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ENGINEERING DESIGN GRAPHICS JOURNAL is published three times per year - November, February and May - by the Engineering Design Graphics Division of the American Society for Engineering Education, for teachers of Engineering Graphics, Computer Graphics and Design Graphics. The subscription rates are: ASEE members (in U.S., Mexico & Canada) $3.00 per year; Non-members (in U.S., Mexico and Canada) - $5.00 per year; All foreign subscriptions - $10.00 per year. Single copies are available at $2.50 per copy. Back issues are available but in general are limited to those issues published within the past year. Xerox copies of back issues can be furnished at 10¢/page.

OBJECTIVES:

The objectives of the JOURNAL are:

1. To publish articles of interest to teachers of Engineering Graphics, Computer Graphics and allied subjects.
2. To stimulate the preparation of articles and papers on the following topics (but not limited to them):
   A. Engineering Graphics
   B. Creative Design
   C. Research in Graphics
   D. Graphic Methods
   E. Computer Graphics
   F. Teaching Methods and Techniques
3. To encourage teachers of Graphics to innovate on, experiment with, and test appropriate techniques and topics to further improve quality of and modernize instruction and courses.

CALENDAR OF ASEE MEETINGS

1973 -- Iowa State University

1974 -- Rensselaer Polytechnic Institute

1975 -- Colorado State University

CALENDAR OF EDG DIVISION MID-YEAR MEETINGS

1972-73 -- Denver, Colorado

1973-74 -- New Orleans, Louisiana

1974-75 -- Williamsburg, Virginia

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3. Two copies of each manuscript are required.
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proudly announces that Mr. Arnold Cammarata, formerly Vice-President of Marketing at Teledyne-Post, is now joining our firm.

He and I, together with the other members of our organization, are looking forward to serving the educational field with increased devotion.

Paul Oppenheimer

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DESIGN OF THE GEOMETRY OF SPACE STRUCTURES USING GRAPH THEORY AND MATRIX TRANSFORMATIONS

M. F. Blade, Associate Professor
The Cooper Union

INTRODUCTION

Eric Bell in his book "Men of Mathematics" tells the beginnings of descriptive geometry about 200 years ago. Gaspard Monge, a young French student was asked to solve a problem in analyzing the geometry of a fortification structure. Monge solved the problem by a method he had just invented. He gave his solution to his instructor who did not believe Monge could have solved the problem so quickly because the analytic method used by his classmates was very time consuming. The instructor said he believed in great facility in calculation but not in miracles! Monge prevailed on his instructor to review the problem solution and it was found, indeed, that a new method of problem solution had been invented. It was this method of descriptive geometry which would eventually largely replace cumbersome analytic procedures in engineering designs.

Today we are turning back to analytic methods because we can use the "miraculous" numerical calculations of electronic computers. Using the concepts of descriptive geometry, we can now write programs so that machines can do the laborious and time consuming calculations for us. This paper describes two mathematical approaches to space problem solution. The first is "graph theory", a branch of topology, which is a new way of conceptualizing design elements. The second is the application of the mathematics of matrix transformations to solve space problems by requiring arithmetic methods.

SPACE DESIGN BY GRAPH THEORY

The traditional method of spatial design is to consider the relative displacement and position of points, lines, and planes. In descriptive geometry we use coordinate geometry. An additional approach to the analysis of spatial design is not to consider displacement. For example in analyzing the space arrangement of points, we could study the connections between points without considering the length or space path of the connector. A diagram of the connection between the vertex points of a cube could be drawn as shown. Note that one face may be considered to lie within the boundary of the external points. (Fig. 1)

Though we lose the length and angular attributes of lines we preserve the connectivity between points. With the cube, at each vertex point there are three and only three edges. The cube may therefore be characterized by its "graph" or non-metrical diagram as (Fig. 2):

- 8 vertex points
- 12 edges
- Each vertex point is the intersection of three edges
- Each edge connects two vertex points
- Each vertex point has three neighboring vertex points
- The "graph" or diagram can be drawn so that there are no intersections of edges except at vertex points and is therefore "planar" or can be drawn on a plane. If a graph is planar, the graph or diagram can also be drawn with straight lines.
- There are six faces or closed loops of vertex points and edges.

We may liken the graph of a cube to a net in which vertex points are nodes and the edges are strings. We may also consider that the edges or strings are elastic and the net may be stretched over any real space configuration

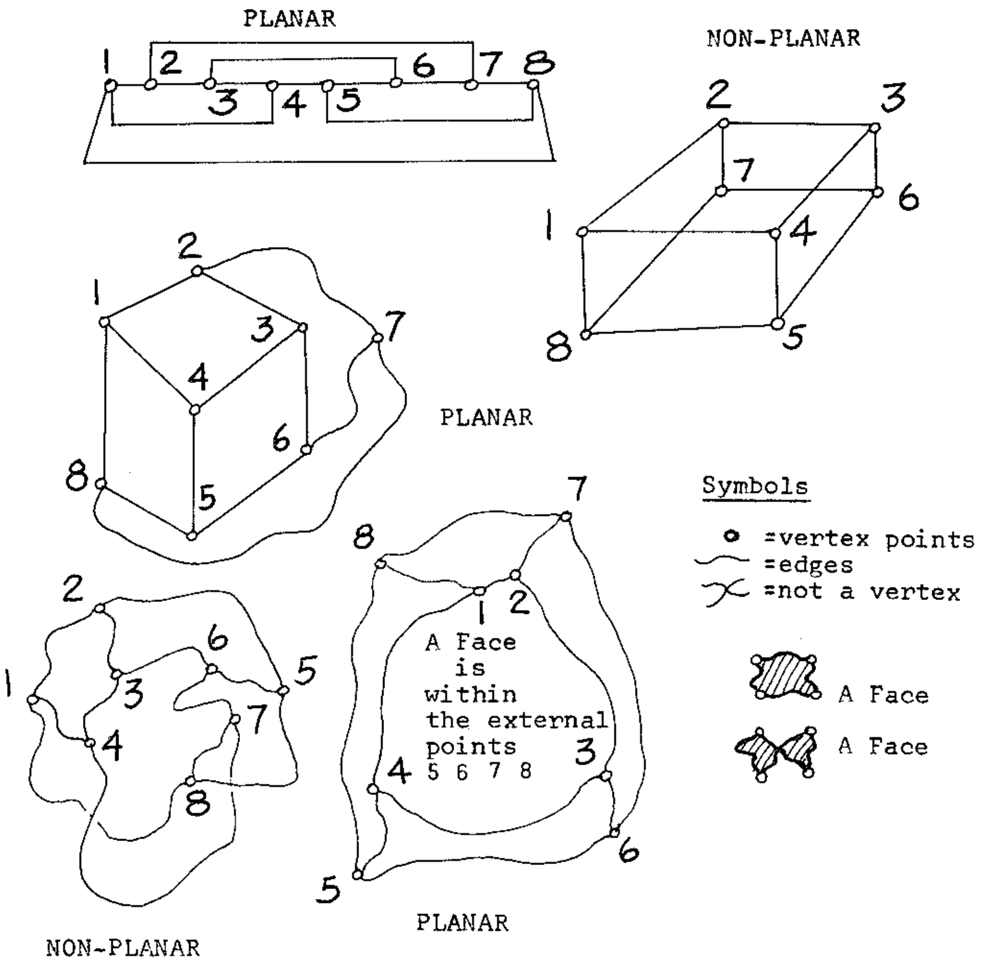


FIGURE 1 - DIFFERENT GRAPHS OF A CUBE

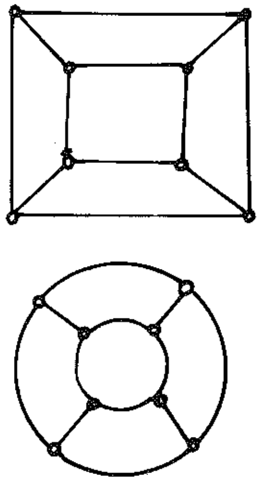


FIGURE 2

and thus may assume metric properties related to the space shape.

A simple example is to stretch the graph of a cube onto a sphere, requiring that each edge be a great circle arc or geodesic path and each edge have a chordal length of $\frac{1}{\sqrt{3}}$ x the sphere radius. $\left(= \frac{\sqrt{3}}{3} \right)$

Another example is to stretch the graph of a cube onto an ellipsoid so that each edge becomes an equal length geodesic.

There are many economic advantages in designing a structure based on a single polyhedral generating frame, the commonest being the cube. The regular and semi-regular polyhedra are all useful as generating structures and are presented here.

GRAPHS OF PLATONIC OR REGULAR POLYHEDRA

The Platonic or regular polyhedra have the following graphs (Fig. 3). Note that the edges are drawn as straight lines, but could be drawn in any desirable shape without changing the graph.

NON-REGULAR POLYHEDRAL GRAPHS

There are, of course, an infinite number of polyhedrons. Specially useful as generating designs are the so-called modern 13 semi-regular polyhedra which have unequal vertex order, but each face is the same and all edges equal and their 13 Archimedeon duals which have equal edges, two or more types of faces, and equal vertex order.

The dual of any graph is made by transforming a face to a vertex and connecting the vertices across contiguous faces. Thus the faces and vertices are interchanged. As shown (Fig. 4) a tetrahedron dual is a tetrahedron, a cube dual is an octahedron. A dodecahedron dual is an icosahedron and vice versa.

It may be convenient to use the semi-regular polyhedra as the generating geometry in designing spherical domes. With an Archimedean polyhedra a circumscribing sphere can contain all vertex points. With their duals,

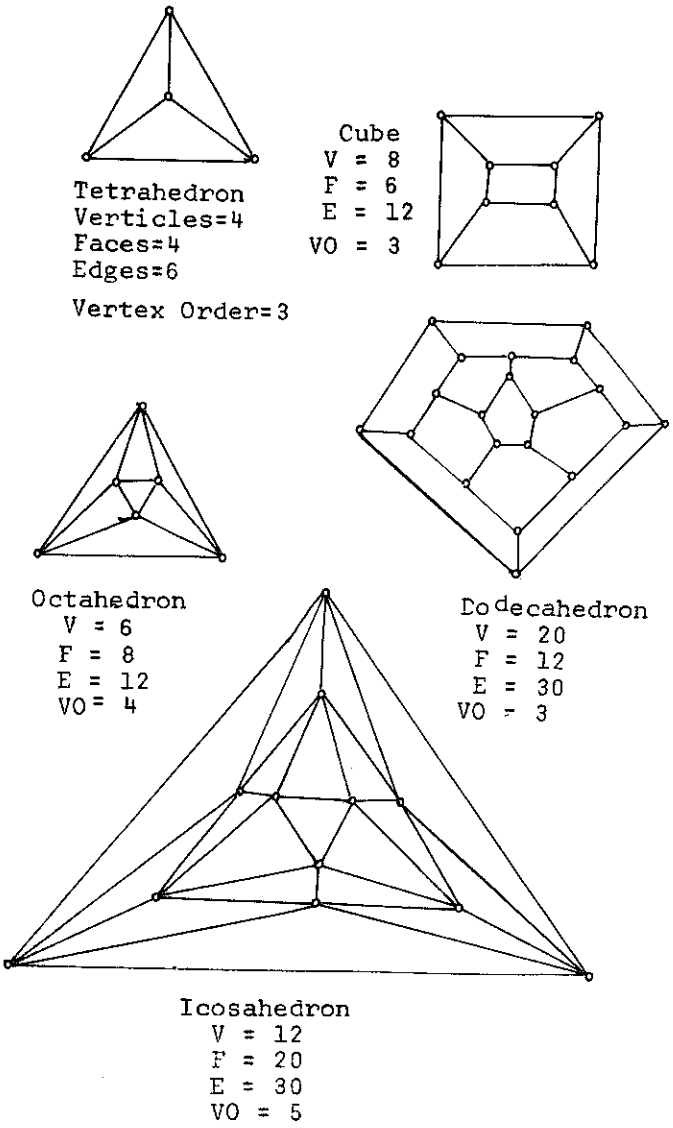


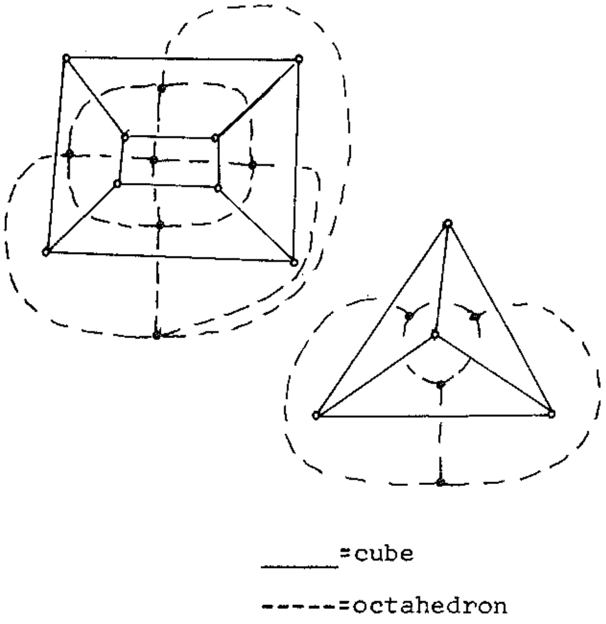
FIGURE 3 - GRAPHS OF THE FIVE REGULAR POLYHEDRA

it is possible to inscribe a sphere tangent to the polyhedral faces.

This suggests that two spheres could be constructed inside each other, one containing the vertex points of a polyhedron, the other containing the face centers of its duals.

The graphs of the Archimedean polyhedra are given (Figs. 6-18).

It should be noted that there is little distortion in the central part of the graphs but increased distortion in the outer region. Distortions may result in polygons such as these examples (Fig. 5).



cube	octahedron
V = 8	V = 6
F = 6	F = 8
E = 12	E = 12
VO = 3	VO = 4

THE TETRAHEDRON HAS A TETRAHEDRAL DUAL

FIGURE 4 - DUAL CONSTRUCTION OF THE TETRAHEDRON AND CUBE

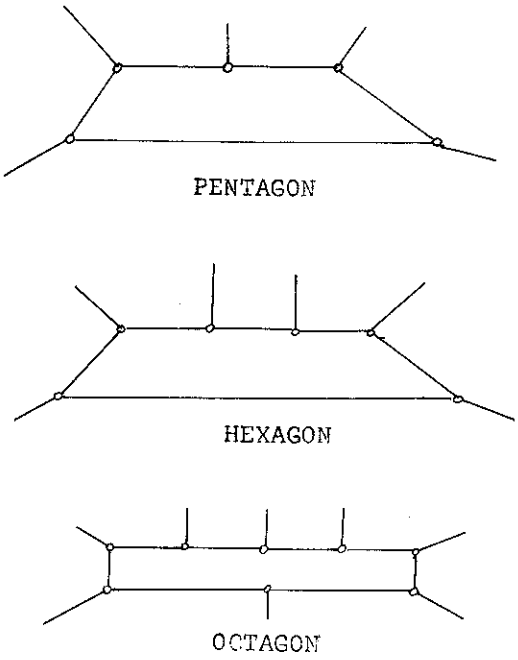
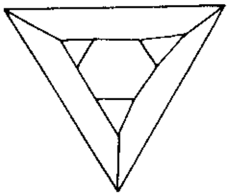
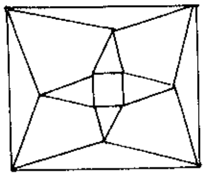


FIGURE 5



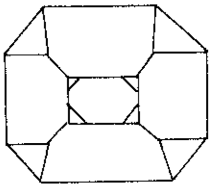
Truncated Tetrahedron
8 Faces
12 Vertices
18 Edges
Vertex Order = 3

FIGURE 6



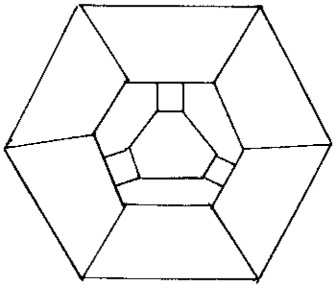
Cubocatahedron
14 Faces
12 Vertices
24 Edges
Vertex Order = 4

FIGURE 7



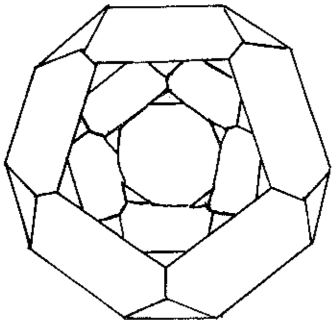
Truncated Cube
14 Faces
24 Vertices
36 Edges
Vertex Order = 3

FIGURE 8



Truncated Octahedron
14 Faces
24 Vertices
36 Edges
Vertex Order = 3

FIGURE 9



Truncated Dodecahedron
32 Faces
60 Vertices
90 Edges
Vertex Order = 3

FIGURE 10

SMALL RHOMBICOSIDODECAHEDRON
62 Faces
60 Vertices
120 Edges
4 = Vertex Order

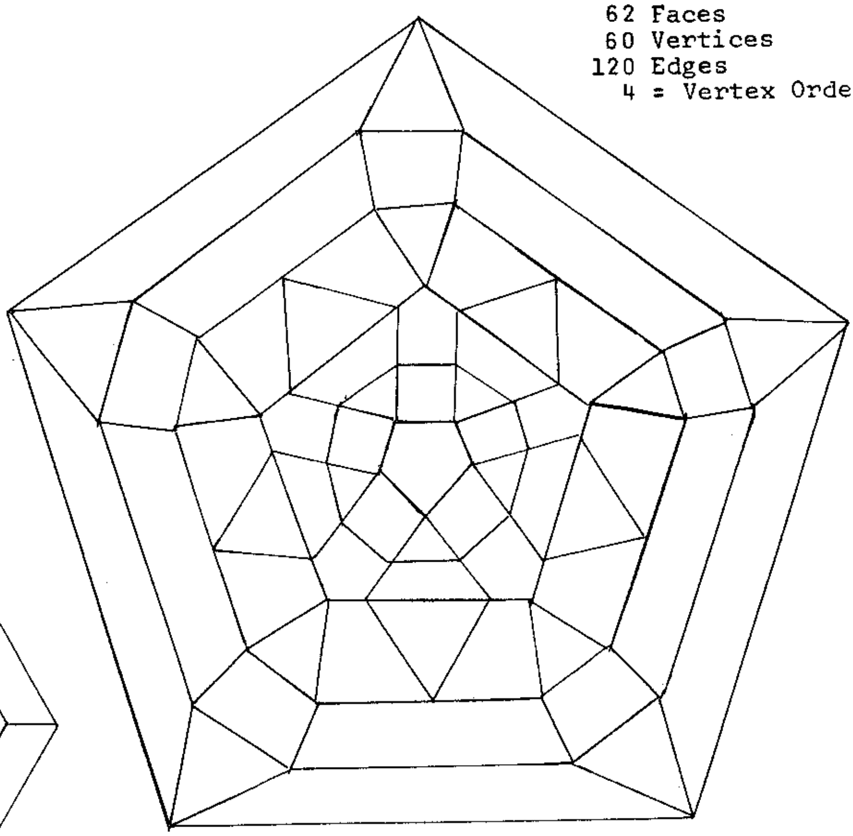
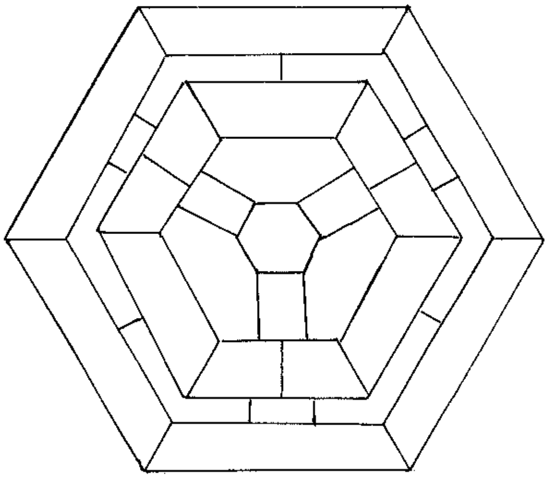


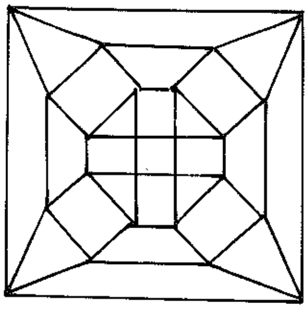
FIGURE 12



Truncated Icosahedron
32 Faces
60 Vertices
90 Edges
Vertex Order = 3

FIGURE 11

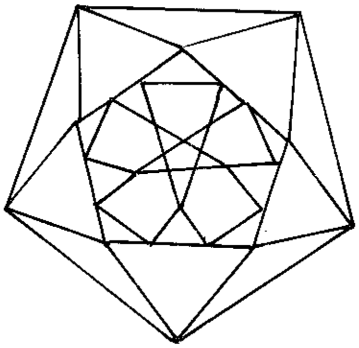
FIGURES 6 - 18 - PLANAR STRAIGHT-LINE GRAPHS OF THE THIRTEEN ARCHIMEDEAN SEMI-REGULAR POLYHEDRA



SMALL RHOMBICUBOCTAHEDRON

26 Faces
24 Vertices
48 Edges
VO =4

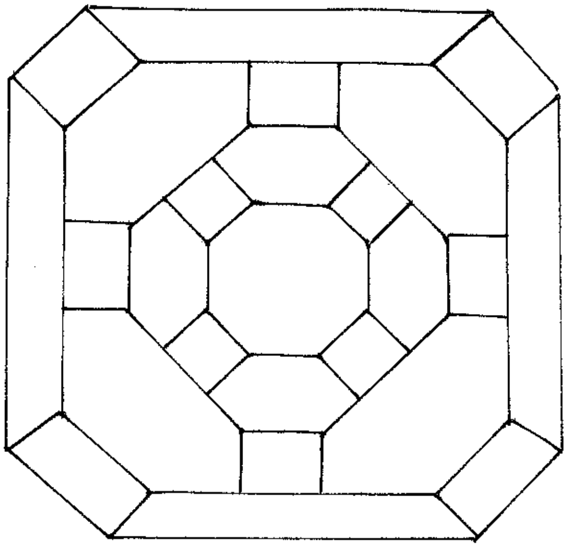
FIGURE 13



ICOSIDODECAHEDRON

32 Faces
30 Vertices
60 Edges
VO = 4

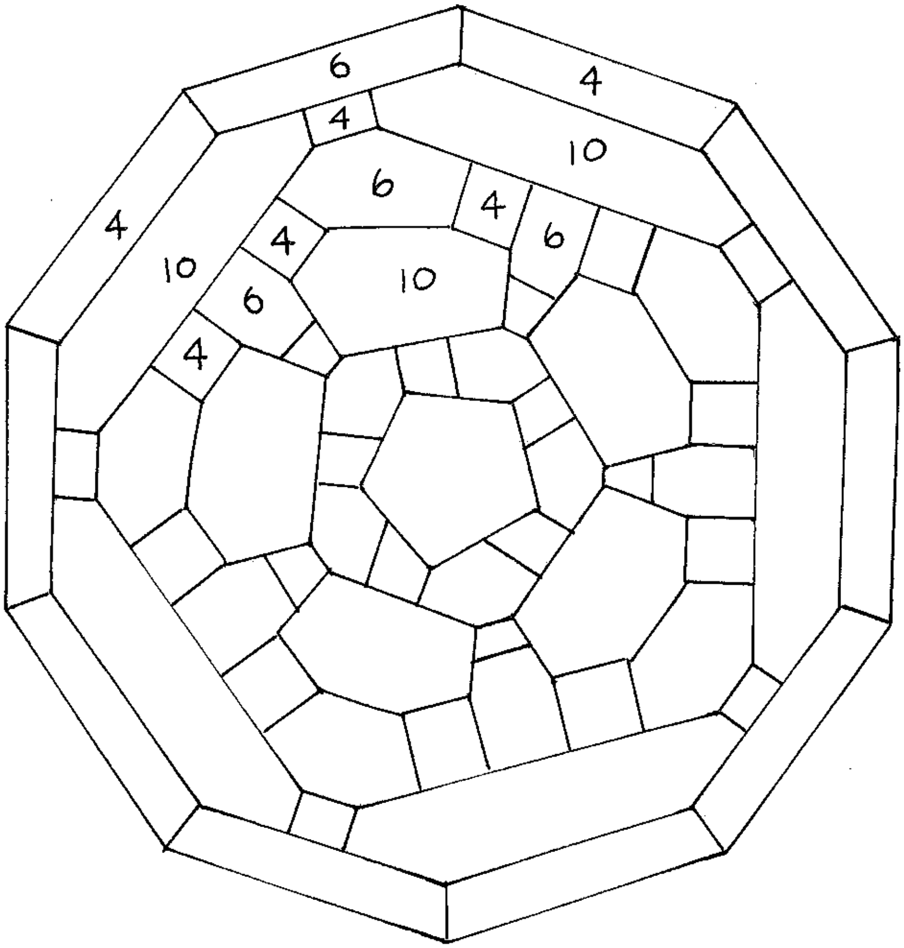
FIGURE 14



GREAT
RHOMBICUBOCTAHEDRON

26 Faces
48 Vertices
72 Edges
3 Vertex Order

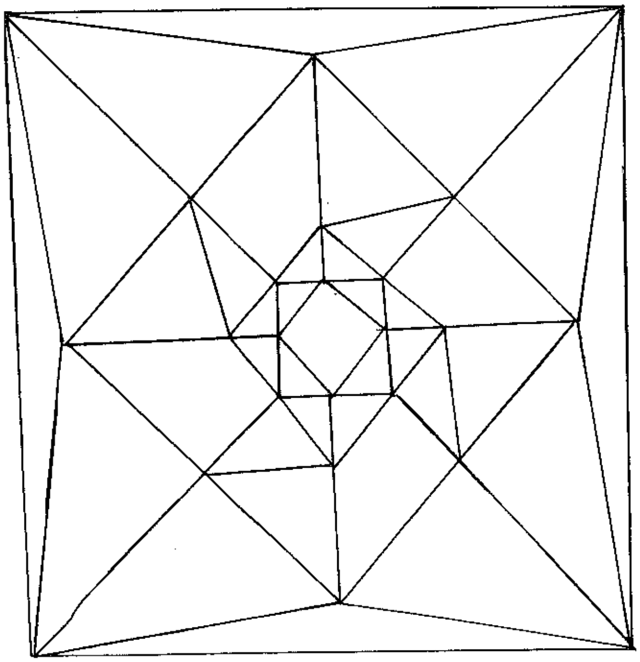
FIGURE 15



GREAT RHOMBICOSIDODECAHEDRON

62 Faces
120 Vertices
180 Edges
VO = 3

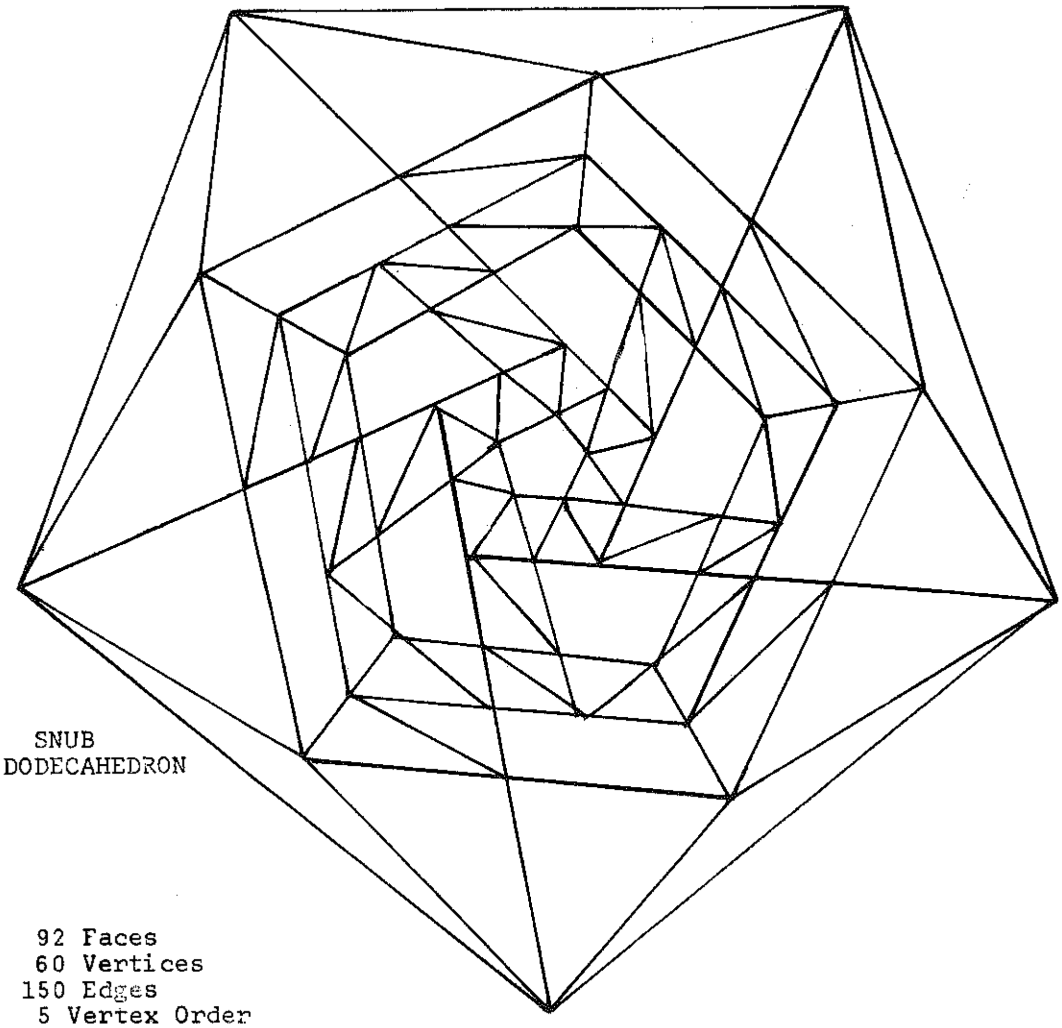
FIGURE 16



SNUB CUBE

38 Faces
24 Vertices
60 Edges
5 = Vertex Order

FIGURE 17



SNUB
DODECAHEDRON

92 Faces
60 Vertices
150 Edges
5 Vertex Order

FIGURE 18

USE OF GRAPHS TO DESIGN DOMES

One application of graph theory is in the design of shell structures or roofs such as domes.

To appreciate that there is a geometrical design problem note that if a large diameter dome is required, the lengths of elements must be small relative to the diameter. This means that the spherical faces of any of the Platonic polyhedra must be segmented into smaller faces. To take the extreme example, a hemisphere of cubic design of 100 ft. diameter would require very long elements. However, if the cubic faces were to be divided into small triangles the lengths of the elements could be small. By studying the graphs of the proposed designs, it is possible to analyze the number of equal elements, the connector requirements, symmetry, and variations in facial patterns, as a preliminary step before calculations of lengths and angles are made.

It is usually astonishing to a student to discover that there are only 5 ways to sprinkle points on a sphere, so that the angles between chordal edges connecting points are all equal and the chordal edges are equal.

Furthermore, the maximum number of points which can be sprinkled on a sphere so that the chordal edges connecting points are equal is 120. This is the great rhombicosidodecahedron with 30 squares, 20 hexagons, and 12 decigons, and all 180 chordal edges are equal.

Graphs may also be used to study the methods of partioning the faces of the generating polyhedron and analyzing the metrical consequences. For example (Fig. 19):

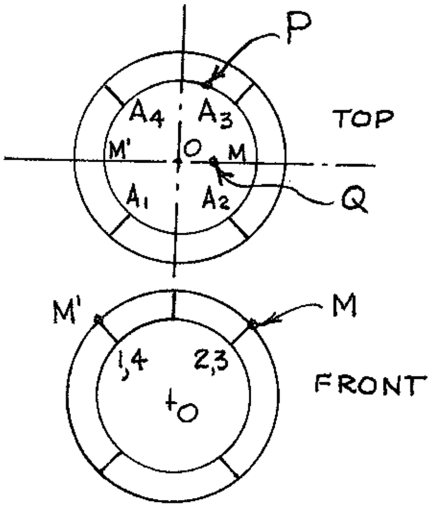


FIGURE 19 - CUBE SPHERE

Let great circle arcs $\overset{\frown}{A_2\ A_3}$ and $\overset{\frown}{A_3\ A_4}$ be bisected by planes containing the sphere center. $\overset{\frown}{P\ A_3} = 1/4\ \overset{\frown}{A_3\ A_4}$ and $\overset{\frown}{M\ Q} = 1/4\ \overset{\frown}{MM'}$. The mid-point of $\overset{\frown}{P\ Q}$ does not lie on plane $A_3\ OA_1$. This may be concluded from an analysis of types of edges. One type connects points on an arc of the generating polyhedron such as $A_3\ A_4$ -- another type connects vertex points not on the generating polyhedron such as M M'.

EXAMPLES OF CUBIC DOME GRAPHS

In the example, a cubic structure is given as the generating frame. Some of the possible patterns are as follows (Fig. 20).

If point coordinates of the space design are determined relative to a common X, Y, Z system, all metrical properties may be determined. Also the whole assemblage may be rotated or displaced by matrix transformations or projected pictorially in axonometric or perspective pictures, and they may be deformed or stressed.

CALCULATION OF SPACE COORDINATES

Once having established a desirable pattern or graph for a space design, the basic generating polyhedron can be sketched in orthographic projection in convenient front, top, and auxiliary views. The faces and the desired points on the faces should be numbered or labeled in some orderly pattern. The coordinates of the points can then be found with any desired precision by matrix transformations and computer computation as given in the follow ing example. The method of matrix transformations is advantageous as it may be used with a slide rule, hand computer and mathematical tables, or with a digital computer.

MATRIX TRANSFORMATIONS

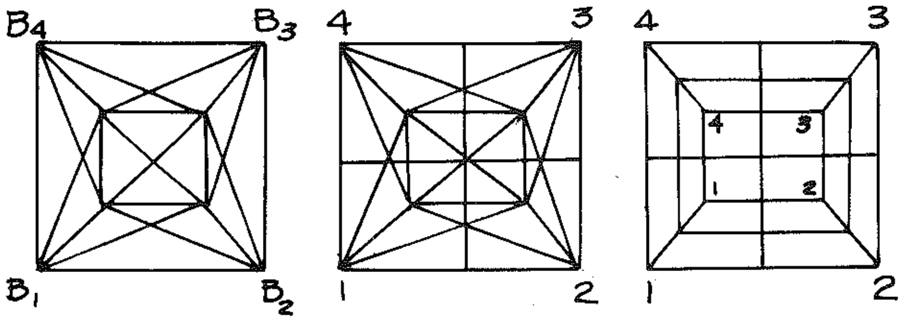
LOCATING A POINT AND MOVING IT

Given a point and three coordinate axes x, y, z. The point can move in space with six degrees of freedom--

Rotation about the X axis
Rotation about the Y axis
Rotation about the Z axis
Displacement in the X direction
Displacement in the Y direction
Displacement in the Z direction

Let us assume the rotation about an axis is in the positive direction if we follow a right-hand rule in which we rotate about the x, y, or z axis as follows (Fig. 21).

SPHERE GRAPHS

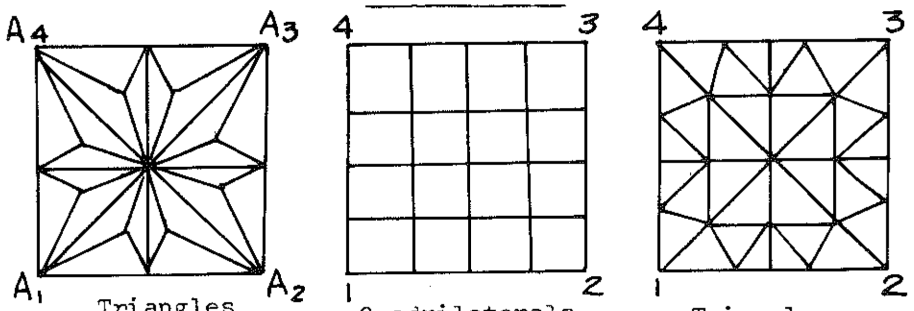


4 TRIANGLES PER FACE
ALL EQUAL
2 DIFFERENT EDGES

8 Δ PER FACE
ALL EQUAL BUT
ORIENTED LEFT, RIGHT
3 DIFFERENT EDGES

QUADRILATERALS
4 PER FACE
ALL EQUAL QUADS
2 DIFFERENT EDGES

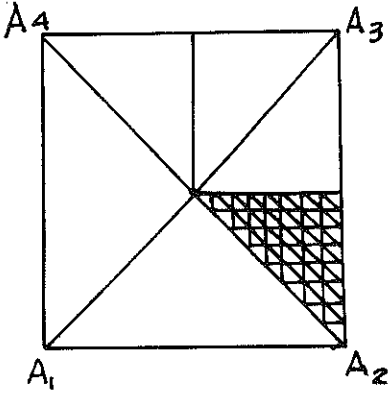
FACE GRAPHS



Triangles

Quadrilaterals

Triangles



DIVIDE EACH TRIANGULAR EDGE BY N. PRODUCING NxN SMALLER TRIANGLES

example = 8x8x8 PER SPHERE FACE

FIGURE 20

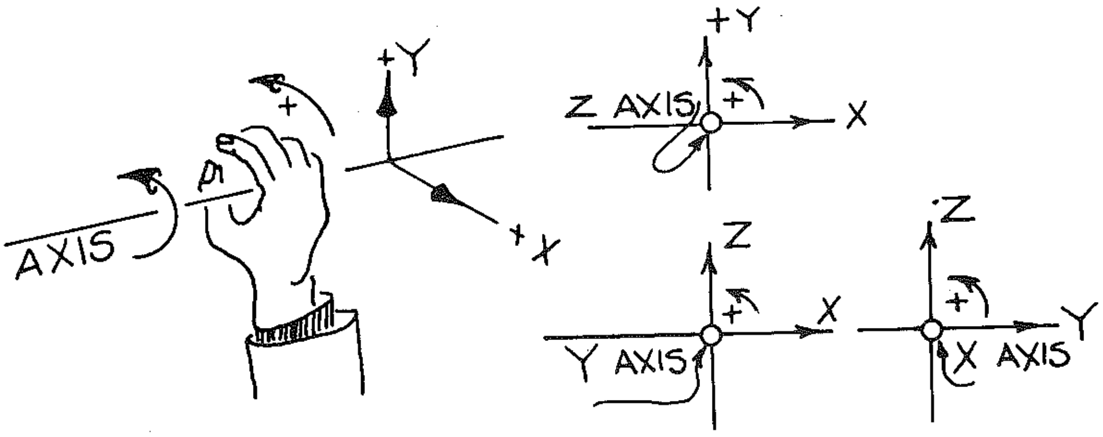


FIGURE 21 - EXAMPLES OF POSITIVE ROTATION POINT P CAN LIE IN ANY QUADRANT

If we consider a point P rotating about the Y axis through an angle θ to P' we may find the new coordinates of the point as follows (Fig. 22):

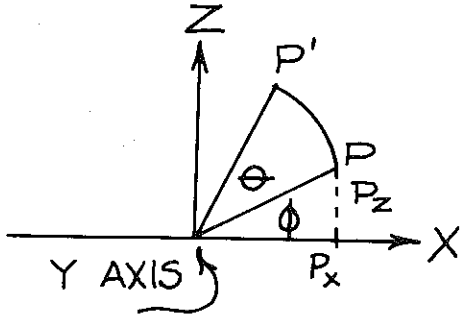


FIGURE 22

$P'x = OP\ \cos(\theta + \phi) = OP\ (\cos\theta \cos\phi - \sin\theta \sin\phi)$ and as $\overline{OP} \cos\theta = Px$ and $\overline{OP} \sin\theta = Pz$

$P'x = Px \cos\theta - Pz \sin\theta$

$P'y = Py$ (unchanged)

$P'z = \overline{OP}\ (\sin\theta + \phi) = \overline{OP}\ (\sin\theta \cos\phi + \cos\theta \sin\phi) = Px \sin\theta + Pz \cos\phi$

This is the same as the vector-matrix product.

$$[Px, Py, Pz] \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix} = P'x,\ P'y,\ P'z$$

$P'x, P'y, P'z = [Px \cos\theta - Pz \sin\theta,\ Py,\ Px \sin\theta + Pz \cos\theta]$

To counter-revolve, for example to return the point to its initial position, we multiply as follows:

$$[P'x, P'y, P'z] \begin{bmatrix} \cos\theta & 0 & -\sin\theta \\ 0 & 1 & 0 \\ \sin\theta & 0 & \cos\theta \end{bmatrix} = Px,\ Py,\ Pz$$

This multiplication is performed as follows:

Given a vector $[PX,\ PY,\ PZ] = P$

and an operator $\begin{bmatrix} a & d & g \\ b & e & h \\ c & f & i \end{bmatrix} = M$

To transform the vector to P': -

$[P]\quad M = P'$

$P'x = P_x a + P_y b + P_z c$

$P'y = P_x d + P_y e + P_z f$

$P\ z = P_x g + P_y h + P_z i$

If a vector component such as Py is to be unchanged, the operator M is $\begin{bmatrix} a & 0 & g \\ 0 & 1 & 0 \\ c & 0 & i \end{bmatrix}$

Examples of a Cubic Dome Design Calculations

Assume we have a cube (Fig. 23) with edges oriented in the X, Y, Z directions and the center of the cube located at 0, 0, 0. The coordinates are as follows: assume for convenience each edge = 2 units.

	X	Y	Z
A_2	+1	-1	+1
A_3	+1	+1	+1
A_4	-1	+1	+1
A_1	-1	-1	+1
B_2	+1	-1	-1
B_3	+1	+1	-1
B_4	-1	+1	-1
B_1	-1	-1	-1

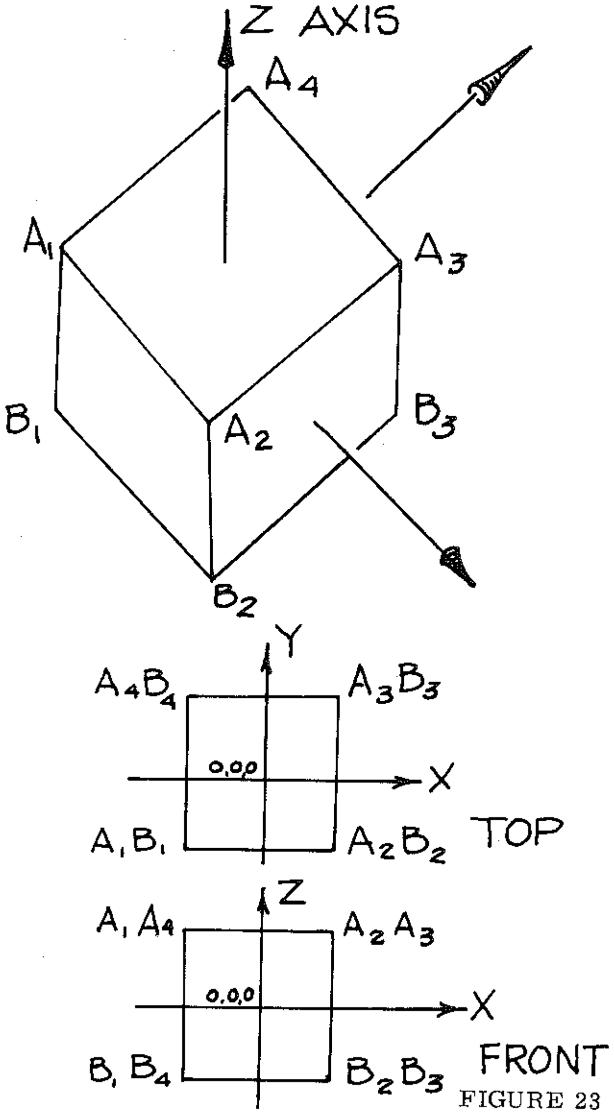


FIGURE 23

We wish to find X, Y, Z coordinates on great circle arcs which lie on a circumscribing sphere containing the cube.

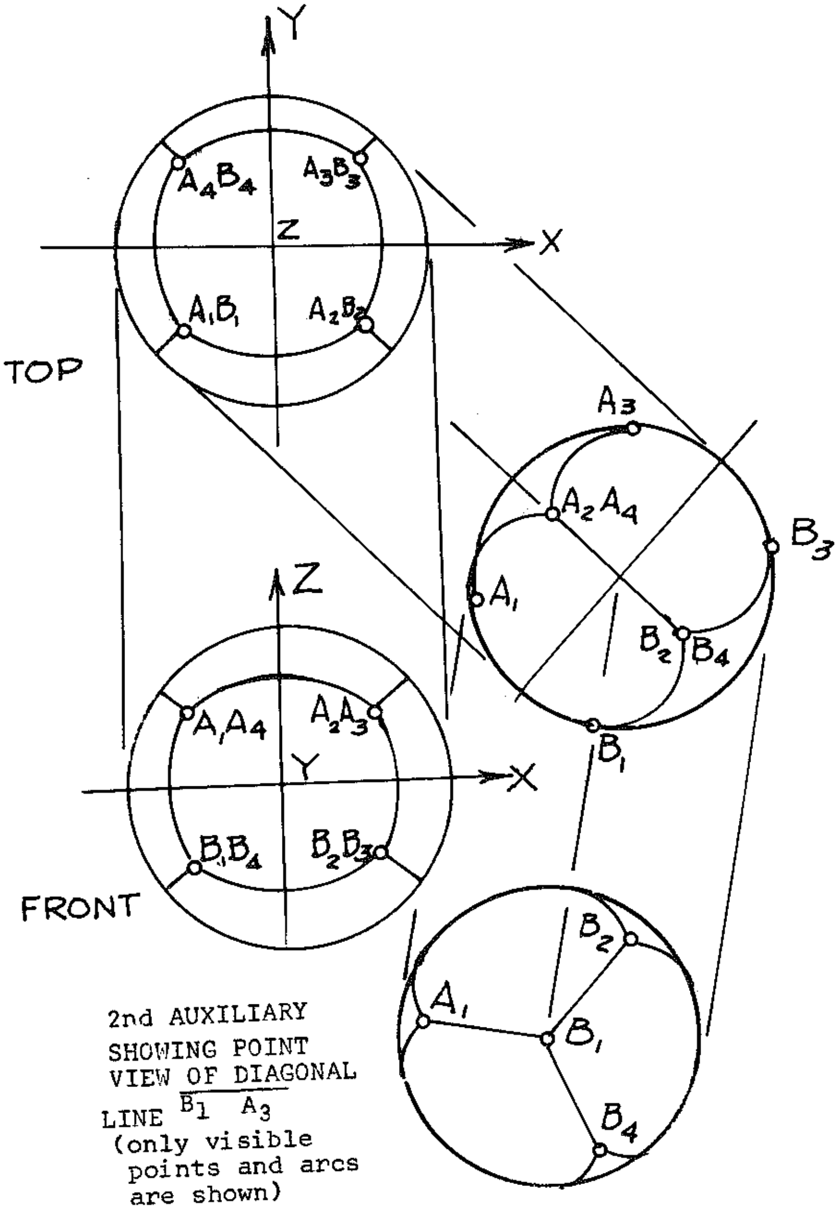
For example: - points on the arc $\widehat{A_1A_3}$, arc $\widehat{A_2A_3}$ (Fig. 24)

To find n points on diagonal arc $\widehat{A_1A_3}$ (Fig. 25)

Revolve cube about z - $\theta_1 = 45^{o}$ ↘

Then revolve A'_1 to any position on $\widehat{A'_1A'_3}$ about Y axis thru angle = θ_5/n

Then counter revolve this point to its relative position on the original sphere by rotating θ_1o about z ↖



2nd AUXILIARY SHOWING POINT VIEW OF DIAGONAL LINE $\overline{B_1\ A_3}$ (only visible points and arcs are shown)

FIGURE 24 - ORTHOGRAPHIC PROJECTION OF CUBO-SPHERE

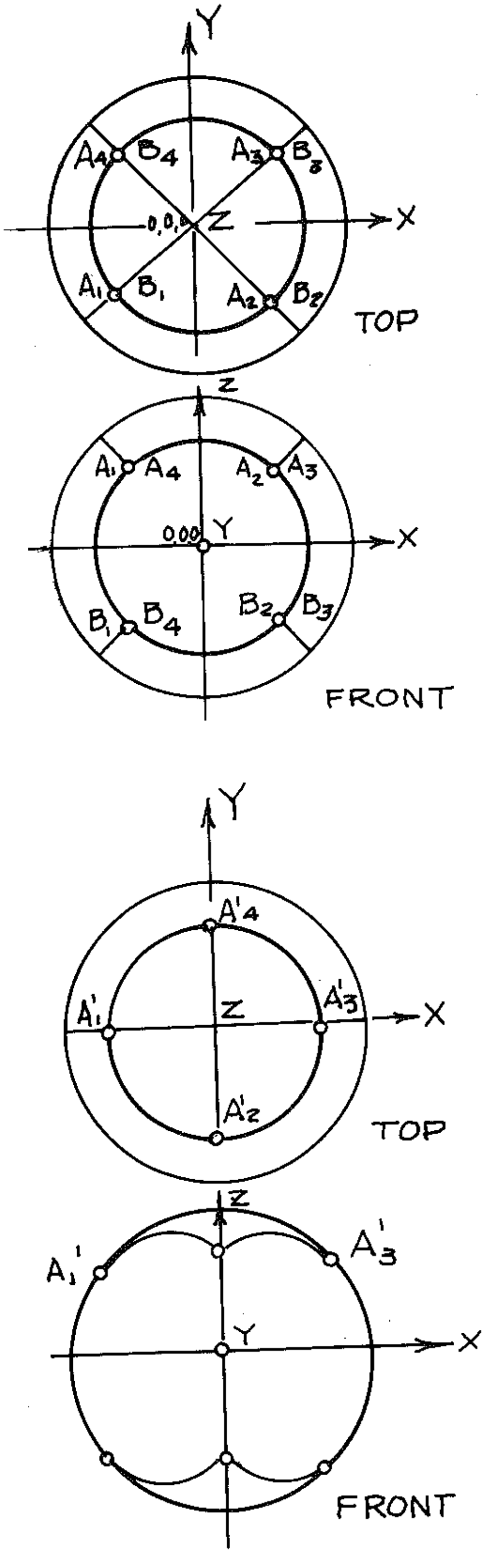


FIGURE 25

Example let n = 1 to find point 22 (see Fig. 26)

$$A_3 = [+1, +1, +1]$$

$$[+1, +1, +1] \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 & 0 \\ 1\ \sin\theta_1 & \cos\theta_1 & 0 \\ 0 & 0 & 1 \end{bmatrix} = A'_3$$

$$\left[+\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}},\ -\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}},\ +1\right] = [+\sqrt{2},\ 0,\ +1]$$

$$[+\sqrt{2},\ 0,\ +1] \begin{bmatrix} \cos\theta_5/n & 0 & \sin\theta_5/n \\ 0 & 1 & 0 \\ -\sin\theta_5/n & 0 & \cos\theta_5/n \end{bmatrix} = A'_5/n$$

where (n = 1)

$$\left[+\sqrt{\frac{2}{3}} - \sqrt{\frac{2}{3}},\ 0,\ +\frac{\sqrt{2}\ \sqrt{2}}{\sqrt{3}} + \frac{1}{\sqrt{3}}\right] =$$

$$[0,\ 0,\ +\sqrt{3}]$$

$$[0,\ 0,\ +\sqrt{3}] \begin{bmatrix} \cos 45 & -\sin 45 & 0 \\ \sin 45 & \cos 45 & 0 \\ 0 & 0 & 1 \end{bmatrix} =$$

$$[0,\ 0,\ +\sqrt{3}] = A_3\theta_5/n \text{ where } n = 1$$

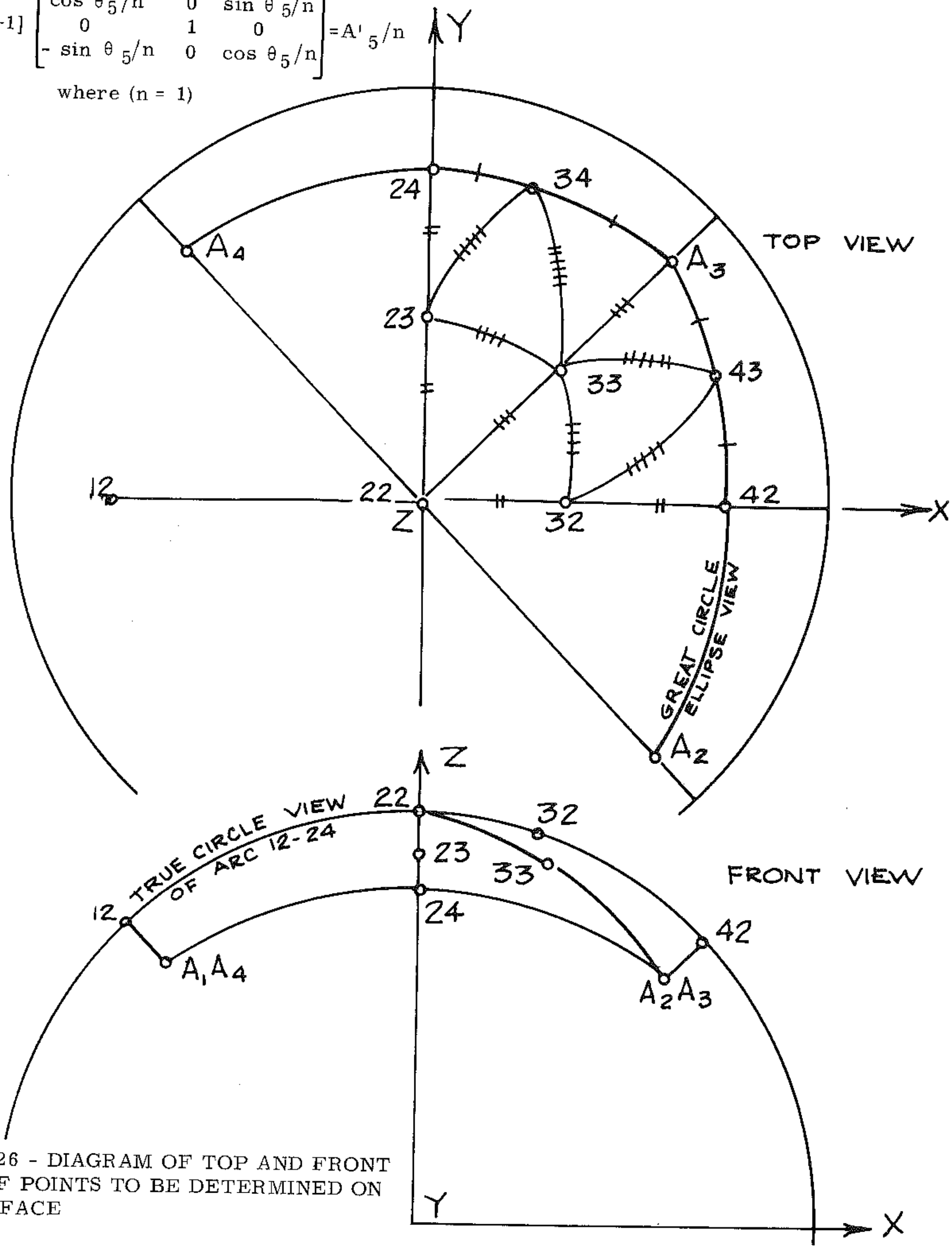


FIGURE 26 - DIAGRAM OF TOP AND FRONT VIEWS OF POINTS TO BE DETERMINED ON SPHERE FACE

To find n points, equally spaced on the arc $\overset{\frown}{A_2A_3}$ (Fig. 27) Rotate the cube about the y axis - θ = -45^o.

The geodesic through $A'_2A'_3$ now is parallel to the XY plane.

geodesic $\overset{\frown}{A'B'}$ with radius = OA_2

$= OA_3 = \sqrt{3}$ units.

$\theta_3 = 1/2 \angle A'_2OA_3'$

$\sin \theta_3 - \frac{1}{\sqrt{3}}$

$\cos \theta_3 = \sqrt{2/3}$

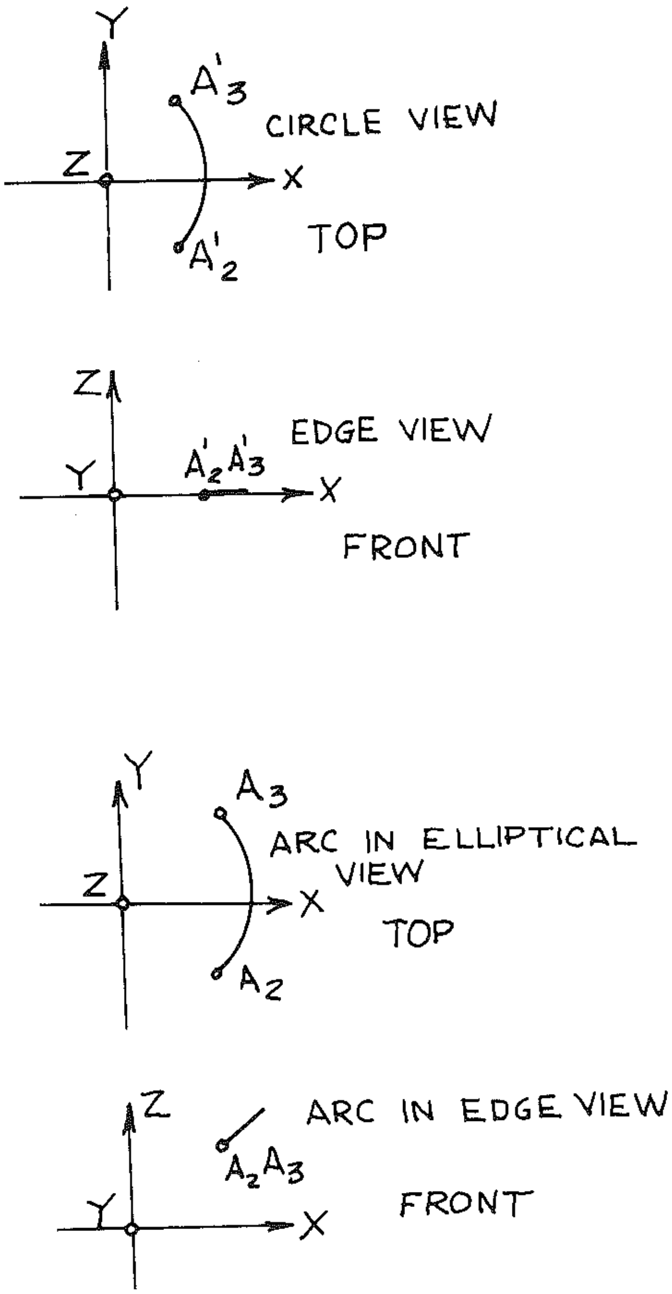


FIGURE 27

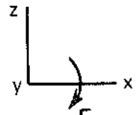
Locate the desired points on the arc $\overset{\frown}{A'_2A'_3}$ and then counter rotate these points $+ \theta_1 = + 45^o$ to their positions relative to the original cube and determine their coordinates.

As an example:

choose the point on Arc $\overset{\frown}{A_2A_3}$ to be the midpoint.

Thus $\theta_3 /n = \theta_3 /1$ = arc sin $1 \sqrt{3}$ = arc cos $\sqrt{2/3}$

$A_2 = [1, 1, 1]$ First revolve $-\theta_1$ about Y
Then revolve θ_3/n about Z
Then counter revolve $+ \theta_1$ about Y



$$[1,\ 1,\ 1]\begin{bmatrix}\cos\theta_1 & 0 & -\sin\theta_1\\ 0 & 1 & 0\\ +\sin\theta_1 & 0 & \cos\theta_1\end{bmatrix} =$$

$$[\cos\theta_1 + \sin\theta_1,\ +1,\ -\sin\theta_1 + \cos\theta_1]$$

$$= [A'_2x,\ A'_2x,\ A'_2z]$$

$$A'_2 = [\sqrt{2},\ +1,\ 0]$$

Point $(42)'' = [\sqrt{2},\ +1,\ 0]$

$$\begin{bmatrix}\cos\theta\, 3/n & +\sin\theta\, 3/2 & 0\\ \sin\theta\, 3/n & \cos\theta\, 3/n & 0\\ 0 & 0 & 1\end{bmatrix} =$$

$$= \left[\frac{\sqrt{2}\ \sqrt{2}}{\sqrt{3}} - \frac{1}{\sqrt{3}},\ -\sqrt{\frac{2}{3}} + \sqrt{\frac{2}{3}},\ 0\right]$$

$A_2\theta\, 3/n$ = Point $(42)' = [\sqrt{3},\ 0,\ 0]$

$$[\sqrt{3},\ 0,\ 0]\begin{bmatrix}+\cos 45 & 0 & +\sin 45\\ 0 & 1 & 0\\ -\sin 45 & 0 & +\cos 45\end{bmatrix} =$$

$\left[+\sqrt{\frac{3}{2}},\ 0,\ +\sqrt{\frac{3}{2}}\right]$ = Point 42
(See Figure 26, line 24)

By these procedures we may find the coordinates of any point K/nth of the diagonal arc or edge arc of a sphero-cubic face. To find the K/nth point on any geodesic or great circle arc of the sphere, the following procedure may be used:

Suppose, instead of triangular segments, we wished to divide the each face into 16 quadrilaterals (Fig. 28). Points 22, 23, 24, 34, 43, 32 are found by the method of the previous example. To find point M so that the geodesic arc 32 - 34 is bisected requires the following procedures.

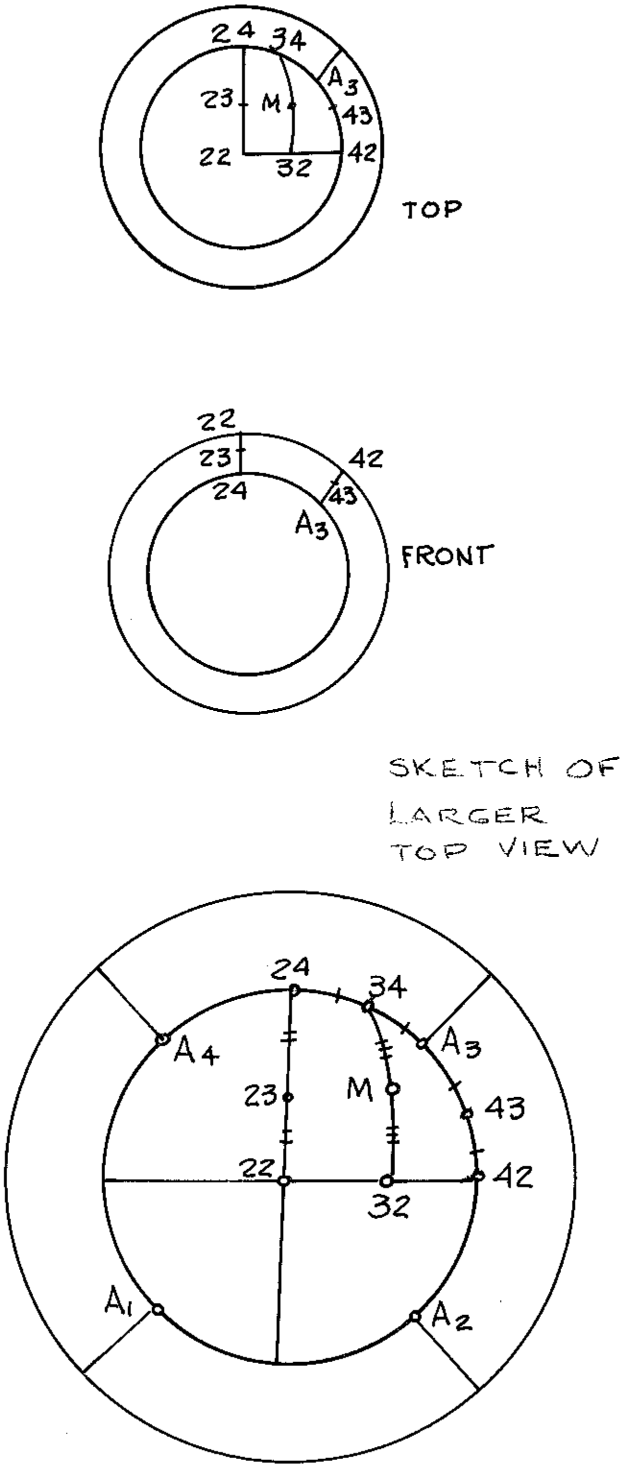


FIGURE 28

GENERAL METHOD FOR FINDING A POINT ON A SPHERE ARC

Given two points, P, Q on a sphere of Radius R with center at 0, 0, 0. Note that plane P, O, Q is not perpendicular to a reference plane. Find the K/nth points on a great circle arc $\overset{\frown}{PQ}$ in plane P, O, Q connecting the two points.

(1) Revolve ϕ_1 about z ↶ so P'Q' is parallel to XZ plane, find coordinates of P'Q'

(2) Then revolve ϕ_2 about Y ↶ so P'' Q'' is perpendicular to XY plane. Find coordinates of P''Q''.

(3) Revolve ϕ_3 about Z ↶ so P'''Q''' is in X plane. Find coordinates of P'''Q''' Revolve $P''' = K\frac{\theta 4}{n}$ Find coordinates of desired point on P'''Q'''.

(4) Counter revolve (-)$\angle\phi_3$ about Z

(5) Counter revolve (-)$\angle\phi_2$ about Y

(6) Counter revolve (-)$\angle\phi_1$ about Z

This gives coordinates of the K/nth division of arc PQ

$$\tan\angle\phi_1 = \frac{(P-Q)y}{(P-Q)x}$$

$$\tan\angle\phi_2 \quad \frac{(P'-Q')x}{(P'-Q')z}$$

$$\tan\angle\phi_3 \quad \frac{Py''}{Px''}$$

$$\tan\angle(\phi_4 \div 2) = \frac{Pz'''}{Px'''} = \frac{1}{2} \text{ arc } P'''Q'''$$

ICOSAHEDRAL DESIGN

Rather than a cubo-sphere, it may be desirable to design a dome or roof structure based on the triangular 20 faced regular polyhedron, the icosahedron. Again, we assume a sphere contains all the vertex points. Once the front and top views are established in coordinate form, the coordinates of points which will segment the faces may be found by matrix transformations. In planning the design a study of alternate graphs is useful.

Example: Given (Fig. 29) a front view of an icosahedron as shown, with vertex point as the pole of the enclosing sphere and the five triangles forming the hexagonal cap each with one horizontal line. This view enables us to

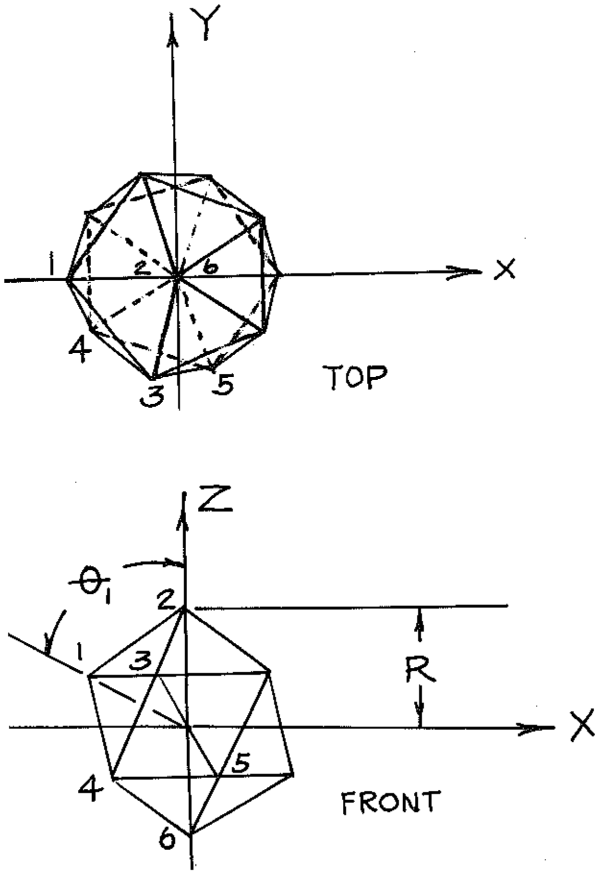


FIGURE 29 - ORTHOGRAPHIC PROJECTION OF AN ICOSOHEDRON

see a true view of the dihedral angle, and the angle between one edge and a face.

The method of solution is as follows: To locate points on a great circle connecting two vertex points, choose the chordal edge which is true length in the front view, revolve the pole point at [0, 0, R] through $\frac{k}{n}\ \theta_1$ where θ_1 = 2 x arc cos = $\frac{\text{Edge length}}{2 \text{ x } R}$

n = number of divisions of the arc and k = 1 to n. If geodesic arcs are internal to the triangle edges, they may be found by the general method previously described.

By rotation and displacement, the points on face 123 may be transferred to faces 134, 345 and 456.

Since the icosahedron has five-fold symmetry about the Z axis, the points on the four numbered faces may be easily transferred to the remaining symmetrical faces of the sphero-icosahedron by matrix transformations.

CONCLUSION

I believe that Descriptive Geometry should continue to be a fundamental course required of all engineering, science and architecture students. The concepts which are treated enable one to organize spatial experience and exercise methods of thinking which are both logical and intuitive. Coupled with the powerful arithmetic methods which are being grasped by students using computers, we have an opportunity to teach a new course in Descriptive Geometry, which will be a required part of the mainstream of technical education.

The methods of geometrical design by the use of space graphs or diagrams and the use of matrix transformations are just two of the New Descriptive Geometry which I encourage you to teach to your students who have been learning a New Math also!

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Several years ago Professor Steve Coons at MIT gave me his notes on "Matrix Transformations". In these he shows how to perform rotations, displacements, scale changes, axonometric and perspective projections. I would like to thank him for introducing me to these methods.

I would like also to thank Ernie Wertheim, architecture student at Cooper Union, for his analysis of the Archimedean graphs.

(see GEOMETRY - p. 48)

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MATHEMATICS AND GRAPHICS ---

GETTING THE POINT ACROSS

L. C. Baird
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Frank Marvin
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I. INTRODUCTION

The engineer needs many tools to solve the varied and complex problems of today's society. Mathematics is unquestionably the basis for most theoretical developments in engineering. Therefore, undergraduate engineering degrees generally require two years of mathematics including differential equations. Unfortunately, students are often lost in a maze of theory.

Engineering graphics is also a recognized part of an engineer's education; but it is often "squeezed out" as a service or support course in deference to the degree-granting departments. Consequently engineering students may fail to recognize engineering graphics as a powerful tool for solving difficult problems encountered in engineering practice.

A recent effort at Virginia Polytechnic Institute and State University has brought together these two important areas of engineering education -- mathematics and graphics. Simple, practical application problems have been used to illustrate the importance and advantages of the required mathematics and engineering graphics courses. The illustrations give the student a better appreciation for why he is required to take these courses. He is thereby protected from an attitude of indifference, an attitude which could ultimately hamper progress toward his engineering goals.

This effort to impress students with the importance of required courses is neither unique nor new. But such efforts are nevertheless rare; for it is difficult to provide suitable examples. There are few graphics teachers who readily solve problems using vector algebra or the calculus; and there are few mathematics teachers who can apply descriptive geometry to the graphical solution of three-dimensional spatial problems.

To overcome this gap, a spatial relationship problem can first be posed and solved by the graphics department. The problem is then turned over to the mathematics department, which provides an analytical solution. Subsequently, the various solutions are refined, correlated for consistency, and put into presentational form. (The authors have found transparencies most useful for classroom presentations.) The following example is a typical product of this process. It effectively demonstrates to the student engineer the importance of his own abilities in both mathematics and engineering graphics.

A classic problem of descriptive geometry is to find the shortest distance between two skew lines. That is we wish to find $\{\alpha, \beta, S\}$ in terms of $\{a, A, b, B\}$ (figure 1). This often seems purely academic to the freshman engineering student until he is told of direct applications in civil engineering, mining, aerospace, etc. Interference between support cables, shortest connecting tunnels, and clearances between control linkages are typical applications of this basic problem.

A precise solution to the problem can only be obtained analytically; but the computations are somewhat complicated. A graphical solution, while only approximate, has the advantage of simplicity. A parallel presentation lets the student see and appreciate the advantages of several solution techniques. In section II the calculus is used to obtain a numerical solution. In section III vector analysis is used to obtain a general solution. The graphic solution is obtained in section IV.

II. THE CALCULUS SOLUTION

Referring to figure 1 we see that the value of S depends upon the positions of α and β. We wish to choose α and β so that

S is a minimum. Elementary considerations from analytic geometry show that:

$$\alpha_y = a_y + (\alpha_x - a_x)(A_y - a_y)/(A_x - a_x)$$

$$= 1.25\alpha_x - 1.25 \qquad (1)$$

$$\alpha_z = a_z + (\alpha_x - a_x)(A_z - a_z)/(A_x - a_x)$$

$$= 3 - \alpha_x \qquad (2)$$

$$\beta_y = b_y + (\beta_x - b_x)(B_y - b_y)/(B_x - b_x)$$

$$= 4.4 - 0.2\beta_x \qquad (3)$$

$$\beta_z = b_z + (\beta_x - b_x)(B_z - b_z)/(B_x - b_x)$$

$$= 3.2 + 0.4\beta_x \qquad (4)$$

The distance between α and β is:

$$S = \left[(\alpha_x - \beta_x)^2 + (\alpha_y - \beta_y)^2 + (\alpha_z - \beta_z)^2\right]^{1/2}$$

$$= \left[3.56\alpha_x^2 - 0.70\alpha_x\beta_x + 1.20\beta_x^2 - 13.74\alpha_x - 2.1\beta_x + 31.94\right]^{1/2} \qquad (5)$$

where equations (1)-(4) have been used to eliminate $\{\alpha_y, \alpha_z, \beta_y, \beta_z\}$.

The minimum value of S occurs when α_x and β_x satisfy:

$$0 = \frac{\partial S}{\partial \alpha_x}$$

$$= (7.12\alpha_x - 0.7\beta_x - 13.74)/(2S) \qquad (6)$$

$$0 = \frac{\partial S}{\partial \beta_x}$$

$$= (-0.70\alpha_x + 2.4\beta_x - 2.1)/(2S) \qquad (7)$$

Simultaneous solution of equations (6) and (7) yields:

$$\alpha_x = 2.07 \qquad (8)$$

$$\beta_x = 1.49 \qquad (9)$$

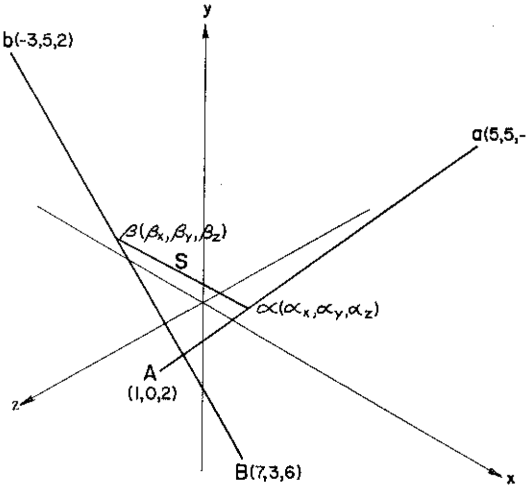


FIGURE 1

Substituting these values into equations (1)-(5) yields:

$$\alpha_y = 1.34 \qquad (10)$$

$$\alpha_z = 0.93 \qquad (11)$$

$$\beta_y = 4.10 \qquad (12)$$

$$\beta_z = 3.80 \qquad (13)$$

$$S = 4.01 \qquad (14)$$

The procedure just demonstrated can also be used to derive a general formula for the values of $\{S, \alpha_x, \alpha_y, \alpha_z, \beta_x, \beta_y, \beta_z\}$ in terms of the coordinates of $\{a, A, b, B\}$; but the derivation and end result are both extremely unwieldy.

III. VECTOR ANALYSIS SOLUTION

General formulas for α, β, and S will be derived in this section; so a more elaborate notation is needed:

(1) An overlying arrow will denote the radius vector for a point. For example, $\vec{A}$ is the vector whose tail is at the origin and whose head is at the point, A; the coordinates of $\vec{A}$ will still be denoted by A_x, A_y, and A_z.

(2) Unit vectors along the coordinate axes will be denoted by $\hat{x}$, $\hat{y}$, and $\hat{z}$.

(3) The vector from β to α will be denoted by $\vec{S}$. The magnitude of $\vec{S}$ will be denoted by S, as before.

It is clear from figure 2 that $\vec{\alpha}$ and $\vec{\beta}$ may be written in the form:

$$\vec{\alpha} = \vec{a} + p(\vec{A} - \vec{a}) \tag{15}$$

$$\vec{\beta} = b + q(\vec{B} - \vec{b}) \tag{16}$$

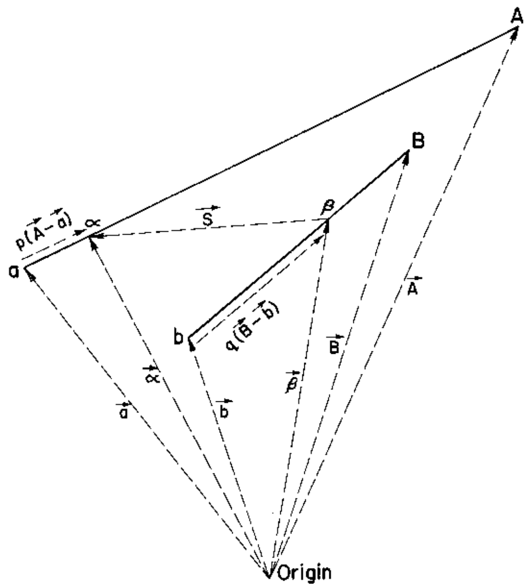


FIGURE 2

$$\begin{aligned}\vec{S} &= \vec{\alpha} - \vec{\beta} \\ &= \left[\vec{a} + p(\vec{A} - \vec{a})\right] - \left[\vec{b} + q(\vec{B} - \vec{b})\right] \\ &= (\vec{a} - \vec{b}) + p\,(\vec{A} - \vec{a}) - q\,(\vec{B} - \vec{b})\end{aligned} \tag{17}$$

Or:

$$p\,(\vec{A} - \vec{a}) - q\,(\vec{B} - \vec{b}) = \vec{S} - (\vec{a} - \vec{b}) \tag{18}$$

We wish to choose $\vec{\alpha}$ and $\vec{\beta}$ so that the magnitude of $\vec{S}$ is a minimum. In that case $\vec{S}$ will be perpendicular to both $(\vec{A} - \vec{a})$ and $(\vec{B} - \vec{b})$; so dot products of $\vec{S}$ with these differences must be zero. Thus, dotting $(\vec{A} - \vec{a})$ into equation (18) yields:

$$p\,(\vec{A} - \vec{a})(\vec{A} - \vec{a}) - q\,(\vec{A} - \vec{a})(\vec{B} - \vec{b}) = - (\vec{A} - \vec{a})(\vec{a} - \vec{b}) \tag{19}$$

Dotting $(\vec{B} - \vec{b})$ into equation (18) yields:

$$p\,(\vec{A} - \vec{a})(\vec{B} - \vec{b}) - q\,(\vec{B} - \vec{b})(\vec{B} - \vec{b}) = - (\vec{B} - \vec{b})(\vec{a} - \vec{b}) \tag{20}$$

We solve equations (19)-(20) simultaneously to obtain expressions for p and q.

These expressions are substituted into equations (15)-(16) for the result:

$$\vec{\alpha} = \vec{a} - (\vec{A} - \vec{a}) \begin{vmatrix} (\vec{a} - \vec{b})(\vec{A} - \vec{a}) & (\vec{A} - \vec{a})(\vec{B} - \vec{b}) \\ (\vec{a} - \vec{b})(\vec{B} - \vec{b}) & (\vec{B} - \vec{b})(\vec{B} - \vec{b}) \end{vmatrix} \div \begin{vmatrix} (\vec{A} - \vec{a})(\vec{A} - \vec{a}) & (\vec{A} - \vec{a})(\vec{B} - \vec{b}) \\ (\vec{A} - \vec{a})(\vec{B} - \vec{b}) & (\vec{B} - \vec{b})(\vec{B} - \vec{b}) \end{vmatrix} \tag{21}$$

$$\vec{\beta} = \vec{b} + (\vec{B} - \vec{b}) \begin{vmatrix} (\vec{A} - \vec{a})(\vec{A} - \vec{a}) & (\vec{a} - \vec{b})(\vec{A} - \vec{a}) \\ (\vec{A} - \vec{a})(\vec{B} - \vec{b}) & (\vec{a} - \vec{b})(\vec{B} - \vec{b}) \end{vmatrix} \div \begin{vmatrix} (\vec{A} - \vec{a})(\vec{A} - \vec{a}) & (\vec{A} - \vec{a})(\vec{B} - \vec{b}) \\ (\vec{A} - \vec{a})(\vec{B} - \vec{b}) & (\vec{B} - \vec{b})(\vec{B} - \vec{b}) \end{vmatrix} \tag{22}$$

Equations (21)-(22) constitute general formulas for $\vec{\alpha}$ and $\vec{\beta}$. It is only necessary to substitute the coordinates of the endpoints of the given lines. The numerical values of figure (1) yield:

$$(\vec{a} - \vec{b})(\vec{A} - \vec{a}) = -48 \tag{23}$$

$$(\vec{a} - \vec{b})(\vec{B} - \vec{b}) = 64 \tag{24}$$

$$(\vec{A} - \vec{a})(\vec{A} - \vec{a}) = 57 \tag{25}$$

$$(\vec{A} - \vec{a})(\vec{B} - \vec{b}) = -14 \tag{26}$$

$$(\vec{B} - \vec{b})(\vec{B} - \vec{b}) = 120 \tag{27}$$

The coordinates of [a, A, b, B] and equations (23)-(27) may be used in equations (21)-(22) to obtain the final results:

$$\vec{\alpha} = 2.07\,\hat{x} + 1.34\,\hat{y} + 0.93\,\hat{z} \tag{28}$$

$$\vec{\beta} = 1.48\,\hat{x} + 4.11\,\hat{y} + 3.79\,\hat{z} \tag{29}$$

We can now compute S:

$$S = \left[(\vec{\alpha} - \vec{\beta})(\vec{\alpha} - \vec{\beta})\right]^{1/2} = 4.01 \tag{30}$$

Round-off errors are responsible for the slight discrepancy between equations (8)-(14) and equations (28)-(30).

It is also possible to compute S directly without first finding $\vec{\alpha}$ and $\vec{\beta}$. Since $\vec{S}$ is perpendicular to both $(\vec{A} - \vec{a})$ and $(\vec{B} - \vec{b})$ it follows that $\vec{S}$ is parallel to $(\vec{A} - \vec{a})\times(\vec{B} - \vec{b})$ (assuming the two given lines aren't parallel. That is:

$$\vec{S} = m\ (\vec{A} - \vec{a})\times(\vec{B} - \vec{b}) \tag{31}$$

where m is some unknown constant. Furthermore:

$$S = \vec{S}\cdot\vec{S}\ /\ S \tag{32}$$

Equations (17) and (31) may be substituted into equation (32) to obtain:

$$S = \left[(\vec{a} - \vec{b}) + p\ (\vec{A} - \vec{a}) - q\ (\vec{B} - \vec{b})\right]\cdot$$

$$m\ (\vec{A} - \vec{a})\times(\vec{B} - \vec{b}) \quad \div \left| m(\vec{A} - \vec{a})\times(\vec{B} - \vec{b})\right|$$

$$= \pm\ (\vec{a} - \vec{b})\cdot(\vec{A} - \vec{a})\times(\vec{B} - \vec{b})\ /\ \left|(\vec{A} - \vec{a})\times(\vec{B} - \vec{b})\right| \tag{33}$$

The terms involving p and q no longer appear because $(\vec{A} - \vec{a})$ and $(\vec{B} - \vec{b})$ are perpendicular to $(\vec{A} - \vec{a})\times(\vec{B} - \vec{b})$. Equation (33) may also be written in terms of the components of the various vectors:

$$S = \pm \begin{vmatrix} a_x - b_x & a_y - b_y & a_z - b_z \\ A_x - a_x & A_y - a_y & A_z - a_z \\ B_x - b_x & B_y - b_y & B_z - b_z \end{vmatrix}$$

$$\div \left\| \begin{matrix} \hat{x} & \hat{y} & \hat{z} \\ A_x - a_x & A_y - a_y & A_z - a_z \\ B_x - b_x & B_y - b_y & B_z - b_z \end{matrix} \right\| \tag{34}$$

Equation (34) is the general formula for S. The ratio is computed as follows. First expand the two determinants. This will yield a number in the numerator and a vector in the denominator. Next, divide the number by the length of the vector. Finally, choose the sign of the result to be positive. The numerical values previously used give:

$$S = 328\ /\sqrt{6674}$$

$$= 4.02 \tag{35}$$

If it so happens that the lines are parallel, then equation (34) gives the indeterminant result:

$$S = 0/0 \tag{36}$$

In this case, the appropriate distance formula is:

$$S = \left\|(\vec{a} - \vec{b})\times(\vec{A} - \vec{a})\right\|\ /\ \left\|\vec{A} - \vec{a}\right\| \tag{37}$$

To evaluate this formula one computes the length of the vector, $(\vec{a} - \vec{b})\times(\vec{A} - \vec{a})$, and the length of the vector, $\vec{A} - \vec{a}$. The ratio of the two lengths gives S. The derivation has been omitted for brevity.

IV. THE GRAPHICAL SOLUTION

The shortest distance between two skew lines will be a line which is perpendicular to both skew lines (figure 3). To find this shortest distance, we construct an auxiliary view showing the point view of one of the given lines -- in this case, line aA. The shortest distance between the lines is readily observed as the perpendicular distance from the point view of aA to the other line bB. The lines do not appear true length in either the front or top views. To obtain the point view of one of the lines we first obtain the true length view of the line in a first auxiliary view by projecting perpendicular to the line. Then we obtain a second auxiliary view by projecting parallel to the true length of the line in the first auxiliary. The shortest distance from the point view of line aA to line bB is the perpendicular from a_2A_2 to b_2B_2. We now locate this line in the principal views. Point β can

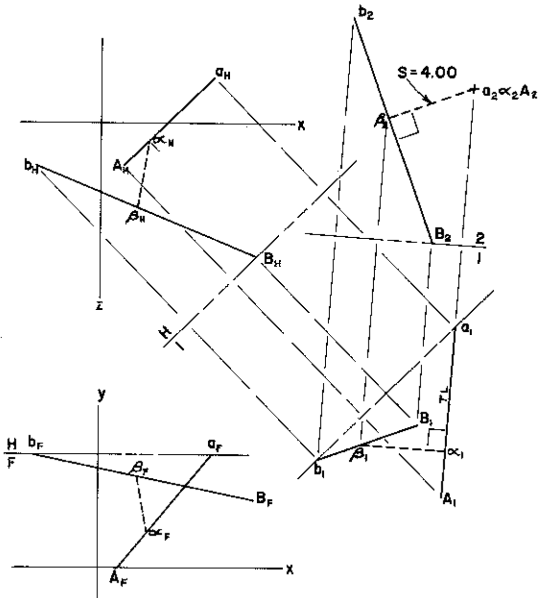


FIGURE 3

be projected back to the first auxiliary view and the principal views with no difficulty. Point β cannot be projected back to the first auxiliary because its position on the line a_2A_2 is unknown. However in the first auxiliary view line aA is true length. Also, the line $\alpha\beta$ is perpendicular to both aA and bB, since the shortest distance between the lines is the common perpendicular. If two lines are perpendicular to each other, they will appear perpendicular if one or both of the lines are true length. Since line aA is true length in the first auxiliary view, $\alpha\beta$ can be located by drawing a perpendicular from β_1 to line $a_1 A_1$. Then α can be projected to the principal views

The shortest connector can be measured in the second auxiliary. The coordinates of α and β can be measured in the principal views. The graphical results are:

$$S = 4.00 \tag{38}$$

$$\alpha_x = 2.08 \tag{39}$$

$$\alpha_y = 1.32 \tag{40}$$

$$\alpha_z = .92 \tag{41}$$

$$\beta_x = 1.52 \tag{42}$$

$$\beta_y = 4.08 \tag{43}$$

$$\beta_z = 3.80 \tag{44}$$

V. CONCLUSIONS

Section II shows that our problem can be solved by a straightforward application of differential calculus. The general approach is easily remembered; but the computations are somewhat complicated and do not readily yield a general formula. Accuracy is limited only by the number of decimal places one wishes to carry.

Vector analysis yields general formulas for the unknowns. One need only substitute values for the endpoints of the two given lines. A small desk top computer can easily be programmed to do this automatically; but only a moderate amount of computation is required if one does the job by hand. Since the derivation presumes a thorough grounding in vector analysis, some students may feel ill at ease using the final formulas. The accuracy of the results is limited only by the number of decimal places one wishes to carry.

The graphical method is relatively fast and simple. It is easy to learn and not difficult to remember. The graphical results are only approximate; but sufficient accuracy will be obtained for most practical applications. The method will be unsatisfactory only if extreme accuracy is required or if it happens to be difficult to plot $\{a, A, b, B\}$ on a convenient scale.

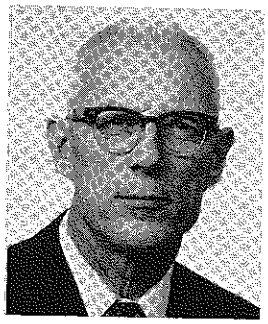
VI. SUMMARY

The material in this paper was compiled for use in a freshman engineering graphics course. The emphasis was on the graphical solution to the problem; but the student definitely profits from a brief introduction to the calculus and vector solutions. The three-fold presentation vividly demonstrates the relevance of the basic engineering curriculum. The student's general outlook is broadened as he sees the same problem solved from several different points of view.

This correlation between mathematics and engineering graphics has proven to be an interesting and effective means of motivating freshmen engineering students at VPI&SU. The three-fold analysis is, therefore, being applied to additional problems for future presentations.

AN APPROACH TO INSTRUCTION IN DESIGN

J. P. Mason, Jr., Professor and Head
Virginia Polytechnic Institute and State University



U. F. Earp, Professor
Virginia Polytechnic Institute and State University

This paper describes a method of teaching engineering design in which each student has an individual project of his own. The course involves one academic year. Emphasis is placed on projects of current interest. Report writing and preparation of material for the press as well as design procedures are emphasized. The method of conducting the course, a statement of the objectives and an appraisal of its effectiveness are discussed.

Introduction: One of the prime characteristics of an engineer is his ability to design or to function with a knowledge of design. The need to teach design is then apparent in educating engineers. The process of teaching this type of behavior involves, or should involve, having the learner practice that which he is supposed to be doing, i. e. to do some design. In view of the tendency of many engineering professors to put less emphasis on the design phases of their respective engineering courses, the challenge of presenting an effective means for providing the senior an experience in engineering design was accepted by the departmental staff several years ago. The resources utilized, educational objectives, academic structure, and our evaluation are discussed based on several years of experience.

A course with educational objectives much less well-defined has been required in the department for many years. Although successful in many aspects - report writing practice, modest use of experimental technique, awards, etc. - the original course had the label or connotation of being a "research" problem. A significant priority was to eliminate the "pseudo-research" portion, both in fact and in title. To provide design practice was the overall objective.

Resources: Much has been said regarding relevance in modern education. In this connection, our departmental staff has ten extension agricultural engineers who are being continually bombarded with problems from a very versatile agricultural complex. Also, our team of research agricultural engineers is always blessed - or plagued - with current problems. It is reasonable, then, that our teaching staff considered that a broad spectrum of relevant problems is always available to challenge vigorous young minds.

A second major resource was the availability of interested faculty who can project these challenging problems and who want to be involved with students. All faculty - teaching, research, and extension - have served as project engineers for the student working on a problem related to the faculty member's area of interest.

Another valuable asset is the availability of resource people in other professions who willingly get involved with projects and thus add an interdisciplinary dimension. Our own faculty are frequently involved across department lines, so it is natural for students to have a similar involvement.

Facilities of the department - shop, technicians, supplies, funds - are also made available. With the close faculty involvement, the successful student project may very well be a useful accomplishment for the cooperating faculty member and the department.

Educational Objectives: Knowing the resources of experience, facilities, and willing project leaders that were available, plus a source of current engineering problems, the specific objectives of the course were as follows:

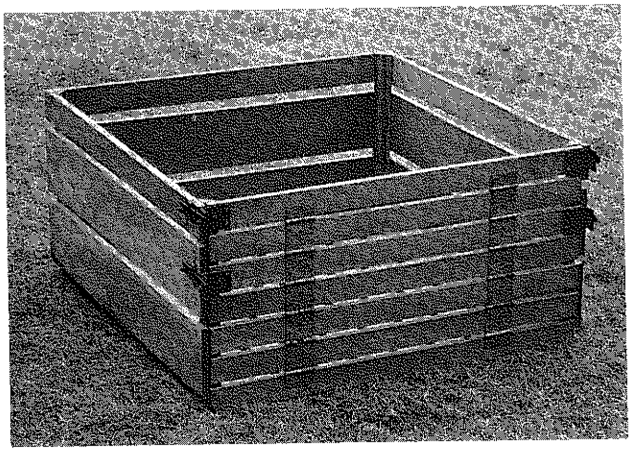
1. Give each student design experience while he is still in the academic environment. This includes the concept of "thinking" as a viable part of design.

2. Minimize the constraints on possible solutions, techniques, sources of information, etc.

3. Motivate students by having them deal first-hand with current problems.

4. Cultivate a professional outlook. Give the learner an opportunity to rub shoulders with at least one professional in his field and perhaps with professionals from other disciplines.

5. Introduce students to technical report writing including the preparation of material for the technical press.



Bulk fruit handling box with a rolled down side to assist in the placement of fruit near the level of the fruit already in the box. This is necessary to prevent the dropping of produce which might cause excessive damage to the harvested fruit.

FIGURE 1

Having identified a problem and considered various criteria several alternatives suggest themselves. They include (a) the concept of a group design project, (b) accomplishing the objectives through conventional class activity, or (c) approach the idea by having an individual project for each student. Although all three alternatives have merit, the latter was chosen because it (1) gives each learner more individual responsibility - if he achieves he gets the credit, if he does not achieve he gets commensurable credit; (2) competent faculty were available and interested in participating and (3) suitable projects were available to challenge the students.

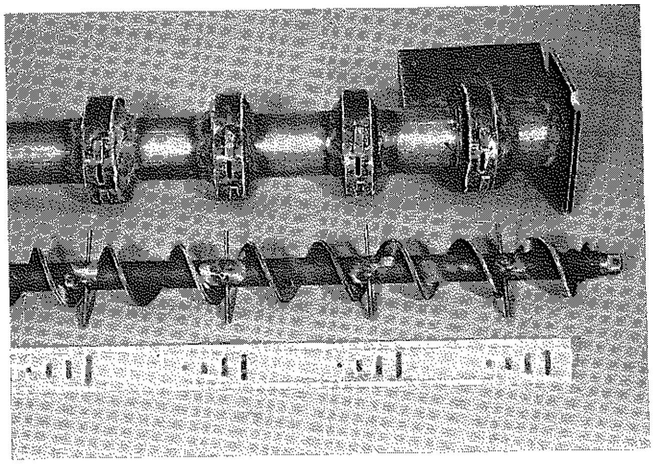
Course Structure: The course is operated according to the following general time-function distribution:

Introduction, problem identification, design procedures, - approximately 20%

Problem formulation and analysis, development of possible alternative approaches, selection of a solution, modeling and testing - approximately 50%

Writing progress reports, a final project report, and an article, - approximately 30%

Within the constraints of the quarter system under which we operate, the first 20% is functional during the fall quarter as a one credit-hour course. The student gets a design project and a project engineer. He submits a written proposal outlining the broad concept of his project to the instructor and his project engineer thus establishing a firm commitment. Normally students select a project rather than having it assigned. This generally makes it possible for a learner to work with a professor of his choosing in an area in which he (the learner) is interested. The faculty considers this to be an important consideration. More recently, at the suggestion of students, the one credit hour is completed by the midpoint of the quarter. This enables participants to proceed with problem formulation, analysis, etc. before the Christmas break at which time many engage in consultation about their problems with industrial and other interests.



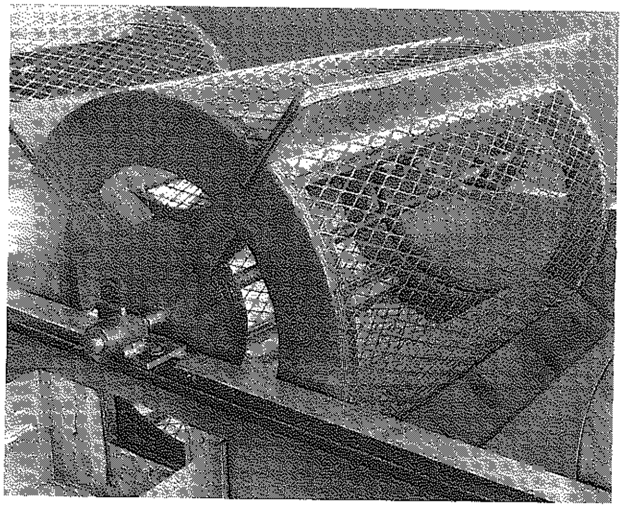
A design for a mechanism for equalizing the distribution of fertilizer from a boom. The shutter mechanism was adjustable thus making it possible to keep approximately the same head on each orifice.

FIGURE 2

The second quarter normally involving two credits concerns itself with the remainder of the design process per se. New ideas and concepts are sought. The literature is investigated. Finally, a number of alternative solutions are generated. These are evaluated as extensively as possible preliminary to reaching a firm decision as to the optimum solution. An appropriate model (computer, scale, etc.) of the system is then developed and suitable procedures for testing it are applied in order to evaluate it. A participant is expected to submit ten weekly progress reports and a term progress report. He is expected to "touch base" with the instructor once each week and with his project engineer as needed.

Finally, during the third term which is also a two credit course, the student completes the performance evaluation, writes a final project report, prepares a journal article based on his project, and makes an oral presentation before the staff and the other members of the class.

Evaluation: What are the advantages of this course? First of all, it offers a limited degree of specialization for those desiring it in an area of one's choosing. It encourages independent inquiry both through library investigation and consultation with recognized professionals. The learner has an excellent opportunity to demonstrate initiative. Many students who for one reason or another had remained relatively obscure have been challenged to accomplish at unexpectedly high levels. Consultation and sharing experiences with professionals in various disciplines have opened channels of communication not exploited before. Students have involved themselves in the design process. Many clever innovations have resulted. Finally, the participants have been involved in writing experiences. These include progress reports, final project reports, and journal article types.



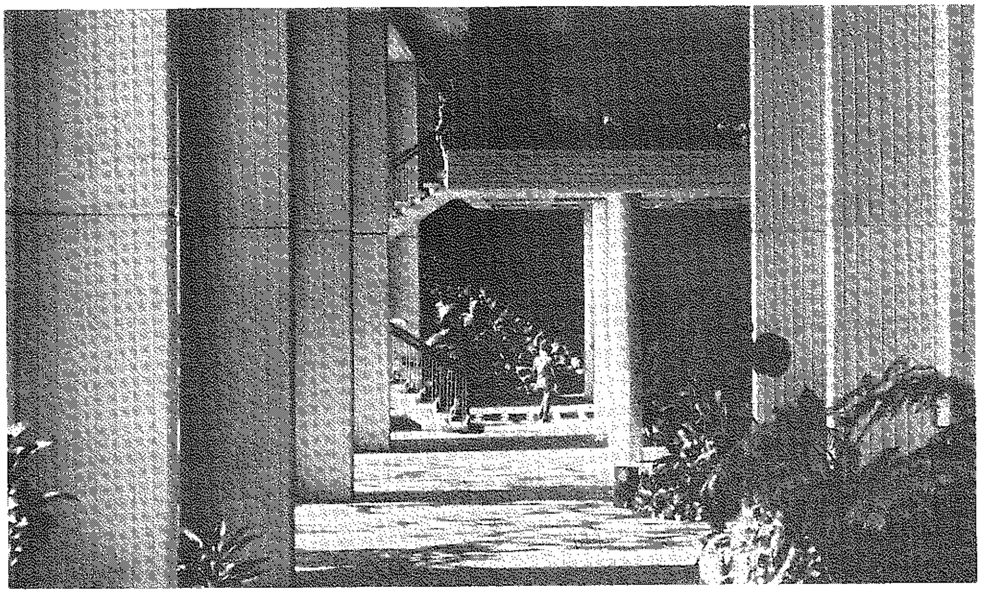
One of several rotating drums used in a vegetable washer that would be utilized in a canning operation. Greens, such as spinach, would be moved through the vat of water by each of the paddle wheels shown. Trash and other foreign materials would be skimmed from the surface of the water.

FIGURE 3

What are the disadvantages? One of the more obvious is the demand on faculty time. If a significant percentage of faculty is unwilling to go some "extra miles" in a meaningful experience with a student, the program is unlikely to be successful. This has been a rare consideration in our operation. Secondly, some very desirable projects die because of lack of funds. Although funding can be a significant constraint, few worthy projects are "scratched" because of it. Thirdly, some students do not work well in this system. It can be established that some students simply are not motivated by the type of learning experience which requires creative thinking, individual initiative, and personal decision making.

Criteria for judging the success of an operation such as this are largely subjective. However, based on our experience, it is concluded that the individual project is a highly desirable mode of teaching engineering design. In the 7-year period, 1965-71, there have been 8 national ASAE paper award winners with at least 1 in each of the 7 years. In the 8-year period, 1963-70, there were 15 Southeast section ASAE paper award winners or an average of almost 2 per year. Projects have included vegetable washers, potato graders, soil moisture testing apparatus, structural problems, instrumentation, etc. The program has developed over many years and many individuals have had inputs. Each year, based on ideas from students, faculty and alumni, modifications are made. Through this process it is hoped that the course can be viable, relevant, and responsive to both student needs and the needs of the profession.

the invigoration of a classic



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Thomas E. French, and **Charles J. Vierck,** University of Florida
1970, 848 pages, $14.95

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GRAPHIC SCIENCE PROBLEMS, Third Edition
Charles J. Vierck, University of Florida and **Richard I. Hang,** The Ohio State University
1972, 64 pages, 135 pages loose-leaf, $7.95

Designed to accompany *Graphic Science and Design, Third Edition,* by French and Vierck, this manual consists of problems which illustrate and clarify all the major concepts in the text. The problems in the new edition reflect the current trend toward making graphics more mathematical for computer graphics purposes. Two features set this book off from other problems books in this area: (1) the use of the "direct method" for solving descriptive geometry problems, and (2) the use of both preplanned (partially drawn) and non-preplanned problem sheets which allow the instructor maximum flexibility in assigning problems.

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NEW TEACHING TECHNIQUES:

THE BASIC INGREDIENT

William J. Jaffe, Professor
Newark College of Engineering
Newark, New Jersey

When Taylor first set out to discover "What is a fair day's work?" he said "our first step" necessarily must be "to look up all that had been written on the subject.". So, with the topic of "new teaching techniques" in general, and programmed learning and teaching machines in particular, to be discussed at an IE session, it seemed appropriate to start in a similar manner.

Perhaps some justification may be needed, since the concept of "looking back" may not seem to be in line with today's scorn of everything "over thirty." However, this backward glance ought not to be a crime associated with the aged in the throes of senility and sentimentality. It was Santayana who used to say that "he who does not read history is condemned to relive it." But, even more, it might prove profitable as so many writers of contemporary textbooks have found out in rediscovering the wheel.

How far does one go back in this spanking "new" era of the electronic computer and those wonderful devices devoted to computing, dating, credit rating, and - teaching ? A couple of centuries ago? Well, there were the famous counting sticks of the ancients. (By the way, they have been revived and painted blue, red, yellow, and green to illustrate set theory to the primary school crowd - giving rise to the story: "How much is 4 and 7?" "Blue!") Too remote? Try something less remote but perhaps just as dear to the hearts of the IE texts - the binary distribution: Pascal's Triangle which dates back to the 1600's. However, get back to the lifetime of some of us here - say, 1926.

What is now called "programmed learning" can be said to have been begun by Sydney L. Pressy, who, at that time, had a "multiple choice testing machine" which, he noted, could be used as a teaching machine. (It can be related to the "wiring diagram" you buy for your children at the toy store - a board that lights up when the child with a lead in both hands places one on a spot marked "2 + 3" and another on "5"). Pressly was quite aware of the capabilities of his machine, but it is doubtful whether most psychologists and school administrators realized how a subject or a course could have had its image enhanced by using such a machine. But, as they are now known, the teaching machines probably can be said to date from the 1950's, and they resulted, to a great extent, from the work done by B. F. Skinner and his associates. Their work had been inspired by "operant conditioning" experiments which had been performed on animals. However, since the 1950's there have been the usual pendulum swings during the years that followed, from exuberance to despair in printed materials whose forms are really akin to machine tape.

Really, most of the programmed materials followed the Skinner Paradigm - a linear sequence of frames, each consisting of a few words (providing the stimulus), some empty space which had to be filled (for the response), and then a correct answer (the reinforcement). Error rate was limited to about 5 per cent - with all students progressing through the same sequence. There were other patterns, too. Among the better known, there was that of Norman Crowder, who used longer frames, having an explanation passage which preceded a number of multiple choice questions, by means of which, each student, depending upon his reply, was led along the "chosen" branch to other frames. The Crowder Programming was often identified by such names as "scrambled", "intrinsic," etc. Obviously, the Crowder and the Skinner plans each had its advantages - as well as those who chose what they considered the best of both. So, on the one hand, there were the programmed learning books - which, in reality, were conventional textbooks with empty spaces strategically placed between the regular printed material - while, on the other, there were flow charts (so dear to the hearts of the computer programmers). In between, there was an unmistakable Skinner pattern with branches necessary to make textbook presentations applicable to machines; these were called Eclectic Programming - selecting the best of each. Of course, there were others - often called Hybrid Programming. About the best of these were the programmed texts of the University of Illinois Committee on School Mathematics and the Mathematics Study Group, which published three versions of Ninth Grade Algebra - one "pure" Skinner (Form CR or Constructed Response), one "pure Crowder (Form MC or Multiple Choice), and one combining the two (called Form H or Hybrid) with the usual explanation and problem sets.

By the way, Pressy, whom we mentioned at the outset, favored the conventional exposition followed by a set of multiple choice questions designed to emphasize the essential points (Pressy Programming).

Also, many others claimed some unique process. It is doubtful if they differed from those noted - except for the "degree" of control on the student's learning activity. Really, the contrast came depending upon the subject matter. For example, in the social science texts, where the content is mostly exposition, there were few empty spaces to aid the student; the mathematics and the foreign language texts, on the other hand, presented printed material, too, but emphasized the accompanying exercises by which the student applied the subject matter. Of course, the majority of programmed learning came in the latter rather than in the former.

Really, many of the mathematics, physics, and engineering texts so familiar to all, for example the "classics" on which many were brought up: Granville, Hausmann and Slack, Grant, Bullinger - were "problem programmed." There was an expositary section, followed by some graded problems (often with partial or complete answers). On working through these, in sequence, one could, after mastering the exposition, increase one's skills, make new discoveries and go on to more complicated problems. They were all there - the stimulus, the response, and the feedback - the sine qua non of programmed learning.

By the way, one should not forget that old standby - and once the symbol of the engineer - the slide rule. This is not necessarily meant in its simple logarithmic or polyphase role (which easily demonstrates the relationships existing between numbers, exponents, and logarithms) - but rather a device that can be easily converted to a calculating device for finding (say) interest rates as well as standard devisions. In reality, these are also teaching machines, even though too few use them as such.

> To summarize, using the words of Professor Kenneth O. May (1) "Educational Programming is the scheduling and control of student behavior in the Learning Process."

Now, this is a good "control" definition and should satisfy many of the managerially oriented IE's at this meeting. If, on the other hand, we have some OR oriented IE's who would rather have some game theory definition, programmed learning consists of a strategy giving the participant (student) the move to make at every point in the learning process, since programmed material presents not only the content of - but the strategy for - learning as well.

Truly, one does not have to be limited to (say) Skinner technique with a unique path, for every book worth its salt - and its present phenomenal price - calls for a response in which the reader does his own programming - supplying first his own idea, which he hopefully finds the author will also give, or then another idea when he finds the author and himself in disagreement.

Clearly this sort of programming is <u>not</u> limited to the printed page - or even to that old professorial standby - the lecture. Nor is it limited to the magnetic tape or the acetate (or nitrate) film. All of which to be successful must request a <u>response</u>. (By the way, even the student who promptly falls asleep in the darkened room where a film is being shown is showing a response. So, too, is the seemingly alert student, with the vivacious pencil who is merely copying his Thermodynamics homework while his OR professor drones on in lecturing on a Single-Channel Poisson Arrival with Nonexponential Service.) The IE has long been subjected to teaching films - such as the dealing of cards at different rates, whereby the student is requested to estimate the percentage of normal rate. To go one step further, the characters may be replaced by cartoon figures or even by other shapes. In fact, the entire film can be replaced by flashing lights. Thus "rating" can be programmed in advance and student response noted. In fact, the student can be conditioned to almost anything. (Note that the statement did not assert "learn" everything.) The creation of such teaching machines is often used as a design problem in many electrical engineering courses: for example, a Morse Code Teaching Device would have its beeps programmed and the student, with conductors in each hand, makes the response with the necessary feedback.

All this has glamour, and consequently appeal. Yet, it is sad to note that this touch of the esoteric has been too often taken on by persons who frequently resent the use of funds for basic science. Moreover, these exotic machines are special favorites at exhibitions where administrators gather. They are particular subjects of that ghettoed portion of TV broadcasts - the Sunday Morning "Educational Hour" (which is usually sandwiched between the illustrated allegories of the publicist religionists and the philosophical mouthings of the elected politicians.) The machine and/or teaching method on display can be simple or complex - the latter is "better" but always "patented." Thus, there is Patent No. 3, 556, 483[a] which consists of six packs of cards of fifty each. Thus, instead of a student picking up a card and noting he has (say) the Jack of Spades, he reads the cryptic message: "What is the Spanish word for "house?" If he guesses "casa" - and he can check by consulting the word list on the other side of the card - he has won the card and is on his way to the "mastery" of Spanish!

Of course, to make these teaching devices even more glamorous, the machine is identified by the announcer with the exposition that what was confronted was "the simulation and implementation of behavioral indices, extraneous to the functional interdependence of variable role perception which have been extrapolated from the motivational interplay."

If the reader (inwardly) admits that he does not understand fully the above explanation, the author wishes (confidentially) to assure the reader that he (the author) does not either, for it was culled from a report of an American Management Association Seminar on Personnel Practices by Allan A. Rudwell (2), a Vice President of Honeywell, Inc. This linguistic fog is known by such names as "bafflegab" and "buzzwords" and can easily be mastered by anyone having the proper generator. The latter is really a card with three columns of ten words each. By random selection from each of its three columns of numbered words, one can create such attention gathering terms as "functional incremental hardware" that can do wonders to sell anything - be it a teaching method, machine, or device. Thus, choosing (say) 3-7-4, get the third term in the first column, the seventh in the second, and the fourth in the third - and the result is something like "balanced transitional time-phase." And, to quote Rudwell,

> This has no meaning whatever but you'll find that no-one - not even the most knowledgeable technician - will challenge the use of such a profound term.

Well, the author hereby solicits the reader's studied judgment as to whether we should make such a challenge here and now.

Nevertheless, consider some of the claims for programmed materials. Really machine or programmed learning - be it on paper, tape, film, gear, electrode, or whatever (pure or mixed) - our real question consists of many parts. Can learning be programmed? What medium? How much in advance? What part by the student? What part by the teacher? What material? What detail?

Unquestionably, it has wide appeal. To the psychologist, it offers a new medium for controlled experiments. To the educational administrator - a seemingly economic means of handling the growing teaching bill. To the layman, who, after all, will pay the bill, regardless of whether he gets his money's worth, that wonderfully contemporary image afforded by the marriage of the electron and the educator. And to the commercial audio-visual entrepeneur, a new and profitable market.

And, carried to its extreme - and some of our state boards of higher education are already planning for it - a transformation of the university into a massive air-conditioned center, replete with whirling dials and flashing lights and catalogues of reels of magnetic tape and acetate film. And do not think that such dreams are limited to political appointees in state capitols - but also to those administrators who visualize a Utopia where they will be able to sit unmolested in their offices far away from either student demands or faculty councils. As for student complaints, if there are any, these can be limited to whether the record is spun too fast or the film projected too slowly; and if such complaints become too vociferous, it is not too difficult to foresee some sound-actuated control which will remedy the difficulty almost instantaneously. As for changes in curriculum, how very simple; enterprising audio-visual companies will be happy to supply new tape (with or without turn in value on the old.)

If the reader thinks the author is depicting some form of devitalized human form of education, he is. However, if the reader thinks such a plan to be far-fetched, the author assures him that the "cassette" is already in the master plan of higher education among the powers that be. If the reader thinks that only the educated "naive" would suggest such a plan, the author wishes to assure you that this is not the case. About six months ago, one of your own publications (3) headlined a story "TV REPLACES TEACHER "which described the action taken by a department head. The article asserted that "like most department chairman. . . (he). . . is often out of town on University business. . . " and he blamed the "uneven coverage" on the various substitutes he used! If he is away from his classroom so much, is he really meeting his contractual obligation? (Let alone his educational obligations!) It is interesting to observe that, according to the article, he is mostly interested in justifying the extra cost of such a process and he points out, with pride, that the technician who runs the tape really earns his keep because he can be used for making laboratory recordings, preparation of visual tape, and even teacher self-evaluation! (Let us not dondemn him, for he had, at least, the foresight to use a flesh-and-blood human to run the tape. Thus, he escaped the fate of the "airport" educator, who prepared tape for use when he was away but who, on returning one day when his flight was cancelled, found his tape on the recorder on his desk playing to a classroom empty except for fifteen other tape recorders situated on the students' desks!)

Nevertheless, to get back to the happy day when the administrators have complete peace - with "no" visible students, and "no" visible teachers. However, before all are carried away, it should be noted that some thirteen years must pass before 1984. Consider some of the claims for programmed learning.

However, there are some prior questions. Do you intend to have teaching machines for every course? For every subject in a course? For every aspect of every subject in a course? Can one so fragment all knowledge? A tape for every atom? If not, for which atom? What will be the criterion? The "difficulty" of understanding the subject matter? Or the expediency of devising such a program? At the moment, it seems, it is the availability of the programmed data rather than the importance of the subject matter that dictates. But eventually - a tape for every aspect of a subject?

Do not let this author lead you astray; he does not claim it is all bad. (After all, he himself is the author of a simulated study - available on either tape or record - which has been successful, at least financially.) We cannot deny an essential fact; students can and do learn. On the other hand, there is no real evidence that the students get this information more effectively or efficiently or more significantly than by the old-fashioned means with a good flesh-and-blood teacher. There is, to fall back on statistical jargon, serious question as to whether there is a significant difference. To quote one case, Sharpe (4) in a two-year study at the State University of New York in Buffalo, indicated that, in a precalculus class, ". . . programmed materials may do an equivalent job, but presents no evidence that programmed materials are superior. . . " Moreover, even in these experiments, they ". . . had programs backed up by good teachers, yet no records were broken!"

All right, the reader may say, if not "in place of", what about "in addition to" - and here he would be on firmer ground, for, the greater the exposure, one would, up to a point, not expect decreasing results. Lane (5), in an experiment with programmed instruction as a supplement to teaching college mathematics by closed circuit TV, would say that this is so, but, as outright substitutes, the results are not impressive. Really, their help came from the fact that programmed materials are frequently more detailed guides than those provided by general texts - but they do have their own weaknesses; they are weak in extended problems and in connected exposition found in ordinary texts. Moreover, as supplements to the living teacher, they still rely on human ingenuity and flexibility and teaching sense. As for related skills, Skinner Programming, for example, gives little practice in reading or writing sustained discourse - something which life after college is full of to the nth degree. Although Crowder programs allow more reading, the resulting writing experience is limited to checking multiple choice boxes - and, hence, also fails to give the reading and writing skills that engineers and managers might need. But, then, the reader may ask - what about the quantitative skills - the sine qua non of engineers and scientists?

The Mathematical Association of America has made extensive studies, and May (6) has, after examining a number of these detailed studies, come to the conclusion:

> Programmed materials are incapable of eliciting full behavior included in the objectives of college mathematics.

This raises a very poignant question to the reader who, as an IE teacher, is fully cognizant of the mathematical aspects of contemporary IE: is all of IE better able to be reduced to a series of "canned" programs? This aspect of "full behavior" over the entire subject bears repeating - but further aspects may be gleaned when treating additional matters relative to the subject.

Does the machine program have "all the advantages of a private tutor?" [See: NEA JOURNAL (7).] There is precious little evidence other than the fact that the program is based on a series of "questions and answers." (It is questionable whether Socrates, for example, went around asking the very same question at all times and whether all students always gave the same answers.) Although psychologists may find this conditioning very helpful in the case of white mice, the carry-over to discriminating humans is questionable. What does the reader think of a tutor who always repeated the same questions? The reader - as a teacher - does he really expect the same answers? Let us be fair, some operative drill may result, and it is entirely possible to program an operation - such as the holding and operating of a stopwatch - but that is entirely different from teaching its expediency. Even the technique of (say) a northwest solution or the steps in a simplex solution of a linear programming problem is also a possibility - but it is questionable if, a student, after mastering this, knows all that he should about the subject.

Thus, really two questions are being asked: (1) what about individual differences among students? and (2) what about content of material?

Consider the individual differences. The machine program dispensers insist that their machines "allow the student to go at his own pace." So does any book. By the way - that is more than what the televised broadcast can do! However, for the individually controlled machines, the reader may still say that it does make sense - but then he should compare similar circumstances. Do not compare individually controlled machines to the "general" lecture - but rather the robot tutor to the flesh-and-blood one. In addition, the advocates of individual pacing have overlooked something fairly important - namely the advantages of group interaction.

However, the author wishes to emphasize that the real potential of the programmed materials' tutorial aspects lie in another direction. And this is important - it lies in a large library collection of brief units dealing with narrower problems suited for specific student difficulties. With such a library, it is possible for the student requiring help or review, to find it - efficiently, economically, and effectively. Here lies the real potential - and not in the replacement of the living teacher by some mechanical tutor. The administrator by the way, who believes that a collection of tapes is an economic saving in the face of rising educational costs will find himself with a balance on the wrong side of the ledger. The robot teacher does not come cheap. In addition, the problem of diagnosing student weaknesses and then prescribing the numerous tapes and/or memory devices is no skinflint operation.

Moreover, it seems that the very persons who publicly advocate individualization (especially in secondary education) - are now pressing for the complete replacement of living teachers by taped cartridges. It is ironic that these so-called educators - goaded by the political will o' the wisp of economy - who bemoan the dehumanization of the student are the very ones who are the greatest force in this new trend to "bend, crease, spindle, and mutilate" the student.

On the other hand, this author wishes once again to emphasize that the greatest value of programmed materials lies in a large library collection of remedial tapes - subject to optional use by and tailored to fit the needs of the individual student - as a supplement to live teachers.

Again, as far as individualization is concerned, does programmed material provide a greater control of the learning process? As far as control is concerned - and the author uses the term control in its management sense, as comparison of actual to plan - we must admit the machine is unquestionably a control device. It programs every move and it allows no departure from plan, no flexibility (except perhaps pacing), and requires the exact same response from every student. Although this may help the programmer to "measure" the effectiveness of his program - even to the extent of learning the detail of the exact frame giving the student trouble - and may be helpful in diagnostic work, there is no assurance that this is "best" for the student in the learning process. The inflexibility is such that every student is restricted to a fixed path and the only freedom is to go back and forth, read (or observe), then check, then return over the same path that gave him trouble in the very first place. The "success" of the program lies in the student following explicit directions with no side excursions. And the author respectfully asks the reader - as an experienced teacher - how often is the side excursion the more profitable one? Again, as to the main path, to use an IE example, if the set program attempts to teach the effect of a series of annuity payments in terms of (say) mortgage payments, he may not be able to "transfer" this to a "new" program dealing with (say) depreciation of machinery.

Skinner, by the way, insists that the "student write his own program". What he means is that the program is continually revised until the error rate is low. So that, eventually, a program is achieved where there is no student failure. Thus - student failure, no; program failure, yes! But is this good? This means that the student never learns that errors in themselves are both inevitable and helpful! Not much preparation for the "real world." Clearly, errors should be permitted, and even incorrect experimentation is in order!

Often, the programmers point out that they offer another "advantage" - viz. the machine prevents "cheating" - no looking ahead for answers or back for clues. But, again, few teachers and students will deny the value of knowing the answer first in the learning process. Although "blind copying" is not advocated, there is even some virtue in that, and frequently a "hint" or a printed answer has its benefits. Preventing students from getting "more information" is certainly no aid to education.

What about motivation? The rabbit's reward of a carrot for having pushed his pink nose through the correct door under the flashing light is quite clear. It is questionable whether the motivation is so strong for a student who has rated the dealing of the bridge hand in the film "exactly right".

Is it any wonder that the Mathematical Association of America's Committee contended: (8)

> Programmed materials inhibit initiative, independence, and responsibility in the learning process and do not contribute to the achievement of related educational content.

The many years of serious study by the august body thus re-emphasizes the question as to whether the real objective of education has been achieved. In this discussion we left unanswered the question as to the effectiveness of programmed learning in transmitting the meaning as well as the philosophy of the method. Thus, if we teach rating by card dealing, does the "success" in learning the rating procedure really make the good rater? The test of a good surgeon is in not only knowing how to wield a scalpel - but also when NOT to wield it. And, just as important, is the question as to why he should or should not wield it. Also fundamental is the question of whether or not there is some other means of accomplishing the objective besides the cold knife - maybe heat, maybe chemistry. Moreover, every surgeon will tell you that he does not perform every resection in identically the same fashion. The patient is different, the environment is different, the conditions are different - and even the mood of the surgeon is different. Has the machine - even in attempting to establish randomness in programming - accomplished this? What about the mistakes? The machine does not provide for them. In machine learning, if the answer is wrong, the student repeats - i. e. he can only go back and try again in the very same manner that led to his first failure. This is a very impractical and questionable way of learning. To go back to our previous example of surgery technique - the surgeon cannot resect again in the same fashion, but he must proceed in another fashion either correcting the old mishap or trying some other technique. In job evaluation, it is easy, for example, to program point assignments for job classifications - but the assignments, in the last analysis, depend not only on the job in question but other jobs that have already been evaluated as well as those that remain to be evaluated - as well as such matters as the evaluator himself. So much for techniques.

What about information? Engineering is more than a mere collection of facts - do you remember the scorn everyone used to have for the "handbook engineer" and his ilk? - and techniques. To go back to the dean of American educators - John Dewey: (9)

> Education is a constant reorganization or reconstruction of experience.

Clearly, education is not a rigid matter - but a flexible and ever-changing one.

Go back to your own experience. Go back to your own student days - or even your teaching days. Are your students the same? Here is an even simpler question: if you have two different classes in the same subject in the same day, can you teach them in an identical manner? Can you rely entirely - despite the glamour - on the canned program?

This is fundamental. In the great educational revolution that is taking place here and now - and we do have a violent turbulence in the form of more people going to college, more student involvement in curriculum and course, more relevance, and greater national and international concern on the campus - is the "transfer of skill" from the flesh-and-blood teacher to the teaching machine the answer? It may seem to be, for the mass production of the industrial revolution found its means in the transfer of skill from the artisan to the machine. Can teaching be reduced to an assembly process, segmented into bits, fragmented and then brought together by a mechanical means of turning the third screw on the left? Even today the furniture of the artisan has greater value than that of the "Grand Rapids" type. As you review your own student career, what do you recall? Surely it is the personality of some great teacher who stirred in you some imaginative goal and the zeal to achieve it. Surely it was a living flesh-and-blood teacher - perhaps supplemented with, but certainly not replaced by, a roll of magnetic tape or a 16 mm. film.

However, let us pause for a moment, and before we engage in an unbridled yearning for the "good old days," let us stop and take note. This stress on the living teacher may sound "old fashioned and stodgy," an over-emphasis of the "personality" and a keen disregard for the "objectivity" in teaching. However, even THE NEW YORK TIMES (10) noted in an editorial that perhaps the time had come when that earliest of the programmed teaching - the "lesson plan" - might be profitably discarded. "Teacher - Drop that Plan" is what it asserted - not the reverse. However, let us not advocate violent pendulum swings.

We live in a civilization which is overly image and underly performance. How else do you account for politicians who project on the TV screen but underperform in their elected executive posts, actors who radiate glamour in the slick magazine pages but perform atrociously in their acting roles, products that promise excellence in the advertisements but fail in their tasks? And even some of our teachers. . . They are to be found in our primary schools with the flashy bulletin boards and the pupils who cannot read. In the secondary schools, where, in their extra-curricular activities they show by the flip of a switch (of an expensive machine) how easy it is to solve a complicated problem with which some striving mathematician spent a lifetime, yet the students are befuddled by exponents. And even in the colleges, where they may be identified by the high ratings they obtain in student popularity contests but whose students come into your classroom ill-prepared, poorly trained, and entirely untaught.

Where are our great teachers? Some feel that too many things have gotten in the way of their blossoming. For one, Peter Drucker (11) seems to put the blame on the entire educational system and the demand for the doctoral theroetician. "Is there any evidence," he asks, "that the Ph. D. makes a better teacher or even a better scholar or is the main reason for the request that it reserves access to appointments and emoluments to people who have paid their fees in time and money at the academic tollgate?" You have probably seen the culprit he names: the fellow who seems to spend most of his student days in building a golden calf known as a dissertation and all of his collegiate teaching life in milking it; his extent of engineering is bounded by the theoretical area between his idol's horns and tail. Any course he teaches - no matter the subject - seems to emanate as a metamorphosis of the dissertation - an acrobatic of remarkable proportions but one in which he has had a good deal of experience, for he has dissected it chapter by chapter, paragraph by paragraph, line by line, commented on every phrase and every word, and spread the good word along the lecture circuit from New York to California via Illinois and from California to New York via Texas. With a heavy on emphasis on publication - and this author will not say that some of it is unnecessary - but with an overly heavy emphasis on the publicity value of a teaching mechanism, are we not overlooking the substance for the shadow? A recent conference (12) on graduate teaching felt that "teaching should be reinstated as a primary purpose and responsibility of the university - not publication or any other convenient evaluation device."

To observe the other - the non-theoretician - side of the coin, that grand old man of management, Col. Lyndall Urwick (13), in his latest contribution to the 1970 edition of ASME's TEN YEAR PROGRESS IN MANAGEMENT, re-echoes Drucker and re-emphasizes the role that the practitioner should play in education. He reinforces his view by an analogy concerning the Third Department of the Royal Military College, where Wellington's staff was educated. In the years following Napoleon's defeat, the College was under the control of the theoreticians who had never practiced the art they taught, and the devastation of the Crimean War was the result. Moreover - miraculously - semblance of success returned when the practitioners returned to some of the posts.

It is too easy to generalize on the instances observed of the pure practitioner in the classroom's confines; too often have they been completely devoid of an over-all and complete study of the subject at hand. Too often - with a complete spurning of any vantage of the theoretical but with an absolute adoration of everything, no matter how trite, practical. They too are guilty of the very bias they ascribe to the theoretician. Almost every class in IE - be it in organization or engineering economics or materials handling - like all the courses taught by the theoreticians, come out in their own image, be it what it may. The entire course in production planning revolves itself into the specialty in which the practitioner spent his day, in a line-by-line analysis of a Move Order in every one of the twelve copies!

So, again, it is necessary to look to good over-all teaching as the great need. In the City of New York alone, where the City itself, pays for such basics as salaries, fringes, contractual obligations, and the like, the educational system relies on the State and the Federal Government for aid for improvements in education. Since 1965 (14) approximately $505, 000, 000 came from the combined State and Federal sources alone - designed principally for educational methods, techniques, and machines for teaching the disadvantaged - with limited (if any) success. A former president of the Board of Education maintained:

> I have lived through all sorts of panaceas designed to improve education in the classroom at a cost of millions, and most of them failed. It seems to me that there is no substitute for the competent and dedicated teacher in the classroom.

"Where, then, are our great teachers?" you may ask. Essentially they exist - right where they should be - in the profession. You can identify them:

> They rely on both their theoretical analysis as well as their own practical design experience. They do not favor the one over the other, but rely on the optimum mix.
>
> They are those who have a firm interest in neither self-aggrandizement nor in a PR image but in the two professions of teaching and engineering. They recognize the needs and interests of the student as novitiates in engineering and as responsible citizens of a concerned nation. They avoid fragmentation of knowledge because that segment happens to be, at the moment, fashionable, image-producing, or convenient, but teach the entire field, including both analysis and design, to the entire student.
>
> They digest their subject matter thoroughly, season it appropriately with a healthy balance of both theory and practice, and present it interestingly and honestly as a living subject to fit the needs of a flexible student body.
>
> They take cognizance of all teaching methods - mechanical, electronic, or simple black-board - and use them all wisely, never relying on one to the exclusion of the other, merely because they happen to have films or tapes or machines on a given subject or because they happen to have an uncontrollable interest (if not a fetish) on some detailed problem.
>
> They are fully aware of their contractual obligations and scorn long term esoteric trips - be they to far off places to remunerate their own consulting prowess or to nearby campus buildings to nurture their on-campus political ambitions - in favor of regular meetings with their students in and out of class.
>
> They avoid any dehumanization of students - be it by conditioned but aloof lectures or by indiscriminant though convenient teaching mechanisms.
>
> They scorn straightforward departmentalization, because it "says" that this is a course in Subject X (even though it may be related to Subject Y); nor do they refuse to elucidate on some pertinent but prerequisite detail because it was supposed to be "taught" in another class.

They stand alert to evaluate all teaching methods - ever willing to improve present methods, reexamine past methods, and consider thoughtfully future methods.

They still strive to inspire students with a desire to pursue further - outside the classroom - the material which had to be restricted to the time-space limitations of the here-now classroom.

But most of all, they consider their obligations as more than mere salaried employees, for they are members of a profession - no, they are members of two professions - with all the responsibilities and obligations - study, ethics, practice, community and professional service - that the broad term "professional" implies.

We must repeat - over and over again - that the basic ingredient of the topic under discussion - NEW TEACHING TECHNIQUES - is, as it was, and as it will probably always be - not the hurried consultant not the harried writer, not the tweedy, pipe-smoking TV personality but THE TEACHER.

Once he enters the profession, he cannot take lightly the obligations of a profession; he must dedicate himself to the task, he must use whatever methods he, after studied concern, deems wise - be they the outside world or the inside one, be they new electronic devices or old cylindrical sticks of calcium carbonate (more commonly known as "chalk").

Only then can we hope to reinstate teaching to what is supposed to be "the primary purpose of the University."

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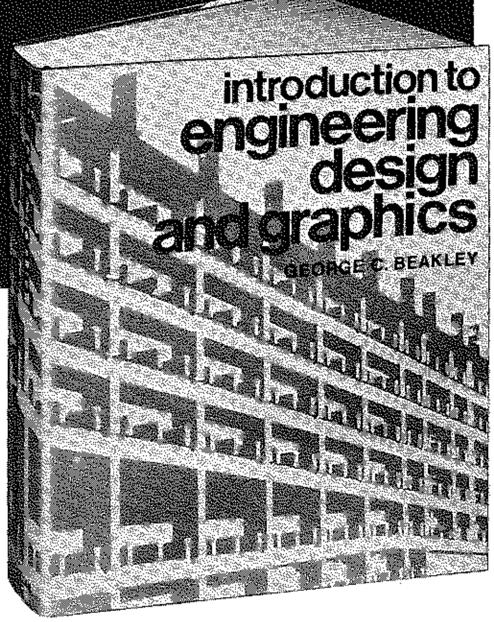

INTRODUCTION TO ENGINEERING DESIGN AND GRAPHICS

By George C. Beakley, Jr.
Arizona State University

Adding an attractive new dimension to the usually rudimentary study of graphic skills, this exciting text for a one- or two-term introductory design or graphics course is superior to any other comparable text. Design and graphics are combined in a modern, meaningful way, reflecting the current approach to teaching this type of course.

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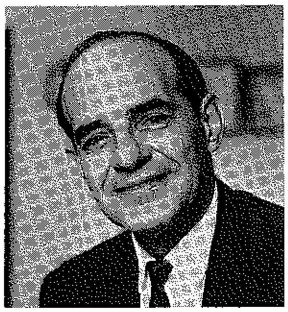


Al Romeo
The Ohio State University
Editor

Clarence E. Hall
Louisiana State University
Advertising Manager

Clyde H. Kearns
The Ohio State University
Circulation Mgr. & Treasurer

Meet the JOURNAL Staff

With this issue of the JOURNAL, you will be exposed to new faces throughout the JOURNAL staff. The natural change of the Advertising Manager occurs because the term of Klaus Kroner expired after the last Annual Meeting. Since he chose not to succeed himself, Dr. Clarence E. Hall of Louisiana State University was elected to succeed him in a term of office of three years. Immediately after the Annual Meeting, Borah Kreimer resigned as Editor of the JOURNAL in order to devote his time to the implementation duties delegated to him by the Chairman of the Division. His term as Editor runs until after the 1973 Annual Meeting. Yours truly has been appointed by Chairman Rogers to fill out the unexpired term. In September of this year, Robert Christenson resigned as Circulation Manager and Treasurer to devote full time as Public Relations Director for our Division. Clyde H. Kearns of The Ohio State University has been appointed to complete the term of office which expires in 1974. Although these changes have a potential for disrupting the activities of the JOURNAL, the more optimistic view should be in terms of the long range future.

The restructuring of the Division is too important to delay for even one day longer than necessary. Borah Kreimer's effort in the implementation of this restructuring is important, not only to the Division, but to the JOURNAL also. He has served the Division effectively in the past and his plan for implementation indicates that his further service in behalf of the Division and the JOURNAL will be as effective in the future.

Bob Christenson has been a long-time "sparkplug" in Division activities, particularly with the JOURNAL. During Earl Black's tenure as JOURNAL Editor, Bob contributed creatively and his contribution was publicly acknowledged more than once. The undersigned will certainly attest to the helpful guidance and counsel he furnished during the "baptism of fire", as Acting Editor.

Klaus Kroner has actively supported Division activities and effectively functioned as the JOURNAL Advertising Manager. His participation as Chairman of the Zone I Sectional Group can contribute substantially to the Division's progress.

On behalf of the Division, we express our appreciation to Kreimer, Christenson, and Kroner for their past services, and look forward to a promising future for the Division as they fill their new positions of leadership.

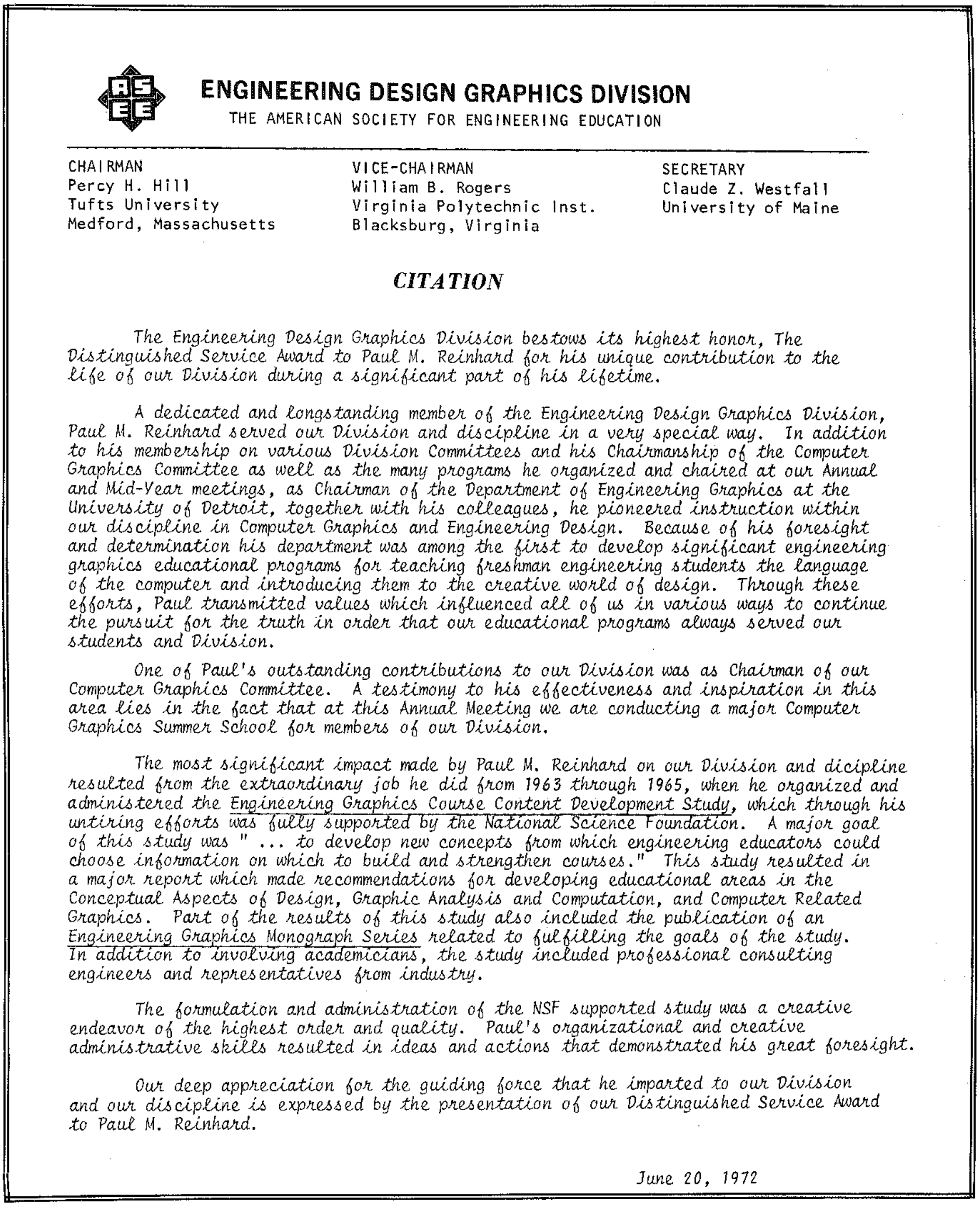
Those of us who are left entrusted with the JOURNAL can only hope to aspire to the goals, examples and achievements set by our predecessors, when we say "We will do the best of which we are capable."

Al Romeo
Editor

Award Presented Posthumously

Mrs. Paul M. Reinhard was an honored guest at the Engineering Design Graphics Division Annual Banquet at which she received on behalf of her late husband, Professor Paul M. Reinhard, the Division's Distinguished Service Award. A reproduction of the citation is shown below.

Prof. Reinhard died on September 5, 1971 after a lengthy illness.



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CITATION

The Engineering Design Graphics Division bestows its highest honor, The Distinguished Service Award to Paul M. Reinhard for his unique contribution to the life of our Division during a significant part of his lifetime.

A dedicated and longstanding member of the Engineering Design Graphics Division, Paul M. Reinhard served our Division and discipline in a very special way. In addition to his membership on various Division Committees and his Chairmanship of the Computer Graphics Committee as well as the many programs he organized and chaired at our Annual and Mid-Year meetings, as Chairman of the Department of Engineering Graphics at the University of Detroit, together with his colleagues, he pioneered instruction within our discipline in Computer Graphics and Engineering Design. Because of his foresight and determination his department was among the first to develop significant engineering graphics educational programs for teaching freshman engineering students the language of the computer and introducing them to the creative world of design. Through these efforts, Paul transmitted values which influenced all of us in various ways to continue the pursuit for the truth in order that our educational programs always served our students and Division.

One of Paul's outstanding contributions to our Division was as Chairman of our Computer Graphics Committee. A testimony to his effectiveness and inspiration in this area lies in the fact that at this Annual Meeting we are conducting a major Computer Graphics Summer School for members of our Division.

The most significant impact made by Paul M. Reinhard on our Division and dicipline resulted from the extraordinary job he did from 1963 through 1965, when he organized and administered the Engineering Graphics Course Content Development Study, which through his untiring efforts was fully supported by the National Science Foundation. A major goal of this study was " ... to develop new concepts from which engineering educators could choose information on which to build and strengthen courses." This study resulted in a major report which made recommendations for developing educational areas in the Conceptual Aspects of Design, Graphic Analysis and Computation, and Computer Related Graphics. Part of the results of this study also included the publication of an Engineering Graphics Monograph Series related to fulfilling the goals of the study. In addition to involving academicians, the study included professional consulting engineers and representatives from industry.

The formulation and administration of the NSF supported study was a creative endeavor of the highest order and quality. Paul's organizational and creative administrative skills resulted in ideas and actions that demonstrated his great foresight.

Our deep appreciation for the guiding force that he imparted to our Division and our discipline is expressed by the presentation of our Distinguished Service Award to Paul M. Reinhard.

June 20, 1972

Letters to the Editor

To the Editor:

I am passing on to you a few of my impressions of the creative design projects judging experience which we discussed in Lubbock last week. From reading them you will see that I am a great believer in working models. I dislike having something "proven" to me on paper when there is no accompanying model to demonstrate the concept being discussed. I object to this especially when I am a judge and can be led down a false path through only words and figures. The time is too short to check both assumptions and calculations, therefore the working model is much more convincing in the short period of time we have.

To a judge there is nothing more convincing than a working model. It does the following :

1. Enables the judge to grasp the design intent and functional sequence used to satisfy the stated requirement.
2. Saves time for a judge in discerning the direction of the entire design presentation.
3. Offers reasonable assurance of operational success, meaningful working drawings, and supporting calculations based on fairly good assumptions.

Without a working model it is impossible to discuss tests that establish feasibility and to build a level of confidence in performance figures. The absence of these data leaves a gap in the expected information a judge needs for assigning good scores.

Some entries seemed inappropriate, that is, they were unsuited to the judging process. If there is no way of measuring conceptual design against functional success, what is there to judge? An example would be Entry #103, a lake development project. The sophisticated investigation type of entry is also hard to judge. It concludes with recommendations, but is not convincing in the absence of tests, models and functional sequence drawings. Example - Entry #104, Design of an Incremental Paper Tape Recorder. Another impediment to good judging is "clutter" - too much literature and procedure and no smooth, simple thrust to a conclusion.

While judges must use some imagination, so must the competitors and their faculty advisers. The assumption that judges immediately grasp specialized terminology and comprehend discussions within a particular descipline is damaging to an entrant. A single paragraph in plain language, a labelled isometric drawing or a photograph of a model would be very helpful.

Good exposition and good drawings were very evident, however, some bad spelling and a few errors in dimensioning were noted. These small mistakes detract and can be eliminated through careful review.

Best regards,

/s/ Frederick H. Roever

Frederick H. Roever
Specialist
Engineering Personnel Development
McDonnell Aircraft Co.

……

The Editor:

In July, 1971 I have submitted for your consideration another article entitled "A Criterion of Correctness of Single-View Graphical Representations".

Would you be kind enough to bring to the notice of those concerned the following correction in the manuscript of the above article:

J_{pr} on [page 47, line 3, left column, Spring '72 issue. Ed.] should read j_{pr} (i. e. lower case j instead of J).

Thank you very much.

Yours sincerely,

A. ROTENBERG
Dept. of Mechanical Engr.
University of Melbourne

……

To The Editor:

I recently sent a letter to Steve Slaby in relation to his chairmanship of the Journal Study Committee. In this letter, I suggested a Journal inclusion in each issue. I am enclosing a copy of the letter sent him for your information and evaluation of the suggestions merit. I would appreciate hearing your comments.

Sincerely,
/s/ William H. Eubanks

William H. Eubanks, P. E.
Professor and Head
Engineering Graphics Dept.
Mississippi State University

Professor Steve M. Slaby, Head
Department of Engineering Graphics
Princeton University
Princeton, New Jersey 08540

Dear Steve:

While clearing up my desk of this past summer's ASEE papers, I reread the report of the Journal Study Committee, reported by you as chairman. This was a good report and I feel your recommendations certainly deserved the approval of the Board.

I don't know if you are still a member of this committee or if a committee is still functioning, but in case you are, I just thought I would drop you a few lines to suggest a possible inclusion in the Journal of a very short paragraph or two from each representative college or university in each issue. It would be interesting to read of new happenings at the various schools where we know the staff members and Department heads. I wouldn't think that a few lines edited down to essentials would take over a few pages. I number of schools would cooperate, and send in a report and others wouldn't as always. This might help for material. I've heard the Journal Editors state many times they need material badly for some issues.

As I stated previously, this is just a suggestion. I know from past experience, when I get my fraternity magazine this section giving a short report from various chapters is one of the most interesting sections of the magazine, and I feel it could be in the Journal. The best of luck to you for the coming semester.

Sincerely,
/s/ William H. Eubanks, P. E.

(Editor's response - The Journal has had a section, IN THE DIVISION, devoted to news items about and of interest to members. We welcome and encourage contributions to that section.)

……

To the Editor of the JOURNAL:

The editor of any journal of scholarship has many difficult responsibilities. He is always ready to accept praise for his work, but somehow his readers simply take him and his work for granted. I know. I had the job fourteen years ago. I was always ready for praise but I was more prepared for complaints; somehow complaints are easier to write. Here's mine:

I realize that line-justification is difficult and expensive, but I doubt whether it is worth paying for if the result is the bad hyphenation that is evident on almost every page of the Spring 1972 issue. I am making a list of some, but by no means all, of the bad syllabication I noticed:

	Page
ac-hieve	i. f. c.
ar-rangement	8
cylind-er	10
mach-ine	10
fr-iend	13
instant-aneously	13
re-presented	13
object-ive	15
dimens-ional	15
orient-ation	15
runn-ing	15
fin-al	16
act-ually	23
excell-ent	32
profess-ional	32
Nov-ember	33
fund-amental	34
Constru-ction	36
Nat-ional	36
Kelvinat-or	36
react-ion	39
Indust-rial	39
pro-blem	42 and 14
de-clination	43
thr-ough	44
err-atic	44

I suggest that you require your printer or whoever it is that sets up the material to consult the dictionary. Anyway, I confess I looked up every one of the above words and many others, too, that I thought were wrongly hyphenated only to discover that I would have made a greater fool of myself than I already have!

Apol-o-get-i-cal-ly yours,
/s/ Vlad
Ir-win Wla-da-ver
As-so-ci-ate Pro-fes-sor
Emer-i-tus of
Me-chan-i-cal En-gi-neer-ing
New York University

(Editor's response: The responsibility for page makeup rests on the editor despite his desire to pass the buck.)

Division Mid-Winter Meeting - 1973

The Midwinter Meeting of the ASEE Engineering Design Graphics Division will take place in Denver, Colorado. The dates are:

WEDNESDAY, JANUARY 17th
THURSDAY, JANUARY 18th
FRIDAY, JANUARY 19th

The Radisson Denver will be the meeting hotel.

Denver was chosen in order to give our members an opportunity to get to know this beautiful state. The mountains are just a few miles from the hotel and tours for the whole group will be planned, including tours for the women who do not attend the meetings. Also, the time for the meeting has been specially chosen to coincide with the National Western Stock Show which is a tremendous event and should be interesting for everybody. A visit to the rodeo is planned for Friday night.

The host committee is as follows:

Carl W. Bechtold, Univ. of Colorado
Betty Beck, Univ. of Colorado
Frank Oppenheimer, Chairman
Grammercy Guild Group, Inc.
1145A W. Custer Place
Denver, Colorado 80223

Ladies Program Hostess:
Mrs. Frank Oppenheimer

The program is as follows:

THEME: Engineering and Society

Wednesday - January 17, 1973

12:00 noon Registration

Thursday - January 18, 1973

7:30-9:00 AM Executive Comm. Meeting

9:30 Welcome

9:45 Morning Session
"Computer Graphics in Biomechanics of the Spine"
Dr. C. H. Suh, Chairman, Department of Engineering Design & Economic Evaluation, University of Colorado, Boulder, Colo.

10:15 "Two Biomechanical Techniques for Spinal Investigations"
Professor L. Duane Ball, Department of Engineering Design and Economic Evaluation, University of Colorado, Boulder, Colorado

10:45 Coffee Break and Equipment Show

11:00 "Effects from the Nuclear Power Plant" Public Service Company of Colorado, Denver

12:00 Busses to Coors, Golden, Colorad

LUNCH

1:30 PM Afternoon Session

"The Metric System"
Miss Frances J. Laner, Dow Chemical Co., U.S. Atomic Energy Plant, Golden, Colo.

2:00 Break

2:30 "One Company's Contributions to Environmental Quality"
Adolph Coors Company, Golden, Colorado

Tour of Coor Facilities

7:00 BANQUET

Friday - January 19, 1973

9:00 AM Morning Session

"Effects of Earthquake on Engineering Design"
National Center for Atmospheric Research, Boulder, Colo.

9:30 "Earthquakes Caused from Discharging Atomic Wastes Into Deep Wells"
Colorado School of Mines, Golden, Colorado

10:00 Coffee Break

(see MEETING - p. 48)

Randolph P. Hoelscher, 1890-1972

Professor Randolph P. Hoelscher, Chairman of the antecedent of this division of the ASEE and former Head of the Department of General Engineering, University of Illinois at Urbana, died January 5, 1972 in Fort Myers, Florida, where he was living in retirement. He is survived by his wife, Ruby, one son, William, and one daughter, Betty (Mrs. H. B. Christianson). Professor Hoelscher was born December 12, 1890, at Evansville, Indiana. He obtained his B. S. in Civil Engineering from Purdue University in 1912, M. S. from the University of Illinois in 1927 and C. E. degree from Purdue in 1929. After four years as a Structural Engineer he began his teaching career at Baldwin Wallace College, Berea, Ohio. In 1918 Professor Hoelscher joined the faculty at the University of Illinois as an Instructor in the Department of General Engineering, rising to the rank of full professor in 1931.

Professor Hoelscher in addition to his chairmanship of the Division, served two terms on the National Council of the ASEE. He was very active in and served as Chairman of the ASA Z-14 Committee on Drawing Standards. He also was a leader in the establishment of standards between A-B-C (American and British and Canadian) countries. He was Chairman of the Faculty of the Drawing Division Summer School in 1946, held at Washington University, St. Louis, Missouri. Following the summer school, with Professor Justice Rising of Purdue University as co-editor, he prepared the Proceedings of the Summer School for Drawing Teachers published in 1949 by McGraw-Hill Book Company. He also was author with Professor H. H. Jordan of Engineering Drawing, first published in 1923. With Professor Springer and Richard Pohle of the Pentagon, he prepared Industrial Production Illustration, first published in 1943. In 1956 in cooperation with Clifford M. Springer of the University of Illinois he prepared Engineering Drawings and Geometry while his most recent publication is Graphics for Engineers prepared in conjunction with Professors Springer and Jerry S. Dobrovolny at Illinois at Urbana. In addition he was co-author of a number of workbooks in drawing and geometry.

In 1946 with the establishment of Navy Pier Branch of the University of Illinois, Professor Hoelscher, Associate Dean of Engineering Sciences, pioneered the development of the faculty and physical facilities of his division. He returned to the campus in 1949 to become Head of the newly established Department of General Engineering, a post he held until retirement in 1959. He was Secretary of the University Senate for many years.

Civic interests and activities were extensive with service as a Commissioner of the Champaign County Housing Authority, 1963-68, member of the Board of Directors of Family Welfare Association, 1945-47, presidency of the Kiwanis Club of Champaign-Urbana, and 50-year membership in the Masonic Lodge and 32 Degree Scottish Rite. He was a member of the Presbyterian Church.

Professor Hoelscher is remembered by his many friends for scholarship, his devotion to duty and his unfailing courtesy. He made a large contribution to the life of the University, the Chicago Circle Campus, the Department of General Engineering, and to the field of Engineering Graphics.

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Articles in the following broad subject areas are particularly encouraged: Computer Graphics, Engineering Graphics, Graphic Methods, Research in Graphics, Teaching Techniques and Methods, 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, Editor
Engineering Graphics,
The Ohio State University
2070 Neil Avenue, Cols., O. 43210
Phone: (Area Code 614) 422-2358

Creative Design Display - 1972

The winning entries in the Creative Design Display have been announced. Each winner is presented with an engraved plaque for his school and a personally inscribed Certificate of Merit. They are as follows:

Freshman Division

FIRST PLACE
Arizona State University
Handicapped Operated Printing Equipment
Dr. E. Chilton

SECOND PLACE
Tarrant County Junior College
Log Splitter
Prof. John F. Pierce

THIRD PLACE
Iowa State University
Safe Clear Following Distance Indicator

Sophomore Division

FIRST PLACE
University of Wisconsin-Milwaukee
Tox-Ecology: Controlled Pesticide Application
Prof. E. W. Knoblock

SECOND PLACE
University of Missouri - Rolla
Ejection System for the Alt-16 Cobra Helicopter
Prof. G. L. Swancutt

Junior Division

FIRST PLACE
University of Wisconsin - Milwaukee
Determining Moment of Inertia Experimentally
Prof. V. Parelic

Senior Division

FIRST PLACE
United States Naval Academy
Design of a Portable Breakwater For Small Marinas
Profs. B. H. Rankin & R. A. Hirsch

SECOND PLACE
University of Dayton
SEMICA - A Systems Approach to Urban Design
Prof. R. L. Mott

THIRD PLACE
John Hopkins University
Design of An Energy Absorbing Automobile Bumper System
Profs. B. H. Rankin & R. H. Hirsch

Graduate Division

FIRST PLACE
University of Wisconsin - Milwaukee
Downtown Traffic Improvements for Port Washington
Prof. F. J. Wegeman

ACKNOWLEDGEMENT

The Engineering Design Graphics Division wishes to acknowledge with thanks the contributions of the following individuals and organizations to the establishment and operation of the 1972 Creative Engineering Design Display.

Contributions of the following industrial organizations:

Colgate-Palmolive Corporation
E. I. du Pont de Nemours & Company
Monsanto Company
Standard Oil of New Jersey
Union Carbide Company - Linde Div.
Zenith Radio Corporation

Professor Ralph Blanchard of Northeastern University, Chairman of Judging and Awards, for his excellent performance in organizing the judges and in obtaining responses from the industrial organizations.

Professor L. M. Graham of Texas Tech University for his cheerful, uncomplaining work as local representative of the Display.

Students and faculty whose work was the Display.

Time and effort contributed by the judges (listed below) in evaluating the projects:

JUDGES

Professor Donald K. Anderson
Chem. Engr., Michigan State Univ.

Professor Steven C. Batterman
Engr. Mechanics, Univ. of Pennsylvania

Mr. Ernest R. Brown
Union Carbide Corp. - Linde Division

Dr. Maurice Carlson, Head
Mech. Engr., Lafayette College

Professor Ernest Dejaiffe
Pennsylvania State University

Mr. M. L. Douglass
LTV Aerospace Corporation

Dean Elmer Easton
Rutgers State University

Prof. David W. Fowler
Arch Engr., Univ. of Texas

Mr. A. E. Hartford, Manager
College Relations, E. I. du Pont

Dr. Francis J. Hassler, Head
Bio & Agri. Engr., N. Carolina State Univ.

Professor H. L. Henry, Head
Indust. Engr. & Comp. Scie., Louisiana Tech U.

Professor Edward R. Herman
Civil Engr., Northwestern University

Mr. Donald E. Irwin, Program Manager
Entry Level Recruiting, Gen. Electric

Dr. Robert M. Koerner
Drexel University

Dr. David Kohlman
University of Kansas

Dr. W. Edward Lear, Dean
Coll. of Engrg., University of Alabama

Mr. Frederick H. Roever
McDonnell Aircraft Company

Dean George P. Schmaling
Southern Methodist University

Mr. Howard R. Shelton, Supervisor
University Relations Div., Sandia Corp.

Mr. William E. Weisel, Director
Educational Rela., Cin. Milacron Inc.

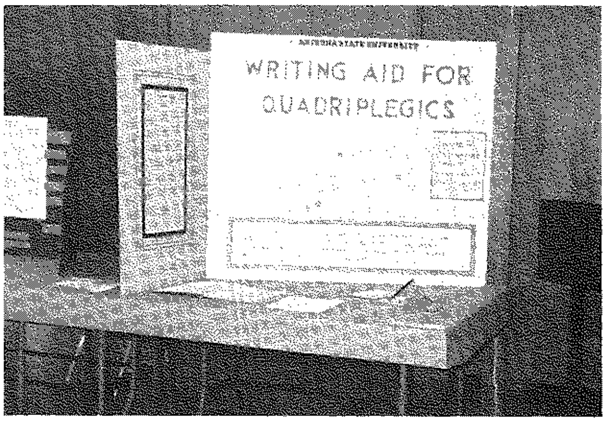
Professor Fred E. Westermann
Dept. Materials Science & Met. Engr.
University of Cincinnati

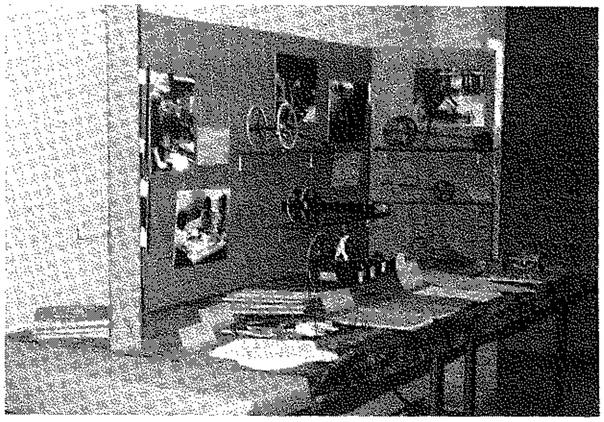
Mr. T. L. Wilson, Manager
Employee Relations Dept., Standard Oil Co.

Professor Lawrence A. Jehn
Mech. Engr., Univ. of Dayton

Mr. C. E. Johnson, Director
University Relations & Prof. Recruiting
Monsanto Company

Professor Adam Jordan
Mech. Engr., Ohio State University





Henry Cecil Spencer, 1903-1972

Professor Henry Cecil Spencer, 69, founder and former director of the engineering graphics department of Illinois Institute of Technology and a national authority in the field of engineering graphics, died Saturday, June 10, in Waco, Texas, where he lived since retirement from IIT in 1962.

Burial was Monday, June 12 in Waco. He is survived by his wife, Juanita, of 5412 Lake Charles Drive, Waco.

Prof. Spencer graduated from Baylor University in 1929 with a Bachelor of Arts degree and received his Master of Science degree from Texas A & M College (now University) in 1930. From 1930 to 1941 he headed the department of engineering drawing at Texas A & M, joining IIT in 1941 to establish and head the engineering graphics department.

Under his leadership IIT became the first university in the country to offer both an undergraduate degree and a master's degree in engineering graphics.

In addition to his work as an educator and administrator, Prof. Spencer was the author of a number of textbooks and workbooks on engineering graphics, including Basic Technical Drawing and Technical Drawing, used throughout the nation. In 1969, he was a co-author of Engineering Graphics, with Prof. Ivan L. Hill, his successor as head of IIT's engineering graphics department.

He received the Distinguished Service Award of the American Society for Engineering Education in 1958, and served as national chairman of the ASEE's engineering drawing division in 1948.

Prof. Spencer was listed in "Who's Who in Engineering", "Who's Who in American Education", "Who's Who in Chicago", and "Who's Who in American Art".

Computer Graphics Summer School

The Summer School on Computer Graphics was held at Texas Tech University on June 21-23, 1972, dovetailed in with the Annual Conference of the American Society for Engineering Education. Overall, the school was successful in its aims and the response was gratifying. During the planning stages early last spring, it was decided by the Computer Graphics Committee to limit enrollment in the Summer School to 70 as it was felt that any number larger than this would dilute the instructional staff and facilities to an inefficient level. Although a valiant effort was made to obtain funding for the Summer School, the effort was unsuccessful, and as a result, a registration fee of $20.00 was charged. The preliminary planning hit the supply and demand curve very well as the school was operated at its full capacity of 70 attendees, and only a couple of applicants were turned away.

The geographical distribution of the attendees indicated a wide interest in the Summer School. The 70 attendees came from 50 different institutions in 28 states and 3 Canadian institutions. Texas, the host state, had the highest totals of 10 people from 7 different institutions.

Some mild frustration was experienced in the realm of hardware, as the Calcomp plotter, loaned free of charge to the School, was dropped off a truck en route to Lubbock. After two days of repairs, it began to operate again, but this delay prevented the staff from running any preliminary test programs before the School started.

The Texas Tech Computing Center, I. B. M. and California Computer Products, Inc. were all generous in allowing us to use their facilities/equipment free of charge.

The principal lecturers for the School were Jack C. Brown, Clarence E. Hall, Byard Houck, Ed Mochel and Michael Pleck.

Because the School was operated at full enrollment, the Computer Graphics Committee was able to repay the Division for some mailing expenses incurred last fall and to put about $50.00 profit into the EDG Division's treasury.

The primary purpose of the summer school was to get more Division members interested in and involved in the area of Computer Graphics. I believe the Summer School accomplished this aim.

E. Mochel

Annual Meeting Notes - 1972

Members of the Division who were privileged to attend the Annual Conference at Texas Tech (Lubbock) are already aware of the excellent facilities made available by the host institution. However, even the facilities were overshadowed by the conference program and the Texas hospitality. The host faculty, staff and their wives left nothing to chance in accommodating their guests. Our own L. M. Graham, despite his responsibilities in overall conference program, was particularly responsive to the needs of the Division and Summer School. We are indebted to him, along with the other Texas Tech faculty members, for the excellent planning.

The Oppenheimer Award will continue to be offered. M. G. Thomas, K & E, has been appointed judge for the 1973 Award.

Next year's Creative Design Display Division will be chaired by P. S. DeJong, Iowa State University. The Judging Division will be chaired by R. A. Britton, University of Missouri-Rolla. Cooperating in the Creative Design Display next year will be the ASEE Relations with Industry Division and the Cooperative Education Division.

R. O. Byers resigned as a Division Director due to pressure of other responsibilities. The chairman will appoint a new director to fill the unexpired term.

Self-Study Implementation Committee recommendation and new By-Laws were referred to the Policy Committee for their consideration and action.

Details of the coming Mid-Year Conference were presented to the membership at the Annual Meeting. The final program is to be mailed in October.

A Computer Graphics Summer School organized and conducted by C. E. Hall and E. V. Mochel attracted 70 participants. Further details are reported elsewhere in this issue.

Preview of JOURNAL Articles

The attached is a list of articles that have been submitted for publication in the JOURNAL for the 1972-73 publication year. JOURNAL readers may be interested in the diversity of topics they may expect to see in this and future issues. This list is not intended to reflect an absolute publication schedule, but rather is representative of the diversity of interests of our authors. You are invited to submit a paper for publication since there are some open spots in our publication schedule.

Freshman Graphics Course With the Computer
  Mosillo
Homology vs. Monge Method
  Rotenberg
Pictorial Shade and Shadow
  Paré
Math Motivated Students to Learn Graphics
  Wockenfuss
Education for Engineering Design Involvement
  Stevenson
Programmed Invention
  Miller
Computer Mediated Instruction in Graphics
  Kroner
Machining of Compound Angles
  Spotts
Graphical Probability Analysis
  Baer
Human Engineering Using Off-the-Shelf Parts
  Woodson
An Approach to Instruction in Design
  Earp and Mason
Computer-Aided Pipe Sketching
  Roberts
The New Teaching Techniques
  Jaffe
Mathematics and Graphics
  Baird and Marvin
Design of the Geometry of Space Structures
  Blade
The Role of Visualization in Creative Behavior
  Faste
Automatic Drafting System Aids Bridge Design
  Schuchardt
Computer Drafting - A Big Step Forward
  DeNapou
A Computer Graphics Package
  Kearns
Computer Graphics Summer School Proceedings
  Mochel, et al
Student Designers Look at Recycling
  Aronson

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10:15	"Engineering to Improve Environment" Western Electric Company, Denver, Colorado
10:45	"Characteristic of Photographic Film for Engineering Designers" Eastman Kodak Company, Windsor, Colo.
11:45	Busses to Martin-Marietta Co.
	LUNCH
1:30PM	Afternoon Session
	Earth Resources Satellite Developments
2:00	Tour Martin Skylab Facilities
	Busses return to Radisson Hotel
6:30	National Western Stock Show & Rodeo

GEOMETRY p. 48

APPENDIX

Shell structures are being designed in many places. One interesting structure is a dome over the South Pole. It will be 164 feet in diameter, 50 feet high, made of small triangular segments which will be flown 900 miles from McMurdo station. In the Engineering News-Record account November 27, 1969, page 21, the sections were to be 10 foot equilateral triangles. As students of this paper realize, these would not make a dome approximately spherical in shape, though they could make a Zome or irregular assemblage.

This is an example of design which requires that the geometry should be correctly designed if the dome is to be easily constructed without problems of closure. As the average temperature at the pole is -56°F and it is sometimes as cold as -110°F, and there is always snow in the air, assembling a dome will not be easy.

Oppenheimer Award Winner

Dr. John G. Kreifeldt, Tufts University, was judged the winner of the Oppenheimer Award for the 1972 Annual Meeting. The Oppenheimer Award is presented for the best presentation of a paper at the Annual Meeting.

The judges deemed his presentation of the paper "Human Factor and Design Engineering" as the best presentation in the Engineering Design Graphics Division program. The award consists of a check and a certificate of acknowledgement. The Oppenheimer Award was established by Frank Oppenheimer, Grammercy Guild Group, to encourage more effective and stimulating presentations.

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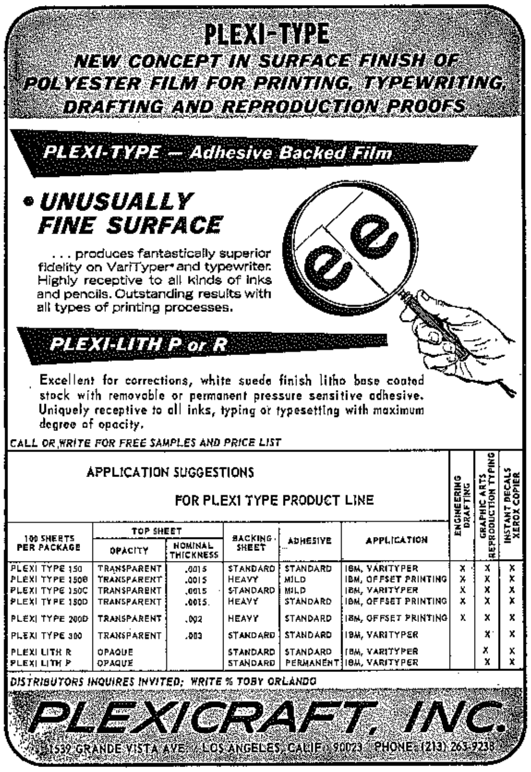

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James S. Rising, M. W. Almfeldt,
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Completely revised, **Engineering Graphics** presents a readable, integrated introduction to graphical communication, problem analysis, and creative design. Included throughout the text are carefully drawn illustrations and step-by-step procedures for problem solution. Outstanding coverage of vector quantities, graphical mathematics, and construction of charts and diagrams is provided. Sample problems of progressive difficulty conclude each unit.

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