R. S. PAFFENBARGER

THE JOURNAL OF

ENGINEERING DRAWING

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Analysis
Synthesis
Communication

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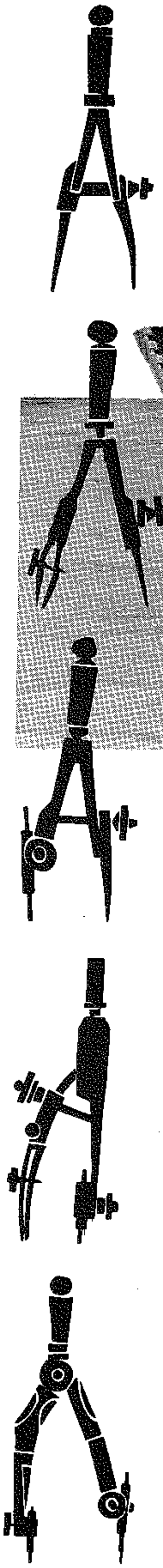

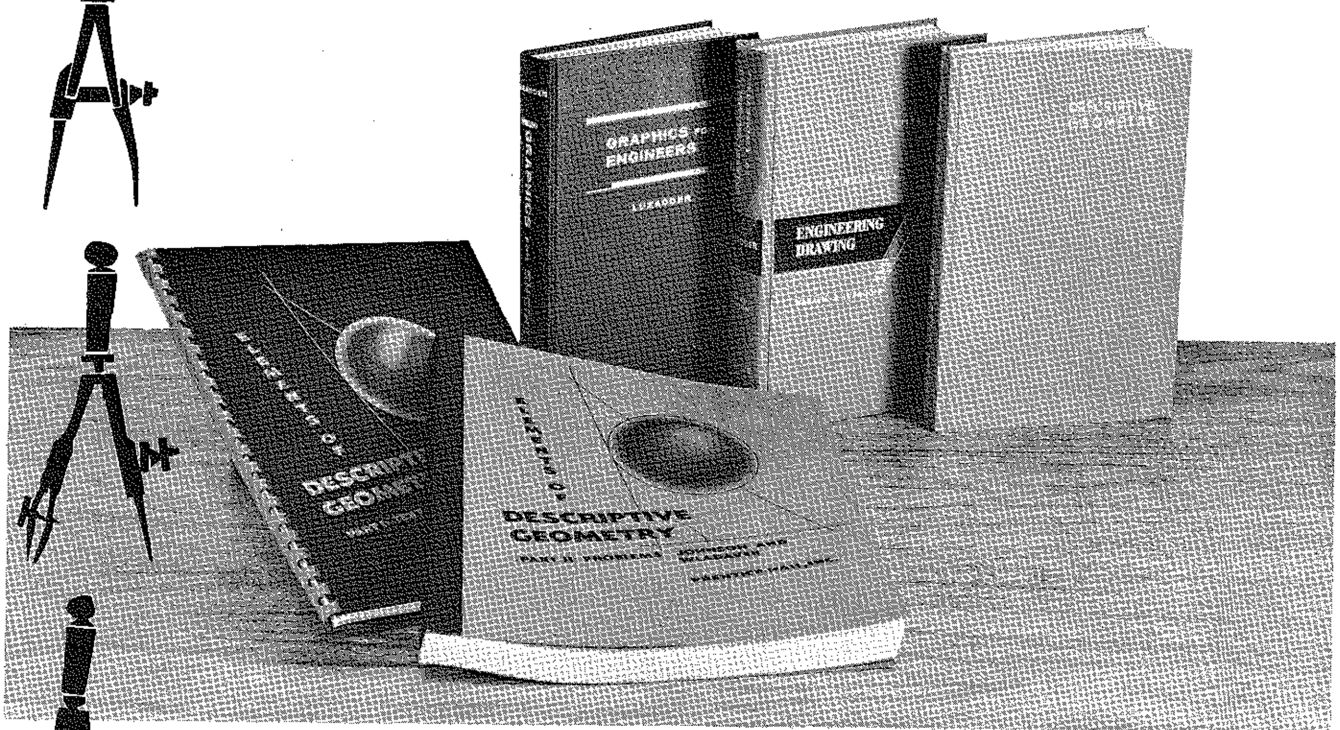

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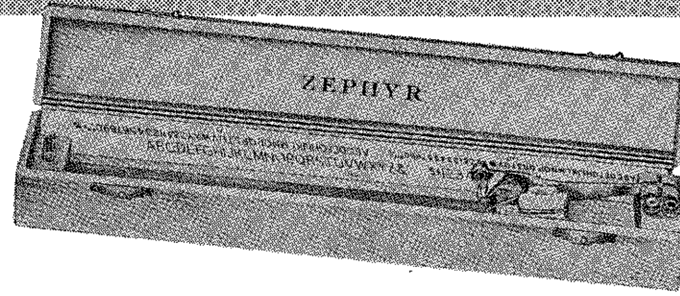

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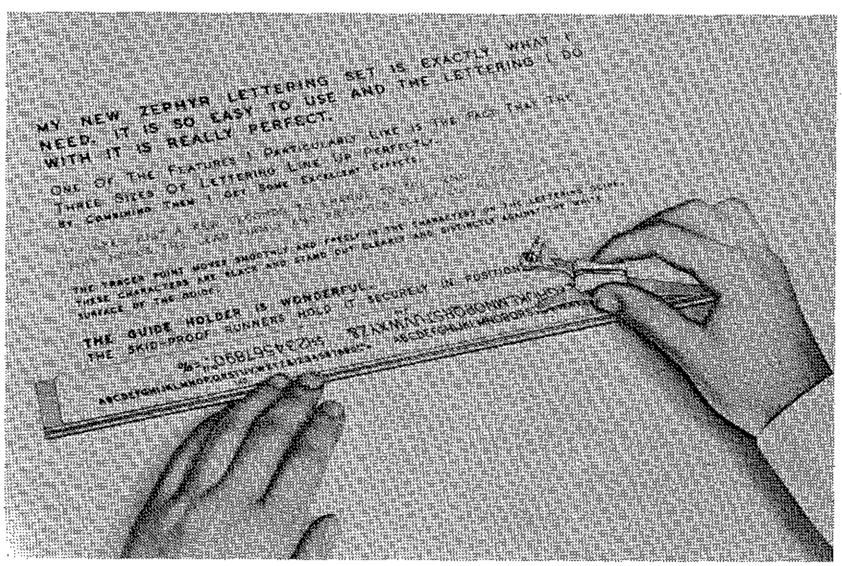

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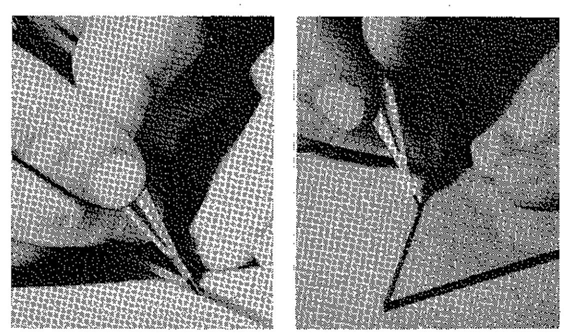

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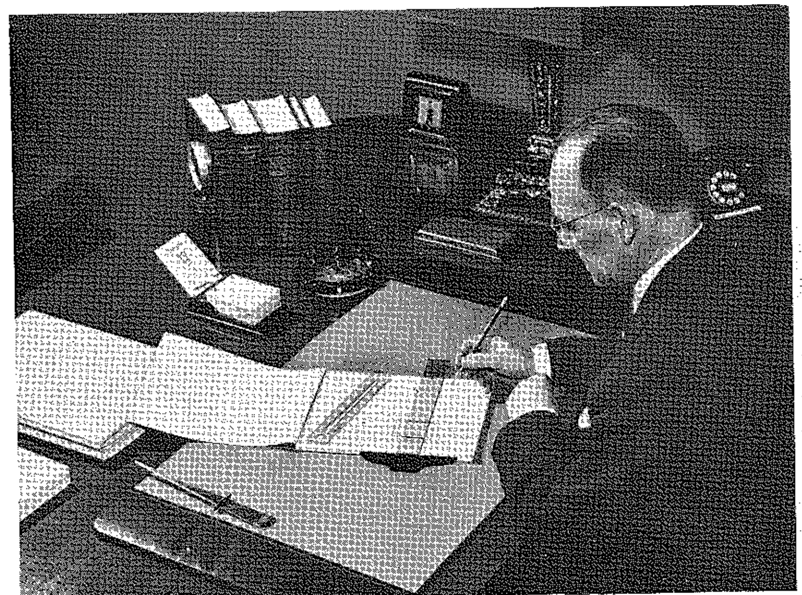

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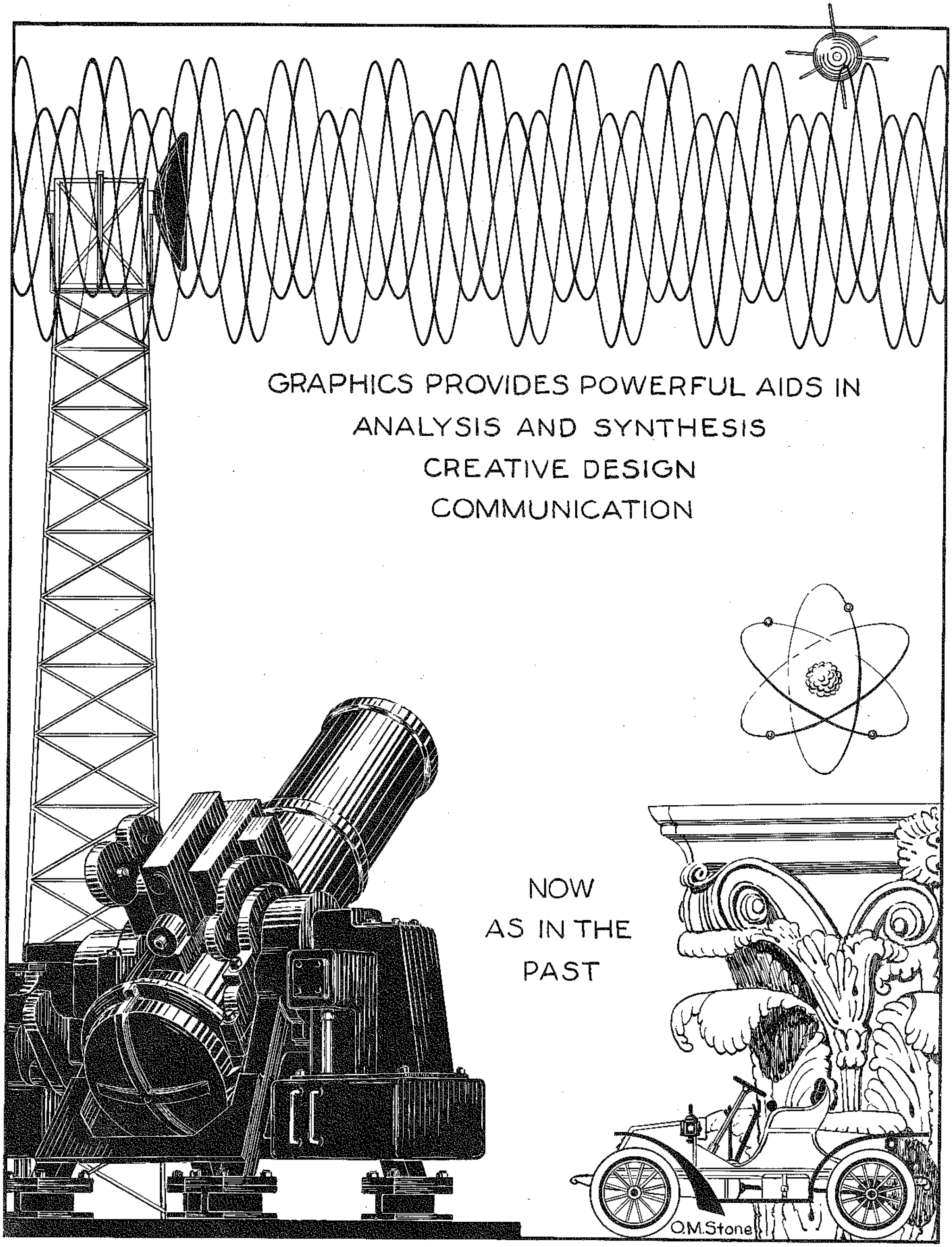
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Editorial Page

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LE PLUS ÇA CHANGE
LE PLUS C'EST LA MÊME CHOSE

The memorable 1946 Summer School of the Drawing Division was opened by Professor Justus Rising, then Chairman of the Division. Among the things he said in the opening address was the following:

"The aims and objectives of a drawing course should be:

1. To train our students in technical and analytical reasoning so that they will be able:
   (a) to analyze a given problem or situation
   (b) to find and analyze the information required for its solution
   (c) to produce the required solution according to specifications
   (d) to express the result according to accepted practice
2. To furnish instruction in the fundamentals of the graphic language including:
   (a) lettering
   (b) freehand sketching
   (c) use of drawing equipment
   (d) shape description
   (e) size description
   (f) applications (working drawings)

"A course in drawing consists essentially of a correlated sequence of assignments to be completed by the students, in connection with his study of principles; the selection, arrangement and method of presentation are the great factors, aside from the personality of the teacher, in the success of the course"

This was almost twelve years ago and basically the statement rings as true today as it did then. Have the objectives changed very much? Not very. But there can be no question or possible shadow of doubt that what we do to try to satisfy these goals has changed substantially. Is there any teacher who hasn't made important changes in the choice of topics and in the content of his course?

Elsewhere in this issue you will find a detailed outline of an "integrated" course, together with reasons in support of methods and items included in the course. It will be interesting to know whether other teachers agree with Professor Carson Buck in his analysis of present day needs.

COMING ATTRACTIONS

A few weeks ago a telephone call came to the editor from a member of the staff of a well known chemical engineering company. He was writing a magazine article and he was searching for some pertinent facts in the history of engineering drawing.

Naturally the first thing to come to mind was Professor Frederic C. Higbee's never to be forgotten talk, "The Development of Graphical Representation," given at the same 1946 Summer School. Before the day was out the editor's precious copy of the talk was on its way.

Within a few days an appreciative letter came back saying, "We found the article by Professor Frederic Higbee exactly what we desired."

In the belief that many new members of the Drawing Division and perhaps some of the older members may not have seen the article when it was first published, we sought permission of the McGraw-Hill Book Company and of Professor Higbee to reprint the fascinating story in the JOURNAL. Both have agreed; in fact, Professor Higbee located certain illustrations that were not in the original publication and many of these will be included.

Look for it in the May issue.

"PUBLISH OR PERISH"

The author of the phrase may be hard to locate, but he had his finger close to the pulse of truth. Science thrives in the public print; so do scientists.

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Status of Engineering Drawing – 1957 Survey For the Drawing Division of ASEE

By Warren J. Luzadder

Purdue University

"Experience is what some of us get while looking for something else."

In conducting this survey the experience was gained too late to be used in the preparation of a questionnaire that might closely approach one-hundred per cent accuracy and be capable of presenting a true and complete picture of the status of engineering drawing in 1957. The word "might" is used because it is doubtful if any questionnaire can ever be devised with questions that are worded so that everyone will interpret them in the same way. Those who prepare questionnaires frequently select their questions and word each of them in accordance with his own thinking and experiences. As one person wrote: "We have tried to answer it as best we can. The trouble with questionnaires is that the maker-upper draws them in terms of his own school and they don't fit elsewhere."

In preparing a summary of the questionnaire the statements above were certainly borne out but who would have guessed that one school among the fifty-four that returned a questionnaire did not follow the credit-hour system. At this institution one merely pursues the prescribed courses until he graduates (United States Military Academy).

The entire blame for the possibility of the summary being somewhat unreliable does not lie entirely on the shoulders of the so-called "maker-upper". In a few cases it seemed to be probable that the person supplying an answer had not read the question carefully.

The summary of the survey is given here in the order in which the items appeared in the questionnaire.

1. Is your institution on the semester plan____or quarter plan____?

Forty-two institutions reported that they were on the semester plan while twelve were following the quarter plan. This question was asked because it seemed to separate the institutions under each plan when making a comparison of laboratory hours and credit hours.

2. Do all students working towards an engineering degree take the same basic course or courses? Yes____; No____.

In answer to this question forty-five institutions reported that all engineering students were required to take the same course or courses. Nine respondents answered No.

3. Basic drawing is presented over a period of one____; two____; three____; four____; five____; six____; seven____; eight____semesters or quarters?

In order to gain a true picture of the present status of engineering drawing, an effort was made to determine the amount of time assigned to basic drawing and to descriptive geometry as separate courses at institutions where they are presented in separate courses. This separation proved to be suitable in spite of the fact that basic drawing and descriptive geometry are integrated at fourteen schools. At two other institutions descriptive geometry is presented over a period covering two-thirds of a semester.

As might be expected the number of institutions having more than two semesters allotted to engineering drawing are few in number. A tabulation of the answers furnished by the respondents to the question above revealed the general situation for 1956-57 to be as follows:

Twenty-five schools that follow the semester plan have only two semesters in which to present both basic drawing and descriptive geometry as separate courses. At five other institutions, where the departments are more fortunate, three semesters are allotted. For those on the quarter plan the picture presented is about the same because the tabulation indicated that five have three quarters for instruction while one institution was given just one quarter. The two schools having four quarters assigned can be classed with the chosen few who have three semesters.

For the presentation of basic drawing alone twenty-five schools have only one semester allotted; six schools have two semesters; and two schools have one and one-third semesters. The last two schools are those at which descriptive geometry is given for two-thirds of a semester. Five institutions on the quarter plan have two quarters for basic drawing; two have three quarters; and one only a single quarter.

The picture at the fourteen institutions where descriptive geometry has been integrated with basic drawing can not be overlooked. For those schools on the semester plan, seven have two semesters allotted; one has three semesters; and, two have only one semester. Two schools on the quarter plan have three quarters assigned; one has two quarters; and, one has six quarters.

Hidden beneath these statements are variations for students in the different fields of engineering. The plain and simple truth revealed by the answers to this question is that the length of time assigned to engineering drawing and descriptive geometry would appear to be insufficient for needed instruction. However, the time allotted at three of our largest institutions is far less than the average, for each has only one term. At one school a student is not required to take any work in engineering drawing although he is strongly encouraged to do so. It was for this reason that the respondent indicated that the credit hours for his department had been cut from six to zero.

4. What is the number of credit hours assigned to the basic drawing courses at your institution?____. If the credit hours are not the same for all curricula please indicate the required credit hours for each field. Aeronautical Engineering;____Chemical Engineering____; Civil Engineering____; Electrical Engineering____; Mechanical Engineering____; Other____.

The number of credit hours assigned to basic drawing and descriptive geometry adds something to our study even though the picture presented may not be clear. Using the findings that follow, each person must make his own interpretation of the results obtained from a tabulation of the answers.

Most of the institutions that operate on the semester plan have a total of either four or six credit hours assigned to basic drawing and descriptive geometry when presented as separate courses. Eight schools give four credit hours, while eighteen assign six credit hours. Two schools indicated five credit hours where descriptive geometry had been assigned two credits. Two schools are in a very favorable position having seven and eight credit hours.

Basic engineering drawing, when presented separate from descriptive geometry, has been assigned either two, three or four credit hours. Eight institutions have two credit hours; fourteen have three credit hours; and, ten have four. For schools operating on the quarter plan, the credit hours for basic drawing and descriptive geometry as separate courses range from six to twelve. Three schools indicated six credit hours; one has seven credit hours; two have nine; one has ten; and one has twelve. At institutions where descriptive geometry has been integrated into the basic drawing courses the assigned credit hours range from three to seven for those operating on the semester plan. One respondent indicated three credit hours; two indicated four; five indicated six; and, one indicated seven credit hours. For schools on the quarter plan, one school has seven credit hours; one has nine; one has twelve; and, one indicated fourteen credit hours.

It is interesting to note the relationship of semester and credits and the number of institutions having each arrangement. At these institutions descriptive geometry is taught as a separate course.

INSTITUTIONS ON SEMESTER PLAN

One	institution	has	two	semesters	with	8	credit	hours.
Fourteen	"	have	"	"	"	6	"	"
Two	"	"	"	"	"	5	"	"
Eight	"	"	"	"	"	4	"	"
Four	"	"	three	"	"	6	"	"
One	"	has	"	"	"	7	"	"

INSTITUTIONS ON QUARTER PLAN

One	insitution	has	three	quarters	with	12	credit	hours.
"	"	"	"	"	"	9	"	"
"	"	"	"	"	"	8	"	"
"	"	"	"	"	"	7	"	"
Three	"	have	"	"	"	6	"	"
One	"	has	four	"	"	9	"	"

*5. What is the total number of laboratory hours per semester or quarter?*____.

If it can be assumed that those persons answering this question understood that the total number of contact hours in laboratory per semester was to be given, then we get a rather startling picture. A picture that is not revealed by the answers to questions 3 and 4 for the number of contact hours vary from 30 hours per semester at one institution to 180 hours at two other institutions.

A summary of the answers received from thirty-nine institutions follows:

TOTAL LABORATORY HOURS PER SEMESTER

Total Number of Laboratory Hours Per Semester	Number of Institutions Reporting
30	1
50-59	1
60-69	5
70-79	2
80-89	5
90-99	10
100-109	2
110-119	0
120-129	2
130-139	0
140-149	0
150-159	1
160-169	0
170-180	2

TOTAL LABORATORY HOURS PER QUARTER

Total Number of Laboratory Hours Per Quarter	Number of Institutions Reporting
40-49	2
50-59	0
60-69	2
70-79	3
80-89	1

The values as given for the laboratory hours per semester for the last five schools operating under the semester plan are open to question. It could be that the word per was overlooked and that the values represent more than one semester.

The questionnaire as marked by the respondent from one university indicated that students in the fields of chemical engineering and electrical engineering take only one basic course of twenty contact hours of laboratory work for one quarter. Civil engineering, mechanical engineering, and industrial engineering students are required to take a second basic course of forty contact hours. At still another university students who are taking chemical engineering have fifty-four contact hours in laboratory while the students in the other fields have seventy-two hours.

6. Do your basic courses have a scheduled recitation hour? Yes____No____.

In reply to this question sixteen institutions on the semester plan indicated that they did have regularly scheduled recitation periods while twenty-two replied that they did not. Sixteen respondents either did not supply an answer or stated that they had brief unscheduled discussions and recitations as part of their laboratory periods.

Among the sixteen institutions having regular recitation periods the total number of hours scheduled per semester were as follows:

Five institutions scheduled from 30 to 32 hours.
Ten " " " 15 " 18 " .
One " " 7 hours.

At certain institutions, where special courses are given to students in different fields of engineering, the number of recitation hours varied. For example, for one of these institutions it was indicated that students taking chemical and electrical engineering had fifteen recitation hours per semester while those students in civil and mechanical had thirty hours.

For those institutions operating on the quarter plan five stated that they had regularly scheduled recitations while seven replied that they did not.

For the five schools mentioned the total number of recitation hours were as follow:

One institution scheduled 30 hours.
One " " 24 "
Three institutions scheduled 12 hours.

7. Do your courses in basic engineering drawing require outside preparation on the part of the student? Yes____; No____.

In answer to this question forty-three respondents indicated that their students were required to study and/or prepare sketches and drawings away from the classroom and laboratory. Eleven persons gave their answer as No.

The number hours of work expected per week at forty-one of the forty-three schools that required work outside of the classroom were as follows:

At two institutions 6 hours of outside work.
" five " 4 " " " "
" thirteen " 3 " " " "
" eighteen " 2 " " " "
" three " 1 " " " "

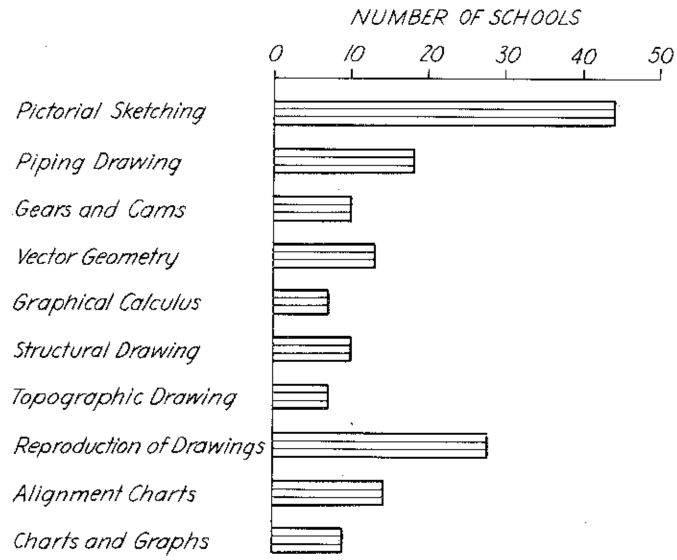
Two who gave Yes as their answer did not indicate the number of hours needed for outside work.

The fact that forty-three of fifty-four schools required outside preparation and drawing reveals that advantage is being taken of the students' time beyond the classroom and that in most cases laboratory hours do not represent the actual time that is available for basic drawing.

8. Question 8 requested the respondent to fill-in a bar chart form so as to give as clear a picture as possible of the subject content and student working hours for the generally recognized divisions of basic engineering drawing such as the use of instruments, geometry, lettering, multiview drawing, freehand drafting, dimensioning, detail drawing, vector geometry, etc.

Some persons found it difficult to make the necessary break-down. In general the results did not seem sufficiently reliable to be worth the effort of preparing a summary.

If we assume that practically all students receive some training in certain basic subject divisions such as the use of instruments, multiview drawing, sectioning we can direct our attention to some of the other divisions of drawing to determine to what extent they are being presented. For this purpose a bar chart is shown below.



It is interesting to note that some experience in the use and construction of alignment charts is being given at nearly one-fourth of our fifty-four schools. Vector geometry is being presented at twelve schools and graphical calculus is not being entirely ignored for it can be observed that it has a bar of appreciable length.

9. Have your basic drawing courses been drastically changed during the last five years? Yes____; No____.

As many members of our Division may have expected drastic changes have been made in the basic courses for engineering drawing during the last five years at almost two-thirds of the fifty-four schools. In reply to question 9, thirty-four indicated considerable change, while nineteen stated that there had been no change.

For those persons who replied in the affirmative there were three additional questions to be answered.

a) Has the number of semesters been reduced? Yes____; No____. If your answer is Yes, what has been the reduction? From____to____semesters.

There were eighteen who indicated that there had been a reduction made at their institution. Since this number of institutions represents exactly one-third of the total number of schools represented in the survey, we can see an appalling picture of what has happened to a subject that is essential to an engineering education.

Although in most cases the extent of the reduction was only one semester or one quarter, many who suffered a reduction had only a minimum of time before the change was made. The indicated reductions were as follow:

At six institutions a reduction was made from three to two semesters.
At four institutions a reduction was made from two semesters to one semester.
At one institution the reduction was from four to two semesters.

b) Has the number of credit hours been reduced? Yes____; No____. If your answer is Yes, what has been the reduction? From____to____credit hours.

The answer to this question shows that engineering drawing has suffered even more reduction than is indicated by item a) for twenty-three schools have had credit hours reduced.

The amount of reduction is as follows:

Number of Institutions	Reduction		
3	8 to 6	semester	credits
1	7 to 6	"	"
1	6 to 5	"	"
3	6 to 4	"	"
1	6 to 3	"	"
1	6 to 0	"	"
4	4 to 3	"	"
1	4 to 2	"	"
1	3 to 2	"	"
1	12 to 9	quarter	"
1	9 to 8	"	"
2	9 to 4	"	"
1	6 to 4	"	"
1	6 to 3	"	"
1	Not given		

c) Has there been a change in the emphasis on subject matter in your basic courses? Yes____; No____.

If your answer to the above question is Yes, please give a brief statement that will reveal the nature of the change.

Forty respondents indicated that there had been a change in the emphasis.

Almost all of the statements that were given to indicate the nature of the changes in emphasis that had taken place were very much alike, with only the wording being different. In general the following statements taken from seven of these questionnaires are representative.

"Less work on applied geometry, sectional views, fastenings, and inked tracings. More work on multiview drawings, freehand drawing, and pictorial sketching" - Univ. of Texas

"Less emphasis is being put on lettering, instrumental work, and fastener drawing. More emphasis is being placed on freehand sketching and theory"- University of Illinois

"More emphasis on problem analysis and in individual initiative in solutions" - Wayne State Univ.

"More freehand drawing" - Colorado School of Mines

"More emphasis on freehand drafting and pictorials; less on dimensioning and assembly drawing" Purdue University

"More on sketching. More on graphical mathematics and computations" - University of California, Berkeley

"Problem material has been changed to emphasize the creative aspects of engineering drawing" - University of Maine

d) Do you now devote more time to freehand sketching? Yes____; No____.

More time to making multiview sketches? Yes____; No____.

More time to making pictorial sketches? Yes____; No____.

The Yes and No answers to the first question revealed that more time is being devoted to sketching at thirty-nine institutions. Remembering that all of this additional time may be allotted either to sketching multiview drawings or to pictorial representations or distributed between them we find that at thirty-six schools more time is being given over to multiview sketches. These thirty-six schools represent two-thirds of the schools supplying answers to this questionnaire. The third question of d) was added so as to determine whether or not any attention was being given to the recommendation that more time should be devoted to teaching pictorial sketching. In general we have paid some heed to this demand for more time has been allotted to pictorial sketching at thirty-one schools.

Since a few of our leaders have suggested that some instruction covering graphical calculus, vector geometry, and alignment charts be given in our basic courses, it seemed desirable to determine to what extent this had been done. The results are rather surprising for, although the departments presenting such material represent a decidedly small minority, they do form a group of noticeable size.

10. Do your basic courses contain problems requiring the use of vector geometry? Yes____; No____.

In giving an answer to this question, seventeen respondents answered Yes while thirty-seven replied in the negative. Since a person is unable to ascertain from this single question whether or not some of the respondents were thinking solely of three-dimensional vectors as presented in descriptive geometry, one is unable to determine the extent to which vector geometry is being taught in our other basic drawing courses.

11. Do you teach graphical calculus in your basic courses? Yes____; No____.

As might be expected the number of departments presenting graphical calculus is not great although the ten institutions where it is taught represent 19 percent of the total number of institutions represented.

12. Do you require your students in the basic courses to construct parallel scale alignment charts? Yes___; No____.

In answer to this question thirteen persons indicated that the construction of alignment charts was presented in their basic courses. In terms of percentage, the number of institutions represented by these individuals is twenty-four percent.

13. Is descriptive geometry integrated into your basic courses? Yes____; No____. If your answer is Yes, what percentage of the total number of laboratory hours, recitation hours, and outside study hours are assigned to descriptive geometry? Laboratory hours ____; Recitation hours____. Outside hours____.

The answers as given revealed the fact that word integrated could be interpreted in at least two different ways. The question as worded was intended to determine whether or not the principles and methods

(Continued on page 57)

Basic Principles for the Design of Drawing Courses to Comply with the 1955 Evaluation Report*

By Charles J. Vierck
The Ohio State University

The preliminary report of the so-called Grinter Evaluation Committee was made in 1953. Many of us criticized this report, from the standpoint of both omission and commission, and were, I believe, justified in our attitude, because many changes were made, culminating in the final report of 1955. In order to obtain a better understanding of this report I have also examined the previous reports of the ASEE. These reports are:

First, the Mann report, published as Carnegie Bulletin No. 11, out of which came the Wickenden report of 1923 to 1929. This is a report of 1320 pages with an additional 283 pages on technical institutes. A supplement was published in 1939. Then came "Aims and Scope of Engineering Curricula" in 1940 and "Engineering Education After the War" by H. P. Hammond in 1944. Of all these, the Wickenden report appears to be the most significant.

It seems reasonable to examine these reports in an effort to obtain information for two basic considerations, (a) Current status and (b) Trends. Comparisons and conclusions for the future can then be made.

Current Status. The Wickenden report gives the following:

"The following subjects should be included in all engineering curricula, although not necessarily to the same extent.

a. Mathematics, to include differential and integral calculus.
b. Inorganic chemistry, with laboratory.
c. General physics, with laboratory.
d. English composition, speech, literature.
e. General economics.
f. Introduction to the economics of engineering.
g. Introduction to the law of contracts.
h. Drawing and the principles of graphics.
i. Technical mechanics.
j. Mechanics of materials, with laboratory.
k. Introduction to hydraulics.
l. Introduction to heat power engineering, with laboratory.
m. Introduction to electrical engineering with laboratory.

In comparison, the Grinter report says:

"Engineering science stems from two basic areas: mechanical phenomena of solids, liquids, and gases; and electrical phenomena. A common practice is to subdivide these into the following six engineering sciences:

1. Mechanics of solids.
2. Fluid mechanics.
3. Thermodynamics.
4. Transfer and rate mechanisms.
5. Electrical theory.
6. Nature and properties of materials."

The Grinter report continues as follows:

"Education directed toward the creative and practical phases of economic design, involving analysis, synthesis, development and engineering research is the most distinctive feature of engineering curricula.

"Approximately one-fourth of the total undergraduate program may be appropriately devoted to engineering analysis and design, including the necessary technological background."

Comparing the two reports, we find that (a) the basic science subjects recommended in both reports are about the same, (b) there was more emphasis in 1929 on economics and law, and (c) drawing and graphics is mentioned specifically in the Wickenden report. But there is a subtle reference in the Grinter report; the words "analysis and synthesis" and the phrase "including the necessary technological background," I think, are significant, especially when the phrase "most distinctive feature of engineering curricula" is included.

Analysis and synthesis taught in graphics courses is definitely a part of the technological background that every engineer must have, and I believe that the Grinter report points this out, although not in the exact wordage that teachers of Engineering Drawing might desire.

Trend. The following comparisons of trend are, however, more significant:

The Wickenden report states the trend in 1929 as follows:

"It is interesting and significant to note the gradual decrease in mathematics in spite of a well-marked simultaneous decrease in the content of mathematical preparation of entering students; the early decrease and later stabilization of the content of English; and the steady decrease in modern foreign languages. In fact, this latter is one of the most striking features of the diagrams. Economics has had some growth, apparently at the expense of history and political science. After a sudden increase in time devoted to shop work in the early years, the amount of this work has gradually decreased except in mechanical engineering. Graphics has decreased almost as sharply as modern languages. The losses suffered by these two divisions appear definitely to have been gained by engineering subjects in the special field of the curriculum."

*Presented at the Drawing Division Summer School, Iowa State College, Ames, Iowa, June 1956.

The Grinter report discusses change and trend as follows:

"It is relatively easy to look backward and recognize changes; it is more difficult to visualize what lies ahead. --------the engineering art taught in colleges will normally reflect practice that is already obsolete in part since the teacher's knowledge of practice becomes rapidly outdated.

"But, fortunately, some things do not change. Reactions, stresses, and deflections will still occur, and they will have to be calculated. Electrical currents and fields will follow unchanging laws. Energy transformation, thermodynamics, and heat flow will be as important to the next generation of engineers as to the present one. ---------These studies encompass the solid unshifting foundation of engineering science upon which the engineering curriculum can be built with assurance and conviction."

I believe we can take comfort in the fact that at last someone has had the common sense to say what I have just quoted from the Grinter report. Even though drawing and graphics are not specifically mentioned, we know, and the deans and other educators know, that drawing and graphics are as much a part of the unchanging portion of engineering education as any of the items mentioned. It is unthinkable for an engineer to be illiterate in the graphic language.

Let us now examine the particular section of the Grinter report dealing with graphics.

"Graphical expression is both a form of communication and a means for analysis and synthesis. The extent to which it is successful for these purposes is a measure of its professional usefulness. Its value as a skill alone does not justify its inclusion in a curriculum. The emphasis should be on spatial visualization, experience in creative thinking, and the ability to convey ideas, especially by free-hand sketching, which is the normal mode of expression in the initial stages of creative work. Though the engineer may only supervise the preparation of the drawings required to execute his designs, he can hardly be expected to do this effectively unless he himself is thoroughly familiar with graphical communication." Here we have something definite for the first time in an ASEE evaluation report. It is as though drawing and graphics had finally "become of age."

Also, in comparing all the reports, it is interesting to note that in all of the 1320 pages of the Wickenden report it is very difficult to find any mention of Engineering Drawing or Graphics. In fact, none of these are even listed in the index.

It is my opinion that the Grinter report, at long last, confirms the facts that engineering drawing is a basic and necessary part of the equipment of every engineer, and that, in the main, it has been taught correctly and efficiently.

After examining these items from the reports what conclusions can we make regarding drawing and graphics? Is revision of curricula necessary or is it even indicated? What should be the direction of our efforts in the future?

In answering these questions, we must certainly examine all phases of our work, but, because of the differences in methodology over the country, I believe it is impossible to here give any recommendations for order of presentation or even to list details of instructional material. Some universities use the old but proven method of course presentation item-by-item. Others employ an integrated system, and some use the project method or a combination of item, integration and project. All are successful and are believed in implicitly by their proponents. Thus, only guiding principles should be discussed.

It is evident, if we intend to follow the Grinter report, that we should include more freehand sketching. This means a shift in emphasis. Where, years ago, much attention was paid to the techniques of making drawings with instruments, now, if we change to more freehand work, the problem of teaching freehand technique could, possibly, become as time-consuming as for teaching instrument technique. The report definitely states that drawing as a skill alone does not justify its inclusion in a curriculum. Therefore, we will also have to be careful to keep freehand technique in proper balance with other course material. In my opinion, we should attempt to save time by freehand sketching in order to make room for more training in graphical solutions or other material contributing to a complete understanding of the graphic language. Actually, the trend has been in this direction for some years and if we continue this trend we cannot fail to follow the philosophy of the report.

Balance is the keynote of course design and of curricula. We must have enough of, and yet not too much of, orthographic theory and practice, freehand and instrument work, technique, geometry, pictorial drawing, commercial practices, working drawings, graphical solutions, and other items that most universities and colleges consider necessary to professional competence in the graphical language.

Over-emphasis, for example, either in the direction of too much attention to techniques, or a complete disregard for techniques, or too much time taken with graphical solutions to the exclusion of other necessary material are extremes in my opinion, and are potentially dangerous.

I urge balance, because if there is any one practice that will produce an opening for criticism, it is the practice of radicalism and radical thinking. To give an easy example, none of the radical designs of automobile bodies that we are all familiar with, have ever been successful. I believe history will prove that a well-balanced course or curricula is difficult to criticize or dislodge.

In accomplishing the tasks of the future, we may examine the record of past performance for an appraisal of what we have to work with.

I am confident that the drawing departments of this country are, as a group, one of the most competent teaching organizations in all engineering education. In support of this statement I believe we can prove that over the years, we have spent more time and effort in studying and perfecting teaching materials and techniques than any other group. We can point to the gradual and steady improvement in problem material, textbooks, workbooks and examinations. We have spent much time, care, and money, in the production and use of visual aids of all types. We have held more summer schools and more conferences for advancement of all phases of our subject. We can well be proud of the effort expended and the results obtained.

From the foregoing, it is my opinion, then, that we need not make radical changes, but simply work intelligently and diligently as we have in the past to steadily improve and keep abreast of new developments.

Change is not automatic and it need not be violent. Change is brought about by intelligent, inquisitive men and women who seek to improve day-by-day. Incidentally, the very fact that we are here assembled today attests to our intentions in the years ahead. For the future, I should like to suggest the direction in which I think our efforts should be expended.

Research in graphical methods and solutions, especially in nomography, empirical equations and calculus, should be encouraged and continued. All colleges and universities, I believe, should teach these phases of graphics.

We should continue to improve problem selection and problem material.

All of us who write textbooks should continue our efforts to supply text material in line with modern trends.

The American Standards are an important phase of our work, and our active participation on standards committees should be continued.

We should continue to develop new teaching aids. Motion pictures, filmstrips, wall charts, models, etc., will, in the future, be increasingly more important. Captive television techniques hold great promise for teaching the large number of students expected in the near future.

Finally, let us remain active in the Division of Engineering Drawing, so that all may be informed of the trends and developments in our work.

These words of conclusion from the Wickenden report state my opinion accurately:

"For better engineering education we must look to better balanced curricula, better selection of students, better teachers, better methods, better subject matter and better advanced training rather than changes in educational organization."

Problems Confronting the Teacher of Engineering Drawing*

By Eugene G. Paré

State College of Washington

Since the brief talks at this meeting are intended to provoke discussion, I would like to pose some problems that I believe confront engineering drawing departments. May I also take the liberty to suggest some possible solutions to some of these problems.

Our main concern pertains to the fact that our courses, engineering drawing and descriptive geometry, are service courses, and that their rated importance depends to a great extent on the degree to which deans and department chairmen recognize that these courses are essential in the development of an engineer or scientist.

But do these administrators know our courses, do they realize that our course material is constantly being altered to keep pace with other technological advancements; or do they have the impression that our present-day courses are identical to those that they took in college some twenty or thirty years ago? If they have this latter impression, I do not blame them for having some doubts about the value of our courses. Yet from the same point of view I do not believe they would look with favor on any course that has remained stagnant over any length of time.

Unless one has a current and intimate knowledge of a particular course, he probably judges that course by several factors:

1. What the course was like when he took it in college.
2. The physical plant and equipment with which the instructor is content.
3. The catalogue description of the course.
4. The textbooks and manuals used in the course.

I doubt that many outside the drawing departments know what our courses are really like. It is possible that I am exaggerating this point, but I do not think so. I did some scouting at the A.S.E.E. meeting in Iowa, in June, 1956, by attending a session of one of our major engineering fields. A speaker expressed some doubt as to the value of the courses in the engineering drawing field. He commented that our engineering graduates were not expected to be trained as skilled draftsmen; he commented further that since industry does but little ink work these days, our students should no longer be required to produce a multitude of finished inked tracings. He cautioned that if the drawing courses are to continue to exist they must devote more attention to technical sketching, blueprint reading, and graphics. At this meeting I tried to assure the speaker that drawing departments were well aware of current trends, and that his criticisms might have been valid twenty years ago, but certainly not today. The speaker apparently was not aware of the fact that the attendance at the Drawing Division meetings of the A.S.E.E. far outnumber those from any other field and that this group religiously keeps abreast of the times by close associa-

*Presented at the Pacific Northwest ASEE meeting, May 10, 1957 tion with industrial leaders. In fact, a Drawing Division committee is currently assigned the task to determine from industry what changes can be made in our present courses to better serve the needs of industry. In addition, the Society, together with representatives from industry, plays an important role in the development of more economical engineering practices related to drafting and design.

We in the engineering drawing field must in one way or another keep other departments and administrators informed of improvements as they are introduced in our courses. This might be done by binding and routing an appropriate collection of student work to interested departments for comment and criticism. An outline of the course, tests, and other pertinent information might also be included.

But regardless of how we do it, we must let others know that engineering drawing and descriptive geometry are being kept constantly up-to-date. I know I wouldn't rate very favorably the impractical descriptive geometry course that I had in college. But I also feel the same way about some other college courses, and I trust that these other courses have been currently modernized to the same extent that our drawing courses have.

Our first problem, then, is essentially a public relations job; we have an indispensable and valuable product; let's not let it deteriorate by failure to keep it up-to-date nor by failure to publicize it adequately.

The second problem is concerned with course content and objectives. Ours is an extremely broad field and if we had additional time we could more adequately cover its many interesting and challenging facets. However, since our time is limited we must select carefully those topics which provide the best foundation for today's engineer and scientist. We must take into consideration other academic activities of the student while he is in college, and we must help prepare him for his responsibilities in industry where he may well be expected to aid in the creative design of a new product or machine. This is no small order and involves varied experience in both college and industry. To create, to analyze the inter-related functions of parts and mechanisms, the engineers must have developed among other things an ability to see or think in terms of three dimensions. For simplicity let's call it an ability to visualize. Above all, then, our courses, and in particular descriptive geometry, must be organized to train the student to visualize in three-dimensions. In addition he must acquire a varied experience in blueprint reading and he must be taught to execute orderly orthographic and pictorial sketches.

In his college courses and in industry our student will have frequent occasion to prepare science and research reports which to be most effective may contain a variety of visual presentations in the form of charts, graphs, curve plots, etc. These topics should be included in our courses and if time and the background of the student permit, I would also add an introduction to alignment diagrams, graphical development of empirical equations and graphical calculus.

These latter topics may be grouped under the title of graphics; those topics related to geometric constructions, orthographic projection and pictorials, may be classified as technical drawing. To the graphics area I would devote 25% of the time allotted to our introductory course in engineering drawing, and the balance in the area of technical drawing.

If time alone prevents us from broadening the scope of our introductory course, may I suggest that perhaps we may be devoting too much of our valuable time to essentially technique exercises such as:

1. Lettering,
2. Dimensioning techniques, and
3. Representation aspects of screw threads and fasteners.

Our third problem as I see it is the fact that laboratory courses are expensive and if possible should be reorganized on a more economical basis. I do not feel that the number of students enrolled in a laboratory section should be increased, but I do believe that three contact hours a week in a supervised laboratory is adequate. The balance of the time allotted to our courses should take the form of outside assignments and a one-hour a week lecture to which as many as 120 students might be enrolled. Such a practice could well reduce the cost of our courses by 40%.

A fourth problem confronting engineering drawing departments is whether or not to combine introductory engineering drawing and descriptive geometry into a single course running for a full year or to retain the identity of each of these courses. The current proponents of combining these courses call it integration but from the efforts in this regard that I have seen so far, I would call it a somewhat heterogeneous mixture, not a homogeneous integration. However, I do not think that this problem is a serious one, for I feel that we can do a good job under either organization.

I trust that I have raised some controversial issues that will provoke discussion, and since I am sure I don't know all the answers I would be delighted to get the reactions of others.

BARBER-COLMAN COMPANY NOMOGRAPHY PRIZE

Competition for the $100 nomography prize announced in the February, 1957 issue closed January 1, 1958. The Nomography Committee, under the chairmanship of Professor A.S. Levens, will announce the winner at the Annual Meeting in June at Berkeley, California.

The prize money was donated by the Barber-Colman Company, Rockford, Illinois.

Objective Evaluation of Drawings

By George K. Stegman

Davenport High School, Davenport, Iowa

In almost all phases of education, particularly industrial education, instructors find they have a tendency to grade subjectively rather than on an objective basis. When a student realizes his drawing or project has been graded on an equitable and reliable balance he will have a greater incentive for doing his work.

Many times engineering, mechanical or machine drawing courses have slipped into a repetitive "do nothing" course, when the interesting problem-solving aspect of true engineering problems has been left behind. If this is the case, interest would certainly be lacking and if the evaluation of such drawings is left to a pure subjective basis, the entire purpose of the course is lost. Regardless of the category of the drafting course, objective evaluation of a drawing must take place in order to be entirely fair to all students.

A degree of variation in grading is probable regardless of the method used. But this variation will be greatly magnified if purely subjective means are administered. In the field of drafting the final grade is usually evolved by a combination of the written page (tests, daily work, notebooks, reviews, etc.), the actual drawing, and possibly the rating of manipulative skills.

By utilizing an objective basis for assigning an evaluation to a drawing, the instructor will not be put on the defensive in justifying any grade. Variance in drafting grades could also be due to the hasty assignment of grades at the last moment when time for a complete evaluation is not available.

Various methods of grading drawings which exist in secondary and higher education are listed below:

1. Comparison With Adjustment
   Drawings are first checked over and the various errors are noted. Following this the drawings are sorted into groups, each representing drawings of approximate equality. All drawings in one group are carefully compared and moved from one group to another.
2. Comparison Without Adjustment
   Errors are noted on each drawing and in turn compared with the best drawing of each representative group. The grade is then assigned without further adjustment.
3. Comparison With Check List
   Errors are noted by the use of a check list printed or stamped on the drawing margin. Then the drawings are sorted into various groups and adjusted as necessary in order to obtain approximate equality.
4. "On The Spot."
   Evaluation is reduced to a routine check by veteran instructors who have certain standards set in their minds.
5. Check List.
   A check list is compiled for each drawing and the grade is determined by the number of errors which exist.

In the previous evaluation methods listed, grading hinged mainly on subjective standards. When subjective standards are relied upon, grades will tend to vary from time to time. Various factors influence the evaluation of the drawing, either consciously or unconsciously, such as attitude, behavior, work habits, personality, etc. A rating scale may be used to eliminate these various factors to a degree and to base a grade upon a fairly concrete basis.

Grading drawings by the use of a rating scale is utilized by some instructors. The rating scale is usually divided into various sections, i.e.: neatness, lettering, lines, etc. Each section of the drawing is taken into account and a value is assigned to each. A rating scale may be constructed as a check list or a series of statements. Each point on the check list or rating scale is enumerated by a series of statements and is rated separately, for example:

Line intersections
1. no air space
2. no overlapping
3. uniform weight

Center lines
1. correct proportion of component parts
2. correct application of alphabet of lines
3. uniform weight
4. extend 1/4" beyond the view or circular part
5. short dashes crossing at center in circular view
6. short dashes in open places

To solve the problem of variation in grading a rating scale should be used. The author of this article has devised the following rating scale for drawings. (Note: this scale is used to measure technique only.)

Figure 1 shows the Technique Rating Scale which is affixed on each plate by means of a rubber stamp.

TECHNIQUE RATING SCALE

				Weight	W. R. S.
A. NEATNESS	Untidy	1 3 (5) 7	Presentable	0.5	2.5
B. ACCURACY	Exact	7 (5) 3 1	In Error	1.0	5.
C. VIEWS	Incorrect	1 3 5 (7)	Correct	1.0	7.
D. LINES	Incorrect	1 3 5 (7)	Correct	1.0	7.
E. LETTERING	Poor	1 3 5 (7)	Excellent	1.5	10.5
F. DIMENSIONS	Correct — Complete	(7) 5 3 1	Incomplete — Incorrect	1.0	7.
			6+ (Grade)	=	39. / 6

Fig. 1. Rating Scale for Technique as it appears stamped on a drawing

CRITERIA FOR RATING SCALE

A. Neatness
1. Corrections not obvious
2. Omission of ink spots
3. Fingerprints not obvious
4. Erasures, scrubbing, not prominent
5. Omission of graphite smudges
6. Smudges from instruments, etc. not visible
7. Torn corners or undue tears not present

B. Accuracy + or — 1/32"
1. Drawing corresponds to dimensions
2. Dimensions correspond to drawing
3. Exactness according to specifications

C. Views
1. Correct position of views
2. All necessary views shown
3. Appropriate scale
4. View selected is the least effort to read
5. Details together
6. Correct choice of views

D. Lines
1. Center lines project 1/8" beyond shape, thus indicating symmetry
2. Point of tangency equal to width of single line
3. Width of component parts of hidden line uniform in length; space between them equal to 1/4 length of a dash
4. Hidden line started with a dash except when a continuation of an object line
5. Constant weight maintained
6. Correct application of alphabet of lines
7. Lines meet at corners; no overlapping or air space

E. Lettering
1. Guide lines not prominent
2. Proper space
3. Proportioned on the basis of width to height
4. Correct spacing of characters
5. Correct spacing of words
6. Balance in title block
7. Uniform weight
8. Uniform slope or verticalness
9. Height of fractions 2/3 of whole numbers

F. Dimensions
1. Parallel dimensions spaced uniformly
2. Figures midway between arrowheads
3. Arrowheads 1/3 as wide as long
4. Fraction line parallel to guide lines and same weight as dimension line
5. Extension line 1/16" from object line and extended 1/8" beyond last dimension line
6. Figures uniform in directional system
7. Notes lettered horizontally to read from bottom of drawing
8. All necessary information given in notes: material, finish construction method
9. Finish marks placed on air side of object line
10. Dimension lines not crossing if avoidable
11. Dimensions not duplicated
12. Dimensions placed at bottom and right side of drawing

Fig. 2. Criteria to be Used with the Technique Rating Scale

The drawing is then compared with each section of the Technique Rating Scale Criteria. (Fig. 2). After considering all of the criteria under each section a decision is made concerning where that particular phase of the drawing falls on the continuum of the rating scale. Only the numbers 1, 3, 5 and 7 are used, to eliminate the comparison to an actual letter grade A, B, C, D and F. The position of the continuum (raw score) is circled and multiplied by the weight of each section. These weighted raw scores (W.R.S.) are added and divided by 6 (number of sections). To eliminate the additional calculation at the end of the quarter or grading period, the decimal values may be eliminated by the following procedure. If the decimal falls between .1 and .5, drop the decimal quantity and add a plus sign. Example: 4.5 = 4+. Also if the decimal value ranges between .6 and .9, drop the decimal quantity, take the next whole number higher and add a minus sign. Example: 6.7 = 7−.

The rating scale has been used with great success in the author's classes for the past two years. The student evaluates his own drawing by the use of the criteria and rating scale. Following his evaluation the drawing is brought to the instructor for his evaluation. At this time the drawing is checked over and all criticisms are made and the grade is either left as is or revised by the instructor.

COMMITTEE APPOINTMENTS

Theodore Dolan, of the staff of the Illinois Institute of Technology, Chicago, has been recently appointed to membership on the Drawing Division's Bibliography Committee. The committee, under the chairmanship of professor S. E. Shapiro, compiles a yearly report which it has become the custom to publish in the JOURNAL.

Col. L.E. Schick, of the United States Military Academy, West Point, N.Y., has agreed to serve on the Drawing Division's Policy Committee. The full committee now consists of Professors T.T. Aakhus, Justus Rising, R.S. Paffenbarger, and Dean J.J. Gerardi. Dean Gerardi is the chairman of the committee.

Members of the Policy Committee will eagerly welcome any ideas that you might have to advance the interests of the Division.

Graphical Analogues of Mathematical Processes*

By John F. Twigg
University of Florida

Over the past several hundred years the field of analytic geometry has been expanded and consolidated into a well-rounded and unified theory. Unfortunately, its counterpart, geometric analysis or graphics, has not undergone a similar development. At the present time we are attempting to explore the possibilities of graphics and lay a foundation for a unified theory in this field. The complexity of problems arising today in science and engineering has given an impetus to the study and development of numerical and graphical methods of solution. Unfortunately, the development of the graphical methods is far from complete. ground work has been laid and some isolated pieces investigated, however, a great deal still remains to be accomplished.

A comparison of the two fields of analytic geometry and graphics should be made here in order to point out the different view points involved. Analytic geometry is basically a method of converting the world of space into the number system or, if you wish, into algebraic symbolism. The space coordinates may, of course, represent some other unit than distance—time for example, but the resulting analysis is a space analysis. Graphics on the other hand employs the line as a symbol. It may or may not be related to space concepts, but it is in no sense tied to a rigid space dictated coordinate system. Thus in analytic geometry the product of two numbers is an area whereas in graphics the product of two line segments is another line segment.

Graphical analysis is not a method of proof, but a method of attack. We are mainly interested in solving, by graphical means, problems of a practical nature. To accomplish the solutions of these problems we make use of the principles of geometry, using points, lines, etc. to represent the given data. In the solutions, however, we do not restrict ourselves to the so-called "allowable tools" of Euclidean geometry. Basically Euclid was interested in the logical validity of operations of space geometry. His constructions were bound by the necessity for logical proof. A marked straightedge or a faired curve involved an inherent and, to Euclid, inelegant inaccuracy that completely destroyed their logical validity.

Graphics, on the other hand, is a line symbolism of the continuous. The continuous can never be completely accurate in the number system, which is discontinuous by its nature. Only counting problems have complete accuracy. All data obtained by graphical methods is inherently not susceptible of complete accuracy and hence graphics employs freely any graphical method so long as it yields results within the desired accuracy. As the results of experimentation are almost always observed and measured by graphical means, that is, scales, gages, etc. the only necessary criteria are that the graphical processes properly symbolize the natural phenomena involved and that the resulting accuracy is numerically within acceptable limits dictated by the problem involved. In general this will be true when the graphical accuracy is well within the accuracy of the incoming data.

It is interesting to note here that one of the inherent weaknesses of a graphical problem is the inability to communicate the solution without reference to a number system. Between the symbolism of analysis and the spoken language there is a one-to-one correspondence. For example, the spoken word five and the symbol "5." Unfortunately there is no oral counterpart for a line segment. Although we may choose any arbitrary line segment as a unit for a problem, the comparisons of lengths must be made through the use of the scale, and the continuous nature of the line converted to the discontinuous number system before it can be talked about. Hence the marked straightedge or scale is the bridge between the mute graphic solution and its analytic counterpart.

There are two basic types of problems which arise in which the graphical analogues of mathematical processes are useful. The difference in these problems lies only in the method of presentation and not in the graphical method of solution.

The first type, and the one which arises less frequently, consists of those problems stated in analytic terms. It may happen, that after the problem has been so stated, the actual carrying through of the analytic processes necessary for the solution are highly complex or impossible. As an example. we may point to certain simple functions such as

$\int e^{x^2} dx$ in which the solution cannot be written down

in terms of a finite number of elementary functions.

The second type of problem, and the one more often encountered by the graphicist is the one in which the basic data is given in empirical form, obtained from a series of observations. The information may be presented in tabular form or possibly as a graph or curve drawn by some mechanical device. Examples arise continually from laboratory experimentation in practically every field.

This second class may be broken down into two categories: one to find, if possible, an analytic expression which will best represent the relationship, and second to perform graphical analogues of mathematical operations on the given information directly without regard to its analytic form.

In order to develop the theory of graphical analysis to the point where it is to be useful as a tool in solving problems, it is necessary to consider some graphical

*Presented at the Drawing Division Summer School, Iowa State College, Ames, Iowa, June 1957.

analogues of basic mathematical processes. Then by themselves, these constructions may seem trivial; however, please keep in mind that we are attempting to lay a solid foundation in order to develop a useful and coherent theory.

It is not my intention at this time to expand in detail on the myriad of graphical devices and the various ramifications which are possible. Instead, I should like to survey the various phases of mathematics and discuss in general with a few examples the graphical analogues of the analytic processes involved.

The operations of graphic arithmetic are elementary; however, as in any mathematics, they are basic in our graphic analogues.

For addition we merely add line segments thus:

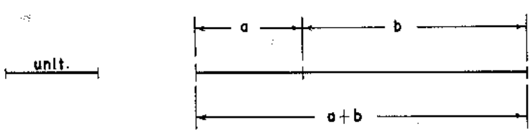


Fig. 1

Note that a unit must be decided upon before values "a" and "b" can actually be drawn. The unit is, of course, an arbitrary length and may have any name we choose to give it. The inverse operation, or subtraction, is naturally just the reverse of this procedure. The processes of multiplication and division are carried out by the use of similar triangles. The simplest form is shown in Fig. 2.

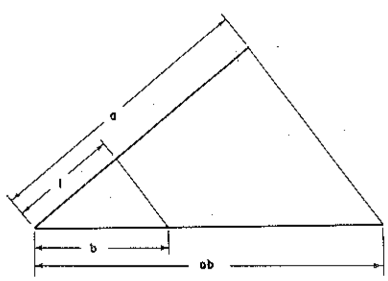


Fig. 2

It is interesting again to note here that we are not interpreting the product of two line segments as an area, according to Euclidean thought, but as a third line segment. An outcome of this simple device allows us to multiply two continuous, single valued functions together to obtain a product function. For example, given f(x) and g(x), Fig. 3, choose a line R passing through the origin and making a convenient angle θ with the y-axis. Choose any convenient point P on line R. Consider the ordinate at x_1. This ordinate will cut the two curves at A and B respectively. Project point A horizontally to point A' on line R and point B horizontally to point B' on the y-axis. Draw line PB' and parallel it from A' cutting the y-axis

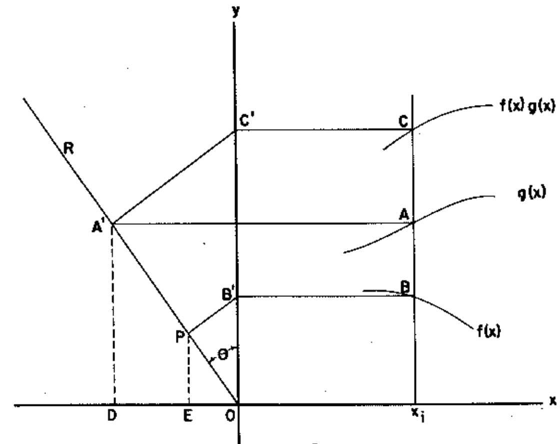


Fig. 3

at C'. Project C' back to the ordinate to point C. The ordinate to C will the represent the product of the ordinates A and B. The proof is obvious is we consider the similar figures DA'C'O and EPB'O. By a repetition of this process, using several ordinates, a sufficient number of points "C" may be established to draw the product function. The ordinate scale for the product curve may be obtained by multiplying the calibrations or the y scale by the ordinate of point P. The process of division may be carried out in a similar manner.

Notice that no mention has been made as to the analytic expressions for the given functions. This operation may be carried out and a product curve obtained even though the analytic forms of the given functions are unknown.

The questions may arise here as to the nature of the solution when one or both of the given functions are multi-valued. This problem remains to be investigated. It may be that the problem itself is meaningless.

Graphical analogues in the field of algebra are as disversified as the processes of algebra itself. I am sure you are all familiar with the process of solving algebraic equations by the use of nomograms and network charts. The use of a nomogram is particularly advantageous when the equation which it represents must be solved many times for various values of the variable. Examples of this graphic device appear constantly in engineering periodicals.

Simultaneous linear equations of two or three variables may be solved readily by a direct cartesian plot, a space analogue; however, the parallel scale method, due to its nature, may be employed to solve simultaneous equations involving any number of variables.

The process of determining real intersections by direct plot is well known to any high school student of algebra. Little has been said, however, concerning the determination of complex intersections. Under certain conditions, it is possible to show these complex intersections on the graph. For example, we might consider the problem of determining the complex intersection of a line and a circle (Fig. 4.)

I should like to point out, without proof, that the

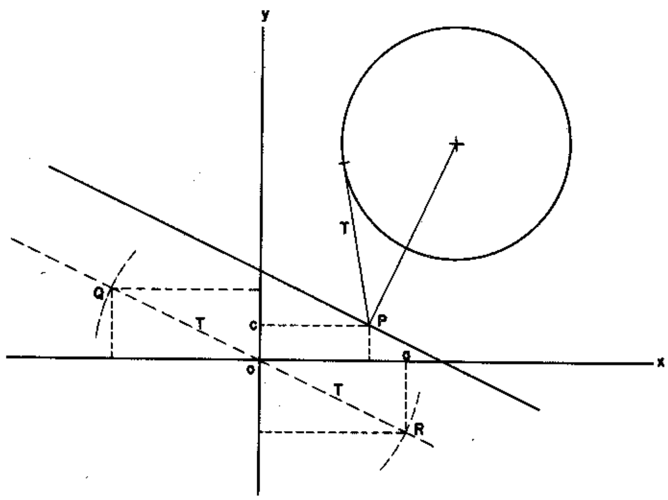


Fig. 4

complex points of intersection may be readily determined. Draw from the center of the circle a line perpendicular to the given line. The coordinates of the point of intersection, P, are the real parts of the complex points. Draw a tangent to the circle from point P and lay off its length on a line parallel to the given line through the origin. The coordinates of the points Q and R thus determined are the imaginary coefficients of the complex points. The determination of the complex intersection of the circle with the x-axis, and hence its roots, follows immediately. A similar treatment will yield the complex roots of a cubic equation (Fig. 5).

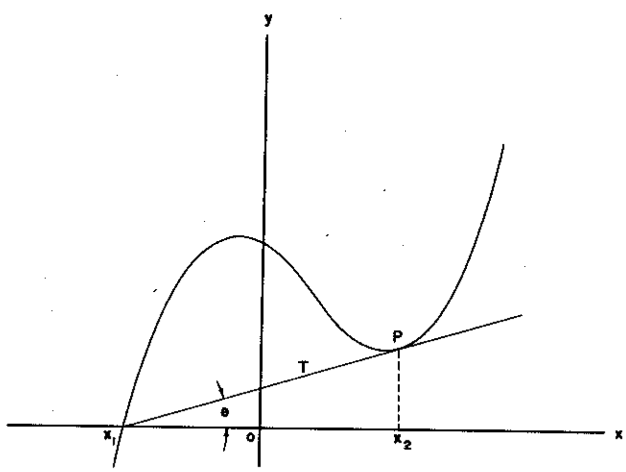


Fig. 5

If a tangent T to the curve is drawn from the real root at x_1 intersecting the curve at point P, then its x coordinate x_2 is the real part of the complex root. The tangent of the angle Θ, the angle which the tangent line T makes with the x-axis, is the coefficient of the imaginary part of the complex root. These constructions are based on two separate plots (superimposed in the examples), one for the real parts of the functions, and a separate plot for the imaginary parts. (Fig. 6)

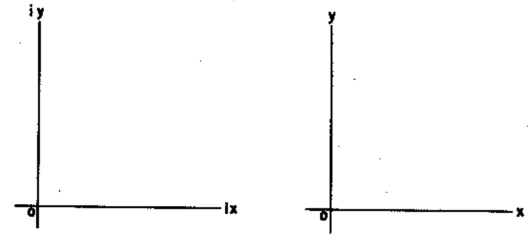


Fig. 6

Although I have not carried this theory to its conclusion, I suspect that many curves will yield their complex roots to this treatment.

Some of the most interesting examples of graphical analogues come in the field of the calculus. I should like to recall to mind that one of the powers of this method lies in the field of empirical curves, and that they play the role of a supplement to the analytic methods, not as a replacement. Not only is it possible to determine areas of irregular curves, but we can also find moments of area, moments of inertia, volumes of revolution, surface areas, etc. An example of the determination of surface areas arose recently in connection with the surface area of a projectile. A concern had the job of coating large quantities of shells to prevent corrosion. In order to determine the strength of the solutions and immersion times, it was necessary for them to know the surface area of each piece. They had no analytic information on the various surfaces involved, only a sample piece. To determine the area a profile was drawn (Fig. 7) on a coordinate system.

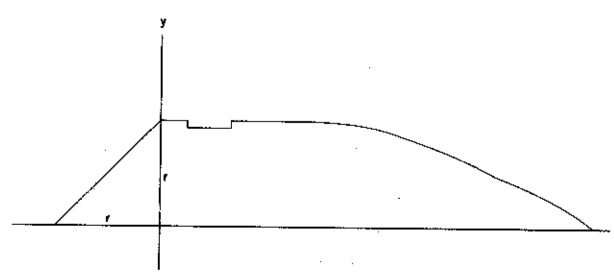


Fig. 7

The curve was divided into a number of short arcs and the arc lengths plotted against the y coordinate. In this fashion a plot of y against s was made and then integrated graphically. To include the area of the circular end, the (y,s) curve is begun by laying off the radius r as shown, making a right triangle with legs equal to r. When integrated, the area is of the triangle is $\frac{r^2}{2}$. The answer was multiplied by 2π to obtain the surface area. Note that this will include the circular end as $\frac{r^2}{2} \cdot 2\pi = \pi r^2$ The process of plotting the (y,s) curve is shown exaggerated in Fig. 8.

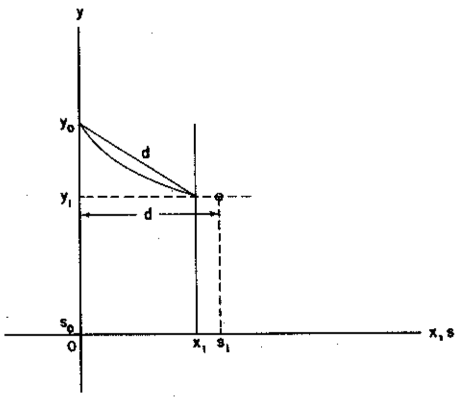


Fig. 8

Various methods for the graphical solutions of differential equations are a natural outcome of the graphical calculus. Although certain graphical devices are available for the solutions of differential equations, they apply for the most part to specific types. At the present we do not have a generalized method for dealing with the many differential equation problems which arise.

The linear first order equation of the form $y' = f(x)$ may of course be solved immediately by integration. An interesting example of plotting arises in the solution of separable equations of the form $y' = f(x,y)$. Condider for example the simple equation $\frac{dy}{dx} = \frac{1}{2}xy$. When separated, we have $\frac{dy}{y} = \frac{1}{2}xdx$. By introducing a parameter, z, such that $z = \frac{1}{y}$ and $z = y$, we may plot two separate graphs (x,z) and (y,z) (shown superimposed in Fig. 9). Each curve may then be integrated separately yielding $\int \frac{1}{2}xdx$ and $\int \frac{1}{x}dy$ as shown. The equation states that $\int \frac{1}{y}dy = \int \frac{1}{2}xdx$. To obtain the solution, we enter the graph with a value of x, say x_i. This yields point A, the value of $\int \frac{1}{2}xdx$. By proceeding horizontally to point B, we obtain the equal ordinate on the curve $\int \frac{1}{y}dy$. This gives in turn the abscissa y_i. To obtain a solution point, we have only to plot $(x_i\ y_i)$. This may be done by establishing a line I at 45° through the origin. The point B may then be reflected through point C to point P on the x_i ordinate. A series of such ordinates will yield sufficient points

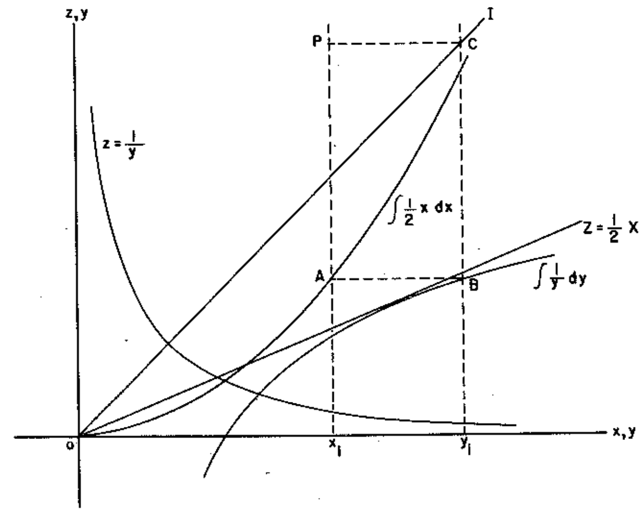


Fig. 9

P to draw the solution curve.

We realize, of course, that no one would attempt to solve the example problem in this manner; however, as in simple integration, examples can be shown where the process can be useful. The example also shows the value of a multiple plot, using the same coordinate system for demonstrating the interrelation of several graphs.

Up to now we have been considering problems dealing with graphical solutions in which their analytic representation is known. Considerable work has been done in the field of graphics involving the determination of the best-fitting analytic expression for a given set of empirical data. Much of this work is accomplished by the use of special plotting papers such as full log, semi log, and polar coordinate paper. In this type problem an attempt is made to find some plot which will rectify the curve representing the data. If this can be accomplished, it is usually possible to determine the nature of the functional relationship which exists between the variables and also the various constants involved. We know, for instance, that a power function $y = ax^m$ will rectify on full log paper and that the exponential $y = ae^{mx}$ will rectify on semilogarithmic paper. Quadratic functions of the form $y = a + c^2$ and hyperbolic functions of the form $y = \frac{x}{a + bx + c}$ may be rectified on cartesian paper and the constants determined by plotting $(x, \frac{y-y_k}{x-x_k})$ and $(x, \frac{x-x_k}{y-y_k})$ in which x_k and y_k are the coordinates of one good experimental point. These are only a few examples of the various special plots which yield information as to the nature of empirical data. Statistical methods such as the method of least squares and the method of finite differences when coupled with the graphic plots are also very valuable in determining functional relationships.

No discussion of graphical methods would be complete without some mention of the contributions of projective geometry. The invariance of cross ratio under central projection gives us a useful tool in problems involving conic lofting and photogrammetry, as well as problems of projective transformations of coordinate systems.

In this modern electronic age of whirlwind computers and numerical and graphical analysers, it may seem rather out of date to consider the drawing board methods of graphical analysis. Such is not the case. If we consider that these modern marvels of computing are not available at a minute's notice to a large percentage of our research engineers and scientists and that the time consumed in programming data and interpreting the results from these machines is often as greet as that needed for a drafting board solution, it will be clear that a complete and unified theory of graphical analysis could be an extremely useful tool in research and development. As you can see, we are still in the beginning stages of the development of this theory. It may be that what we propose to do is not practical. I feel, however, that the possiblilites are great enough in this field to be worth further investigation.

Concerning Ellipses

By D. Mazkewitsch

University of Cincinnati

In the February, 1957 issue, p. 37, of this JOURNAL, Prof. Martin J. Orbeck puts the question: Will the envelope of circles whose centers lie on a given ellipse be another ellipse?

This curve, which is identical with the curve obtained when in each point of the given ellipse a normal is drawn, and from the point of the ellipse the radius of the circle is laid off, is a curve of eighth degree. (See: G. Salmon, "A Treatise on Conic Sections," 5th Ed., p. 325; "A Treatise on the Higher Plane Curves," 2nd Ed., p. 68).

The derivation of the formula is lengthy and cumbersome.

Here is a simple proof that the distance between the points of tangency of two parallel tangents to two concentric ellipses with the difference of the major and minor semiaxes equal to a given value R cannot be equal to R.

Let the equations of the two ellipses be respectively

$$\text{I} \quad \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \text{ and}$$

$$\text{II} \quad \frac{x^2}{(a+R)^2} + \frac{y^2}{(b+R)^2} = 1.$$

The tangents in P_1 of I and P_2 of II are:

$$\frac{xx_1}{a^2} + \frac{yy_1}{b^2} = 1 \text{ and}$$

$$\frac{xx_2}{(a+R)^2} + \frac{yy_2}{(b+R)^2} = 1.$$

Since the tangents are parallel:

$$\frac{b^2}{a^2}\frac{x_1}{y_2} = \frac{(b+R)^2}{(a+R)^2}\frac{x_2}{y_2} = m.$$

$$\therefore \quad x_1 = \frac{a^2 m y_1}{b^2} \text{ and } x_2 = \frac{(a+R)^2 m y_2}{(b+R)^2}$$

Substitution of these values in I and II respectively gives:

$$y_1 = \pm \frac{b^2}{(b^2 + a^2 m^2)^{1/2}}; \quad y_2 = \pm \frac{(b+R)^2}{((b+R)^2 + (a+R)^2 m^2)^{1/2}},$$

and

$$x_1 = \pm \frac{a^2 m}{(b^2 + a^2 m^2)^{1/2}}; \quad x_2 = \pm \frac{(a+R)^2 m}{((b+R)^2 + (a+R)^2 m^2)^{1/2}}.$$

Hence:

$$\overline{P_1 P_2}^2 = \left[\frac{(b+R)^2}{((b+R)^2 + (a+R)^2 m^2)^{1/2}} - \frac{b^2}{(b^2 + a^2 m^2)^{1/2}}\right]^2 + \left[\frac{(a+R)^2 m}{((b+R)^2 + (a+R)^2 m^2)^{1/2}} - \frac{a^2 m}{(b^2 + a^2 m^2)^{1/2}}\right]^2$$

This expression becomes R^2 only when $a = b$, and, of course, for $m = 0$ and ∞.

ulties to teach the series of courses outlined above. While a few students from these countries can attend school in foreign countries, those few represent only a drop in the bucket compared to the thousands of engineers needed for the job of road building that is ahead.

The opinion is general that a very first essential for any country planning to do a good job of road building is the establishing of an adequate engineering college. In the United States of America many of the state highway departments have their materials testing and research laboratories located on university campuses. This arrangement is excellent both for the students who have an opportunity to use the testing equipment and for the highway administrative department which can utilize university staff and students for performing tests on road building materials.

The International Road Federation has been doing a wonderful job in highway engineering education for the past several years by selecting each year a few young men of exceptional promise from several countries and sending them to a university in the United States for post-graduate schooling in highway engineering. I have had the pleasure of having many of these young men at The Ohio State University and have thoroughly enjoyed working with them.

At least three of my former I.R.F. fellowship students have, while with me, completely outlined the equipment and staff needed for a highway materials laboratory and then have proceeded to establish such laboratories in their home countries. In these laboratories our former students serve as instructors for laboratory technicians who may become future engineers.

Training of Technicians

It must be kept in mind that for each engineer in highway work we need several technicians. Much of the work of detailing of drawings for large projects, surveying, performing routine tests of materials, etc., can be done quite satisfactorily by a technician who has not had a full course of schooling as an engineer. To properly supervise and coordinate the work of technicians, however, requires competent engineering ability.

Generally, in engineering colleges, only 20 to 30 per cent of the students entering as freshmen eventually complete their courses and graduate. Many young men who have had this training in drawing, surveying, and some mathematics can become quite proficient technicians. Technical courses can also be set up for training capable men or women who have not had the opportunity to attend college.

In-Service Training for Practicing Highway Engineers

Obviously, no young engineering graduate from a college will at once be assigned to administrative responsibility for all five of the general phases of highway planning, design, construction, maintenance, and operation. Rather, the young engineer will usually be assigned to one job in one area. If his training and experience are to develop his abilities, he must have an opportunity to acquire experience in several areas. The highway maintenance engineer has a good opportunity to observe the mistakes made in construction. The construction engineer sees many mistakes which were made in design, and the design engineer discovers errors in planning. For the development of ultimate administrative ability, the young engineer should have an opportunity to work in all phases of highway engineering.

Young engineers should be encouraged to visit active highway projects which are well organized and well managed; such visits are quite valuable in this training.

Highway Engineering Conferences

With the rapid development of mechanized equipment and with much research in materials during the past few decades, highway construction and maintenance methods have been drastically changed. As long as our work is based on free enterprise and competitive bidding, we can expect continued advancement in road building methods, materials, and machinery. Every year we have new and better methods tried out somewhere in highway construction. While magazines and technical journals do a good job of reporting these developments, they can not replace conversation as a medium for exchange of ideas.

In the United States, many leading universities (where highway engineering is taught) hold annual conferences sponsored jointly by the state university and the local state department of highways. These conferences are planned as a medium for the integration of all highway interest within the state. The programs are arranged to afford an opportunity for highway engineers and administrators, contractors, students and faculty, materials and equipment men, and all persons interested in the state's roads to get better acquainted and to exchange ideas on methods, machinery, and materials of road building.

The programs for these conferences are generally planned to extend over two or three days. On the programs are included talks by local, state, and national authorities on new developments in road building techniques, problems of handling traffic, rights-of-way, etc. A part of the time of each conference is devoted to group discussions where engineers may informally and off-the-record discuss the problems of road building and help each other by telling of their accomplishments as well as difficulties and even failures. Papers presented at these conferences are usually published after the meeting and sent to all engineers who have attended the meeting. Rereading of these papers is quite helpful to engineers in solving their own problems.

Highway conferences tend to help the practicing engineer to keep up to date in technical developments. They help the university teaching by keeping the instructors aware of developments. They give students contacts with professional engineers and contractors and encourage these students to enter the field of highway engineering.

Graphic Calculators

By CLYDE H. KEARNS
Assistant Professor of Engineering Drawing

A specially designed graphic calculator may provide a more rapid solution to an engineering problem than the standard slide rule. On occasion better accuracy may be achieved, since scales can be designed to cover only desired ranges of value. Because answers are obtained quickly and easily, errors occur less frequently. A variety of graphic devices are made available by manufacturers to aid in product selection and equipment design. The special slide rule of Fig. 1, prepared by the Associated Spring Corporation for designing coil springs, is an example of such devices.

There are many cases in industry where the process of manufacture, test, or research involves recurring computations that are time-consuming and monotonous. The engineer with a problem of this type, for which a calculator is not already available, may wish to prepare or have prepared one of his own. This article enumerates some of the principles involved in the design of two calculator forms, slide and disc charts, and shows typical illustrations thereof.

Slide Charts

Design Principles

Slide charts resemble the standard slide rule in the manner in which scales are employed to solve problems but differ in that they are designed and calibrated to solve specific equations. A description of these charts should begin with an explanation of the properties of sliding scales.

Two parallel straight scales, arranged so that one may slide along the other, provide for the addition of two scale distances. The total may be recorded on a third scale. Thus, a stock with two fixed scales and a slide with one scale and an index arrow make possible, at *A* in Fig. 2, the addition of scale distances, *a* and *b*, to obtain scale distance, *c*. If, as at *B*, the arrow is replaced by a fourth scale, the sum of the distances, *a* and *b*, may be equated to the sum of the distances, *c* and *d*. A second slide, with one or two additional scales, makes the manipulation of five or six scale distances possible. A runner or indicator is occasionally employed to read corresponding values on separated scales. It may also mark an intermediate value while the slide is readjusted or the chart is turned over to make use of scales on the back side.

An equation of the form, $f(u) + f(v) = f(w)$, each term of which is a function of a single variable, may be solved with a slide chart of the type illustrated in Fig. 3. Uniformly graduated functional scales represent the linear equation, $2u + v = w - 5$, at *A*. The equation, $u^2v = \frac{w}{2}$, when placed in logarithmic form, becomes $2 \log u + \log v = \log \frac{w}{2}$ and is represented by logarithmic scales at *B*. Numerical values satisfying the equation are obtained in each case by adjusting the slide to set the arrow at a *u* value and reading a *w* value opposite a value of *v*. The scales of each chart are constructed with the same modulus or scale factor, and scale origins and arrow are aligned on the stock and slide.

An equation of the form, $f(u) + f(v) = f(w) + f(x)$, each term of which is a function of a single variable, may be solved with a slide chart of the type shown in

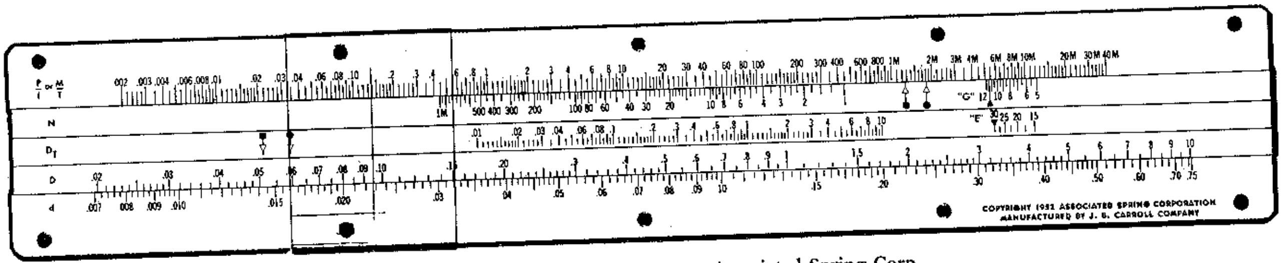


Fig. 1.—A special slide rule. Courtesy Associated Spring Corp.

Fig. 2

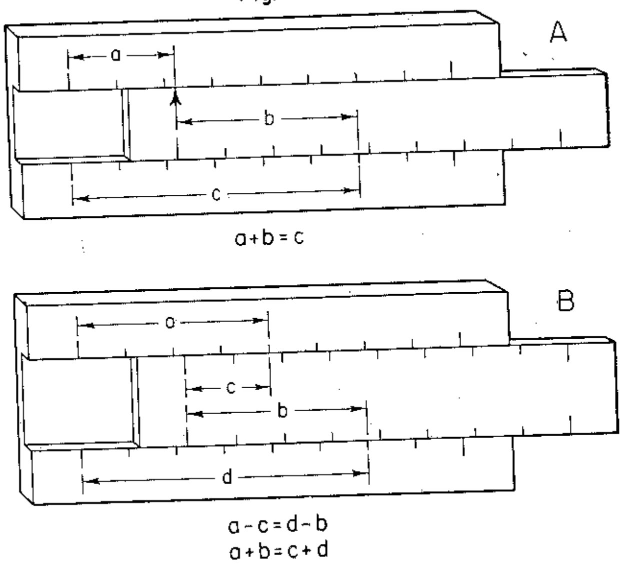


Fig. 3

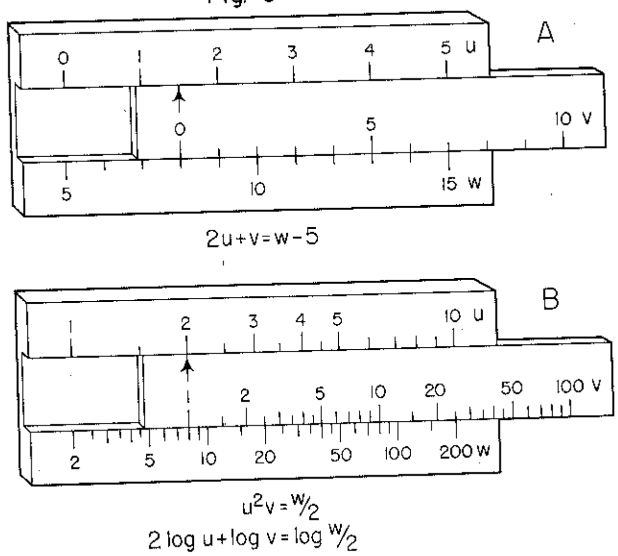


Fig 4

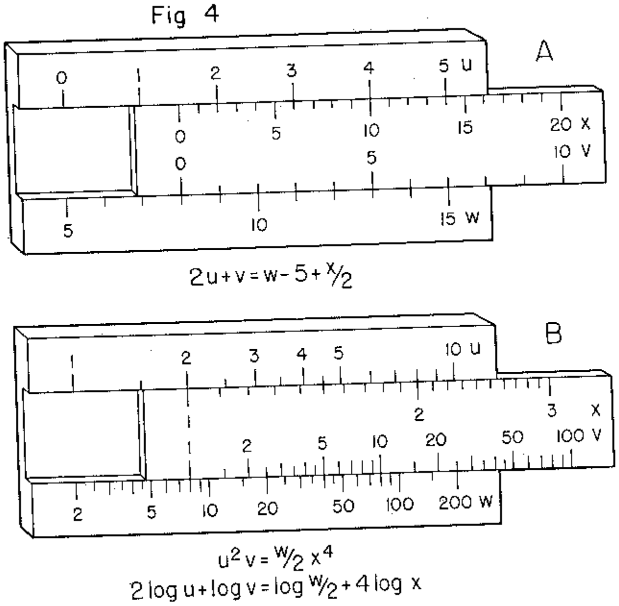
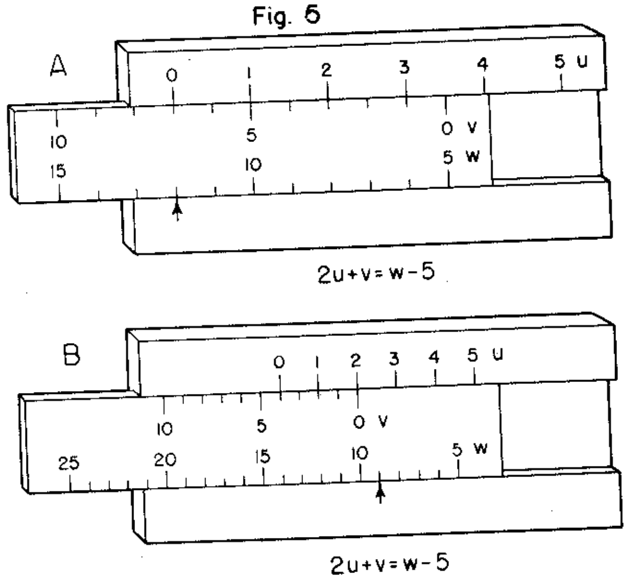


Fig. 5



Figs. 2, 3, 4, and 5.—Sliding scales.

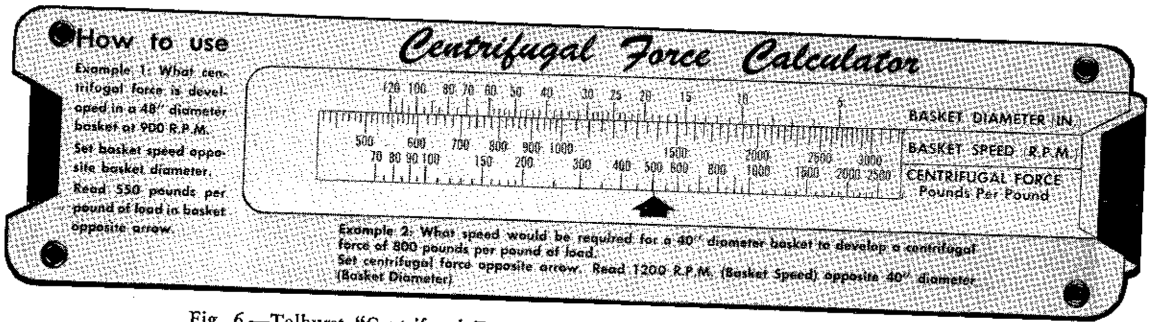


Fig. 6.—Tolhurst "Centrifugal Force Calculator." Courtesy Graphic Calculator Co.

Fig. 4. Uniform scales make up the chart at *A* and logarithmic scales the chart at *B*. Numerical values satisfying the equation are obtained in each case by setting an x value opposite a value of u and reading a w value opposite a value of v. The scales of each chart have the same modulus, and scale origins are aligned on the stock and slide. Comparison of the charts and equations of Figs. 3 and 4 shows that the arrow in Fig. 3 may be considered a scale having but a single graduation.

The order of scales is not necessarily that shown in Fig. 3 or Fig. 4. Scale sequence may be altered without affecting the validity of the calculator. Adjacent scales may be inverted, that is, interchanged and reversed. This includes inversion of the slide. Alternate scales may be interchanged without reversal. Thus, the slide chart for the equation, $2u + v = w - 5$, shown at *A* in Fig. 5, may be considered to have been obtained from that at *A* in Fig. 3 by first interchanging the w scale and arrow and then inverting the slide. Numerical values satisfying the equation are now obtained by setting u and v values opposite and reading a value of w opposite the arrow.

Scale origins and arrow need not be aligned on a slide chart since a shift in the horizontal position of one scale may be compensated for by a similar shift in the position of another scale or the arrow. In the construction of the chart at *B* in Fig. 5 the three scales are located horizontally in convenient manner and the position of the arrow determined by a trial solution. All scales have the same modulus, the w scale having been lengthened relative to the other two to furnish a complete range of values.

Typical Applications

Design principles having been discussed, it is desirable to examine some typical applications. The "Centrifugal Force Calculator" of Fig. 6, distributed

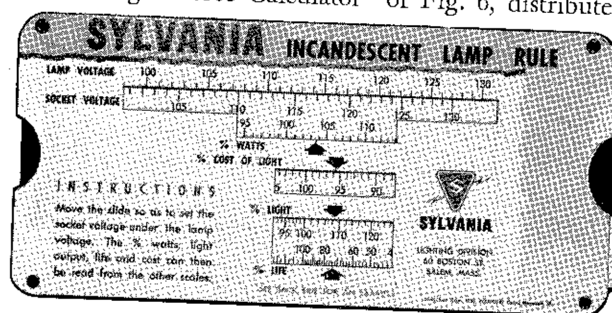


Fig. 7.—Sylvania "Incandescent Lamp Rule." Courtesy Perrygraf Corp.

by the Tolhurst Centrifugals Division of American Machine and Metals, Inc., is an example of the three-scale logarithmic slide chart. Centrifugal force in pounds per pound of load is indicated by the arrow when basket speed in revolutions per minute is set opposite basket diameter in inches.

Sylvania Electric Products, Inc., uses the "Incandescent Lamp Rule" of Fig. 7 to provide values of four lamp characteristics: wattage, relative electricity cost, light output, and life, each as a percentage of rated value. These four are indicated on appropriate scales when socket voltage is opposite lamp voltage.

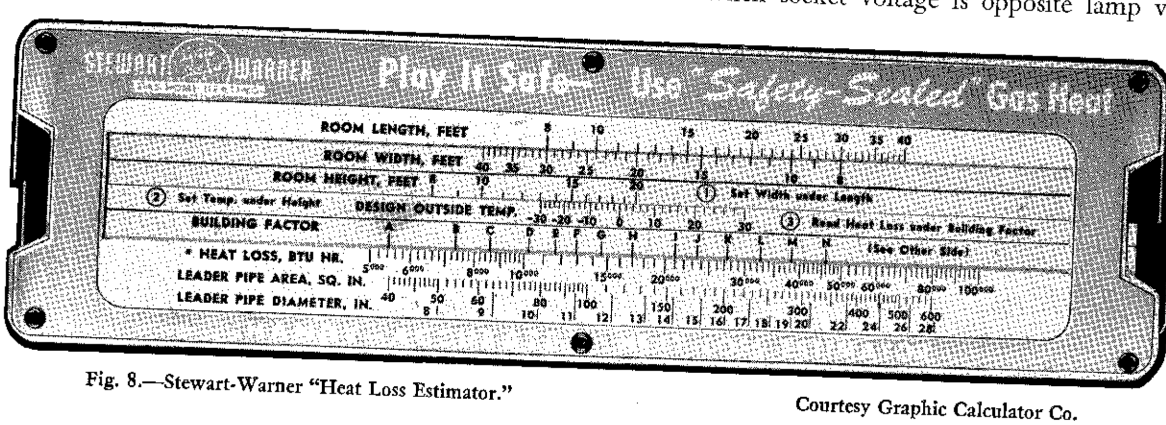
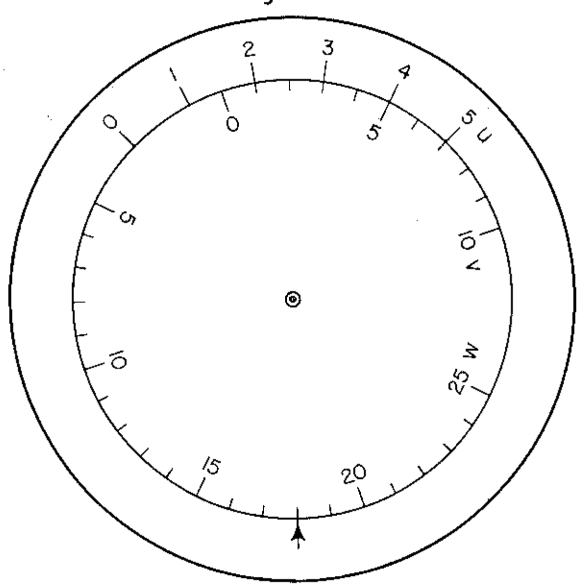


Fig. 8.—Stewart-Warner "Heat Loss Estimator." Courtesy Graphic Calculator Co.

Fig. 8 shows the Stewart-Warner "Heat Loss Estimator," a chart making use of two slides. In solving a problem with the calculator, the upper slide is first adjusted to set room width in feet under room length in feet. The lower slide is then shifted to set design outside temperature in degrees Fahrenheit under room height in feet. Heat loss in British thermal units per hour is read on the bottom scale opposite a building factor which is a function of the type of structure and wall construction. Leader pipe diameter and area, in inches and square inches, respectively, are also indicated on the stock.

Fig. 9



$2u+v=w-5$

Fig. 9.—Disc chart.

Disc Charts

Disc charts differ from slide charts in physical form but design principles are similar. A disc functions to add distances on circular scales in the same manner that a slide provides for the addition of lineal scale distances. Comparison of the disc chart of Fig. 9 with the slide chart at *B* in Fig. 5 bears out this fact.

The equation, $2u + v = w - 5$, is solved in Fig. 9 by rotating the disc to set u and v values opposite one another and reading a value of w indicated by the arrow. All scales have the same diameter and therefore the same modulus.

The "Coil Weight Calculator" of Fig. 10 for cold rolled strip steel, distributed by the Rowe Machinery and Manufacturing Company, is a double instrument in that two separate steps are involved in its operation. The disc is first adjusted to set inside and outside coil diameters, both in inches, opposite one another at the top and pounds per inch width read over the arrow. The disc is then rotated to set this value under the arrow at the bottom and total weight in pounds read opposite strip width in inches.

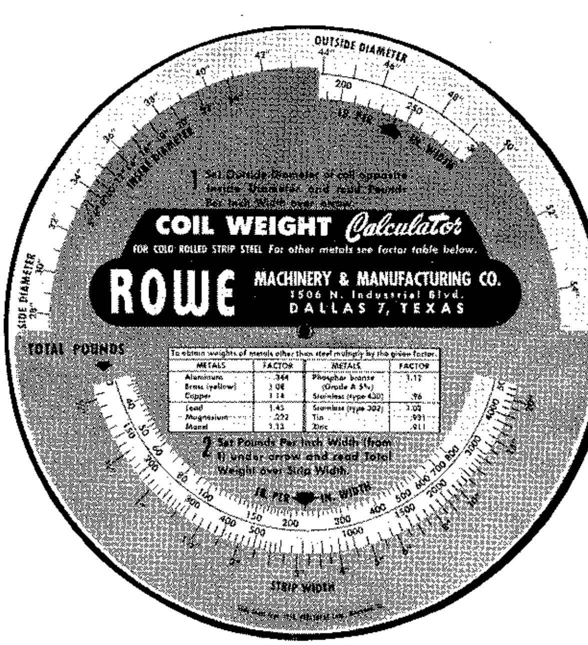


Fig. 10.—Rowe "Coil Weight Calculator." Courtesy Perrygraf Corp.

The General Electric "Air Turbine Drive Calculator" of Fig. 11 illustrates a more complex chart form using two discs. Eight separate scales, representing values of nine variables, appear on this chart.

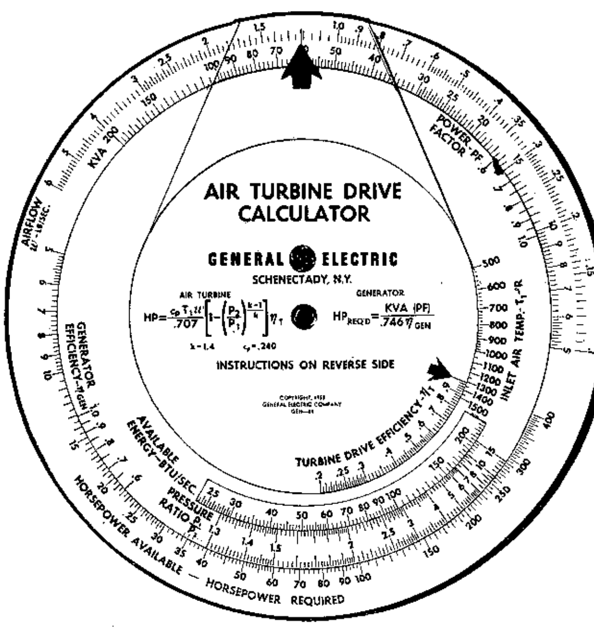


Fig. 11.—General Electric "Air Turbine Drive Calculator." Courtesy Graphic Calculator Co.

Commercial Manufacture

Graphic calculators, selectors, and demonstrators of all types are manufactured commercially. Two companies, the Graphic Calculator Company of Chicago, Illinois, and the Perrygraf Corporation of Maywood, Illinois, and Los Angeles, California, each with twenty years experience in the field, supply the greater part of the market. Many companies find graphic devices valuable for introducing products, promoting sales, and improving customer service. Although most applications are of a technical nature and deal with industrial products, they are also employed for determining such diverse items as proper packaging methods for fruits and vegetables, adequacy of daily diets, correct rules of parliamentary procedure, size of home loan payments, and the odds on poker hands. Purchase in quantity is not a requirement and special calculators, in small quantity, are prepared on many occasions. Some are for plant engineering purposes, where relatively high unit cost is more than offset by the time saved through their use.

Calculators are made up to meet customers' individual tastes and requirements by trained staffs of designers, aided by others who do art work and layout. Designs are printed by letterpress, silk screen or photoengraving, in black and white or in color, on flat sheets of Vinylite plastic or heavy paperboard. The results are ingenious, attractive, and accurate.

In describing future prospects in the field, C. R. Gulbransen, Jr., of the Graphic Calculator Company states,

"At first thought of as only an interesting gadget, the specially designed calculator has come of age in an era where time is the most precious commodity known. There is a great awakening of interest and an appreciation of what the calculator can do in the industrial field. The potential has not been reached and a tremendous opportunity exists to do worthwhile work in the medium."

Summary

The engineer is often faced with the responsibility for executing or supervising computational work in connection with research, design, or production. Mindful of the need for reducing man hours spent in such effort, he should be familiar with all methods available to him for getting the work done. Computing machines are not always available. Graphic devices like the slide and disc charts, because of their simplicity and convenience, may best serve the situation. Only the well-informed engineer can expect to make an intelligent choice of the best means for accomplishing the task.

Sound Recording for Motion Pictures

By Clair R. Tettemer*

From the first moment of a film idea, sound recording comes in for its share of planning. The time has long since passed when films can be made with sound added as an afterthought, for the sound track is an integral part of a good motion picture and, as such, helps carry out the purpose of the film.

At the first production conference, recording decisions must be made which affect the story, the budget, and the technical aspects of the film. It has to be decided, for example, whether or not the picture will use synchronized sound. "Sync" sound is imperative where dialogue, music, or sound effects must be recorded at the same time they are filmed.

Dubbing, Prescoring, Postscoring

If it is decided to use sync sound, then special plans have to be made to place microphones properly, cameras have to be "blimped,"[1] sets or rooms have to be acoustically treated to improve the sound pickup, camera angles and lighting must be planned so the microphone or its shadow will not show, a constant power source must be available, and some method of interlocking the camera and sound recorder must be worked out to assure synchronization.

Should it be decided not to record the sound at the time of shooting the picture, then provisions have to be made for "dubbing-in"[2] sound effects, music, and

* 1953-55 Graduate Assistant, Department of Photography, The Ohio State University; presently Director, School Program Department, Station KETC-TV, St. Louis, Mo.; his O.S.U. Ph.D. dissertation is in preparation.

[1] Enclosing the camera in a soundproof case during operation to prevent mechanical noise from being recorded on the sound track.

[2] Re-recording from tape, film, or disc after the film is shot. Most producers have a library of specially recorded material for backgrounds.

Slide and Disc Calculators*

By Clyde H. Kearns
Ohio State University

A specially designed graphic calculator may provide a more rapid solution to an engineering problem than the standard slide rule. On occasion better accuracy may be achieved, since scales can be designed to cover only desired ranges of value. Because answers are obtained quickly and easily, errors occur less frequently. A variety of graphic devices are made available by manufacturers to aid in product selection and equipment design. The special slide rule of Fig. 1, prepared by the Associated Spring Corporation for designing coil springs, is an example of such devices.

There are many cases in industry where the process of manufacture, test, or research involves recurring computations that are time-consuming and monotonous. The engineer with a problem of this type, for which a calculator is not already available, may wish to prepare or have prepared one of his own. This article enumerates some of the principles involved in the design of two calculator forms, slide and disc charts, and shows typical illustrations thereof.

SLIDE CHARTS

Design Principles

Slide charts resemble the standard slide rule in the manner in which scales are employed to solve problems but differ in that they are designed and calibrated to solve specific equations. A description of these charts should begin with an explanation of the properties of sliding scales.

Two parallel straight scales arranged so that one may slide along the other, provide for the addition of two scale distances. The total may be recorded on a third scale. Thus, a stock with two fixed scales and a slide with one scale and an index arrow make possible, at A in Fig. 2, the addition of scale distances, a and b, to obtain scale distance, c. If, as at B, the arrow is replaced by a fourth scale, the sum of the distances, a and b, may be equated to the sum of the distances, c and d. A second slide, with one or two additional scales, makes the manipulation of five or six scale distances possible. A runner or indicator is occasionally employed to read corresponding values on separated scales. It may also mark an intermediate value while the slide is readjusted or the chart is turned over to make use of scales on the back side.

An equation of the form, $f(u) + f(v) = f(w)$, each term of which is a function of a single variable, may be solved with a slide chart of the type illustrated in Fig. 3. Uniformly graduated functional scales represent the linear equation, $2u + v = w - 5$, at A. The equation, $u^2v = \frac{w}{2}$, when placed in logarithmic form, becomes $2 \log u + \log v = \log \frac{w}{2}$ and is represented by logarithmic scales at B. Numerical values satisfying the equation are obtained in each case by adjusting the slide to set the arrow at a u value and reading a w value opposite a value of v. The scales of each chart are constructed with the same modulus or scale factor, and scale origins and arrow are aligned on the stock and slide.

An equation of the form, $f(u) + f(v) = f(w) + f(x)$, each term of which is a function of a single variable, may be solved with a slide chart of the type shown in Fig. 4. Uniform scales make up the chart at A and logarithmic scales the chart at B. Numerical values satisfying the equation are obtained in each case by setting an x value opposite a value of u and reading a w value opposite a value of v. The scales of each chart have the same modulus, and scale origins are aligned on the stock and slide. Comparison of the charts and equations of Figs. 3 and 4 shows that the arrow in Fig. 3 may be considered a scale having but a single graduation.

The order of scales is not necessarily that shown in Fig. 3 or Fig. 4. Scale sequence may be altered without affecting the validity of the calculator. Adjacent scales may be inverted, that is, interchanged and reversed. This includes inversion of the slide. Alternate scales may be interchanged without reversal. Thus, the slide chart for the equation, $2u + v = w - 5$, shown at A in Fig. 5, may be considered to have been obtained from that at A in Fig. 3 by first interchanging the w scale and arrow and then inverting the slide. Numerical values satisfying the equation are now obtained by setting u and v values opposite one another and reading a value of w opposite the arrow.

Scale origins and arrow need not be aligned on a slide chart since a shift in the horizontal position of one scale may be compensated for by a similar shift in the position of another scale or the arrow. In the construction of the chart at B in Fig. 5 the three scales are located horizontally in convenient manner and the position of the arrow determined by a trial solution. All scales have the same modulus, the w scale having been lengthened relative to the other two to furnish a complete range of values.

Typical Applications

Design principles having been discussed, it is desirable to examine some typical applications. The "Centrifugal Force Calculator" of Fig. 6, distributed by the Tolhurst Centrifugals Division of American Machine and Metals, Inc., is an example of the three-scale logarithmic slide chart. Centrifugal force in pounds per pound of load is indicated by the arrow when basket speed in revolutions per minute is set opposite basket diameter in inches.

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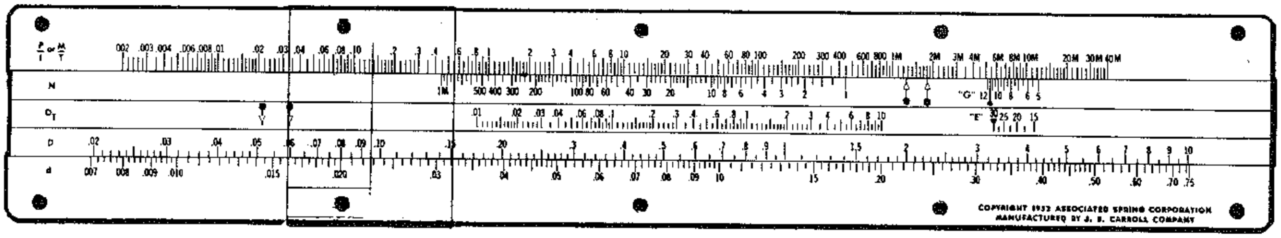


Fig. 1.—A special slide rule. Courtesy Associated Spring Corp.

Fig. 2

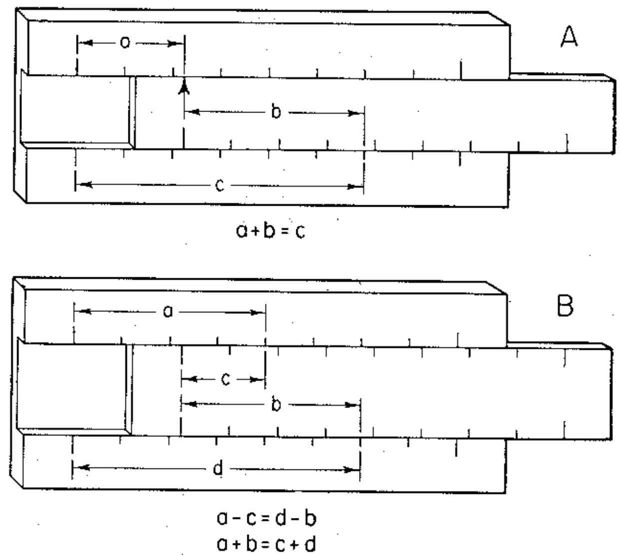


Fig. 3

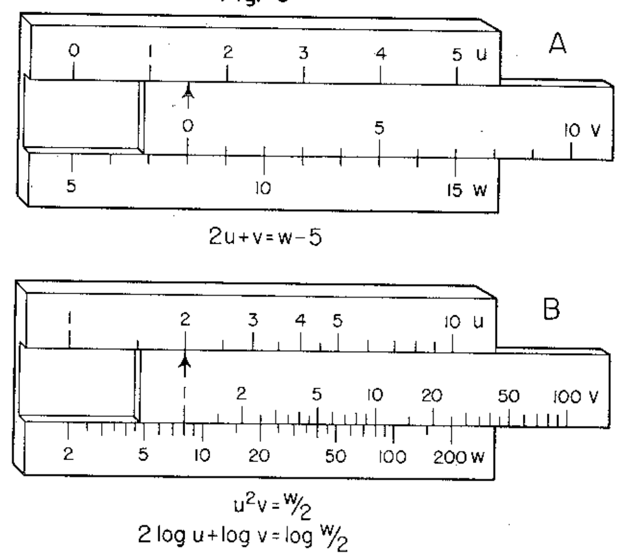


Fig 4

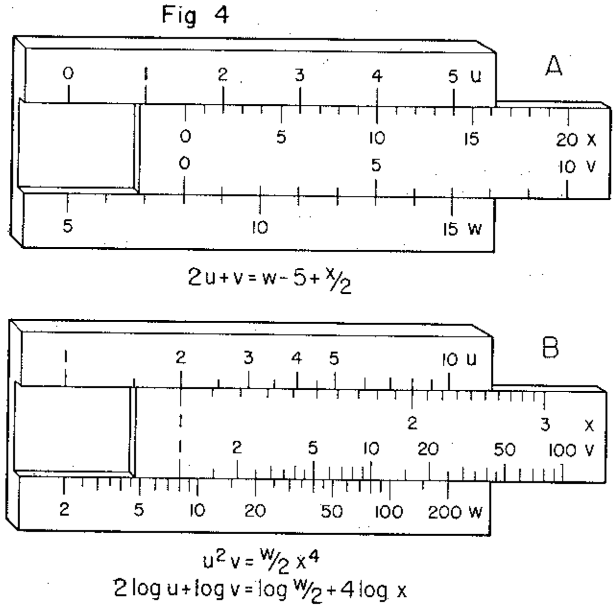
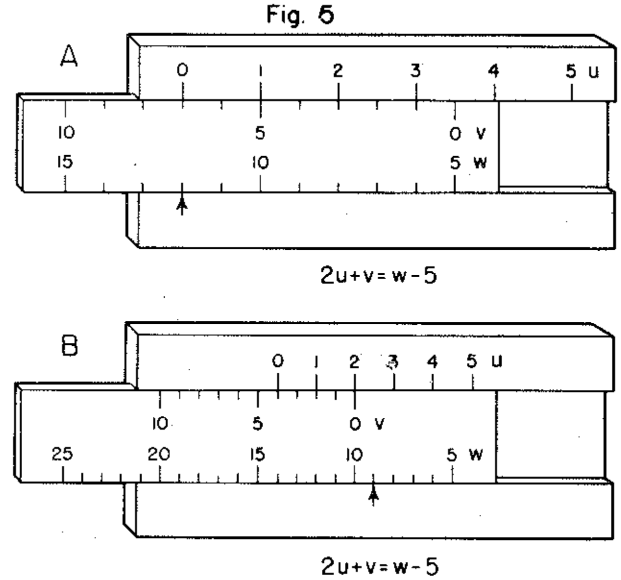


Fig. 5



Figs. 2, 3, 4, and 5.—Sliding scales.

(Continued on page 41)

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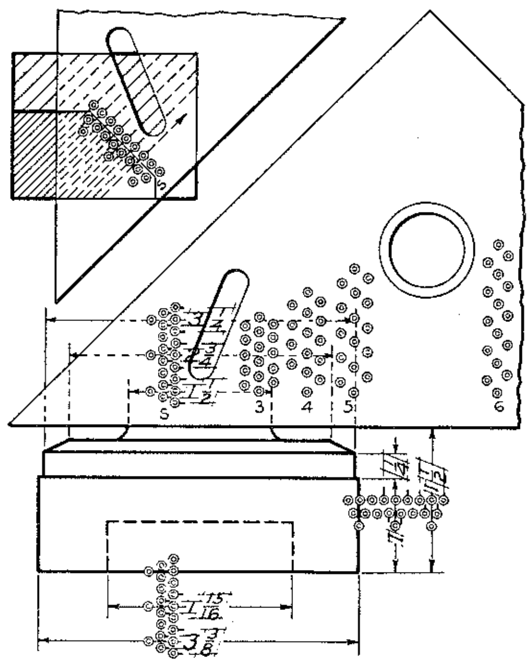

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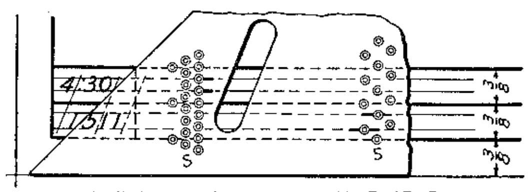

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8"-60	8"-60
9"-60	9"-60
4"-45	4"-45
5"-45	5"-45
6"-45	6"-45
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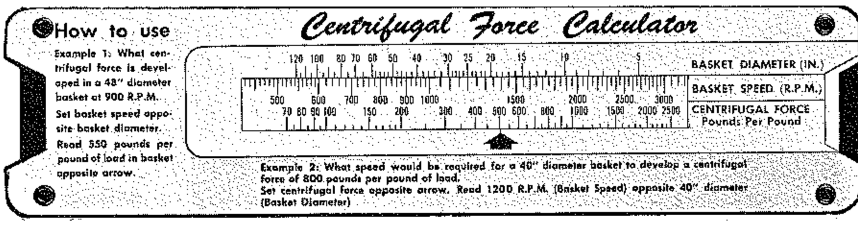


Fig. 6.—Tolhurst "Centrifugal Force Calculator." Courtesy Graphic Calculator Co.

Sylvania Electric Products, Inc., uses the "Incandescent Lamp Rule" of Fig. 7 to provide values of four lamp characteristics: wattage, relative electricity and wall construction. Leader pipe diameter and area, in inches and square inches, respectively, are also indicated on the stock.

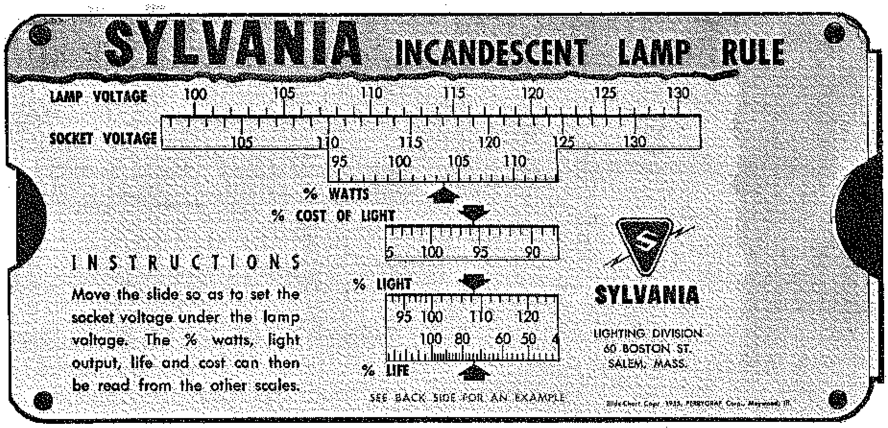


Fig. 7.—Sylvania "Incandescent Lamp Rule." Courtesy Perrygraf Corp.

cost, light output, and life, each as a percentage of rated value. These four are indicated on appropriate scales when socket voltage is set at lamp voltage.

Fig. 8 shows the Stewart-Warner "Heat Loss Estimator," a chart making use of two slides. In solving a problem with the calculator, the upper slide is first adjusted to set room width in feet under room length in feet. The lower slide is then shifted to set design outside temperature in degrees Fahrenheit under room height in feet. Heat loss in British thermal units per hour is read on the bottom scale opposite a building factor which is a function of the type of structure

DISC CHARTS

Disc charts differ from slide charts in physical form but design principles are similar. A disc functions to add distances on circular scales in the same manner that a slide provides for the addition of lineal scale distances. Comparison of the disc chart of Fig. 9 with the slide chart at B in Fig. 5 bears out this fact.

The equation, $2u + v = w - 5$, is solved in Fig. 9 by rotating the disc to set u and v values opposite one another and reading a value of w indicated by the

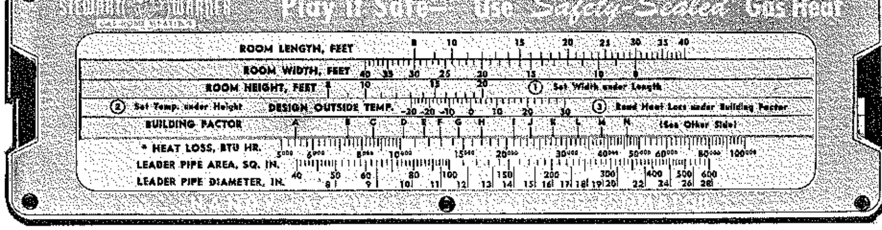
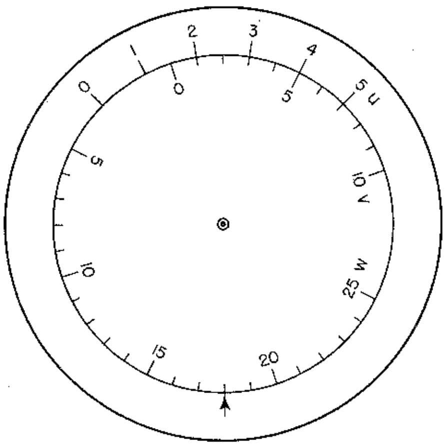


Fig. 8.—Stewart-Warner "Heat Loss Estimator." Courtesy Graphic Calculator Co.

Fig. 9



2u+v=w-5

Fig. 9.—Disc chart.

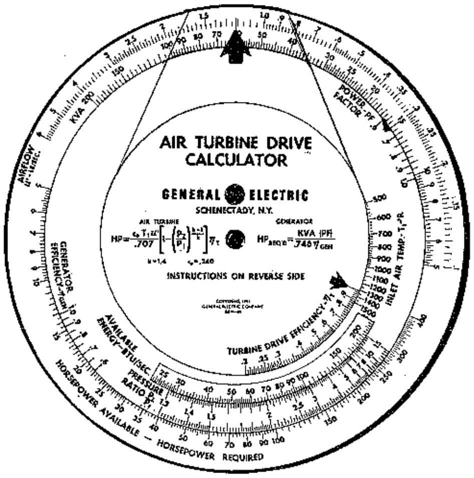


Fig. 11.—General Electric "Air Turbine Drive Calculator." Courtesy Graphic Calculator Co.

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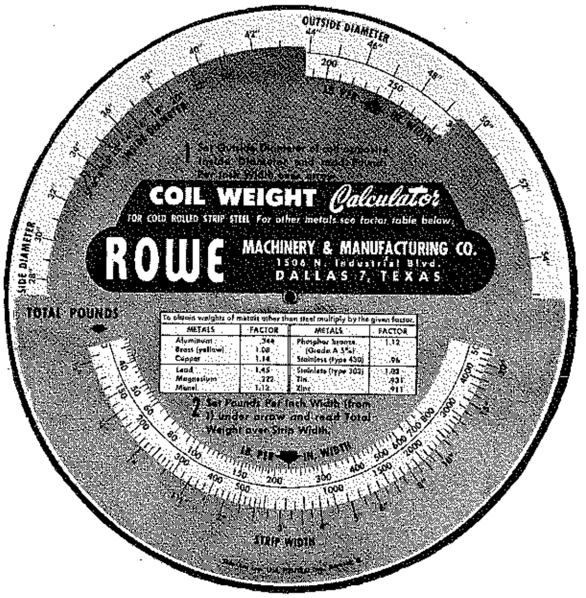

Fig. 10.—Rowe "Coil Weight Calculator." Courtesy Perrygraf Corp.

COMMERICAL MANUFACTURE

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A New Perspective Method

By Wayne Lambert Shick
University of Illinois, Urbana, Illinois

Whether perspective ideas are difficult may depend upon whether the student has been taught classical descriptive geometry, and is well versed in projection to planes of projection and methods of revolution, or whether he has been taught the so-called "direct" or "hopeful-guess" method. Furthermore, there is no published method for drafting perspective directly from orthographic views to the perspective view without intermediate points; that is, there is no published "direct" method of perspective.

direct measurement involve either the lines between vanishing points and revolved position of S, or measuring points on the lines between vanishing points.* These methods require a device having portions of the lines between vanishing points, or extending supports for measuring points which occur on the lines between vanishing points. The projections by any of these methods are comparatively long, slow and inaccurate, and may require a cumbersome device the size of the dash-lines (Fig. A). For practicality, it

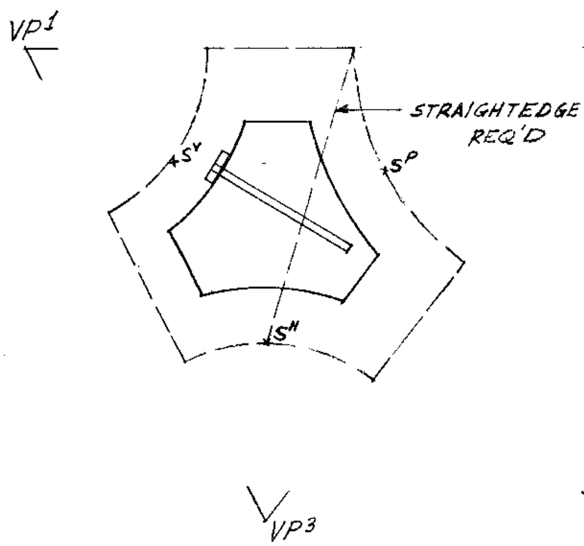

Figure A

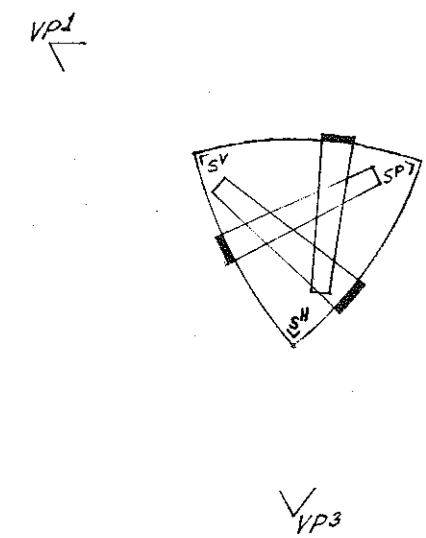

Figure B

The practical users of three-point perspective have for many years employed devices with substitute arcs for vanishing points, since a three-point perspective of practical size with minimum distortion is made from a distant point of sight, entailing remote vanishing points. One of the earliest of such devices was shaped as in Figure A. All published methods of three-point perspective using orthographic views or has been common procedure to use perspective grids or measuring axes—the perspective being drawn on a tracing paper overlay. With this procedure, the de-

*An exception is a method I devised in 1953: Isometric-Three-Point Perspective, "Engineering Drawing and Geometry," Hoelscher and Springer, pp. 18-11-12.

vice has the small size shown in Figure A, and the measurements are transferred from orthographic to perspective. The speed and accuracy are somewhat better than methods using views or direct measurement (published to date)—the principal advantage being the more convenient size of device.

THE NEW METHOD

This method has been used in my classes for two years, and has been rapidly and accurately executed. It is especially suited to the device shown in Figure B with the "corners" of the device being S^H, S^V, and S^P. The method may be used without the device for comparatively small illustrations or for academic purposes. The lucite blade or blades converge toward the vanishing points. For an equilateral or nearly equilateral system of three-vanishing points, only one blade suffices.

The method is shown in Figure C for the H-projection, a similar process being used for the V or P projections. The proof of the method may be stated as follows: Point A is revolved about the line of intersection of the H-plane with the picture plane (A moves in a circle in a plane perpendicular to the picture plane with circle-center at M); Point of Sight S is revolved about VP1-VP2 (intersection of picture plane and horizontal plane through S) (S moves in a circle in a plane perpendicular to the picture plane, with circle-center at N). Therefore, the line SA is an element of an Oblique Cone with Apex at the perspective of A, and Axis MN; S is on one nappe, A on the other nappe. For each point in the H-plane this analysis applies, and the collective revolving of such points brings the H-projection into the picture plane in true shape, and S-revolved is the same as S^H. Therefore, the perspective of the H-projection (or any other projection) may be drafted directly in perspective, without intermediate points, the perspective of a point in the H-projection appearing directly along from S^H to the H-projection in revolved position. The perspective is then built up or down from this "perspective plan" (perspective of the H-projection).

In a similar manner, the V or P projections may be employed, or the heights may be set off in a direct measurement manner, using S^V or S^P as the measuring point. The method may be used as a di-

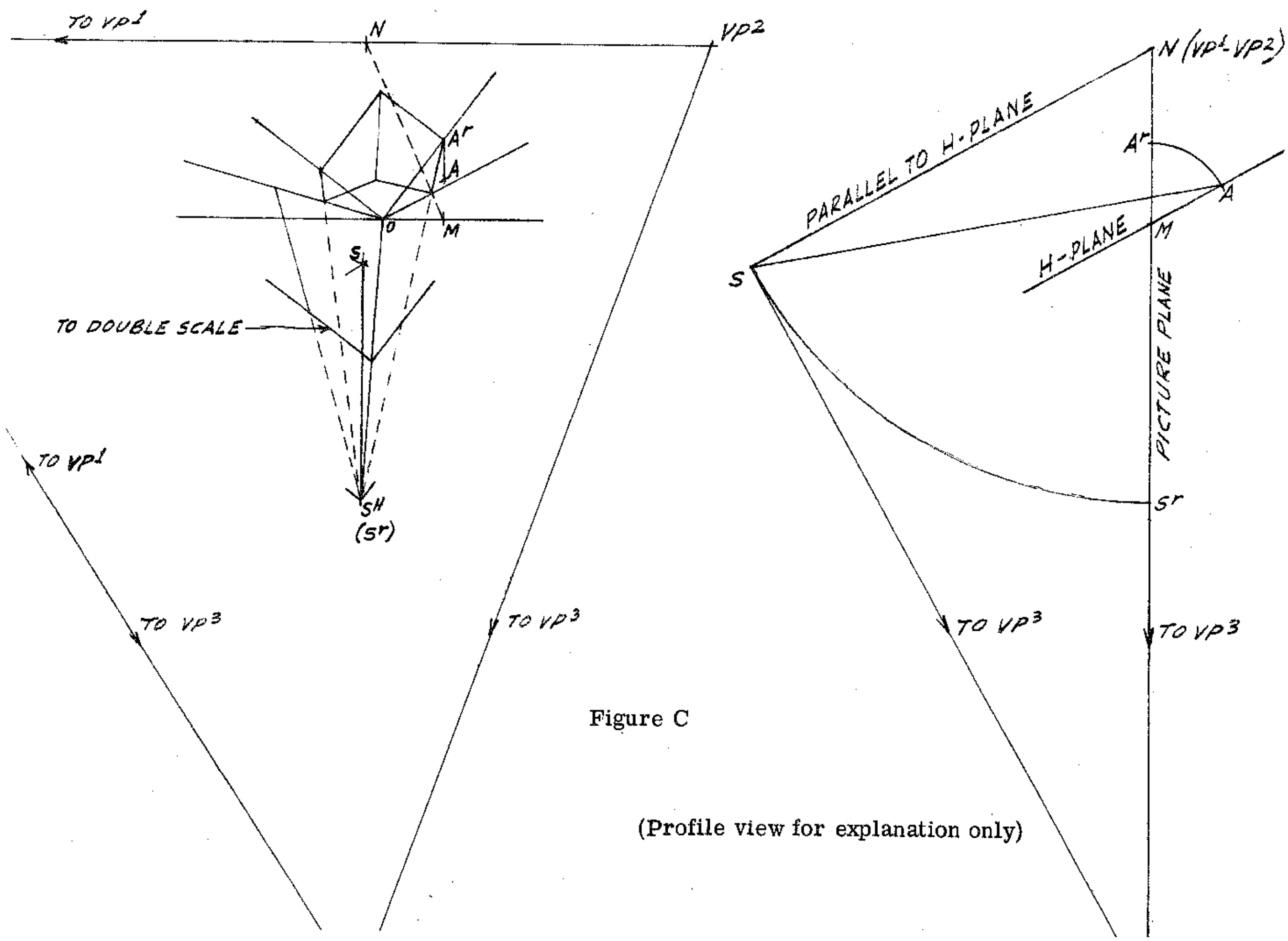

Figure C

(Profile view for explanation only)

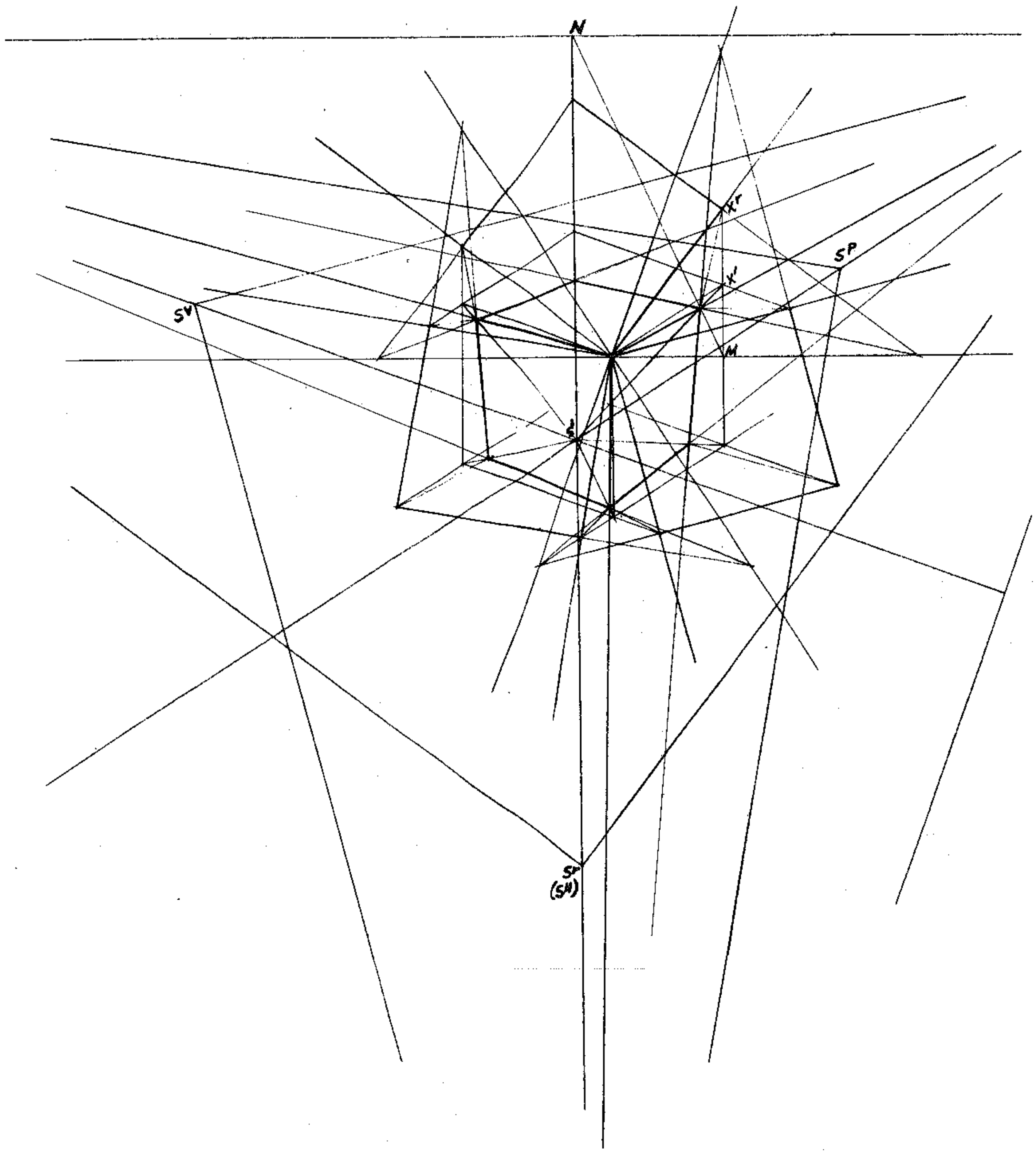

Figure D

rect measurement process using axes, or the orthographic views may be used with the perspective being drawn on a tracing paper overlay. Thus, the projections from orthographic to perspective (whether in direct measurement or using views) are quite short, in some cases a fraction of an inch, since the orthographic and perspective views are so intimately associated. This promotes great speed and accuracy. Note especially, that the method gives us freedom from the lines between vanishing points (not possible in other methods) enabling a small self-contained device of arcs S^H-S^V-S^P, whose size encompasses the maximum size perspective without distortion. It is quite simple to enlarge scale with the method, or to measure very great distances. For example, if the linear measurements are to be doubled, merely move the view as shown to a location midway between O and S^H. In the projection to the perspective plan, the measurements are automatically doubled. This procedure is applicable in dealing with very large objects or with remote points.

For drawing perspectives of complex objects or for wholesale production of such views, I have for some time advocated photographing the orthographic views taped in their related positions on the faces of a cube, then completing the perspective by placing the photograph on a device which is matched to the photographic point of sight and tilt of focal plane. Thus, the perspective measurement problem may be solved perfectly and instantly, and any novice can complete the perspective view. Such a process may be systematized for rapid, automatic production of perspectives. Of course, the advantage of direct measurement processes, which have wide application, is that NO orthographic views are required; the draftsman may draw the perspective from mathematical information, dimensioned freehand sketches or from his imagination.

In Figure D, three perspective methods are superimposed: (1) by lines of sight as above described; (2) by extension of lines into picture plane; and (3) by projection to S from axonometric-projection-view.

The theory of the perspective method explained in this article may also be applied to two-point perspective and is usually employed for the H-projection only.

Nearly all of the "old" perspective methods deserve respect and appropriate use. Fortunately for our graphic science, however, not all of the aspects of drawing (including perspective) have been solved, standardized, systematized or simplified to the ultimate—and never will.

An Outline for An Integrated Course

By Carson P. Buck

Syracuse University

The May 1956 issue of the JOURNAL OF ENGINEERING DRAWING carried an article on Integration[1] which set forth a number of reasons in favor of this method of presentation of engineering graphics. Since writing the article, we have had several requests at Syracuse concerning our course outline and topical emphasis. With the thought that there may be general interest on the part of others as to what might be done along the lines of an integrated course, I am submitting the following outline of our present course at Syracuse. It should be noted that we are currently in a stage of transition; this semester we have begun to offer graphics in the sophomore year instead of the freshman year.[2] The outline, therefore, represents the initial thinking as to topical sequence.

In preparing our present course outline, we first established the objectives of the course, based on what appeared, after study, to be the following needs of engineers and engineering students in the field of graphics.

Need for a basic knowledge of the various methods of representation. This implies an ability to read drawings that he may encounter. Fundamentally it means a working knowledge of orthographic projection, though this is only the necessary core of knowledge of representation. Other methods of representation would include pictorial, charts, diagrams, etc.

2. Ability to solve problems graphically.
   a) Knowledge of the use of orthographic projection and principles of descriptive geometry in solving spatial problems.
   b) Knowledge of fundamental graphical mathematics, basic types of graphs, nomography, alignment charts, etc., and an appreciation of their uses in the solution of problems.
   c) Experience in creative engineering in the solution of problems involving original design[3] or redesign.
   d) In the solution of problems, an appreciation for a logical approach in reasoning out the solution.
   e) An appreciation, as needed, of accuracy, and thereby neatness, in the solution of problems.

3. Ability to present his ideas to management or to laymen through the use of the above.

4. The engineer is not likely to be a draftsman, but he may be called upon to supervise draftsmen, and he should be able to translate ideas to paper in the form of sketches or more carefully executed layouts. He will therefore need:
   a) An ability to sketch.
   b) An ability to use drafting instruments.

5. He will be expected to clearly annotate his work and should therefore have an appreciation for a neat, clearly legible, form of lettering.

With these needs in mind we developed an outline which has subsequently been modified as follows:

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1. Integration—Trend or Fad? by C. P. Buck, J.E.D., page 39, May 1956.
2. We feel that placing graphics in the sophomore year accomplishes, among others, two things: it brings training in know-how closer to actual use in advanced undergraduate work and subsequent practice; and it gives the student an opportunity to come into graphics work with a better mathematical background.
3. The use of the term "design" is not intended to be limited to the possible connotation in connection with the preparation of working drawings, but rather to the use of any phase of the graphics language that may contribute to the creation or development of any engineering project.

GENERAL (TOPICAL) OUTLINE
FOR AN INTEGRATED COURSE IN GRAPHICS
First Semester

	Periods Lecture (1 hr.)	Lab. (2 hrs.)
I. Freehand Techniques (Fundamentals)	1	3
A. Lettering		
B. Sketching		
II. Orthographic Projection		
A. Projection Theory	1	3
1. Projection angles (Four Quadrants explained)		
2. Principal and auxiliary views (Third angle)		
B. Points (Included with Item A in lecture)		
1. Position		
2. Location on lines and surfaces		
C. Lines	1	3
1. Classification		
a. Principal lines		
b. Oblique lines		
2. Size and position (true length, direction, angle with principal planes)		
3. Point view		
D. Planes	1	3
1. Classification		
a. Principal		
b. Inclined		
c. Oblique		
2. Size and position (Edge view, true size, direction-strike and dip)		
III. Vectors		
A. Coplanar Vector Systems	1	3
1. Concurrent		
2. Non-concurrent		
B. Non-coplanar vector systems		
1. Concurrent		
2. Non-concurrent		
IV. Connectors	1	3
A. Line method -(perpendiculars)		
B. Plane method - (grade connectors)		
V. Intersections	1	3
A. Piercing points - line and plane		
B. Intersection of planes		
C. Dihedral angles		
VI. Projections on any plane	1	3
A. Point on plane		
B. Line on plane		
C. Shortest distance, point to plane		
D. True angle of line and any plane		
VII. Surfaces	2	6
A. Principal types: plane, single-curved, double-curved, warped		
B. Intersection of various surfaces		
C. Developments		
VIII. Rotation	1	3
A. Points		
B. Lines		
C. Planes		
IX. Pictorial	2	6
A. Axonometric		
B. Oblique		
C. Perspective		
Totals:	13	39 (x2) = 78
Total:	91 hours	

Second Semester

	Periods Lecture (1 hr.)	Lab. (2 hrs.)
X. Sections	1	3
A. Principal types		
B. Basic Methods		
XI. Dimensions	2	6
A. Fundamentals		
B. Shop processes		
C. Limit dimensions		
XII. Working Drawings	3	9
A. General types		
B. Fasteners, welding, piping		
C. Details and assemblies		
D. Industrial print reading		
XIII. Charts, Diagrams, Graphs	2	6
A. Charts and Diagrams		
1. Presentation of data to the layman		
2. Presentation of data to the management		
B. Graphs		
1. Types		
2. Theory		
3. Techniques of layout and construction		
4. Determination of empirical equations		
XIV. Graphical Mathematics	3	9
A. Graphical Algebra		
B. Graphical Calculus		
1. Differentiation		
2. Integration		
XV. Alignment Charts		
A. Design of individual components of a chart	2	6
B. Design of a two variable chart		
C. Design of a three variable chart (Parallel line)		
Totals:	13	39 (x2) = 78
Total:	91 hours	

As indicated in the outline, the course consists of one hour of lecture and six hours of laboratory per week for two semesters of 13 weeks each. Some lecturing is done in the laboratory as needed.

The following paragraphs indicate the emphasis given to various topics included in the course and also point out how other topics, apparently not included, are handled.

Continuing Topics

Certain topics such as the use of instruments, geometry, technique, lettering, and sketching are of a continuing nature, that is, the student continues to learn in these areas throughout the entire course. Because of this they are not necessarily handled as separate topics in the course of study.

The use of instruments is taught to the student as he has need for particular pieces of his equipment. A knowledge of plane and solid geometry is assumed; but drawing board methods, which may differ from theory, are pointed out as the need for them arises.

Technique is one thing that causes a considerable amount of controversy. If the graphics teacher emphasizes it at all, he is apt to be accused of training draftsmen; and frequently, whether he does or doesn't, he is apt to be accused by members of other departments of not having taught current juniors and seniors any drawing at all, "their design work is so atrocious." The drawing department has tried to approach the matter of technique from the standpoint of accuracy. It is essential that an engineer be accurate. In this respect "fair-to-middlin'" is not good enough. He must be accurate within the limits of his problem. Thus approached, neatness and line-technique are secondary and, to a considerable extent, naturally come about in the attempt to produce accuracy.

In the matter of technique, considered from the standpoint of accuracy of solution, and clarity in the case of lettering, training is needed and must be continuous. However, such training can not be achieved by practice in the graphics course alone, just as training in good English can not be expected of the student unless it is emphasized in all of his work. All engineering teachers should have an appreciation of and should especially require good technique from their students.

Visualization may also be counted as a topic that receives continuing emphasis. In graphics the increasing ability to visualize clearly moves ahead hand in hand with the ability to correctly solve the course problems. It is here that the student receives training in transferring his spatial ideas to paper, and, equally important but generally more difficult, in being able to visualize the three dimensional situation or problem portrayed by the two dimensional drawing. The majority of engineering students have an ability to visualize that is far superior to that of non-engineering students. Yet in engineering curricula we frequently ignore this fact by not encouraging a concurrent use of graphics in the analysis of the student's engineering problems.

Creative ability is encouraged at every opportunity. Whenever possible, laboratory problems are assigned that involve original thinking in their solution and presentation. This is particularly true of problems that involve any design where the student has control over the individual results.

Freehand Techniques

Sketching and lettering are offered together because we feel that the technique of sketching is involved in the design of good lettering. Our outline calls for a week to be devoted to this topic, but only in its formal introduction. Actually there is a continuing emphasis on lettering and sketching throughout the course. Every assignment carries some lettering, which is evaluated by the instructor. A considerable amount of sketching is called for, both as a finished product in the solution of a particular problem, and more especially as "thinking out loud" in the form of the preliminary study of a problem. Artistic presentation is not expected on the part of the student's sketch, but rather clearness and accuracy of expression.

Orthographic Projection

Presentation of the topic is made through the use of simple objects, which can readily be visualized. The theory of projection and of the principal planes of projection are discussed. Emphasis is given to third angle projection. After being able to lay out two principal views of an object the student is then taught to use projection as a means of creating other principal or auxiliary views.

Students usually have difficulty in working with the more abstract points, lines and planes because of not being able to grasp their relationship to actual objects. In the integrated course the approach that is adopted to forestall this difficulty is that of associating the initial discussion of these elements with an actual object, and then moving directly into the solution of the fundamental type of problems that involve the points, lines, or planes.

At this stage of the course, study is made of the solution of the first of the two fundamental types of spatial problems in engineering: those of true size, involving primarily true length of lines and true size of planes.

Vectors

This topic is introduced at this point because the development of the subject follows as a natural application of the theory material immediately preceding it, and also because of the correlation with the sophomore courses in mechanics at Syracuse.

Vectors and their graphical applications are useful to engineering in general. Because of the natural adaptation of vectors to graphics, this topic had long been considered a standard one in descriptive geometry courses. The purpose of presentation of this material in graphics courses is not to provide complete training in the graphical use of vectors, but rather to provide the basic fundamentals. The underlying princples in vectorial analysis are the same whether one is discussing stresses, velocities, accelerations, impedances, etc. Our object is that of showing the student the similarity between all vectorial analysis, and providing the broad, common knowledge usable in any future studies involving vectors.

Connectors

A major application of graphics is that of spatial analysis. In this work the objective is not so much that of representing an object on paper as it is to solve graphically, spatial relationships which would otherwise require involved mathematical computations.

One such fundamental analysis is that of connectors; the determination of the shortest distance between two objects. This has numerous applications useful in engineering, among which are problems involving clearance, shortest distance (especially at prescribed angles), and the interconnecting of members of a structure with prescribed locations.

Rotation

One week is formally devoted to the theory and application of rotation. However, for the remainder of the course, the fundamentals of rotation can be used at the discretion of the student in solving subsequent problems.

In addition to its use in solving problems, the student is also shown that a knowledge of the fundamentals of rotation is extremely useful in the design of rotating equipment.

Intersections

This is the second of the two fundamental types of spatial problems. At this time intersections are analyzed to the extent of problems involving lines and planes. The principles developed here have several direct applications in the field of engineering.

Projections on Any Plane

The principles used in the projection of points and lines on a plane are extended to more advanced problems. In this material lie the principles of all pictorial projection-axonometric, oblique and perspective. Here also are the basic principles of spatial information on any plane.

Surfaces

The basic principles of intersections have been previously studied. At this point these principles are applied to various types of surfaces.

Pictorial

Axonometric and oblique drawing are given emphasis. Perspective projection is given a very limited coverage involving only the basic fundamentals of one and two point perspective. Sketching is used to a considerable extent in the coverage of the topic.

Sections

In addition to the usual presentation of the material in connection with objects, the theory of sections is also applied to analysis (i.e., in taking profiles.)

Dimensioning

The fundamentals are presented at this time. Proper technique in applying dimensions so that they may clearly be understood is emphasized. Such factors as function, processing, economy, as well as geometrical shape are introduced.

Working Drawings

The goal or prime purpose of the representational aspect of graphics might be considered as being the "working drawing." The connotation of the term is probably not an especially good one since it is apt to bring to the mind of most engineering teachers the mechanical engineering aspect of engineering application to other specific fields. Any drawing carrying complete instructional information which may be the culmination of design and which is to be used in the direction of construction, processing, manufacture, maintenance, etc. is considered to be a working drawing. This is the general approach to the treatment of this topic, which is an important part of the entire language of graphics.

Charts, Diagrams and Graphs

A graphical description is usually more comprehensive and impressive than simple tabulation, or even a written or verbal description. Such descriptions are useful in showing the values of variable quantities in terms of known quantiteis; to assist in studying technical or financial problems; conveying information to the public and serving the engineer as tools in his professional work. The student is taught, through the use of pie charts, bar charts, pictorial charts how to present technical data to the layman (such as stockholders). It is also demonstrated how such charts and diagrams are used by technical departments of industry in reporting to higher management.

In the plotting of graphs, special emphasis is placed on how a graph should be drawn, considering items such as proper placing and identifying of scales, titles, accuracy of data, etc. The various types of graph paper are discussed and the theory of their construction is explained. Then the graphical representation of empirical data is discussed along with methods of determining the best graph paper for presentation of these data. Finally methods are taught for determining the empirical equations for plots of empirical data, made on rectangular, semilogarithmic, and logarithmic grids.

Graphical Mathematics

To lay a foundation for graphical algebra and calculus the fundamentals of addition, subtraction, multiplication and division are taught. Then these techniques are applied to advanced algebraic problems. Through the graphical representation of these problems, one can provide a counterpart to the mathematics and thereby better visualize a problem under study.

Upon completion of these types of problems, graphical differential and integral calculus are studied. It is pointed out that mathematical and graphical calculus complement each other and that there is an appropriate time to use each. It is shown that graphical calculus is used when the mathematical equation representing the data is not readily available. Along with the purely graphical techniques are taught some of the semi-graphical methods such as Simpson's rule and the Trapezoidal rule.

Alignment Charts

Nomography, with alignment charts in particular, is playing an ever increasing role in engineering as in other fields. It is virtually impossible to pick up a design textbook or magazine without encountering them. Such charts are used wherever repetitive solving of a mathematical equation is performed. Alignment charts are now also found in many catalogs and advertising brochures. Engineers should have an understanding of the basic theory of chart construction, know where they should be used, and realize their limitations. In the course work, the student is given the basic knowledge which enables him to design and construct the simpler forms of charts.

Summary

The integrated outline combines engineering drawings, descriptive geometry, and graphical mathematics. Basically this should be a very sound approach to the study of the subject of graphics. Why it has not been adopted long before can only be explained in the light of the gradual change in emphasis on what kind of an engineer the colleges are trying to produce, which is toward one more professionally prepared and having fewer qualities of the technician. In an integrated course the student is given under one "roof" an appreciation of all the fundamental phases of graphics as one of the basic tools of the engineer.

100% SCHOOLS

At the last count, according to grapevine reports, twelve schools have the right to hang out 100% banners. This means that all regular members of the staff who teach engineering drawing, descriptive geometry, or graphics as their major fields have subscribed to the JOURNAL. It does not necessarily include part time members of the respective departments.

The schools that have reported to Professor E. M. Griswold that they are 100% subscribers are:

Clemson Agricultural Coll.	Univ. of Maine
Univ. of Colorado	New York Univ.
The Cooper Union	Notre Dame Univ.
Univ. of Detroit	Ohio State Univ.
Univ. of Illinois (Navy Pier)	Rice Institute
Iowa State Coll.	Syracuse Univ.

It seems impossible that there are only twelve schools who should rightly be included in this list. If your school should be listed among the others, please write to Professor Griswold and tell him so.

Of course, if you have to get a few new subscribers in order to qualify, by all means do.

APPOINTMENTS

Klaus E. Kroner has accepted an appointment as assistant professor of drawing at the University of Massachusetts. Professor Kroner has been on the staffs of the University of Maine and of New York University.

Eugene G. Paré has accepted an appointment as professor of mechanical engineering at Washington State College, Pullman, Washington. Professor Paré was formerly on the staff of Illinois Institute of Technology.

Herbert T. Jenkins has accepted the chairmanship of the Department of Engineering Drawing at the University of Michigan, at Ann Arbor. Professor Jenkins had been connected with Cornell University for about twenty-four years.

SUGGESTIONS, LETTERS, ETC.

Suggestions on how to make the JOURNAL more readable, more useful, and more informative are always sought for by the editor.

One such suggestion has been to include news items about members of the Division, especially such items as changes in affiliation.

The JOURNAL will insert notices of this kind whenever the information becomes available. The persons involved are urged to send the information to the editor as soon as it becomes official.

In addition, letters to the editor will be published if they are intended for this purpose and if they appear to be of general interest. Letters commenting on articles, whether in agreement or not, are especially desired.