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Advocating the Development of Visual Perception as a Dominant Goal of Technical Graphics Curricula

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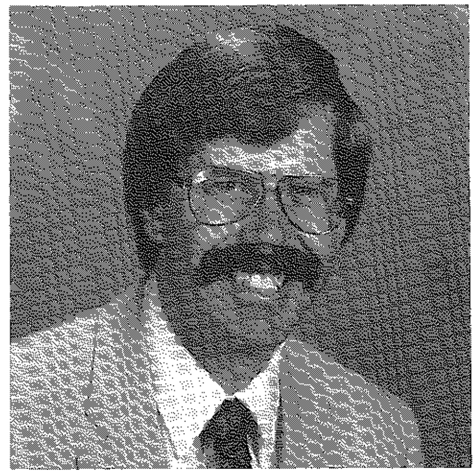

I. Introduction: Educational Status and Goals in Visual Disciplines

Many have recognized that visual disciplines in higher education have enjoyed an exciting, yet frustrating period of change. Greater emphasis is being placed on new technology, curricula are becoming more vocationally oriented, and graduates are expected to demonstrate greater competence in both specialized and diversified areas of their fields. Yet along with these changes, traditional problems still exist. Visual disciplines continue to have tighter departmental budgets, lower student enrollment and faculty pay, limited course offerings, and lower amounts of scholarly activity when compared to verbal or quantitative subject areas.

These conditions appear to be widespread within all fine art, graphic design, and technical visual disciplines in American education. Some suggest that these conditions may stem from cultural biases against visual subjects or the relative high expense of visual learning. Others cite an inability to identify and agree upon relevant educational goals. Most visual educators would argue that the primary purpose of their disciplines is to produce visual products. But the public and educational community have noted that attempts to obtain this goal are often made with curricula utilizing equipment, production methods, and media which are weak, trendy, and technology bound. The curricula justifications sometimes given may contribute to a public perception that "graphics people just make pretty pictures." Changing that perception may require a shift toward more relevant educational goals.

Effective scholarly activity normally supports relevant educational goals which promote professional growth and contribute to increased status. But scholarly activity in visual fields has often been diagnosed as vestigial because it appears to support goals that are too narrow, temporary, and questionable in value. Graphics instructors may focus too heavily upon certain kinds of drawing equipment or processes and other instructors may support current stylistic trends. This kind of narrow focus may lead to a failure to see the limitations of justifying programs by teaching "things and stuff". What is needed are educational goals that transcend media, equipment, and drawing processes, goals that can lead to the greater relevance and status of visual learning.

II. Limited Research, Limited Professional Status

Visual research has a shorter history than research in verbal and quantitative areas and most has been done by scientists, psychologists, and military personnel; persons only indirectly connected with visual education. The low quantity of visual research by educators in fine art, graphic design, and technical areas has been considered a key contributor toward the low status of visual education. White[1] indicated that those who earn advance degrees in visual disciplines typically become involved in only one research project during their entire career and that research project is almost always their own doctoral dissertation. White further explained that only one percent of those who did any kind of research did more than one project.

Within higher education advanced degrees have been earned in many areas relating to visual disciplines. One dominant terminal degree has been the doctoral degree in art education. Dissertation research from this degree tends to support topics relating to educational psychology, teaching methods, and the production and analyzation of visual works. Considering this degree alone, less than one hundred were earned by 1940 amd over half of the total awarded have been earned since 1965[1]. Of those earned, only a small percentage could be considered empirical investigations. Most are historical or descriptive studies. An argument can be supported that the low status of all visual disciplines may partially result from fixing upon weak goals and failing to produce meaningful amounts of effective research.

III. Visual Perception Development as a Dominant Educational Goal

Long[2] commented about technical illustration, and Eisner[3] about art education, and both agree that meaningful visual research should primarily be concerned with identifying effective teaching practices that support meaningful educational goals. But therein lies the problem. What constitutes "meaningful educational goals" has been a grab bag for many of us. It follows, however, that if we can identify relevant educational goals, then research can become more relevant, teaching practices more effective, and the status of visual disciplines may improve.

Visual educators from fine art through technical disciplines have been struggling to establish global educational goals, goals large enough and relevant enough to encompass their disciplines, provide a foundation for effective research, and promote status. Many have cited the production of various kinds of visual works as the purpose for their fields but have largely failed to identify overall goals which support that purpose. Nevertheless, a dominant, relevant goal exists. It is a goal widely recognized by art educators but largely overlooked by those in other visual disciplines, such as technical graphics. That goal is the development of visual perception. Research in art education has already shown that the production and analyzation of visual works improves when teaching methods are aimed toward developing a student's visual perception ability. If graphics educators can adopt that goal and produce effective research, then teaching practices may become more effective and the academic status of the profession may advance.

IV. Defining Visual Perception and Its Relationship to Technical Graphics

Eisner[3,4] stated that the development of visual perception should precede all other visual goals since it underlies them or makes them possible. Technically defined, visual perception ability is the ability to comprehend our environment through the neuro-visual system[5]. Popularly defined, visual perception ability means the ability to "see" or understand what one is observing. It also means the ability to visualize possible changes in what one is observing, or a kind of vivid mental picturing which aids in visual design and problem solving. For the technical illustration student, this could mean the ability to comprehend two views of a multiview drawing and the ability to determine a missing third view through internal visualization. In this way, technical graphics processes and equipment become the formal means for communicating what has already been perceived mentally.

The alternative is to determine a missing view by completing a drawing sequence, a step-by-step geometric construction process which leads to a correct graphic solution. But this method does not necessarily guarantee that the student visually comprehends the solution even though the view may be correctly drawn. It may be true that visual comprehension can come during or after the drawing is completed, but this comprehension may also be limited only to a particular drawing problem.

We can probably agree that comprehending and mentally determining a missing view is a higher level skill than the actual task of drawing the missing view. The former is a cognitive process while the latter is primarily a psychomotor process. Bloom[6] established this hierarchy and advocated the teaching of higher level skills whenever possible. Developing both processes aims toward the more global purpose of producing visual works, but developing visual perception should take precedence since it develops a higher level skill and leads to greater overall visual comprehension. Following this argument, if visual educators can identify methods for developing visual perception and implement them into curricula, then students may be able to master a wider array of visual tasks more rapidly with increased visual understanding.

Some educators, however, may not feel a need for change.

V. Biases, Assumptions, and Educational Practices

Typically, curricula in visual education have had more to do with developing psychomotor skills than developing visual perception. We may have assumed that by emphasizing drawing skills visual perception is always increased. We have not, however, adopted the development of visual perception as a goal upon which to focus. We may have centered on particular kinds of drawing equipment, processes, media, and techniques with the result that a variety of psychomotor skills have been developed, but not necessarily visual perception ones. We may have incorrectly concluded that the development of drawing skills equates to "educational success". Students may also have adopted this philosophy because the message has been projected through projects, teaching practices, and the structure of the curriculum.

Consider for a moment some existing course titles: Engineering Drawing, Advanced Drafting, Technical Sketching, Color Illustration, or Introduction to Solid Modeling. They sound as if they have more to do with drawing processes, media, and equipment than developing visual perception. Of course, there's nothing wrong with the course titles mentioned, but while we are in the process of teaching, we can become more oriented toward developing visual perception and communicate that goal to our students.

VI. Balancing the Value of Drawing and Visual Perceptual Development

If visual perception can be recognized as a dominant educational goal in technical graphics curricula, then drawing processes, equipment, and media may assume a different status. They can become additionally understood as a means through which students communicate what they already understand visually. But some educators may hold that learning a drawing process always leads to the development of visual perception and therefore the drawing process is what is important. But this argument only confirms the goal. The goal of the drawing process is to develop visual perception, but if visual perception can be developed through other means, then the drawing processes may not be so singularly important.

Research shows that visual perception can also be developed through non-drawing tasks, tasks not dependent on the production of visual works or on particular kinds of drawing processes. Dunn[7] used formal analysis of high resolution photographs to increase the perceptual ability of elementary students. Dorethy[8] used animated cartoons to develop depth perception through the analization of spatial relationships. Visual understanding then, can be developed through analytical contact with graphical documents and presentations, whether they are static or dynamic (animated). Even blueprint reading can be developed by means other than just board time. It is true that visual perception has been developed predominantly through drawing processes, but the overall goal of developing visual perception has been shown to be tool and process independent. Since this is true, it may also be global enough to merit adoption as a dominant curricular goal within the technical graphics profession.

VII. Common Educational Practices and the Real World of the Classroom

Is there a real need to make visual perceptual development a priority? Consider the typical student entering a fundamental engineering drawing course. Studies have shown that students entering visual fields in higher education have an average of only one semester of formal visual training during their entire public school education[9]. This includes all fine art, graphic design, and technical visual training in grades K - 12. They have probably had little or no experience with any kind of technical drawing. Most have worked with only very simple, very easy to perceive geometric objects. Most have learned only a limited number of technical drawing processes, such as the mitre line method of view-to-view information transfer.

At the beginning of a typical engineering drawing course, graphic fundamentals, such as the relationship between various views through the reference line method, are taught using a "Goss Box" and two-dimensional line drawings of more complicated geometric objects. The instruction may also include accompanying isometric drawings which show the multiviews in their 3-D relationship. After appropriate concepts are taught, the student is familiarized with drafting equipment and expected to solve graphical problems. But often the student can't get a mental picture of what the solutions should look like and may fail to solve problems adequately or may solve them correctly through the drawing process but without full visual comprehension of the solution. This can happen even if the student is reasonably competent with drafting equipment and has had the benefits of studying related isometric views. In reference to these deficiencies, it is possible that neither the instructor nor the student has understood what has contributed to the student's perceptual deficiency. And, both may incorrectly conclude that only more drawing will lead to full perceptual understanding.

VIII. Curricula Assumptions, Visual Deficiency, and Visual Experience

Two educational assumptions may have been made which may not be effective in correcting the perceptual deficiency of the student. First, the instructor may have assumed that using 2-D orthographic and 3-D isometric drawings is the correct way to begin the process of developing a visual understanding of 2-D multiviews. And second, the instructor may ignor the student's lack of visual experience and depend too heavily on the execution of a particular drawing process to develop visual perception.

As for the first assumption, it must be remembered that both the 2-D orthographic and 3-D isometric drawings of geometric objects are static, linear abstractions of real objects. But real objects are normally viewed three dimensionally. They are viewed at an oblique perspective (the truest-to-life perspective) and have color, texture, and value characteristics which communicate qualities about the object to the viewer. In addition, many real objects can be picked up, handled, and rotated, thereby providing dynamic cues. When real objects are held and rotated, edges sheer, colors and values change, and out-of-view surfaces can be perceived by touch. Through these dynamic interactions a variety of characteristics are assimilated to provide a rather complex perception of the object.

Concerning the second assumption, the instructor may not have realized that 3-D isometric line drawings can be very alien to inexperienced students and especially those who come from lower socio-economic backgrounds. Their environments tend to provide less visual enrichment and their families and peers tend to place less value on visual training. Their environments may be visually poor and contain little which relates to 2-D or 3-D line drawings of geometric objects. So, fewer visual perceptual "bridges" can be built between their experiences and engineering drawing. Thay may lack a variety of visual skills related to both the perception and production of visual products.

Visual inexperience can also hinder transfer of training. Thorndike[10] defined transfer of training as the influence an acquired skill exerts on the learning, retention, and performance of another skill. To explain, competency in roller skating enables one to master ice skating at a faster rate than someone with no prior skill in roller skating. Likewise, competency in elementary geometric construction or linear perspective drawing may enable one to master 2-D and 3-D engineering drawings generated by reference planes at a faster rate than someone with little related experience. The greater the amount of visual experience the more accelerated transfer of training will be between related visual skills. Inexperienced students, however, literally have "little to draw from" and may need to be assisted through educational experiences in the curricula.

IX. Curricula Adjustments for Developing Visual Perception

Curricula can be reformatted to provide increased visual perceptual experience. One possibility would be to structure curricula so that they provide a series of instructional steps that lead a student more slowly from perceiving and drawing real 3-D objects (cut blocks or machine parts) to perceiving and drawing isometrics, then multiviews. These steps move in a smooth progression from the real to the abstract (Fig. 1) and provide the inexperienced student with a greater number of intermediate steps to provide experience they may not have received in the past. Their visual perception ability could be developed by experiencing heirarchical levels of

1) REAL OBJECT, (One-piece Machine Part, No Abstraction)

2) 3-D VIEW OF OBJECT IN PHOTOGRAPH, (2-D Photo of 3-D Object, a First-level Abstraction)

3) LINEAR OBLIQUE PERSPECTIVE DRAWING, (True-to-life 3-D Line Drawing of 3-D Object, a Second-level Abstraction)

4) 2-D MULTIVIEW DRAWING, (True-to-life 2-D Line Drawing of a 3-D Object, a Third-level Abstraction)

5) 3-D ISOMETRIC DRAWING, (Abstracted 3-D Line Drawing of 3-D Object)

Fig. 1 Perceptual Steps in the Curricula

linear information that begins with real objects and progresses toward more abstracted linear drawings. As object abstraction increases, difficulty of visual perception increases. Compensation for this effect can be made by incorporating perceptual steps in the curricula, as in the example of Fig. 1.

In the example already mentioned, the instructor may have assumed that a novice does not need the initial step of understanding the relationship between a real object and 2-D or 3-D drawings which represent it. The instructor may also have assumed that there is little need to point out that some engineering drawings are abstracted from real objects to provide controls for representation through drawing "conventions". As an example, isometric drawing conventions allow true length construction of object dimensions along isometric axes and therefore isometric drawings are not true-to-life representations. The inexperienced student may have had trouble perceiving certain characteristics of an isometric object since the abstracted drawing convention is not true-to-life. In addition, the instructor may have used an isometric drawing of an unfamiliar object which was why the student could not relate to it from past experience. Some students have had very little exposure to mechanical objects. Some of our pet isometric cubes with mind-bending oblique planes may prove nearly incomprehensible to them.

Incorrect assumptions and oversimplified teaching practices may not correct a student's visual perception deficiency. If it becomes apparent that a visual "language barrier" exists, then teaching practices may need to be adjusted to contain steps which build a better visual understanding of graphical representations. Non-drawing methods can be integrated into the curricula.

X. Visual Perception Teaching Methods from Research in Art Education

Effective perceptual principles from visual perceptual research in art education can provide additional information for curriculum design. Improvement of visual perception has been a primary goal of art educators for some time. And while a number of technical graphics educators have been aware of that goal, it has not been universally recognized or advocated within the field. Yet daily classroom experiences point to the need to develop courses with that in mind.

Gibson[11], an educational psychologist, defined general perception as "the process by which we gain firsthand information about the world around us". She explained that stimulus inputs are processed by the various perceptional systems of the body and that each human "sense" is really a complex stimulus processor that feeds into and is interpreted by the neuro system. Of the various perceptual systems, the visual perceptual system is the most dominant. With respect to education, visual perceptual learning refers to increasing abilities to extract, interpret, and act upon information coming from the environment into the visual system. Case-Gant[12] indicated that ninety percent of learning is handled by the visual perceptual system. But the visual perceptual system involves more than just the eyes. Eisner[3] stated that visual perceptual learning is also a cognitive discriminative process. To an extent, visual perception is an innate capacity, but it is also a developmental process. Psychological research in visual perception has provided an understanding of the developmental stages through which individuals pass[11,13]. But more importantly, research in art education has shown that visual perception can be enhanced by specific training methods.

Empirical studies by Salome[14], Dorethy[8], Doornek[15], and Dunn[7] tend to confirm that specific training methods are more successful in developing specific visual skills than traditional teaching methods for educational experiences of relatively short time durations. The "traditional teaching methods" to which these studies refer are the teaching of general media processes, such as watercolor techniques. This traditional approach assumes that visual perceptual understanding will be developed as a result of constant contact with some kind of media and the process of using it to produce a visual work. The aforementioned studies, however, indicate that the development of specific visual skills is better achieved through very specific teaching practices. As clarification, let's select Dorethy's study of motion parallax.

Motion parallax is the ability to perceive apparent changes in the location of an object as a result of continuing changes in its position in space or continuing changes in the position from which it is viewed. Dorethy's investigation revealed that specific visual analysis of moving animations containing multiple depth cues (i.e., Roadrunner cartoons) were more effective in developing a visual perceptual understanding of pictorial depth than either general or specific analysis of static visuals such as single frame Roadrunner cartoons (which also contained multiple depth cues). Subsequent drawings from the control group indicated an increase in both the quantity and quality of depth cues. Skill in handling the drawing media was not appreciably affected, but the pictorial content revealed an increase in the visual perceptual skill that was targeted for development through a specific training method. The educational principle revealed is that the development of specific goals requires specific training. The other three studies in art education yielded results which demonstrated the same principle.

The results of Dorethy's study may apply to any instruction seeking to develop visual depth perception. For instruction in technical graphics, this could mean help for topics such as board-generated rotating auxiliary views, architectural perspective, surface or solid modeling animations, or axonometric illustrations. Dorethy's study did not use a drawing process to develop a visual perceptual skill. Rather, it used animations to develop the skill and then checked results through the drawing process. The drawing process was secondary in importance because it was a means through which increases in visual perceptual learning were revealed and assessed.

XI. Additional Teaching Methods from Technical Graphics Research

The previous studies were concerned with assessments of visual perception skills after instructional treatments which lasted only short time periods. In two separate studies the writer has assessed visual perceptual abilities after long time periods. One study involved art students[16]. The other involved technical illustration students[17]. Both assessed the effect of cumulative general training, training received over months or years, upon visual perception abilities. Results indicated that the art students required greater amounts of training than technical illustration students to reach an equal perceptual level.

Both investigations utilized the Group Embedded Figures Test (GEFT)[18] as the instrument for the assessment of visual perception ability (Fig. 2). The GEFT assesses perceptual ability by requiring the subject to disembed a simple geometric shape from within a more complex geometric figure. The subject studies the

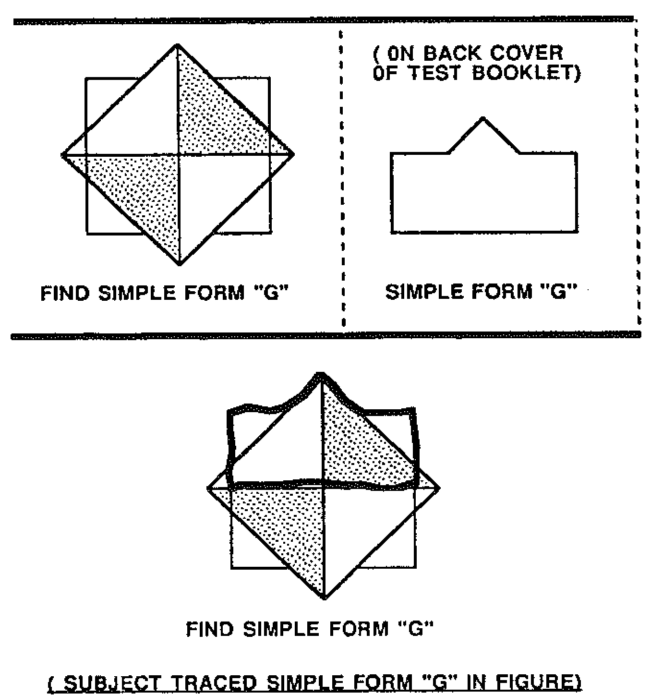

Fig. 2 Group Embedded Figures Test

simple figure at the back of the test booklet, then turns back to the complex figure and traces it.

The disparity in the results for the two groups may have to do with two key factors. One factor is that the training which art students receive is qualitatively different from that received by technical illustration students. An art student is likely to receive greater amounts of training, but the training is probably more general, less technical, and less geometric than that of a technical illustration student. In addition, the art student is more concerned with influences from the Affective Domain. They may wish to express feelings, emotions, concepts, beliefs, and ideas through their visual works.

The technical illustration student is more concerned with the technical side of drawing and reflects heavy influences from engineering graphics and descriptive geometry. The higher performance of technical illustration students may have to do with the pictorial content of the GEFT. It is a highly geometric test and the higher performance by technical illustration students may be due to their concentrated contact with geometric drawing even during early stages of their training.

XII. Summary of Strategies for Developing Visual Perception Ability

The preceding information reveals several strategies which can be incorporated in the curricula:

A. Adopt the development of visual perception as a dominant curricular goal.

B. Continue to use the instruction of drawing processes to enhance visual perception.

C. Use a specific training method to develop a specific visual perceptual skill.

D. Incorporate use of non-drawing tasks, such as formal analysis of visual documents, whether static or animated, or freehand, mechanical, or computer generated.

E. Analyze real objects that show their relationship to particular kinds of engineering drawing.

F. Restructure the curricula to provide detailed sequential steps between real objects and various levels of abstracted engineering drawings.

G. To predetermine a student's perceptual ability, use the Group Embedded Figures Test.

H. To predetermine a student's visual experience level, use a detailed survey form.

XIII. Conclusions

In general, the various studies indicate that a variety of teaching methods will increase visual perception ability. It follows then, that adoption of visual perceptual development as a dominant curricular goal and implementation of effective methods may benefit our students. In addition, another primary need can be served. Continuing research in this area may lead to a growth in status for the field of technical graphics. We may yet be able to gain greater credibility with the educational community and the public.

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The Errors in Rectifying Circular Arcs

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Two methods of rectifying circular arcs are described and rectifying errors are compared.

To rectify a circular arc is to lay out its true length along a straight line. The applications of this geometric method can be found in showing the path of travel of the end of a spring for clearances and other engineering designs (Hoelscher, R. P., et al).

A common method of rectifying a circular arc, as shown in Fig. 1 and described in most engineering graphics textbooks, uses the following steps:

1. Given the arc AB

2. Draw the tangent at A.

3. Draw the chord AB and extend it to D, making AD equal to half AB.

4. With center D and radius DB, draw an arc intersecting the tangent line at E.

5. The tangent line AE is approximately equal in length to arc AB.

In this method, the tangent line AE is slightly shorter than the given arc AB. The error varies according to the subtended angle of the arc. In Fig. 1, let the angle of the arc be 2θ, the radius r, and AE = L_1, then the length of the arc is $2r\theta$. Let the error be e_1, then

$$L_1 / (2r\theta) = \sin\theta / (2\theta) \cdot [(\cos^2\theta + 8)^{0.5} - \cos\theta] = 1 - e_1 \quad (1)$$

To prove Eq. (1), let the mid-point of chord AB be C, then

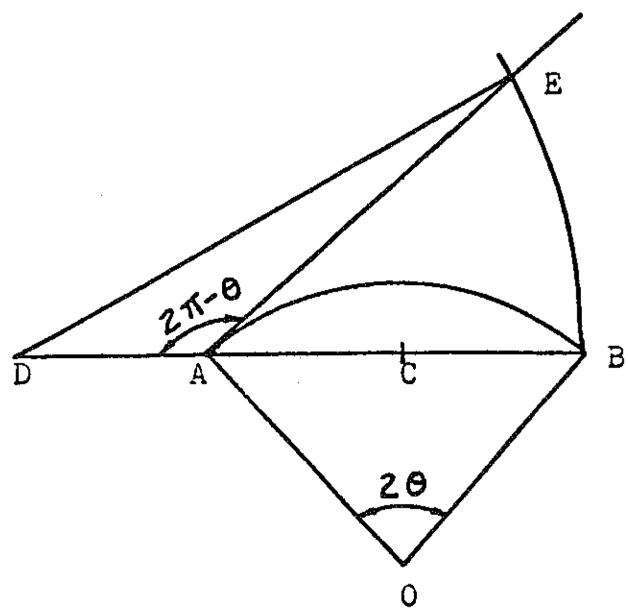

Fig. 1

$$AC = r \sin \theta \quad \text{and}$$

$$AD = AC$$

$$= r \sin \theta$$

$$DE = 3\ AD$$

$$= 3\ r \sin \theta$$

In $\triangle$ DAE,

$$DE^2 = AD^2 + L_1{}^2 - 2\ AD\ L_1 \cos (2\pi - \theta)$$

or

$$(3\ r \sin \theta)^2 = (r \sin \theta)^2 + L_1{}^2 + 2\ r \sin \theta \cdot L_1 \cos \theta$$

Thus,

$$9\ r^2 \sin^2 \theta = r^2 \sin^2 \theta + L_1{}^2 + 2\ r\ L_1 \sin \theta \cos \theta$$

Therefore,

$$8\ r^2 \sin^2 \theta = L_1{}^2 + 2\ r\ L_1 \sin \theta \cos \theta$$

or,

$$L_1{}^2 + 2\ r \sin \theta \cos \theta\ L_1 - 8\ r^2 \sin^2 \theta = 0$$

Thus,

$$L_1 = [\ -2\ r \sin \theta \cos \theta \pm (\ 4\ r^2 \sin^2 \theta \cos^2 \theta + 32\ r^2 \sin^2 \theta\ )^{0.5}\ ] / 2$$

$$= -\ r \sin \theta \cos \theta \pm r \sin \theta\ (\cos^2 \theta + 8\ )^{0.5}$$

Since L_1 cannot be a negative value, therefore

$$L_1 = r \sin \theta\ [\ (\cos^2 \theta + 8\ )^{0.5} - \cos \theta\ ]$$

and

$$L_1 / (\ 2\ r\ \theta\ ) = \{\ r \sin \theta\ [\ (\cos^2 \theta + 8\ )^{0.5} - \cos \theta\ ]\ \} / (\ 2\ r\ \theta\ )$$

$$= \sin \theta\ [\ (\cos^2 \theta + 8\ )^{0.5} - \cos \theta\ ] / (\ 2\ \theta\ )$$

$$= 1 - e_1$$

As an example, when the subtended angle is 90° , that is when $2\theta = \pi / 2$, then

$$L_1 / (\ 2\ r\ \theta\ ) = \sin (\ \pi / 4\ )\ \{[\cos^2(\pi/4) + 8]^{0.5} - \cos (\pi / 4\ )\} / (\ \pi / 2\ )$$

$$= 0.7071\ (\ 2.9155 - 0.7071\ ) / 1.5708$$

$$= 1 - e_1$$

Thus, the error of the tangent line

$$e_1 = 0.0058828$$

$$= 1 / 170$$

Therefore, for a 90° arc, the tangent line AE will be 1 / 170 part short. For a 60° arc, the line will be 1 / 860 part short, and at 30° ,the tangent line will only be 1 / 14400 part short.

An alternate method to rectify arc AB is shown in Fig. 2, using the following steps:

1. Find the center F of the arc AB.

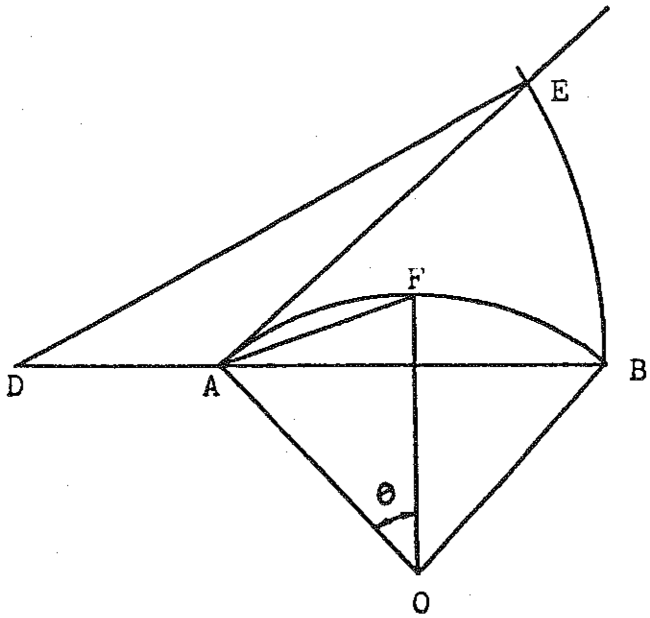

Fig. 2

2. Connect chord AF and extend AD equal to AF.

3. With center D and radius DB, draw an arc to intersect the tangent line at E.

4. The tangent line AE is approximately equal in length to arc AB.

In this solution, the error is less than the error obtained from the first method. Let the length AE be L_2, and the error be e_2, then, with $\beta = \theta / 2$ for ease of notation

$$L_2 / (2 r \theta) =$$

$$\sin \beta \{ [\cos^2 \theta + 4 \cos \beta (\cos \beta + 1)]^{0.5} - \cos \theta \} / \theta$$

$$= 1 - e_2 \qquad (2)$$

To prove this equation, investigate $\triangle$AOF.

$$AF^2 = AO^2 + FO^2 - 2\ AO\ FO \cos \theta$$

$$= 2 r^2 - 2 r^2 \cos \theta$$

$$= 2 r^2 (1 - \cos \theta)$$

$$= 2 r^2 (\sin^2 \beta + \cos^2 \beta - \cos^2 \beta + \sin^2 \beta)$$

$$= 2 r^2\ 2 \sin^2 \beta$$

$$= 4 r^2 \sin^2 \beta$$

Thus

$$AF = 2 r \sin \beta$$

Since AD = AF, then

$$AD = 2 r \sin \beta$$

In $\triangle$ADE,

$$DE = AD + AB$$

$$= AF + AB$$

$$= 2 r \sin \beta + 2 r \sin \theta$$

Also,

$$DE^2 = AD^2 + L_2^2 - 2\ AD\ L_2 \cos (2 \pi - \theta)$$

Therefore,

$$(2 r \sin \beta + 2 r \sin \theta)^2 =$$

$$(2 r \sin \beta)^2 + L_2^2 + 2 (2 r \sin \beta) L_2 \cos \theta$$

Or,

$$8r^2 \sin \beta \sin \theta + 4r^2 \sin^2 \theta =$$

$$L_2^2 + 4 r L_2 \sin \beta \cos \theta$$

Finally,

$$L_2^2 + 4\, r \sin \beta \cos \theta\, L_2 - 4\, r^2 \sin \theta\, (2 \sin \beta + \sin \theta) = 0$$

Solving this equation for L_2 yields

$$L_2 = - 2\, r \sin \beta \cos \theta + [16\, r^2 \sin^2 \beta \cos^2 \theta + 16\, r^2 \sin \theta\, (2 \sin \beta + \sin \theta)]^{0.5} / 2$$

$$= - 2\, r \sin \beta \cos \theta + 2\, r\, (\sin^2 \beta \cos^2 \theta + 2 \sin \theta \sin \beta + \sin^2 \theta)^{0.5}$$

$$= - 2\, r \sin \beta \cos \theta + 2\, r \cdot (\sin^2 \beta \cos^2 \theta + 4 \sin^2 \beta \cos \beta + 4 \sin^2 \beta \cos^2 \beta)^{0.5}$$

$$= 2\, r \sin \beta \{ [\cos^2 \theta + 4 \cos \beta (\cos \beta + 1)]^{0.5} - \cos \theta \}$$

Thus, dividing by $2\, r\, \theta$, Eq. (2) is obtained.

$$L_2 / (2\, r\, \theta) = \sin \beta \{ [\cos^2 \theta + 4 \cos \beta (\cos \beta + 1)]^{0.5} - \cos \theta \} / \theta$$

$$= 1 - e_2$$

When $2\, \theta = \pi / 2$,

then

$$L_2/ (2\, r\, \theta) = 0.78506259/0.78539816$$

$$= 1 - e_2$$

or

$$e_2 = 0.00042726$$

$$= 1/2300$$

Thus, for a 90° arc, using the second method, the tangent length is 1/2300 part short. This method is even more accurate than the first one. In both methods, the smaller the subtended angle is, the smaller the error will be. In either method, the error is so small that the drawing constructions are well within the range of accuracy of drawing instruments when the subtended angle is less than 60° for the first method and less than 90° for the second method.

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The Complete Engineering Graphics System

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Numerous graphic production and reproduction techniques are available to today's engineers and designers. Design and engineering concerns can function more effectively and efficiently through the judicious use of these techniques. The techniques are examined in the context of producing and reproducing graphic products. In addition, the shortcomings of depending on selected techniques and technologies is explored as well as the benefits of melding those techniques and technologies. Engineering graphics, as suggested, is more than simply the generation of original graphic products. It also involves the management and dissemination of those products.

Most scholars would agree that engineering graphics can be defined as the means by which the graphic language is used to communicate ideas. Furthermore, they would agree that engineers and engineering technologists must possess a sound understanding of graphics theory and practice.

In addition, today's engineer and engineering technologist should have an understanding of the complete engineering graphics system used in producing and reproducing graphic products. This fact is substantiated by the attention given to this aspect of engineering graphics by most authors of engineering graphics texts. Engineers and technologists should be able not only to communicate ideas graphically using accepted conventions, but also should possess an understanding of the system which generates and regenerates the graphics used in communicating ideas. They should be aware that the efficient production of graphic products actually (a) exists on a continuum, (b) encompasses three overlapping generations of graphics (Fig. 1), and (c) includes the use of traditional or manual methods, the more contemporary, fully automated methods, and a number of semi-automated procedures.

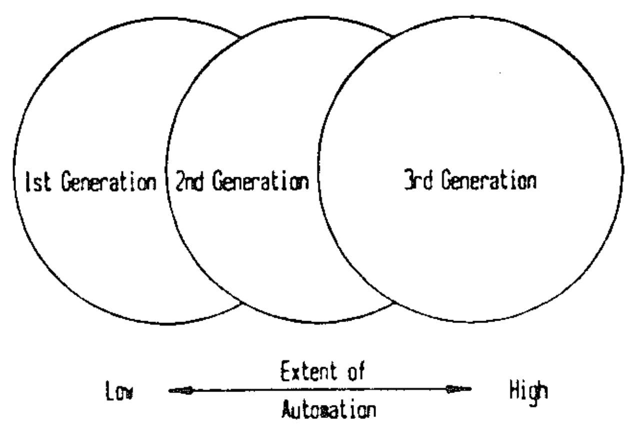

Fig. 1 Generations of engineering graphics

Engineers and technologists should also understand that efficient production and reproduction of graphic products can only be achieved through judicious use of automated, semi-automated, and manual techniques. As an example, it seems contrary to the competitive nature of business and industry to make real-time revisions, especially minor ones, on computer graphic products each time design changes occur. This problem is particularly acute on "D" and "E" size computer graphics products. Furthermore, it makes no sense to plot the graphic product each time revisions are made when more efficient methods exist to achieve the goal of document revision.

The purpose of this paper is threefold. First, an attempt is made to place into perspective the components of the complete engineering graphics system: how the components coexist, and how they constitute a complete production and reproduction system.

Secondly, an attempt is made to examine the precursor to CADD. Even though this forerunner to CADD actually contributes to enhancing drawing productivity and the usefulness of automated, as well as manually expressed graphic products, it is the one dimension of the complete engineering graphics system that does not receive the attention it should. Consequently, engineers and engineering technologists are not as aware and are not as apt to take full advantage of techniques available for use in the efficient production and reproduction of graphic products.

Finally, an attempt is made to illustrate how manual methods, fully automated methods, and semi-automated procedures complement one another.

These points are of particularly importance to engineers and engineering technologists. At some time in their professional careers they will have to come to grips with the means by which graphic products must be managed.

In a preceding paragraph, it was suggested that three generations of engineering graphics prevail in the design environment today. It was also suggested that what best distinguishes the three generations from one another is the degree of automation associated with each.

First generation graphics encompasses the techniques and products normally associated with what is frequently described as manually expressed engineering graphics. Products of this generation are a direct result of the application of graphite or ink onto a media aided by the T-square and triangles, and more recently, drafting machines. The products of first generation engineering graphics will be around for some time and comprise an extensive data base from which other graphics can be created. Furthermore, it is by default the most familiar because of its longevity.

At the other end of the continuum, third generation engineering graphics encompasses the practices which have fully automated engineering graphics--computer-aided design and drafting (CADD). Because of CADD's notoriety, current awareness of third generation engineering graphics rivals the familiarity which exists with first generation graphics. More often than not, CADD has supplanted the manually expressed practices, thus earning it notoriety.

Engineering graphics' second generation, though, has been the sleeper. Semi-automation best characterizes this generation of graphics, which can be thought of as having come to life with the introduction of the blueprint process in 1876. In today's industrial setting, systems drafting is the term used to describe the sum of the techniques associated with the production and reproduction of graphics by semi-automated means. It is also the term used to describe the use of various reprographic techniques in the engineering graphics environment, including the blueprint process.

Reprographics can be defined simply as the art and science of reproducing documents[1]. The underlying philosophy of reprographics is that the same line should never be drawn twice. The role of second generation engineering graphics, then, is to enhance drawing productivity and quality by taking advantage of modern reprographic processes and capabilities.

Repetitious work is not only tedious but also very expensive. The Eastman Kodak Company[2] notes that the cost of creative drafting for an industrial drawing averages $145 a square foot. Furthermore, it was noted that the average cost for architectural drawings was $722 a square foot. The use of reprographic techniques, however, can yield a cost savings of up to 90 percent and reduce graphics production and reproduction time by as much as 80 percent[1]. But how is this done?

Graphic objectives are achieved through systems drafting by way of four reprographic processes: (a) electrostatic copying, (b) the use of photographic systems, (c) diazo reproduction, and (d) offset lithography. Other reprographic techniques are available and in use; however, these alternatives yield very limited benefits.

Electrostatic copying is most frequently associated with the process of Xerography. The process involves the use of electrical charges and heat fusion to form an image on a given media. Systems drafting, aided by the electrostatic process, can be accomplished at a rudimentary level with most office copiers. However, copiers which do more than simply copy documents (i.e., reduce, enlarge, control density) provide additional creative dimensions to designers and drafters.

The use of photographic systems includes the various means of projecting images onto photosensitive material. Development of an image is achieved by a chemical action resulting from the application of light. Production of a finished product, though, usually involves other processes, such as diazo or offset lithography.

The diazo process involves the use of a substrate coated with a light sensitive diazo compound which, after being exposed, is subjected to ammonia vapors or moist development to produce a positive image. In the design and drafting environment, diazo is normally associated with the production of whiteprints and sepias.

Offset lithography involves the use of a plate which is ink-receptive where the image is to be printed and ink-repellent in the non-image area. When the plate is inked, the image is transferred to a rubber blanket, which in turn offsets the image onto a sheet of paper. Offset lithography, however, is dependent on the photographic process as the medium through which an original image is transferred to the plate. Furthermore, offset lithography normally yields a relatively high quality finished product, whereas the other processes are more apt to be used both to create and modify parts of a drawing, and to produce a finished product. But what is the role of these processes in the engineering graphics environment, and how do they relate to manually expressed graphics and CADD?

Each reprographic technique yields unique products and benefits. Greatest flexibility, though, is achieved through the more diverse electrostatic and photographic processes. In addition to the efficient production or reproduction of original presentations, whether they are expressed manually or plotted by automated means, both processes are mediums through which opaquing and blocking out can be accomplished.

Opaquing and blocking out are efficient techniques used in removing unwanted material from a drawing: lines, dimensions, views, or entire details. Furthermore, opaquing and blocking out can be used to remove soil or age marks and other blemishes.

Scaling can also be facilitated through either process. Rather than scaling an existing design by hand or replotting a drawing for a new application, accurate scaling can be achieved in much less time using the electrostatic or photographic processes. In addition to an increase in productivity, the resulting graphic is usually of a higher quality than the original from which it was scaled.

High quality repetitive details or multiple images can also be produced efficiently. Rather than laboriously redrawing or replotting details, the details can be duplicated from masters when needed, in the quantities desired.

Phantom images and screening/subordinate imaging are used to produce subdued backgrounds or subordinate images, and to enhance the contrast between images (Fig. 2). This is normally achieved photographically with the aid of screens that reduce the density of original lines.

A number of creative graphic techniques have evolved from these basic reprographic processes. The more common include scissors or paste-up drafting, photo-drafting, restoration, reformatting, and pingraphics.

Pingraphics

Also referred to as registration or overlay drafting, pingraphics makes use of precision machined pin bars located at standard intervals, spaced to close tolerances. Accuracy is further achieved through the use

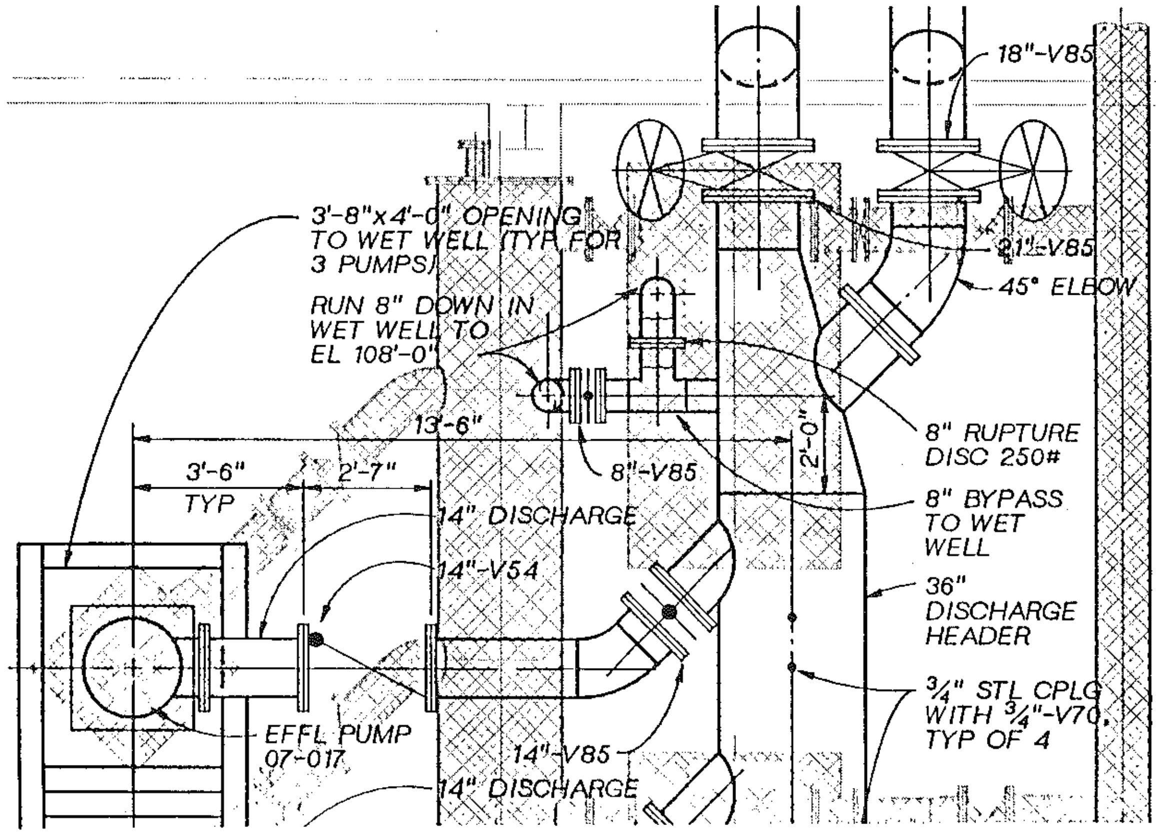

Fig. 2 Screening/subordinate imaging (from Roll Vac Corp.)

of dimensionally stable polyester film, a synthetic media which is unaffected by changes in temperature or humidity.

The process of pingraphics begins with the production of an original base drawing containing information common to the various disciplines involved with the design (Fig. 3). In the design of a commercial building as an example, a base drawing consisting of a plan view would be produced. The original base drawing is then keyed to a pin bar, reproduced, and the duplicate base drawings, called "slicks", are distributed to the various consulting engineers. Designers then place their slick on a pin bar and overlay it, using the slick as a guide in their design work. As the base design changes, updated slicks are produced and distributed.

When the various disciplines complete their overlays, a negative is made for each overlay and the base. The negatives are then exposed to the final positive through either the diazo process or offset lithography and yield the desired composites. Depending on its use, the final product may be polychrome or monochrome.

Some of the most frequent users of pingraphics are those involved with mapping, electronic circuitry design, and architectural design. Once the design work has been completed, the originals can be scaled, screened as required,

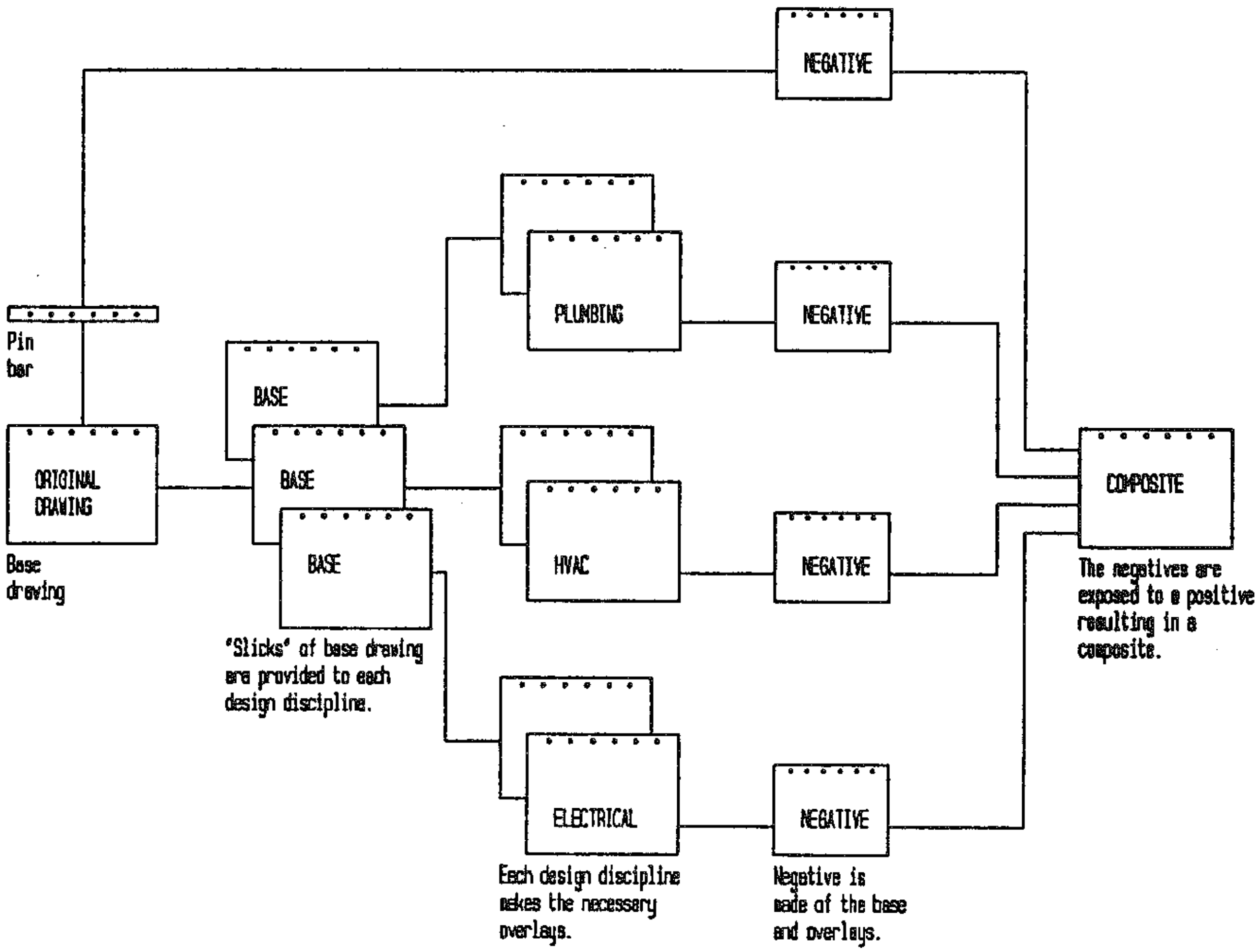

Fig. 3 Traditional pingraphics

opaqued, etc., to meet the specific graphic requirements of the client.

The pingraphics concept has been improved upon, and productivity has been enhanced with the introduction of CADD and the level or layer functions available with most CADD packages (Fig. 4). Rather than producing the base drawing manually, it is produced electronically. The resulting electronic slick is then shared with the consultants who can, in turn, complete their respective overlays either manually or electronically. Finally, copies of the work from the various disciplines are plotted. Rather than plotting a multicolor composite, the consultants produce a plot of their respective overlays. The composite is then produced photographically and the hardcopy by offset lithography.

Today's high speed, high-tech plotters are capable of generating accurate, high quality, multicolor products. However, they still cannot produce products economically and in the quantities required for bid letting, as an example. The solution then is to plot the various levels or

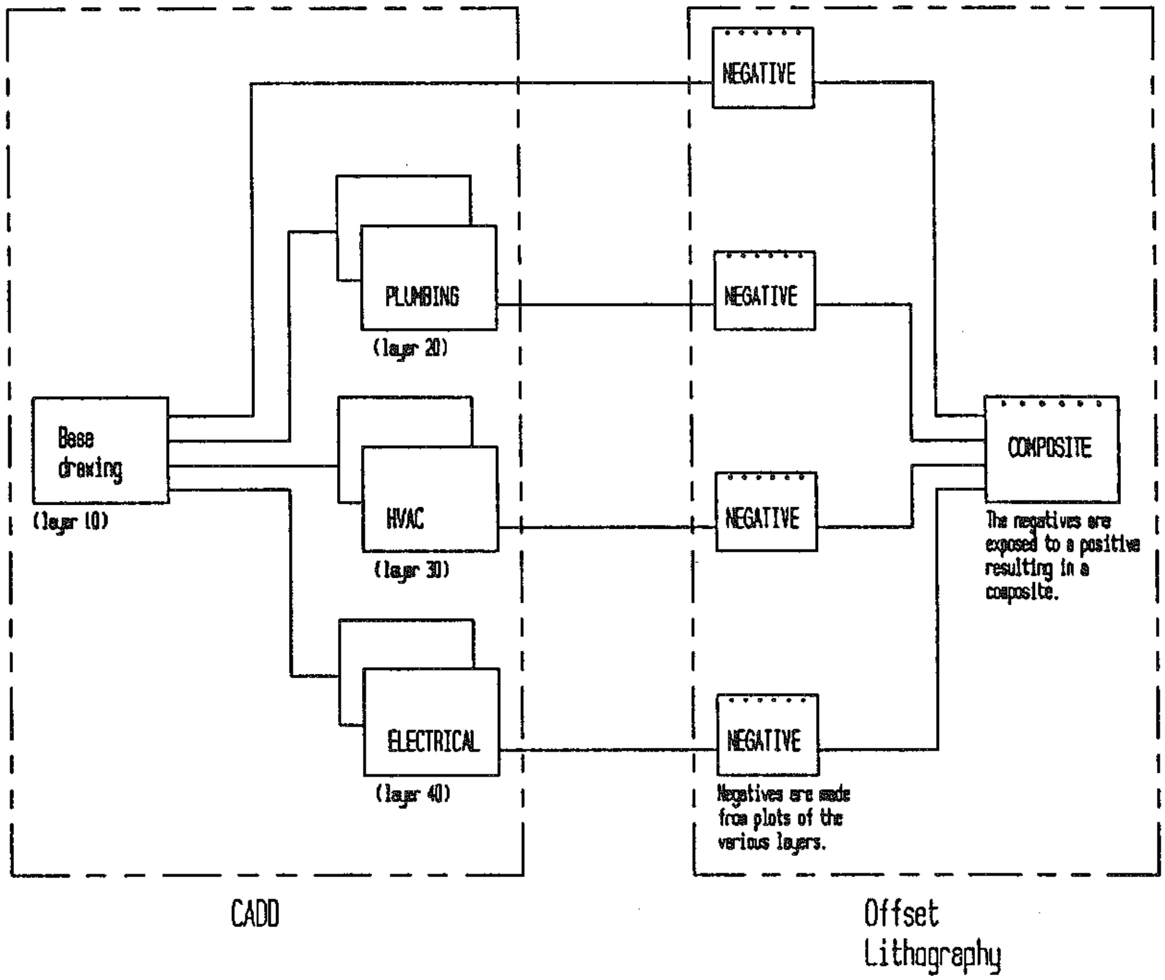

Fig. 4 Automated pingraphics

layers monochromatically and employ offset lithography to produce the required polychrome hard copies.

Scissors and Paste-Up Drafting

This particular technique makes use of existing graphics regardless of the source or scale, and like other techniques is intended to aid in production and reproduction of graphic products. A copy is made of the original drawing or detail to either the original scale, enlarged, or reduced, according to design requirements. The source of the original can include catalogs, manually drafted drawings, or computer graphics, for example. Opaquing fluid is applied to the details, or the details are trimmed to eliminate unwanted material. Conversely, information can be added prior to the production of a final print. The details are then taped to a base which is usually a title block sheet. When the editing has been completed, a final print is produced according to specified requirements using the diazo, electrostatic or lithographic method.

Scissors or paste-up drafting also encompasses applique techniques which facilitate the handling of multiple images or repetitive details. Rather than duplicate a detail on bond paper or vellum, the detail is copied onto commercially available transparent adhesive film. Once copied, the detail is trimmed and applied in the quantities desired.

Quite often it is much more efficient to use appliques of standard details rather than plotting them, even though the details may be part of an existing electronic data base.

Reformatting

Reformatting involves the transfer of an existing drawing to another drawing or drawing format and is a form of scissors or paste-up drafting. Reformatting occurs frequently as a result of change in titling format, reorganization of the company, or company takeovers.

In reformatting, the drawing is trimmed from the original sheet and may be opaqued or otherwise edited to eliminate unwanted information. The drawing is then transferred to the new title sheet. Once the drawing has been reformatted, a final copy is produced according to the graphic requirements.

Many times it is more efficient to cut and paste than to plot graphics which must be reformatted.

Restoration

Restoration involves bringing life back to damaged or worn drawings and can be accomplished by using any one of three methods: manual retracing, digitizing (CADD), or reprographic techniques. Both retracings and digitizing are labor-intensive, even though the latter yields a higher quality product than the former. By-products of restoration using reprographic techniques, however, include efficiency, the production of a higher quality drawing, and the production of a drawing which is more suited to the rigors of revisions.

In restoring a drawing, a copy or negative is made (Fig. 5). The severity of drawing deterioration and the desired quality of restoration will dictate whether it is produced photographically or electrostatically. The damaged areas are then opaqued or touched up by a drafter. After editing has been accomplished, a copy of the restored drawing is produced on the desired media.

Photo-Drafting

Photo-drafting makes use of existing photographs to generate working drawings. A screened or half-tone negative is produced from a high quality photograph. The image is then projected onto a matte positive film along with the material which appears on the title block sheet. During the process, material can be opaqued or added, according to the drawing requirements.

Summary

Judicious use of the three principle approaches to the complete engineering graphics system results in higher quality prod-

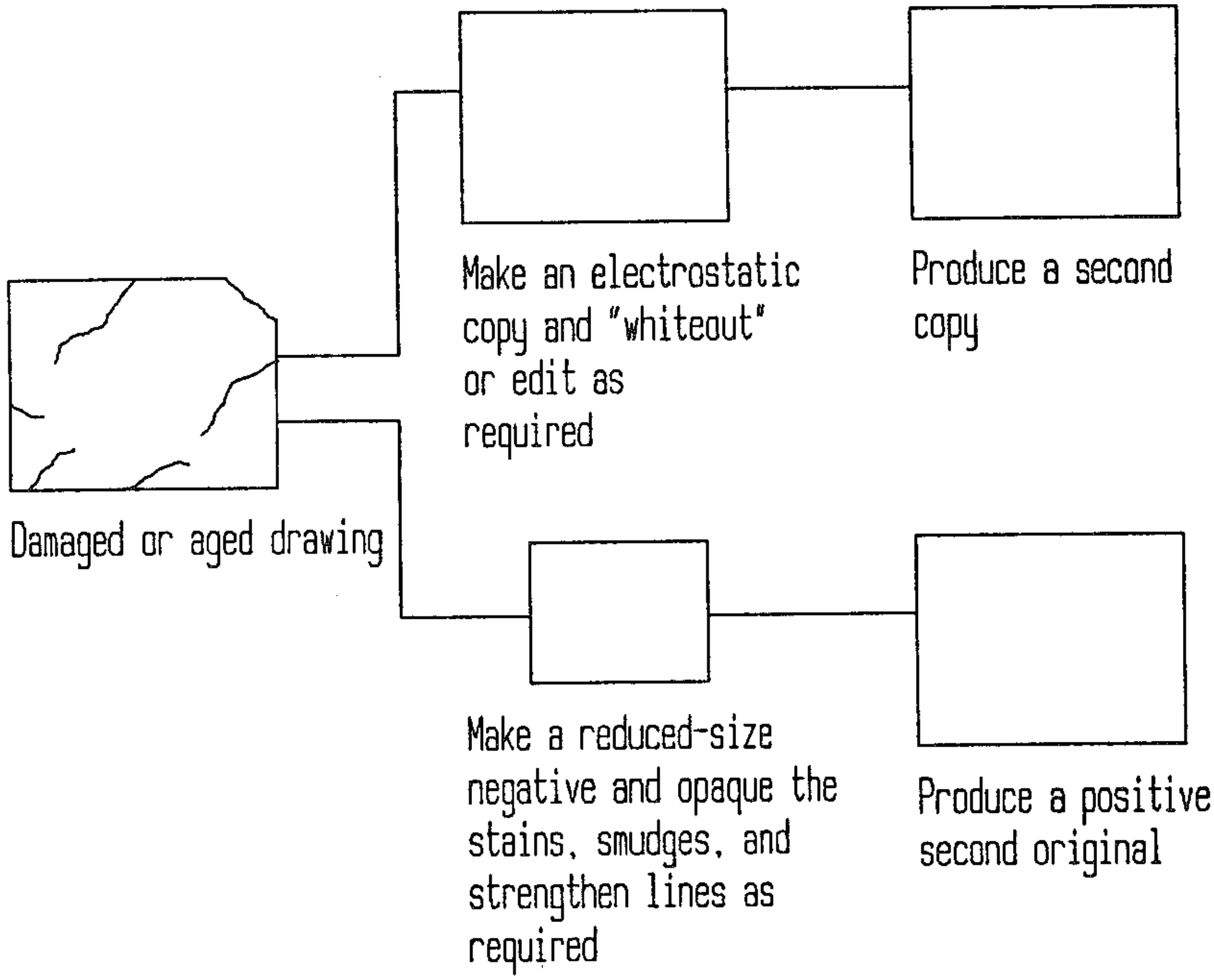

Fig. 5 Restoration graphics

ucts and increases in productivity during both the design process and in the production and reproduction of graphic products. This feat is being achieved daily by business and industry as they take advantage of (a) the hard-copy data bases all engineering departments maintain, (b) computer graphics, and (c) reprographics. More importantly, shortcomings of the three approaches can be minimized through a melding of the techniques. As has been pointed out, the key is in the use of reprographics and the means by which it complements traditional methods (Fig. 6) as well as CADD (Fig. 7). It makes no sense to (a) replot or manually redraw repetitive details, (b) draw common hardware when these details are readily available, or (c) digitize a worn drawing simply to restore it when all three tasks can be accomplished readily on an office copier.

An appropriate balance, however, must be maintained in the use of the three approaches to achieve efficiency. This balance can only be accomplished through an understanding of the composi-

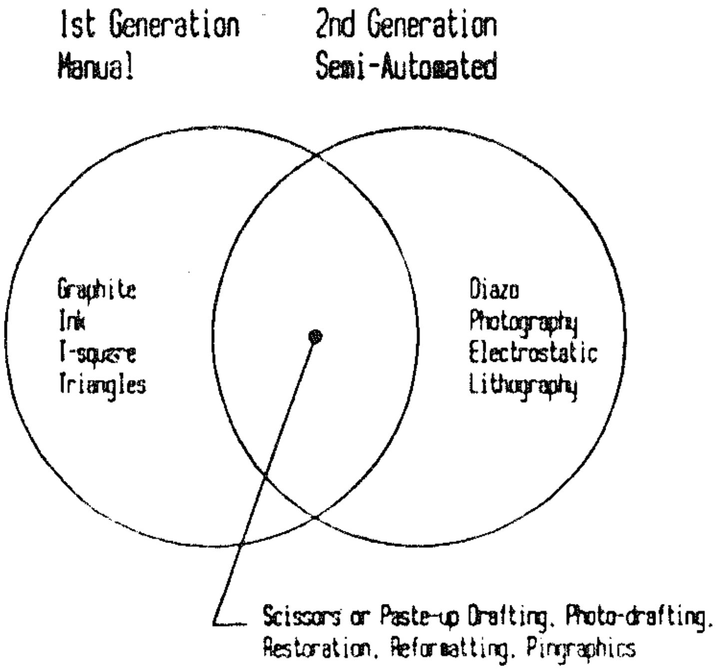

Fig. 6 Manually expressed graphics enhanced by reprographics

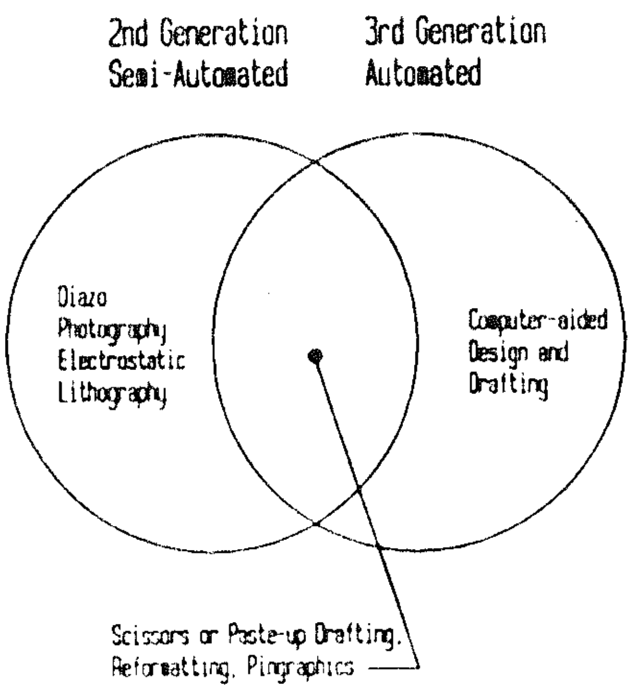

Fig. 7 CADD enhanced by reprographics

tion of the complete engineering graphics system and its strengths and weaknesses.

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Analyzing, Selecting, and Purchasing CAD LAN Systems

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Local Area Network (LAN) systems, one method of sharing information, are arranged into three main topologies according to one of three geometric configurations - bus, ring, or star. The physical connection of nodes is referred to as the transmission medium, classified as bounded (baseband) or unbounded (broadband). Bounded techniques include the twisted pair, the coaxial cable, and the optical fiber, while the use of radio, microwave and infrared signals are classified as unbounded techniques. Networks can be linked together by bridges. Bridges match the signals, control the messages, and transfer signals upon clearance. With the great number of LANs on the market, the connectivity must comply with standards established by the International Standards Organization (ISO). This assures conformity in designs. When choosing a LAN system, seven questions must be considered - will the system be a multi-use media, what is the length of the backbone, are heterogenous connections to be considered, what data rates are required, are there any existing network facilities, what are the installation costs, and what flexibilities exist in design? Basing a decision on these questions can help produce a reliable system for any company.

Introduction

One of the most valuable tools in industry is the ability to communicate. Communication provides the channel for sharing and exchanging information or ideas. This includes not only person-to-person communication but also communication between computer operating systems. Operating system communication is accomplished by means of networking. "Communications form the backbone of modern business, and computer communications are no exceptions."[1]

T. J. Byers[1] states that more than three-fourths of all business correspondence occurs at the local level. Even though it is essential to have satisfactory long distance communication, greater emphasis must be placed on messages transmitted in a close proximity, such as within a plant. An innovation called Local Area Network (LAN) gives computers this dimension. With technological development and growth, the affordability of LAN is becoming more realistic.

It is estimated by the year 1990, that some 38 million computerized workstations of various kinds are likely to be installed in offices, factories, and schools. With such a demand for computer workstations, the demand for LAN will become commonplace and will in turn lead to an overcrowding of LAN manufacturers in the market.

Purpose of the Study

The purpose of this study was to develop a document to serve as a guide for industrial and educational CAD/CAM computer managers in analyzing, selecting, and purchasing a LAN system. According to T. J. Byers[1], there were 70 different networks on the market in 1984. At present, network manufacturers clutter the market. Due to the vast amount of networking systems, this study was limited to those systems which deal with industrial CAD/CAM LAN applications.

At this time, researchers are continually updating and revising LAN technology. This causes great difficulty in comparing LANs as prices are constantly being lowered. This study concentrated on LAN equipment currently in use.

Review of Literature

A Local Area Network allows the communication between computers over a short distance for the purpose of sharing data, programs, or resources. It is difficult to define the size of a local area. The limits of LAN are set according to the defined workspace and can range anywhere from a few feet up to a five mile radius. "The only thing smaller than a local area network is the bus network contained in a computer."[1]

The factory and engineering environment can benefit from LAN by linking typical group members, such as robots, data collection devices, and programmable controllers. "By facilitating machine-to-machine communication, LANs can weld the different phases of a manufacturing operation into a single, unified process."[2]

The most popular LAN designs were examined under three topics - the topology or logical arrangement of the devices; access method, the way access is gained to the communication channel; and transmission medium, the physical interconnection over which the data actually travels.

Topology

A network is created by the geometric arrangement of the link and the nodes. A link can be a line, channel, or circuit used as a communication path between nodes. A node (user-station) is an end point to any branch of a network or a junction of two or more branches.

There are several factors to be considered when selecting one topology over another. Some topologies fit into an environment better than others do. Another problem involves the cost of each topology. The choice between two topologies should not be based on cost alone. LAN topology has three main configurations: *bus*, *ring*, and *star*.

The *bus network* is the latest to be introduced; its introduction was in the mid-1970s. Now, it has grown to be the most popular and widely used local area topology, even though it is the most basic of all LAN configurations. In a bus network, nodes branch from a central backbone (Fig. 1). "The bus network is based on the theory of interconnections developed in the internal architecture of computer systems, where the transmission medium between devices is a single shared resource."[3] According to Coscarelli[4], the bus topology is the easiest to implement and generally the most reliable.

The bus network allows a linear transmission along a cable to which additional work stations may be added as required. The transmissions are sent in either direction along the wire, permitting the work stations to receive the messages addressed to them.

Reliability and ease of servicing are some of the advantages with the bus topology. A negative aspect of this topology is that the speed of transmission is degraded when the length of the cable is increased.

The *ring network* connects nodes in a series which generally requires all work stations to be operational during applications (Fig. 2). This topology should not be confused with the loop. The loop is a subordinate of ring topology. It has a central intelligence placed in charge of the ring. The ring network eliminates the central intelligence

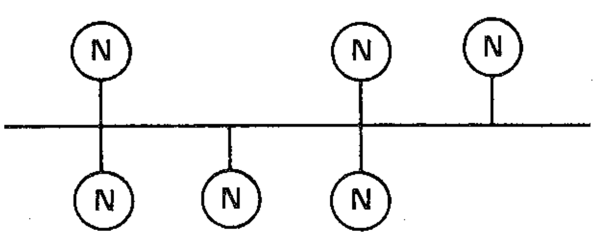

Figure 1: Bus Network

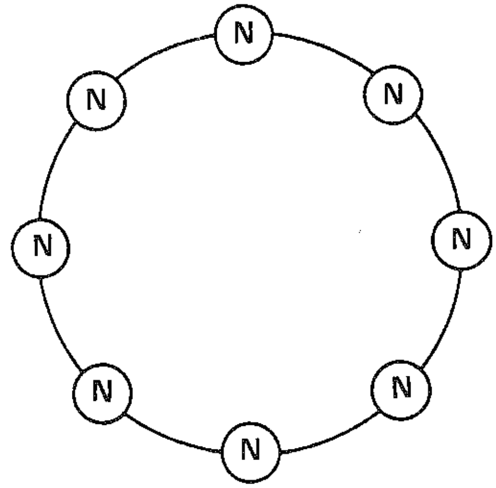

Figure 2: Ring Network

in order to give a certain amount of network freedom.

Data is limited to flow in one direction, thus eliminating routing decisions. Information is passed from one node to the next. The advantage of this is the avoidance of collision. According to Coscarelli, the reliability is high with ring topology; if one work station fails, it typically will not cause the entire network to fail. As with bus networks, the speed of transmission using a ring network will also slow down with the addition of work stations due to the review and retransmission of messages.

The *star network* gets its name by the shape it represents, a star (Fig. 3). A message in a star network is routed to a central computer (central intelligence, cental node, main frame). These messages are then analyzed and retransmitted to the intended work station. "The central station controls communication by deciding when and how the outly-

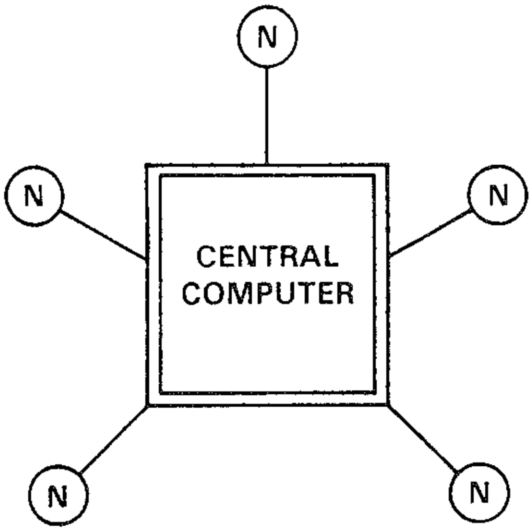

Figure 3: Star Network

ing stations can communicate with each other."[2] Each node must have its own path to the central computer. This causes large amounts of cable to be used. "Active stars require the central controller to be responsible for all network affairs, including messages monitoring, traffic routing, and call forwarding."[1]

Another disadvantage of the star network is that the central node is a single point of network failure. If the central node fails, so does the entire network. Thus the size and capacity of the network is a direct function of the power of the central node.

According to Maira[2], star topology differs from bus and ring topologies by its central control point. The ring and bus topologies provide a distributed control, which allows more direct, reliable, and efficient communication between individual stations. However, the distributed control leads to the problem of competing for access to the network.

Access Method

Access techniques describe the connection of the node to the network medium. The two popular types of LAN access methods are: Carrier Sense Multiple Access with Collision Detector (CSMA/CD), otherwise known as contention; and token passing, also call deterministic.

Contention gives the node access to the medium any time. After listening to the channel, checking for activity, the station transmits its message immediately. If activity is sensed on the channel, then it waits until the channel is free. A problem can occur when two or more stations transmit data simultaneously. When this takes place, a collision will occur. The system senses this and stops sending the message immediately. It retransmits the message after a random period of time.

Deterministic token passing occurs when access is determined by sequential order. This eliminates the possibility of collision by allowing only one message to be transmitted at a time. "The 'token' in a token passing network is a code that is passed continually at high speeds around the network in a precisely defined sequence, called logical ring."[2] The station holding the token can transmit its message and then passes it on to the next station. Token passing can typically be found in both ring and bus networks.

The token pass is more reliable, which gives managers the ability to calculate access time under any type of load. From these calculations, managers can develop a priority level for the network.

Transmission Medium

The physical connection used to link nodes is called the transmission medium. The two basic transmission media for LAN are classified in either *bounded* (basebound) or *unbounded* (broadband).

Bounded media include wires, cables, and optical fibers, and are actually linked to convey a signal from one node to another. Included in the bounded media are: twisted pair, coaxial cable, and optical fiber.

The *twisted pair* media, originally found in the telephone, is essentially two wires twisted together. The wire is inexpensive (approximately $.25 per foot) and is the easiest to install. This wire is highly susceptible to electricity and other outside interference. "Wire emits and absorbs a high amount of electrical interference, resulting in a relatively high error rate and posing a problem where security is important."[4]

The *coaxial cable* is the simpliest media to reduce noise. A metal shroud is wrapped around the cable to block the outside interference. An example of this is the cable used for cable TV. Coaxial cable offers high speed and low cost (from $.35 to $3 per foot). It has a much greater bandwidth than twisted pair, but less than fiber-optics.

Optical fibers, made of hairlike plastic or glass strands, supports ring and star topologies best. Electronic signals are converted to light pulses by a modulator, sent over these plastic or glass fibers, and converted back to electrical signals by photoelectric diodes upon reaching their destination. "Fiber-optic technology has great potential for factor applications because it offers enormous bandwidth -- several optical fibers have the signal carrying capacity of many hundreds of twisted-pair wires."[2]

The different varieties of components of fiber optic systems include:

1. Light Source - Light Emitting Diodes (LED) or Laser Diodes

2. Optical Fibers - Stepped Index, Graded Index, or Single Mode

3. Detectors - Pinsulated N channels (PINs), or Avalanche Photo Diodes (APDs)

Being the newest LAN transmission medium, fiber optics is also the most expensive ($5 per foot and up). The best thing about optical fiber is that it is nearly inpenetrable by outside interference, and it has the greatest accommodation for signals. The disadvantage of fiber optics is the difficulty in tapping and repairing.

Unbounded medias are still in the early stages of development, though there are a few commercially available unbounded networks. The three major types of broadband signals are radio, microwave, and infrared.

When choosing a network medium, several characteristics must be considered, such as the price, including installation costs, expandability for future needs, ease of access, network speed, and maintenance.

Bridges

When a setting is too big for just one network, two or more networks can be linked by a bridge. "The bridge is a communication device that selectively passes data from one network to another."[1] The bridge would most naturally be located at a point where the two subnetworks are physically adjacent. Actually, the bridge connects two interface elements, one on either side of the bridge.

Inside the bridge, there are three important components: an interface, a filter, and a buffer (Fig. 4). The interface is a node-matching device which matches voltage levels and supplies amplification to the signal. In the middle of the bridge lies the filter. It screens messages and decides whether they are allowed to cross. A buffer is a small memory bank that stores the message until it can be transferred.

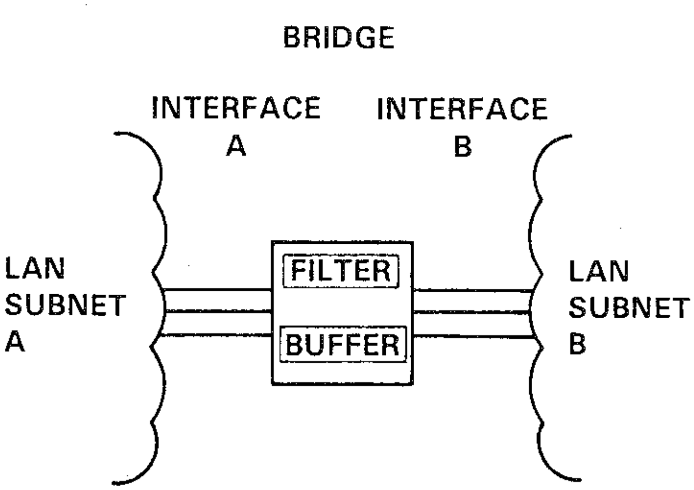

Figure 4: Bridges

Long-Distance Modems

In situations where it is not possible to have two subnetworks physically close enough to be joined by an ordinary bridge, the networks can be linked by a long-distance bridge known as a modem. Long-distance modems have easy accessibility and low cost, which generally leads to the use of leased telephone lines for a long-distance link. Two modulation techniques commonly used for modems are frequency modulation and phase-shift modulation.

Frequency modulation uses digital pulses and encodes it into a frequency. This form of frequency is called Frequency-Shifted Keying (FSK) because the frequencies shift back and forth according to the digital encoding. This takes the form of binary coding, using 1 and 0 as data inputs. With phase-shift modulation, the digital bits are carried by shifting the phase of the sine wave back and forth, thus giving it the name of Phase-Shift Keying (PSK).

Gateways

One of the problems that network users face is the interconnection of dissimilar networks, that is networks with no values in common. "When interconnecting dissimilar networks, one frequently encounters a protocal language barrier. The words spoken by one network are usually quite foreign to the other."[1] This problem is solved with an intelligent device called a gateway. A gateway connects the subnetworks, and translates messages from one language to the other, quite like a translater interpretes one language to another (Fig. 5).

The gateways that exist presently are specially tailored items geared for specific situations. As for the future, gateways are essential for the harsh incompatibility of networks.

Standards

Industrial standards are essential for worldwide use of LAN. Groups, such as the International Standards Organization (ISO), the Institute of Electrical and Electronic Engineers (IEEE), the Initial Graphics Exchange Specification (IGES), and the European Computer Manufacturer's Association (ECMA), will set a prototype for LAN to follow. They will ensure conformity and compatibility of all LANs. "The development of such standards significantly lowers the cost of LAN products due to industry-wide semiconductor implementation and provides the basis for increased compatibility with other vendor's products."[5]

Customers want to be assured of long-term, multiple solution LANs before making a major investment. This can only be accomplished by the implementation of good standards. In 1978, the ISO issued recommendations for greater conformity in design of networks. The recommendation was for a seven-layer model network architecture (Fig. 6) with the following layers:

1. Physical Link Layer - The physical medium for transmission as well as the software driver.

2. Data Link Layer - An error-free communication channel between nodes.

3. Network Control Layer - Sets-

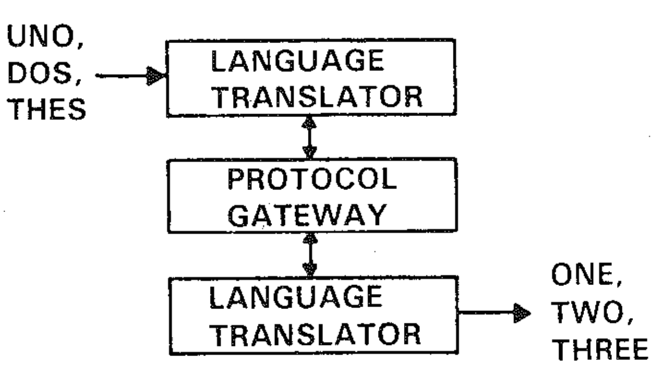

Figure 5: Gateway

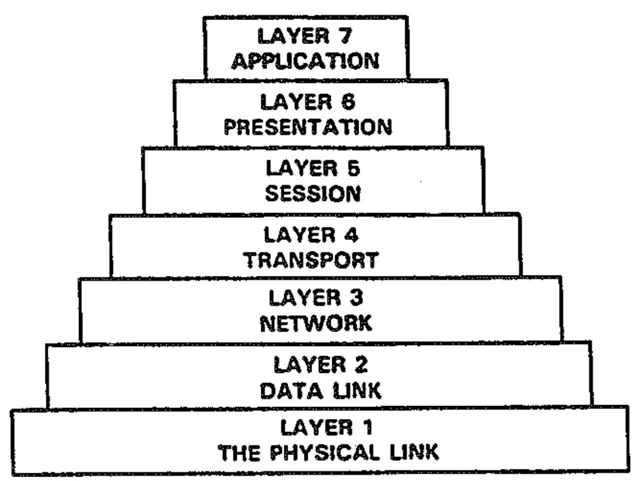

Figure 6: Seven-Layer Model for Open System Interconnection

up, routes, and addresses messages between nodes.

4. Transport Layer - Controls communication session once path is established, independent of which systems are used.

5. Session Control - System-dependent aspect are established and controlled during transmission.

6. Presentation Control - Encodes, translates, and converts transmitted data to usable form.

7. Application/User Layer - Services provided by the network. Examples are data base management and file transfer.

The above are examples of standards and their applications. The more standards implemented, the more conformity the industrial setting will have.

Choosing an Appropriate LAN Technology

The decision on which LAN technology to install is a difficult one. The previous sections gave a basis for selecting a particular LAN technology. This section will present the steps that might be taken in the selection process. Keep in mind that different criteria, along with local conditions, might alter the selection process. Therefore, the selection process might trace the following line of seven questions:

1. Will the communication medium be specified to data alone, or will it also carry voice, video, security or environmental control functions?

2. What is the total trunkline length of the system?

3. Are hetrogeneous connections required?

4. What data rates (speeds) are desirable?

5. Are there any existing network facilities?

6. What are the installation costs?

7. What flexibilities in design are available?

Multi-Use Media

Multi-use media will be required in the future. The emphasis will be toward getting the most for the least. Since it is no different when it comes to LANs; one might be able to "kill two birds with one stone."

"Developemnt of multi-use media can actually work in two directions. First, if a system is being constructed for data, then other systems might 'piggy-back' on the project; second, if a system is being constructed for some other purpose, then it might be possible to modify the design to allow for data communication."[6] The possibility of cost sharing among departments will minimize the funding that might otherwise not exist.

Madron[6] displays a table of media currently adaptable to various technologies (Fig. 7). This table indicates what is technologically convenient to implement

COST PER CONNECTION	BROADBAND LAN	TELEPHONE LAN	HARDWARE SYSTEM	PRIMITIVE
TOTALS	$515,640	$747,840	$506,640	$556,640
TOTAL CONNECTIONS	540	540	540	360
COST PER CONNECTION	$965	$1,365	$938	$1,546

Figure 7: Alternative Network Costs

and is only one possible solution to the problem.

Length of Backbone

The length of the trunkline is another question to consider when choosing a local area network. In any organization, a significantly large portion of the institution is linked for data transmission. If an organization were to occupy several buildings, such as a university campus or corporation, it would not be feasible to purchase a LAN system to cover only half the area. It would be more appropriate to invest in a long distance system that could handle short distances as well. For example, baseband LANs have a distance limitation of only a few thousand feet and originally, Ethernet was specified for about 1.5 kilometers. However, CATV (cable television) extends for many miles, while twisted wire broadband systems travel the world.

Heterogeneous Connections

A network must have the ability to handle a great variety of computers while retaining the high speed and compatibility of data files. Since the establishment of standard IEEE 802.3, network compability has been widely accepted and installed. A huge variety of computers and workstations can be connected to an Ethernet/IEEE 802.3 network. Vendors have implemented high level, industrial standard protocols such as TCP/IP which allows all of the various systems to communicate reliably with one another.

Data Rates

Each LAN system has a specific data rate (speed) at which it works best. Whether the speed is 5 kilobauds per second (kbps) or 5 millibaud per second (mbps), it is the speed at which the system works most efficiently. A problem exists with the mixing of these data rates. Devices operating at different speeds would require some flexibility in the network. In fact, most technologies provide varying rates per second for their support devices. Determining these supported services is the catch. Baseband does not support all these devices and the ones that are supported are usually specialized interfaces. Twisted-pair systems, on the other hand, often require similarity in speeds on both ends of the network for operation. Baseband is the ideal solution. Each end is allowed to work at its optimum speed and the network takes care of the rest.

What is the fastest system? Baseband technologies out-perform other systems due to their bandwidth and dedicated interface devices. For generalized systems (systems that can serve the largest numbers of different devices), broadband is better than twisted-pair. Twisted-pair, also known as telephone-based systems, run at about 1,200 to 4,800 baud while broadband systems run up to 5 mbps. Cost is the deciding factor when it comes to getting the fastest system and should be considered heavily for this part of the selection process.

Existing Network Facilities

When considering a network system, an existing system cannot be overlooked. For example, an existing phone system (twisted pair) may be the least desirable system to specify as a new network installation. However, it may be necessary to consider future expansion that might overload the phone system. It may be more advantageous to install the system that allows for this expansion. Both possibilities should be weighed equally. An existing network may or may not have a significant cost advantage.

Cost of Installation

It is very difficult to obtain an exact cost to install a network system. The only accurate way might be to put out a "request for bid." Analyzing costs in this manner is expensive, time consuming, and will cause delays waiting for responses. A less rigorous procedure that gives a reasonable estimate is to make assumptions about the size of the system (and what is to be accomplished) and then to use reasonable estimates based on costs per connection, cost per mile of trunkline, and similar guidelines. This softer approach to comparative cost analysis is the road that large organizations take most frequently.[6] Most likely, relative costs of one technology when compared to another would be about the same. Prices are constantly changing and relationships will vary also.

Flexibilities in Design

When choosing a network system, flexibilities should be considered. The ability to add workstations or extend backbone lengths should be one of the decision-making criterion.

Network design and topology is often very dynamic. Network user requirements change; additional users may wish to take advantage of the network; users relocate; organizations change. Each of these factors, as well as others, cause the network to grow and change. With this concept in mind, a static system may be detrimental to an organization.

Keep the expandibility option open. This decision criterion should be followed carefully when

Company Name	Topology	Transfer Media	Access Method	Number of Connections	Cable Type	Data Rates	Maximum Node Distance	Gateway	LAN Name
Apollo Computer, Inc.	Bus Physical ring (Addressing)	Baseband	Token passing (statistical polling)	Several Hundred	Coaxial	12 Mbps	1 Kilometer	IBM	Domain Distributed Operating Multi-Access Interactive Network
Apple Computer, Inc.	Bus Physical ring (Addressing)	Baseband	Contention (CSMA/CD)	128	Twisted Pair	1 Mbps	2,000 Feet	Ethernet	AppleNet
Control Data Corporation	Branching Nonrooted Tree	Baseband	Contention (CSMA/CD)	Several Hundred	Coaxial	10 Mbps	1,500 Meters	Ethernet	CDCNET
Digital Equipment Corporation	Bus	Baseband	Contention (CSMA/CD)	1,024	Coaxial	10 Mbps	2.8 Kilometers	Ethernet or DECNET	DEC Ethernet
Harris Corporation	Bus	Baseband	Token passing (statistical polling)	32	Coaxial	1 Mbps	5,000 Feet	SNA	HNET Work GroupLink
IBM	Bus	Baseband	Contention (CSMA/CD)	64	Coaxial	375 Kbps	3,230 Feet	Not Specified	PC LAN
Prime Computer, Inc.	Physical ring (Addressing)	Baseband	Token passing (statistical polling)	247	Twinax	10 Mbps	750 Feet	X.25	RINGNET
Sun Microsystems, Inc.	Token Bus	Baseband	Contention (CSMA/CD)	Not Specified	Coaxial	10 Mbps	Not Specified	Ethernet	SUNLINK X.25
Xerox Corporation	Bus Physical ring (Addressing)	Baseband	Contention (CSMA/CD)	1,024	Coaxial	10 Mbps	1.5 Miles	Ethernet	Ethernet

Table 1 Local Area Networks

selecting a network system. When considering cost alone, it is obvious that there is no clear-cut difference among the competing technologies for a data communications network. All factors that might alter the decision must be considered and the selection should be based on priority alone.

Local Area Network Listing

Table 1 lists local area networks gathered by the researchers from literature supplied by various vendors, T. J. Byers[1], and S. P. M. Bridges[3].

There is no one way to select a LAN system, but hopefully this report has cleared up some of the confusion surrounding the process. A glossary of networking definitions is available from Dr. John G. Nee, Central Michigan University, Mt. Pleasant, MI 48859.

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Invariant Properties of Four-Dimensional Geometric Elements Projected into Three-Dimensional Space

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Properties of four-dimensional geometric elements projected onto three-dimensional space are developed. This lays the foundation for development of a new, simplified method for solution of four-dimensional engineering problems. The new method is based upon the invariant properties of geometric elements in four-dimensional space projected into three-dimensional space. This method simplifies solution of four-dimensional engineering problems by projecting geometric elements in four-dimensional space into three-dimensional space, establishing a Cartesian coordinate system, and then solving the governing equations in the Cartesian system.

Introduction

Higher order space is of increasing interest to scientists and engineers. In this century the theories of special relatively and chaos have reshaped our formulation of physical phenomena. Special relativity[1] introduces time as a fourth dimension and chaos[2] permits complex phenomena to be described in geometrically simple terms by formulating the phenomena in multidimensional phase space.

The most well known group of four-dimensional physical relationships are those that are a part of the special theory of relativity. This theory may be fitted into the framework of classical mechanics if the equations of motion are cast in a four-dimensional system that is comprised of the three spatial dimensions and time. The Lorentz transformation which preserves the speed of light uniformly in all moving systems can be shown to be a rotation in four-dimensional space. The Einstein addition law for parallel velocities and Thomas precession also can be described by classical mechanics in four-dimensional space-time[1]. Scientists and engineers working in high energy physics have observed the above mentioned relativistic phenomena experimentally. Relativistic effects must be considered in the design and operation of particle accelerators.

Engineers deal more often with chaotic systems than systems exhibiting relativistic effects. Chaotic phenomena are characterized by random unpredictable motion. This motion was thought to have no simple explanation until scientists and engineers showed that simple but nonlinear equations could be used to describe this chaotic behavior. These equations, when cast in multidimensional phase space, show motion to be confined to surfaces in phase space. The phase space used to describe these systems often has more than three dimensions. Weather systems, turbulent fluid flow, and ecological balance have all been shown to be at least partially described by chaos[2].

Recently, graphical methods in space with four or more dimensions have become of interest to engineers because contemporary computer graphics systems can rapidly display projections of higher dimensional space. Hence, engineers can visualize models in space of four or more dimensions by displaying projections of the model. For example, by displaying successive rotations of a four-dimensional model about a plane in four-dimensional space, an engineer can visualize the model by observing changes in the projection of the model.

In general, it is difficult to evaluate problems in higher order space by solving the governing equations in the higher order space. To address this problem, the new method that is developed simplifies the solution of four-dimensional problems by the following procedure:

First, the problem is cast in three-dimensional space by projecting the four-dimensional systems into a three-dimensional projection space and by establishing a Cartesian coordinate system in this three-dimensional projection space.

Then, using the invariant properties of four-dimensional geometric elements projected into a three-dimensional space and invariant properties of rotating transformations in four-dimensional space, solutions are obtained to the four-dimensional governing equations in the three-dimensional Cartesian projection space.

The properties and corollaries developed lay the foundation for this new method of solving four-dimensional engineering problems.

Synthetic logic is used to determine invariant properties of geometric elements (points, lines, planes, hyperplanes, spheres, hyperspheres, curves, and surfaces) of four-dimensional space projected into three-dimensional space. The first five properties are those of individual elements. These are followed by five properties of elements in relation to other elements. Next, the properties of the projections of curves and surfaces are covered. Finally, the invariant properties of spheres and hyperspheres are presented.

Invariant Properties of Four-Dimensional Elements in a Three-Dimensional Projection Space

The invariant properties of elements of three-dimensional space form the basis for several procedures in descriptive geometry. For example, establishing that parallel lines in three-dimensional space are parallel in two-dimensional projection space is fundamental to solving graphics problems using descriptive geometry. Many of the invariant properties of elements of three-dimensional space familiar to those versed in descriptive geometry are similar to the invariant properties of elements of four-dimensional space developed in this paper.

Four-Dimensional Point, Line, Plane, and Hyperplane.

Property 1: The projection of a point in four-dimensional space into a three-dimensional projection space is a point.

Sommerville[3] formulates the result of projection of formative elements in explorative space into projection space as follows:

$$r = p + q - n \tag{1}$$

where

r = the number of spatial dimensions of geometric elements that result from projection.

p = dimensions of the projection space.

q = the number of spatial dimensions of the formative element used in projection. The dimension of the formative element, q, is one greater than the dimension of the geometric element unless: 1) the formative element is orthogonal to the projection space, or 2) the geometric element has the same dimension as the explorative space. For these two exceptions, the dimensions of the formative and geometric element are equal.

n = dimensions of the explorative space.

Using Eq. (1), project a point (formative element dimension q = 1) in four-dimensional space (explorative space dimension n = 4) into three-dimensional space (projection space dimension p = 3) to obtain a point (projection result geometric element dimension r = 0). (0 = 3 + 1 - 4) (Note that the geometric point and the formative point are assigned different dimensions.)

The next 4 properties follow from Eq. (1).

Property 2: In four-dimensional space, the projection of a line inclined to a three-dimensional projection space is a line (1 = 3 + 2 - 4). The projection of a line orthogonal to a three-dimensional projection space is a point (0 = 3 + 1 - 4).

Property 3: In four-dimensional space, the projection of a plane inclined to a three-dimensional projection space is a plane (2 = 3 + 3 - 4). The projection of a plane orthogonal to a three-dimensional projection space is a line (1 = 3 + 2 - 4).

Property 4: In four-dimensional space, the projection of a hyperplane inclined to a three-dimensional projection space is a three-dimensional solid (3 = 3 + 4 - 4). The projection of a hyperplane orthogonal to a three-dimensional projection space is a plane (2 = 3 + 3 - 4).

Property 5: The projection of a hypersolid in four-dimensional space into a three-dimensional projection space is a solid (3 = 3 + 4 - 4).

Four-Dimensional Parallelism and Perpendicularity

Property 6: In four-dimensional space, the projections of two parallel planes into a three-dimensional projection space are parallel.

Proof:

∵ plane (ab) // plane (cd)

∴ line a // line c, line b // line d

From Ref. (3) and Property 3,

a_1 // c_1, b_1 // d_1,

∴ $(ab)_1$ // $(cd)_1$

where the subscript refers to the geometric element resulting from projection.

Property 7: In four-dimensional space, when one of two orthogonal lines is parallel to a three-dimensional projection space M, the projections of the two orthogonal lines into M are orthogonal.

Proof:

From Property 3, the projection of plane (ab) is $(ab)_1$. As shown in Fig. 1, planes (ab) and $(ab)_1$ are elements of space T. It is known that line a_1 is perpendicular to line b_1.

From Ref. (3)

c_1 // b_1

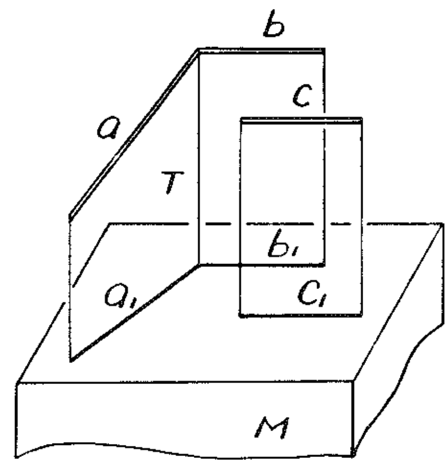

Fig. 1

∴ $c_1 \perp a_1$

Property 8: In four-dimensional space, when a line c is orthogonal to a plane (ab) and plane (ab) is parallel to a three-dimensional projection space M, the projections of this line and plane into M are orthogonal.

Proof:

∵ $c \perp (ab)$

∴ $c \perp a$, $c \perp b$

∵ (ab) // M

∴ a // M, b // M

From Property 7,

$c_1 \perp a_1$, $c_1 \perp b_1$

∴ $c_1 \perp (ab)_1$

Property 9: When one of two half-orthogonal planes in four-dimensional space is parallel to a three-dimensional projection space M, projections of these two half-orthogonal planes are half-orthogonal. (Note that orthogonal and half-orthogonal are equivalent in three-dimensional space.)

Proof:

$$\because (ab) \perp (cd),\ (cd) // M$$

$$\therefore b \perp (cd)$$

From Property 8,

$$b_1 \perp (cd)_1$$

$$\therefore (ab)_1 \perp (cd)_1$$

Property 10: In four-dimensional space, the projections of two absolutely perpendicular planes into a three-dimensional projection space are half-orthogonal.

Proof:

As shown in Fig. 2, OX, OY, OZ, and OU are four linearly independent axes, and three-dimensional space T is established by axes OX, OY, and OZ.

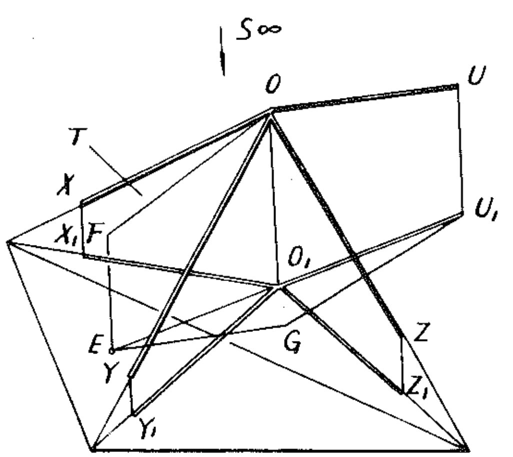

Fig. 2

From Eq. (1),

$$r = 3 + 3 - 4$$

$$= 2$$

Therefore $(XYZ)_1$ is a plane. From Ref. (3), it follows that:

$$OU \perp (XYZ)_1$$

Construct $OO_1 \perp M$. Plane (O_1OU) is not in the projection space M. In four-dimensional space, plane (O_1OU) intersects plane $(XYZ)_1$ in a point E. On plane (O_1OU) passing through point E, construct EF // O_1O and EG // OU. According to Ref. (3),

$$(O_1U) \veebar (XYZ)_1$$

$$\therefore (XY)_1 \perp (OU)_1$$

In Euclidean space supplemented with an infinity element, plane OUZ intersects projection space M in a line $(UZ)_1$, and plane OXY intersects space M in a line $(XY)_1$.

$$\because OXY \veebar OUZ$$

$$\therefore (XY)_1 \perp (UZ)_1,$$
$$(xy)_1 \perp (OUZ)_1$$

$$\therefore (OXY)_1 \perp (OUZ)_1$$

From the above, it follows that:

Corollary 1: In four-dimensional space, when one of two absolutely perpendicular planes is orthogonal to a three-dimensional projection space, the projection is a line orthogonal to a plane.

Corollary 2: In four-dimensional space, when a plane is parallel to one of two absolutely perpendicular planes, the projection of this plane and the projection of one of two absolutely perpendicular planes into a three-dimensional space are half-orthogonal.

Proof:

Let (ab) // (cd)

$\because$ (cd) $\veebar$ (ef)

$\therefore$ $(ab)_1 \perp (ef)_1$

Curves and Surfaces in Four-Dimensional Space

Property 11: The projections of curves in four-dimensional space into a three-dimensional projection space are hyperplane curves.

Proof:

Let L define a curve in a four-dimensional space,

$$F_i(x,y,z,u) = 0 \quad (i=1,2,3) \tag{2}$$

After projecting into a three-dimensional space OXYZ,

$$G_i(x,y,z) = 0$$
$$u = 0 \qquad (i=1,2) \tag{3}$$

Thus, G_1 is a hyperplane curve on OXYZ space.

Property 12: The projection into three-dimensional space of points on four-dimensional curves fall on the projection of hyperplane curves.

Proof:

Points P(x,y,z,u) satisfying Eq. (2) also satisfy Eq. (3).

Property 13: The projections into three-dimensional space of secants of four-dimensional curves are the secants of hyperplane curves.

Proof:

Construction of a secant (AB) on four-dimensional curve L produces two points A and B. From Property 12, points $A_1$and B_1 must lie on hyperplane curve L_1. Therefore, $(AB)_1$ is the secant of L_1.

Property 14: In four-dimensional space, the projections of the tangent line and the tangent point of four-dimensional curves into a three-dimensional projection space are the tangent line and tangent point of hyperplane curves.

Proof:

Let a curve F in four-dimensional space be defined by:

$$x = f_1(t),$$
$$y = f_2(t),$$
$$z = f_3(t),$$
$$u = f_4(t) \tag{4}$$

The tangent line of a four-dimensional curve at point P(x,y,z,u) is:

$$x-f_1(tp)/f_1(tp)$$
$$= y-f_2(tp)/f_2(tp)$$
$$= z-f_3(tp)/f_3(tp)$$
$$= u-f_4(tp)/f_4(tp) \tag{5}$$

If $u = 0$, to all appearances, Eq. (4) represents a hyperplane-curve, Eq. (5) represents a tangent line of hyperplane-curve on projection space OXYZ and point $p(x,y,z)$ is a tangent point.

Property 15: The projections of hyperplane surfaces in four-dimensional space into a three-dimensional projection space are three-dimensional hyperplane surfaces, and the degrees and types are invariant.

Proof:

Let hyperplane surfaces in four-dimensional space be given by:

$$F(x,y,z,u) = 0 \tag{6}$$

$$\begin{gathered} Ax + By + Cz + Du + E = 0 \\ (A + B + C + D = 0) \end{gathered} \tag{7}$$

When $u = 0$, substituting Eq. (7) into Eq. (6) gives a three-dimensional hyperplane surface on projection space OXYZ. The degrees and types of new equations are invariant because Eq. (7) is a linear equation.

Corollary: From Property 4, in four-dimensional space, if a hyperplane surface S orthogonal to a three-dimensional projection space M is projected into M, the projection of surface S is a plane. Boundary curves of a surface S are contour curves of the projection space M.

Proof:

Eqs. (6) and (7) represent a four-dimensional hypersurface that can be transformed to give surface S.

$$\begin{gathered} F(x',y',z',u') = 0 \\ u' = h \end{gathered} \tag{8}$$

The projection of surface S is a real image on space O'X'Y'Z'.

$$F(x',y',z',u') = 0$$

$$u' = 0$$

Orthogonal projection into space O'X'Y'Z' yields the contour curve:

$$F(x',y',h) = 0$$

$$z' = 0$$

Property 16: In four-dimensional space, 1) chords of a two-dimensional surface and the intersection points of chords and a two-dimensional surface, and 2) tangent lines and the tangent point of a two-dimensional surface, are invariant after projection into a three-dimensional space.

Proof:

As shown in Fig. 3, chord AB intersects surface S in intersecting points A and B. Construct a curve L on surface S through points A and B. If follows from Properties 13 and 15 that chord AB on curve L projected into a three-dimensional projection space is chord $(AB)_1$ on curve L_1. Therefore, chord $(AB)_1$ is on surface S_1 because curve L_1 is on surface S_1.

Next, construct a tangent line m and normal line n through point

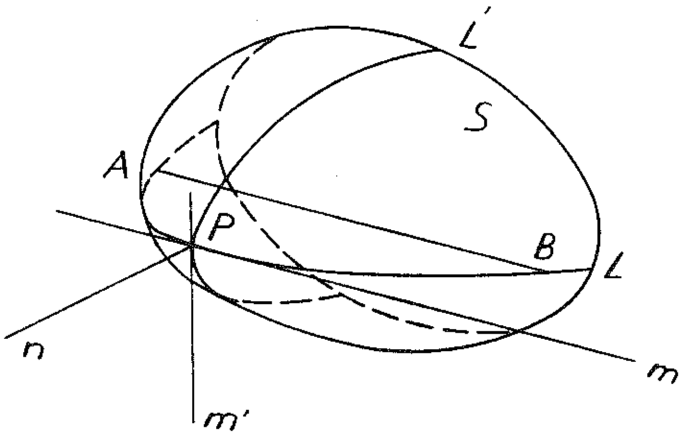

Fig. 3

P on surface S. Plane (mn) intersects surface S in plane-curve L and tangent line m tangent to curve L on tangent point P. According to Property 14, the projection m_1 of tangent line m is tangent to the projection L_1 of curve L on projection P_1 of tangent point P. The projection m_1 of tangent line m is tangent to the projection S_1 of surface S on projection P_1 of tangent point P, because curve L_1 is on the surface S_1.

Property 17: Tangent planes of two-dimensional surfaces in four-dimensional space projected into three-dimensional space are invariant.

Proof:

As shown in Fig. 3, construct tangent plane (mm') through point P and normal line n on surface S. Next, through normal line n construct two planes (mn) and (m'n). Plane (mn) intersects surface S in plane-curve L, and plane (m'n) intersects surface S in plane-curve L'. From Property 14, m_1 is tangent to L_1 and m_1 is tangent to L_1 on point P_1. Therefore, plane $(mm')_1$ is the tangent plane of surface S_1 on tangent point P_1.

Four-Dimensional Sphere and Hypersphere

Property 18: The projections into three-dimensional space of two mutually orthogonal circle planes in four-dimensional space on a sphere through its center are two conjugate diametral planes of an ellipsoid.

Proof:

As shown in Fig. 4, let two mutually orthogonal circle planes through the sphere center be ABCD and CDEF. Ellipse $(ABCD)_1$ and $(CDEF)_1$ are the projections of circle planes ABCD and CDEF into a three-dimensional space. Construct circle plane 1234 parallel to circle plane ABCD. Circle plane 1234 intersects circle plane CDEF in points 1 and 2. Chord 12 is parallel to chord CD and intersects diameter EF in point N. As a result: 1N = N2

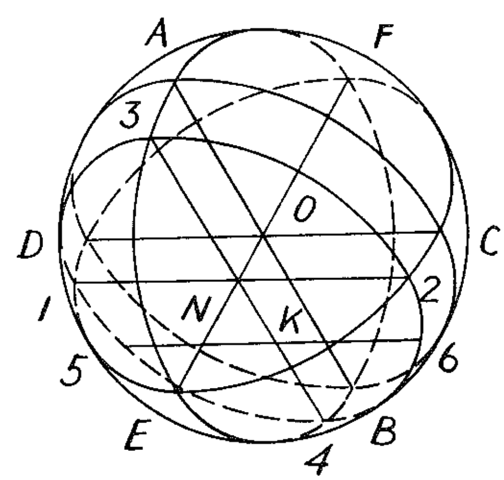

Fig. 4

and projection $(1N)_1 = (N2)_1$; and chord CO = OD and projection $(CO)_1 = (OD)_1$. Next, construct chord 56 parallel to chord 12 on circle plane 1234. Taking K as the midpoint of chord 56 makes 5K = K6 and $(5K)_1 = (K6)_1$.

Analogously, midpoints of other chords parallel to chord CD are in a plane that is established by the midpoints O, N, and K of chords CD, 12, and 56. The projection of midpoints of other chords parallel to the projection $(CD)_1$ of chord CD lie in a plane that is established by projection O_1, N_1, and K_1 of midpoints O, N, and K of chords CD, 12, and 56. According to Ref. 6, the ellipse plane $(ABCD)_1$ is a diametral plane with chord $(CD)_1$ as a conjugate direction. Similarly, it can be proved that ellipse plane $(CDEF)_1$ is a diametral plane with chord $(AB)_1$ as a conjugate direction.

Corollary: When one of two circle planes is parallel to the projection space, according to Property 9, the projections into three-dimensional space of two mutually orthogonal circle planes are two main planes of the ellipsoid.

Property 19: The projection into three-dimensional space of a hypersphere in four-dimensional space is a solid sphere.

Proof:

Let the equation of the hypersphere be:

$$(y-b)^2+(z-c)^2+(u-d)^2-r^2 = 0 \tag{9}$$

Projecting this hypersphere into projection space OXYZ gives:

$$(x-a)^2+(y-b)^2+(z-c)^2 = r^2-d^2$$

$$u = 0 \tag{10}$$

When d is equal to any value less than r:

$$d^2 \geq 0$$

$$r^2-d^2 \leq r^2$$

So, points satisfied with Eq. (10) are satisfied with Eq. (9).

Corollary: The projection into three-dimensional space of a hyperellipsoid in four-dimensional space is a solid ellipsoid.

Symbols

- ∵ Given
- ∴ Therefore
- // Parallel
- ⊥ Perpendicular
- ⊻ Absolutely perpendicular

Definitions

1. Absolutely Perpendicular[5]: Two lines perpendicular to a plane at a point determine a second plane. The planes are related such that every line of one plane passing through the point is perpendicular to every line of the other plane also passing through the point. If this point is the only one common to both planes (that is, their intersection), they are absolutely perpendicular.

2. Half-orthogonal: Two planes that are orthogonal in three-dimensional space are called half-

orthogonal in four-dimensional space.

3. Hyperplane: A linear geometric element of dimension = 3. Hyperplanes are elements of space of four or more dimensions. Hyperplanes are given by the subspace of points satisfying the following linear equation:

$$(x-a)+(y-b)+(z-c)+(u-d) = 0$$

Hyperplanes are also given by a set of four linear parametric equations that represent x, y, z, and u as functions of the parametric coordinates s, t, and v.

$$x(s,t,v)=C11+C12\cdot s+C13\cdot t+C14\cdot v$$
$$y(s,t,v)=C21+C22\cdot s+C23\cdot t+C24\cdot v$$
$$z(s,t,v)=C31+C32\cdot s+C33\cdot t+C34\cdot v$$
$$u(s,t,v)=C41+C42\cdot s+C43\cdot t+C44\cdot v$$

4. Hyperplane curve: A curve that lies in a hyperplane. A curve where the parametric coordinates of the hyperplane (s, t, and v) are given as functions of parametric distance along the curve (r) will lie in the hyperplane.

$$s = s(r)$$
$$t = t(r)$$
$$v = v(r)$$

5. Hyperplane surface: A surface that lies in a hyperplane. A surface where the parametric coordinates of the hyperplane (s, t, and v) are given as a function of the parametric coordinates of the hyperplane surface (g,h) will lie in the hyperplane.

$$s = s(g,h)$$
$$t = t(g,h)$$
$$v = v(g,h)$$

6. Hypersolid: Regions in four-dimensional space.

7. Hypersphere: A geometric element of dimension = 3 described by:

$$(x-a)^2 + (y-b)^2 + (z-c)^2 + (u-d)^2 - r^2 = 0$$

where a, b, c, and d are the coordinates of the hypersphere center and r is the radius. Hyperspheres are elements of space of four or more dimensions.

8. Line: A linear geometric element of dimension = 1. Lines are elements of space of two or more dimensions. Lines are defined mathematically by the locus of points satisfying the equation:

$$(x-a) + (y-b) = 0$$

Lines are also described by linear parametric equations for the spatial coordinates x and y as a function of the parameter s = distance along the line.

$$x(s) = C11 + C12 \cdot s$$
$$y(s) = C21 + C22 \cdot s$$

9. Plane: A linear geometric element of dimension = 2. Planes are elements of space of three or more dimensions. The following linear equation represents a plane in three dimensional space.

$$(x-a) + (y-b) + (z-c) = 0$$

A plane is also given by linear parametric equations that represent x, y, and z as functions of the parametric coordinates s and t.

$$x(s,t) = C11 + C12 \cdot s + C13 \cdot t$$
$$y(s,t) = C21 + C22 \cdot s + C23 \cdot t$$
$$z(s,t) = C31 + C32 \cdot s + C33 \cdot t$$

10. Point: A geometric element of dimension = 0. Points are elements of space of one or more dimensions.

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[3]Sommerville, D. M. Y., *An Introduction of the Geometry of N Dimensions*, Dover, New York, NY, 1958.

[4]Manning, H. P., *Geometry of Four Dimensions*, Dover, New York, NY, 1956.

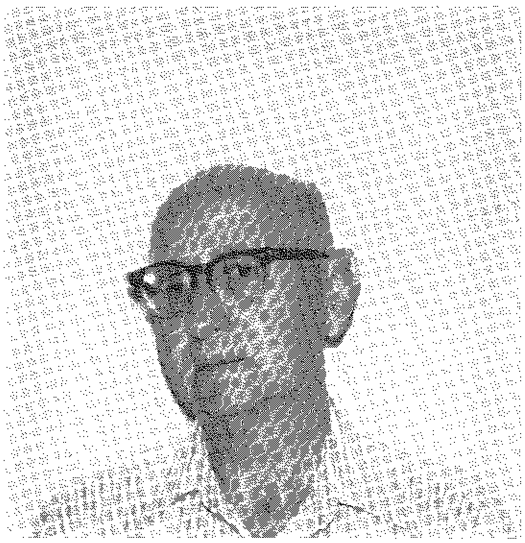
[5]Lindgren, C. E. S. and Slaby, S. M., *Four Dimensional Descriptive Geometry*, McGraw-Hill, New York, NY, 1968.

[6]Zhu, D., *Analytic Geometry*, Science-Tech, Shanghai, China, 1981.

A Remembrance

Irwin Wladaver

1905 - 1988



Irwin Wladaver, a member of ASEE and this Division since 1943, passed from this life on the 20th of June 1988 at his residence in Miami Beach, Florida. 1988 was his 83rd year of life and his 60th year of marriage. He is survived by his beloved wife, Sadelle, one son, one daughter, and four grandchildren. Or, as Vlad might have written it: An old New York City carpet salesman has liquidated his inventory and moved to a better location. Let this be a remembrance for those of us who knew him well ... enlightenment for our members who knew him only by reputation or not at all.

After graduation from college in 1926, Vlad worked for 16 years as a carpet salesman. He entered the field of engineering education in 1942, teaching an intensive course in engineering fundamentals for the government's Defense Training Institute in Brooklyn, New York. For two years, he was an instructor in engineering drawing at Franklin and Marshall College in Lancaster, Pennsylvania. In 1945, he returned to New York City as an instructor in engineering graphics at New York University's School of Engineering and Science on the Washington Heights Campus in the Bronx. He taught engineering graphics, descriptive geometry ... and calculus. Vlad remained at NYU until his retirement as Associate Professor Emeritus in 1972. At the time of his retirement, he was Assistant Dean in charge of the Evening Division of the School of Engineering and Science. He was the author or coauthor of numerous texts and problem books.

Vlad's first "public appearance" on the ASEE's national agenda was the presentation of a paper at the 1951 Summer School of the Division of Engineering Graphics at Michigan State University. His interest in and service to the Division never ceased. He edited the Journal from 1955 - 58, was vice-chairman from 1959 - 1960, and was chairman from 1960 - 1961. Vlad was presented the Division's Distinguished Service Award in 1974. The accomplishment in which he took the most pride was the completion of a comprehensive index of all issues of the Journal from 1936 through 1978.

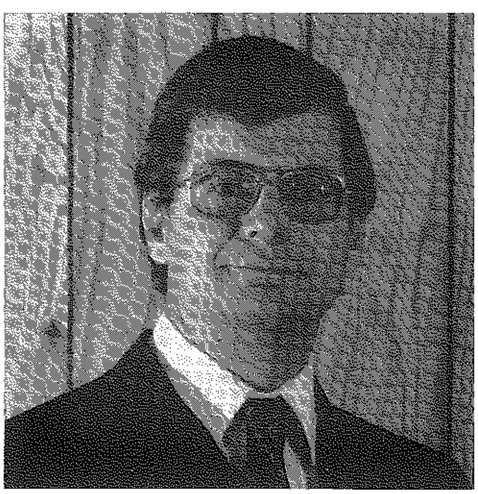
Vlad held no engineering degree; his undergraduate study was in the classics, his graduate work in education. His B.A. degree was from City College of New York, his masters and Ph.D. degrees from New York University. He was a scholar in the truest sense of the word, literate in several languages, a musician, philosopher, student and teacher. Vlad was eager to listen and learn; he freely taught, sharing his wealth of knowledge and joy of life with all comers. An evening of conversation with Irwin Wladaver was equivalent to a three-semester-hour course in the humanities at any university in the country.

Vlad, your many friends, all of whom were your students, will greatly miss you ... And, whether you are raising hell with the imps of Satan for a view out of projection or confounding a class of heavenly cherubs with a unique solution to a problem in descriptive geometry, we know that both you and your students are greatly enjoying the experience. Whatever the fourth dimension location of your carpet shop, that place is a better place because you are there. Shalom.

W^{m}BR

Chairman's Message

by
Merwin Weed



At this writing, I have just returned from the Division's Mid-year Conference at New Harmony, Indiana, hosted by the University of Southern Indiana. For those of you who were there, you do not need me to tell you how good this conference was. For those of you who could not be with us, please know that you were missed.

I want to express my thanks to Larry Goss, Facility Chairman, and Linda Bode, Program Chairman, for the fine job they did to make this conference such a success. I also want to thank the officers for their dedication and service to the Division. Without their support, the Chairman's job would be an impossible task.

The next meeting of the Division will be at the National ASEE Conference to be held in Lincoln, Nebraska in June. We will have several sessions during this conference, so please plan to attend. Next year, the Mid-year Conference will be hosted by the University of Alabama and is scheduled for early November. Looking even further ahead, there are two international conferences on the horizon sponsored by this Division. The Fourth International Conference on Engineering Graphics and Descriptive Geometry will be hosted by the Florida International University. The proposed date for this conference is June 11 - 15, 1990. The Fifth International Conference is to be hosted by the Royal Melbourne Institute of Technology. This school is in Australia and the proposed date is August 17 - 21, 1992. Now that's planning ahead, but time does fly when you are having fun!

EDGD Executive Committee

For your ease in contacting the members of the Executive Committee of the EDGD, the following list is supplied.

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Past Chairman

Ron Barr
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Calendar of Events

by
Josann Duane

1989 Annual ASEE Conference
June 25-29, 1989
Lincoln, NB

1989-90 EDGD Mid-year Conf.
November 5-7, 1989
Tuscaloosa, AL

1990 Annual ASEE Conference
Toronto, Canada

1990 4th International Conference on Engineering Graphics and Descriptive Geometry
June 11-15, 1990
Miami, FL

1990-91 EDGD Mid-year Conf.
Tempe, AZ

1991 Annual ASEE Conference
New Orleans, LA

1991-92 EDGD Mid-year Conf.
Norfolk, VA (tentative)

1992 Annual ASEE Conference
Toledo, OH

1992 5th International Conference on Engineering Graphics and Descriptive Geometry
August 17-21, 1992
Melbourne, Australia

1992-93 EDGD Mid-year Conf.
San Francisco, CA (tentative)

International Computer Graphics Calendar

by

Vera Anand

April 30 - May 4, 1989

CHI '89 - Conference on Human Factors in Computing Systems
Austin, TX

June 19 - 23, 1989

Graphics Interface '89 - 15th Canadian conference devoted to computer graphics and interactive techniques
London, Ontario, Canada

June 27 - 30, 1989

Computer Graphics International '89 - 7th conference of the Computer Graphics Society
Leeds, United Kingdom

July 18 - 20, 1989

3rd International Conference on Image Processing and its Applications
Coventry, United Kingdom

July 23 - 26, 1989

UPCAEDM '89 - 7th Annual Conference on University Programs in CAE/CAD/CAM
Laramie, WY

July 31 - Aug 4, 1989

SIGGRAPH '89 - 16th Annual Conference on Computer Graphics and Interactive Techniques
Boston, MA

Sep 4 - 8, 1989

Eurographics '89
Hamburg, West Germany

Sep 12 - 15, 1989

Engineering Education '89 - 18th International Symposium on Engineering Education
Munich, West Germany

Sep 18 - 22, 1989

HCI International '89 - 3rd International Conference on Human-Computer Interaction
Boston, MA

Oct 23-27, 1989

Second International Conference on Computer-Aided Drafting, Design, and Manufacturing Technology
Hangzhou, China

For further information, contact Vera Anand, 302 Lowrey Hall, Clemson Univ., Clemson, SC, (803)-656-5755.

1989 ASEE Annual Conference

by
Moustafa R. Moustafa
(Program Chairman)

Now is the time to begin planning for the 1989 Annual ASEE Conference to be held in Lincoln, NB from June 25 - 29. The EDGD is cosponsoring one of the six miniplenary sessions with the Design in Engineering Education Division. The EDGD is also cosponsoring several other sessions, as indicated in the partial listing which follows:

Theoretical and computational graphics research. Cosponsors solicited: Mathematics and Architectural Engineering Divisions

Graphics in capstone design courses. Cosponsors solicited: Design in Engineering Education and Architectural Engineering Divisions.

A complete listing of sessions of interest to EDGD members will be included in the Spring issue of the EDG Journal.

Accommodations:

Downtown area hotels	$65
Airport motels	40
University dormitories	20

Transportation:
The Lincoln airport is small. It is served by TWA, United, Northwest, and American (commuter). Omaha's airport is larger and arrangements are being made to transfer members from and to Omaha and the University of Nebraska campus (about one hour's drive). A limited number of flights serve Lincoln, but negotiations will take place between ASEE headquarters and airlines serving Lincoln to request more flights and/or larger aircraft during the conference.

The 3rd International Conference on Engineering Graphics and Descriptive Geometry

by
Klaus Kroner

This year's (1988) most important event in engineering graphics education took place at the Technical University of Vienna, Austria from July 11 - 16. The Third International Conference on Engineering Graphics and Descriptive Geometry convened on the morning of July 11 with 145 professionals and many spouses in attendance. This writer was a privileged observer of the proceedings at this conference, witnessing the exchange of ideas, participating in the ancillary social events, and enjoying and savoring the famed Viennese ambiance. It is hoped that what follows will give those readers who could not attend a feeling of the conference atmosphere and an overview of the professional sessions.

Vienna and the Technical University

Just the mention of the city's name instills nostalgic, even romantic, feelings in one's imagination, and there is a notion that few places can surpass Vienna in the richness of its history and in its unique role in present-day international politics. The host institution was founded in 1815, receiving university status in 1872, and played an important role in the engineering education and technical achievements in Austria and surrounding countries during the imperial and republican periods alike. It is under the control of the Federal Ministry of Science and Research. The University's stately buildings command an impressive presence in the Karlsplatz area, a short distance from the famed Opera House. The newest building in the University complex was the site for this conference. Its lecture halls are exceptionally well designed and equipped and have excellent acoustics.

Add to this physical backdrop a group of colleagues on the local scene who were dedicated to having a first-class conference, and the result was just that. The superb organization and management by the Technical University of the entire event was due to the hard work and attention of Professors Hellmuth Stachel and Steve Slaby and the members of their organizing committees.

The Professional Program

Welcoming addresses were given during the Opening Ceremony by Professors Stachel and Slaby, as well as by Dean Karl-Heinz Wolff of the Technical University. The conference was officially opened by Dr. Hans Tuppy, Minister of Science and Research of Austria.

A highlight of this particular event was the presentation to the conference of a poem entitled "Wish" by Prof. Zhao Qinghuan from Beijing, China. The object of the poem was to wish for a "grand" conference and, more importantly, for world peace. It was read in both Chinese and English (the official language of the conference) and a beautifully executed scroll was given to the host institution. The various parts of the Opening Ceremony were punctuated by short musical offerings of a student instrumental group. This was, after all, the city of music!

The Plenary Session followed at which invited lecturers set the tone for the professional program. Prof. M. C. Queiroz de Andrade (Brazil) spoke about the "Past, Present, and Future of Design in Brazil" and augmented his presentation with a lively thematic movie especially created for this occasion. Prof. K. Suzuki (Japan) gave an overview of the status of computer graphics education in his country based on a recent survey. The third presentation was by Prof. S. Slaby (USA) in which he offered and explained his own definitions of the terms "geometry" and "visualization", as well as urging scientists to incorporate geometric visualization into their work.

The nearly 100 presentations which followed over the next several days were grouped around three main themes: 1) Theoretical Graphics and Applied Geometry, 2) Engineering Computer Graphics, and 3) Education in Engineering Graphics. Many of the papers provoked lively debates expressing varying points of view from different areas of the globe. For example, the issue of a standard labeling convention for descriptive geometry problems was touched upon, although no consensus was reached. The exchange of ideas and learning about other ways of teaching were, of course, two major ojectives of the conference organizers. The presentations themselves were collectively published in the 2-volume Proceedings and were issued to the participants at the time of registration. A limited number of copies was available for purchase from Prof. Steve M. Slaby, Civil Engineering Department, Engineering Quad., Princeton University, Princeton, NJ 08544 (cost - $75).

One observation of this writer is that our colleagues from abroad are far more adept at addressing their presentations to an international audience. One must not assume that teachers on other continents can operate in an educational environment which is at all similar to ours. Financial and technical resources differ greatly and for different reasons. Local customs as to what is tactful on the professional level should also be respected. If in doubt, a more formal approach is always the correct avenue to take. Needless to say, one must be sensitive to the needs and expectations of other people.

Some statistics of the conference are shown in Table 1. It is an indication of the diligent work of the organizing committees, their effective publicity effort, and their development of a first-class program that teachers from 22 countries participated in the meeting.

A special exhibit had been set up with the cooperation of the University's library in which books and journals, both new and old, were put on display. Of particular interest was a copy of the original treatise on descriptive geometry by Monge.

The Closing Ceremony was chaired by Prof. Slaby. Out of respect for the hosts, the customary resolution was presented at this occasion in German, and then in English.

Social Events and Tours

The hosts also had seen to it that the guests' need for diversion from the professional program were taken care of and that the spouses had an enjoyable stay as well. An unexpected event was an invitation by the mayor of Vienna to a reception and dinner-dance at the City Hall on Monday night. Thus, everyone was wined and dined in two large palace-like ballrooms complete with giant crystal chandeliers, tapestries, and banners. An orchestra played the traditional waltzes as well as Broadway tunes beckoning all to the dancefloor.

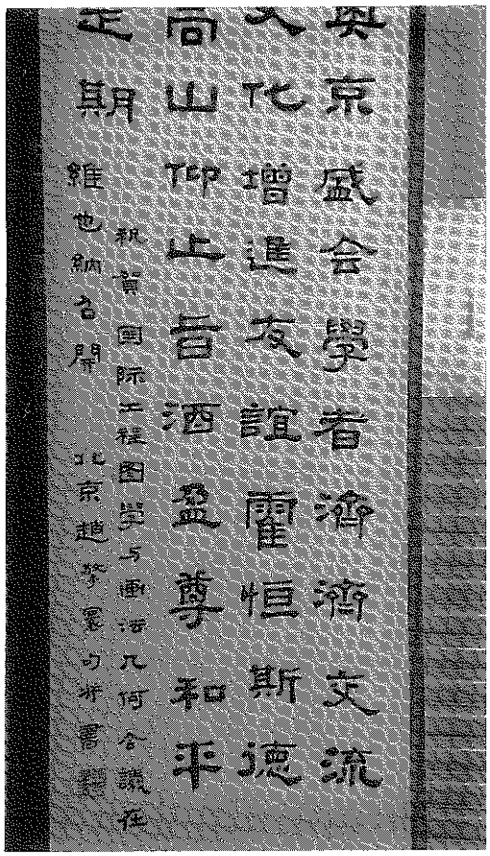
On one of the afternoons, the

Country	Professionals	Spouses	Paper Topic Area		
			1	2	3
Australia	1		1		
Austria	23	11	6	3	
Brazil	4	1	2		
Bulgaria	2		1		
Canada	3	3	1		1
China	5	1	2	2	
Czechoslovakia	3		2	1	
East Germany	1			1	
Egypt	1		1		
France	1	1		1	
Hungary	10	3	3		1
Israel	1	1	1	1	
Italy	3		1		
Japan	21	10	3	8	4
Poland	4		2		
Portugal	1			1	
Sweden	2			1	
U.S.A.	35	23	8	9	17
U.S.S.R.	1				
West Germany	10	2		2	1
Yugoslavia	12		2	2	2
Zimbabwe	1				
Totals	145	56	36	32	26

Table 1 - Conference Participation
(Data from official program and list of participants)

wives of the participants were invited to the home of Prof. and Mrs. Stachel for a typical Austrian "Kaffeeklatsch". Several sightseeing tours had been arranged with the help of a very efficient travel agency, some within the city, as well as excursions to areas outside Vienna. A boat trip on the Danube while dining on "Wiener Schnitzel" and Austrian wine was especially memorable. Visits to several grand palaces and magnificent cathedrals were, of course, included on these trips. Thursday evening we were all treated to one of Vienna's tourist attractions - a Heuringen wine-tasting in Grinzing which was accompanied by appropriate music and a splendid variety of specialities. A grand time was had by all!

The hosts also arranged for the Austrian postal service to design a special cancellation stamp, bearing the conference logo, which was used during the meeting at a temporary post office located in the building.



Poem by Prof. Zhao Qinghuan Entitled "Wish"

Conclusion

This conference should be remembered in the annals of engineering graphics education as an important milestone in furthering international understanding of the ways in which the subject can be taught, sharing information on recent research, and encouraging the scientific community to avail itself of the attributes of descriptive geometry in its work.

The success of this conference in Vienna has already led to the planning of the next meeting. During the Closing Ceremony, it was announced that the 4th International Conference would be held in the summer of 1990 on the campus of Florida International University in Miami.

Call for Papers

1989-90 Mid-year Conference - Engineering Design Graphics Division of ASEE

Hosted by:

University of Alabama
Tuscaloosa, Alabama
November 5, 6, and 7, 1989

Theme "After CAD - What?"

Topics to include:

A. Geometric Modeling
B. Visual Perception
C. Geometric Dimensioning and Tolerancing
D. Interaction Between CAD and CAM
E. The Engineering Graphics Curriculum of the Future

Deadlines:

Abstracts Due: July 1, 1989
Final Papers Due: Sep 1, 1989

Facilities Chairman:

Jim Weiss
University of Alabama
P. O. Box 1917
Tuscaloosa, AL
Office phone: (205) 348-1713
Home phone (205) 758-8655

Program Chairman:

Bruce Rogers
Dept. of Industrial Technology
Univ. of Northern Iowa
Cedar Falls, IA 50614
Office phone (319) 272-2537
Home phone (319) 277-1839

Conference Proceedings

1988-89 Mid-year Conference

Proceedings from the 1989-89 Mid-year Conference of the Engineering Design Graphics Division of the American Society for Engineering Education are available at $15.00 per copy, postage paid. Make your check or purchase order to: USI, and reference account number 4-45949. Address your request to:

Larry D. Goss
Univ. of Southern Indiana
8600 University Blvd.
Evansville, IN 47712

The proceedings publication contains 180 pages and has both a table of contents and an index.

Third International Conference on Engineering Graphics and Descriptive Geometry

A limited number of copies of the two-volume set of the *Proceedings of the Third International Conference on Engineering Graphics and Descriptive Geometry*, held in Vienna, Austria July 11 - 16, 1988, are available.

The price is $75.00, which includes shipping. Orders are being taken by:

Prof. Steve M. Slaby
Civil Engineering Department
Engineering Quad
Princeton University
Princeton, NJ 08544

Telephone: 609-452-4654
fax: 609-987-6744

When ordering, include your name, title, complete mailing address, and telephone number.

Engineering Graphics

J. B. Speed Scientific School of the University of Louisville

The J. B. Speed Scientific School of the University of Louisville is seeking qualified applicants for a tenure-track position in Engineering Graphics at the assistant professor level. The appointment is for twelve months. Duties will include teaching Engineering and Engineering Technology students introductory courses in engineering graphics, including computer-aided graphics. Required qualifications include a Master's degree in engineering or a related field and teaching and/or industrial experience in engineering graphics. Preferred qualifications include experience in computer-aided drafting, design, and manufacturing and evidence of ability to develop in a CAD environment. The ability to develop courses in computer-aided graphics and design for Engineering and Engineering Technology programs is desired.

The J. B. Speed Scientific School is the School of Engineering and Applied Science of the University of Louisville. The school's principal program emphasis is on the Master of Engineering as the first professional degree in six programs. A baccalaureate degree program is offered in Information Science and Data Processing. Associate degree programs are offered in Electrical and in Mechanical Engineering Technology. The Graduate School offers Ph.D. programs in Chemical Engineering, Industrial Engineering, and Computer Science & Engineering and M.S. programs in selected fields of engineering. Approximately 2,300 students are currently enrolled in all programs.

Send vita (including statement of education, experience, honors, awards, and publications) and names, addresses, and phone numbers of three (3) references to Donald L. Cole, Assistant Dean, J. B. Speed Scientific School, University of Louisville, Louisville, KY 40292. Applications will be accepted until the position is filled. Immigration status of foreign nationals should be stated in the resume.

The University of Louisville is an affirmative action/equal opportunity employer.

Industrial Technology Faculty

Department of Industrial Technology
Ohio University

POSITION: Full-time, academic year, tenure track faculty in the Department of Industrial Technology beginning September, 1989.

DUTIES AND RESPONSIBILITIES: Teach undergraduate courses in engineering drawing and documentation; also teach courses in one or more of the following areas: quality control, geometric dimensioning and tolerancing, metrology and/or product design. Advise undergraduate students. Participate in departmental course and curriculum development. Develop and maintain industrial contacts. Participate in departmental, college, and university committees, as well as in professional associations. Promote the department, college, and university through writing, research, or other scholarly activities.

MINIMUM QUALIFICATIONS: Master's degree in appropriate field; doctorate is preferred. Appropriate industrial and/or teaching experience.

ACADEMIC RANK AND SALARY: Commensurate with education and experience.

CLOSING DATE: The position is open until filled. Applications received after March 31, 1989 cannot be assured of consideration.

APPLICATION PROCEDURES: Persons interested in applying for this position should send a letter of application, resume, and listing of three references to:

Dr. James F. Fales, Chairman
Department of Industrial Technology
College of Engineering and Technology
116 Stocker Center
Ohio University
Athens, OH 45701-2979

Telephone: (614) 593-1455

Ohio University is an Equal Opportunity/Affirmative Action Employer.

POSITION VACANCY

GRAPHIC COMMUNICATIONS

NORTH CAROLINA STATE UNIVERSITY

ENGINEERING GRAPHICS/CAD: The Graphic Communications Program at North Carolina State University invites applications for a position as Lecturer with employment to begin in August of 1989. The successful applicant should have aquired at least a Master's degree in engineering, technology or related field, should be abreast and competent in 2D and 3D computer graphic systems and software as well as demonstrated competencies in engineering/technical graphics, and should be able to develop/revise instruction, specify equipment, software and instructional needs, and manage computer graphic classrooms and laboratories. Teaching experience in other areas encompassed by engineering/technical graphics would be highly desirable. Industrial experience and activity in professional organizations would be advantageous. The Graphic Communications Program at NCSU currently provides nine service and/or elective courses in engineering graphics, technical graphics, descriptive geometry, furniture graphics and computer graphics including 2D and advanced 3D courses. The program also offers a 15 hour Minor in Graphic Communications. Approximately 900 to 1000 students are served each semester by 9 full-time faculty and 5 part-time faculty. Review of applications will bigin February 10, 1989 and will continue until the position has been filled Applicants should send cover application letter, current resume, transcripts, current placement papers and three current references to:

Garland Hilliard, Chairman of Search
Graphic Communications
North Carolina State University
Box 7801
Raleigh, North Carolina 27695-7801
Phone (919) 737-2234.

North Carolina State University is an equal opportunity, affirmative action employer.

Editor's Comments

by
Barry Crittenden

It became obvious to the Executive Committee of the EDGD at its business meeting in New Harmony that a less than total distribution was made of the Autumn, 1988 issue of the EDG Journal (Vol 52., No. 3). A less than complete mailing list was received from ASEE headquarters. Approximately one hundred of our members received their Autumn issue of the Journal late. The initial mailing was made in late October using bulk rate postage. The majority of EDGD members received their copy before the Midyear Conference in New Harmony. My apologies to those members who received their copy after the New Harmony meeting - I shall certainly be aware of mailing label problems in the future.

Since the mailing of the Autumn issue of the EDG Journal, the bill for publication has arrived. It seems that to produce approximately one thousand copies of a 50-page Journal, including small amounts of type-setting and photographs, the cost to the Division will be approximately $2000 per issue, or $6000 per year. Obviously your typical membership dues of $3, plus nonmember and foreign subscriptions, resulting in yearly income of approximately $2500, will not cover the publication costs. We must, therefore, rely on advertising. Jerry Smith, the Journal Advertising Manager, is working diligently in this area and advertisements are increasing. However, we ask for your assistance - if you are a textbook or software author, please consider having your product advertised in the Journal. The costs are reasonable and the distribution of the Journal is to graphics educators not only in the United States, but also in foreign countries. For more information, contact:

Jerry Smith
363 Knoy Hall
Purdue University
West Lafayette, IN 47907
(317)-494-4585

ENGINEERING DESIGN GRAPHICS JOURNAL

ISSN 0046-2012

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Article copies and 16, 35, and 105 mm microfische are available from: University Microfilm, Inc, 3000 Zeeb Road, Ann Arbor, MI 48106.

Scope

This Journal is devoted to the advancement of engineering design graphics technology and education. The Journal publishes qualified papers of interest to educators and practitioners of engineering graphics, computer graphics, and subjects related to engineering design graphics in an effort to (1) encourage research, development, and refinement of theory and application of engineering design graphics for understanding and practice, (2) encourage teachers of engineering design graphics to experiment with and test appropriate teaching techniques and topics to further improve the quality and modernization of instruction and courses, and (3) stimulate the preparation of articles and papers on topics of interest to the membership. Acceptance of submitted papers will depend upon the results of a review process and upon the judgement of the editors as to the importance of the papers to the membership. Papers must be written in a style appropriate for archival purposes.

Submission of Papers and Articles

Submit complete papers, including an abstract of no more than 200 words, as well as figures, tables, etc. in quadruplicate (four copies) with a covering letter to J. B. Crittenden, Editor, Engineering Design Graphics Journal, EF - VPI&SU, Blacksburg, VA 24061. All copy must be in English, typed double-spaced on one side of each page. Use standard 8 1/2 x 11 inch paper only, with pages numbered consecutively. Clearly identify all figures, graphs, tables, etc. All figures, graphs, tables, etc. must be accompanied by a caption. Illustrations will not be redrawn. Therefore, ensure that all line work is black and sharply drawn and that all text is large enough to be legible if reduced to single or double column size. High quality photocopies of sharply drawn illustrations are acceptable. The editorial staff may edit manuscripts for publication after return from the Board of Review. Galley proofs may not be returned for author approval. Authors are therefore encouraged to seek editorial comments from their colleagues before submission of papers.

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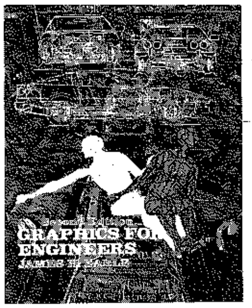

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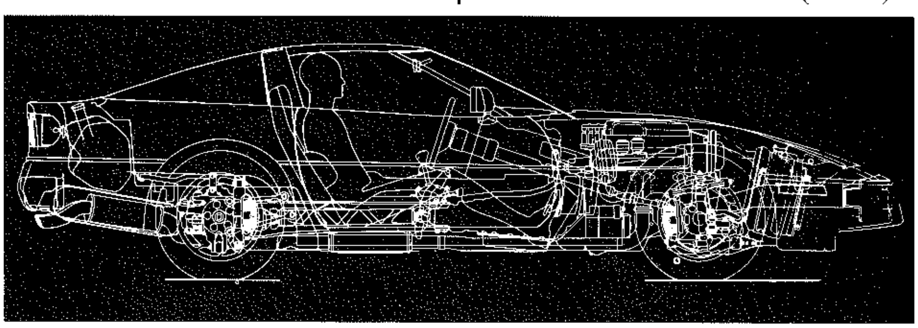

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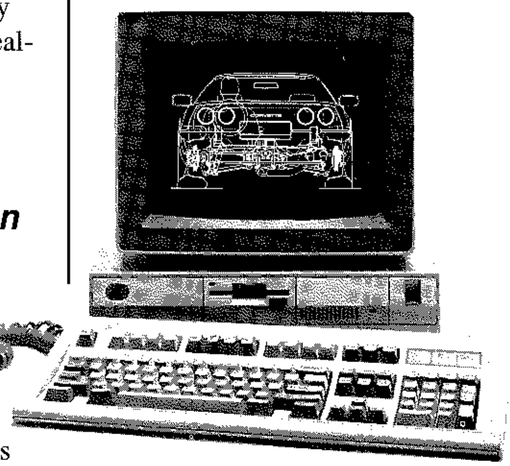

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