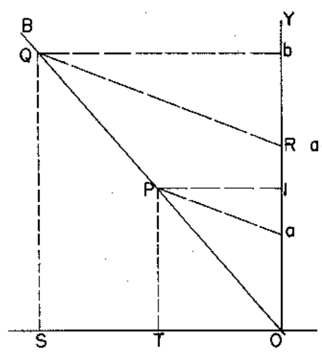


fig.5

Proof: Consider the similar quadrilaterals (SQRO) and (TPaO)

$$\frac{SQ}{PT} = \frac{RO}{a}$$

Substituting SQ = b PT = 1

we have $\frac{b}{1} = \frac{RO}{a}$

Therefore RO = a x b

It should be noted that where a unit length is impractically short or long, any convenient length, k, may be used. The resultant product curve will then have an ordinate scale calibrated to k times the original ordinate scale.

The foregoing procedure will apply regardless of whether or not "a" or "b" or both are negative. Figure 6 shows the configuration for "a" negative and "b" positive. Figure 7 shown both "a" and "b" negative. From the figures it can be seen that the procedure is consistent in sign, the product being negative if "a" and "b" have opposite signs, and positive if they have like signs. It should also be noted that an interchange in the roles of "a" and "b" does not change the results.

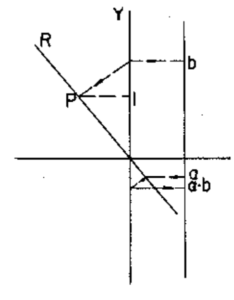


fig.6

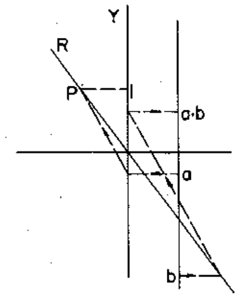


fig.7

The process of graphic division follows immediately by a change in the roles played by points R and either "a" or "b".

To illustrate one of the many practical uses of this construction consider first an example which can be easily be verified. (Fig. 8) Plot graphically the two straight lines.

$$y_1 = \frac{x}{3} + \frac{1}{2} \qquad Y_2 = \frac{x}{2} - 1$$

The product $$y_3 = \frac{x^2}{3} - \frac{x}{6} - 1$$

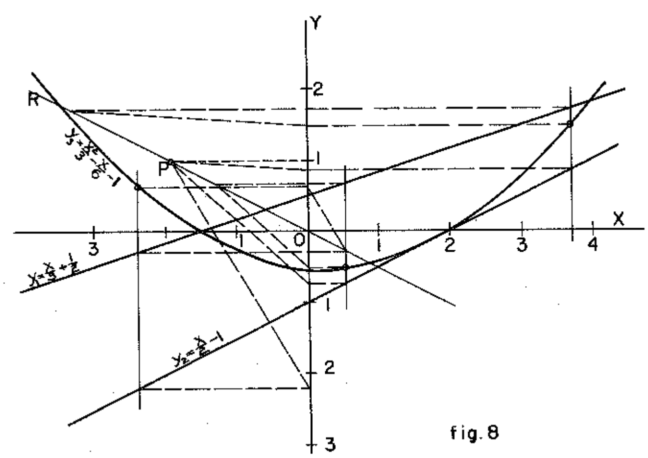
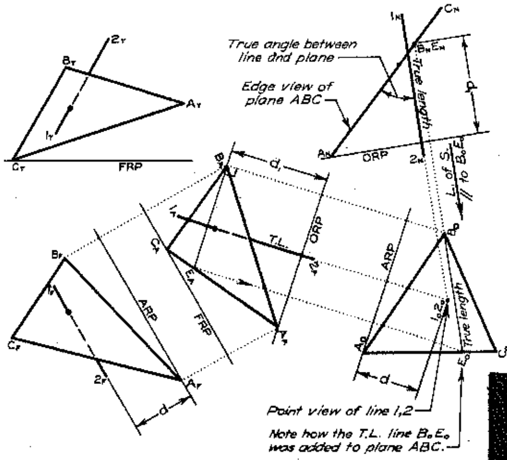
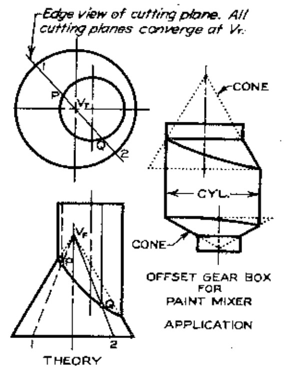


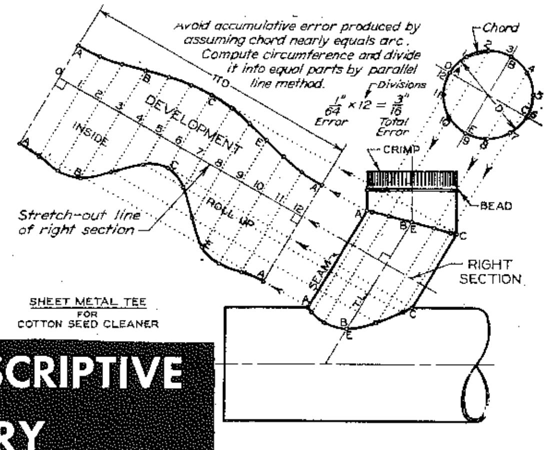
fig.8

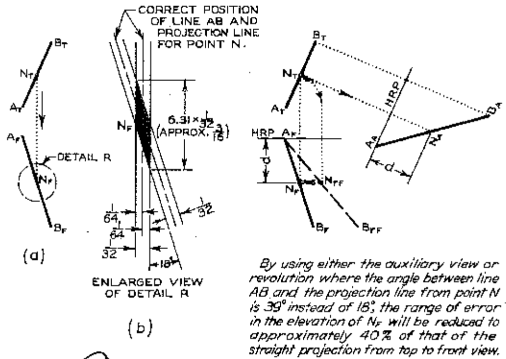
The product curve has been obtained by multiplying the pair of values along each ordinate and spotting the product on that ordinate. The process may be very rapidly performed by use of T square and triangles. Each "a" value is moved to the "y" axis and each "b" value to the line CQ. The entire process involves only

(Continued on page 33)









(a) (b) (c)

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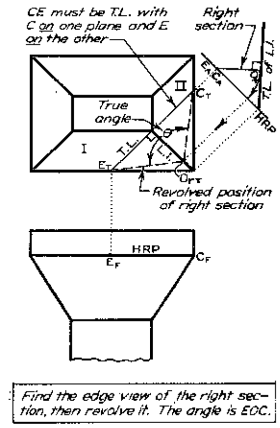
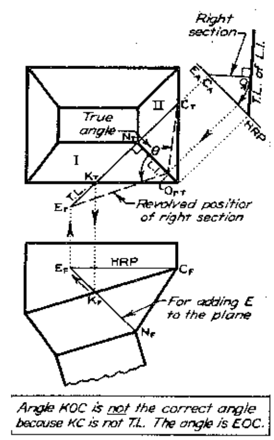
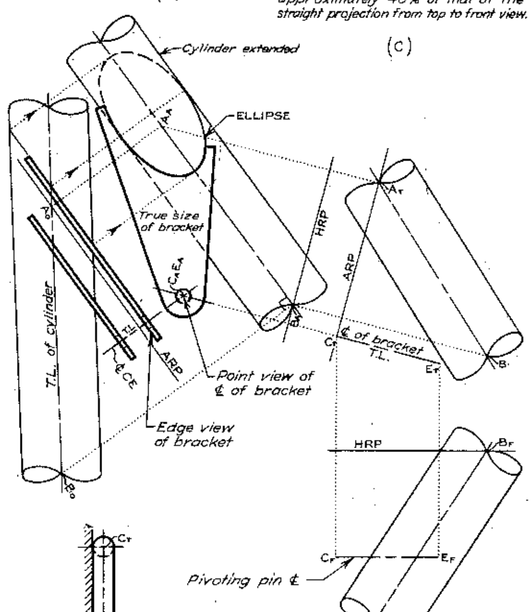
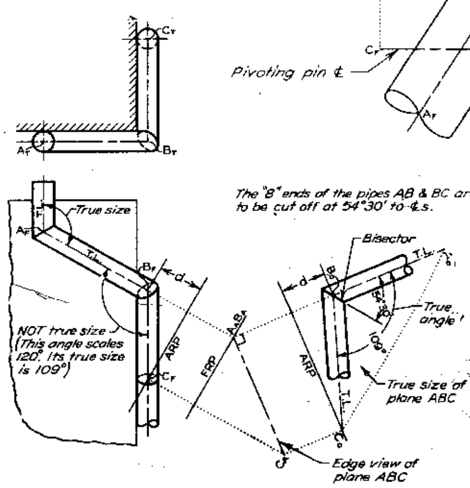


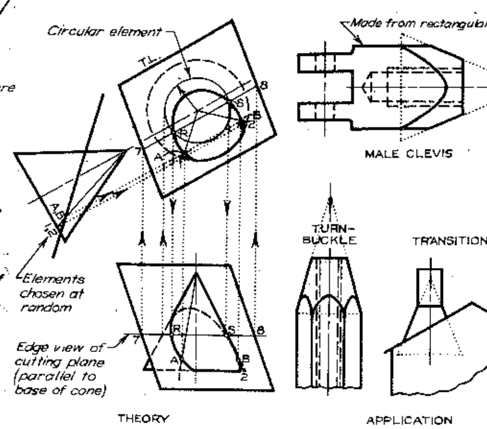
(a)



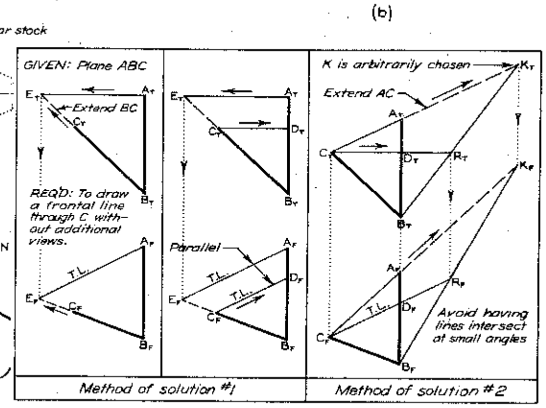
(b)







THEORY (a) APPLICATION (b)



(a) (b)

(Continued from page 10)

for example. Step 1 is all you see because there is no other one there. Step 2 on the next overlay may be in blue, so the blue will be predominant for Step 2 which is what you now with to emphasize. Step 1 will still be visible however because of the different color, so the relationship between step 1 and step 2 is quite apparent. The process continues through the logical sequence step by step with no chance for the student to see and wonder about line XY which may be in step 4 while you are talking about line AB in step 2.

The uses of color overlays are practically limitless. They can be easily made for such topics as (1) orthographic projection, (2) sections, (3) conventions, (4) fasteners, (5) assembly drawings, (6) double auxiliaries, (7) perspective, (8) shades and shadows, (9) charts and (10) even the steps in inking, as well as many others. The great saving of time through the use of overlays so far as the teacher is concerned is due to the fact that it is not necessary to redraw the problem each time. All that is necessary is to draw the one step on the overlay. The next step is drawn on the next overlay. The original problem is never redrawn nor is any preceding step redrawn.

You may ask, "Why not do the same thing with black and white?" It may be done with black and white in overlay form and would without question be much superior to showing the completed problem as is now the practice. However, the black and white overlay is much less effective than the color for the very obvious reason that the separate colors emphasize the separate steps as black and white can never do.

May I reitterate that the merits of color overlays are, first--they emphasize the steps in logical sequence; second, all steps are completely visible at the conclusion; third, there is a great saving of the teacher's time in not having to redraw the preceding steps each time, and lastly, and most important, the student grasps the steps more quickly through the use of color than by ordinary black and white.

These overlays as you see them are not without shortcomings and I am fully aware of the most prevalent one as I'm sure you are. The question foremost in your minds is how can you present this material to a class since there is only one copy of the overlay. There are a number of solutions to this problem. First and probably least effective is to circulate the overlay around the class while you go through the problem step by step on the blackboard. The second solution is to have several overlays, thus eliminating the blackboard session completely. Third is to have a large wall chart with the complete solution, but drawn with color for each step, the same as the overlay. The wall chart would thus replace the blackboard for the lecture. The last and most effective method is to make color slides of the overlay and the lecture given from the screen. The overlay is still available for any member of the class who wishes to trace back through the steps. (If time permits I shall show you some color slides of overlays as well as other color applications.)

It may be concluded by many of you that I am critical of the conventional "chalk talk." Such a conclusion is for the most part correct. The blackboard is without a doubt the most widely used teaching device in existence and for some type of work has no equal, however for a complicated explanation or drawing it is the least effective of all. I am thinking in particular of an intersection problem. A great deal of practice is required to make blackboard drawings of an intersection problem if the teacher starts with the bare problem. The time spent in practice for a sketch <u>which will have to be repeated for the next class</u> might better be spent on making a permanent drawing in color to begin with. Inaccuracies of the blackboard drawing must always be "explained away," which as everyone knows is psychologically unsound. A color wall chart, overlay or slide eliminates the error.

We will now assume the blackboard drawing and the lecture are finished but someone still doesn't understand step 2. All of you have experienced this. You now have a maze of lines on the board. The student is confused, and you will many times confuse him still further by trying to trace through your solution, because he isn't seeing just step 2--he is seeing the entire "spider web" of lines. Once again through the use of color by any of the above mentioned methods, you are able to focus the student's attention upon the one step in question. The color of the wall chart will emphasize the steps by contrast, however as I pointed out earlier, having the complete solution visible to the student even in color is not as effective as being able to show only one step at a time. It might be parenthetically added that through the use of color you will find that there will be many less questions than you have experienced in the past because of clarity of the first explanation.

I have been greatly stimulated to carry on color experiments by the work being done by the Foundation For Better Reading. The reports which I have read concerning the results they are obtaining are almost unbelievable.

The items which have impressed me most are (1) the rate of reading has increased on an average of over three-fold and (2) the tests which have been given indicate that the rapid reader has more comprehension than the slow reader (this is most revealing) and finally the rapid reader retains <u>more</u> learning <u>longer</u> than the slow reader. These, Gentlemen, are mighty potent facts. I believe they have a definite relationship to drawing.

Some time ago I performed a simple experiment (and I hasten to add that there were not enough for the results to be completely valid) to give me some indication of how long students retain drawing knowledge. In advanced classes of students, who were completing their second and third semesters of drawing. I gave each man a complete solution of a double auxiliary problem. (Continued on page 33)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(Continued from page 31)

The front and side views were given and the complete view was shown in each of the auxiliaries. I asked them to indicate, in the final view, the top surface by simply writing the word "Top" on the proper surface. Only 40% of the students could correctly recognize this surface in 60 seconds. This indicates to me that we are teaching drawing, not by visualization but by mere mechanics. I believe that we at Notre Dame are typical and I am confident you will find similar results if you will check in your own schools.

Observation has convinced me that students can be taught to visualize objects through the use of color more quickly and thoroughly than by any other medium. I say observation because I have not obtained factual information yet, but mere observation may be quite valid if properly conducted.

Color research is a comparatively new and fascinating field and like any other research, it must start from an hypothesis. I have no doubt that color is eventually going to alter completely our techniques of teaching drawing as well as many other subjects. I could not find a single piece of evidence dealing with color and its relationship to learning and the retention of that learning. However the two phases which have had a profound influence upon an hypothesis I have formulated are these--(1) from observation I have assumed that I can teach drawing principles and visualization more quickly with color than by the present conventional methods, and (2) the findings of the Foundation For Better Reading have proved the rapid reader comprehends more and retains the learning longer. You will note that three factors are prevalent; reading speed, comprehension, and retention. If the rapid reader of the printed page comprehends more and retains the learning longer, does it not follow that the same would be true for the reading of drawings?

The problem as I see it is to prove that through the utilization of color, a student will learn quicker, comprehend more, and retain learning longer than he will without the use of color. Observation plus a few minor tests have indicated to me that the above hypothesis is true in all three respects. I hope to have factual data to either prove or disprove the assumptions by the time this meeting is held a year from now.

And now for the final point. What do you use to correct the students' work? A color lead perhaps? The irony of it, Gentlemen--using color to emphasize the students' mistakes with never a thought of using color to prevent those mistakes.

(Continued from page 29)

drawing parallel lines. The construction lines for three sample ordinates are shown.

A more practical example can be demonstrated if we consider an average alternating current circuit containing both resistance and inductance. The curves for a, the voltage, and i, the current are shown. (Fig. 9)

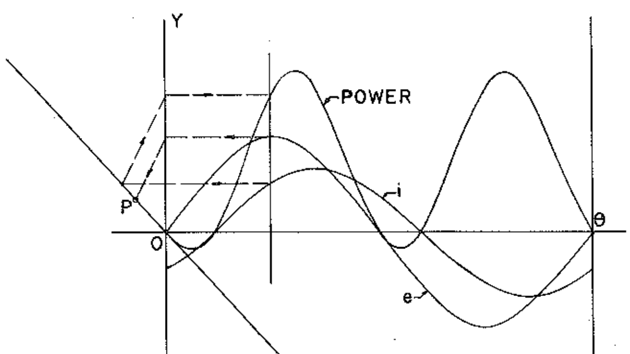

fig.9

The power in such a circuit is given by

$$P = ei$$

If, then, we multiply graphically the curves for a and i, we obtain the curve representing the power supplied to the circuit. The result is shown above.

A wattmeter in the circuit would indicate the average power. This may be obtained from the diagram by constructing the mean ordinate of the power curve.

For the purpose of illustration, the examples given possess relatively simple analytic solutions. However, here again the great power of this graphical process lies in the fact that two curves for which no analytical equation exists may still be multiplied together by this method. Such curves are very frequently encountered in scientific work and always present a difficult problem to the analytic mathematician. Natural extensions of this basic type may well lead to complex analytic computations. However, providing the components can be expressed graphically, the method of graphic solution retains the same basic form. It can be seen that there exists here a wide field of exploration in the solution of many engineering problems in which the accuracy of solution is limited by the nature of empirical data, bringing the accuracy of the results within graphic limits.

(Continued from page 13)

chart shown in Fig. 3, which is one of the most useful tools in the air-conditioning industry. Universal in application, the psychometric chart has two important functions:

1. If two properties of moist air are known, all other relevant properties may be read directly from the chart.

2. It is the basis for graphic analysis of the air-conditioning processes.

The psychometric chart is a network chart that may be constructed from thermodynamic equations, but the more accurate printed chart, available in several popular types, is generally preferred. Most psychometric charts are made for normal temperatures and standard barometric pressure. The horizontal bottom scale measures dry bulb temperature of air as indicated by an ordinary thermometer. The vertical right scale measures specific humidity in grains of moisture per pound of any air. The lines curving upward to the right indicate percent relative humidity. The wet-bulb lines indicate the temperature shown by a thermometer whose bulk is covered by a wet wick exposed to a rapid current of air. The constant volume lines show the volume of the air-vapor mixture in cubic feet per pound of dry air. At saturation the wet-bulb, dry-bulb, and dew-point temperatures are all equal, and the temperature scale for these lines appears beside the line of 100% humidity, the saturation curve which forms the left border of the chart. Outside the saturation curve is the offset scale of enthalpy at saturation for measuring total heat in Btu per pound of dry air.

Several time-saving uses of the psychometric chart will be briefly described. For the first example take an ordinary temperature of 70°F and a wet-bulb temperature of 80°F. From 70° on the dry-bulb scale follow a vertical line up to its intersection with a sloping line from 60° on the wet-bulb scale. This point of intersection A determines all desired values on the chart. By interpolation between curves, point A indicates a relative humidity of 56%. By interpolation between constant volume lines, point A shows 13.5 cubic feet per pound of dry air. From point A follow a horizontal line to the saturation curve and read 54°F on the dew point temperature scale. Follow a horizontal line to the right vertical scale and read 61.5 grains of moisture per pound of dry air. In like manner any desired properties of air may be read on the chart if two properties are known.

Another example illustrates on air-conditioning process in which the relative humidity is held constant while the air is heated or cooled to suit winter or summer conditions. In an unheated room the air temperature may be 40°F and its relative humidity 50%. If we turn on the heat and raise the temperature to 70°F, the relative humidity will drop to 17% unless we add moisture to the air. To determine how much moisture is needed follow horizontal lines from intersection points where the 50% relative humidity curve crosses the 70° and the 40° vertical lines to the right to the moisture scale and read 54-18 = 36 grains of moisture per pound of dry air. A room 16' x 25' x 9' containing 3600 cu. ft. of air would require 130,000 grains, or about 1.4 pints of water to be evaporated. This calls for heating and humidifying.

Conversely, in summer with windows open the same room may have an air temperature of 90°F with 50% humidity. If we close windows and lower the temperatures to 70°F, the relative humidity will rise to an uncomfortable 96% unless we take moisture out of the air. The amount to be removed to maintain 50% relative humidity, is read on the moisture scale, 106-54 = 52 grains per pound, or about 1.7 pints of water for this room. This is a case of cooling and dehumidifying.

As it is expensive to condition fresh air, it is customary to mix it with room air in suitable proportions. In this example 25% fresh air is used, so that we have one part by weight of outside air combined with three parts by weight of inside air. If the outside air has an ordinary temperature of 95°F and a wet bulb temperature of 80°F, while the inside air has an ordinary temperature of 75°F and wet-bulb temperature of 60°F, locate these two conditions as points A and B respectively on the psychometric chart shown in Fig. 4. Draw a straight line connecting A and B and on it locate point C at a distance from B equal to one-fourth of AB. Point C represents the conditions of the mixture of fresh air and room air. By reference to the proper scales the properties of the mixtures are read as follows:

dry bulb temperature = 80°F
wet bulb temperature = 66°F
moisture content = 72 grains per pound of dry air

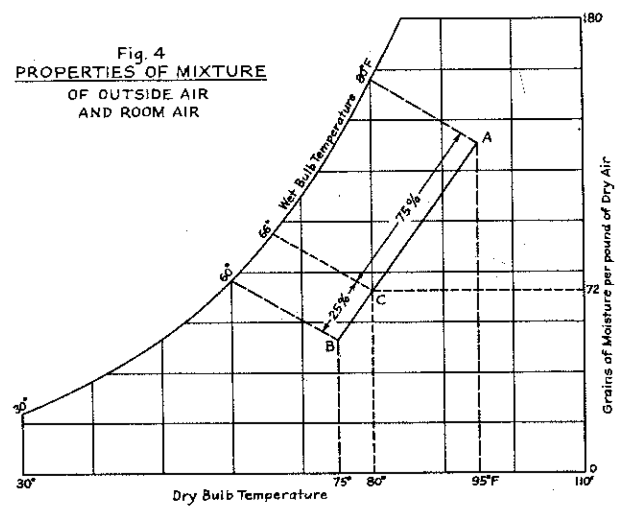

Fig. 4 PROPERTIES OF MIXTURE OF OUTSIDE AIR AND ROOM AIR

To bring this air mixture to the desired room conditions requires much less cooling and

(Continued on page 37)

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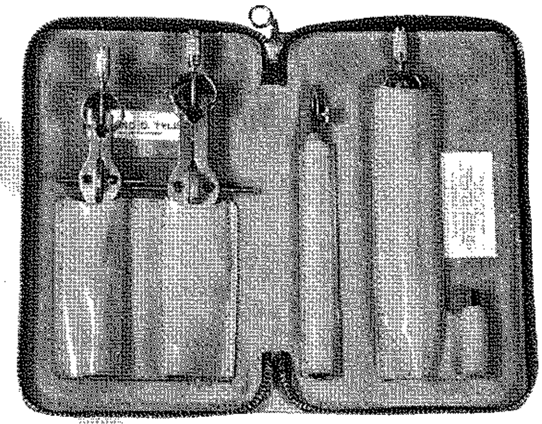

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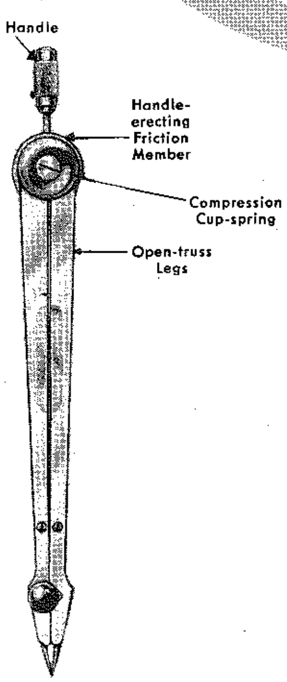

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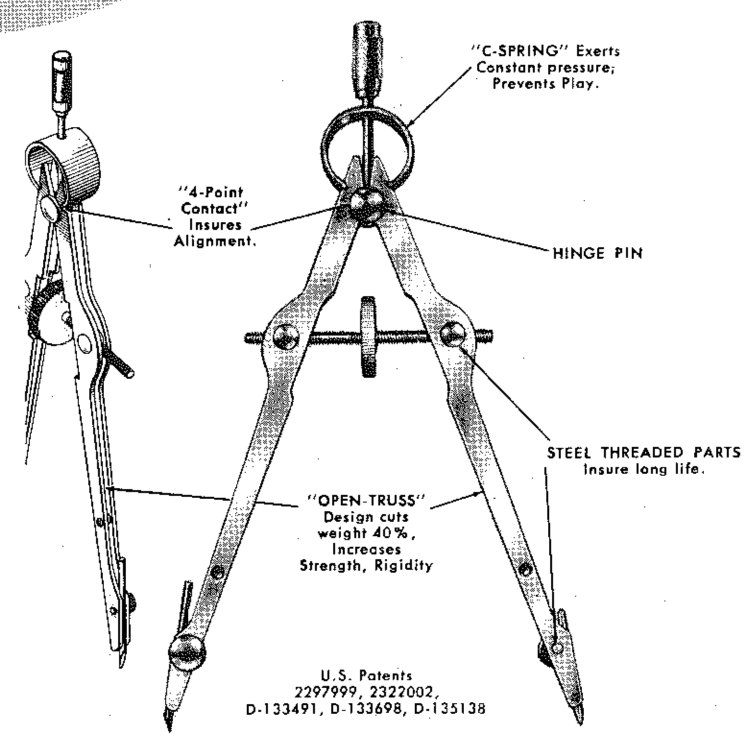

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(Continued from page 35)

dehumidifying than would be necessary for fresh air to give satisfactory interior comfort under summer conditions.

A good many moist air problems that are encountered every day in heating, air-conditioning and refrigeration design are worked out to advantage with the aid of the psychometric chart. The solution of most of these problems involves a simple geometric construction which requires drawing a few pencil lines directly on the chart, or on transparent paper placed over it. For this purpose there is available a commercial chart printed on plastic material instead of paper, so that pencil lines can be readily wiped off the chart after they have served their purpose. As a useful and accurate time saver the psychometric chart is indispensable in its field.

A third kind of graphic method in the three-dimensional stereogram which is a valuable aid to technical thinking and imagination in the analysis of research problems. The stereogram is an accurate pictorial diagram of a surface which represents the interrelationship of three variables. A stereogram may be constructed in the form of a three-dimensional model whose surface represents the desired basic relationships, but an accurate pictorial diagram is usually satisfactory. Typical stereograms of current and of voltage will be described in reference to their useful application to an analysis of transient phenomena in electric circuits.

The electric power passing through a given point in a circuit at a certain instant of time may be expressed as the product of the voltage component and the current component. As the value of both voltage and current may change from point to point and from instant to instant, it is necessary to know the function of voltage with respect to time and distance and also the function of current to time and distance. This pair of functions may be represented graphically by a pair of stereograms, the voltage-stereogram and the current-stereogram for this particular circuit.

For the original condition of the circuit there is a steady state of constant voltage and current, or their values may vary only with respect to distance from a point of reference. When circuit conditions change, the power assumes a new steady state, but an interval of time occurs before the new state is attained. During this time interval there are transient changes of current and voltage which are represented by a succession of points, or by lines connecting consecutive points on a current-voltage chart, called a surge diagram. This diagram defines the interplay of current and voltage throughout the transient interval. It provides data for constructing both the current and voltage stereograms and it is the key to this method of graphic analysis. The surge diagram is drawn as shown in Fig. 5, which illustrates the simple case of a battery to supply constant voltage, a switch, and a free conduit. The conduit is assumed to have no resistivity and no initial potential.

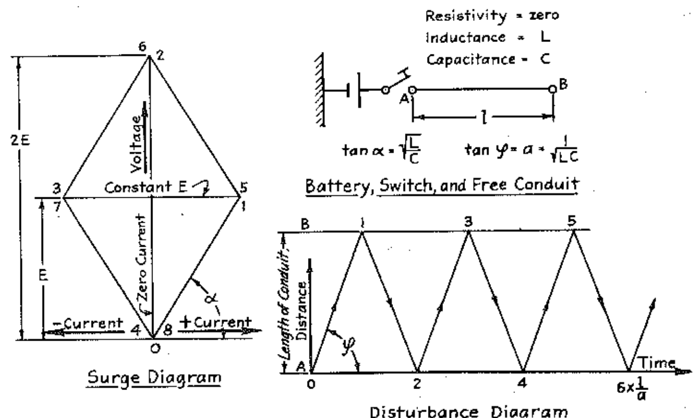

Fig. 5

By closing the switch a constant voltage E is applied to one and of the conduit. The surge diagram shows that this change of potential from zero to E is accompanied by a change of current along the straight line from point 0 to point 1. When the voltage wave reaches the free end of the conduit the current is reduced to zero and the voltage is increased to 2E along the straight line 1-2. Now the electromagnetic energy is changed to electrostatic energy and the new wave returns along the conduit to the battery where its voltage is reduced to E while the current is reversed along line 2-3. When the wave again reaches the free end of the conduit, its current is reduced to zero along line 3-4. The cycle is then repeated (5-6-7-8) and would continue indefinitely if its energy were not dissipated.

Fig 5 also shown a time-distance chart, called a disturbance diagram because it represents the forward movement of the disturbance-front as a function of time. This diagram is the horizontal base of both the current and voltage stereograms. At each significant point of the disturbance diagram a vertical ordinate is erected to determine the corresponding point on the stereogram. The length of each ordinate is a value obtained from the surge diagram. For the stereogram of current shown in Fig. 6 the value of the current at each point of the surge diagram is laid off on the vertical ordinate whose base is the corresponding point of the disturbance diagram. The points determined by these ordinates are then connected in consecutive order to form the surface of the current stereogram shown in Fig. 6.

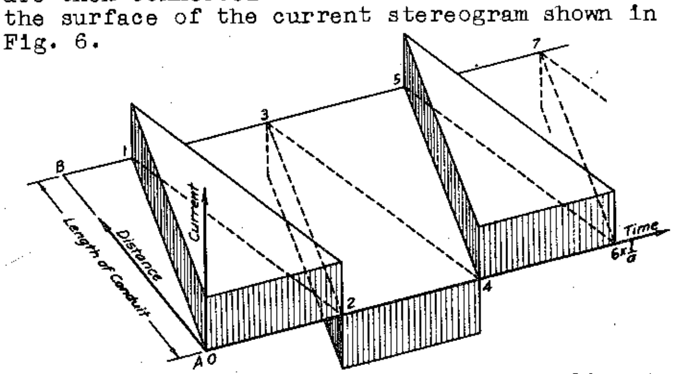

Fig. 6. Stereogram of Current

(Continued on page 39)

MINUTES OF THE ANNUAL MEETING OF THE DRAWING DIVISION OF A.S.E.E. UNION BUILDING AT MICHIGAN STATE COLLEGE LANSING, MICHIGAN JUNE 26, 1951

After luncheon Chairman Paffenbarger called for a report of the nominating committee.

Prof. Thompson reported for the committee, the following results of the election that had been previously held by mail.

Chairman - C.H. Springer
Secretary - R.T. Northrup
Member Ex. Com. - J.S. Rising
Editor T-Square Page - B.L. Wellman
Adv. Manager - C.J. Vierck

Chairman Paffenbarger presented the new chairman who asked that all committee members continue in their duties for another year.

He also stated that the policy committee was formulating a plan for combating enroachment on drawing time. Then, as secretary, C.H. Springer, presented an amendment to the articles of procedure as attached hereto.

Adoption of the amendment was moved by Springer, seconded by Hoelscher. Passed.

Chairman Paffenbarger called for nominations for Vice-Chairman from the nominating committee.

Prof. Thompson nominated Dean Jasper Gerardi.

Chairman called for nominations from the floor.

Prof. Justus Rising moved that the nomination be closed and the secretary cast a unanimous ballot for Dean Gerardi. Seconded and passed.

Chairman Paffenbarger presented other new officers.

Prof. Aakhus presented the report for the Journal of Engineering Drawing.

Dean Gerardi reported as Editor of the T-Square page and for the committee on student work and outlines.

Prof. Heacock reported for the committee on advanced graphics.

Prof. Howe reported for the committee on Teaching Aids.

Prof. Porsch reported for the committee on Drawing Instruments and materials.

Prof. Northrup reported for the committee on instrument display.

Chairman Paffenbarger reported that the midwinter meeting will be held in New York January 23, 24 and 25, 1952.

Chairman Paffenbarger reported that the mid-winter meeting for 1953 will be held at the University of Nebraska, at Lincoln, Nebraska.

Meeting adjourned.

Respectfully submitted.

s/ C.H. SPRINGER

C.H. Springer,
Secretary

MINUTES OF THE EXCEUTIVE MEETING OF THE DRAWING DIVISION OF A.S.E.E. JUNE 23, 1951

The meeting was called to order by Chairman Paffenbarger at 7:00 p.m. after a dinner in the Union Building at Michigan State College at East Lansing, Michigan.

Those present were Professors, Paffenbarger, Aakhus, Higbee, Hoelscher, Griswold, Northrup, Grant, Rising, Jud, Rising J.S., Rowe, Potter, Street, Spencer, Springer, Vierck, Wellman, Col. Shick, Gerardi, Luzadder, and McGuire.

The minutes of the preceding meeting were approved without reading.

The Chairman announced the results of the ballot which elected the following officers:

Chairman - C.H. Springer
Secretary - R.T. Northrup
Member Ex. Com. - J.S. Rising
Ed. T-Square Page - B.L. Wellman
Adv. Manager - C.J. Vierck

Chairman Paffenbarger called on the chairman elect for a general statement of policy for the coming year.

Chairman-elect Springer suggested that, in view of the great concern felt by members of the Drawing Division about the continued and progressive squeeze being placed on all drawing departments for time, that the Policy-Committee of the division be instructed to formulate a policy that could be implemented by the entire division to combat this tendency.

After discussion this suggestion was moved by Prof. Street, and seconded by Prof. Northrup. The motion was passed.

The secretary read the proposed changes in the Articles of Procedure attached to these minutes.

It was moved by Prof. Street that nominations from the nominating committee and from the floor be accepted for the office of Vice-chairman if the proposed changes were approved. Seconded by Hoelscher. The motion passed.

The nominating committee stated that they wished to nominated Dean Gerardi for the office of Vice-Chairman.

Prof. Street moved that this nomination be approved. Seconded by Prof. J. Rising. The motion passed.

The Chairman suggested that the reports from the three officers of the Journal be combined and presented as one report.

Chairman Paffenbarger read a letter from Prof. Lee concerning the mid-winter meeting.

The dates will be January 23, 24, and 25, 1952.

Prof. Vierck moved that these dates be approved. Seconded by Prof. Rising. Motion passed.

Prof. Griswold reported that Wednesday, January 23 would be spent at Cooper Union in registeration, and a visit to the Brooklyn Navy Yard.

Thursday, January 24 would be spent at West Point.

Friday, January 25 would be at Columbia.

The trip to West Point will leave the Bus Terminal at 8:00 a.m. Lunch will be at the Cadet Mess hall and the afternoon will be devoted to an inspection of the Academy.

Chairman Paffenbarger read a letter from Prof. Aakhus inviting the Drawing Division to hold the mid-winter meeting of 1953 at the University of Nebraska at Lincoln. Prof. Potter moved that we accept this invitation. Seconded by Prof. Vierck. Motion passed.

Chairman Paffenbarger asked the new editor of the T-Square page to write up an account of the Summer School just completed.

Prof. Aakhus asked that the program for the mid-winter meeting be in his hands by October 1st.

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Fig. 7 shows the stereogram of voltage for this example. As the other member of this pair of stereograms it has the same base as the current stereogram of Fig. 6, but its ordinates are different. In this case the value of the voltage at each point of the surge diagram is laid off on the vertical ordinate whose base is the corresponding point of the disturbance diagram. The points thus determined are then connected in consecutive order to form the voltage stereogram of Fig. 7.

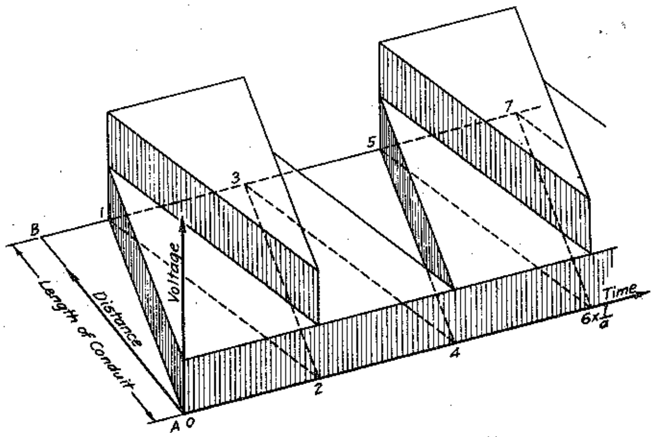

Fig. 7 Stereogram of Voltage

This pair of stereograms gives a complete picture of changes in current and voltage during the transient interval between one steady state and the next for the simple case of a free conduit. When conditions of the circuit are changed by adding to its resistance, ground, inductance, or capacitance, or any combination of these elements, a different surge diagram must be constructed. For each case we have an entirely different pair of stereograms of current and voltage.

These stereograms are a valuable aid to the visualization of transient phenomena. An important application of the stereogram principle is realized by taking vertical sections of the current and voltage stereograms cut by planes parallel to the time axis. These sections are called history diagrams, or simply histograms of current and voltage, respectively, because they depict the behavior of current and voltage as functions of time during the transient interval.

This brief description of the stereogram and its companion surge diagram is only an introduction of a useful method of graphic analysis. A complete discussion of this concept and its application to transient electrical phenomena was published by K.G. De Juhasz in 1939 in the Journal of the Franklin Institute. Professor DeJuhasz is in charge of Engineering Research at the Pennsylvania State College. He has published a dozen articles on the graphic analysis of impact, fluid flow, and other engineering problems.

The three examples described in this paper illustrate the versatility of the graphic approach. Many discerning persons in various fields of learning and research have adopted the graphic method because they recognize its inherent advantages. In closing I would like to make an earnest appeal to my colleagues in graphics that they take a wider interest in the development of graphic methods for the solution of technical problems, engage in research projects involving graphic analysis, and publish reports on their investigations as significant contributions to scientific knowledge.

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Chairman Paffenbarger requested that the Policy Committee set up a few rules for the guidance of the Awards Committee in making their selection. This was approved.

Prof. Grant suggested that a program on advanced graphics similar to the one given in the last afternoon of the Summer School be arranged and that all Deans be invited to attend.

Chairman Paffenbarger thanked everyone for their help and cooperation during the year.

The executive Committee went on record as expressing hearty congratulations to Prof. Paffenbarger for the success of the summer school.

Meeting Adjourned at 9:00 P.M.

Respectfully submitted,

s/ C.H. Springer,

C.H. Springer, Secretary

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Technical institute instruction, particularly in the drawing field, is not a watered-down version of engineering. It is an intense, practical medium of instruction designed to do a well defined and socially significant job all of its own.

The technical institute concept is not new, but its recognition and application on a nationwide basis is new. It might be said that the whole idea currently is an idea on trial. The intelligent understanding of its philosophy and objectives, not only by drawing teachers but by educators generally, will help it develop as it should.

Photo courtesy Douglas Aircraft Co., Inc.

WHAT you see above is a real plane inside and out . . . except that it is made of plywood, inside and out. It is a "mockup" in which no pilot will ever seat himself, a make-believe that will never fly.

There is a sad analogy here to youngsters in every classroom, seemingly equipped in every respect for "flying", but in whom the pilot of self-direction, ambition, vision and daring will never take a seat, never to lift the personality above humdrum earth. These are boys who have become unconsciously convinced by vile circumstance that their bodies and minds are but "make-believes," who through misdirection and indifference will be consigned to the great scrapheap of life.

It is the task of all right-minded men of Education to show these boys they are equipped for the great adventure of life, the expansion of the horizons of the mind, the uplift of spirit, winging to new heights of conquest. No educator worthy of the name will disclaim this responsibility but shoulder it to the full. And *no* educator has greater opportunity to establish habits of right thinking, of clear thinking, of strength of purpose, of high standards, of unfaltering ambition than the instructor in mechanical drawing. Here is the study that abuts so closely on one of the most honorable careers in the world. Here he can cite as examples and inspiration the deeds of great engineers. Here he can appeal to the creative desire that is instinct in all. Here the boy uses tools of precision, tools of creation, tools that link hand and brain and reflect back into moral standards. Here is an opportunity without equal. Shall the instructor cast it away through carelessness on his part, through lack of respect for his subject or its tools? Can he say it does not matter what drawing instruments the young student will use? The risk attending such negligence is great. The need for such negligence does not exist. The thoughtful instructor *demands* his students have the best drawing instruments it is possible to buy.

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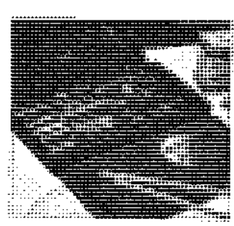

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