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EDITORIAL

About four thousand and ninety-four years ago, one of the first big engineering projects was designed in which engineering drawings were used to plan and design the project. According to Davison, * the ruler of Sumeria had decided to build a space project which would enable the righteous to reach heaven. The project was the Tower Of Babel. As I recall the consequences, as described in the Bible, God punished the builders for their presumption, causing a confusion of tongues which in turn caused labor troubles, misunderstanding, and consequent failure of this first space effort.

It was at this time however, that the engineer first made an attempt to formulate a "language of the engineer". It was conceived that there should be a universal language for communicating ideas about the real world which should be unambiguous, simple and easily taught.

But it was not until eight hundred and ninety - four years later that a simplified engineering problem solving method was invented which established the principles of the "language of the engineer". A Frenchman, Gaspard Monge, in 1764 , discovered a method which he called "GEOMETRIE DESCRIPTIVE", thus becoming "the father of the engineering language".

He subsequently organized one of the first schools in the world as an engineering school, the Ecole Normale, later the Ecole Polytechnique. He planned the curriculum to include a strong core of mathematics, chemistry , physics, and the humanities, with descriptive geometry as a key subject marrying the theoretical scientific courses with the practical arts. This school had as some of its first teachers , Laplace and Lagrange for mathematics, Berthollet for chemistry, and Monge for descriptive geometry. One of the advisors, representing the E C P D of the day, was Lavoisier.

It is only necessary to read the preface to Monge's text to realize that although the principles of descriptive geometry are simple, he felt that application and use would give a new direction to national education. Booker ** has translated this preface which is reprinted as follows:

GASPARD MONGE (1746–1818) AND HIS EFFECT ON ENGINEERING DRAWING

"In order to raise the French nation from that position of dependence on foreign industry, in which it has continued to the present time, it is necessary in the first place to direct national education towards an acquaintance with matters which demand exactness, a study which hitherto has been totally neglected; and to accustom the hands of our artificers to the handling of tools of all kinds, which serve to give precision to workmanship and for estimating its different degrees of excellence. . . .

It is necessary in the second place to make popular a recognition of a number of natural phenomena indispensible for the progress of industry, and to exploit, through the advancement of the general instruction of the nation, the fortunate condition in which it finds itself of having at its command the principal resources which are necessary.

Finally, it is necessary to disseminate among our craftsmen the knowledge of the processes used in the crafts and in machines which have for their object either the diminution of manual labour or the imparting of more uniformity and precision to the results of workmanship; and in this respect it must be admitted that we have much to learn from foreign nations.

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EDITORIAL

All these objectives can only be reached by giving a new direction to national education. This is to be done in the first place by familiarising all young persons of intelligence with descriptive geometry. . . . This art has two principal objects.

The first is to represent with exactness upon drawings which have only two dimensions such objects as have three and which are susceptible of rigorous definition. From this point of view it is a language necessary to a man of genius, who conceives a project, to those who are obliged to direct its execution, and finally to the craftsmen who are to make the different parts.

The second object of descriptive geometry is to deduce from the exact description of bodies all which necessarily follows from their forms and respective positions. In this sense it is a means of investigating truth; it perpetually offers examples of passing from the known to the unknown; and since it is always applied to objects with the most elementary shapes, it is necessary to introduce it into the plan of national education . . . . and make use of this geometry for the representation and determination of the elements of machines by which man, controlling the forces of nature, reserves for himself, so to speak, no other labour in his work but that of his intelligence"

Two hundred years after Monge wrote this , and about four thousand years after the Tower Of Babel, Descriptive Geometry is taught to about 65,000 young persons every year in the engineering schools of the United States.

In the next year or so, the curricula of most of these engineering schools will again be reviewed to determine what courses are important to development of engineering talent. Professor Steve Coons, of MIT, recently wrote in the Journal about "The Future Course Of Engineering Graphics" . (See the MAY 1962 - JEG) He concludes that Engineering Graphics has as its most important functions, AID to CREATIVE THOUGHT, THE ELUCIDATION OF IDEAS, COMMUNICATION AND ANALYSIS.

As we scale down our space efforts from a gate to heaven, as conceived by the descendants of Noah, to a trip to the moon, or perhaps to Mars, we may still view descriptive geometry and drawing as the educational key to enginneering curriculum. Creative thought is, after all, the aim of all engineering and scientific endeavors and we should nurture it in our educational programs.

This is my last Editorializing in the Journal. With this issue, the privilege goes to the next editor. My three year stint has been a lively one and I hope you have been stimulated and challenged by my provocation of authors, letters and advertisers, There is still unfinished business,. Some of the Graphics Tantalizers must have been Tranquilizers as there were no responses.There are still some financial problems , but with the assistance of the W. C. Brown Publishing Company and all our loyal advertizers, we should be able to continue to publish a Journal which will serve to keep the Division as a vital part of the American Society For Engineering Education.

See you in Maine where our past Chairman of the Graphics Division will be host to the ANNUAL MEETING of the ASEE at the University of Maine.

Sincerely,

Mary Blade, Editor

* ** See paper read by P. J. BOOKER, Nov. 1, 1961 - to the Newcomen Society, Science Museum, London.

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REFLECTIONS ON SOME QUESTIONS RAISED BY ASEE GOALS OF ENGINEERING EDUCATION STUDY

by
Professor Steve M. Slaby, Chairman
Department of Graphics and Engineering Drawing
School of Engineering and Applied Science
Princeton University

The current Goals of Engineering Education study which is being conducted by the ASEE is one of the most comprehensive and probing studies ever attempted for the field of engineering. It is most important that all engineering educators take part in this study via the written and spoken word. This study is shaping up as a real dialogue on engineering education and its role in human affairs and providing that we all get personally involved in it, it should prove to have a most significant impact on how engineering education and engineering will develop in the present and the future.

I have attempted below, to answer a number of questions which were raised in Information Document #3 of the Goals of Engineering Education study. This document, including the introductory documents #1 and #2, are available from: Project Headquarters, Office of the Dean of Engineering, Engineering Administration Building, Purdue University, Lafayette, Indiana.

A. Present and Future Goals of Engineering Education.

1. What role will engineering graduates have in our society during the next ten to twenty years?

The engineer's role in our society during the next ten to twenty years is a role which the engineer should fulfill more than he has in the past, and that is, that he must take a more direct part in the way our society will develop. Up to now he has basically been an "employee" of small and large industries and government. He has not taken the lead in areas of economics and politics as well as areas concerned with sociology as they relate to the impact of technology on society. Traditionally he has been concerned with the design and manufacture of "things" which may or may not be beneficial to society and which are predominantly oriented toward profit rather than need. The engineer has been overly involved with the armaments business whose emphasis is on destruction rather than construction.

This larger role will only be fulfilled by engineers who are made aware, early in their education, that engineering, to be truly a profession dedicated to the benefit of mankind, must look above and beyond its concerns with machinery, computers, and "hardware" in general. An engineer must, right now, be aware of the social, economic, and political consequences of his products. If he does not shoulder his full responsibilities, which must be his in our modern society, then he is shirking his duty as a positively contributing member of our society. He, under these circumstances, could be considered to be someone who is taking from society rather than giving to it in terms of a sense of values.

Much must be done in the area of engineering for human need and use rather than engineering for profit. Our country is a prime example of the unfettered growth of engineering and technology, with the result of polluted water and air, jammed and congested traffic systems, rundown cities and communities, and a general pervading atmosphere of a boom-town country rather than a country which emanates the sense of purpose, culture, and a sense of values conducive to real human growth and development. This is most forcefully demonstrated and illustrated by the fact that we have among our people over 30 million living on the "edge of poverty" in a land of plenty - but not for all.

The engineering profession has direct responsibilities for solving the food shortage problem in the many areas of the world and it is integrated very closely with the responsibilities of modern agriculture since in this country it has been shown that a farmer with modern methods and machinery is able to produce phenomenal crops on a limited land area. The creative thought and imagination that went into the design of this machinery came from engineers.

The engineer also has another responsibility here which is related to his role as a constructive member of society, he must be not only concerned with agricultural problems of growing more and better food but he must also be concerned with the means of equitable distribution of this food throughout the country and for that matter throughout the world. This of course implies international economics and politics as well as local and national economics and politics and therefore further implies that the engineer must have an awareness of these problems which normally lie outside the field of technology but really are integrally related to it.

One vast challenge in the engineering profession is in assisting the under-developed nations of this world to help them to help themselves. In order to do this properly the engineer must be aware of the various cultures and traditions that he may be exposed to in his work with foreign countries. He must guard against attempting to transplant his "system" to another country. Rather he should attempt to provide assistance to under-developed countries in a manner which is commensurate with their traditions and cultural backgrounds. This is all important since too often the engineer and politician tend to forget that each nation has a sense of pride in its past and present as well as a sense of hope for the future within its own context.

In regard to the engineering profession's assistance or aid in space exploration and the development of military offensive and defensive space systems, it seems to me that the engineer has a definite professional responsibility for helping to determine policies in these areas. To remain merely an employee of the defense industry and government means that he is following "orders"blindly and we have seen, not too many years ago what that can result in, as was horribly demonstrated in Nazi Germany. The engineer's position in this case is one, where without question, he must be in a position to determine and influence policies at the governmental level, since due to his ingenious developments, war is now obsolete as a means of settling problems between nations.

The engineering profession must be involved in new or interdisciplinary fields such as biomedical engineering, nuclear engineering, etc. These are areas which require the "engineering approach" and therefore is just another place where the engineering profession can more fully fulfill its constructive role in human society.

2. <u>What are the needs of the engineering profession over the next ten to twenty years?</u>

A question is raised as to whether the educational program of engineering students today is adequate for enabling him to match technical work to the social, economic, and political needs of society? The answer to this question obviously is <u>no</u> since traditionally the engineering profession has not been vitally concerned with the social, economic, and political needs of society. How therefore can this deficiency be rectified? It is my feeling that we must start the education of the engineer in the field of sociology, economics, and politics, <u>before</u> he reaches the colleges or <u>universities</u>. It may be argued that our students are too young at this early stage to appreciate these areas and their relations to society. But we should be aware of the fact that many attitudes and prejudices are forged early in a person's life and therefore it would make sense to start teaching the person, in a basic and rudimentary way the facts of social, economic, and political needs and actions of society. By doing this we would expect a student, upon entering the college or university, to be fairly well versed in some of the jargon in these fields, some of the methodology of study in these fields, and also he would have been exposed to some of the basic readings and ideas in these fields. With this background his exposure to these areas, at the university level, could proceed at a more higher level and with a greater appreciation and impact. Presently many of our engineers take courses in economics, take courses in politics, and take courses in sociology but never relate one to the other and especially never relate them all to the role of engineering in all of society.

Engineering students and graduates represent a broad spectrum of talent, education, and occupational interest. Each interest and occupation requires special talents and highly specialized training while others require more broad experiences in education. The role of engineering education at many universities has been one where an attempt has been made to expose our students to a substantial number of courses in the social sciences and humanities. A reduction in the so-called engineering "art" courses has had to take place in order for this to be possible. In my opinion the idea, in principle has some merit, but its total validity and effect on the students' future thinking and work is doubtful. Students have come to the universities with pre-conceived notions in the area of politics and economics and sociology and therefore it is a little late to be starting this education in earnest,(since we all know that political "science" may be scientific in its study of politics but as yet to come up with an effective application of this science.) And also we all know how difficult it is to revise established habits of thoughts and action.

3. What changes, if any, must be undertaken in engineering education to continue to incorporate the rapid developments in scientific knowledge?

As a side remark, it is interesting to note that in the "Goals of Engineering Education", Document #3, one engineering educator was quoted as saying "To increase our rate of economic growth and to outstrip other countries we must develop a capability for converting the knowledge obtained by the scientist into devices and processes....". What is interesting about this statement is that it illustrates the narrow approach to engineering which is taken by "professionals". Should the purpose of any educational process be to "outstrip other countries"?? How does this fit into the context of engineering for the purpose of benefiting mankind? This illustrates very vividly many of the points I have made above.

The changes that must be undertaken in engineering education in order to continue to incorporate the vast developments in scientific knowledge are changes which basically will teach the student to think and to give him a broad base from which to grow and finally and most important a continuing desire for learning and self-education. This is a very general statement and how to go about accomplishing such a purpose is not easy to put into a "recipe" form. Perhaps the biggest change that could take place in engineering education is to attempt to show, through an interdisciplinary approach, what engineering really is and what main ingredients go into making an engineer. It goes without saying that we could detail various types of courses which supposedly would incorporate rapid developments in scientific knowledge. But if we did this we could end up with a limitless number of courses and curricula. Therefore it seems to me that the best way to incorporate rapid developments in scientific knowledge into engineering education is by teaching some of the very basic fundamental approaches to science, mathematics, and engineering in such a manner so that the student develops a sense of confidence in himself and an insight in the areas to which he is exposed so that the self-learning motivation is inbred into his thinking and work.

If we speak in terms of revolutionary changes in the concepts of the needs of engineering education we must then think in terms of the future but in doing so we should not neglect the past. For it is the past upon which the future is based and if we lose sight of this then it is difficult to foresee the true fulfillment of engineering education in world society.

The goals of engineering without question should be goals which will guarantee that the efforts of engineers will actually contribute to the benefit and welfare of mankind to the fullest extent that is humanly possible.

B. Organization of the Undergraduate Educational Program.

1. What are the relative advantages and disadvantages of retaining or changing the more common current subdivisions of engineering (Chemical, civil, electrical, mechanical, etc.) in undergraduate curricula?

We have admitted previously that our students have different degrees of talent and different interests. Yet there is an engineering unification in terms of the necessity for knowledge of nature through the study of physics, mathematics, and geometry, and the ability to manipulate and conceive of ideas in the three different modes which include the verbal, symbolic and graphical.

A common pre-engineering program leading to a baccalaureate degree is feasible and may be perhaps desirable providing that the pre-engineering studies at the college level include general areas of engineering such as conceptual design, and some specialized and illustrative engineering analysis. In other words, the student even in a general pre-engineering program, should have an opportunity to be exposed to the engineering approach since I think it would be a mistake for us to wait until he reached the graduate school level for him to actually be involved in engineering. Many great discoveries in the physical and mathematical sciences have been done by young men in their late teens or early twenties and there is no reason to believe why this cannot be true in engineering. If we postpone until quite late in a student's academic career his exposure to creative endeavor then it is quite possible that this type of educational arrangement could (and there is evidence that it has) seriously damaged early development and promotion of creativity in the student.

Since our students have different interests engineering education perhaps should follow two paths, one leading towards the concept of design and the other leading towards the concept of research-development. Both are equally important to society.

The distinction between research, development, and design, can be important depending upon the interest and abilities of the students. All three equally require a high degree of ability and achievement and all three are inter-related in the final product and all three should be made available to the student in a limited form throughout his entire college career so that through this experience in formal education he can determine his direction for his life.

2. In light of current and anticipated expectations regarding the performance of the engineering graduate, how long and how heavy a load should the normal academic program be for the first professional degree?

The first "professional" degree cannot be attained at the undergraduate level. About all that we can do at the undergraduate level under the present circumstances due to the rapidly expanding scientific knowledge, is to present him with material which will make him aware of and be able to manipulate reasonably well, mathematics and physics with a basic introduction to the engineering thinking processes especially the design process. In terms of lengths and loads of a program this is dependent upon the preparation a student receives prior to coming to the university.

The fact that the Russians are requiring a year of successful practice before awarding an engineering degree indicates a very realistic approach on their part because in awarding a degree under these circumstances the word professional can validly be attached to the degree a student receives.

3. What is the proper relationship between the engineering faculty and undergraduates, especially freshman and sophomore students?

   a. Are the engineering drawing-graphics courses an adequate introduction to engineering?

The traditional engineering drawing-graphics courses in today's environment cannot be considered a fully adequate introduction to engineering. On the other hand a properly designed engineering drawing-graphics course can serve to be one of the best introductions to engineering especially as the introduction to the conceptual design process. It is in this area that engineering graphics stands to serve best and fulfill most its function and role in engineering education. The teaching of draftsmen at the college level is of limited value to the professional engineer today. The engineer must approach engineering graphics from a point of view which places it at the same level as physics and mathematics. It is one of three ways of manipulating ideas and if it is kept in this context then its role as an introduction to engineering makes sense and is assured.

Certain courses in engineering problems do meet the needs of freshman as orientation for an engineering career. The character of the problems are most important in this case. The problems should be general and encompass many facets, at the freshman level, and should be primarily involved with conceptual design, since the student at this level is not well enough prepared to handle all detail and sophisticated analysis of large scale problems and it would be a mistake to permit him to do so, especially if the problems are watered down, since they would give him a false impression of how complicated problems really are solved.

The contact between faculty and students is a most important factor. Unfortunately in today's world the student's time is very limited as is the faculty's time. What to do? Perhaps each term should contain some free time where no assignments are given and where faculty can take a deep breath along with the students and just get together and "shoot the bull". This can be done on a formal basis but ideally should be done on an individual basis where students and faculty arrive at a real spirit of comradship in an academic atmosphere.

Under present conditions, with the tight schedules of both faculty and students, it is not possible very often for either to get together except occasionally in the faculty member's office. This office atmosphere is not necessarily the best one and it is my feeling that the best atmosphere can be developed in the student's dormitory, if a faculty member can visit them there, and in the faculty member's home, if the faculty member can get the students to come.

These contacts are most important since it is the faculty-student relationship on any campus which makes the campus a home for learning and teaching. The more that these contacts can be expanded informally and formally, the better the image of the engineering faculty vis-a-vis the students will become and this can have a long lasting positive impact on engineering in general.

4. What are the general facts regarding attrition?

The problem of enrollment and attrition and the attempt to develop a meaningful and powerful plan of study in engineering education cannot be resolved by juggling courses around within the various areas of engineering, for one source of our problem possibly is to be found in the market weakness of the "engineering industry" itself and in the disguised unemployment in the field. Students are not majoring in engineering perhaps because long term careers in engineering are not immediately promising for any but the exceptionally talented minority and for those who are willing to perform peripherial functions in the technological fields. The problem of attrition seem to be symptomatic of this structural weakness. It is not necessarily due to the curricula we offer except that in recent years it seems that most engineering curricula tend to offer more and more science and less and less exposure to some engineering experiences.

A solution to the problem of attrition in engineering education, cannot be found only in the content of curriculum changes and as long as there are indications that the "engineering industry" is in a state of relative stagnation, we will have a problem attracting students and of students transferring out of engineering. These considerations should be looked at carefully as a possible causal factor.

The teaching of courses at the freshman and sophomore years to motivate students for engineering and reduce attrition is a possibility.

For example it might be well to consider whether physics and mathematics and other similar subjects should be taught by the faculty of the engineering schools rather than by the physics and mathematics faculty. The record is clear that physics and mathematics must become a more meaningful experience to our freshmen and sophomores from an engineering point of view and as such it might be well for the students to be exposed to these subjects first by engineering faculty and then followed up by subsequent courses with instruction by regular physics and mathematics faculty. This is a possibility which needs study and exploration and is not something that can be resolved in a short time.
The area of motivation is not very well understood since no completely reliable device has been invented to measure or predict it. Likewise the concept of motivation is one which involves internal as well as external factors. In other words every student must possess some

"spark" of interest or self-motivation before he will fully respond to external motivational stimuli on the intellectual level. This means that if a student does not want to be motivated there is very little that can be done for him in the framework of intellectual stimuli designed to motivate. We could use Pavlov's approach but obviously his approach would not be a real intellectual stimulus.

Since we as faculty members are working in an area which at best, in the present state of the "art" of motivating students, involves many unknowns, we can without question say that no one person - or single group of persons - has the complete answer to this problem. On the other hand we, as engineering faculty, individually have all had experiences with students at various intellectual levels. Some of us have specialized at undergraduate levels, the freshman and sophomore, for example, while to others have fallen the work of dealing primarily with upperclassmen and graduate students. With this broad spectrum of experience available, it seems that it should be possible to evolve an approach for intellectual motivation of students (who want to be motivated) towards engineering which, though the approach might not be perfect, would still offer some base from which this evolution could develop in a systematic manner. It is hoped that the Goals of Engineering Education Study will shed some light on this problem of motivation and attrition.

In terms of the heavy academic load in engineering curricula, it seems that if a student is interested in what he is doing the degree of the load is secondary. Obviously the study load and work load must be considered but my feeling is that this is not necessarily the first order of business.

In terms of counseling systems for engineering students, my experience with freshmen and sophomores and also on the basis of personal discussion with fellow colleagues, indicates that there are some approaches, and expecially at the freshman year, which are possible to bring the freshmen into direct and meaningful contact with the engineering faculty as part of a program of "motivation". These approaches can be listed as follows:

1. Arrange the schedules of all engineering freshmen to have one afternoon free - preferably the same afternoon for the whole class if this is possible.

2. Leave the free afternoon for:

   a. Seminars conducted by engineering faculty from all departments.

   b. Projects related to a course or field of engineering.

   c. Lectures by engineering faculty on the application to engineering of physics and mathematics currently being studied by freshmen.

   d. Field trips to faculty research laboratories, industrial engineering departments, and engineering sites.

   e. Free time - "breathing space" - or thinking time for freshmen.

   f. Eliminate classes during midterm examination week. This would gain some time for the student where he would have a chance to collect his thoughts and be able to sit back and look critically at some of the course material to which he has been exposed.

In order for the above program (and it can be considered to be a program) to have meaning, direction, and continuity it is my feeling that it should be tied to a formal course in engineering at the freshman level. This course feasibly could be an elective course so it hopefully would attract students who have the ingredients of self-motivation and would eventually generate a curiosity in those students whose self-motivational "instincts" are weak.

The above scheme would permit time for the student to be involved in a variety of activities which would not always involve outside work. The above program would also permit a certain amount of free time to the student in order for him to be able to casually and informally keep in contact with his faculty in engineering. And further this program would enable the freshman engineering student to come into contact with faculty members in all departments of engineering.

Counselors in our high schools play a very important part in directing students to or from the engineering fields. The answer to the problem here is to coordinate the engineering schools activities of our colleges and universities more closely with the counselors of the high schools - in other words let us get together with these high schools counselors more often and let us keep them aware of what we are doing in engineering and also let professional engineers in industry keep these high school counselors informed as to what is going on. In this way perhaps we can educate the high school counselors and they in their way can educate us as to the problems that exist in guiding students at this level.

5. What are the factors that affect the motivation and values of engineering students?

My own feeling is that the motivation and values of engineering students are pretty well established before they reach the college level. This is a serious problem and as been pointed out earlier must be attacked early in the student's learning career. It must start at the grammar school where he must receive an education which whets his curiosity to learn and provides him with the tools of objective learning and thinking so that as he goes through high school and college he is in the position to judge with a great amount of credibility the experiences and knowledge to which he is being exposed.

We can talk about high quality performance demanded from our students and this in itself can be a critical factor, providing the students have the "guts" to stick with it. If they don't stick with it then they will depart from engineering. To encourage long life learning, this attitude again must be inbred into the student early in his life.

6. What changes in engineering accrediting procedures will strengthen and improve engineering education?

It seems to me that it would be most desirable to change accreditation from specific undergraduate curricula to the overall accreditation of the entire undergraduate program of each engineering college. Accreditation should be based on whether the individual colleges and schools of engineering are fulfilling the goals and programs they have set for themselves. And if the quality of the faculty and institutional facilities meet a general standard which can be established and revised accordingly by professional engineering societies and industrial institutions then we are in the position to have a more valid accreditation system. Likewise it should be possible to have accrediting teams comprised of industrial, government, and academic representatives so that a more balanced approach to accreditation can take place. If we continue the present accreditation process where academic people accredit each other, then we are in danger of first getting a misdirected orientation in engineering education and secondly a possibility of accrediting ingraining and stereotyping in the name of excellence and foresight.

Accreditation should consider all facets of an engineering program and should not neglect nor ignore instruction, nonresearch functions, and undergraduate work. To put undue stress on the research function and graduate work without relating it to the undergraduate program is a dangerous trend since the trend can lead, and in many cases is leading to, a situation where many engineering schools in reality are becoming glorified research laboratories very similar to those that exist throughout industry.

C. Subject Matter of Undergraduate Engineering Curricula.

1. What is, and what should be, the status of instruction in design in engineering?

It is often said that the main function of engineers is design. Design is invention and the sooner a student is put into a position where he can use his creative ingenuity, even at a very elementary level, he then is being exposed to an early stage of the engineering design process.

The creative process is not completely understood if it is understood at all. In the engineer's case, no one can say, including the engineer himself whether the inspiration for a new design or a new idea stems from a particular source. More than likely an inspiration occurs in persons who have been exposed to a variety of experiences in their academic and educational careers and intellectual experiences. Likewise these inspirations may stem from a variety of environmental factors during the student's pre-adolescent, adolescent, and early adult stages of life. From this, one can reason, that the creative design process can be facilitated and enhanced in a student by exposing him to as many ideas and ways of thinking about these ideas as it physically is possible during his days as a student from the grammar school through the college and university. This means, under these conditions, that education in design must start early and be continued throughout the career of the student.

It is very feasible and is currently being done in freshman engineering graphics courses at Princeton, to expose the student to engineering notions and engineering conceptual design. One basic aim of the engineering graphics courses at Princeton is to develop in the student the engineering attitude. It is believed that by exposing a student to a situation where he is confronted with the necessity of making judgments and decisions early in his academic career, that this will help him to develop his judgment and decision making capabilities as he proceeds through his academic programs. The student in the basic engineering graphics courses is placed into a position where he actually has to make real engineering judgments and decisions commensurate with his background. This means that the student becomes a partner in the solution of professional type problems after receiving instruction in the basic principles of engineering graphics and while he is currently studying basic physics and mathematics. In effect, the basic engineering graphics courses, under this philosophy can be considered to be first courses in engineering.

To accomplish the above purposes, time in the Princeton engineering graphics programs are devoted to a number of engineering design projects. The early stages of these design projects involve the application of some of the basic principles of descriptive geometry and graphics to the solution of relatively elementary engineering design problems.

Even these elementary design problems however force the student to make value judgments and design decisions.

The major design activity takes place at the end of the term where a total of two uninterrupted weeks are devoted to one conceptual design project. In order that the project have real meaning the students are divided into design teams with 3 men each and each team, according to the mutual interest of its members, select an area of engineering in which to work. Each team is introduced to a faculty member who is doing research in an area of interest to a particular team. The faculty researcher then discusses what research in his area means, what some of the problems are, how some of the problems in the past have been attacked and solved, how some of the problems have been attacked and not been solved, etc. In addition the faculty researcher takes his engineering freshman design team to his laboratory so its members can actually see the research apparatus and discuss various aspects of the system and components of the apparatus. The faculty researcher then presents an actual problem, based on his research project, to the design team to consider for their project. This may involve the redesign of an existing piece of apparatus which the researcher wants to change or improve or the researcher may say that he wants to perform a special experiment and will outline to the students what procedures this experiment entails and the sort of system which is necessary to make it possible to conduct the experiment. This is assigned as a design project to the team and must be completed within the two-week allotted time.

With the above background the freshman engineering design team is expected to develop ideas for their own conceptual design of whatever problem they choose to handle which is related to a particular faculty researcher's work. This project becomes the team's own <u>independent</u> conceptual engineering <u>design project</u> and is part of the required engineering graphics course work.

The design teams prepare a report which includes a written summary of their design activity as an engineering design project report including completed drawings and sketches of the design. Copies are made of the design project report, including the drawings, for each member of the student design team as well as for the faculty researcher who participated in this program.

The results of this program during the past two years have indicated positive response from most of the faculty researchers who have participated and an enthusiastic response from most of the students who have been involved in this activity. The program so far indicates that the experience gained by freshman engineers has been most valuable since it has placed each student in a situation where he has had to make engineering judgments and decisions and where he has been exposed to an actual engineering situation in an actual engineering experimental laboratory.

Indications are that this program has had a high motivational effect on students who had this opportunity to participate in a conceptual design project. The emphasis in the freshman engineering design project has been on "conceptual design" while detailed "analysis" has not been emphasized since time is unavailable for this as well as the fact that the background of the students is not at a level where they can cope with all the details of a complete engineering design. But it is made very clear to each student that what he has experienced in this program is an important first step in conceiving of an idea and representing and communicating it to himself as well as somebody else and that beyond this lays the detailed and equally important work of design analysis.

2. What is, and what should be, the status of computer education for the engineering profession?

It is my feeling that the students should be exposed to the concepts of digital and analogue computers and be familiar with some of their programming and operational techniques. To teach the student to become an expert programmer in my opinion is wasting time since this in many cases is being relegated to hired programmers and is taking on a connotation which is analogous to draftsmen. We want the student in graphics for example to be aware and be able to handle the larger aspects of this field while relegating the detailing and drafting aspects to a draftsman and eventually to a machine. Likewise in computer education the student should be exposed to the broad aspects of computers while leaving the minute tedious detail work to technicians.

3. What action must be taken in engineering education to correct the serious and long existing complaint that engineering graduates can neither write or speak effectively?

Teach them how to read and write their own language at the grammar and high schools. It is appalling that time must be spent at the university level in this country to teach to our students their own native language. The solution to the problem exists at the grammar school and high school levels. Bad reading habits and speaking habits and the inability to write effectively cannot be easily corrected at the university level. A good and proper job should and must be done before the students come to the university if effective results are to be expected.

4. What mathematical requirements are realistic for each type of engineering curriculum?

The teaching of mathematics should be done in such a way so as to give the student a basic insight to some of the philosophies of mathematics. This can be done prior to entering the university of college. Upon entering the university or college the nature of the mathematical programs for engineering should be such that the student is exposed to higher mathematical concepts and manipulations on the one hand while on the other hand he should be given the opportunity to apply, in a meaningful and correct way, these concepts to problems and projects which make him adept at using his mathematics in an engineering context. It is unfortunate that so many of our students learn the rules of manipulating mathematical techniques without having a real appreciation of their underlying philosophy. It is my opinion that because of this lack of appreciation of the underlying philosophy the student is hesitant to use his mathematics to the extent that he should and to the extent required in modern engineering.

As to a detailed mathematical curriculum, it seems that each area of engineering should receive as much mathematics as a program will permit and that perhaps as a matter of principle each program should expose a student to a course above and beyond what normally would be expected only to keep the student abreast of some of the most recent mathematical developments and to impress upon him the fact that mathematics is a constantly growing art and science. (This incidently should also be true for courses in physics and graphics).

We must guard against losing a very valuable resource in the engineering field and these are persons who are geometrically oriented in their approach to problem solution rather than symbolically or mathematically oriented. The use of mathematics in design analysis obviously cannot be questioned. Likewise the use of geometric or graphical manipulations of ideas during the conceptual aspects of the design process should not and cannot be neglected if we expect to take advantage of all varieties of student talent. Both areas are equally important and vital in this field we call engineering.

ARE YOU FRUSTRATED?

Each year the Vice-Chairman of the Engineering Graphics Division must set up Committees for the following year. The usual practice is to attempt to add new members and relieve those who have served long and faithfully. Only in this way can the committees be kept active and vigorous. However, no one man can possibly know all members of the Division, especially since not all of them are able to attend all meetings. Each year somebody questions the membership of the committees and wonders how one becomes a member. The answer is simple. Write the Chairman or Vice-Chairman and tell him of your desire to work for the Division and with which committee you'd like to work.

So if you're a frustrated member of this Division and would like to become active in its work - write now to the Vice-Chairman and express your desires. If at all possible, he will add your name to the committee's roster.

Vice Chairman
ROBERT H. HAMMOND
Department of Earth, Space and Graphic Sciences
United States Military Academy
West Point, New York

DESCRIPTIVE GEOMETRY

Some Reflections of the Past and Speculations for the Future

by
William B. Rogers
Associate Professor
United States Military Academy

Ever since that day, nearly 200 years ago, when young Gaspard Mongé's graphical solutions to certain engineering problems were rejected by the learned faculty of the military school at Mézières, descriptive geometry has been suspect. General recognition was slow because Mongé's work was of such significant value to the military engineers of the French Army that for about 30 years no publication was permitted. After military security restrictions were lifted, Mongé published a series of lecture notes, Leçons de Géométrie Descriptive, in 1795, and in 1800 he published the first text book explaining his graphical solutions. In 1816, descriptive geometry was imported into the United States by Claude Crozet then assistant professor of engineering at the United States Military Academy, West Point, New York. Descriptive geometry has remained in the USMA curriculum, in one guise or another, from that day to this. The disease quickly spread to civil(ian) engineering colleges and the technical community of the entire nation and most of the world was infected. Descriptive geometry can be highly contagious and a rare group of engineering faculty members, when subjected to prolonged exposure in the laboratory, are particularly susceptible. Undergraduates, on the other hand, under almost identical conditions of exposure have been found to be almost totally immune.

In 1821, Professor Crozet published the first edition of his Descriptive Geometry,[1] the first of many English language textbooks. Since that time, each generation of textbook authors has endeavored mightily, with some success, to simplify the Mongéan method and present descriptive geometry in a form both comprehensible and palatable to the undergraduate student. At the same time he has striven, and sometimes strained, to discover practical engineering applications for his favorite thesis. These simplifications and practical applications were deemed necessary to bring the subject matter within the grasp of the freshman student, and to convince the administration that here was something still alive and applicable to "today's engineering problems." (The widespread use of television gave the practical application school of descriptive geometry quite a boost. How did practical descriptive geometry ever exist without the guy wires supporting the television antennae?)

In spite of the considerable efforts

[1] Crozet, Claude, Descriptive Geometry, 1st ed. (New York: A. T. Goodrich Co., 1821).

of a small but dedicated group of followers of the mathematician of Mēzièrs, descriptive geometry has never won any popularity contests among undergraduates, alumni, or administrators. In the preface of his Descriptive Geometry[2] published in 1933, Professor F. H. Cherry describes the long prevailing situation as follows:

> "There is probably no subject in the curricula of colleges, at least of engineering colleges in the last twenty-five years, that has had a more unsatisfactory reputation among students than has descriptive geometry. When descriptive geometry is mentioned to the average graduate, he seems to have but little interest or knowledge of the subject and often expresses bitter memories of the course. The practicing engineer usually confesses complete inability to apply the principles of the subject to the solution of practical problems of every day life. This lack of understanding and appreciation of the subject has resulted, through pressure brought by students and alumni, in the reduction of the course from a two or three semester one to the present one semester, in a large majority of the schools and colleges in America."

Judging from comments written in the old fashioned schoolboy hand of long ago in the margins of the copies of Professor Albert E. Church's text[3] preserved in the rare book room of the USMA Library, the cadets of 1864 received the descriptive geometry of their day with comparable enthusiasm.

How then has this illegitimate relative of classical mathematics managed such amazing longevity? Did Mongē perpetrate and his latter day disciples blindly perpetuate a collosal fraud which became a sacred cow of the engineering curriculum surrounded by such an aura of incomprehensibleness that only a few hard headed realists dared attack it? In the past these detractors have been quickly shouted down by self-righteous slogans containing such phrases as, "the language of the engineering profession"; "an incomparable mental gymnastic"; "the great separator. . . a sure indicator of an engineering aptitude"; "develops spatial visualization"; "contributes to self-discipline"; and more. Perhaps it is because a powerful engineering drawing lobby has successfully insured descriptive geometry a place in the curriculum as a necessary transition piece relating the journeyman draftsman and the academic theorist. Whatever the reasons, it has survived for two hundred years. However, in recent times, the proponents of descriptive geometry have been conducting a strategic withdrawal. Administrators are becoming ever more difficult to convince. Is there enough of the disease culture left alive to reinfect and spread as a new strain for another 100 years, or has the present genus Administrator mutation achieved a state of total immunity to descriptive geometry? Will this generation witness the morte de gēomētrie descriptive?

Can descriptive geometry as it has been known for the past 50 years continue to serve the engineering profession as it presently exists? Probably

2 Cherry, F. H., Descriptive Geometry: An Introduction to Engineering Graphics, 1st ed. (New York: The Macmillan Co., 1933).

3 Church, Albert Ensign, Elements of Descriptive Geometry, (New York: A. S. Barnes & Co., 1864).

not. Historically, Monge was a mathematician. His graphical solutions were expedients, used because the techniques of classical mathematics were denied him. Since precise graphical solutions require a facility with the drawing instrument, this method gradually became the almost exclusive province of the draftsman. Quoting from the preface of another descriptive geometry text,[4] also published in 1933, Professor W. H. Roever states,

> "The subject of Descriptive Geometry may be properly regarded as belonging to the mathematical disciplines. Notwithstanding this fact it has been almost entirely ignored, or regarded as trivial, by many, if not by most, mathematicians in America. It is partly for this reason that its instruction has been left to drawing teachers, who have, in general, but slight interest in the mathematical aspects of the subject. Furthermore, the subject was developed for technical needs, and it is thus natural that it is taught almost exclusively in technical schools. In general the authors of the textbooks in this country are not mathematicians and they make their appeal primarily to the draughtsman."

For descriptive geometry to be restored to a reputable place in the engineering curriculum, and there is no reason to restrict its usefulness to engineering, it must first of all reclaim a respectable relationship with classical mathematics. The bar sinister — the T-square — must be erased from the family escutcheon.

Use the propositions of descriptive geometry for the development of logic in the abstract. Be not over zealous in seeking and pointing up the practical application. If the principles are thoroughly understood and the problems imaginative and without directed solutions, and if enough time is spent to develop and relate the entire mathematical picture, the applications will follow naturally without being forced. Both the mathematician and the dogmatic drafting board practitioner must come out from behind their respective, and previously impregnable, barricades of "pure" numbers and dazzling delineations and meet on open ground. The rapid advances being made in an area of mutual interest, computer oriented design, is already forcing this confrontation and it is proving a beneficial and revealing experience to both the "far out" mathematician and the "practical" draftsman. A merger appears inevitable.

What can such a union, or more properly reunion, produce? It should result in an engineering curriculum presenting an integrated program of the theoretical and practical aspects of both analytical and descriptive mathematics In time, such a curriculum can equip the young engineer to make an intelligent estimate of the whole situation and to apply the total arsenal of available knowledge to the solution of a problem rather than being forced to attack by trying and dulling each tool in turn before finding one that might work.

Descriptive geometry is still alive, but it has been severely wounded and can be beaten to death —— with a T-square!

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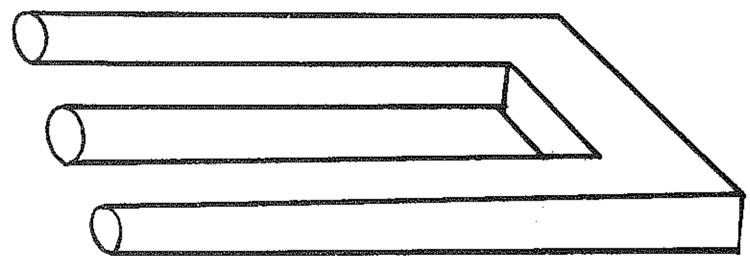
4 Roever, William Henry, The Mongéan Method of Descriptive Geometry, (according to the procedure of Gino Loria, Professor of Mathematics, University of Genoa), 1st ed. (New York: The Macmillan Co., 1933).

YOU FIGURE THIS OUT!

Melvin L. Betterley
Prof. Of Head Of Engineering Drawing
State University Of Iowa, Iowa



Obviously the drawing is the design sketch of a transformer core. This was done for a chief engineer friend of mine in industry by a young electrical engineer on his first assignment after having received honors when graduating from a university in which electrical engineering degrees are granted to those completing a "modern" curriculum unencumbered by an old-fashioned course called engineering drawing. Because of "hysterioresis" and other factors, the chief engineer suggested some changes in the design and requested a sketch of the mating part.

After having spent the better part of three months attempting to design the mating part, the young engineer was "encouraged" to accept foundation or government grants so as to pursue an M.S. degree or to accept a better position in the Federal government.

Factitious as the above may appear there is a growing concern in my mind for the fact that industry finds it next to impossible to hire top grade B.S. graduates because of the many foundation and government grants for advanced study. I am not against advanced study per se, but I believe that it must be tempered with some experience in industry in order that the Ph.D. who eventually is interested in industry finds that industry is still interested in him. I am concerned that this is liable not to be the case when the "over-educated", "under experienced" doctorate informs industry of his unrealistic ideas as to his salary, size of office suite, location of same, country club connections, relationship to the productive members of the company, etc.

A second item of concern is the assumption on the part of engineering educators generally that all engineering students are interested only in research--hence in a completely educational orientation continuing until the completion of the Ph.D. The facts of the matter are that industry is interested only in a small percentage of the top graduates as research and development material. They are interested in those with "big ideas"--the fly in the ointment being that the big ideas usually concern security, fringe benefits, plush, etc. On the other hand industry is interested in those who can deal realistically with hardware and help earn an honest buck for the company.

This tendency toward education and research (stimulated by many grants) has penetrated the thinking not only of engineering educators but of all educators of the sciences. At a recent high school symposium on "Science, Engineering, and the Humanities" conducted at the University of Iowa (sponsored by the United States Army), many speakers looked down over their noses, regaled the Ph.D. and told these talented high school people that they were nothing until they had gotten the doctorate, that they could expect much help from foundation grants, and that upon completion of a continuous education they would be welcomed into the universities, government agencies, and industry at salaries in excess of $10,000 per annum. I have a feeling that many were discouraged from continuing in their chosen field because of the long educational road ahead be it engineering or botany.

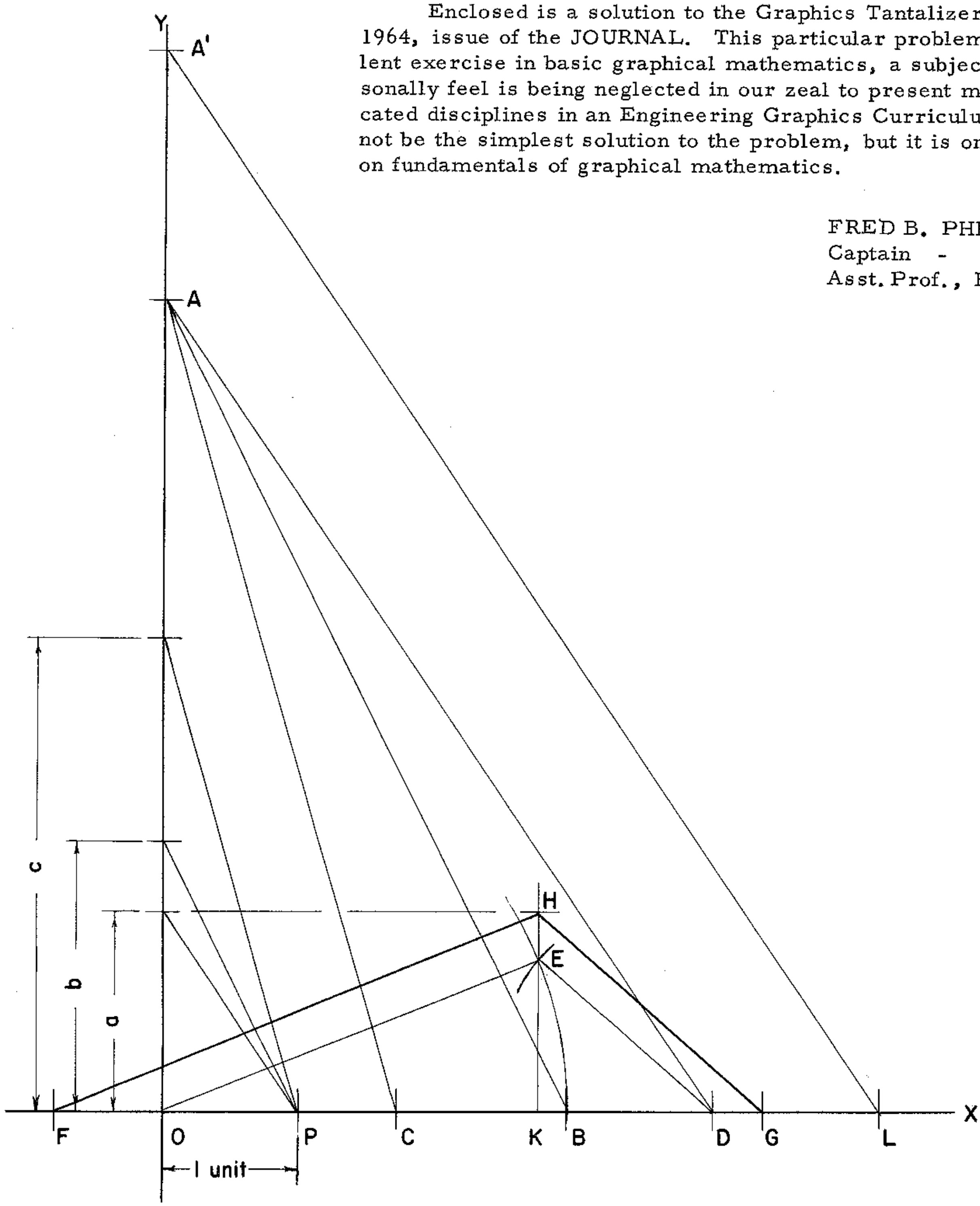
In conclusion, we must assume that it is the duty of all engineering educators, regardless of the branch of engineering or the degree of sophistication, to rub elbows now and then with the people from industry who desire a product--the engineering graduate on the baccalaureate level as well as the scientist now and then. Thus all engineering graduates would likely receive a basic foundation in time-tested engineering--upon which practice and graduate study would build toward the future.

SOLUTIONS TO THE GRAPHICS TANTALIZER

Dear Professor Blade:

Enclosed is a solution to the Graphics Tantalizer in the Spring, 1964, issue of the JOURNAL. This particular problem is an excellent exercise in basic graphical mathematics, a subject which I personally feel is being neglected in our zeal to present more sophisticated disciplines in an Engineering Graphics Curriculum. This may not be the simplest solution to the problem, but it is one that is based on fundamentals of graphical mathematics.

FRED B. PHILLIPS
Captain - USAF
Asst. Prof., Engr. Fund.



SOLUTIONS TO THE GRAPHICS TANTALIZER

GIVEN:

The altitudes a, b, and c of a triangle.

REQUIRED:

Construct the triangle.

Step I. Lay off a, b, and c along the Y axis.

Step II. Select point P a convenient distance from "O" along X axis. Let OP = 1 unit.

Step III. Select point A on Y axis. (A is really an assumed area of the triangle multiplied by 2.)

Step IV. Graphically divide A by a, b, and c to obtain OD, OC, and OB.
$\therefore$ a(OD) = b(OB) = c(OC) = A

Step V. Construct triangle ODE so that OE = OB and ED = OC. This triangle is similar to the desired triangle.

Step VI. Extend altitude KE to H so that KH = a.

Step VII. Construct FH // OE and HG // ED forming triangle FGH.

FGH is the desired triangle with area = $(\frac{1}{2})$ A'.

Mary:

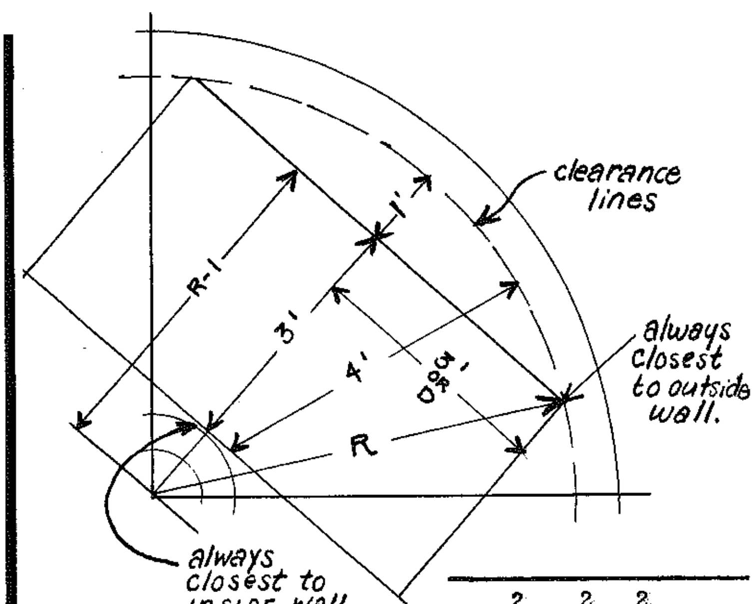
I'm either very stupid or this is a simple problem! Tell me which? The minimum radius will occur when both pairs of wheels are free to swivel and they swivel equally. The solution is shown smaller than the published answer but mathematically quite direct.

If only the front wheels are free to swivel and if the cart is on rails then the front wheels must also be able, with the axle, to swing off center. We will discard this as unlikely.

If, as the word <u>cart</u> implies, there is only one pair of wheels <u>then</u> if the axle is under the center of the cart the answer is the same as shown. If there is only one pair of wheels <u>not</u> under the center and non-swivelling but <u>slightly</u> back of center as is true of most <u>carts</u>, then if d is the distance of the axle from the front of the cart the formula for R as shown in the figure becomes

$$(R-1)^2 + d^2 = R^2 \quad \text{or} \quad R = \frac{1+d^2}{2}$$

Prof. John T. Rule,
Mass. Inst. Of Tech.



$$(R-1)^2 + 3^2 = R^2$$

$$R^2 - 2R + 1 + 9 = R^2$$

$$R = 5 \text{ ft.}$$

R to outer wall $5\frac{1}{2}$ ft.

R to inner wall $\frac{1}{2}$ ft.

R to ℄ 3 ft.

"ABOUT SCALES"

Sandor T. Halasz
Lecturer, Graphics And Architecture
City College Of New York, N. Y.

Graphical calculations* have become an established part of the graphics curriculum during the last few years and in this sense they represent something new, although the topic itself has a rather old history, as engineering topics go. This revival in the interest in graphical calculations came fairly suddenly (cf. the dates of publication of the more representative books in the field) and there was no evaluation of the foundations of a discipline that was at the peak of its popularity at the turn of the century: We teach it and apply it, by and large, in the manner in which it was handed down to us.

This situation has several implications. First, the very language of graphical calculations was geared to a generation whose thinking was much more geometric than ours. This change in outlook poses difficulties that would not be easily understood by the originators of graphical calculations. Secondly, at the time of their first development graphical calculations had no competition as the most effective aids to certain, usually repetitive, computations. This has changed, even if the time has yet to come when every engineer or scientist will have unlimited access to an electronic computer.

This writing is devoted to a question which has received limited attention as it was taken for granted. It concerns the nature of scales and the concept of the scale modulus.

As usually defined the scale modulus is a numerical factor enabling the chart-maker to give his scales any length he desires: "Modulus (m) is simply a constant introduced into the equation to control the length of scale required..." (6) and "the length m inches is chosen arbitrarily to represent the unit segment used in laying off the values f(u), and it is called the scale modulus." (3)

I have no quarrel with these definitions. Indeed, the purpose of the scale modulus is just what the definitions say, and it was originally introduced to this end. Conversely, it is possible to treat nomography, say, without even mentioning the scale modulus.

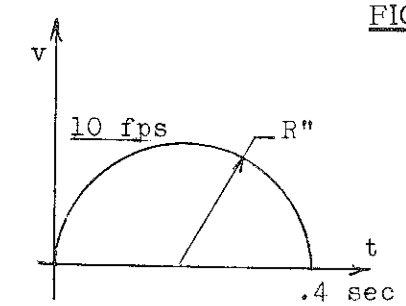
But let us pause for a moment and reflect on how it is possible to represent birthrates, or tons of a commodity, or velocity, or time, or, more recently, even emotions, along a scale? The fact that we are familiar with charts, is of little help. What is it that we really lay off along a scale if the quantity in question is something other than length. Well, we lay off distances that are related to the quantities they represent. Related, but how?

The following two examples will show that these reflections are more than mere academic subtleties.

1. What is the slope of a curve representing a function in a Cartesian coordinate system at any given point? Every introductory text in analytic geometry states that the slope is the numerical value of the derivative of the equation of the curve at the point in question. But it is obvious that the scales of the axes have something to do with it too, at least if the word slope is to be taken literally. Correspondingly, some texts assert that the "same scale" must be used on axes. But what is the slope if the scales are not "the same"? Furthermore, what does "same scale" mean when the abscissa measures time for example and the ordinate displacement?

2. As a routine graphical calculus problem I once assigned a velocity-time curve (Fig. 1) in form of a semi-circle.** The students were to construct the displacement and acceleration curves and to submit analytic solutions as well for checking and comparison. It was during this latter phase that spooky things began to happen. The students had difficulties in developing the velocity-time function albeit they knew the equation of a circle, or perhaps because they knew it. Also, the seemingly innocent question of the area of the circle turned out to have pitfalls of its own. In short, the circle was not really a circle, after all.

FIGURE 1



* Surprisingly, there is no generic name for all the topics usually lumped together as graphical calculations. I would be inclined to propose "graphocal."

Mathematicians will point out that the slope of a curve, as they define it, does not necessarily have to do with the actual angle a tangent makes with the x axis and that it is naive to think that a curve that happens to appear as a circle in a particular coordinate system will exhibit all the properties of a circle, as normally understood.

We agree. But the very fact that such questions arise points to a void in the previous education of those who ask them. This void, I argue, exists because the nature of scales has never been questioned in this light.

The difficulty can be eliminated in a number of ways. The one proposed here is as simple as any and probably simpler than most; it consists of a reinterpretation of the nature of scales and the scale modulus.

a. Only lengths can be represented along scales directly. Pure numbers as well as variables having dimensions other than length must be converted into distances; this conversion is accomplished by means of the scale modulus.

b. The scale modulus is a means by which it is possible to graphically represent numbers. It is always present wherever numbers are graphed, whether or not explicitely stated.

c. The scale modulus is not a dimensionless number, nor has it any fixed dimension; its dimension is always such that the dependent variable in the scale equation

$$X = m_x f(x)$$

is given in inches. For example, if the dimension of $f(x)$ is hours, say, or kilowatts, the dimension of $\underline{m}$ is inch/hour or inch/ kilowatt respectively. It follows that manipulations on scale moduli, such as occur in nomography or in case of the graphical calculus, are fully amenable to dimensional checks.

d. Scales may be interpreted as measuring various quantities, but in reality they only measure lengths. In this sense one may speak of X as the "true" variable represented along the scale.

** The original was slightly different because in this form the problem has no physical meaning (infinite accelerations).

Let us see now how these propositions help solving the two sample problems.

1. (Fig. 2) The scales show the "true" variables X and Y.

$$\tan \phi = \frac{\Delta Y}{\Delta X} = \frac{m_y \Delta y}{m_x \Delta x} \rightarrow \frac{m_y}{m_x} y' \quad \text{as } \Delta x \rightarrow 0$$

The slope depends on the derivative as well as the ratio of the scale moduli. "Equal scales" means that the two moduli are numerically (but not necessarily dimensionally) equal.

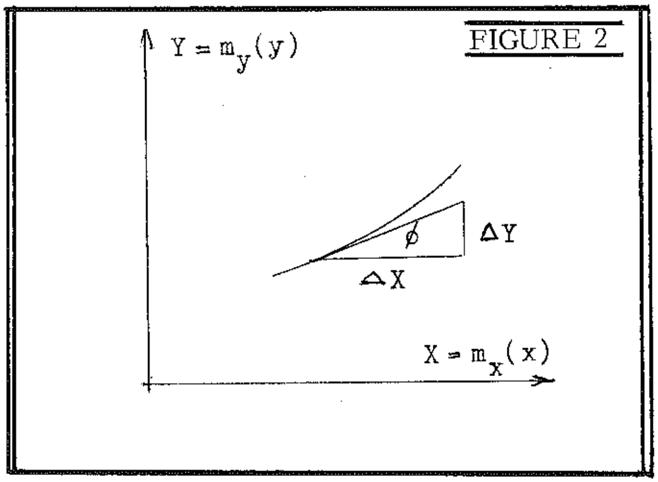


FIGURE 2

2. (Fig. 3) The equation of a circle applies to the variables X and Y:

$$(X - R)^2 + Y^2 = R^2 \qquad \text{(inches)}$$

Substituting $X = m_t(t)$ and $Y = m_v(v)$ and transformation yields

$$\frac{(t - R/m_t)^2}{(R/m_t)^2} + \frac{v^2}{(R/m_v)^2} = \frac{(t - t_o)^2}{t_o^2} + \frac{v^2}{v_o^2} = 1,$$

the equation of an ellipse and the correct relation between $\underline{v}$ and $\underline{t}$. All expressions are dimensionally homogeneous and consistent.

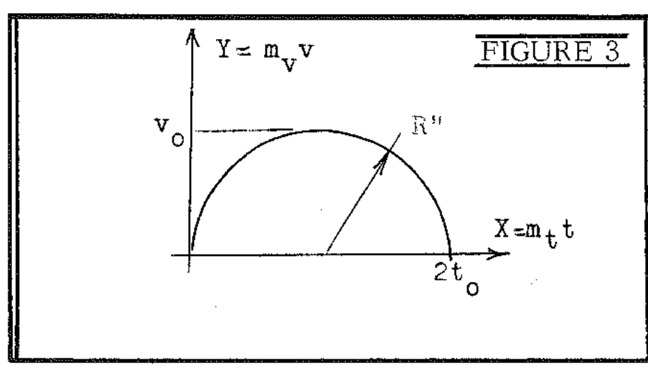


FIGURE 3

All those who have applied the graphical calculus know that the determination of the scale on the ordinate of the derived function is of major importance. How is that done? Lipka, e.g., shows a deductive procedure that must be applied in every single case, without arriving at a general formula. (3) Most other authors do likewise. Vierck (6), on the other hand, gives a formula based on the principles developed here, without spelling out the principle itself.

The gist of the matter may now be summarized as follows: Every scale (even a yardstick) is a "functional" scale; it is the graphic representation of a mathematical function. The scale equation is a transformation of the mathematical function into a "geometric function" of the general form

$$X_u = m_u f(u)$$

where X_u is a length measure of any change in the argument $f(u)$; the scale modulus is a conversion factor that makes the transformation conceptually feasible and practically convenient.

It is not proposed, of course, that in the future all scales be treated in this manner, or that coordinate axes be labeled as Figures 2 and 3 suggest. All we propose is a way of looking at scales that will help remove some difficulties now attached to graphical calculations and thus, we hope, will bring them one step closer to the position they justly deserve among the tools of science and engineering.

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1. Kraitchik, M., Alignment Charts, Van Nostrand, 1944
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3. Lipka, J., Graphical and Mechanical Computation, Wiley, 1918
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5. Newski, B. A., Praktikum der Nomogrammkonstruktionen, Translation, Akademie-Verlag, Berlin, 1955

The following are graphics texts containing good elementary treatment of some phases of graphical calculations:

6. French and Vierck, Graphic Science, McGraw-Hill, 1963
7. Hoelscher and Springer, Engineering Drawing and Geometry, Wiley, 1961
8. Luzzader, Basic Graphics, Prentice Hall, 1962
9. Pare, Francis, Kimbrell, Engineering Design, Holt, Rinehart, and Winston, 1963

PRINCETON UNIVERSITY
SCHOOL OF ENGINEERING AND APPLIED SCIENCE
PRINCETON, NEW JERSEY

April 10, 1964.

Dear Colleague:

The Department of Graphics and Engineering Drawing of the School of Engineering and Applied Science of Princeton University is sponsoring an Engineering Graphics Seminar entitled: "GRAPHICS TAKES A BRIDE".

The theme of this seminar shows how well graphical processes lend themselves to computer representation and how efficient modern computer graphical output is, compared to conventional methods.

Professor Douglas P. Adams of the Department of Mechanical Engineering of the Massachusetts Institute of Technology will conduct this seminar.

We invite all interested persons from your organization to participate in this seminar and look forward to seeing you at Princeton.

The seminar will take place on Thursday, April 23rd at 4:30 P.M. in Room C-207 of the Engineering Quadrangle on the Princeton Campus.

Sincerely yours,

Steve M. Slaby, Chairman
Department of Graphics and
Engineering Drawing.

SMS:sf
Enclosure.

NOTE:
For copies of this paper send to:

"ENGINEERING EDUCATION & ENGINEERING GRAPHICS"

Irwin Wladaver
Assoc. Prof. Of Engineering Graphics
New York University, N. Y.

Why is it that disagreement on fundamental principles of their profession can exist among reasonable men? How is it that certain sincere professors of engineering can say that this or that discipline is absolutely basic and essential to the education of young engineers, yet other equally sincere and experienced professors can brush off the entire discipline with such expressions as "inconsequential," "not pertinent to engineering education," and a host of other diminishing phrases.

I'm not talking about engineering graphics alone. I'm talking about the study of foreign languages, the history of Western civilization, philosophy, music, any other subject usually included in the liberal arts. I'm talking, too, of engineering graphics, vector rather than scalar mechanics, and perhaps less controversial engineering design courses.

Have you every asked a bewildered freshman, "Why do you want to be an engineer?" Or worse yet: "What is engineering? What does an engineer do for a living?" Of course you have asked such questions many times and by now you know just what to expect. "A chemical engineer? Well, he designs chemical plants." "An aeronautical (or astronautical) engineer? Well, he designs airplanes." "A civil engineer? He builds bridges with a hardhat and a blueprint under his arm." "An electrical engineer? Well, he guides missiles." And you know that if you press another question or two on your victim, the result is only chaos and confusion.

No wonder that a freshman or, for that matter, a senior cannot say what engineering is when his teachers are themselves not fully convinced. I go further: I claim that his teachers are not in agreement on what engineering is, nor on what engineering will be when our present freshmen are seniors, nor on what engineering education should consist of right now or five years from now. One step more: I claim that many engineering teachers believe that the study of any subject outside of the immediate, vocational spectrum of engineering technology is useless, if not positively harmful. I can't submit proof of that last statement, but we have all heard strong assertions of such feelings by our colleagues. The other claims, however, can be supported by daily evidence in faculty meetings and in informal campus conversations.

I do not take the stand that we must have monolithic agreement on definitions and procedures in all colleges of engineering all over the country. This would not be possible nor would it be intellectually healthy. Then what do I want? What courses of action are open?

I think the time has come for every engineering faculty to say what in its opinion engineering is. Not what it will be twenty-five years from now, but what it will be four years from now when some fifty per cent of these freshmen will be graduated. Of course we make assumptions. And what is more, we state these assumptions openly and clearly. The excuse that engineering is many things is only an excuse for inaction and I'd rule it out of order. The idea that we can teach anybody everything he will need even in his first job is patent nonsense.

As I said, we state our assumptions openly and clearly in faculty meetings called for this purpose: to guide our curriculum makers. Will the faculty meetings be boring and tiresome? I need not dwell on that! Will they be productive? Yes, I think so. If every faculty member assumes that his colleagues are as sincere and as well informed as he is himself - maybe in different areas - there is a reasonable chance that a good curriculum will come out of the colloquium.

To what end must this talk be addressed? I think we must define engineering in terms of the activities every practicing engineer is likely to engage in. The old time definition that "engineers use men, money and materials to convert the forces and resources of nature into forms more useable to man" is useless for this purpose. Henry T. Heald, President of the Ford Foundation says it a little better: "Engineering is an art of synthesis, of consolidating the gains of scientific research, and of fashioning knowledge into systems and designs that are most effective, feasible, and economic." If Dr. Heald is right and engineering is an art of synthesis, then the art of engineering should be applied to the design of an effective system of engineering education.

It should be clear that every engineer is likely to need some control of the engineering sciences. Every engineer is likely to have to write occasionally, to speak and to persuade occasionally. He should learn how to keep up to date with developments in his field. He should learn in school that the hope for profit is a basic force that underlies almost everything he will have to do. He should learn that his activity in technology has social repercussions. He should learn that action without philosophy is likely to be animal behavior. You make up your own list.

And so I think that agreement must be found on what few things we can do in college to help our students toward an education. If there is no longer any place for machine shop and foundry practice in engineering education, the case for their deletion should be made out openly. If engineering graphics - you define it any way you wish - does not belong in the curriculum, then say why not. It's for us in the Division to make the competing case. Even with our prejudices aside, we know the truth.

Of course there is change everywhere about us. "All this suggests alertness," says Dr. Heald, "to the need and the means of change. Of all the institutions, a university should have the foresight to anticipate the dictates of change, to make its choices before pressures and temptations become irrestible, and to choose wisely among the kaleidescope of choices facing higher education."

It seems to me increasingly impossible to put into an undergraduate curriculum enough vocational material to enable a young student to take an engineering job and perform profitably for his employer. He always needs a period of intensive training or graduate study. Why, then, do we continue to fragment the curriculum into engineering branches and stuff it with engineering sciences? Why do we continue to decrease and to neglect the involvement of our students in the art of engineering? And how can we look with disdain on disciplines that might help a man to a life, rather than on those that help only to make a living?

There is another aspect of engineering education that is currently accorded less emphasis than it deserves. In past years when undergraduate engineering education was more general - two years of a common curriculum was the normal thing - many graduates did not go into engineering at all. Twenty-five per cent, I guess, went into businesses of all kinds other than engineering and found their college training entirely suitable for their work. Nowadays early specialization makes such eventualities more and more unlikely.

I think that a forthright proclamation of our definition of engineering, followed by our assumptions of what a good undergraduate engineering education is and the part we can contribute to it, is a moral essential. I believe such an exposition would immeasurably increase the mutual confidence and cooperation of the faculty and the administrative staff. The improved morale of the more conservative faculty would be reflected to the students, for mutual understanding is a great peace maker and pace maker.

If we know what we want, if we can say clearly what our intentions are so that everyone will know them, we will have a reasonably good chance of reaching our announced destination.

Final Program

Engineering Graphics Conferences
Annual Meeting of ASEE, University of Maine
June 21 - 26, 1964

Sunday, June 21, 6:00 P.M.
Executive Committee Dinner and Business Meeting (closed)
Presiding: B. L. Wellman, Worcester Polytechnic Institute

Tuesday, June 23, 8:00 A.M. to 9:50 A.M.
Joint Conference - Engineering Graphics and Mathematics

Theme: The Mutual Interests of Graphics and Mathematics

Presiding: D. P. Adams, Mass. Inst. of Technology
Speakers:
1. Suggested Graphical Mathematics Topics for Engineering Graphics Courses
   C. J. Baer, University of Kansas
2. Geometrical Overlaps
   Howard Eves, University of Maine

Tuesday, June 23, 1:00 P.M. to 1:50 P.M.
Business Meeting of the Division
Presiding: B. L. Wellman, Worcester Polytechnic Institute

Tuesday, June 23, 2:00 P.M. to 3:50 P.M.

Theme: A Study of Graphics Course Content

Presiding: C. P. Buck, Syracuse University
Speaker: A Study of Engineering Graphics
E. C. Schamehorn, West Virginia Institute of Technology
Panel Moderator: P. H. Hill, Tufts University
1. For Mechanical Engineering
   W. H. Weaver, University of Massachusetts
2. For Civil Engineering,
   R. C. Brinker, New Mexico State University
3. For Electrical Engineering,
   P. M. Seal, Norwich University
4. For Chemical Engineering,
   J. D. Lindsay, Texas A. & M. University

Wednesday, June 24, 2:00 P.M. to 3:50 P.M.

Theme: Televised Graphics Instruction

Presiding: R. A. Campbell, Pennsylvania State University
Speakers: 1. TV or Not TV, That is the Question
C. G. Sanders, Iowa State University
2. Television at Rensselaer
H. G. Kinner, Rensselaer Poly. Institute
3. Designing and Operating a Low Cost Closed-circuit TV System
W. A. Wockenfuss, University of Maryland

Wednesday, June 24, 6:00 P.M.
Annual Engineering Graphics Dinner

Presiding: B. L. Wellman, Worcester Polytechnic Institute

Speaker: Some Responsibilities of Engineers
Eric A. Walker, Pennsylvania State University

Presentation of Awards:
1. Nomography Award
Presentation by J. H. Sarver
University of Cincinnati
2. Descriptive Geometry Award
Presentation by I. L. Hill
Illinois Institute of Technology
3. Distinguished Service Award
Presented by Irwin Wladaver
New York University

Thursday, June 25, 8:00 A.M. to 9:50 A.M.

Theme: Teaching Techniques in Graphics

Presiding: C. W. Chance, University of Texas
Speakers: 1. Research in Engineering Graphics
J. A. Earle, Texas A. & M. University
2. Teaching Sketching by Programmed Learning Methods
C. R. Bissey, University of Massachusetts
3. Preparation of Projectuals for Teaching Graphics
L. O. Johnson, New York University

Dear Professor Blade:

Thank you for the publication of my paper on descriptive geometry of four dimensions.

I have some comments to make about its contents which, I suppose, are also the object of questions from your readers. I by-pass the corrections of my obvious errors in English composition for they are many. However, that was the best I could do after three years of acquaintence with the language.

The page numbers in the items that follow are in reference to the Fall 1963 issue of the Journal where my article appears.

Page 45 - In enumerating some of the consequences of the postulates, I used the word "existence" refering to the four-dimensional space and etc., I wish to clarify that the reference is to the <u>geometric possibility</u> and not to the <u>physical possibility</u>.

Page 46 - The "Conclusions" related to the system of reference are demonstrated in an "Appendix I" to this article, submitted to you for publication.

The method or fundamental artifice used to obtain a plane representation of the projected figure on the system of reference is also shown in the "Appendix I". This artifice is not clearly explained in the article.

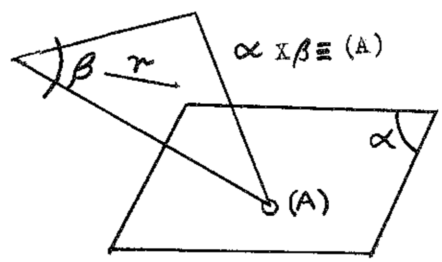
The following was stated: "all the projections made are from a point of the infinity in a perpendicular direction to the space." I want to say that there is much to be analysed to verify this. Most important: the concept of "infinity" which should be established in a four-dimensional projective geometry, unfortunately non-existing at this time. For the time being, the concepts introduced by Dr. Henry P. Manning in his "Geometry of Four Dimensions" are helpful.

By "real distance" I meant "true distance". This was a lapse in the translation from my originals in Portuguese.

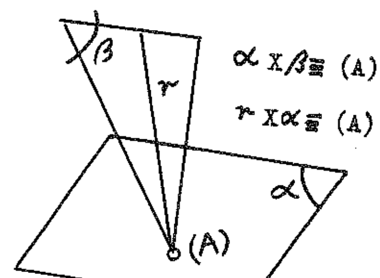
I say that "the question of considering the regions of the space of four dimensions, situated between the spaces of projection, can be considered immaterial." I am not so sure about this. It all depends. However, as far as geometric properties of geometric forms are concerned, indeed the question is immaterial. This is the way I want the statement to be interpreted.

Page 47 - The observations about the point that has two coinciding projections are incomplete. Further analysis is due to include the study of the point with three coinciding projections.

Page 53 - "Problem: demonstrate that a line and a plane that do not belong to the same space do not have a point in common." The demonstration is not satisfactory. It should be modified to say that the plane β of the given line r determines with the given plane α a point (A). The line <u>r</u> does not <u>necessarily</u> belong to (A). However, it could, and this possibility was not covered in the given demonstration.



CASE 1



CASE 2

Sincerely Yours,
<u>C. Ernesto S. Lindgren</u>

P.S. Please note that <u>case 2</u> is the one that contradicts the hypothesis of the problem, for <u>r</u> and α determine a space to which they both belong.

Dear Professor Blade:

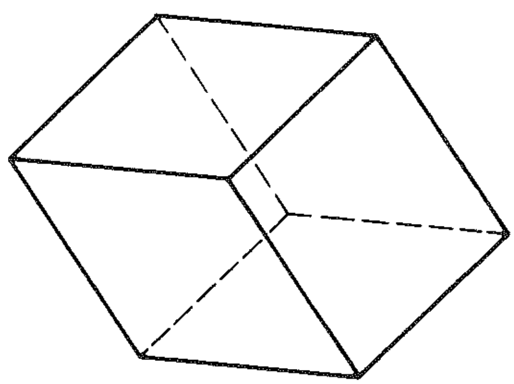
Here is an item I stumbled onto purely by accident. While attempting to demonstrate visibility to my Descriptive Geometry class, I sketched on the blackboard the top and front views of a cube (or so I thought,) and proceeded to establish visibility of its edges. To my embarrassment, and to the utmost delight of my students, it wouldn't work! Upon further investigation, I discovered that I had drawn simply a hexagonal plane with some extra lines in it.

I thought this might be of interest to Journal readers, so I have enclosed some figures I worked up more carefully.

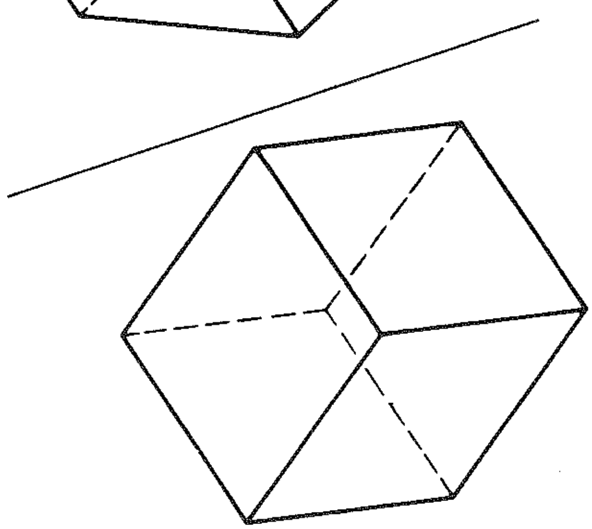
The "visibility" of lines in Plate B doesn't make sense, of course, but Plate A without notation appears perfectly normal at a glance.

Sincerely,

Michael P. Guerard, Instructor
Engineering Graphics Department
Texas A&M University



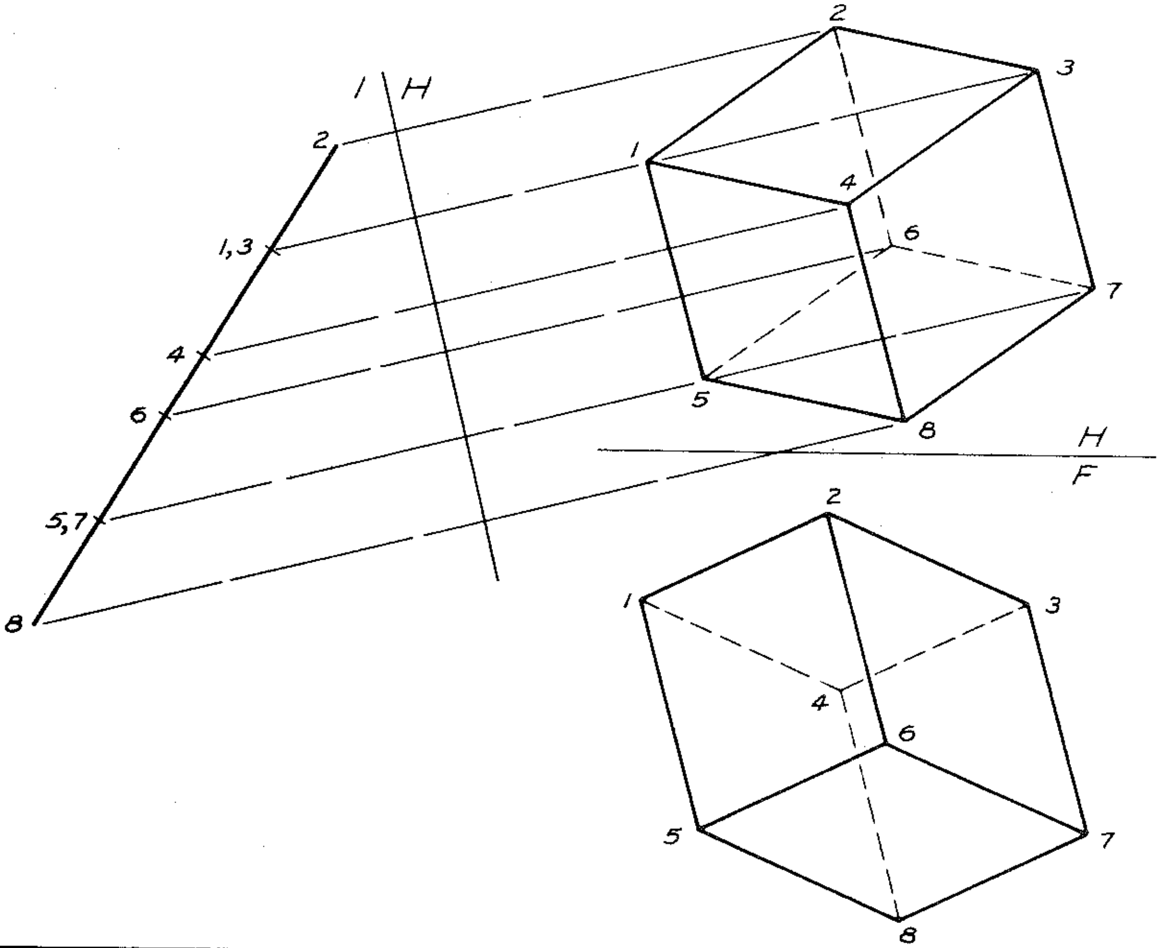
WHEN IS A CUBE NOT A CUBE?



TURN PAGE FOR ANSWER

WHEN IS A CUBE NOT A CUBE?

ANSWER—WHEN IT'S A PLANE!



Dear Professor Blade:

Currently I am working on a thesis as partial fulfillment for a Masters of Education degree in the Industrial Arts curriculum at California State College, California, Pennsylvania. I am in the process of gathering information of background material for the bibliography of the thesis. The thesis will be experimental in nature and will be an investigation of the problem: "Is instruction in beginning drawing classes more effective if orthographic projection is taught first followed by pictorial representation or should pictorial representation be taught first?"

It would be very helpful to me if you could send me any information pertaining to my problem. Any help you might give me would be greatly appreciated.

Sincerely,

Wayne R. Shaulis

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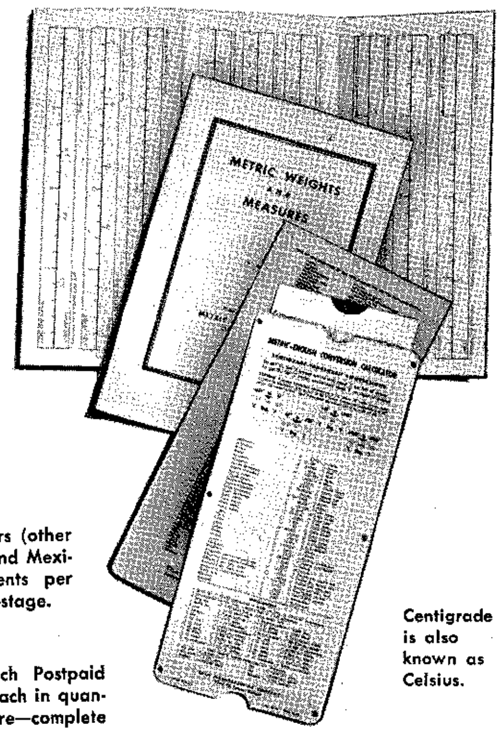

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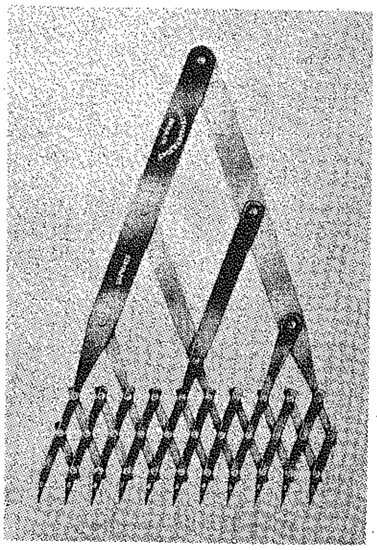

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Published 1952
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This well-known text of 197 pages, 6" X 9", in hard covers, deals with alignment charts, empirical equations, the design of special slide rules, and the use of the standard slide rule. Examples are numerous, and there are problems at the end of each chapter.

The seven chapters are: (1) Standard Slide Rules, (2) Empirical Equations from Engineering Data, (3) Alignment Charts, (4) Graphical Calculus, (5) Alignment Charts with Determinants, (6) Special Slide Rules, (7) Movable-scale Nomographs.

Formerly available from McGraw-Hill; now a Balt book.

SLIDE RULE PROBLEMS AND SOLUTIONS
by J. N. Arnold

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DESCRIPTIVE GEOMETRY PROBLEMS
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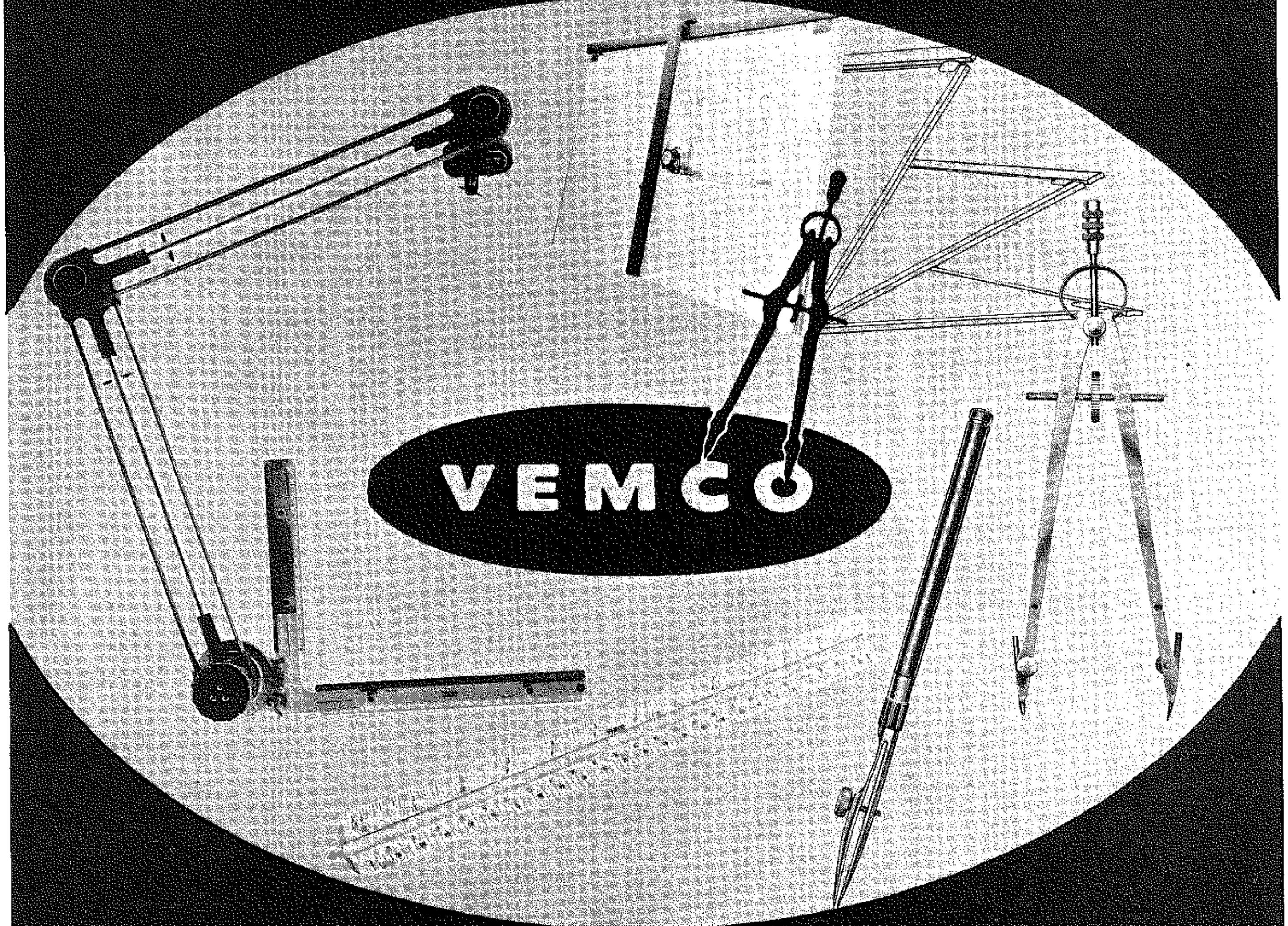

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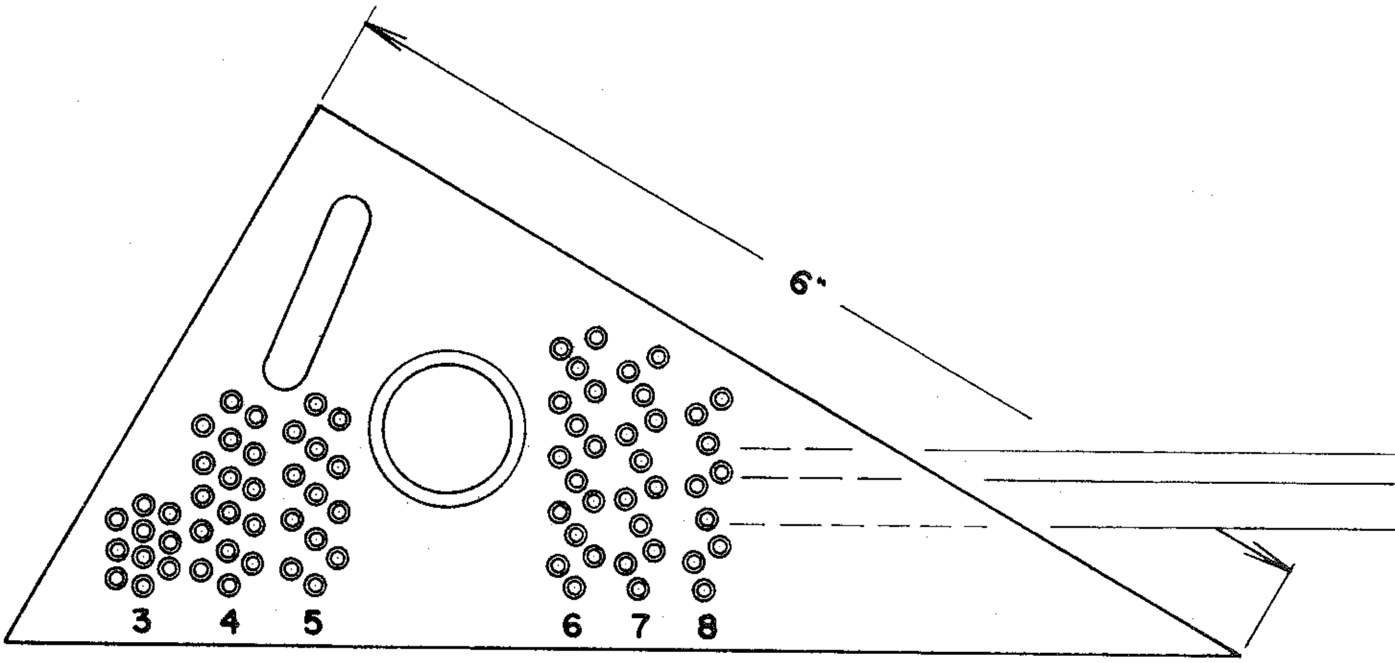

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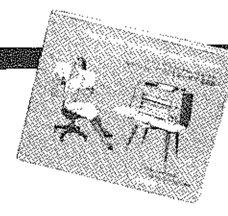

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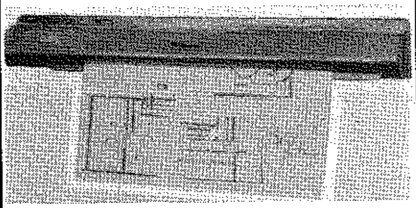

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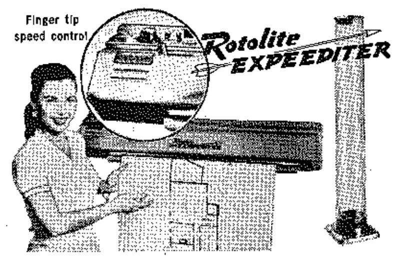

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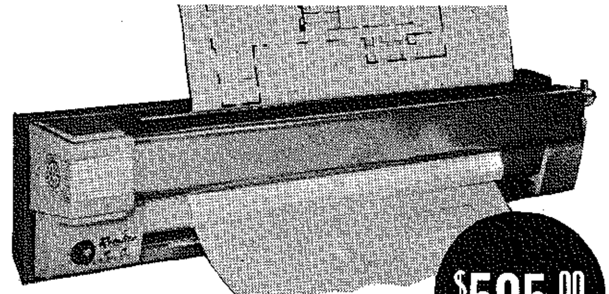

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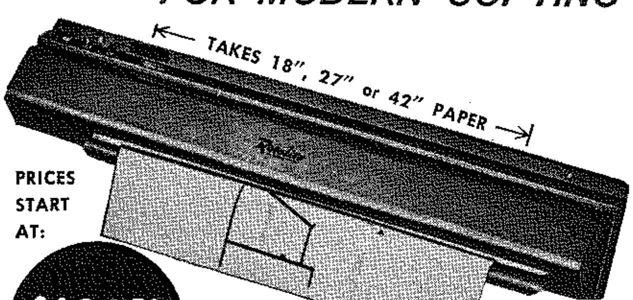

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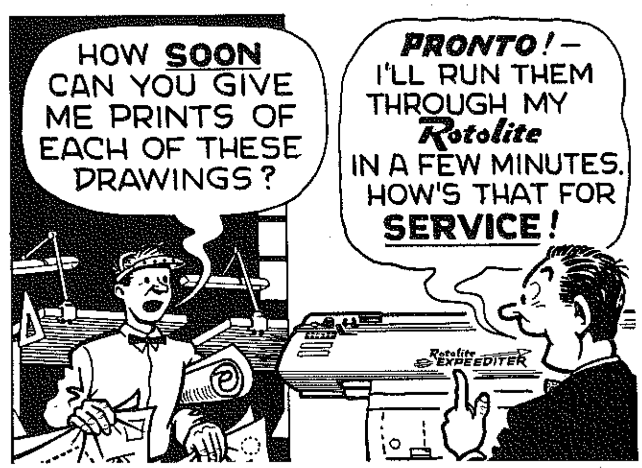

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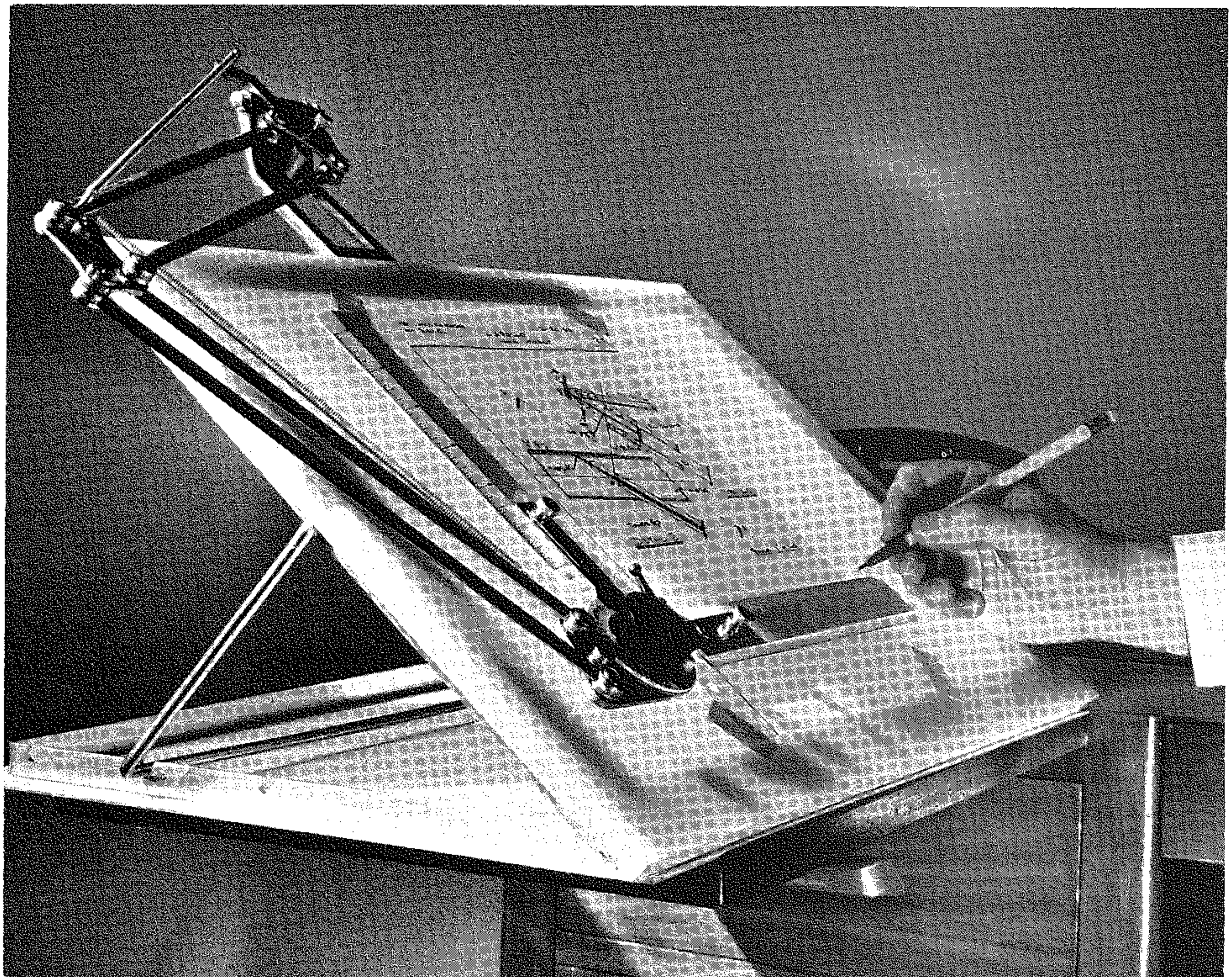

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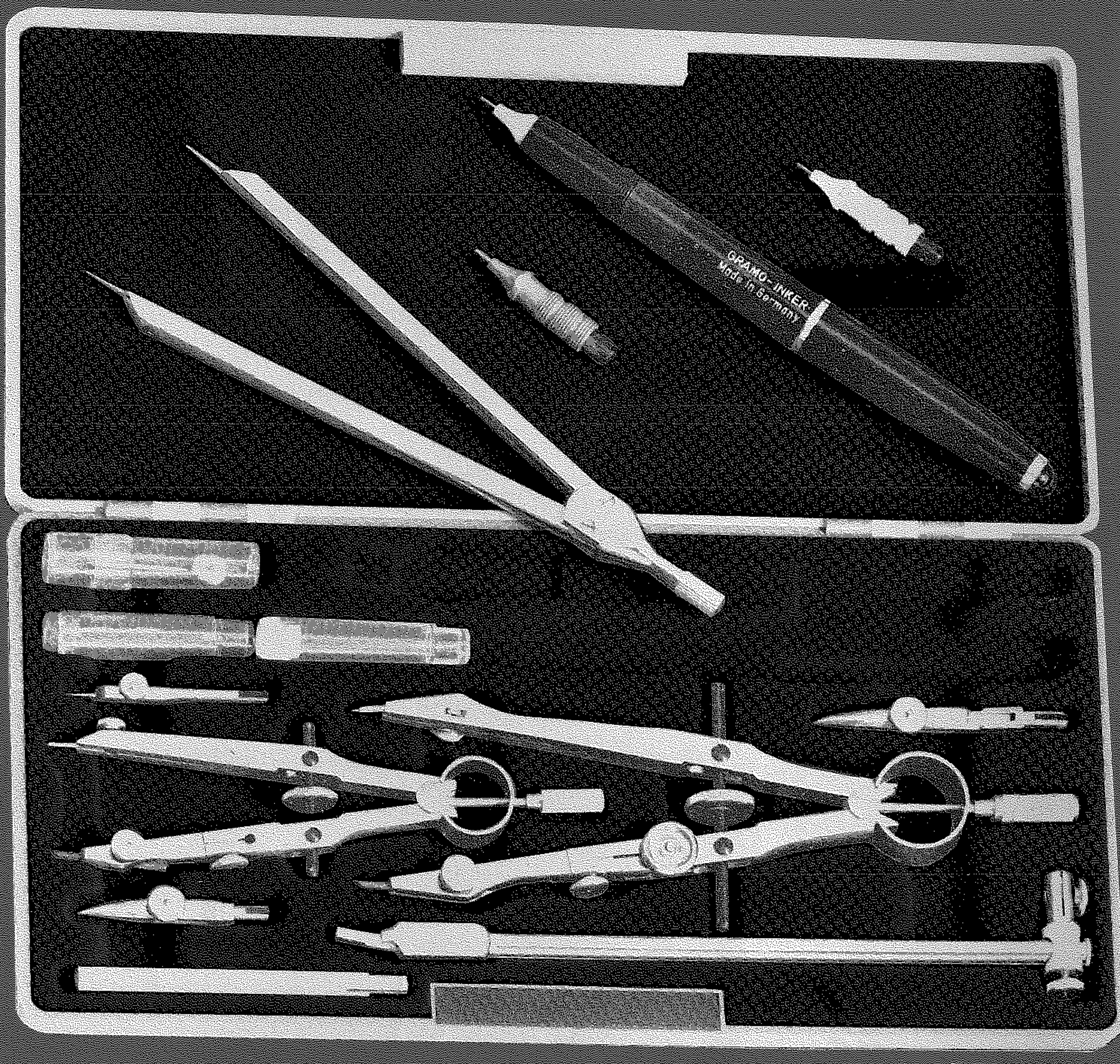

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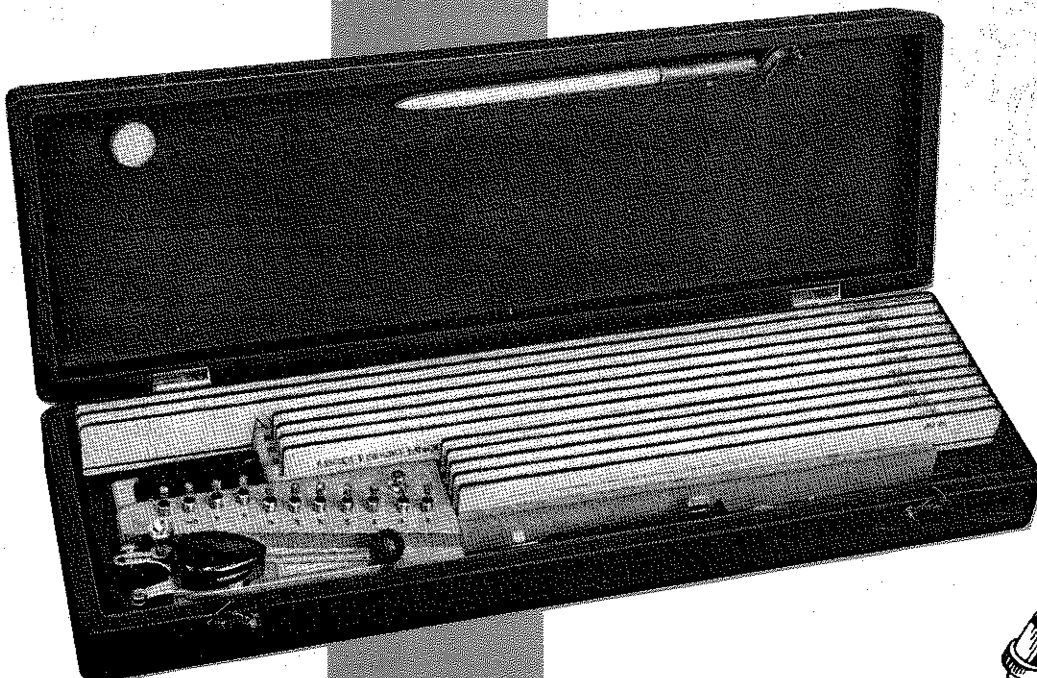

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