engineering design graphics journal

Published by the Engineering Design Graphics Division, American Society for Engineering Education

SPRING 1972 VOLUME 36 NUMBER 2 SERIES 108

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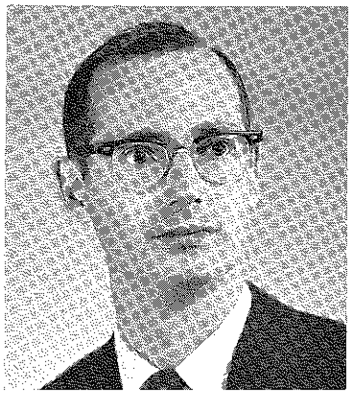


THE RATIONALE OF ONE-PERIOD DESIGN PROBLEMS

Robert J. Foster
Assistant Professor of Engineering Graphics
The Pennsylvania State University

(Presented at the 1971 ASEE Annual Meeting)

"Professor, what are you leading up to?" Your own students may well ask themselves this question if a one-period problem follows a "quickie" design problem. So often we think of graphical design problems from our own viewpoint as teacher, rather than through the eyes of our students.

A beginning student's outlook in the graphical area is usually drafting oriented, if he has had any experience at all. He may understand well what you're talking about when you explain orthographic projection and primary auxiliary views. You are entering a new ball game with him, however, when you refer to design problem identification, analysis of options, decision point, and design layouts.

After a student has proceeded through a "quickie" problem, he perhaps has an inkling of what design graphics implies. However, doubts may well linger in his mind. He will probably still wonder, "Why should I bother with this whole approach to engineering graphics? Why doesn't the teacher just give me more practice in drawing skills?"

Here one faces the whole question of a student's relationship to course goals. The student should come to understand that drafting skills are indeed very necessary in the engineering technician field where drafting could possibly be a person's primary responsibility. Within baccalaureate engineering programs, on the other hand, skill in drafting in and of itself cannot aim the student toward using graphical concepts and his own creativity to solve engineering problems involving graphical procedures. The student should realize early the philosophical difference between a detailer and a designer. To become eventually a responsible designer, the student will want to learn early how design problems are approached and solved.

By the end of an engineering design graphics course, the student will need to know how to identify the problem, set specifications for solution, how to select a reasonable approach from among alternate routes, and how to physically create a scaled layout drawing. Perhaps in courses offering sufficient time and credits he can also sharpen his drafting skills by working on fully dimensioned detail drawings.

In a one-period problem the students and teacher proceed with the process begun during the "quickie" problem. Initial student fears and tensions of working in a new area probably have been lessened. Students better understand the design solving process.

The student and teacher interact as learning continues. The teacher brings with him convictions of what he should do. He may well believe the following items are necessary:

a) Complete one open-ended problem that can be solved in primarily a graphical manner.
b) Provide the student with the problem, in that time does not permit students to think up their own problems and also to solve them within a single period.
c) Concentrate on concepts and process leaving involved drafting for later and longer problems. Emphasize sketching.
d) Reinforce the student's understanding of the design-solving process.

Should you as teacher use a system or product-design problem? In the space of one period a product-design problem can be handled satisfactorily, but tackling a systems problem or feasibility study would result usually in frustration arising from the severe time squeeze.

Assume briefly that you are a student. The instructor walks into the room and presents you with one problem. You note that the problem is limited in scope, that the specifications for an adequate solution have already been given. You need only to solve it in one period!

Your students may well verbalize several questions. You may be sure that they are at least brooding over these:

a) Why should I even be bothered?
b) Where do I start this problem?
c) How do I know when I'm finished?
d) How do I know if I've done well?

These questions relate to a basic sequence of thought in learning: OBJECTIVES - ACHIEVEMENT - EVALUATION.

We alluded to objectives with the student question raised earlier, "Why should I be bothered with this approach to engineering graphics?" The student should be at least partially in agreement with course goals following the "quickie" problem and discussion of the role of skills and concepts in engineering design.

The second element of the sequence, achievement, is related to the student questions "Where do I start?" and "How do I know I'm finished?"

The teacher has a primary responsibility to guide the student at this point. He can encourage the student to immediately begin to sketch out various ideas as they come to mind. These sketches can then serve to indicate the best alternative to the solution. Specific references in the text can also help, plus information give-and-take among students, especially if student teams are used.

Encouragement and even tactful prodding are needed to get the students to pick a specific approach and finalize it in a layout drawing, however simple that layout may be. Beginning students tend to postpone the act of drawing. Some fear they will make a mistake and will thereby be penalized. The student should realize that even experienced engineers make numerous changes on their initial layouts.

"How do I know when I'm finished?" If the graphical expression before him fulfills the desired specifications of the solution, the student is indeed finished. In a one-period problem, the final result is in no sense a fully completed design, but by meeting the problem specifications, it can at least be a legitimate step toward a fully finished design. Help your students to see that their one-period problem is a vital portion of the design process.

"How well have I done?" This is a fair and honest question. The student should be given information before he starts work on how he will be evaluated. Evaluation looms large among student priorities. It is only ethical that you let him know early how you plan to evaluate his performance.

You might well provide him with a checklist containing weighted items to which he may refer as he works. The list items may include:

a) Degree to which specifications are met.
b) Directness and simplicity of solution.
c) Sufficiency of information given by views.
d) Graphical correctness of views used.
e) Graphical clarity and quality.

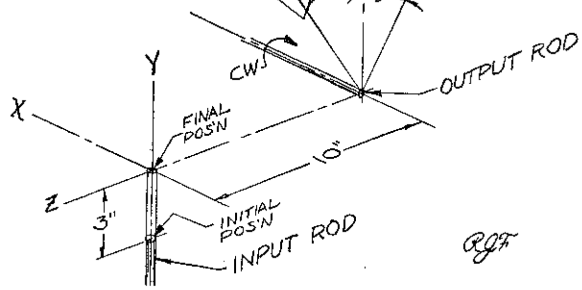
Students appreciate an early return of their work. Your considered comments and evaluation will help prepare your students both motivationally and in subject matter for more difficult and challenging problems. Their confidence should be increased and their thinking sharpened as they progress toward the end point of competent designer.

ONE-PERIOD ENGINEERING DESIGN GRAPHICS PROBLEM

Within this period a solution is needed for a specific problem. A designer needs a linkage system which will provide the desired output for the given input. As the designer's support man, you are asked to offer your solution within the following specifications:

SPECIFICATIONS

1. INPUT MOTION: Three-inch range in elevation differential of a rod within a vertical plane perpendicular to axis X. See sketch below.



AXONOMETRIC SKETCH

(See DESIGN - p. 45)

GRAPHICAL SOLUTION BY MAPPING

William M. McKinney
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Although the use of graphics to solve mathematical problems is well known to those in engineering, it is less familiar to those in the earth sciences. This is unfortunate, as one of the most basic tools of geoscience, the map, lends itself readily to graphic solution.

A few examples of this are given in standard textbooks of cartography. To eliminate the distortions of area which plague many maps, special projections, such as the sinusoidal or Mollweide, can be employed (provided one is willing to forego fidelity of shapes.) Other mathematical possibilities of cartographics may be found in the Mercator projection, which preserves constancy of direction for straight lines, and in the gnomonic, upon which straight lines come out as great circle routes.

The author, convinced that many more possibilities of such applications could be discovered, embarked upon a series of experiments in 1961. Several results of this activity have already been described. (1) More recently, while pursuing post-doctoral studies in geoscience and while teaching his own course in aerial photo interpretation, he became aware of the need for a quick, graphical method of determining the azimuth and elevation of the sun, for a given time and a given location. The azimuth is required to convert readings of a simple protractor sun compass, often used in field geology, into degrees of compass direction. The elevation is required to determine the heights of trees, towers, etc., on aerial photographs when only the length of their shadows is known.

Both of these items, the azimuth and the elevation, can be computed by spherical trigonometry if certain basic data (namely, the latitude and day, and the longitude and hour) can be known. However, this requires a good deal of computation, including access to tables of functions and to calculating equipment. One might then wonder whether quick graphical solutions to the problems are possible.

This same question arose during the early days of sail, when the average marine officer was not competent to deal with the astronomy and trigonometry required for navigation. To resolve the difficulty, the English mathematician Emery Molyneux designed a navigational globe which was fitted with special features on its mounting. By following instructions, an intelligent and perceptive seaman could obtain reasonably good solutions to navigational problems. (2) (It is noteworthy that astronomers of this period also made use of globes as instruments). As their formal education improved, mariners gradually abandoned the navigational globe, but its principles have recently been revived and studied by theoretical geographers.

For mathematical usage, the globe should be freely mounted within a cradle mounting, preferably one with a horizon ring. Under these conditions it can be <u>rectified</u>, or made to assume the same attitude in space as the larger earth beneath it. In this position, which is basic to many globe demonstrations, the locality of the observer will be at the very top of the globe. One can then work out spatial relationships in a convenient manner.

Early in the century the astronomer Skilling showed how the rectified globe and a string of given length, stretched tautly from the locality of rectification to various other points on the surface, could solve many problems of the earth-sun relationship. (3) While an ingenious demonstration of popular science, it lacks the precision required for the goals stated earlier in this article. Furthermore, the globes of the required size are expensive and difficult to handle. The cartographer, accustomed to

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THE NEW MARS DURAGLIDE JEWEL POINT

thinking of maps as substitutes for globes, might well turn to map projections as possible solutions to these difficulties.

The Azimuthal Equidistant Projection

The most logical choice for the substitution would be the azimuthal equidistant projection. Although notorious for the distortion of space around its periphery, it does have qualities which have proved useful in technical applications: distances and directions remain true when measured from the center of the projection. Not only are these characteristics desirable in radio monitoring and seismological work, but they would also permit the map to be used in solving the problems of solar azimuth and elevation.

The construction of such a projection can be made from directions obtainable from textbooks of cartography. For the purposes described in this article, it is not necessary to draw more than one hemisphere of the earth, the one centered around the locality for which the projection is made. The reason for this time-saving step is simple: when the subsolar point is more than 90° from the observer, the sun will be below the horizon and one need not concern himself with the shadow effects which are to be interpreted by the map.

Although a simple outline map of the hemisphere will suffice for our purposes, its utility can be increased by the addition of certain graphic aids. One of these is a protractor rose about the center of the projection, permitting the direction reading of azimuths from the center. The other is an analemma, a peculiar figure-eight graph which may be seen on many globes. This graph, which runs from tropic to tropic, may be centered about any meridian, but the familiar position over the eastern Pacific has been preferred for globes since it will thus not interfere with the detail of any land masses. However, for our purposes it would be more convenient to center the analemma over the central meridian of the projection. A third convenience would be to number the standard meridians (15 degrees apart) in terms of the hours of the day, with the central one designated as the meridian of noon. Finally, one might place a scale of distances adjacent to the map, reading in degrees of a great circle rather than in miles or kilometers. (Fig. 1)

The Subsolar Point

When thus drafted and equipped with aids, the map becomes a nomogram, or a device for the graphical solution of a mathematical problem. To understand its use, one should become familiar with a basic concept of planetary geography, the subsolar point. This point may be defined as that location on the earth where, at any given moment, the sun is directly overhead. It is not stationary but is constantly moving in harmony with the earth's motion. Due to rotation, it moves westward at the rate of 15° per hour, circling the earth each day. Due to revolution and the inclination of the axis, it moves north and south during the seasons, getting as far poleward as the tropic lines at the times of the solstices.

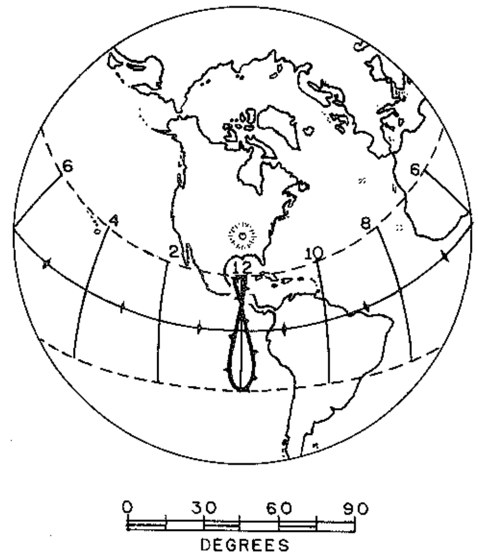


Figure 1

Its approximate location by longitude can be found by remembering the basic relationship between time and the meridians. At noon, standard time, one would expect the subsolar point to be over the standard meridian for his time zone. An hour earlier, it will be over the meridian 15° to the east, an hour later, over the one 15° to the west. Intermediate times can be obtained by allowing four minutes for each degree of travel. The appropriate hourly markings of these meridians, combined with convenient subdivisions of the spaces between the meridians, should make this task easy.

Unfortunately, this simple computation is complicated by the fact that the sun is rarely "on the meridian" at noon. Certain factors of the earth's orbital path can cause the subsolar point to arrive as much as a quarter hour ahead or behind the schedule. The correction for this factor, known as the equation of time, can be obtained from the analemma. This graph is drawn to locate the positions of the subsolar point, at noon, mean solar time, for its central meridian and for every day of the year. Thus, when it bends to the east of its central meridian, the sun is behind schedule ("sun

(See MAPPING - p. 43)

COMPUTER REASSURED DAREDEVIL

BEFORE HE SPIRALED CAR

(Reprinted from Machine Design, February 10, 1972.

When a car was caused to take to the air and spiral like a forward pass down the football field at the Houston Astrodome last month, the driver was not taking as reckless a gamble with his life as it seemed. Prior to the demonstration, a computer predicted the stunt would be successful, and this finding was confirmed by testing with an unmanned vehicle.

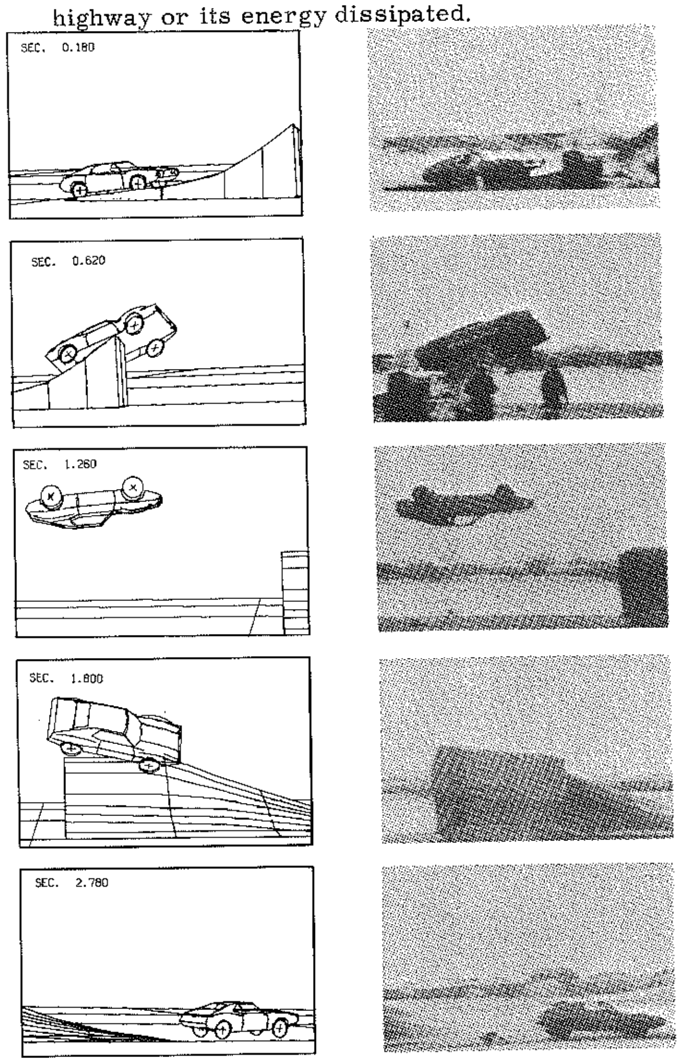
A sophisticated computer program that eventually will help to make the nation's highways safer was used by Cornell Aeronautical Laboratory in the intricate design of takeoff and landing ramps for the manned Astro Spiral Jump. But although the ramps were designed and "fine tuned" with computer aid, a strong challenge still was imposed on the driver. He had to bring the car up to the takeoff ramp at a precise speed and angle of approach to make possible a soft landing on the receiving ramp.

The computerized highway-safety research program in which the Astro Spiral Jump has its roots was developed during the past five years. The program is aimed at the eventual reduction in damage to cars and injuries to motorists that often occur when cars shoot off the road in accidents involving a single car.

Applying this computer simulation technique to such an extreme maneuver as the Spiral Jump has advanced technology in an important area of auto dynamics, with future significance to highway safety, according to Raymond R. McHenry, assistant head of CAL's Transportation Research Dept.

The computer program involves the description of various aspects of the automobile ---such as its suspension system, weight distribution --- in terms of complex equations which are fed into a computer for solution. Also formulated were equations that describe the environment that a car might traverse in a single-car accident.

With such equations, McHenry said, a computer is capable of predicting how an automobile will behave in various maneuvers. These include traversal of irregular terrain -- such as bumps, ditches, and embankments -- or while crashing into roadside obstacles -- such as trees, utility poles, guardrails, and bridge railings. Thus, McHenry continued, the computer can predict a car's behavior at the outer limits of driver control in any accident situation. The goal of protecting motorists and their cars in single-vehicle accidents will be achieved eventually by changes in roadside and automobile design in such a manner that a car would be redirected back onto the highway or its energy dissipated.



Computer predictions (left) were confirmed by testing with an unmanned vehicle before J. M. Productions Inc. performed the manned spiral jump.

(See CAR - p. 40)

THOMAS NEWCOMEN: THE INVENTOR OF THE STEAM ENGINE

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Chartered Engineer
Lecturer in the University of Manchester
Institute of Science and Technology

(Reprinted with permission of CONSULTING ENGINEER, February 1972)

Thomas Newcomen, the man who made the world's first successful steam engine, was born in 1663 in Dartmouth, England. His ancestors have been traced back to the 12th century as lesser landowners, while his great-grandfather Elias Newcomen was Rector of Stoke Fleming. But we find Thomas in business as a maker and supplier of tools and china clay industry of Devon, while in his spare time he acted as Pastor to the Baptist community of Dartmouth.

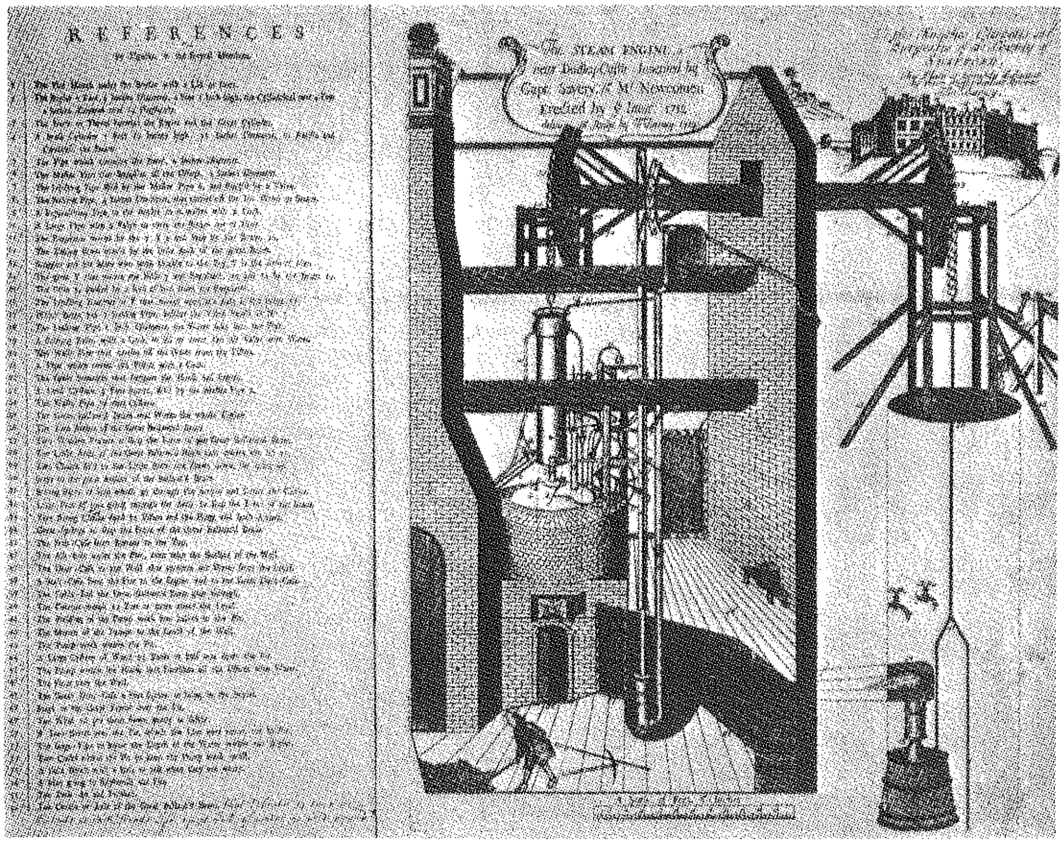
From his association with the mining industry he had been aware of the difficulties and expense of pumping the water out of the mines. Sometimes water wheels and windmills could be used, but often horses were employed to work the pumps and the cost of this, always high, became prohibitive in many places.

Earlier attempts had been made to harnass the force of steam. The Marquis of Worcester, in his Century of Inventions published in 1663, described an apparatus he had invented for pumping water. This was taken up by Thomas Savery, patented by him in 1698 and advertised as suitable for draining mines. It consisted of a container filled with water with a fire below. As steam was generated it drove the water out of the container and up a pipe, discharging at a higher level. When the water was all gone the steam was condensed and the vacuum drew up a further supply of water from a lower level. With this arrangement, the maximum lift was about 40 yards. Beyond functioning as a novelty, it proved totally useless for any serious work.

Newcomen's Approach

Meanwhile Newcomen was proceeding along a different line. He followed up the idea of Denis Papin who had shown that if a cylinder into which a piston fitted were filled with steam, and then the steam condensed, a vacuum would result and the piston would be forced in by the pressure of the atmosphere, in practice well under 14 psi.

Papin, having supplied the idea, went no further, but Newcomen took it up around 1702 and spent 10 years in developing a successful engine capable of useful work. A brass cylinder and piston were mounted over a boiler in which steam was raised to a pressure of 1-1/1 psi, and the piston was suspended from a pivoted beam at the other end of which was a weight representing the pump rods and water in a mine. First a cock allowed steam to enter and fill the cylinder and then water was poured over the outside of the cylinder so cooling it and condensing the steam inside. Because of the resulting vacuum the atmospherr was intended to press on the top of the piston with a



pressure of perhaps 9 psi, forcing it down and so bringing up the other end of the beam, and with it the weight representing useful work. However, Newcomen came up against practical difficulties. Pouring water on the outside was only a slow method of condensing the steam and by the time it was accomplished, a good deal of aid had leaked past the piston and largely destroyed the vacuum. Hobert Hooke, the celebrated mathematician, told him that a speedy vacuum was the answer to his troubles but could not tell him how to get it.

Newcomen then tried encasing the cylinder with a water jacket, which was not much of an improvement except that it led to a lucky accident. A defect in the cylinder developed into a small hole and the partial vacuum drew in a jet of cold water which produced immediate and complete condensation. The piston came down with such unexpected force that it broke the bottom out of the cylinder and smashed the apparatus, but Newcomen was delighted. He had seen, in a flash, the way of getting an instantaneous condensation and he now built another experimental engine, connected up a high level tank of water, and by means of a cock that was opened and shut at the right time produced a jet of cold water inside the cylinder. The desired result was achieved. He now designed a valve gear for opening and shutting the cocks at the appointed times by the motion of the engine and then announced himself as being willing to undertake the draining of mines.

The first people to accept his offer were John Bate and Company of Connygree Colliery at Tipton in Staffordshire. Because the engine was in sight of Dudley Castle, it is known as the Dudley Castle engine. Here in 1712 Newcomen and his assistant John Calley and various carpenters, blacksmiths, plumbers, and masons erected and set to work the first successful steam engine ever to do useful work in the world.

Difficulties of the Times

At this point we might pause and reflect upon the difficulties of building a steam engine in 1712. When most of us think of steam engines, we think of the heyday of steam power, perhaps towards the end of last century. We summon up visions of long workshops with rows of line shafting and everywhere the whir of wheels and the slap of belts. Ranged along the floor are lathes and planing and drilling machines attended by skilled artisans in blue overalls, while in the adjoining workshop can be heard the thump of the steam hammer as it forges a huge crankshaft. Or perhaps our imagination conjures up the lights, sights, and smoke of a foundry as castings are produced. But Newcomen had none of these. The framing was made by carpenters who might have come from framing up and rearing a half-timbered building, and mechanical engineering had not gotten beyond the wooden machinery for wind and watermills. In Newcomen's engine the valve gear was all made in the blacksmith's shop. The pipework was of lead, and to produce this sheet lead was cast, then cut into strips, and each strip was formed around a wooden mandrel with welted joints, which were then soldered, so producing a pipe. The only part of the actual engine obtained from outside was the brass cylinder purchased from a brass-founder, and the cost even in those days was about $725, but this was greatly reduced by 1725 when cast iron cylinders began to be available at a cost of about $100.

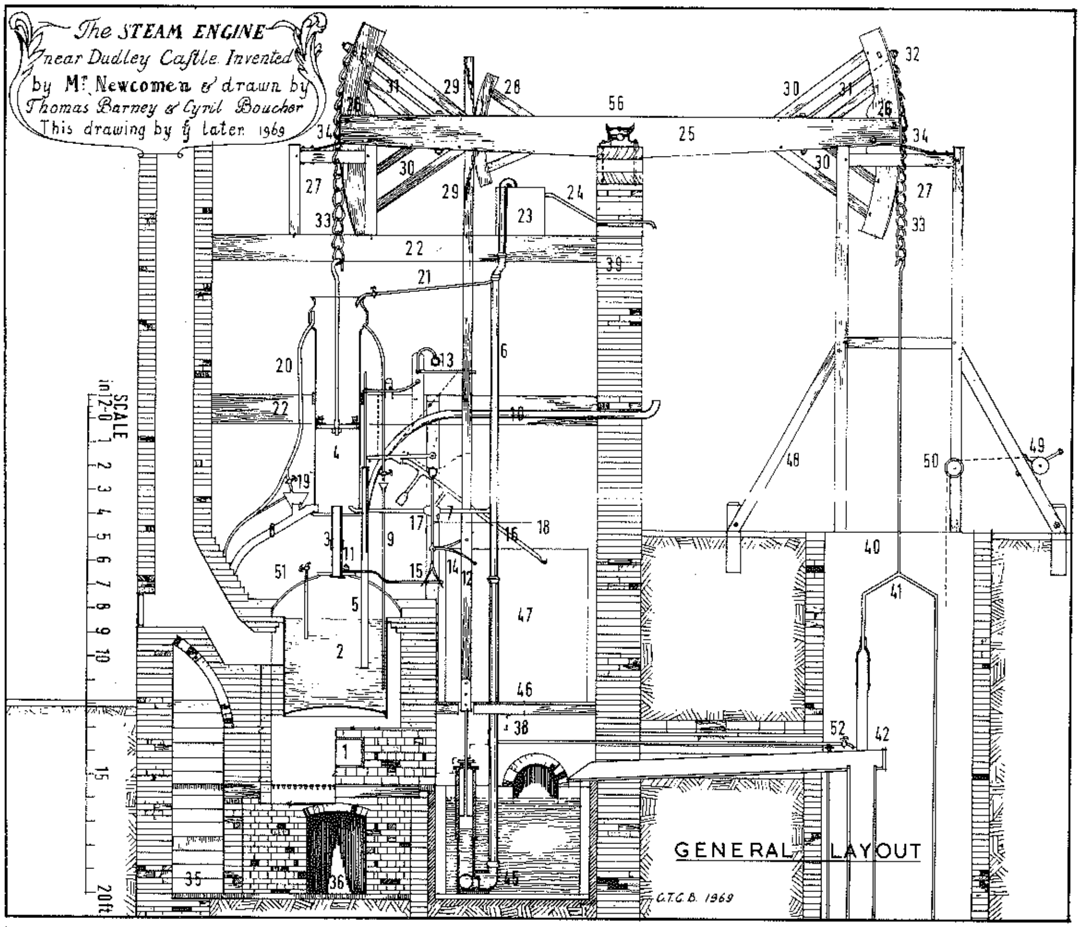
The cylinder had not been machined and the piston was made airtight by having a leather washer around its circumference just like a pump bucket. As a pump bucket has to be primed, so the piston washer had to be kept wet, and for this purpose a tap discharged over the open top of the cylinder, the overflow going as feedwater to the boiler.

Capacity

Newcomen's first engine could lift 3 million pounds of water 1' on a bushel of coal (a bushel can be taken as about 90 lbs.), and if we take 3 as the salient figure, Smeaton increased it to 10, James Watt lifted it to 30, Richard Trevithick in England and Oliver Evans in the United States got up to 100, while at its highest state before it began to disappear, the stationary engine could register 150. Clever men began to make improvements right from the first engine, but we still need to remember that most difficult work of the pioneer -- doing a thing for the first time -- and Newcomen deserves our respect as the sole inventor and actual builder of the first successful steam engine to do useful work.

Even today steam is the basis of most industry. Although the brilliant invention of the steam turbine spelled the passing of the piston and cylinder engine, more steam is now produced than at any time in the history of the world, for the bulk of our electricity is generated by that prime mover -- steam.

Savery had patented his engine, but Newcomen had no patent. So their position was that Savery had a patent and an engine of no value while Newcomen had an engine of value but no patent. They lived only a few miles apart and they seem to have gotten together as partners, one providing the patent and the other the engine, a doubtful arrangement that did not escape some of their contemporaries.

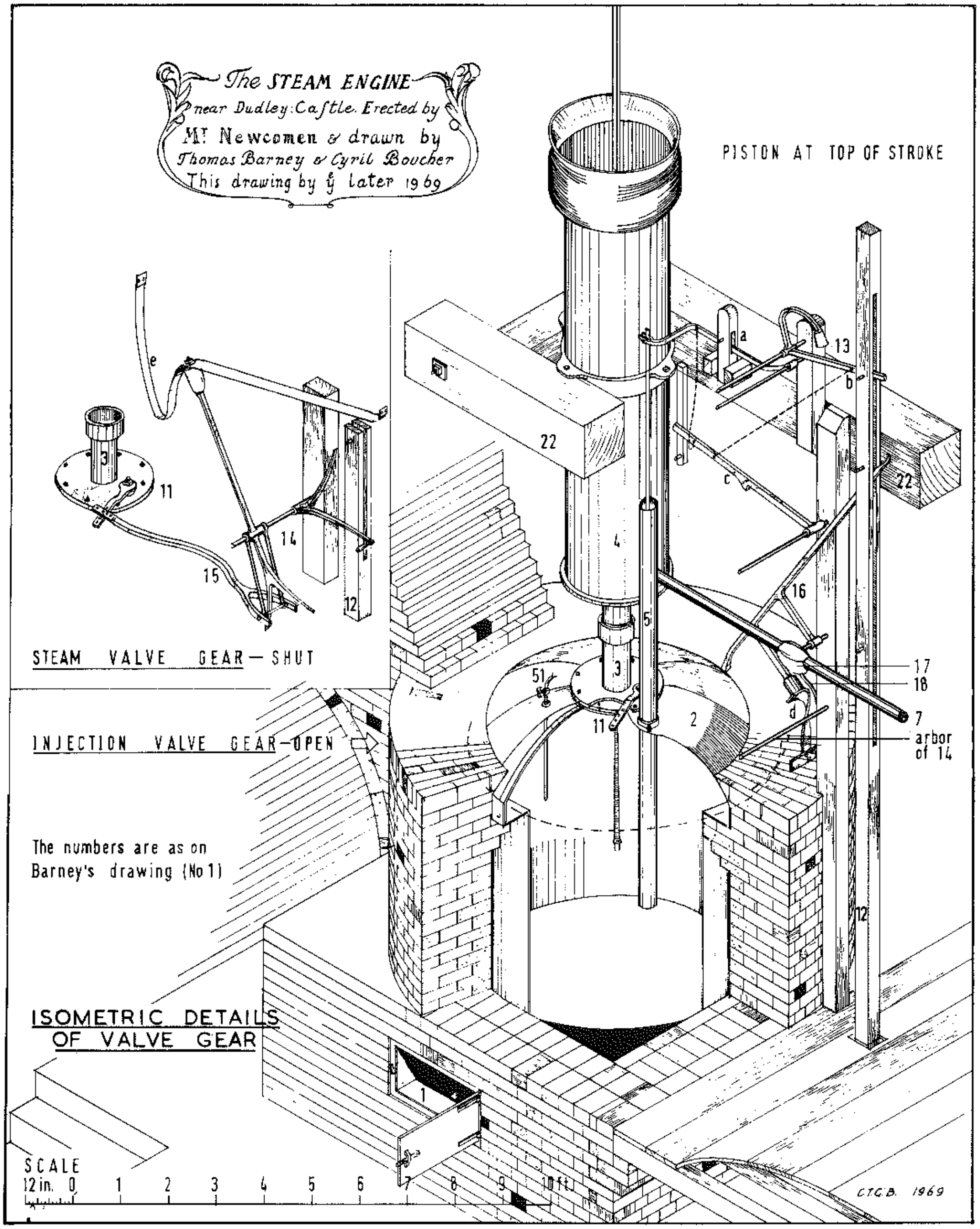


THE STEAM ENGINE NEAR DUDLEY CASTLE (2)

This first engine at Dudley Castle was visited in 1719 by Thomas Barney who, taking a working drawing by Newcomen, converted it into a perspective, indicated improvements that had been made since it was built, numbered the parts, supplied a key and description, and added an ornamental inscription and a view of Dudley Castle as it appeared from Connygree Colliery. This drawing shows that Barney's perspective was dreadful and put in piecemeal, but the basic elevation is correct to scale and astonishingly accurate, including the improved controller or scoggan added by Humphrey Potter soon after the engine was built.

Recent Replica

In 1968 it was decided to build a one-third full size replica of the Dudley Castle engine for the Manchester Museum of Science and Technology and I had the very interesting task of redrawing the engine in intelligible terms. Taking Barney's drawings as the No. 1, I first redrew it with Barney's perspective removed



THE STEAM ENGINE NEAR DUDLEY CASTLE (3)

so that it was restored to an elevation, much as the original drawing would have appeared when it left the engineer's hands. Then I produced a sectional isometric view that made clear -- as I hoped -- the general construction of the engine, and finally another sheet with details of the valve gear.

These drawings, in which the same figures are used as in Barney's key, will help to explain the working of the engine. The piston rises in the cylinder (4) not from the steam pressure but by the action of the heavy pump rods at the other end of the beam sinking down the shaft. Steam at 1-1/2 psi generated in the boiler (2) follows the piston and fills the cylinder. Now the beam has just reached its highest point and the plug rod (12) attached to it lifts the scoggan (13), so releasing the weighted lever (16) which drops, and turns on the tap (17) thus allowing water to rush through the injecting pipe (7) and squirt all around inside the cylinder, in this way condensing the steam. Under the influence of the resulting vacuum, which reaches about 9 psi, the atmosphere presses on top of the piston and forces it down so lifting up 10 gallons of water from the well, a distance of 51 yards. In the next cycle as the piston rises again, so the plug rod (12) falls shuts off the water, and, then, near its lowest point turns on the steam by depressing a prong of the fork (14). Attached to the axle about which the fork turns is a weight which when it has reached the mid-point falls over forwards, or backwards, as the case may be, so instantaneously opening or shutting the steam valve. The cycle as described is now repeated and continuous motion takes place at the rate of 12 strokes a minute.

In this first engine and in subsequent engines for some years the pipework was all of lead with soldered joints, the beams and framing of timber, the chains and valve gear of wrought iron, the cylinder of brass, and the boiler base of sheet copper with a domed top of sheet lead supported on ribs, the lead joints being soldered together. The engine house was a large and substantial masonry structure into which the main framing of the engine was permanently built.

Other Projects

The Dudley Castle engine was an engineering and commercial success and Newcomen and Calley were called upon for repeat performances all over Great Britain. The second engine was at Griff in Warwickshire, and the agreement for this engine, dated April 1714, has recently been discovered. It is with "Thomas Newcomen of Dartmouth in the county of Devon, merchant... at his own charge to set up on some part of the colework called the Griffe, an engine to draw water by the impellant fforce of ffire which should draw or cast up seventy hogsheads of water per hour... not above fforty yards from the sough."

This second engine was duly erected and put in operation. It forms the subject of the oldest drawing of a steam engine that we have. Though Thomas Barney had made his drawing of the first engine at Dudley Castle in 1719, his effort had been preceded by Henry Beighton, a young man living near Griff and himself destined to become a steam engine erector and designer, who in 1717 made in excellent perspective drawing of the Griff engine of 1714. The existence of this drawing had long been forgotten, but in 1925 a copy of it was discovered in the library of Worcester College Oxford. No other copy is known to exist.

With the death of Savery - owner of the patent - in 1715, a new company or syndicate was formed to build engines or to license others to do so, in which business it continued until the expiration of the patent in 1733. There was some talk in 1725 of upsetting the patent on the grounds that it was for Savery's engine and not for Newcomen's quite different one, and a certain Stonier Parrott wrote out a memorandum on the subject that is still in existence. However, by now it was approaching the time of expiration of the patent and nothing was done.

Thomas Newcomen died on August 6, 1729 at age 67. He remained a member of the steam engine company all his life, but because of the impossibility of simultaneously erecting engines all over England, living in Dartmouth, and attending meetings in London, he was represented on the syndicate by his personal friend Edward Wallin, a Baptist minister, in whose house he died while on a visit to London.

From the two letters of his that have been found, the style of his language shows that he was a courteous and well educated man. As a Baptist he suffered persecution from the repressive measures against nonconformists in the period following the trial of Dr. Sachervell in 1711, which ended when the Jacobite Rebellion of 1715 halted the persecution.

Newcomen's home in Dartmouth was a large, old, half-timbered house that faced High Street and backed onto Lower Street. It was pulled down in 1864 by the Town Council, but fortunately there had arrived on the scene Thomas Lidstone (1821-88) an architect who had a great admiration for Newcomen, perhaps the first person in modern times to take an interest in the inventor. He wrote several pam-

(See INVENTOR - p. 44)

EXPLOITATION OF COMPUTER GRAPHICS CAPABILITIES

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From its outset, computer graphics has been a very promising area to the Design Enginner and the Graphicist. The possibility of having the computer do the drawing and to never again have an aching back and sore fingers was attractive to everyone from the freshman in his first month of engineering to the senior faculty member, to saynothing of those managers whose drafting payroll is a favorite target for efficiency experts. All of these were promised relief from the tedium by those who were pioneering computer graphics in the late fifties and early sixties.

It could be pointed out that immediately prior to that stage the computer culture was assuring us that accountants and bookkeepers were rapidly becoming obsolete and that in a very short period, the staff of our university accounting and record keeping operations would be reduced to a few people who would feed cards and paper and dust off the machines once a month.

At this point in time, neither of these Utopian states seems to be upon us. On the other hand, the computer seems to be here to stay, perhaps not living up to its original advertising to the letter, but in many ways going beyond the original forecasts.

If one looks for an underlying thread which connects many of the current applications of computers, one characteristic is quite prominent: computers are doing things which never were done before, rather than simply replacing people because they are faster and more accurate.

The extrapolation of this history into the area of computer graphics suggests that the place to implement computer graphics is not in the construction of production drawings, but in the generation of graphic aids which do not currently exist. The implication of this is that there are many such applications and that they are not obvious.

Another characteristic of the early efforts in computer graphics was the expense involved. Computer graphics projects in existence ten years ago were mainly large activities with correspondingly large budgets. It is now possible to get a graphic device on a system for less than Ten Thousand Dollars and to have with it a variety of software capable of generating lines, curves, and all types of annotations. This puts in the hands of the user a great deal of capability without his having to be a bona fide computer scientist. He need only be a man with a problem who can cope well with a higher level language.

The type of problem is, of course, relevant and although it would be an over simplification to write rules about what is or is not a problem which could be treated with computer graphics, some indications do exist.

The first point to be made is that graphics is a people oriented thing. One only has to worry about talking to people with computer graphics. With few exceptions, there is no benefit to be gained by using graphics as an intermediate form of communications between machines. The entire basis for graphics is that people can process information presented this way much faster than any other communication form.

The capability of the machine is primarily in making exact or accurate drawings in very little elapsed time. This suggests that the primary applications will be in "class" problems, that is, situations where a number of drawings will have to be made, and where it will be possible to use a single program or group of programs to generate these drawings.

There are a variety of reasons for desiring that drawings be exact, but often this requirement is somewhat synthetic, the real requirement being that variations be accurate, so that comparisons can be made.

These characteristics suggest some of

those systems already in wide use. The use of computers to generate annotated radar displays, to make animated movies, to simulate views for pilot training and many other activities falls into this category. Although these efforts are worthwhile and certainly sound like the kinds of things that we would all enjoy doing, there are limited resources available to most of us which precludes our getting into these kinds of activities. The purpose of this paper is to describe some applications which are interesting, useful and within the capabilities of more commonly available systems. Each of these applications represents a low budget computer graphics application. Each is currently fulfilling a need which could not be easily served in any other manner.

Dosimetry in Radiological Implants[1]

One technique for treating cancerous tumors is to implant radioactive needles in the tumor and surrounding tissue. That tissue exposed to a sufficient time-intensity combination of radioactivity will be destroyed. The objective of this treatment is to insert a needle pattern which causes a high dosage level within the tumor while minimizing the dosage to surrounding healthy tissue. The problem is complicated by the fact that it is impossible to implant the needles exactly as planned. It is, therefore, necessary to implant the needles, X-ray to determine their locations, and then make the required dosimetry calculations, from which the time for removal of the needles can be determined. Unfortunately, the time required to do the hand calculations may exceed the optimum treatment time.

M. Mehta has written a program which takes data measured from the X-ray plates, as well as the information regarding the radioactivity of the needles and computes the dosage levels at a series of points on a three dimensional grid. From this data the program then displays the isodose curves (lines of equal dosage) for a series of planes in the vicinity of the implant. The display is on a Cathode Ray Tube and is photographed for a permanent record (Figure 1).

The program has a built-in check for data accuracy. The end points of the needles are located independently and the program calculates the length of each needle and compares it with the length given in the input data.

This system was developed and is running on an IBM 360 model 30, with a 65K byte core. It was programmed in PL/1 and is currently in regular use at the New England Medical Center Hospitals.

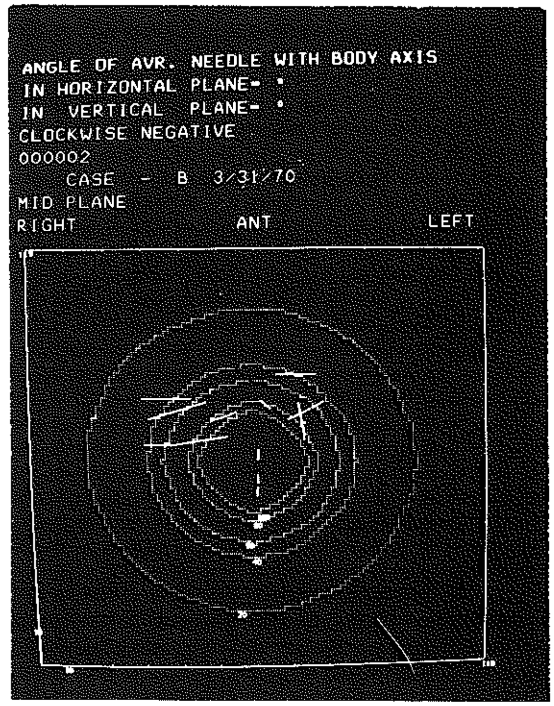

Figure 1

Steroscopic Vector Cardiogram Display[2]

The Electrocardiagram is a record of the electrical potentials present in the heart. These potentials can be thought of as representing a single dipole in the heart, with orientation and magnitude varying in time. Although this model is a great simplification of the actual mechanism, the observed potentials modeled in this manner present an excellent diagnostic tool to the cardiologist. The time space plot of the dipole's behavior can be presented as a space curve representing the path of the end point of a potential vector. This EKG loop is difficult to visualize even from a three-view drawing. The cardiologist is interested in the shape of the loop, which can vary a great deal in a normal healthy heart. Specific variations in the loop indicate heart damage at various locations within the heart muscle. A great deal of effort has been made to apply signal analysis techniques to the cardiogram with very little success.

J. Otis programmed a system which plots steroscopic views of the cardiogram loop which enables the cardiologist to get an immediate overall impression of the loop shape. The program operates from point to point data off the three orthogonal leads, and draws the loop with a great deal of augmentation to aid visualization (Figure 2). The major problems encountered were in deciding how to present the information.

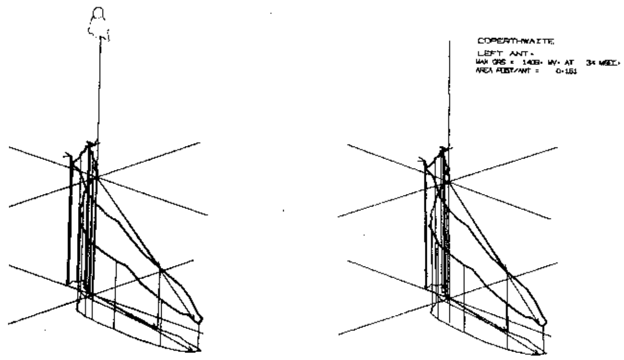

Figure 2

The cardiologists have an understanding of the three dimensional loop and its behavior but the loop, even in stereo, was difficult to draw in a way which was meaningful. The final decision was to draw a cylindrical surface with the loop as the top and the projection of the loop on a horizontal plane as the bottom. The elements of the cylindrical surface represent points spaced evenly in time, thus adding an extra dimension to the information.

The program is written so that the loop may be viewed from any direction but two preferred positions have been determined.

This particular program is an example of using the computer to manipulate the image and to present it in a way which is easily understood. There is a small amount of computing for purposes of annotating the drawings but the major effort is in transforming the image, to make it more easily understood.

The system was written in FORTRAN and implemented on an IBM 1130 with 8K core and a calcomp 11 inch plotter. It is useful to diagnose patients, and loops have been drawn for use in training cardiologists.

Graphic Realization Aid for Statistics.[3]

It is often difficult to bring statistical concepts to beginning students in a manner which they can understand. Of particular difficulty is the discussion of what happens in small samples of large populations. What would one expect to see in a sample of ten values from a large population having a given distribution?

In an effort to develop aids for the teaching of this kind of concept, T. Radi developed a set of FORTRAN programs which use random number generating techniques to provide a synthetic form of producing the required data.

The system has three major portions. The first segment is capable of generating statistical samples having the characteristics required. These can be either one or two dimensional systems of values, providing simple operations as well as regression capabilities.

The next portion of the program provides statistical analysis of the sample generated. This portion has a variety of tests available, and, of course, the results do not normally correspond exactly to the characteristics of the larger population from which the sample was theoretically drawn.

The last phase of the system plots out the data in whatever manner is desired. Annotation of the plots is automatic, and the form is designed to provide classroom visual aids. Figure 3.

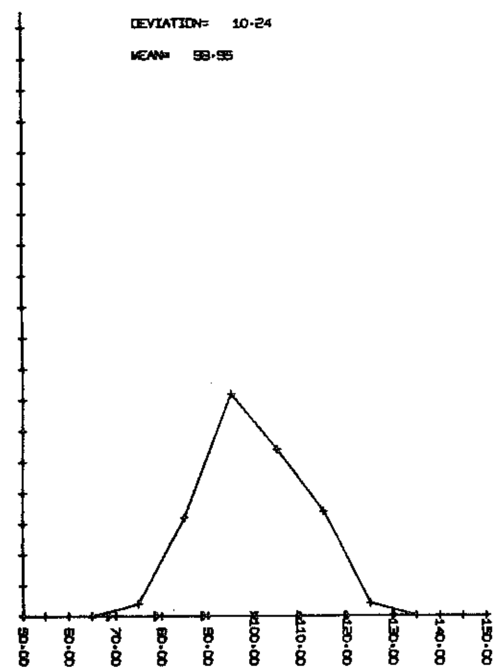

Figure 3

The system is operational on an IBM 1130 with 16K core. It is normally used in an interactive mode. The user selects population characteristics and sizes, performs tests as he sees fit, may increase the sample size, or make other changes. He can plot out histograms, cumulative curves, or distribution curves, using any scales he desires, on a full, half or quarter page (8 1/2 x 11).

The system may be used to analyze a data sample supplied by the user, having available all of the analyses and graphics capabilities in the basic system.

This particular system was designed with a long term view of having a remote graphic terminal in the classroom, where the instructor could use it to generate examples on the fly. As presently used, the instructor must prepare his materials ahead of time, but the system provides accurate analyses and graphs of reasonable data, providing virtually limitless visual possibilities.

The Visual Machine.

This software system was written by G. Meyfarth and P. Meyfarth as a teaching aid, helpful in understanding how computers function. The system is a program which simulates a small (100 word memory) computer. While doing the simulation, all of the registers and the entire memory are displayed on a C. R. T. The numbers move through the display as instructions are executed, resulting in a very graphic illustration of the machine's operation.

Within the obviously stringent size capability, the Visual Machine will accept and execute any program. This includes a capability to do subroutine calls and other complex operations. The input and output capabilities are limited, but in every other way it is a real computer operating in slow motion and explaining itself as it goes along.

This system was programmed in assembler language and operates on an IBM 1130 with an IBM 2250 display terminal. The computer being simulated is also an 1130 and the system functions as an instruction aid in training people to program the 1130.

In order to make the system more useful, a display controlled movie camera has been added so that the visual machine now literally takes movies of itself.

This concept has great potential in helping people understand how computers function, it is certainly extendable to other machines, and to broader applications.

Machining Drawing.

The Bellofram Corporation manufactures rolling diaphragms, often for O. E. M. applications. These units are formed in molds, which, of course, must be designed and built for each application. The engineering staff has been able to reduce the design problems to a series of set calculations which produce all of the mold dimensions.

It is only a small step from the point to feeding the application data into a computer programmed to make the mold machining drawings. The programming of such a system is not complicated and can be done in higher level languages. Such a system, once programmed, could make a drawing of this kind for perhaps 5 or 10 dollars in computer time. This would appear to be an ideal application for computer graphics, repeating sets of drawings, graphic information etc.

The staff at Bellofram did not see it that way. A Wang programmable calculator was acquired and programs were written to do the dimension calculations. Once this was working, a typewriter was interfaced to the system and a preprinted form with the basic mold drawing was made up. To use the system now, one loads the program, puts a copy of the form in the typewriter and adjusts the position, and keys the application data into the calculator. The system types all of the dimensions on the form, and the result is a finished manufacturing drawing. The machine cost is probably about one dollar per drawing.

The reason that this system doesn't belong on a plotter is that the information being output is not graphic in nature. The drawings of the molds would all look the same anyway, and it is possible in this situation to make that drawing only once. The machinist needs this information for a general shape concept but the dimensional data must be transmitted numerically. If a template kind of manufacturing process were to be used, if a numerically controlled miller tape were to be generated from the application data, a totally different situation would exist.

The preceding examples each had this graphical information concept as an integral part of the problem. The Isodose curves had to be graphic because the radiologist has a graphic concept of the tumor he is treating which he must match with the treatment pattern.

The Electrocardiagram must be graphic because this form again relates to the physics of the problem being considered. The problem actually becomes one in pattern recognition which is a task currently done better by people than computers.

The statistical package is attempting to teach a concept and although it may not be important that the drawings in this case be accurate, it is important that the student believe that they are, and in this case, it is probably easier to be honest than dishonest.

The visual machine is essentially a problem in animation which relates to human perception and a variety of related problems. In order to make animation work, however, a certain level of accuracy or consistency must exist and the computer controlled display is the optimum technique for obtaining this characteristic.

Summary

These examples serve to illustrate the fact that it is possible to do interesting things with computer graphics with relatively modest

(See COMPUTER - p. 42)

COMPUTER GRAPHICS - ITS ROLE IN ENGINEERING GRAPHICS AND DESIGN COURSES

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(Presented at the 1971 Mid-Year meeting of the Engineering Design Graphics Division)

Interactive computer graphics and automated design techniques are being heralded by some as the panacea for all of the problems encountered by engineering graphics departments as they endeavor to teach more material, including computer graphics, in the time usually allotted for a two or three semester hour course in engineering graphics. The display of computer graphics is always dynamic and motivating to the viewer although he may not realize the depth or level of knowledge of either engineering graphics or mathematics required to generate such programs. It is agreed that computer graphics holds some very promising potentials which may be utilized to enhance the study of engineering graphics principles if they are used effectively and at the appropriate time. The competency of the professional educator is revealed by the manner in which he plans his course work as well as by the techniques and devices he uses to effect learning by his students. This level of evaluation will be applied also toward his efforts to make use of the computer and its various output devices such as films, video-tapes or the CRT. However, no engineering educator when in his right mind would jeopardize his chances of entering the "pearly gates" by advocating that students can learn the fundamentals of engineering communications and design graphics by observing the display of computer graphics in lieu of actually solving various engineering graphics problems on a drawing board. Neither will he deny that through the proper use of computer graphics one may effectively teach more material in the same allotted time while reducing the actual number of graphics problems that the student would be required to solve on the board.

Graphical communications and design analysis with the aid of computer graphics and the associated software and hardware are becoming significantly more important in the man-computer interactive systems. Presently, we are witnessing a period of accelerated activity in the development of interactive computer graphics systems on the part of manufacturers of hardware, software development organizations, and educational establishments who have obtained federal funds for research in the graphics area. Some of the more important contributions in this field have been made by the aerospace industries.

Regarding the influence of certain industries upon the development of computer graphics Mr. Eugene H. Brock, Chief Computation and Analysis Division, NASA Manned Spacecraft Center, Houston, Texas said:

> Attendees of recent national, computer-oriented conferences, such as the Association for Computing Machinery (ACM), have been strongly influenced by exhibits featuring computer-aided design and computer graphics equipment. On-line drafting equipment, display terminals, and plotters are emphasized in every section of the exhibit halls. Nearly every computer hardware manufacturing organization is now emphasizing this equipment for use in graphics.
>
> Several manufacturers have developed special software for their equipment and are marketing both software and hardware as a package. The vendor is stressing the fact that his product will provide the engineer with the capability to enter data, analyze, make changes, produce drawings and schematics, to develop and solve equations, and produce plots. (1)

Many of us have witnessed computer graphics displays produced by manufacturers of computer and/or associated software for use in their sales routine. Despite the fact that these programs have very little, if any, educational value in their present form, they could serve as skeletons for a number of computer graphics programs having significant educational value.

There can be no denial of the significance of a computer and an online interactive computer graphics display unit in the hands of an experienced design engineer. The era of automated design and numerical control of manufacturing processes is here, even though it is still in its infancy. Only time and additional experience will reveal the full value of these new tools, but it must be observed that tools suitable for design and manufacturing in industry are not always in the best suitable form for educational use. As a general rule, they need to be modified and usually simplified before they can be used in the class room.

In reviewing the computer graphics programs which are available, they were found to be neither modular nor standard. Most of these programs have been developed by individuals or individual organizations to serve a particular purpose, and most have been written in a language peculiar to their local computer system. Too, few computer technologists have had sufficient experience in the science of engineering graphics (descriptive geometry) or the teaching philosophies to develop the necessary software to assure that optimum learning situations will develop through the use of their programs.

As the use of the computer becomes more commonplace in our educational programs we must not lose sight of our basic objective of teaching potential engineers how to read drawings and make them when necessary. In view of this, an indepth study of engineering graphics fundamentals through the use of the drawing board, t-square, and triangles must be emphasized. The student may be highly motivated to study graphics with the use of the computer but to really learn the fundamental theory of engineering graphics and design, he must actually work a number of problems himself.

The value of engineering graphics in all departments of science and engineering not only as a language, but as a discipline of the mind can hardly be overestimated. Most students who enter college can think in one dimension, some few in two dimensions, but those who can think in three dimensions are exceedingly rare. This last facility must reside to some extent with all engineers, and it is one that can best be learned through the study of engineering graphics. In our writing and discussions as engineering educators we must emphasize documentarily that the study of descriptive geometry is the best form of subject matter for developing a creative imagination.

After the development of descriptive geometry in the 18th century, educators soon realized its value as a learning tool and for almost 130 years this discipline was considered a fundamental subject for all engineering students. Not only did it occupy a place in the engineering curricula of many civilized nations, but it was a required course for many prospective mathematicians. (2) Monge, when emphasizing the significance of his "Descriptive Geometry" said:

> The charm which accompanies these studies will conquer the repugnance which men have in general for intense thought, and make them find pleasure in that exercise of their intellect which almost all regard as painful and irksome. (3)

Descriptive Geometry also has a unique philosophical peculiarity as noted by the Italian philosopher Augusto Conti. He said:

> The study of descriptive geometry possesses an important philosophical peculiarity, quite independent of its high industrial utility. This is the advantage which it so pre-eminently offers in habituating the mind to consider very complicated geometrical combinations in space, and to follow with precision their continual correspondence with the figures which are actually traced--of thus exercising to the utmost, in the most certain and precise manner, that important faculty of the human mind which is called "imagination" and which consists, in its elementary and positive acceptation, in picturing to ourselves, clearly and easily, a large and variable collection of ideal objects, as if they were really before us. (4)

It should be further emphasized that computer graphics programs make use of various levels of mathematics and that descriptive geometry is one particular type of applied mathematics which may be employed when writing certain programs. Monge, who is credited with the development of descriptive geometry, was a mathematician and he used this type of geometry to solve various engineering problems graphically. In making use of the computer to solve these problems, the process must be reversed. That is, these graphical data must be described mathematically, or digitized, so they can be manipulated by the computer.

In considering the work of the design engineer, we observe that he employs structures and/or geometric elements which consist of forms such as prisms, pyramids, cylinders, cones, etc. Each of the parts is bounded by surfaces which are planes, single curved, double curved or warped. These surfaces intersect in edges which are straight or curved lines. The resulting edges intersect as points at the corners of the forms. Engineering drawings constructed in accord with the fundamental theorems of descriptive geometry enable the designer to translate the results of his efforts in a manner which no other means of communication affords. Since each form or shape on a working drawing has specific dimensions, the problem in writing a computer graphics program becomes one of converting these dimensions into data which the computer can manipulate and subsequently display.

The administrator of an engineering graphics program must come to grips with three significant problems when he considers supplementing the instructional program with computer graphics. These problems are (1) the level of sophistication of some of the "canned" programs available, (2) the freshman engineering student has very little, if any, experience in computer programming, and (3) the student does not have the level of knowledge of the language of the engineering profession (engineering graphics) that he should have prior to being subjected to an indepth exposure of computer graphics.

In view of these prevailing circumstances, it would seem more desirable to develop some elementary programs to accommodate any given teaching and/or learning situation. Some of these programs could be modular in form so all or a portion could be used as the situation requires.

As a general rule, each computer graphics program should be simple and straightforward so students can understand its development. It has been observed that freshmen students will have little, if any, knowledge or previous experience relative to computer graphics. However, after a few weeks of instruction pertaining to orthographic projection and adjacent view arrangement, they will be able to follow the development of each step of the computer graphics program.

Three relatively simple computer graphics programs have been prepared for this presentation and it is felt that each may be used effectively by engineering freshmen students. A fourth program pertaining to axonometric projections (secondary auxiliaries) has also been included. It is suggested that it be used in the study of descriptive geometry after the students have completed similar drawing assignments.

In order to make use of these programs, the instructor must adapt each one to his particular computer system. When using a program, it is suggested that a copy be given each student along with a written or oral discussion of its purpose. The student should be required to add only the dimensions of the object or whatever digitized information is required to solve the problem. If, after the student has used the program, he wishes to modify it, it is suggested that he be allowed to pursue his interests as time and computer funds permit. Previous experience indicates that some students will write new programs as they have the opportunity.

The primary purpose of the first program is to introduce the student to the system employed to control the movement of the plotter and drawing pen. Other computer systems mayvary from that used to generate these programs but the pattern will, in general, be similar. After this system is understood, the development of each program is not difficult to follow. Since the plotter was an X, Y coordinate plotter, there must be in the "call plot" statement a value for the X and Y coordinates as well as an instruction with respect to an origin and pen control, that is, whether or not the pen is on or off the paper.

In the CALL PLOT (0.0, 0.0, -3) statement, all of these factors are present. The first or left-most argument is the X coordinate while the second argument is the Y coordinate. The sign of the last or third argument refers to the origin while the third argument itself stipulates whether or not the pen is raised off the paper or is on the paper in a drawing position. The negative sign establishes the point represented by the set of coordinate values in the argument as the new origin. If the origin is not affected, the sign is omitted. If the pen is to be in the raised position a 3 is used while the 2 causes the pen to be lowered as it is being moved to the point defined by the coordinates enclosed in the set of parentheses. Following this sytem of instruction the machine is instructed to map or draw the U-shaped figure as shown in the print-out for the first program.

The objective of program 2 is to reproduce a three-dimensional form on a two-dimensional surface. The input data may be selected arbitrarily or they may be chosen to represent a given form. It should be emphasized that these data may be obtained from a simple two-view drawing but care must be exercised in reading the proper coordinate values. For any one point the program has been written so that the X and Z values are obtained from the top view while the X and Y values may be obtained from the frontal view. The resulting computer

Program 1.

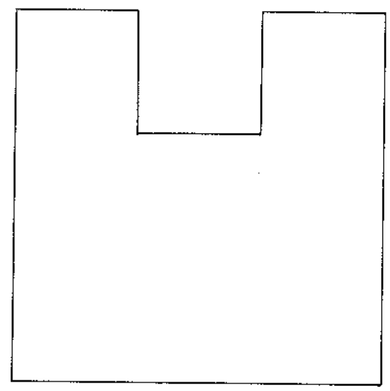
The above program instructs the plotter to position the pen at some point and designates it as the origin. From this new origin the two-dimensional figure is drawn without lifting the pen. The first entry inside the opening parentheses of line three is the x-coordinate for the plot while the second entry is the y-coordinate. The third or last entry is for pen control. The 2 is used to draw a line or lower the pen while the 3 is to raise the pen as the plotter moves it to that designated point. The negative sign used with the pen control establishes that point as the new origin.

The pen control 999 informs the plotter of the end of the program. The first two cards or lines of the program contains information for the plotter while the last two cards informs the compiler and computer of the end of the program.

All of the attached programs were run on an IBM 360/65 computer and plotted on a tape driven Cal Comp 750 plotter.

In order to run any program one must comply with the operating procedures of his computer center for entering and removing data.

```
C     LOUISIANA STATE UNIVERSITY AT BATON ROUGE
C     ENGINEERING GRAPHICS DEPARTMENT
C
C     COMPUTER GRAPHICS IN ONE OF ITS SIMPLEST FORMS
C
C     PROBLEM. TO MAKE A TWO DIMENSIONAL DRAWING
C
C
      DIMENSION BUFFER (5000)
      CALL PLOTS (BUFFER(1),5000)
      CALL PLOT(0.0,0.0,-3)
      CALL PLOT(2.0,2.0, 3)
      CALL PLOT(5.0,2.0, 2)
      CALL PLOT(5.0,5.0, 2)
      CALL PLOT(4.0,5.0, 2)
      CALL PLOT(4.0,4.0, 2)
      CALL PLOT(3.0,4.0, 2)
      CALL PLOT(3.0,5.0, 2)
      CALL PLOT(2.0,5.0, 2)
      CALL PLOT(2.0,2.0, 2)
      CALL PLOT(0.0,0.0, 3)
      CALL PLOT(0.0,0.0,999)
      STOP
      END
```



plot is an isometric drawing since the angles employed in the program are thirty degrees. Other angular values could have been used. The students should be encouraged to use different angles and compare their results.

Program No. 3 is used to reinforce the student's learning relative to the development of three adjacent views of an object. He is asked to develop data by establishing the correct coordinate value for each corner of the object with reference to some one point as the origin. Since the hidden line problem is to be avoided in this program, the coordinate values for the lower rear corner of the object as shown by the pictorial view is omitted from the input data.

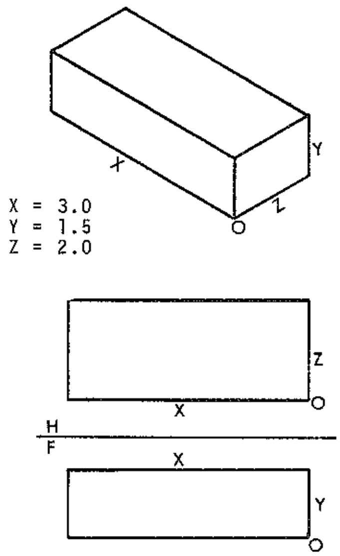
In reviewing the program, it should be observed that two arrays of values are developed for each view, with the top view being developed first. The X, Z coordinates are used for the top view. For plotting the top view the Z values control the Y direction of the plotter.

For the front view, it is only necessary to develop the array for the Y values since the X values are common to both the front and top views. For the profile view, the Z coordinate values developed for the top view were used while the Y values developed for the front view were repeated. In plotting the profile view, the Z values served as the X coordinate on the plotter. The resulting plot is a three-view drawing of the object without any hidden lines. This particular object was especially chosen so there would be no hidden lines in the final output. It should be emphasized that programs do exist for treating the hidden line problem. However, they are considered too complex for the beginning student.

The fourth or last program considers the application of secondary auxiliary views and their role in engineering design. The axonometric plane of projection, onto which the secondary auxiliary view is projected, is defined in terms of the X, Y and Z dimensions of a right prism and one of its diagonals which serves as the line-of-sight arrow. Not only is the line-of-sight parallel with the prism's dia-

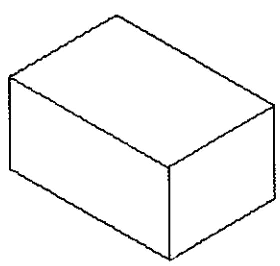
```
C
C    LOUISIANA STATE UNIVERSITY AT BATON ROUGE
C
C    ENGINEERING GRAPHICS DEPARTMENT
C
C    COMPUTER GRAPHICS IN ONE OF ITS SIMPLEST FORMS
C
C    PROBLEM, TO MAKE AN ISOMETRIC DRAWING
C
       DIMENSION BUFFER (5000)
       CALL PLOTS (BUFFER(1),5000)
C    DIMENSION OF OBJECT TO BE DRAWN
       X=3.0
       Y=1.5
       Z=2.0
C    TO CONSTRUCT AN ISOMETRIC DRAWING,AXEX MAKE 30 DEGREES WITH
C  HORIZONTAL AXIS AND Y AXIS VERTICAL.
       Q=30.*3.1416/180.
C
C    COORDINATES FOR PLOTTING POINTS ON ISOMETRIC DRAWING
C
       X1=0.0
       Y1=0.0
       X2=Z*COS(Q)
       Y2=Z*SIN(Q)
C
       X4=0.0
       Y4=Y
       X5=-(X*COS(Q))
       X3=X2
       Y3=Y2+Y
       Y5=X*SIN(Q)
C
       X6=X5
       Y6=Y5+Y
C
       X7=X6+X2
       Y7=Y6+Y2
C
       CALL PLOT(0.0,-15.0,3)
       CALL PLOT(5.0,2.0,-3)
       CALL PLOT(X1,Y1,3)
       CALL PLOT(X2,Y2,2)
       CALL PLOT(X3,Y3,2)
       CALL PLOT(X4,Y4,2)
       CALL PLOT(X1,Y1,2)
       CALL PLOT(X5,Y5,2)
       CALL PLOT(X6,Y6,2)
       CALL PLOT(X7,Y7,2)
       CALL PLOT(X3,Y3,2)
       CALL PLOT(X4,Y4,3)
       CALL PLOT(X6,Y6,2)
       CALL PLOT(0.0,0.0,-3)
       CALL PLOT(0.0,0.0,999)
       STOP
       .END
```

Input: Given the lengths of the x,y, and z axes of the object to be drawn.The above information may be given directly or taken from one or more views of the object. If a two-view drawing is used the x and z coordinates are obtained from the top view while the x and y coorinates are obtained from the front view. The z and y values are in the profile view.



Output: The plot. The values of the coordinates may be printed if desired.

Note: The output is an isometric drawing.

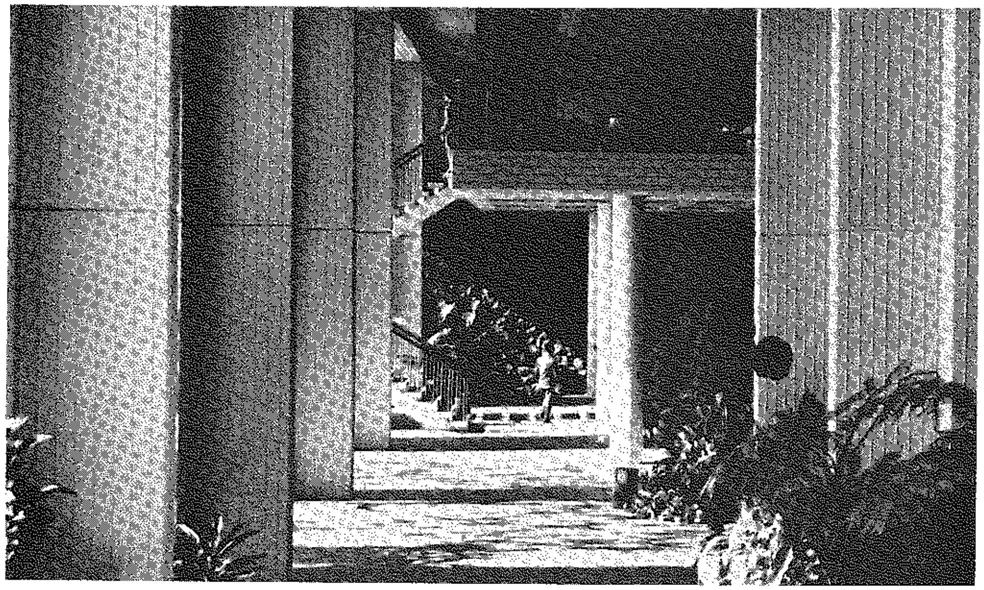


gonal but the corresponding axes of the object and the line-of-sight prism are also parallel. These relationships are well illustrated in the drawing accompanying program four.

Although the program is rather complete with comment statements, the student's attention should be especially directed to the two executable statements just preceeding statement No. 300. It is these two expressions that transform the three-dimensional object onto the two-dimensional surface. Again the problem concerning the hidden line was omitted. The writer has an extension of this program which treats the hidden line and a copy is available upon request.

In summary, it should be re-iterated that computer graphics should be employed to enhance the student's learning of engineering graphics and not used as a substitute for actually drawing the object during the initial learn-

the invigoration of a classic



McGraw-Hill Book Company
proudly announces the eleventh edition of
ENGINEERING DRAWING AND GRAPHIC TECHNOLOGY
Thomas E. French, and Charles J. Vierck, University of Florida

1972, 850 pages (tent.), $12.00 (tent.)

Yes, this renowned text has been rejuvenated with the implementation of the latest refinements in book design.

Realizing recent research has proven that page makeup, effective use of color, illustration placement, and caption content greatly effect the learning process and student retention, Professor Vierck has incorporated these findings while revising his textual material.

In accomplishing his objectives, author Vierck has revitalized the basic layout of the text for easier reference use by the students. Additionally, he has inaugurated the employment of a second color for greater separation within figures and improved readability throughout the volume.

While recognizing the increased emphasis on graphic communication and design in this text, as well as in its briefer version *Fundamentals of Engineering Drawing and Graphic Technology, Third Edition,* Professor Vierck still stresses the development of drafting skills and their precision in his explication.

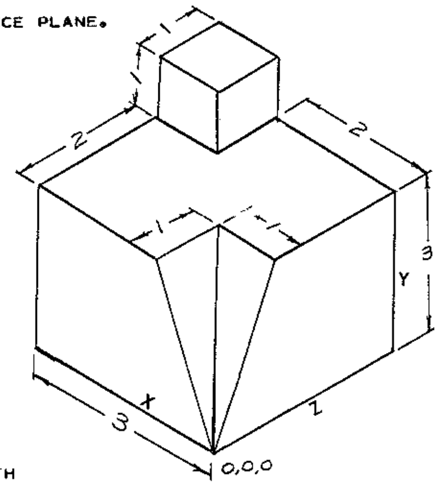
FUNDAMENTALS OF ENGINEERING DRAWING AND GRAPHIC TECHNOLOGY, third edition

1972, 604 pages (tent.), $9.00 (tent.)

This briefer edition of the standard text in engineering drawing for over six decades incorporates all the major changes and refinements in design, format, and use of color of the larger version. A compilation of the first eleven chapters, the third edition has been expanded to include an additional chapter on drawing for engineering design and construction, as well as containing many of the appendices from *Engineering Drawing.*

Beginning with an examination of the instruments used in drawing, this handbook of techniques continues through to discussions of lettering, sketching, and design.

```
C            ORTHOGRAPHIC  PROJECTION
      DIMENSION BUFFER (5000)
      DIMENSION TOP(100.3).FRONT(100.3).RSIDE(100.3)
      DIMENSION X(50). Y(50). Z(50). IC(45)
      DIMENSION XA(50). YA(50)
      CALL PLOTS (BUFFER(1).5000)
      READ(5.12)X1.Y1
C     ESTABLISH A MINIMUM DISTANCE FROM EACH VIEW TO REFERENCE PLANE.
C     H=DISTANCE BELOW H--PLANE
C     D=DISTANCE BEHIND F--PLANE
C     W=DISTANCE TO RIGHT OF P--PLANE
 12   FORMAT(2F5.1)
      READ(5.13)W.H.D
 13   FORMAT(3F5.2)
C     X=WIDTH--MEASURED FROM RIGHT SIDE OF OBJECT
C     Y=HEIGHT--MEASURED FROM TOP OF OBJECT
C     Z=DEPTH--MEASURED FROM FRONT OF OBJECT
C     IC(I)=PEN CONTROL
      I=1
      WRITE(6.1006)
   27 READ(5.16)X(I).Y(I).Z(I).IC(I)
 1006 FORMAT(3X.'X(I)  Y(I)  Z(I)        IC(I)'.//)
      WRITE(6.46)X(I).Y(I).Z(I).IC(I)
      N=I
      I=I+1
      IF(IC(N).NE.999)GOTO27
  46  FORMAT(1X.3F6.2.1I10)
C     CONSTRUCT ARRAYS FOR EACH VIEW
C     ARRAY TOP(I.1)IS FOR WIDTH. TOP(I.2)IS FOR DEPTH
C     ARRAY FRONT(I.1) IS FOR HEIGHT. FRONT(I.2) IS FOR WIDTH
C     ARRAY RSIDE(I.1) IS FOR HEIGHT. RSIDE(I.2) IS FOR DEPTH
 16   FORMAT(3F10.1. 1I5)
C     N=NUMBER OF PEN MOVEMENTS
 22   WRITE(6.138) I
 138  FORMAT(1X.'I='.I5/)
      WRITE(6.142) N
 142  FORMAT(1X.'N='.I5//)
      K=N-1
      DO200I=1.K
      TOP(I.1)=-(X(I)+W)
      TOP(I.2)=(Z(I)+D)
      FRONT(I.1)=TOP(I.1)
      FRONT(I.2)=-(Y(I)+H)
      RSIDE(I.1)=FRONT(I.2)
      RSIDE(I.2)=TOP(I.2)
 100  WRITE(6.44)TOP(I.1).TOP(I.2).FRONT(I.1).FRONT(I.2).RSIDE(I.1).RSID
     1E(I.2).IC(I)
 44   FORMAT(1X.6F15.2.I15)
 200  CONTINUE
      CALL PLOT(10..10..-3)
      CALL PLOT(-5..0..3)
      CALL PLOT(5..0..2)
      CALL PLOT(0..-5..3)
      CALL PLOT(0..5..2)
      DO 39I=1.K
      XH=TOP(I.1)
      YH=TOP(I.2)
      II=IC(I)
      CALL PLOT(XH.YH.II)
 39   CONTINUE
      DO 49 I=1.K
      XF=FRONT(I.1)
      YF=FRONT(I.2)
      II=IC(I)
      CALL PLOT(XF.YF.II)
 49   CONTINUE
      DO 59 I=1.K
      XP=RSIDE(I.2)
      YP=RSIDE(I.1)
      II=IC(I)
      CALL PLOT(XP.YP.II)
 59   CONTINUE
      CALL PLOT(0.0.0.0.-3)
      CALL PLOT(0.0.0.0.999)
      STOP
      END
```



<u>INPUT</u>: The student is given the pictorial view of the object with dimensions and the origin designated as shown in the illustration.

The X,Y,Z coordinate values for each corner is established with respect to the origin and entered as data on a coding form. This information is punched onto cards and submitted into the main program.

<u>OUTPUT</u>: Printed data that was read in, the computed value for each point to be plotted in each view, and a three-view drawing.

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ing period. Rather, it should be carefully introduced after the student has been instructed in the fundamentals of projection.

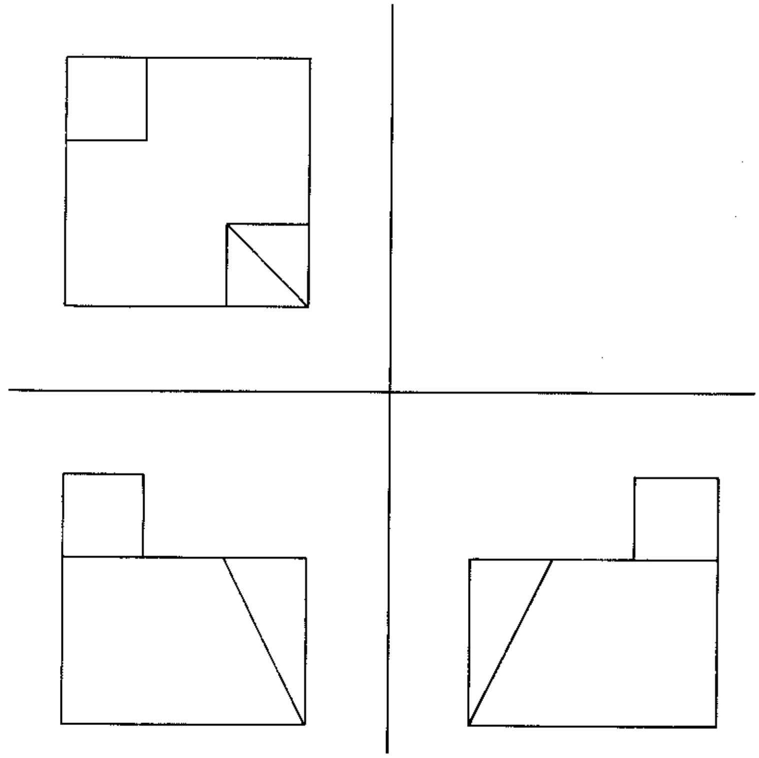
The engineering graphics educator must not overlook a significant learning situation which is an inherent by-product of computer graphics work. That is, the strengthening of the student's understanding of applied mathematics. Since the computer is a calculating device and all graphical information must be converted to digitized data before submitting

Input Data

X(I)	Y(I)	Z(I)	IC(I)
0.0	0.0	0.0	3
3.00	0.0	0.0	3
3.00	0.0	2.00	3
3.00	0.0	3.00	2
2.00	0.0	3.00	2
2.00	0.0	2.00	2
3.00	0.0	2.00	2
3.00	1.00	2.00	2
2.00	1.00	2.00	2
2.00	1.00	3.00	2
2.00	0.0	3.00	2
2.00	1.00	3.00	3
0.0	1.00	3.00	2
0.0	1.00	1.00	2
1.00	1.00	1.00	2
1.00	1.00	0.0	2
3.00	1.00	0.0	2
3.00	1.00	2.00	2
3.00	1.00	0.0	3
3.00	3.00	0.0	2
0.0	3.00	0.0	2
0.0	3.00	3.00	2
0.0	1.00	3.00	2
0.0	1.00	1.00	3
0.0	3.00	0.0	2
1.00	1.00	0.0	2
1.00	1.00	1.00	3
0.0	3.00	0.0	2
0.0	3.00	3.00	3
3.00	3.00	3.00	2
3.00	3.00	0.0	2
3.00	3.00	3.00	3
3.00	0.0	3.00	2
2.00	1.00	2.00	3
2.00	0.0	2.00	2
0.0	0.0	0.0	3
0.0	0.0	0.0	999

I= 38

N= 37



TOP VIEW		FRONT VIEW		R. SIDE VIEW		PEN CONTROL
(X)	(Z)	(X)	(Y)	(Z)	(Y)	IC
-1.00	1.00	-1.00	-1.00	-1.00	1.00	3
-4.00	1.00	-4.00	-1.00	-1.00	1.00	3
-4.00	3.00	-4.00	-1.00	-1.00	3.00	3
-4.00	4.00	-4.00	-1.00	-1.00	4.00	2
-3.00	4.00	-3.00	-1.00	-1.00	4.00	2
-3.00	3.00	-3.00	-1.00	-1.00	3.00	2
-4.00	3.00	-4.00	-1.00	-1.00	3.00	2
-4.00	3.00	-4.00	-2.00	-2.00	3.00	2
-3.00	3.00	-3.00	-2.00	-2.00	3.00	2
-3.00	4.00	-3.00	-2.00	-2.00	4.00	2
-3.00	4.00	-3.00	-1.00	-1.00	4.00	2
-3.00	4.00	-3.00	-2.00	-2.00	4.00	3
-1.00	4.00	-1.00	-2.00	-2.00	4.00	2
-1.00	2.00	-1.00	-2.00	-2.00	2.00	2
-2.00	2.00	-2.00	-2.00	-2.00	2.00	2
-2.00	1.00	-2.00	-2.00	-2.00	1.00	2
-4.00	1.00	-4.00	-2.00	-2.00	1.00	2
-4.00	3.00	-4.00	-2.00	-2.00	3.00	2
-4.00	1.00	-4.00	-2.00	-2.00	1.00	3
-4.00	1.00	-4.00	-4.00	-4.00	1.00	2
-1.00	1.00	-1.00	-4.00	-4.00	1.00	2
-1.00	4.00	-1.00	-4.00	-4.00	4.00	2
-1.00	4.00	-1.00	-2.00	-2.00	4.00	2
-1.00	2.00	-1.00	-2.00	-2.00	2.00	3
-1.00	1.00	-1.00	-4.00	-4.00	1.00	2
-2.00	1.00	-2.00	-2.00	-2.00	1.00	2
-2.00	2.00	-2.00	-2.00	-2.00	2.00	3
-1.00	1.00	-1.00	-4.00	-4.00	1.00	2
-1.00	4.00	-1.00	-4.00	-4.00	4.00	3
-4.00	4.00	-4.00	-4.00	-4.00	4.00	2
-4.00	1.00	-4.00	-4.00	-4.00	1.00	2
-4.00	4.00	-4.00	-4.00	-4.00	4.00	3
-4.00	4.00	-4.00	-1.00	-1.00	4.00	2
-3.00	3.00	-3.00	-2.00	-2.00	3.00	3
-3.00	3.00	-3.00	-1.00	-1.00	3.00	2
-1.00	1.00	-1.00	-1.00	-1.00	1.00	3

it to the computer, the student soon learns the significance of applied geometry and algebra. His level of motivation is often improved as he observes the graphical output of the different programs. Here for the first time he is able to define and plot forms and shapes in a manner that man has not previously witnessed. Not only may he develop these various forms, but he can have them intersect and define their line(s) of intersection.

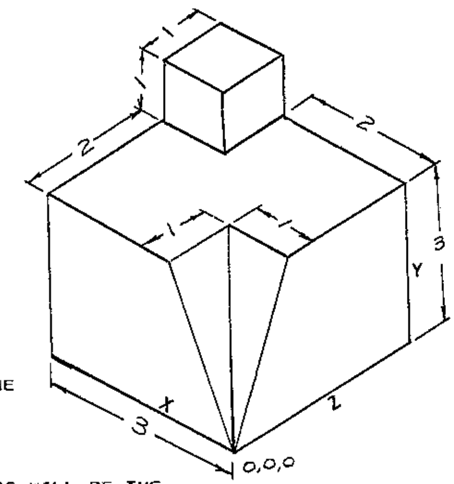
In closing, may I reiterate that we educators have the golden opportunity to bring the study of descriptive geometry into its full fruition as a pedagogical discipline for teaching design and creativeness through the use of computer graphics at the freshman level.

I want to thank you for being such a kind audience this morning and if the Engineering Graphics Department staff of Louisiana

Program 4

Axonometric Projection

```
C
      DIMENSION X(50),Y(50),Z(50),IC(50),NA(50),XX(50),YY(50)
      DIMENSION XPLOT(50),YPLOT(50)
      DIMENSION BUFFER (5000)
      CALL PLOTS (BUFFER(1),5000)
C
C  DIMENSIONS OF LINE OF SIGHT PRISM
C     READ(5,1)X,Y,Z
C  1  FORMAT(3F5.1)
C DIMENSIONS XP,YP,ZP ARE THE LENGTHS OF THE AXES OF LINE OF SIGHT PRISM
      XP=1.0
      YP=1.0
      ZP=1.0
C
C  LENGH OF DIAGONAL OR LINE OF SIGHT LM
      DIAG=(XP*XP+YP*YP+ZP*ZP)**0.5
C
C  PRINCIPAL PROJECTION OF DIAGONAL LM
      PDIAGH=(XP*XP+ZP*ZP)**0.5
      PDIAGF=(XP*XP+YP*YP)**0.5
      PDIAGP=(ZP*ZP+YP*YP)**0.5
C
C  DEFINE ANGLES U,V,W IN TERMS OF XP,YP AND ZP
C
      U=ATAN(ZP/XP)
      V=ATAN(YP/XP)
      W=ATAN(YP/ZP)
C
C  AXONOMETRIC PLANE IS PERPENDICULAR TO DIAGONAL LM.
C  DETERMINE LENGTH OF LINES AB,AC,BC OF AXONOMETRIC PLANE
      AB=ZP/COS(U)
      AC=ZP*TAN(U)/SIN(V)
      BC=ZP/SIN(W)
C
C  THE ALTITUDES OF TRIANGULAR PLANE(AXONOMETRIC PLANE)ABC WILL BE THE
C AXOMETRIC AXES OF PICTORIAL VIEW. THE ORTHOCENTER OF PLANE IS THE
C ORIGIN. THE ORIGIN IS THE ORTHOGRAPHIC PROJECTION OF POINT L OF LINE
C OF SIGHT PRISM ONTO AXONOMETRIC PLANE.
C
C  THE ANGLES ALPHA,BETA,PHI ARE THE ANGLES BETWEEN THE X,Z,Y AXES OF
C LINE OF SIGHT PRISM AND AXONOMETRIC PLANE ABC.THESE ANGLES ARE
C DEFINED AS.
C
      ALPHA=ATAN(YP/PDIAGH)
      BETA=ATAN(ZP/PDIAGF)
      PHI=ATAN(XP/PDIAGP)
C
C THE PROJECTIONS OF THE XP,YP,ZP AXES ONTO THE AXONOMETRIC PLANE GIVES
C  AO,BO,CO
C
      AO=ZP*TAN(U)*COS(ALPHA)
      BO=ZP*COS(BETA)
      CO=(ZP*TAN(U)/TAN(V))*COS(PHI)
C
C     CO=CL*COS(PHI),WHERE CL=AL/TAN(V)
C     BO=AL*COS(ALPHA),WRERE AL=ZP*TAN(U)
C   POSITION AXONOMETRIC AXES SO CO.THE YP AXIS IS VERTICAL AS SHOWN
C IN CONVENTIONAL ORIENTATION
C
C  DEFINE  OBTUSE ANGLES AOB, COA,BOC AS ANGLES BETWEEN AXONOMETRIC
C  AXES. USE LAW OF COSINE.
C
C
      BOC=ARCOS((CO*CO+BO*BO-BC*BC)/(2.0*BO*CO))
C
      COA=ARCOS((CO*CO+AO*AO-AC*AC)/(2.0*AO*CO))
C
      AOB=ARCOS((AO*AO+BO*BO-AB*AB)/(2.0*AO*BO))
C
C   EXPRESS ANGLES AOB,COA,BOC IN DEGRES ,AOB=AAOB,ETC.
C
      AAOB=AOB* 180./3.1416
      ACOA=COA* 180./3.1416
      ABOC=BOC* 180./3.1416
C
      WRITE(6,3)AAOB,ACOA,ABOC
    3 FORMAT(10X,'ANGLE AOB=',F7.2,10X,'ANGLE COA=',F7.2,10X,'ANGLE BOC=
     1',F7.2//)
```



Input:
Same as for Program 3.

Output: Data for plotting on axonometric on axonometric plane, a plot of the axonometric plane,ABC and a plot of the axonometric projection of the object.

Note: The program will produce a dimetric or a trimetric projection as well as the isometric. If any two axes of the line of sight prism are equal and yet not equal to the third axis the projection will be dimetric. If all three axes are of unequal lengths the projection will be trimetric.

```
C
C  P IS THE VALUE OF THE SUM OF COSINES SQUARED
      P=(COS(ALPHA))**2.+(COS(BETA))**2.+(COS(PHI))**2.
      WRITE(6,4)P
    4 FORMAT(10X,'P= ',F5.0//)
      CALL PLOT(5.0,5.0,-3)
      CALL PLOT(0.0,0.0,3)
C    FOR THE AXONOMETRIC PLOT OF THE PLANE AND ITS AXES THE Y-AXIS (CO)
C  IS VERTICAL
      CALL PLOT(0.0,-CO,2)
      CALL PLOT(0.0,0.0,3)
C
C
C   ANGLES Q1 AND Q2 ARE THE ANGLES BETWEEN AXES BO AND AO AND THE  X-
C  AXIS OF THE PLOTTER OR A HORIZONTAL LINE THROUGH THE ORIGIN OF THE
C   AXONOMETRIC PLANE
      Q2=(COA-3.1416/2.0)
      Q1=BOC-3.1416/2.0
C   DEFINE THE X,Y COMPONENTS OF BO(Z-AXONOMETRIC AXIS)
C
      XBO=BO*COS(Q1)
      YBO=BO*SIN(Q1)
      CALL PLOT(XBO,YBO,2)
      CALL PLOT(0.0,0.0,3)
C   DEFINE THE X,Y COMPONENTS OF AO(X-AXONOMETRIC AXIS)
C
C   FOR THE AXONOMETRIC PLOT THE X-COMPONENT OF AO IS NEGATIVE
      XAO=-(AO*COS(Q2))
      YAO=(AO*SIN(Q2))
      CALL PLOT(XAO,YAO,2)
      CALL PLOT(0.0,-CO,2)
      CALL PLOT(XBO,YBO,2)
      CALL PLOT(XAO,YAO,2)
      CALL PLOT(-5.0,-5.0,-3)
C  IC(I) IS THE PEN CONTROL UP OR DOWN,NA(I) IS FOR HIDDEN LINES
C  X(I),Y(I),Z(I) ARE X,Y,Z COORDINATES OF OBJECT TO BE DRAWN
C
C   THE HIDDEN LINE TECHNIQUE WAS NOT EMPLOYED IN THID ONE PROGRAM
      I=1
      WRITE(6,19)
   19 FORMAT(11X,'X(I)',11X,'Y(I)',11X,'Z(I)',14X,'IC(I)',14X,'NA(I)'//)
   27 READ(5,7)X(I),Y(I),Z(I),IC(I),NA(I)
    7 FORMAT(3F10.1,2I5)
C
      WRITE(6,9)X(I),Y(I),Z(I),IC(I),NA(I)
    9 FORMAT(10X,F5.1,10X,F5.1,10X,F5.1,10X,I10,10X,I10)
      N=I
      I=I+1
      IF(IC(N).NE.999) GO TO 27
      K=N-1
      WRITE(6,270)
  270 FORMAT(10X,'I',10X,'N'/)
      WRITE(6,271) I,N
  271 FORMAT(6X,I5,6X,I5,//)
C
C    XX(I) AND YY(I) ARE THE X AND Y COORDINATES OF POINTS ON THE
C    OBJECT PROJECTED ONTO THE AXONOMETRIC PLANE
C
      WRITE(6,276)
  276 FORMAT(10X,'XX(I)',10X,'YY(I)',10X,'XPLOT',10X,'YPLOT',//)
      DO 300 I=1,K
      XX(I)=X(I)*COS(ALPHA)+Y(I)*COS(PHI)*SIN(BOC)/SIN(AOB)
      YY(I)=Z(I)*COS(BETA)+Y(I)*COS(PHI)*SIN(COA)/SIN(AOB)
  300 CONTINUE
      CALL PLOT(5.0,10.0,-3)
C
C    XPLOT(I) AND YPLOT(I) ARE THE X AND Y COORDINATES OF THE
C    PROJECTED POINTS SITUATED FOR PLOTTING
C
      DO 260 I=1,K
      XPLOT(I)=(YY(I)*COS(Q1)-XX(I)*COS(Q2))
      YPLOT(I)=(XX(I)*SIN(Q2)+YY(I)*SIN(Q1))
      CALL PLOT(XPLOT(I),YPLOT(I),IC(I))
  275 FORMAT(10X,4F10.2)
      WRITE(6,275) XX(I),YY(I),XPLOT(I),YPLOT(I)
  260 CONTINUE
      CALL PLOT(0.0,0.0,3)
      CALL PLOT(0.0,0.0,999)
      STOP
      END
```

ANGLE AOB= 120.00 ANGLE COA= 120.00 ANGLE BOC= 120.00

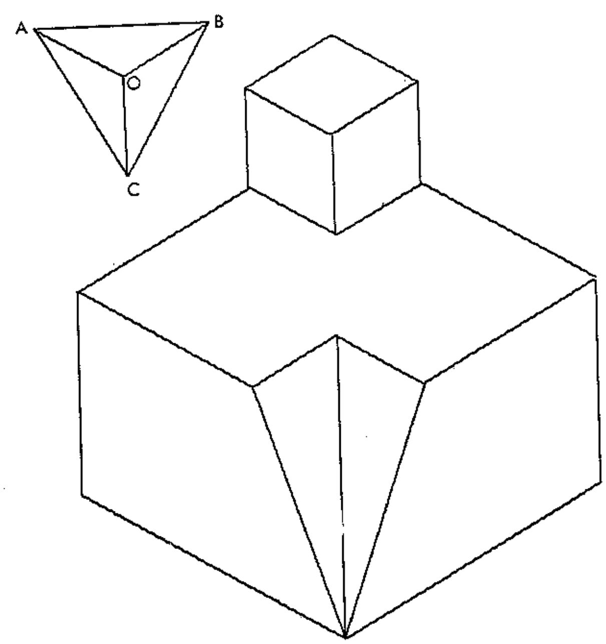
P= 2.

Input Data

X(I)	Y(I)	Z(I)	IC(I)	NA(I)
0.0	0.0	0.0	-3	0
0.0	0.0	3.0	2	0
0.0	2.0	3.0	2	0
0.0	2.0	1.0	2	0
0.0	0.0	0.0	2	0
0.0	2.0	1.0	3	0
1.0	2.0	1.0	2	0
0.0	0.0	0.0	2	0
1.0	2.0	1.0	3	0
1.0	2.0	0.0	2	0
0.0	0.0	0.0	2	0
3.0	0.0	0.0	2	0
3.0	2.0	0.0	2	0
1.0	2.0	0.0	2	0
3.0	2.0	0.0	3	0
3.0	2.0	2.0	2	0
3.0	3.0	2.0	2	0
3.0	3.0	3.0	2	0
2.0	3.0	3.0	2	0
2.0	3.0	2.0	2	0
3.0	3.0	2.0	2	0
3.0	2.0	2.0	3	0
2.0	2.0	2.0	2	0
2.0	3.0	2.0	2	0
2.0	2.0	2.0	3	0
2.0	2.0	3.0	2	0
2.0	3.0	3.0	3	0
2.0	2.0	3.0	2	0
0.0	2.0	3.0	2	0
0.0	0.0	0.0	3	0
0.0	0.0	0.0	999	0

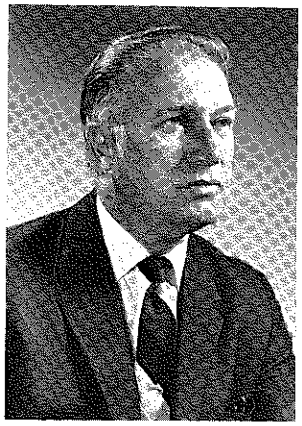
I	N
32	31

XX(I)	YY(I)	XPLOT	YPLOT
0.0	0.0	0.0	0.0
0.0	2.45	2.12	1.22
1.63	4.08	2.12	2.86
1.63	2.45	0.71	2.04
0.0	0.0	0.0	0.0
1.63	2.45	0.71	2.04
2.45	2.45	0.0	2.45
0.0	0.0	0.0	0.0
2.45	2.45	0.0	2.45
2.45	1.63	-0.71	2.04
0.0	0.0	0.0	0.0
2.45	0.0	-2.12	1.22
4.08	1.63	-2.12	2.86
2.45	1.63	-0.71	2.04
4.08	1.63	-2.12	2.86
4.08	3.27	-0.71	3.67
4.90	4.08	-0.71	4.49
4.90	4.90	0.0	4.90
4.08	4.90	0.71	4.49
4.08	4.08	0.0	4.08
4.90	4.08	-0.71	4.49
4.08	3.27	-0.71	3.67
3.27	3.27	0.0	3.27
4.08	4.08	0.0	4.08
3.27	3.27	0.0	3.27
3.27	4.08	0.71	3.67
4.08	4.90	0.71	4.49
3.27	4.08	0.71	3.67
1.63	4.08	2.12	2.86
0.0	0.0	0.0	0.0



Axonometric Projection
(Isometric)

(See GRAPHICS - p. 42)



1971-72 and the Next Decade

ANNUAL REPORT TO THE ASEE DIVISION OF ENGINEERING DESIGN GRAPHICS - BY - CHAIRMAN PERCY H. HILL, TUFTS UNIVERSITY

"An examination of today's engineering college curricula shows that only a few courses are at all design oriented, and these seem to appear in the junior or senior years of the undergraduate program. If you wanted to train a champion tennis player, a champion skier, or a champion yachtsman, you would not teach him all possible theory and analysis first and then turn him out to play the game. You would teach him all this, but you would also put a tennis racket, a ski pole, or a tiller in his hand at the earliest possible age. He would learn his theory and be coached while practicing his sport.

The good designer should practice and be coached in his profession from the earliest possible age, from the freshman year in college through the doctorate degree. During his formative college period, he would then develop the intuitive judgement so essential to a creative engineer.---"

---

from a paper INDUSTRY NEEDS FOR DESIGN ORIENTED ENGINEERING GRADUATES by Ira Grant Hedrick, Vice President - Engineering, Grumman Aircraft Engineering Corporation.

This is the kind of thinking members of the Division have been responding to in recent years and their actions have been such as to render Mr. Hendrick's examination inaccurate . This is so today more than ever with emphasis on creative design education with engineering graphics as the vehicle of instruction. We are beginning to see the digital and analog computers take their place alongside graphics as fundamental to design education. As Division Chairman I can point with pride to the achievements of a number of dedicated educators who are attempting to get to the heart of the problem of educating today's engineering student. This includes approximately 950 members of the Division. About 10% or 95 members from 70 institutions distributed throughout the U. S. and Canada are actively involved in committee work. It is this dedication to engineering education and a sincere desire to further the aims and objectives of the Division that make us strong and influential. This has been an excellent year for me; a year of appreciation to ASEE colleagues who are sincerely devoted to Division activities and further the cause that has been established, forging ahead in new frontiers. This cause involves the communication of techniques and methodology and the professsionalism necessary to advance the state-of-the-art in design graphics. This has been a year for me of total involvement in all of the activities of the Division, and for this opportunity I am most grateful. At the time of this annual report, we can point with pride to the following inventory of activities for the year 1971-72:

(1) Mid-year conferences are to be held at off-campus sites in convention areas offering central transportation facilities with attractive accommodations in a geographical area known for its recreation attractions. The November 4 and 5, 1971 Mid-year conference was held at the multimillion dollar Galleria complex in Houston, Texas jointly hosted by Rice, Houston, and Texas A&M universities. The program included a number of thought provoking papers in the general area of design graphics including computer graphics, engineering graphics, and a general discussion of curriculum reform. The conference was concluded with guided tours of the Astradome and the NASA Space Center. The Mid-year Conference in 1972 will be held in January in Denver, hosted by the University of Colorado and Gramercy Guild Group. Plans are now under way for an exciting meeting.

(2) The Journal of Engineering Design Graphics is published three times a year - fall, winter, and spring - and is now in its 36th consecutive year. Publication is achieved through the efforts of non-paid volunteers.

(3) The Creative Design Displays (design competition), now in its 5th consecutive year, is an all-ASEE function sponsored by the Division and participated in by all Divisions and Committees. It is being held this year in June at the Annual Conference at Texas Tech and is organized by two most important Division Committees: one on displays, the other on judges.

(4) The year 1971-72 saw the conclusion of the Division's Self Study. This self examination into the organization, objectives, and goals of the Society culminated in a final report from committees representing members East and West. This report was presented to the membership in the Journal and at the Mid-year Conference in Houston. At this conference an Implementation Committee was formed to produce the mechanism to implement the recommendations made as a result of the Self Study. The committee has met and formed a plan for implementation which is now in effect. These changes are intended to make our efforts as a Division of ASEE more relevant to the changing emphasis in engineering education.

(5) The program at the Annual Conference at Texas Tech in June of 1972 embraces the following areas of interest to our members: Creative Design, Human Factors in Design, joint design session with the Engineering Design Committee, joint B. S. - B. E. T. session with the Technical Institute Division, and the Computer Graphics Summer School. This meeting promises to be one of our very best.

(6) The first brochure designed to attract new members to ASEE and the Division was prepared in early 1972 and has been distributed throughout the country. It, singularly, has been responsible for bringing in the largest membership to the Division in any one year.

The foregoing is evidence that we have an active Division, probably the most active in ASEE. This kind of activity makes me proud to be a member, makes me proud that more is written in the areas of graphics and design than any other discipline in engineering and as much as many of them combined. This has been my best year as a member for I was totally involved in Division activities and realized, for the first time, the number of dedicated and hard-working individuals that make up our membership. My best advice to members, if they really want to benefit from what the Division has to offer, is to get involved; join a committee; work for the Division; and above all, attend meetings. This has been an easy year for me; one of coordinating activities of our many committees and minimal attention to putting out small fires. These fires prove we have an active membership, a dynamic membership, who intend to do something about engineering education.

The future of engineering education with emphasis on engineering design graphics (graphics - design - computer) looks bright in the next decade. The recent Nixon "cutbacks" although drastic in nature and upsetting to many academicians, have played right into our hands. We no longer see a reduction in time allocated to our courses and I predict that we will be requested to increase this time in the near future for the following reasons:

(A) To motivate students at the freshman level to remain in engineering. A carrot.

(B) To offer courses where students in the Liberal Arts may enroll to learn of technology without numerous prerequisites.

(C) The return to engineering fundamentals through a reduction of the engineering sciences.

(D) The new B. E. T. degree programs will more and more demand graphics and design as their introductory courses of study.

The next decade affords members of the Division and scholars of graphics and design a number of excellent opportunities. We must seize these opportunities as we have in the past to continue as leaders in engineering education. These opportunities involve:

Techniques of instruction and methodology of creative engineering design.

Efficient instruction in graphics fundamentals; programmed instruction -- independent study -- use of television -- need to know instruction -- etc.

Computer graphics as a device to release the individual to creative thinking (computer aided design graphics).

Human factors in design.

Group dynamics in team design situations.

Operations research (decision theory, case studies, management techniques, decision modeling).

Systems design at the introductory level.

C. P. M. /P. E. R. T. and other organizational techniques.

Design critique presentation techniques.

Legal aspects of engineering design and consumer product liability.

These are but a few of the opportunities available to instructors of engineering design graphics. To deviate from our present course and objectives in the next decade would be a mistake. It is now a known fact that the industrial complex in the U. S. will withdraw from fundamental ("blue sky") research and will focus its technological attention on applications engineering. This means an emphasis on ecological problems, transportation and related areas, productive new power sources, and new products. If there was ever a right time for engineering design graphics to expand its horizons and to become more influential to engineering education, it is NOW!

Percy H. Hill
Division Chairman
1971-72

Participate in Your Profession - Enhance Your Career

Engineering Design Graphics Journal invites you to submit your papers and articles for publication. It is through the continual presentation of timely, vital articles on graphics and design that the only Journal exclusively serving your field, can continue to fulfill the voracious "need to know" technical appetites of its readers.

Articles in the following broad subject areas are particularly encouraged: Computer Graphics, Engineering Graphics, Research in Graphics, Teaching Techniques and Methods, Human Factors, and Creative Design. Journal authors know that when their papers are published in Engineering Design Graphics Journal, they benefit in terms of increased prestige and professional stature. Through the Journal's pages, information is disseminated, knowledge shared, problems aired and solutions offered. Most of all, you share in the satisfaction gained from contributing significantly to advancement in your field.

Our Editorial Department is available for any assistance you may require. We will be pleased to discuss your plans for an article with you and help in any way we can.

Call or write:

Al Romeo, Acting Editor
Engineering Graphics, OSU
2070 Neil Ave., Cols., O. 43210
Phone: (Area Code 614) 422-2358

Engineering Design Graphics Division Sessions
1972 ASEE Annual Meeting

Day	Time	Theme
Monday	7:30 a. m.	Executive Committee, Breakfast Meeting (closed) Percy H. Hill, Tufts University
	3:45 p. m.	Techniques of Creative Problem Solving The Role of Visualization in Creative Behavior R. A. Faste, Syracuse University Laboratory in Consumer Product Evaluation A. H. Clemow, Tufts University Programmed Invention S. W. Miller, Van Dyck Corp.
Tuesday	12 noon	Division Luncheon and Business Meeting (open) William B. Rogers, V. P. I.
	6:00 p. m.	Division Annual Banquet Percy H. Hill, Tufts University
	7:30 p. m.	Engineering Design Rap Session (Joint session w/M. E. Division Design Comm.)
Wednesday	10:00 a. m.	Human Factors Engineering Human Factors and Design Engineering J. G. Kreifeldt, Tufts University Teaching Human Factors W. R. Ferrell, University of Arizona Human Factors - Present and Future Needs W. G. Matheny, Life Science, Inc.
	1:45 p. m.	Computer Graphics Summer School Registration Fortran Programming E. V. Mochel
Thursday	9:00 a. m.	Computer Graphics Summer School Two-Dimensional Computer Graphics (Elementary program for a Plotter) Jack Brown, Texas A & M Programming Workshop Clarence Hall & Staff
	2:00 p. m.	Computer Graphics Summer School Plotting Applications Clarence Hall, Louisiana State Univ. Programming Workshop E. V. Mochel & Staff
Friday	9:00 a. m.	Computer Graphics Summer School Three-Dimensional Programs Byard Houck, North Carolina State Univ. Programming Workshop E. V. Mochel & Staff
	2:00 p. m.	Computer Graphics Summer School Space Geometry E. V. Mochel, Univ. of Virginia Choosing Equipment for Computer Graphics M. H. Pleck, University of Illinois

Perspective

Jasper Gerardi Retires

Jasper Gerardi, Associate Dean, College of Engineering, University of Detroit, plans to retire effective May 1, 1972.

Dean Gerardi was born in Detroit, Michigan, December 6, 1906. He graduated from Case Technical High School in that city in 1924. Following graduation from the University of Detroit in 1929 with the degree, Bachelor of Civil Engineering, he remained there on the staff of the College of Engineering. During his undergraduate days he had served as a student assistant in Engineering Drawing and Surveying.

While working on a five-year co-op course, he also acquired valuable industrial experience with George Jerome (Civil Engineers and Surveyors), Postiff and Tappan (Civil Engineers and Surveyors), and Wood Construction Company in Detroit. He attended the University of Michigan parttime 1933-35 and graduated with a master of science degree in structural engineering.

In 1935, Jasper married Gertrude Knoll of Detroit and they are the parents of four children.

Jasper was named Professor and Chairman of Engineering Drawing in that department in 1943 and served in that capacity until 1947, when he was named Associate Dean of the College of Engineering. Dean Gerardi still maintains his interest in Engineering Graphics and has continued to teach various courses in his parent department, as well as Mathematics, Engineering Mechanics, and Surveying.

Jasper became a registered professional civil engineer in the state of Michigan in 1948 and has been employed several summers on special assignments by Detroit Edison Company; Mason L. Brown Company, Civil Engineers; Detroit Engineering Service; Puffard and Darling (tool designers); Nash-Kelvinator Co., Burroughs Corp., etc.

His professional activities include: American Standards Association (ASA) (Section Committee B-46 Chairman; Executive Committee Y-14), American Society for Engineering Education (ASEE) (Aims and Scope of Engineering Graphics Courses Committee Consultant; Executive Committee; General Council Committee; Policy Committee), Engineering Society of Detroit (ESD) (Executive Committee; Junior Section Advisor; Educational Committee Chairman), Society of Automotive Engineers, Inc. (SAE) (Automotive Drafting Standards Committee, Vice-Chairman; Aero-Auto Drafting Standards Committee a. Delegate representing American interests in International Conference on American, British, and Canadian Engineering Drawing Standards; and b. Microfilming Subcommittee Chairman); Standards Engineering Society (SES); National Honor Societies: (Tau Beta Pi Association, Michigan Delta Chapter; Chi Epsilon Fraternity, Civil Engineering).

Among Dean Gerardi's engineering and research interests and activities through the years are the following: Research development of metal blades for helicopters, Nash-Kelvinator Company (1943-45). Engineering Consultant on titanium, electronic computers and air cleaners for military vehicles, Detroit Tank Arsenal (1954-55). Consultant on Engineering Standards, Burroughs Corporation (1955-56). Consultant for National Science Foundation Project - Graphics Course Content Development Study.

Dean Gerardi's publications include: fifteen articles published through the years 1939-1965 in the Journal of Engineering Drawing (and the Journal of Engineering Graphics); two articles in Product Machinery Magazine; three in the Society of Automotive Engineers Journal; one article in Jesuit Quarterly; and one article in Business Week.

In recognition as a truly great engineering educator, administrator and dynamic and forceful leader, Dean Jasper Gerardi has been significantly honored by receiving the following awards:

(See GERARDI - p. 40)

A Survey of JOURNAL Readers

Klaus E. Kroner, Advertising Manager

Some time ago it was decided that it would be helpful, particularly in the work of the advertising manager, to obtain data about the readership of the Journal. For this purpose, a questionnaire was sent to all subscribers in late November. Usable returns amounted to 36.5% which is a very good response to a mail conducted survey. We thank the readers for their cooperation which also indicated their personal interest in the affairs of the Journal.

The results of the survey are given below without any attempt to interpret the answers at this time. In some cases the percentages do not add up to 100% because of rounding.

1. Subscribed to Journal for how many years?

0 - 4 yrs.	37%
5 - 9 yrs.	22
10 - 14 yrs.	7
15 - 19 yrs.	10
20 - 24 yrs.	10
25 yrs. or more	13

(5 years represented the median)

2. Your present age?

26 or under	1%
26 - 25	14
36 - 45	21
46 - 55	31
56 - 65	20
over 65	13

3. Your position? (if more than one checked, only one counted)

Instructor	20%
Asst. Prof.	17
Assoc. Prof	15
Professor	12
Head of Dept.	16
Other Academic Admin.	6
In Industry	6
Retired	9

4. Your position is at a:

High School	9%
Community College	16
2-yr. tech. inst.	9
4-yr. college or univ.	52
Manuf. company	3
Library	7
Other	3

5. Indicate with 1, 2, and 3 the ranking by importance of your three major areas of professional interest:

	1st	2nd	3rd
computer graphics	8%	9%	13%
descriptive geometry	17	28	15
engineering design	23	22	31
engineering drawing	34	25	20
freshman orientation	4	5	7
mechanical engineering	6	6	10
other	9	6	3

6. You read the Journal:

from cover to cover	36%
selectively	64%

7. Your copy of the Journal is usually shared by how many other readers?

None	39%
1	23
2	10
3	9
more	20

8. If you are currently an educator, typically how many students do you have in your classes per year?

fewer than 50 students	12%
50 to 95	22
100 to 145	23
150 to 195	17
200 to 245	14
250 to 295	6
over 300	7

120 students per year represented the median.

9. During the past 3 years have you used a textbook which was advertised in the Journal?

Yes - 78% No - 22%

10. During the past three years have your students used any instruments or other products which were advertised in the Journal?

Yes - 89% No - 11%

Summer School on Computer Graphics

Suggestions for Attendees

The first session of the Summer School on Wednesday, June 21 is particularly design - ed for aid to those attending with no previous experience in FORTRAN programming. If you have had this experience, you will probably want to skip the first session.

Anyone attending with no previous computer experience should familiarize themselves with the computer facilities at their home institution before attending the School. For example, go and learn to punch cards, find out how to submit a job, and see what specific equipment is available.

Also desirable is preliminary study for those without experience in FORTRAN. Buy a manual such as A Guide to Fortran IV Programming, by Daniel D. McCracken, John Wiley & Son, Inc. and try to run a program before you arrive.

Please bring a 3-ring notebook, as the lecture notes will be furnished punched on 8.5 x 11 paper.

Wednesday, June 21, 1972

Session I.	Presiding, Clarence Hall, Louisiana State Univ.
1:45-2:45 p.m.	"FORTRAN Language", Jack C. Brown, Texas A & M Univ.
2:45-3:00 p.m.	Break
3:00-3:30 p.m.	"FORTRAN Programs", Jack C. Brown, Texas A & M Univ.

Thursday, June 22, 1972

Session II	Presiding, Michael Pleck, Univ. of Illinois
9:00-10:00 a.m.	"Introduction to Plotting", C. E. Hall, L. S. U.
10:00-10:10 am	Break
10:10-11:45 am	Workshop Session - Writing a simple plot program - staff.
Session III.	Presiding, Larry Goss, W. Va. Inst. of Technology.
2:00-3:00 pm	"Plotting in 2D", Jack C. Brown, Texas A & M Univ.
3:00-3:10 pm	Break
3:10-4:30 pm	Workshop Session - Writing a 2D Plot Program - Staff
4:30-5:30 pm	Registration Period. For both pre-registered and unregistered attendees.

Friday, June 23, 1972

Session IV.	Presiding, Robert Hammond, N. Carolina State Univ.
9:00-10:00 am	"Introduction to 3D Programs" Ed Mochel, Univ. of Va.
10:00-10:10 am	Break
10:10-11:45 am	Workshop Session Writing a 3D Program - Staff
Session V.	Presiding, Robert LaRue, Ohio State University
2:00-3:00 pm	"Features of a 3D Program" Byard Houck, N. Carolina State Univ.
3:00-3:10 pm	Break
3:10-4:10 pm	"Computer Graphics Equipment" - Michael Pleck, University of Illinois
4:10-4:45 pm	Workshop Session Practice using TRIDM program.

Saturday, June 24, 1972

No sessions. Programs from previous day may be picked up.

Dear Professor Kreimer:

I have just finished reading the "Self-Study Report" in the fall issue of the "Engineering Design Graphics Journal." I am very favorably impressed by that report and extend my congratulations to all those who are involved. The report is very well written and is one of the most sensible committee reports that I have seen in a long time.

Last year it was my privilege to serve as a judge at the Creative Engineering Design Display, and am looking forward to serving in that capacity again this year. That involvement has focused my attention upon the engineering design graphics division, and I like what I see. It does create a problem, however, since I am already committed to three other divisions of ASEE. I wonder if it would be possible to have my name placed on the division mailing list until the next dues statement comes out and I can indicate the division as one of my preferences. I also plan to send for a subscription to the Journal so that I may keep informed as to the division activities.

Listed below are a few comments for your consideration about the "Self-Study Report." Please keep in mind that these comments are made based on extremely limited knowledge about the past activities of the division. In fact, the comments will reflect impressions made by an uninformed individual who has read your report. On the other hand, I have served four years as a Director of the Cooperative Education Division of ASEE and have a good working knowledge of ASEE activities.

It seems to me that the report reflects very effectively a carefully thought out analysis of the division. I see nothing in the report that I consider negative. The only negative reaction I have to the report is caused by that which has been omitted. Reference to business industry and governmental agencies is almost non-existent. The fifth purpose listed seems to be the only reference.

As an employer member of ASEE I am more sensitive to the lack of involvement of employers than would be an educator. There is no question in my mind that most students affected by the Engineering Design Graphics Division will eventually be employed. Hopefully, a representative number of their employers will be involved with the activities of the division. Unfortunately, this does not seem to be the case. Of course, as one who has little experience with the division, I am not sure if this is a matter of divisional philosophy or results from a lack of interested employers. My experience with the Cooperative Education Division would indicate that the latter is the case.

For example, a review of the Self-Study committee reveals that none of the committee members is from industry, business, or governmental agencies. Of course, General Motors Institute is half and half. A review of the names of the officers and all committee members listed in the fall issue of the Journal shows an extremely small percentage of employer representatives.

The functional grouping of the appointed committees indicates that the study committee is recommending the elimination of the Industrial Relations committee.

As an employer, it seems that the Industrial Relations committee should be a key committee under the director for liaison committees. Admittedly, this action may make more sense to me if I had more background about the past history of the Division on which to base my opinion.

The committee is to be congratulated for suggesting a change to the By-Laws that would permit elimination of an ineffective individual. There are a number of instances in my past organizational work where I would have welcomed such a mechanism.

I hope these comments are of some value to you. In no way have I meant to be critical, but hope to be of some direct assistance.

Sincerely
/s/ William E. Weisel

William E. Weisel
Director,
Educational Relations
Cincinnati Milacron, Inc.

To the Editor of the JOURNAL:

Congratulations on two of the finest articles I have ever read in the JOURNAL.

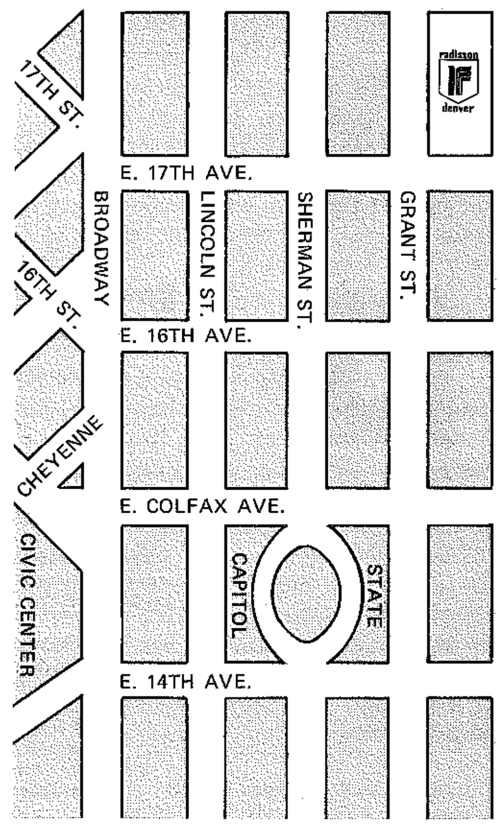
The first piece, "Time for a Change", written by Bill Rogers, is a masterpiece of reasoning coming, as it does, just when it

(See LETTERS - p. 45)

1972-73 Mid-Year Division Meeting is Announced

The Division's Mid-Year Meeting Committee (consisting of Professor Carl Bechtold and Professor Beck, both of Colorado University (Boulder), and Frank Oppenheimer, President of Gramercy, as Chairman) have established the dates and location of the 1972-73 Mid-year Division meeting in Denver Colorado. The dates are Wednesday afternoon January 17 through Friday, January 19, 1973. The place is the Radisson-Denver, the location of which is shown on the map.

Details of the sessions and special events will be announced later but the Committee feels that the membership should be aware that the timing of this meeting coincides with the National Western Stick Show and an authentic rodeo, which members and their wives may want to attend. Therefore, early hotel reservations are suggested since the Division meeting will be competing with the stock show. The Radisson-Denver is about five minutes from downtown Denver's shopping area. The hotel rates start at $19 per night for a single and $13 per person per night in a double or twin. Reservations should be made with Frank Oppenheimer, Gramercy, 1145A West Custer Place, Denver, Colorado 80223; phone: 303-534-4251.



(GERARDI)

Distinguished Service Award, presented by the American Society for Engineering Education, Graphics Division, in June 1962 at the Annual Meeting held at the Air Force Academy, Denver, Colorado.

Fellow - an award given by the Standards Engineering Society for outstanding contributions in the field of Engineering Standards, September 18, 1967, Detroit, Michigan.

The officers and members of the Division join in wishing for him the fulfillment in his retirement that he so richly deserves.

(CAR)

It was a modification of the same computer program used in the highway-safety research project that was utilized in the extremely sensitive design of the ramps for the Spiral Jump. The fine-print equations describing the vehicle motions on the two ramps consume over 100 8 1/2-by-11 in. pages. A high speed computer solved these 100-plus pages in less than 20 sec.

It would take years of an engineer's time to work out a single solution by manual calculation. Without the computer, it would be a matter of costly, time-consuming experimentation---designing and building ramp after ramp and destroying dozens of cars on a trial-and-error basis before a successful ramp design might possibly be achieved.

The successful ramp designs were achieved after 33 relatively low-cost computer runs, varying the computerized shape and angles of the ramps on each computer simulation of an actual Spiral Jump. The "drivers" on these computer runs who were "killed" or "injured" were complicated mathematical equations --- not human beings. Without the computer techniques, it is unlikely that a manned Spiral Jump would even have been attempted.

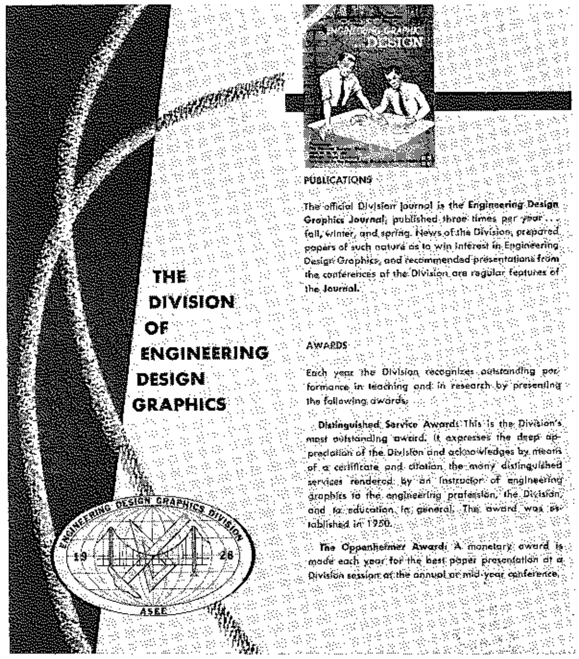
"The Astro Spiral Jump is providing Cornell Laboratory with a useful, scientific validation, or proving out, of the computer program that is concerned with minimization of the severity of single-vehicle accidents on the nation's highways," McHenry concluded.

New Division Brochure Is Prepared

In the mail recently, each member of the Division received a copy of the new Division promotional brochure (illustrated below). This brochure was developed under the leadership of our Secretary, Claude Z. Westfall, to whom we all owe a vote of thanks for assuming this responsibility, on our behalf.

The brochure is attractive and well-conceived and is particularly informative about the Division objectives and activities. Our members should be challenged to put this brochure into the hands of every eligible candidate for membership. If each of us would assume the responsibility for delivering or mailing this brochure to a colleague in a university, college, technical school or industrial plant, the productivity of the brochure would be multiplied many fold over that which our officers can handle alone. Make no mistake about it, you and I are the grassroots of the Division and, despite all the efforts of the officers, the ultimate success of the Division rests in our hands. Let each of us support our officers and Executive Committee in these efforts to develop a stronger and more effective Division.

To whom did you say that you are going to pass along a brochure? Do it today!



α λ ρ

A GRAPHICAL MEANS OF OBTAINING SLOPE AND INTERCEPT

S. K. Foss
P. E. Hainault
Michigan Technological University

It is often necessary to generate an equation of an empirical line plotted on rectilinear, semi-log, or log-log paper. If these lines appear to be linear or can be interpreted as straight lines, their equations will fit one of three general forms, with only the slope (M) and intercept (B) to be determined. The following is a total graphical approach in determining these constants.

A straight or near straight line (I) plotted on rectilinear paper (figure 1) takes on the form of $Y = MX + B$. The extension of curve (I) to the vertical axis yields the intercept, B, for the equation. A second curve (I') is drawn parallel to (I) and through the (0, 0) point. Starting from the '1' position on the horizontal axis, move up parallel to the vertical axis until curve (I') is met; from that point move left parallel to the horizontal axis until the vertical axis is crossed. This crossing point gives the numerical value of the slope of curve (I).

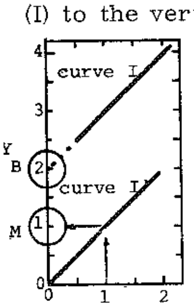


Figure 1

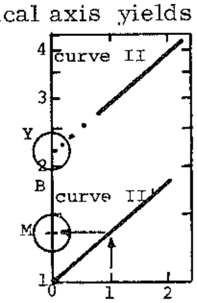


Figure 2

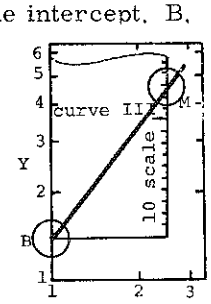
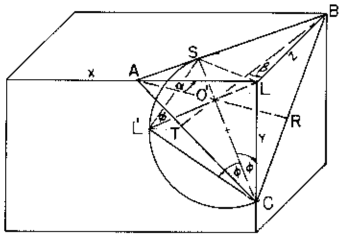


Figure 3

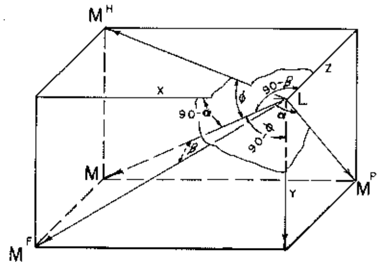
A similar approach can be used for semi-log paper where the governing equation is $Y = BM^X$. The only variation on the above approach is that the curve (II') must go through the (0, 1) point on the graph (figure 2).

In a log-log plot (figure 3) with a governing equation of $Y = BX^M$, the slope M can be determined by taking a 6 inch engineer's scale that is exactly one inch wide. Then, set the left edge of the scale on the vertical axis where curve (III) crosses. From the right edge of the scale read the value of the slope. It is important to remember that, if the 10' scale is used, divide the reading by 2 for the actual slope; 30 scale divide by 3, etc.

(GRAPHICS)

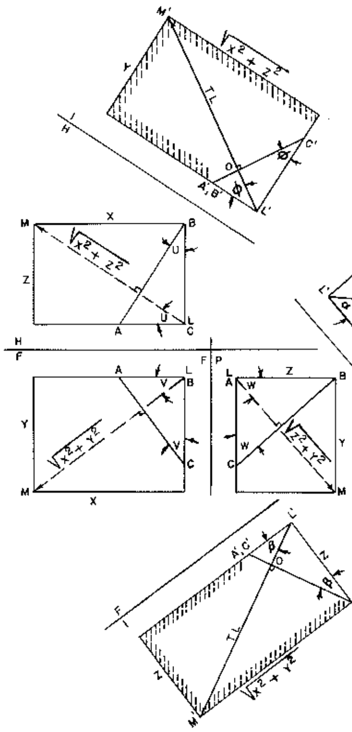


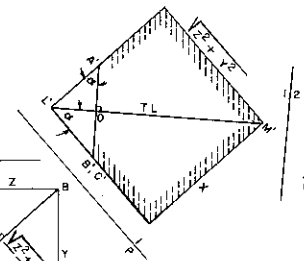
Line of Sight Prism

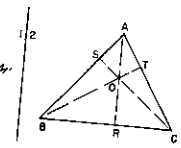


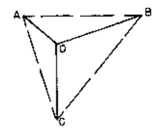
The pictorial illustration of the line of sight prism with its diagonal as the line of sight also shows the axonometric plane perpendicular to the line of sight.

The primary and secondary auxiliary views shows the true relationship between the axes of the prism, its principal surfaces and the axonometric plane. These relationships were used to develop the program as presented.









CONVENTIONAL ORIENTATION

State University at Baton Rouge can assist you in any way with computer graphics, please feel free to call upon us.

REFERENCES:

(1) Brock, Eugene H., "The Engineer and Computer Graphics" (Paper read at the Mid-Winter Annual Meeting of Engineering Graphics and Design Division, American Society for Engineering Education, Baton Rouge, Louisiana, January, 1969).

(2) Hall, Clarence E., "The Historical Development of Multiview Drawings and Its Role in Engineering Education", (unpublished Master's thesis, The University of Tennessee, Knoxville, 1950),. p. 83.

(3) Booker, Peter Jeffrey, A History of Engineering Drawing, (London: Chatto and Windus, 1963).

(4) Hall, W. W., Descriptive Geometry, (New York: D. Van Hostrand Company, 1903) p. 7.

(COMPUTER)

amount of hardware and programming sophistication. Each of the systems discussed had as its major step, the identification of a need for the capability. The programming required was done in less than a calendar year in each case, making use primarily of the graphics programs already available on the computer being used.

Predicting the developments in the area of computers on a long term basis seems to be of dubious value but there is little doubt that computers and computer generated displays will be very much in evidence. The applications will be again, things not at this time obvious, and the major breakthrough, as has often been the case, will be in identifying the problem.

REFERENCES:

1. Mehta, M. "Software Design for Display of Isodose Curves in Implant Dosimetry". Thesis, Tufts University, 1970.

2. Otis, J. C. "Computer Generated Display of Vectorcardiogram Loops". Thesis, Tufts University, 1969.

3. Radi, T. "Graphical Realization Aid for Statistics". Thesis, Tufts University, 1971.

Editor's Note: This paper was presented at the 1971 Annual Meeting of the American Society for Engineering Education.

slow") to the amount indicated. When it bends to the west, the sun is ahead of its schedule ("sun fast"). By graphing this equation of time, one can readily apply the needed correction, in terms of degrees of longitude, to the assumed position of the point.

Further inspection of the analemma will show that it can also be used to determine the latitude of the subsolar point (or the sun's declination) for any day of the year. The graph runs from one tropic to the other, touching each tropic at the appropriate solstice and crossing the equator on the dates of the equinoxes. The appropriate latitude of the point for other dates of the year can beread between these four basic positions.

Practical Applications

Let us now apply the foregoin principles to a given example. We might wish to determine the location of the subsolar point for 10:30 A. M., Central Standard Time, October 1st. The analemma will show the latitude of the point for that day to be 3^{o} S. The longitude can be obtained noting that, in the morning, the sun is presumed to be east of one's standard meridian which, for Central Time, is 90^{o} W. The one and one-half hour differential equates to 22^{o} 30' of longitude, giving a preliminary answer of 67^{o} 30'. To find the equation of time, we examine the analemma and note that, on the first of October, it bends two and one-half degrees west of the central meridian, indicating an equation of time of ten minutes. The corrected longitude is thus 70^{o} W.

The position of the subsolar point is important in that, when located on the azimuthal equidistant projection, it can readily determine either of the desired final values: the sun's azimuth and its elevation above the horizon for the location at the center of the map. These are obtainable by relatively simple principles, based upon the fact that straight lines radiating from the center are great circles. First, a line may be drawn from the center to the subsolar point. Since directions are true when determined from the center of the projection, the protractor rose will give the desired azimuth immediately if it has been aligned with its zero point directly north of the center. (Fig. 2)

Secondly, the length of the line must be measured and compared with the scale of degrees. In the equidistant case of the projection, distances as well as directions will remain true when measured from the center. Now, at the subsolar point the sun is at its zenith, with an elevation of 90^{o} above the horizon. For each degree that one moves, along a great circle route, away from the point, the sun drops one degree lower toward the horizon. Therefore, subtracting the length of the line, measured in degrees, from 90^{o} will give the sun's elevation at the center of the map.

Some cautions might be given for the practical use of this nomogram. For one thing, it will only work at, or very near, the locality chosen for the center. If one moves to a different location, a new map must be created.

For another limitation, the map gives only theoretical solutions for the earty-sun relationship. Such factors as the refraction of light, which could require significant corrections at times of low solar elevation, are not included in the graphical answers. However, in this respect the results are no worse than those obtained by conventional spherical trigonometry.

Figure 2

Finally, the theoretical results given by the nomogram will be subject to a limitation common to all graphical solutions, a lack of fine precision. If one requires highly accurate results, he would do better to resort to the more orthodox use of the ephemeris and calculating equipment.

Nevertheless, the nomogram carries with it certain clear advantages. Once it has been created, it is easy for the average technician to understand and employ. A careful application of its techniques should give results which are within the margins of error of the laboratory and field procedures for which it is designed.

(See MAPPING - p. 44)

(INVENTOR)

phlets on his hero, but also to the point, he rescued the large framed frontages with their picturesque gables and together with the carved stone fireplace that the engineer must often have sat around, incorporated them in a house that he had designed for himself in Dartmouth. Thus "Newcomin Cottage" now more than 100 years old in its new existence, is in fact the reembodiment of Newcomen's house, in its pre-existence an Elizabethan habitation. With its pleasant lawns it forms an attractive link with the inventor, while down below in the public gardens a Newcomen Engine has been reerected to mark the tercentenary of Newcomen's birth in 1663. Although too infirm for steaming, the old fellow is galvanized into action as required by a concealed apparatus and shows forth for all to see the genius of the parent who begot him 270 years ago.

In these same public gardens and close to where the engine has been placed, the president of the American Newcomen Society, Charles Penrose Jr., laid a wreath on the great inventor's memorial as part of the 1963 celebrations, and before a large assembly gathered to pay homage to his memory.

Manchester's Engine

It was mentioned earlier that construction of a one-third full size replica of the Dudley Castle engine was undertaken in the workshops of the University of Manchester Institute of Science and Technology. The work went through as a nonurgent task to fill in slack times, but in due course the engine was finished and erected in the Museum. It took a lot of patience and many adjustments to get it to work continuously, which gave a sense of understanding of the troubles Newcomen must have experienced when he and Calley were making an engine for the first time with nobody's experience to draw on, but eventually it settled down to regular working as required. Some concessions had to be made to present conditions. It would, for instance, have been very undesirable to have had coal firing with its smoke in a smokeless zone, so steam is generated by electric immersion heaters inside the boiler, but externally everything is as in the first engine.

The atmospheric engines had an impressive range of sound effects. First the pump rods and the outdoor end of the beam were drawn up convulsively as if by an unseen hand. There was a pause, then after a loud snort they sank slowly down again. These motions were enlivened by the clanking of chains, loud groans, and prolonged hisses so that the effect was very much that of a great giant confined in a dungeon and forced to labor by his captors, which was indeed the case.

Successful Model

People have frequently made small models of Newcomen engines, but it is difficult to get them to work like the big ones because of side effects. No cold water injection is needed because the volume of steam is small against the surface area of the cylinder when compared with a full sized one, for instance, and again the properties of steam and water do not vary as the scale alters on a model, so that the working of models is usually jerky and erratic.

With the one-third full size engine however, having a cylinder diameter of 7", the size of everything is large enough for there to be no side effects, and the engine has a full repertoire of groans, hisses, and snorts while visually it is an impressive spectacle demonstrating to students a page from the history of the heat engine; to economists, the pioneer of the industrial revolution; to philosophers, the remarkable progress made from that day to this; and to all eyes, ears, and noses, the physical attraction of a primitive monster, touching sight, sound and scent.

(MAPPING)

REFERENCES

(1) "Maps and Globes in Earth-Space Relationships," by William M. McKinney, Journal of Geography, Vol. LXVI, No. 9., December 1967

(2) Tractatus de Globis, by Robert Huse, Hakluyt Society Publications, 1st Series, Vol. 79, London 1889.

(3) "Astronomical Geography Taught From the Globe", by William T. Skilling, Journal of Geography, Vol. IX, No. 9., May 1911.

Late Flash! Presenting Your Division Officers

Chairman
William B. Rogers
Virginia Polytechnic Institute

Vice-Chairman
Kenneth E. Botkin
Purdue University

Director (5 years)
C. Gordon Sanders
Iowa State University

Secretary
Robert D. LaRue
Ohio State University

Advertising Manager
Clarence E. Hall
Louisiana State U.

(DESIGN)

2. OUTPUT MOTION: Sixty degrees rotatation of a rod lying in a horizontal plane and parallel to axis X. See sketch below.

3. Output rod rotates clockwise while input rod moves upward. See sketch.

4. Axes X, Y, and Z are mutually perpendicular. See sketch.

5. Material: commercially available ferrous stock capable of transmitting 10 pounds without plastic deformation. Auxiliary parts, your choice.

6. Cost: In keeping with standards for mass produced automotive throttle linkages.

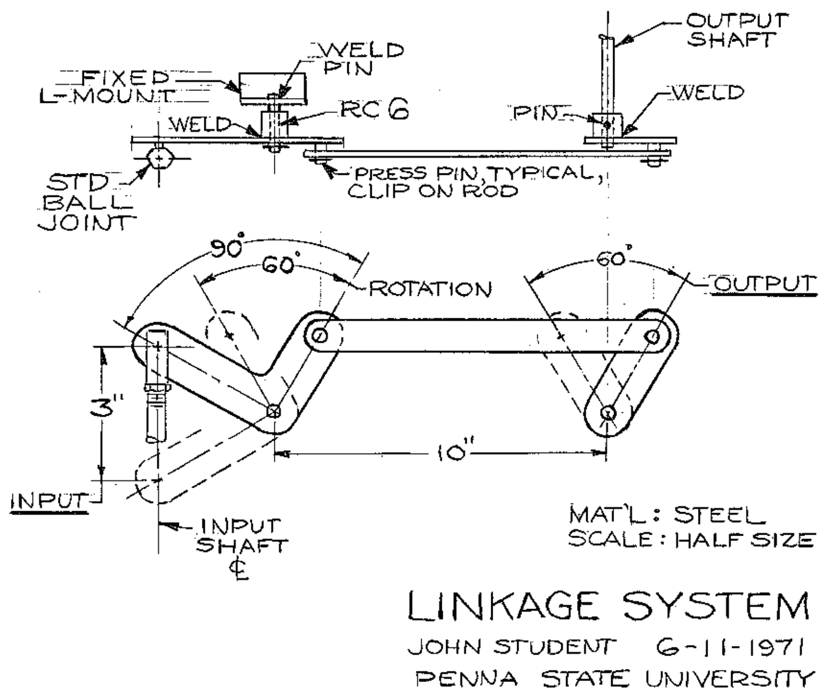
SOLUTION REQUIREMENTS

1. Submit in multiview a scaled layout of a solution to meet the given specifications.

2. Indicate initial and final positions of input and output shafts.

3. Use primarily centerlines of links. Do not detail hardware which can be purchased (pins, bolts, clips, etc.). Indicate such hardware by notes only.

4. Omit elaborate title blocks and borders, but give part name, scale, date, your name and school.



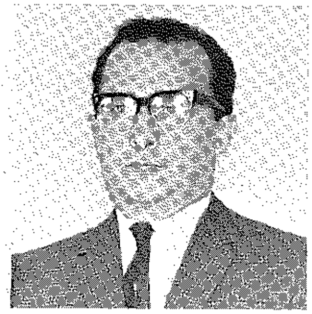
(LETTERS)

seems to me that the present name of our Division has proved itself to be a misnomer. It's true that I voted for the present name of the Division because a change was in order then and "Engineering Design Graphics Division" was the best compromise we could get at that time.

But now, as Bill Rogers has stated so eloquently, the time is exactly right for another change. I won't repeat Rogers' reasoning; I couldn't possibly improve on his reasoning or on the sheer beauty of his language. Rogers is right: "Division of Engineering Fundamentals" describes perfectly everything we do or can do, even though not all schools do the same things. I hope I get a chance to vote for the change he proposes. The membership will approve, I feel certain.

Then, as I read Bob Hammond's article, "Engineering Graphics Passe, No!", I realized that this article was a very well stated piece of evidence in support of the Rogers' thesis. If both of these men were still colleagues at the Academy, it would be a good guess that they would naturally have similar ideas. But I believe their ideas stem from the fact that they're both thinkers, doers, and superb writers.

/s/ Vlad
Irwin Wladaver
Assoc. Prof. Emeritus
of Mech. Engineering
New York University



A CRITERION OF CORRECTNESS OF SINGLE-VIEW GRAPHICAL REPRESENTATIONS

A. ROTENBERG,
Lecturer in Mechanical Engineering
University of Melbourne

ABSTRACT:

This article discusses the sufficiency condition for a two-dimensional line-diagram to be a correct representation of a real three-dimensional object.

The following theorem may be of some interest to engineers: -

> A necessary and sufficient condition for a two dimensional line-diagram Σ to be a correct graphical representation (1) of a real three-dimensional object is that Σ include a simple closed curve j_1 such that all points of Σ are inside or on j_1.

It is understood here that the curve j_1 may be a subcontinuum of any curve of Σ. The reader is referred to (2) for the proof of the necessary part of this theorem. This article deals with the sufficient part of the theorem in the case of representation by orthographic projection.

Let the diagram Σ (Fig. 1a) consist of:

(i) any finite number of dendrites (1) $d_1, d_2, \ldots, d_p, \ldots\ldots, d_n$;

(ii) any finite number of simple closed curves $j_1, j_2, \ldots, j_k, \ldots, j_m$.

Furthermore, let all points of Σ be inside or on j_1.

The simple closed curves j_k may have points (or arcs) common with each other and each dendrite d_p may have one point M_p^k common with any of the curves j_k. Such definition

In Fig. 1b, construct arbitrary simple closed curves $L_1, L_2, \ldots, L_p, \ldots, L_n$ satisfying the following conditions: -

(i) All end-points of the dendrite d_p are also points of the curve L_p;

(ii) All other points of d_p are inside L_p;

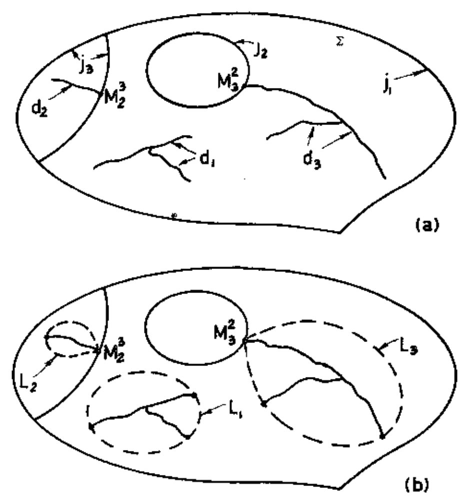


Figure 1

(iii) the curves L_p have no points common with each other or are inside each other;

(iv) the curves L_p have no points common with any of the closed curves j_k, except the points M_p^k;

(v) no points of j_k are inside L_p;

(vi) the curves of L_p are smooth at all their points other than M_p^k.

The bounded domain defined by L_p is

separated by the dendrite d_p into z_p disjoint domains, each of which has as its frontier a simple closed curve J_{pr}, where r = 1, 2, . . , z_p. Each curve j_{pr} may be regarded as an orthographic representation of a solid S_{pr} (Fig. 2) bounded by: -

(i) a plane figure (1) Q_{pr} congruent with the plane figure J_{pr};

(ii) a cylindrical surface ξ_c generated by a straight line AB normal to Q_{pr};

(iii) a smooth (1) surface ξ_s such that: (a) ξ_s is tangent to Q_{pr} along the smooth simple arc $M_1\ M_2\ M_3$; (b) no straight line parallel to AB may be tangent to ξ_s.

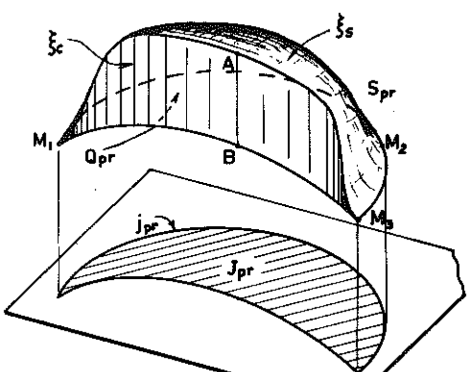


Figure 2

The solids S_{pr} may be assembled into one solid S_p (Fig. 3) so that the curve $L_p \cup d_p$ may be regarded as an orthographic representation of S_p. On the other hand each of the curves j_k may be regarded as an orthographic representation of a solid S_k (Fig. 4) bounded by some cylindrical surface ξ_k and two planes normal to the generators of ξ_k.

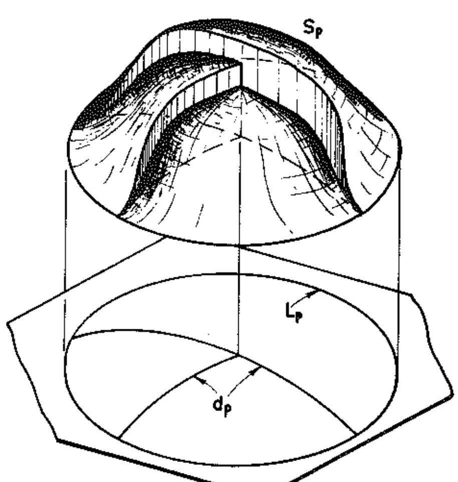


Figure 3

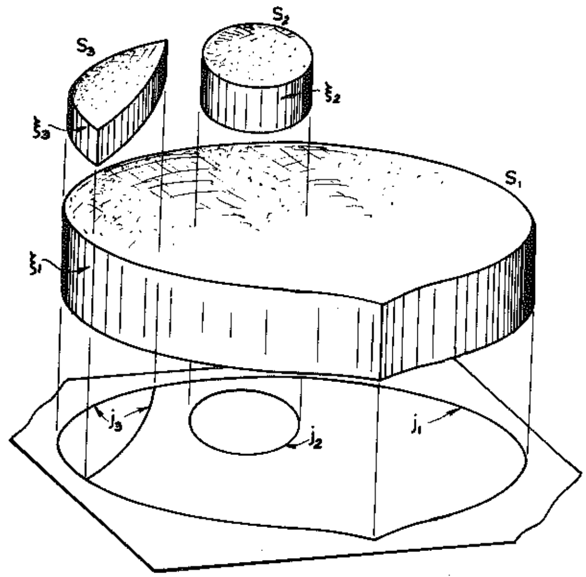


Figure 4

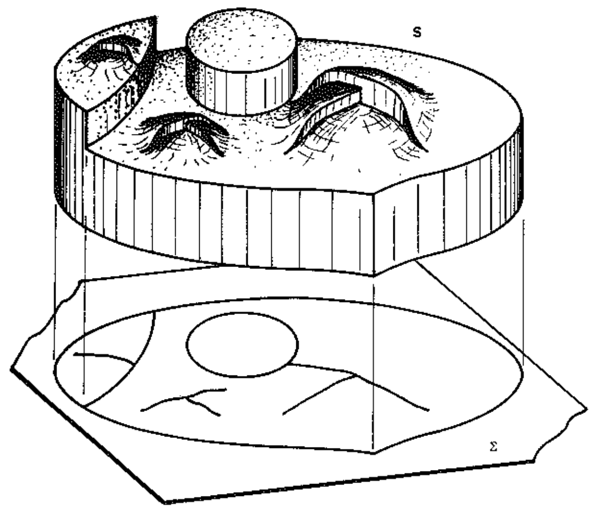


Figure 5

The solids S_p and S_k may be assembled to form a single solid S having the desired orthographic projection Σ. The method of assembly is clear from Fig. 5. Because of the tangency condition of ξ_s to Q_{pr} (condition iii (a) above), the line L_p will not be an edge of the single solid S.

No special treatment is required if the diagram Σ includes also "hidden" lines. In this case, the relevant solids S_p and S_k should be assembled on the hidden plane face of S_1.

A similar reasoning may also be applied to the general case of central projection.

REFERENCES:

(1) The definition of this term is given in the Appendix at the end of this paper.

(2) A. Rotenberg, "Visual Illusion or Ambiguous Drawing," J. of Eng. Design Graphics, Winter 1972

ACKNOWLEDGEMENT:

My thanks are due to Dr. C. J. Pengilley for his assistance in preparation of this article.

KEY WORDS:

Drawing 1405

Engineering drawings

Geometry 1201 1409

Descriptive geometry

APPENDIX

A two - dimensional line - diagram Σ (Fig. 6) is said to be a correct graphical representation of a real three-dimensional object S, if Σ consists of all contours of S and projections of all edges on the surface of S. It is assumed that the projecting apparatus is given and consists of an arbitrary projection plane P and a pole C which is not on P and is not a point of S. All points of Σ are finite and a drawing convention distinguishes between "visible" and "hidden" contours or edges.

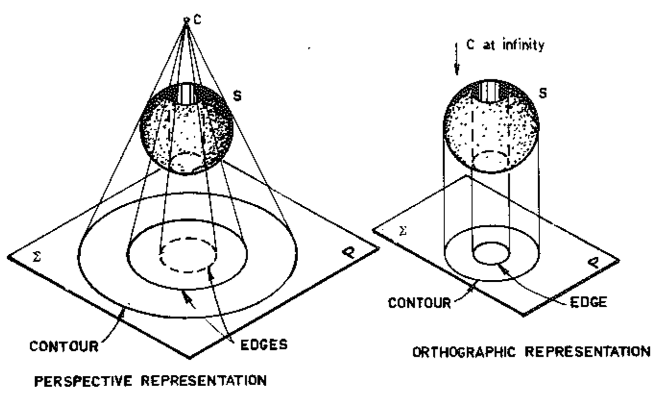


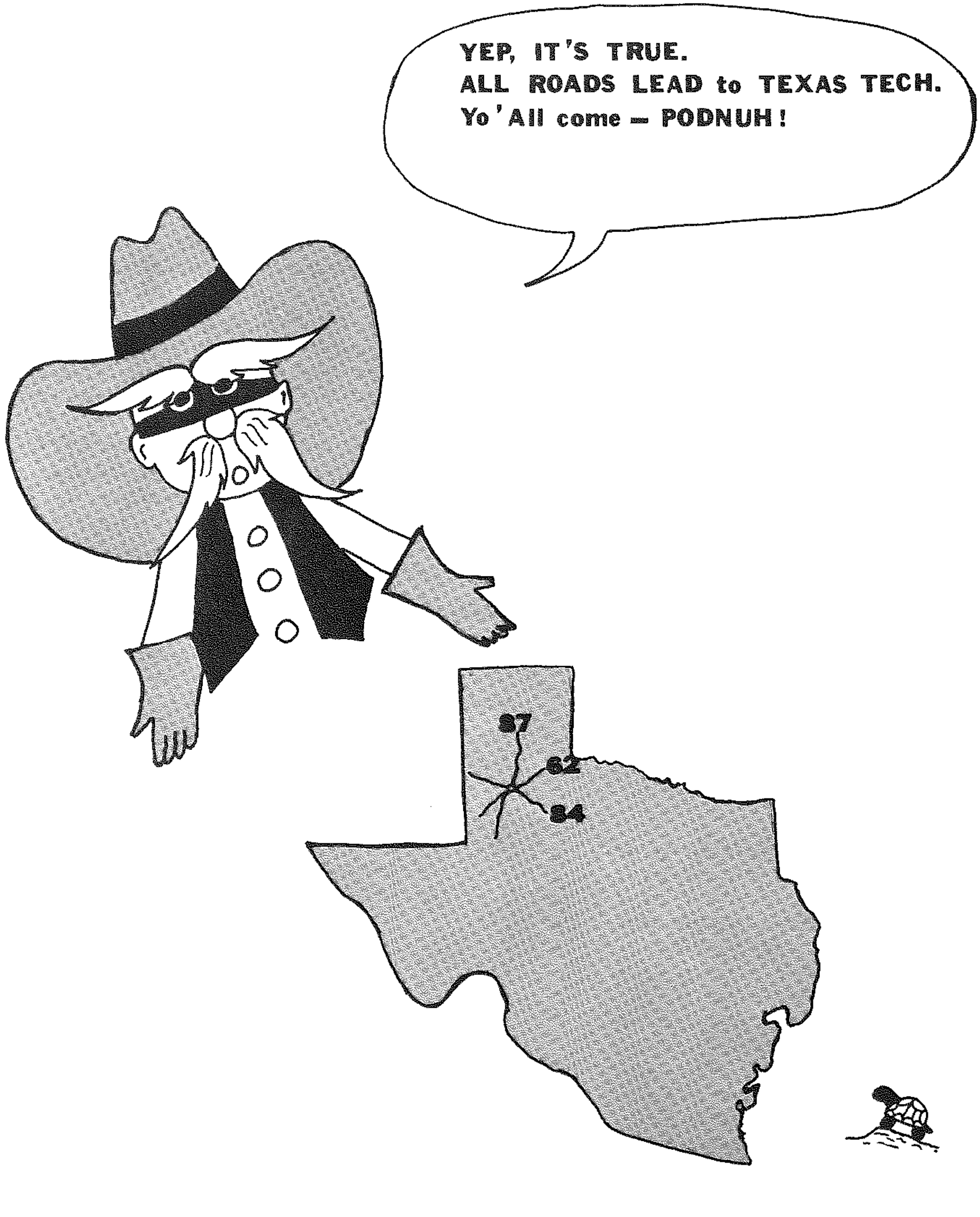
Figure 6

A plane curve j_p is a dendrite if every point of j_p is either an end-point or a cut-point.

A surface ξ is said to be smooth if at every point of ξ there exists one and only one tangent to ξ. A curve j is said to be smooth if at every point of j there exists one and only one straight line tangent to j.

A plane figure J_{pr} is the bounded part of a plane whose frontier is the single closed curve j_{pr}.

ADVERTISERS' INDEX


YEP, IT'S TRUE.
ALL ROADS LEAD to TEXAS TECH.
Yo'All come — PODNUH!
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