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WINTER 1980 VOLUME 44 NUMBER 1

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ENGINEERING DESIGN GRAPHICS JOURNAL

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ASEE ANNUAL CONFERENCES

1980 - University of Massachusetts, Amherst. June 22 - 27

1981 - University of Southern California

EDGD MIDYEAR CONFERENCES

November 1980- V.P.I. & S.U. - Williamsburg, VA

ENGINEERING DESIGN GRAPHICS JOURNAL is published - one volume per year, three numbers per volume, in Winter, Spring, and Fall - by the Engineering Design Graphics Division of the American Society for Engineering Education, for teachers and industrial practioners of Engineering Graphics, Computer Graphics, and Design Graphics, and Creative Design.

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ENGINEERING DESIGN GRAPHICS JOURNAL OBJECTIVES:
The objectives of the JOURNAL are:
1. To publish articles of interest to teachers and practioners of Engineering Graphics, Computer Graphics and subjects allied to fundamentals of engineering.
2. To stimulate the preparation of articles and papers on topics of interest to its membership.
3. To encourage teachers of Graphics to innovate on, experiment with, and test appropriate techniques and topics to further improve quality of and modernize instruction and courses.
4. To encourage research, development, and refinement of theory and applications of engineering graphics for understanding and practice.

STYLE GUIDE FOR JOURNAL AUTHORS

The Editor welcomes articles submitted for publication in the JOURNAL. The following is an author style guide for the benefit of anyone wishing to contribute material to Engineering Design Graphics Journal. In order to save time, expedite the mechanics of publication, and avoid confusion, please adhere to these guidelines.

1. All copy is to be typed, double-spaced, on one side only, on white paper, using a black ribbon.

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3. Two copies of each manuscript are required.

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Illustrations cannot be redrawn; they are reproduced directly from submitted material and will be reduced to fit the columnar page.

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7. Enclose all material unfolded in large size envelope. Use heavy cardboard to prevent bending.

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9. Send all material, in one mailing to:

Mary A. Jasper, Editor
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REVIEW OF ARTICLES

All articles submitted will be reviewed by several authorities in the field associated with the content of each paper before acceptance. Current newsworthy items will not be reviewed in this manner, but will be accepted at the discretion of the editors.

DEADLINES FOR AUTHORS AND ADVERTISERS

The following deadlines for the submission of articles, announcements, or advertising for the three issues of the JOURNAL:
Fall--September 15
Winter--December 1
Spring--February 15

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Engineering Design Graphics Journal

WINTER, 1980 VOLUME 44 NUMBER 1

LOOKING FOR SOMEONE?

ENGINEERING DESIGN GRAPHICS DIVISION
American Society for Engineering Education

TABLE OF CONTENTS Page

ANNUAL MEETING

CREATIVE ENGINEERING DESIGN DISPLAY

DESIGN DISPLAY AWARDS

FINAL REPORT

12th Annual
"Creative Engineering Design Display"

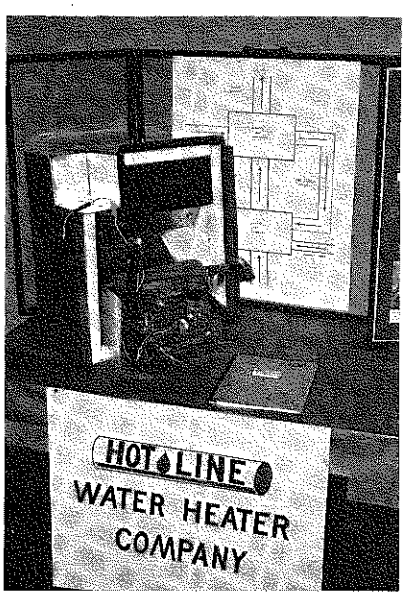
The 12th Annual Creative Engineering Design Display was held on June 25-27, 1979 as part of the Annual ASEE Conference at Louisiana State University, Baton Rouge.

The number of entries was less than in previous years due to a delayed mailing of the announcement for the display. However, the 30 projects entered fit nicely into the LSU Union Art Gallery. The location of the Art Gallery relative to the conference registration area resulted in very good attendance and visiability for the display.

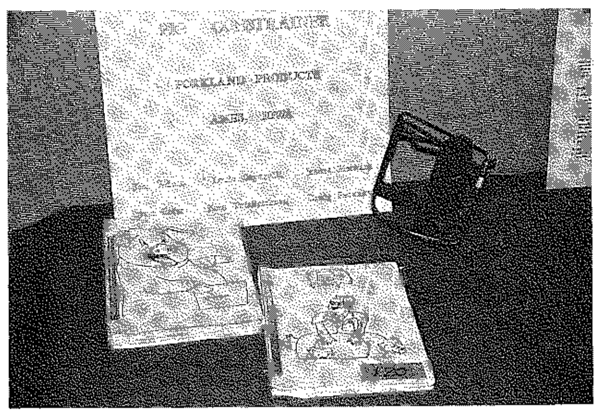
Awards were presented as follows:

FRESHMAN CATEGORY

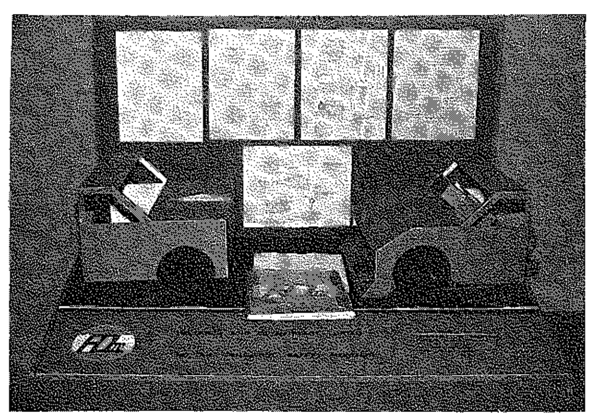
First Place: Marquette University
"In Line Water Heater"



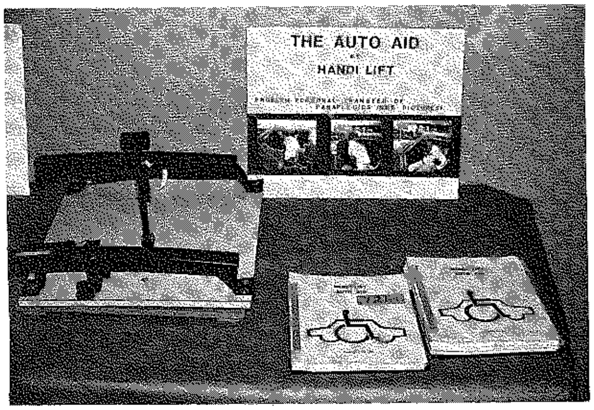
Second Place: Iowa State University
"Pig Constrainer"



Third Place (Tie): Arizona State University
"No Tail Tailgating"



Iowa State University
"Auto Aid"



JUNIOR CATEGORY

First Place: Southern Methodist University "Rock Bit Bearing Seal Tester"

SENIOR CATEGORY

First Place: U.S. Naval Academy "Ocean Currents Energy Generator"

All other entries received Honorable Mention awards.

A great deal of the success of this annual event is due to the people and organizations that committed their time and/or financial resources to provide for judging the display entries and for supplying award plaques and certificates.

Judges for this year's display were:

Prof. H. L. Henry
Louisiana Technical University

Prof. Blaine R. Butler
Purdue University

Dean Edward Cook
U.S. Naval Academy-Annapolis

Prof. Donald Miotto
Delta College

Prof. N. Dario
General Motors Institute

Ms. Barbara Ramey
A.S.E.E.

Mr. Carl Hough
The Boeing Company

Prof. Tracy Nabers
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Mr. Norwood L. Snowden
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Hughes Airlines

Mr. Ernie Brown
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Prof. Marc Sauvageau
Ecole Polytechnique

Prof. Edward Lear
University of Alabama

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Arnold Air Force Station, Tenn.

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Stanford, Conn.

Union Carbide Corporation
New York, NY

Amoco Research Center
Naperville, IL

General Motors Corporation
Detroit, MI

Boeing Company
Seattle WA

Celanese Corporation
New York, NY

In conclusion, the committee wishes to thank all those who helped make the 1979 Creative Engineering Design Display a success.

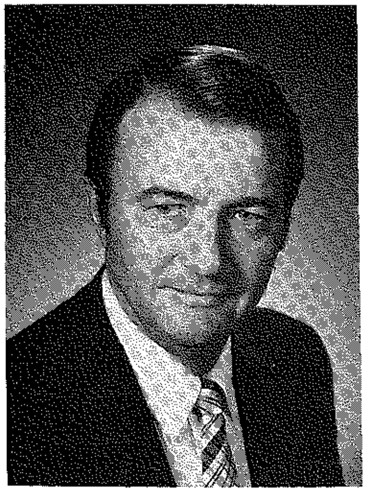
1979 CEDD Committee

Borah Kriemer } Co-Chairmen
Byard Houck }

Ed Knoblock

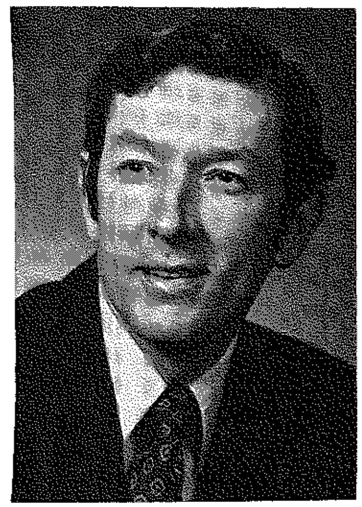
Jay Abramowitz

from the midyear conference



C. G. Sanders
Professor, Freshman Engineering
Iowa State University

PLANNING AND DEVELOPING FACULTY ACTIVITY EVALUATION



A. R. Eide
Professor, Freshman Engineering
Iowa State University

UTILIZATION OF FACULTY ACTIVITY EVALUATION

ABSTRACT

This paper presents a synopsis of committee and administrative activity involving the development of a comprehensive faculty evaluation plan to be administered in the Department of Freshman Engineering at Iowa State University.

In includes a summary of literature research, including background history, what faculty characteristics and activities should be evaluated, what evidence should be gathered, who should authenticate an evaluation and what vehicles should be used to gather such evidence.

A chart of the comprehensive "master plan" for evaluating all professional activities of a faculty member is included, together with sample questionnaires for student and faculty peer ratings and cumulative summary administration forms to be used for a final composite faculty rating.

ACKNOWLEDGEMENTS

The authors of this paper wish to acknowledge the individual and collective contributions of the Iowa State University Freshman Engineering Faculty Evaluation Committee, other participating members of the faculty, and the authors cited in the attached bibliography for information gleaned from their work.

Committee members:

1977-1978	Roland D. Jenison - (Chm.) Cletus R. Mercier C. Gordon Sanders
1978-1979	C. Gordon Sanders - (Chm.) Roland D. Jenison Alan M. Russell
1979-1980	C. Gordon Sanders - (Chm.) Roland D. Jenison Lane H. Mashaw

INTRODUCTION

"Advance and be Recognized"[19]

Those familiar with the armed services in time of war have no doubt heard and understood the phrase used in the tile above. In the teaching profession, the phrase also seems appropriate and takes on a double meaning when one reverses the phrase to: be recognized and advance. Regardles of a "chicken vs. egg" allusion, it does seem that reward should follow recognition. The "free world" educational system universally accepts the philosophy of rewarding "superior teachers" with merit salary increases, tenure, promotions, and various other forms of recognition. In fact, we are "programmed" (definitely committed) to such a system for the forseeable future.

When facing up to this fact, we must also face up to the critical fact that in order to maintain a tenable position through the reward phase of the process (relatively easy to implement), pertinent decisions must necessarily be based on judicious assessments of the worthiness of the recipients (the far more difficult task).

The quest for appropriate, valid, reliable, and acceptable methods of evaluating a teacher continues cautiously, timidly, and at times -- reluctantly. Hopefully if the "merit system" of reward for superior teaching continues, the timid, reluctant approach to teacher evaluation will be overrun with a bolder, better, and more vigorous attack.

What can and should be evaluated in regards to a teacher? How, when and by whom should any proposed evaluation be accomplished?

Some people contend that the only valid measure of a teacher is determined from the lasting effects on their products (students). This is called "teaching effectiveness". Too often, it is feared, the cry for evaluation of effectiveness, as opposed to performance, is simply a "dodge" by some teachers who don't want to be evaluated or by administrators who don't want to put forth the effort to perform on-goint evaluation of their faculties.

However, educational research on teaching effectiveness with control groups when time was not a major consideration, has undoubtedly been helpful. The greatest benefit from this kind of endeavor has probably been in the area of establishing (or verifying) behavioral and other characteristics common to those eventually judged to have been superior teachers.

These "wanted" characteristics are almost always recognizable in "teacher performance". Teacher performance is what the teacher does now, in and out of the classroom to motivate students and assist tem in the learning process.

The case for evaluating on the basis of teaching "performance" seems considerably stronger than that of trying to measure teaching "effectiveness". There is widespread agreement as to the qualities and behavioral characteristics of superior teachers. These qualities and characteristics can be adequately observed. There is strong evidence supporting a positive correlation between teacher performance and teacher effectiveness. Logic clearly supports the contention that superior teaching performance at least enhances the student's motivation and opportunity to learn - surely theis is the primary responsiblity of the teacher. After all, the student must assume part (a very significant part) of the final learning process.

This philosophy is forcefully expressed in the following excerpt from an article by Henry C. Johnson, Jr. (a lawyer) in Court, Craft and Competence: A Reexamination of Teacher Evaluation Procedures:

> "In conclusion, it will be useful to return to the language of the courts. While the TAP (Teacher Assignment Program) clearly does build on the notion of providing a "reasonable measure" for teacher competence, the Supreme Court's ruling also stipulates that it be a measure of "job performance". The crucial question is as we said then: how we define that job. If we define the job as producing learning, there is little if any hope of resolving the muddled situation we are in. If, however, we define the job as doing what teachers ought to do, there are constructive possibilities."

Finally, performance is a "now" process, not something to be determined months or years after the fact and therefore it is the primary element in the teacher evaluation process that can be used for rewarding and promoting good teaching in time to be of practical value to the educational system we have adopted. It is, then the element in the evaluation of a teacher to which we must give our first and foremost attention.

There seems to be quite universal acceptance of the contention that the outstanding teacher should be rewarded. From a practical "we can do something about it" standpoint, faculty groups must assist in and support the development of a practical system for evaluating teacher performance. A tenable approach to developing a desirable performance evaluation must be based on a background analysis and logical resolution of the root problems connected with such an endeavor.

These "root problems" of teacher evaluation take many diverse and often conflicting forms that are semmingly nurtured in the nature of the teacher, the administrator, and in others who seek to make the evaluation. On the one hand, we have the teacher's

- -desire for privacy (the "big brother is watching me" syndrome)
- -desire for classroom autonomy (freedom from overt or covert censorship)
- -reluctance to divulge professional secrets (the competitive spirit to an extreme.)

On the other hand (frequently within the same individual), we have the teacher's

- -desire for peer and public recognition (Professor of the Year, Faculty Citations, publications, promotions, tenure, merit salary increases). Note that this factor is not totally compatible with the preceding three.

Other root problems, even harder to define and resolve are:

- -The illusive, intangible, indistinguishable, enigmatic, equivocal or otherwise obscure nature of many of the facets that are characteristics of what is recognized as good teaching performance.
- -The maze of uncertainty as to the desired mix of certain elements that make up good performance.
- -The almost infinite degrees of differences in those being taught (backgrounds, inherent capabilities, goals, etc.)
- -The need for thoughtful, judicious people to make the evaluation.
- -The need for whole-hearted, full cooperation from those being evaluated.
- -The inherent laziness of some people.
- -The time and effort required to make a comprehensive assault on the problem.
- -The planning and procedures essential to a good evaluation system must be accomplished "above and beyond the call of FTE designated duties."

The foregoing "root problems" do not, however, negate either the need for, or the ability to do, a creditable job of evaluating a teacher. Indeed, analysis of most of these problems to provide rather convincing clues to the personal characteristics common to outstanding teachers. It seems obvious after thoughtful analysis of such items that, in general, an outstanding teacher must have a keen intellect, excellent judgement, and be adaptable to change and unusual situations. The person must also be honest, fair and even-handed; have a dynamic convincing personality; put forth vigorous, continuing effort, and be productive. A positive hypothesis must incorporate the conviction that these attributes are discernible -- that they can be adjudged on a comparative basis to a good degree of accuracy -- that they can be fairly and equitably evaluated.

We must set reasonable goals to improve the techniques and to provide better evidence of the quality and quantity of the performance of those teachers being evaluated so that fair and equitable judgements can be made. Practical, acceptable solutions to the problems outlined are possible if a positive, cooperative attitude is taken by the people most critically affected.

As a teacher, you must first admit and resolve the inconsistency between "your rights" for secrecy regarding teaching techniques, characteristics, etc., and your desire for peer and public recognition for being outstanding in your profession. Unless you openly share your talents with others, there is no basis (and perhaps no desire) for administrators to compare you with other teachers and laud your attributes and achievements. You must be objective, honest and fairly and willingly cooperate in any part of the evaluation procedure in which you are asked to participate and make constructive criticism when and where you feel it is needed.

COMMITTEE ACTION

During the fall of 1977, the Chairman of the Department of Freshman Engineering at Iowa State University appointed an ad-hoc committee of three faculty members to study the current faculty evaluation system and to make recommendations for improving the existing system, with particular emphasis on faculty performance related to classroom teaching and to advising. At that time the department chairman made use of: 1) faculty rating by students, 2)anecdotal records, 3) committee reports, and 4) informal faculty interviews and hearsay accounts from students and faculty peers.

After considerable background research of the subject and many discussions, the committee recognized that impmovements could be accomplished, that because of the complexity of the problem and the rather delicate nature of certain aspects of faculty evaluation, that careful, thorough planning would be required; and that a permanent standing committee of from three to five faculty members should be formed to develop such improvements. The ad-hoc committee was promptly redesignated as the recommended "standing" committee.

The initial action of the committee was to do further literature research. Following are brief summaries of the research reported by individual committee members and a report of the joint committee action taken.

RESEARCH

One committee member reported on the history of faculty evaluation, current trends and recent impetus given to faculty evaluation. A condensation of this report incorporates significant findings from individual and group studies made for the American Association of University Professors[4],The American Association of Colleges[10], The American Council on Education[11], and from a survey taken in 1973 of the deans of all liberal arts colleges in the United States.

- Increased interest in faculty evaluation results from student unrest in the 1960's, emergence of affirmative action organizations and teacher's unions, growth of educational institutions and increased fiscal restraints.

- Past evaluations have stressed:

  1. Student opinions
  2. Off-campus work
  3. Research
  4. Peer opinions

Conclusions reached in a study made by Barbara von Wittich (Department of Foreign Languages), Iowa State University, include the following statements:

> "The instructor wishing to be evaluated can facilitate the task by providing pertinent and well organized evidence including: course outlines, statement of objectives and proof for their attainment description of methods used and evaluations by students. The evaluators must remember that trends rather than incidents should be taken into consideration when using student evaluation of instructors."

A general consensus of all studies indicates that meaningful evaluation is still rare and than most methods employed are both inaccurate and unreliable, but there is agreement that there has been slow but promising improvement.

Research indicates that students are, and probably will remain one of the best sources for evaluating faculty (<u>but only as a part of such an evaluation</u>); that faculty peer ratings hold great potential; and that other sources can and should be employed for comprehensive, tenable solutions to the problem.

A second committee member reported on studies mainly concerned with the specifics of <u>what</u> should be evaluated, i.e., the primary characteristics of teachers. From the Sheffield Study[6], a study conducted at the University of Toledo[7], a survey conducted in the Department of Freshman Engineering at Iowa State and from other sources, a list of "important characteristics of effective teachers" was compiled, rated and grouped in homogeneous categories. Note: Although it was obvious from a discusssion of this report that complete agreement as to the appropriate categories and their corresponding sub-topics could probably not be firmly established to the satisfaction of everyone desiring such an arrangement, the committee did concur on the items, ranking and major categories. At a later date, the suggested classification of these teacher characteristics was presented to the Iowa State University Freshman Engineering faculty and with a few minor changes, was approved. The final summary version of this classification will appear later in this paper.

The third member of the Freshman Engineering Evaluation Committee researched and reported on:

1. Evidence that can be evaluated to determine the relative effectiveness of instruction in satisfying established criteria.
2. The major means of obtaining such evidence.
3. Who can collect such evidence and by what specific methods.
4. Assuning a significant degree of validity, how the various illusive pieces of evidence involving the evaluation of teaching can be grouped reliably and consistently to show the relative effectiveness of instruction.
5. The vehicle(s) that can be used to effectively communicate the evidence collected to those who need the evaluation.

Following is a summary of "Consensus" information gleaned from the various sources cited in the bibliography to this report.

SOURCES OF OBTAINING EVIDENCE FOR EVALUATION OF TEACHING EFFECTIVENESS

First-party participants: Instructor and student directly involved in the ongoing instructional activities (both within and outside the classroom).

Second-party participants: Directly observing or experiencing the activities or output of the first party participant, i.e., substitute instructors, peer associates, department administrator, etc.

Third-party associates: There are individuals involved with first and second party participants only in circumstances not directly involving the instructor being evaluated, i.e., faculty outside the department, alumni, others.

<u>WHO SHOULD EVALUATE WHAT</u>
(From Selected Criteria)

Criteria	Who Can Evaluate
Personal Characteristics	Students, peers, chairman, self,
Personal Characteristics	Students, peers, chairman, self, others
Teaching Methodology	Self, peers, chairman, students, others
Motivational Techniques	Students, self, chairman, peers, others
Interpersonal Relationships	Students, self, peers, chairman, others
Student Achievement	Self, students, chairman, peers, others
Professional Activities	Self, chairman, peers, students, others

NOTE: It probably boils down to:

1. Who has the genuine interest in instructional evaluation
2. Who has the best opportunity to get valid evidence
3. Who can be relied upon to do the work necessary to accumulate and interpret the information

POSSIBLE TECHNIQUES FOR EVALUATION OF INSTRUCTION

1. Self Evaluation (by the teacher)

Informal introspection (pointedly reflects on own activity and achievement)

- Critiques own taped lectures
- Critiques own daily teaching preparations
- Analyzes student ratings
- Analyzes peer or other ratings of self
- Analyzes anecdotal records (all sources)
- Analyzes own teaching methods

Formal Introspection
- Self evaluation rating form (questionnaire)
- Daily diary or anecdotal record system

2. Student Evaluation

- Instructor rating forms (improvement in design and use)
- Comment or suggestion box
- Student evaluation committee
- Student/faculty/administration interaction
- Daily diary or anecdotal record system

3. Peer Evaluation

Informal
- Casual commentary, assessment of peers

Formal
- Peer evaluation committee (various forms)
- Peer rating forms
- Evaluate student output
- Evaluate instructor output (i.e., committee activity exams, quizzes, stu- work collected, etc.)
- Evaluate student ratings
- Evaluate instructors self-rating

4. Outside Faculty, Alumni, Industry, Other

- Occasional voluntary written or verbal feedback
- Instructor ratings (questionnaire)
- Occasional solicited individual rating

5. Chairman's Evaluation

- Collection of evidence
    - Instructor's application information and interviews
    - Student ratings (questionnaire)
    - Instructor's self rating
    - Faculty committee ratings or peer ratings
    - Add, Drop, Transfer records
    - Grade reports/grade sheets
    - Committee reports
    - Faculty activity reports
    - Personnel files
    - Submission of papers, articles, books, etc., innovative methods, etc.
    - Anectdotal records
    - Perusal of student and instructor work such as: Notebooks, quizzes, major exam projects, etc.
    - Personal observations (appearance, work habits, conversation)
    - Verbal feedback (instructor being evaluated, instructors, peers, students, counselors, other faculty, etc.)
    - Perusal of instructor's written work (articles, lesson plans and other instructional material, articles, books or other publications)
    - Observations while substitute teaching, viewing taped lectures, during seminars, etc.

FINAL FORMAL EVALUATION

- Criteria established - value decisions made -- all preceding input considered - judgement made on a given individual faculty member's final composite rating.

SUMMARY OF THE COMMITTEE'S CONCLUSIONS AND RECOMMENDATIONS

General Conclusions

- The trend of these times seems to indicate more improved accountability, more conflict yet more openness in group meetings; customary or traditional methods as being exposed or purported to be ficticious.
- Measuring the excellence of teaching is probably more complicated, controversial and difficult than measuring excellence in most, if not all of the other professions.
- Excellence in teaching can be evaluated.
- Excellence in teaching must be evaluated.
- Valid evidence of excellence in teaching exists.
- Valid evidence of excellence in teaching takes many forms.
- Collection of multiple evaluators (for many significant reasons) is preferable to any single evaluator.
- Valid evidence of excellence in teaching can be documented and combined to to provide a relatively accurate evaluation of the composite effectiveness involved.
- The planning, follow-through, and ongoing upkeep required for any successful evaluation system is extremely difficult, time-consuming, and delicate to implement.
- Faculty members wishing to be evaluated are responsible for supplying documented evidence of their performance to the administrator making the evaluation.
- Especially in a department where teaching is the major function of all personnel involved, it seems imperative to require excellence in teaching.

- To require excellence - evaluation is essential.
- To require evaluation requires dedication to the task by all concerned.
- Members of the Department of Freshman Engineering at Iowa State are concerned.

RECOMMENDATION

What Must Be Done to Obtain Evidence for Evaluation of Teaching

1. By the University and College Administration

   - Establish broad policy guidelines defining acceptable degree of instructor autonomy and the right to privacy in the teaching environment based on both legal and academic restraints.
   - Recognize and reward excellence in teaching via promotions, salary adjustments, and honor awards.

2. By the Department Head or Chairman

   - Establish and use a valid, reliable, comprehensive system for collecting evidence for the evaluation of instruction as is judged appropriate and compatible with the administration's imposed guidelines, faculty morale and other real restrictions such as time, work loads, etc.

3. By the Teaching Faculty

   - Group action
     - Cooperate in all appropriate ways to assist the department administrator in developing all phases of the evaluation process.
     - Take the initiative to generate, collect, interpret any additional evaluation evidence for self or departmental use.

SUGGESTED PLAN FOR ESTABLISHING DEPARTMENTAL INSTRUCTION EVALUATION POLICY-PROCEDURES

1. Draft a formal faculty evaluation plan. Said plan to be based on criteria determined from the preceding committee study and to be organized under five to ten major categories in groupings of approved criteria that are similar in nature or type.

2. Make value decisions as to the relative worth (percentage wise) of the major categories.

3. Present a "plan" to the department administrator for faculty consideration and possible amendment.

4. A further function of this committee might be to formulate plans for improved or additional methods for collecting and interpreting evidence for evaluating teaching and possibly assist the department administrator in making value decisions on factors involving promotions.

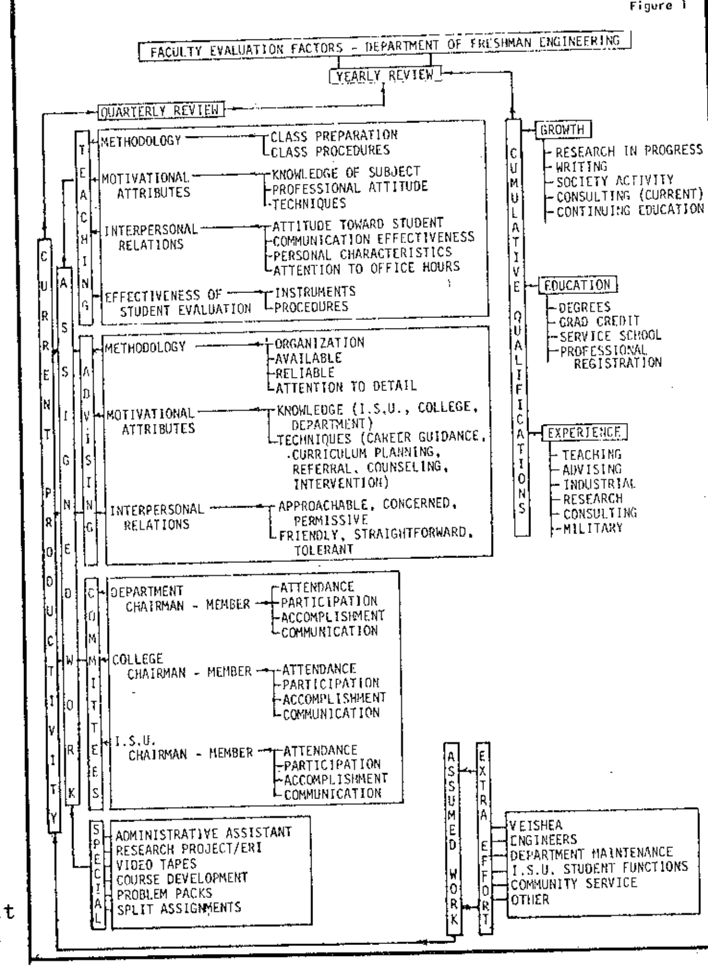
A COMPREHENSIVE MASTER PLAN FOR FACULTY EVALUATION

Upon submitting the committee's interim conclusion and recommendation to the department chairman, it was decided that a master plan for comprehensive faculty evaluation be submitted to the Freshman Engineering faculty for input, and hopefully for their approval.

A Faculty Evaluation Factors chart (Figure 1.) was designed which shows the various categories and contributing factors that would be considered in the yearly review used in making decisions related to tenure, promotions, special awards and merit salary adjustments.

After receiving input and approval of this plan from the Freshaman Engineering faculty, the committee again met with the department chairman to determine appropriate priority action to make specific improvements in the overall evaluation system.

Figure 1



FRESHMAN ENGINEERING

INSTRUCTOR AND COURSE PERFORMANCE SURVEY

FR.E. 161

Figure 2

INSTRUCTIONS: Page 1 deals with the instructor performance only and page 2 with course evaluation. Do not judge the instructor by the course or vice-versa. Your name should not appear on any of the questionnaire material. Read each statement carefully, then record your rating.

RATING SCALE	
10,9	EXCELLENT
8,7	GOOD
6,5	FAIR
4,3	POOR
2,1	UNSATISFACTORY

METHODOLOGY - The instructor consistently:

1. ( ) Began and ended class on time.
2. ( ) Explained clearly course objectives, assignments, grading policy, attendance, make-up.
3. ( ) Took care to prevent cheating.
4. ( ) Came prepared with notes, visuals, handouts, and used them effectively.
5. ( ) Returned graded assignments promptly.
6. ( ) Stayed in classroom and was available for assistance.

EFFECTIVENESS - The instructor consistently:

7. ( ) Used homework, quizzes, and major exams in a fair and reasonable manner.
8. ( ) Allowed sufficient time for quizzes or exams.
9. ( ) Provided meaningful feedback on exams.
10. ( ) Returned exams promptly.

MOTIVATIONAL ATTRIBUTES - The instructor consistently:

11. ( ) Demonstrated comprehensive knowledge of the subject and communicated it effectively.
12. ( ) Showed practical applications of the subject and related it to other courses in your curriculum.
13. ( ) Showed enthusiastic and sincere interest in the course.
14. ( ) Encouraged intelligent, independent thought by students.
15. ( ) Motivated students to do their best.

INTERPERSONAL RELATIONS - The instructor consistently:

16. ( ) Treated students with respect and was patient and tactful.
17. ( ) Encouraged student participation.
18. ( ) Tried to know students as individuals and establish good rapport.
19. ( ) Was available for consultation and provided appropriate assistance.
20. ( ) Used good voice projection and effective enunciation.
21. ( ) Showed a good sense of humor and good judgement in its use.

OVERALL EVALUATION

22. ( ) Carefully, considering all of the above items, rate your instructor's "OVERALL" performance as a teacher.

- SPACE IS PROVIDED FOR INSTRUCTOR COMMENTS ON BACK OF SHEET -

A careful revision of the Instructor Performance Questionnaire (student evaluation of their current classroom instructor, Figure 2) being used in each of our academic courses was accomplished.

The committee next revised the Advisor Performance Questionnaire (Figure 3). One of the guiding principles followed in these revisions was to be consistently uniform in terminology and denoted meaning for major and sub categories. Comparison of the sample questionnaires included in this paper will show this consistency.

The next specific step in the design of the system was the development and testing of a faculty Peer Teaching Performance Questionnaire (Figures 4A, B, C, D, and E), with accompanying "directions" for its use.

Recognizing the variance in faculty peer association, a "contact" or familiarity" factor was invoked to place greater authentication on evidence submitted by the evaluators who had the most intimate working relationship with a peer being evaluated. This rating factor is briefly described in the sample form.

At this stage in the development of the evaluation system, it was decided to revise the department chairman's cumulative summary form used for recording qualitative teacher performance characteristics in terms of numerical ratings. This revision was primarily a conversion to categories and subcategories that would correspond to those in the various "questionnaires". It was hoped that this consistent use and arrangement of terms would facilitate rapid combining of homogeneous evaluation characteristics gathered from the various sources and that it would make possible a more efficient and indisputable authentication of each instructor's final composite faculty performance rating.

FRESHMAN ENGINEERING

ADVISOR PERFORMANCE QUESTIONNAIRE Advisor's Name ____________

Figure 3

INSTRUCTIONS: Please rate your advisor on the traits listed below. Rate only those characteristics and responsibilities that you have observed in your relationship with your advisor using the rating scale on the right. Use NA for items not observed.

RATING SCALE	
10,9	Excellent
8,7	Good
6,5	Fair
4,3	Poor
2,1	Unsatisfactory

METHODOLOGY - Your advisor was:

1. ( ) Available: could be located in his/her office or contacted by telephone during the day and could be seen within three days.
2. ( ) Reliable: made appointments and kept them.
3. ( ) Well Organized: had records and other information readily available.
4. ( ) Helpful in Scheduling: checked your preclassification schedule carefully to assure that it was appropriate and reasonable.

MOTIVATIONAL ATTRIBUTES - Your advisor was:

5. ( ) Knowledgeable: well informed about rules and procedures of the University.
6. ( ) Knowledgeable: well informed about rules and procedures of the College.
7. ( ) Knowledgeable: well informed about rules and procedures of the Department.
8. ( ) Helpful in Career Guidance: helped integrate career information with information about your abilities and interests relating to curriculum selecti
9. ( ) Helpful in Curriculum Planning: explained the objectives and requirements of curricular interests and helped select courses for a chosen curriculum.
10. ( ) Helpful in Referral: informed you about university and community resources and assisted you in contacting them.
11. ( ) Helpful in Personal Counseling: provided counseling on problems of personal or social adjustment.
12. ( ) Helpful in Intervention: helped represent your interests in problems arising with faculty or university officials.

INTERPERSONAL RELATIONS - Your advisor was:

13. ( ) Approachable: encouraged you to contact him or her when you had a problem.
14. ( ) Friendly: expressed genuine interest in you.
15. ( ) Concerned: showed concern for you as a person.
16. ( ) Straightforward: gave you frank and honest opinions.
17. ( ) Tolerant: accepted your weaknesses without undue criticism.
18. ( ) Permissive: made suggestions but allowed you to make final decisions.

OVERALL EVALUATION

19. ( ) Carefully, considering all of the above items, rate your advisor's "OVERALL" performance.

How often do you consult with your advisor each quarter? ________

How many quarters have you had your current advisor? ________

Space is provided for comments/suggestions/or improvements on back of sheet.

Figure 4A

FRESHMAN ENGINEERING PEER
TEACHING PERFORMANCE QUESTIONNAIRE

Directions

NUMERICAL RATINGS - Please rate the teaching performance during the S'79 - W'80 time period for the subject of this questionnaire by evaluating his/her performance in each of the subtopics (A,B,C) given. Use the 22 - 50 rating scale described at the top of each page and place your numerical rating in the parentheses at the left of each subtopic.

An overall numerical rating for each section (I, II, III, IV) is also requested. This can be done either by averaging the ratings of the two or three subtopics within a given section or by circling a value different from this avarage on the scale at the end of each section (see discussion which accompanies this scale at the end of each section).

COMMENTS - Of equal or greater importance than these numerical ratings are the comments requested in each section. If at all possible, the minimum response in each area should be one comment on something the instructor does well and one comment on an area in which the instructor could improve. Other comments in addition to this one positive and one negative comment would be most welcome.

* * *

Which of the following apply to your contact with this staff member during the past two years? Check all which apply.

A. _____ I shared a team teaching assignment with the subject.

B. _____ I was an office partner with the subject.

C. _____ I was a course supervisor for a course while the subject was teaching the course.

D. _____ I taught a given course during the same quarter the subject was teaching that course (apart from Item A above).

Figure 4B

SUBJECT'S NAME ____________ EVALUATOR'S NAME ____________

Assuming that all faculty members in Freshman Engineering are Fair, Good, or Outstanding teachers, use the following scale to indicate how, relative to peers teaching the same subject(s), you would rate the instructor on each of the major criteria listed. Place your rating number for each subtopic in the parentheses provided.

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

I. METHODOLOGY

A. ( ) Class Preparation. The instructor

- Follows a planned sequence of pre-class, in-class, and after-class activities.
- Adequately prepares lectures (i.e. edits old lectures, adds new material).
- Prepares quality visual aids and checks media and equipment in advance.

B. ( ) Class Procedure. The instructor

- Starts and ends class on time.
- Follows a logical sequence of activities in scheduling lecture, test, and lab time during each class period.
- Keeps lectures to an appropriate length.
- Allocates lab time equitably among students needing assistance.

____ (A + B) $\frac{A + B}{2}$ = ( )

(+) COMMENTS

(-) COMMENTS

If you feel that important criteria in the area of METHODOLOGY have been omitted, or that the subtopics are not of equal importance (the "average" is not valid for the category), record what you believe to be a more accurate rating for this category by circling the appropriate number on the following scale:

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

Figure 4C

SUBJECT'S NAME ____________ EVALUATOR'S NAME ____________

Assuming that all faculty members in Freshman Engineering are Fair, Good, or Outstanding teachers, use the following scale to indicate how, relative to peers teaching the same subject(s), you would rate the instructor on each of the major criteria listed. Place your rating number for each subtopic in the parentheses provided.

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

II. MOTIVATIONAL ATTRIBUTES

A. ( ) Knowledge of the Subject. The instructor

- Has comprehensive knowledge of the material being taught.
- Ties theory to practical application with discussion of actual experience and case histories.
- Shows adaptability in mastering and incorporating new material in the course.

B. ( ) Professional Attitude. The instructor

- Shows sincere interest and generates enthusiasm for the course material.
- Deals openly and honestly with students in evaluating their work.
- Maintains professional competence by reading, attending society meetings, etc.
- Maintains his/her dress and grooming at a level appropriate for the classroom.

C. ( ) Techniques. The instructor

- Uses techniques to maintain interest in lectures.
- Uses techniques to motivate student alertness and pre-class preparation.

____ (A + B + C) $\frac{A + B + C}{3}$ = ( )

(+) COMMENTS

(-) COMMENTS

If you feel that important criteria in the area of MOTIVATIONAL ATTRIBUTES have been omitted, or that the subtopics are not of equal importance (the "average" is not valid for the category), record what you believe to be a more accurate rating for this category by circling the appropriate number on the following scale:

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

Figure 4D

SUBJECT'S NAME ____________ EVALUATOR'S NAME ____________

Assuming that all faculty members in Freshman Engineering are Fair, Good, or Outstanding teachers, use the following scale to indicate how, relative to peers teaching the same subject(s), you would rate the instructor on each of the major criteria listed. Place your rating number for each subtopic in the parentheses provided.

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

III. INTERPERSONAL RELATIONS

A. ( ) Attitude Toward Student. The instructor

- Reacts to students' questions and behavior with patience and respect.
- Generates a relaxed class atmosphere that encourages discussion.
- Attempts to learn students' names quickly and deals with them as individuals.
- Maintains authority on class procedure and grades with tactful firmness.
- Sets and maintains appropriate office hours.

B. ( ) Communications Effectiveness. The instructor

- Speaks with appropriate volume and clear diction.
- Speaks and writes with proper use of English (grammar, spelling, terminology, etc.)
- Uses visual aids effectively to support lecture content.
- Is willing to spend additional time with students in need of help.

C. ( ) Attitude Toward Other Staff in Regard to Teaching Matters. The instructor

- Contributes constructively to curriculum, course, and exam committees.
- Shares ideas and material for lectures and tests with other instructors.

____ (A + B + C) $\frac{A + B + C}{3}$ = ( )

(+) COMMENTS

(-) COMMENTS

If you feel that important criteria in the area of INTERPERSONAL RELATIONS have been omitted, or that the subtopics are not of equal importance (the "average" is not valid for the category), record what you believe to be a more accurate rating for this category by circling the appropriate number on the following scale:

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

The departmen chairman indicated there was considerable convincing documented evidence of each faculty member's performance in the areas of professional growth, educational background, years of teaching and advising experience, committee activities and special and assumed achievements. However, in the two areas in which the department is primarily responsible, i.e., teaching and advising, there was inadequate documented, demonstratable evidence of a given individual performance. Therefore, it was decided to first tackle improvements in those two areas.

ADMINISTRATOR'S ACTION

If major functions of a department are teaching and advising, then performance related to those areas must be considered a major criterion when evaluating faculty members for reasons relating to promotions and/or merit salary adjustments. It is not the only consideration; however, the overall value of the faculty member to the department, college, and University must also be considered as a very important standard for such an evaluation.

It is probably true that in some cases excellence in one particular area of special interest may result in lowered performance in some other area, e.g., concentration on a research project might take time from teaching preparation to the detriment of classroom performance. However, it is logical that some reasonable degree of balance in various areas such as research, committee activities, classroom teaching, etc. is desirable. The diverse interests and activities of faculty do have a positive influence on both the potential and the actual teaching performance, as well as the overall worth of a given faculty member; therefore, meaningful evaluation of a faculty member must be based on criteria that properly reflect the relative importance of the major components of this "desired balance".

Utilizing input from the offices of the Vice President for Academic Affairs, from the Dean and Associate Dean of Engineering, the Engineeering Cabinet and from several of our Engineering Faculty, the department chairman has utilized a variety of evaluation forms and other information as an aid in making decision judgements relating to the annual budget preparation.

Major categories of concern relating to potential and actual productivity of a faculty member with pre-determined "weighting" factors to account for the relative significance of each criterion are used.

Subsequently, all faculty members are rated in the light of each category. These independent ratings are recorded as numerical values (using a 10 point scale), tallied, weighted, and averaged -- resulting in a final summary score to reflect (hopefully) the most accurate overall rating for each individual.

Admittedly, it is doubtful that a score assures a truly accurate, wholly reliable, merit rating that can be used with perfect confidence and certain justice for all.

It does, however, force the evaluator to a systematic procedure that assures a much more thorough and objective consideration of the major strengths and weaknesses of each individual and provides a much sounder base for making decisions than would likely be achieved if using a less systematic approach. The chance of bias resulting from being unduly influenced by exceedingly good, or bad, performance should be lessened considerably becuase one is forced to judge an individual's worth in respect to all major standards. The process also points up the need for, and encourages, better record-keeping and an ongoing search for more and better evidence to assist the evaluator in making judgements.

To accomplish annual merit evaluation, the following steps are completed by the department chairman:

1. All faculty members are rated each academic quarter. This evaluation is conducted by the department chairman and retained in a confidential file. A copy of the form used to record this evaluation, called the Quarterly Productivity Assessment (Figure 5) is attached.

2. Individual faculty members are encouraged to visity with the department chairman concerning results of these quarterly evaluations.

3. Each individual faculty member is urged to take the necessary time to report pertinent actions to the departmental administrator. Without such documentation, it is impossible to recall, at a given point in time, a complete year's activity without such ites as committee minutes, copies of reports, oetters, correspondence, paper, etc.

4. Each year all members of the faculty are scheduled to meet with the department chairman for a professional development revies. At this annual meeting, merit and promotion considerations are discussed.

5. At the end of each fiscal year, the individual Quarterly Productivity Assessment sheets are averaged and recorded under the column labelled "Productivity" on the Yearly Evaluation of Faculty Qualifications sheet (Figure 6). Growth activities, education, and experience are also evaluated primarily from submitted documented material. This summary sheet is used as a guide at the end of each merit year to furnish salary codes.

Figure 4E

SUBJECT'S NAME ____________________ EVALUATOR'S NAME ____________________

Assuming that all faculty members in Freshman Engineering are Fair, Good, or Outstanding teachers, use the following scale to indicate how, relative to peers teaching the same subject(s), you would rate the instructor on each of the major criteria listed. Place your rating number for each subtopic in the parentheses provided.

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

IV. EFFECTIVENESS OF STUDENT EVALUATION

A. ( ) Instruments. The instructor

- Writes quiz and exam questions relevant to the subject content taught.
- Makes quizzes and tests of reasonable difficulty and length.
- Writes quiz and exam questions concisely and unambiguously.
- Updates quizzes and exams.
- Consistently does an even-handed job of grading student work.
- Grades and returns quizzes and exams promptly and discusses them in class.

B. ( ) Procedure. The instructor

- Announces deadlines well in advance and enforces deadlines consistently.
- Announces time allotted for tests and abides by it.
- Takes appropriate steps to prevent cheating.
- Keeps legible grade records which are interpretable by others at a later date.
- Keeps students appropriately informed of their current grade status.
- Handles student complaints on grading matters in a judicious manner.
- Maintains grading standards consistent with departmental standards.

____ (A + B) $\frac{A + B}{2}$ = ( )

(+) COMMENTS

(-) COMMENTS

If you feel that important criteria in the area of EFFECTIVENESS OF STUDENT EVALUATION have been omitted, or that the subtopics are not of equal importance (the "average" is not valid for the category), record what you believe to be a more accurate rating for this category by circling the appropriate number on the following scale:

FAIR	GOOD	OUTSTANDING
22, 24, 26, 28, 30	32, 34, 36, 38, 40	42, 44, 46, 48, 50

Figure 5

QUARTERLY PRODUCTIVITY ASSESSMENT

Name ____________________

Date .... F W S SS

Rating Scale: 10-9-8-7-6-5-4-3-2-1-0

(10-Outstanding, 6-Good, 3-Fair, 0-Irrelevant)

EVALUATION FACTORS	Rating	Appointment	Score
TEACHING			
Methodology			
Motivational Attributes			
Interpersonal Relations			
Effectiveness of Student Evaluation			
Composite Total:	____	1-2-3-4	____
ADVISING			
Methodology			
Motivational Attributes			
Interpersonal Relations			
Composite Total:	____	1-2-3-4	____
SPECIAL/SPLIT APPOINTMENTS			
Administrative Assistance			
Course Development			
Problem Packs			
Research			
Video Tapes			
Other			
Composite Total:	____	1-2-3-4	____
COMMITTEES			
Department			
College			
I.S.U.			
Other			
Composite Total:	____	1-2-3-4	____
ASSUMED WORK	____	____	____
TOTAL:	____	____	____

Figure 6

ANNUAL EVALUATION

Name ____________________

Date ____________________

Rating Scale: 10-9-8-7-6-5-4-3-2-1-0

(10-Outstanding, 6 - Good, 3 - Fair, 0 - Irrelevant)

EVALUATION CRITERIA	Rating	Rating Factor	Score
PRODUCTIVITY			
Teaching Advising Special/Split Appts. Committees Assumed Work (E.C.)			
Composite Total:	____	5	____
GROWTH ACTIVITIES			
Research Writing Society Activities Consulting (Current) Continuing Education			
Composite Total:	____	2	____
EDUCATION (Formal)			
Degrees Grad. Credit Service School Professional Registration			
Composite Total:	____	1	____
EXPERIENCE			
Teaching Advising Industrial Research Consulting Military			
Composite Total:	____	1	____

SUMMARY:

To date, the Freshman Engineering Department Faculty Evaluation Committee has:

1) developed a master plan for comprehensive faculty evaluation that recognizes both ongoing quarterly productivity and yearly professional growth,

2) designed or redesigned questionnaires for student rating of instructors in all courses taught in the department,

3) developed a questionnaire for student rating of faculty advisors,

4) established a questionnaire and procedure guide for faculty peer rating and provided administrative summary forms for combining homogeneous teacher/advisor performance characteristics and to expedite a final, composite individual rating for each faculty member,

5) The department chairman has combined the use of forms and suggestions developed by the department committee with evidence obtained from a variety of other sources into a comprehensive faculty evaluation system with which to make the critical decisions required relating to honors, tenure, promotions and salaries.

CONCLUSIONS

- The system is not perfect but it has been improved.
- It is a system based on sound and tested principles.
- It is a workable system, The faculty response has been excellent.
- The plan has drawn the favorable attention of the Dean of Engineering at Iowa State University and expressed interest by other departments in the college.
- The work is far from complete. As faculty evaluation (like student evaluation), is an ongoing activity, continuing analysis and upgrading of the system sill be required.
- It is headed in the right direction and it's moving!

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CHARLES J. VIERCK 1906-1979

Charles J. Vierck, age 73, of 787 Turtle Beach Road, Lost Tree Village, Florida, formerly of Doone Road, Upper Arlington, OH, died at his home, Friday, December 14, after an extended illness. Mr. Vierck received a B.S. degree in Mechanical Engineering from the University of Iowa in 1929, was Assistant to Professor Frederick G. Higbee of the University, and in 1930 was chosen to teach and co-author with Professor Thomas E. French of Ohio State University the book "Engineering Drawing." Subsequently he received a full professorship at Ohio State University remaining there for 25 years. In 1929 he retired to devote full time to authorship, in conjunction to McGraw Hill Publishing Company of his numerous textbooks. In 1959 he became a visiting professor at the University of Florida. Professor Vierck was a world renowned author, having co-authored with Thomas E. French "Engineering Drawing" now in its 12th edition and sales of over 2 million copies. He also authored "Graphic Technology," "Fundamentals of Engineering Drawing," "Graphic Science" and other engineering textbooks and films used in major universities and engineering schools throughout the world. The books were translated in numerous languages.

He was a member of the American Society of Mechanical Engineers, American Society of Engineering Education, Sigma Psi and American Standards Association. He is survived by his wife Elizabeth of Lost Tree Village; 2 daughters, Mrs. Thomas M. Metler of Palm Beach, Florida, Miss Elizabeth Vierck of Boston, Mass. and Washington, D.C.; a son, Dr. Charles J. Vierck of Gainesville, Florida; a brother Robert K. Vierck of State College, PA, and 6 grandchildren.

from the midyear conference

"QUIZ TIME!"

ENGINEERING GRAPHICS QUIZZES WITHOUT DRAWINGS

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Perhaps the title is just a bit misleading. The quizzes in question may very well have drawings, but they are as complete as need be before the student receives them. Consider the alternative of having the class do a drawing-type quiz: The instructor walks into the classroom and announces "quiz time". What follows is -- first, panic, then a general state of confusion as equipment is pulled from lockers (or from wherever) and at least one scale has to hit the floor before the class gains a relative state of readiness. Now, you have to wait for the four late-comers who have just come in to gather their equipment and get settled.

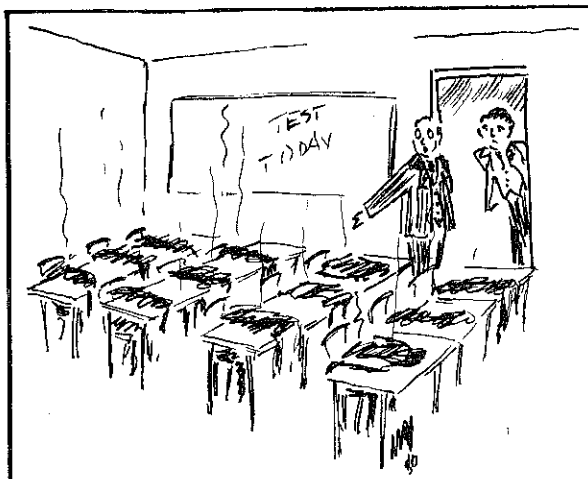
The following is a description of a quizzing system that has been found to work equally well for Engineering Graphics classes as large as 150 students in a lecture setting or 30 or less students in a lab session.

The quizzes are generally designed to take ten minutes. Examples A through E have the ten minute time limit while Example F, which is more comprehensive, is a twenty-minute quiz. When "quiz time" is announced using this type of quiz, there is nothing for the student to do except to close his book, close his mouth, and deal with his initial panic -- quietly.

The quizzes are given at the very beginning of the class period. They are unannounced, but the students are told the first day of class to be prepared for a quiz every time they walk into the room. Also, they are told that first day that everyone will start the quiz together and all work on the quiz is to cease when time is called. Therefore, they know that if they come to class late they have lost valuable time to work on the quiz. There are no make-up quizzes, but the lowest two grades are dropped at the end of the course. It is made clear that if the student misses two classes in which quizzes are given - these are the two lowest grades dropped. It does not take long for the students to figure out that they dare not miss a quiz for fear that they might need to take advantage of the drop action on a quiz or two on which they may not do well. The end result is that attendance is strong and tardiness is rare.

The number of quizzes given per term may vary according to the objectives of the quizzing system. For example, one term all graphics students were assigned to a common large lecture session per week and one of the several smaller drawing labs. To encourage attendance in lecture that term, a quiz was given every week. This did increase the attendance, and it automatically took roll. If quizzes are given to encourage dedication to the course, a quiz might be given only when this dedication is falling off.

The types of quizzes are limited only by the instructor's imagination. Example A is the old familiar True and False quiz. Examples D, E, and F all ask "in which view or views would you find . . .?" This type of questioning has worked very well; it challenges the student to analyze the situation under the pressure of a time limit. He presents his solution by simply placing a number and/or letter on the provided line. Example C is a smorgasboard of five different types of questions. It would not be proper for the class to think that the professor is in a <u>rut</u>!



I made a mistake and gave one of my hour quizzes in 10 minutes!

Students always want to know about grading. If the grading procedure is made clear at the outset, there is generally no dispute as the term progresses. On questions such as those found in example quizzes D, E, and F, the student's answer is given full credit only if the entire answer is correct. Any incorrect answer on the line makes the total answer wrong; and, if only part of an answer is given but there is nothing incorrect on the answer line, half credit is given.

To illustrate: Question 10 on Example Quiz D has four answers -- auxiliary view 2, auxiliary view 3, frontal view, and profile view.

Student answer to Quest. 10, Ex. D.	Credit
2, 3, F, P	full credit
2, 3, F	1/2 credit
2, 3	1/2 credit
3	1/2 credit
2, 3, F, P, 1	no credit
2, 3, F, 1	no credit

The grading procedure has generated virtually no controversy since the rationale is explained that a person may overlook a correct answer, therefore partial credit is in order; but if he puts down an answer which is incorrect, it is obvious that he has a breakdown in his reasoning, penalty - no credit.

Overall, the student's reaction to this quizzing system if favorable. Perhaps not at first but as the term progresses he realizes that he is gaining on the subject matter becuase of the continuous quiz preparation. And, the idea of no major tests is appealing.

In conclusion, the following is a list of advantages of this quiz system:

1. It keeps students up-to-date in the work.
2. It improves attendance.
3. Tardiness is rare.
4. It can be used to take roll.
5. It sharpens the student's ability to analyze under pressure.
6. It provides positive feedback to the instructor of his strengths and weaknesses.
7. It distributes the load of testing over the full term.
8. Quizzes can be graded very rapidly.
9. Students know where they stand at all times.

TRUE AND FALSE

Circle T or F

T F 1. Any view adjacent to the frontal plane of projection will show height measurements.

T F 2. All elevation orthographic views will show the true slope of a line provided the line is seen in true length.

T F 3. It is not possible to see a horizontal line in true length in more than the horizontal view.

T F 4. The bisector of a line will appear to bisect the line, no matter how the line is viewed, provided the line does not appear as a point.

T F 5. Three points not in a straight line cannot appear to be in a straight line in more than one view.

T F 6. Any view adjacent to the profile plane of projection will show width measurements.

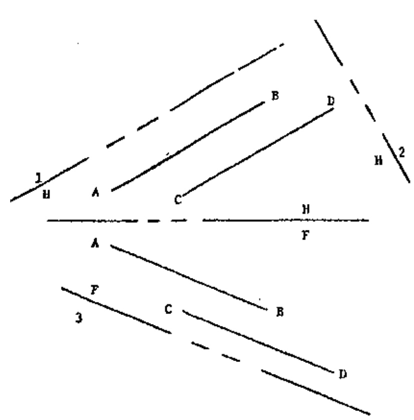
T F 7. All three space dimensions, height, width, and depth, are shown in any two principal orthographic views.

T F 8. The slope of a line can be seen in the profile view if the line is a frontal line.

T F 9. A line can appear either in true length or shorter than true length, but never longer than true length in any orthographic projections.

T F 10. It is possible to see a given line in true length in all three principal planes of projection.

EXAMPLE A



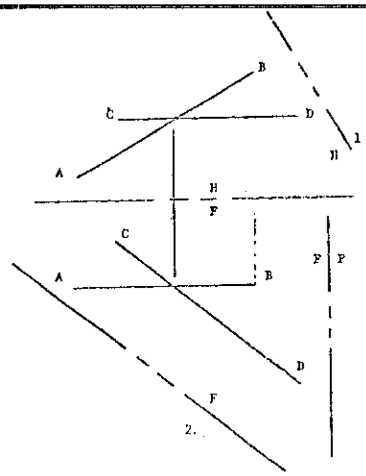
Select your answer for questions 1 through 5 from the following list and place the letter(s) and/or number in the space provided.

P - Profile
H - Horizontal
F - Frontal
1 - Auxiliary 1
2 - Auxiliary 2
3 - Auxiliary 3
N - No view shown

In which view or views would you find:

1. The true length of line AB? ______
2. The bearing of line CD? ______
3. The slope of line AB? ______
4. The point view of line CD? ______
5. The true distance between lines AB & CD? ______

EXAMPLE B(1)



Select your answer for Questions 2 through 5 from the following list and place the letter(s) and/or number(s) in the space provided.

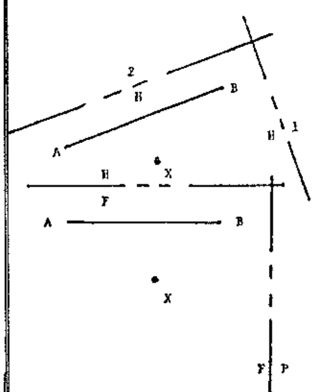
P - Profile
H - Horizontal
F - Frontal
1 - Auxiliary 1
2 - Auxiliary 2
N - No view shown

1. Are lines AB and CD interesting lines? (Circle answer) YES NO

In which view or views would you find:

2. The true slope of line CD? ______
3. The point view of line AB? ______
4. The true length of line AB? ______
5. The bearing of a line AC? ______

EXAMPLE B(2)



SELECT YOUR ANSWER FOR QUESTIONS 1 THROUGH 5 FROM THE FOLLOWING LIST AND PLACE THE LETTER(S) AND/OR NUMBER(S) IN THE SPACE PROVIDED.

P - Profile
H - Horizontal
F - Frontal
1 - Auxiliary 1
2 - Auxiliary 2
N - No view shown

I. IN WHICH VIEW OR VIEWS WOULD YOU FIND THE:

1. Strike of plane ABX ______
2. True distance between point X and point B ______
3. Perpendicular distance between point X and line AB ______
4. Point view of line AB ______
5. Slope of plane ABX ______

II. 6. The point view of the line of intersection of two planes will always show the true angle between the two planes and the dip of each. T F

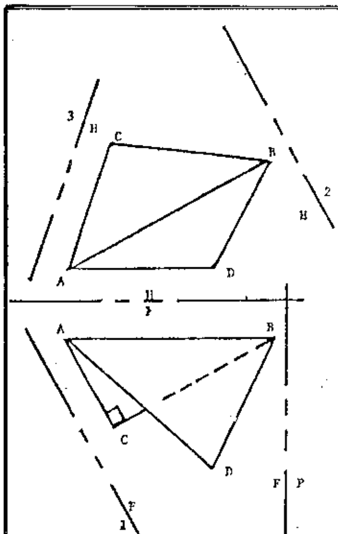
7. A plane has a slope direction of N30°E. What is the strike of the plane? ______

8. Three points appear to be in a straight line in two consecutive views. The points are therefore truly in a straight line. T F

9. What space dimension is found in both the profile view and the horizontal view. ______
   a. height
   b. width
   c. depth

10. A line has a slope of 4:30. What is the % grade? ______

EXAMPLE C



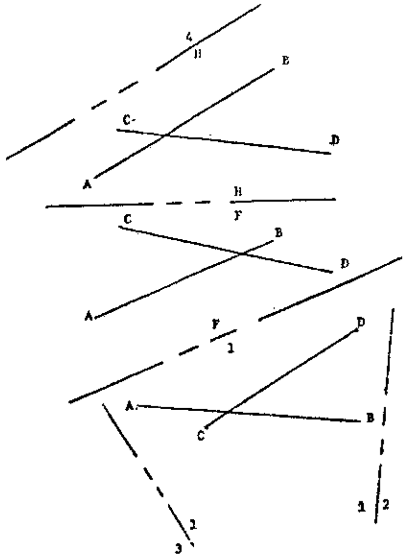
SELECT YOUR ANSWER FOR QUESTIONS 1 THROUGH 10 FROM THE FOLLOWING LIST AND PLACE THE LETTER(S) AND/OR NUMBER(S) IN THE SPACE PROVIDED.

P - Profile
H - Horizontal
1 - Auxiliary 1
2 - Auxiliary 2
3 - Auxiliary 3
N - No view shown

EXAMPLE D

IN WHICH VIEW OR VIEWS WOULD YOU FIND:

1. The true length of line AC ______
2. The point view of line AB ______
3. The true ∠ between planes ABC & ABD ______
4. The true ∠ between lines DA and DB ______
5. The strike of plane ABC ______
6. The dip of plane ABD ______
7. The normal view of plane ABC ______
8. The edge view of plane ABC ______
9. The slope of line AC ______
10. Elevation dimensions ______



SELECT YOUR ANSWER FOR QUESTIONS 1 THROUGH 10 FROM THE FOLLOWING LIST AND PLACE THE LETTER(S) AND/OR NUMBER(S) IN THE SPACE PROVIDED.

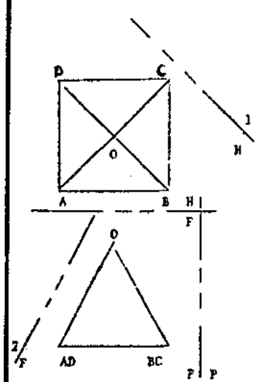
EXAMPLE E

P - Profile
H - Horizontal
1 - Auxiliary 1
2 - Auxiliary 2
3 - Auxiliary 3
N - No view shown

IN WHICH VIEW OR VIEWS WOULD YOU FIND:

1. The bearing of the shortest connector? ______
2. The true slope of the shortest connector? ______
3. The true length of the shortest connector? ______
4. The shortest connector appearing perpendicular to line AB? ______
5. The slope angle of line AB? ______
6. The angle line AB makes with the frontal plane of projection? ______
7. The point of view of line CD? ______
8. Depth dimensions (front to back)? ______
9. Elevation dimensions? ______
10. Width dimensions (left to right) ______

EXAMPLE F



In which view or views would the following be found:

1. The true slope of line OA ______
2. The point view of line AB ______
3. The strike of plane AOB ______
4. The slope of Plane AOB ______
5. The slope of plane BOC ______
6. The Normal View of plane AOD ______
7. The true ∠ between lines OB and OD ______
8. The true ∠ between lines AB and AD ______
9. The true ∠ between planes AOB and DOC ______
10. The point view of line OC ______
11. The true ∠ between line OA and plane ABCD ______
12. The true ∠ between lines OA and OD ______
13. The true ∠ between line OB and plane ABCD ______
14. The ∠ between planes BOC and ABCD ______
15. The shortest distance between line AD & line OB ______
16. The true distance between lines AB and CD ______
17. Distance between point O and plane ABCD ______
18. Distance between line AB and plane COD ______
19. Distance between point O and line CD ______
20. The true slope of line OB ______

Take Answers from:

H -- Horizontal
F -- Frontal
P -- Profile
1 -- Auxiliary 1
2 -- Auxiliary 2
N -- no view shown

Bonus Question: What line or lines are not shown in true length in any view represented? ______

The author's answers to the example quizzes follow, if you would like to compare answers.

ANSWERS TO A - F

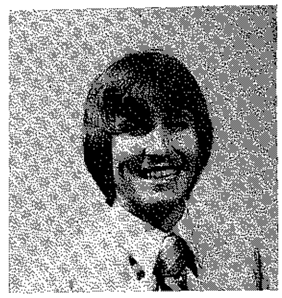
Example A	Example B	Example C	Example D
1. F	1. 1, 3	1. H	1. 1, 3
2. T	2. H	2. N	2. 2
3. F	3. 1	3. 1	3. 2
4. T	4. N	4. 1	4. N
5. F	5. N	5. 1	5. H
6. T	1. Yes	6. F	6. 2
7. T	2. F	7. N60°W	7. N
8. F	3. 1	8. F	8. 2
9. T	4. H	9. C	9. 3
10. F	5. H	10. 13.33%	10. 2, 3, F, P

Example E	Example F	
1. H	1. N	11. N
2. N	2. P	12. 2
3. 2	3. H	13. 1
4. 1(4,2)	4. P	14. F
5. 4	5. F	15. F
6. 1	6. 2	16. H, P, 2
7. N	7. 1	17. 1, F, P
8. H, 1	8. (F,P)H, 2	18. P
9. F, 4	9. P	19. P
10. F, H	10. N	20. 1
		BQ. OC

from the midyear conference

CREATOR - ITS USE AND PROBLEMS

John T. Demel



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ABSTRACT

CREATOR™ is a computer-aided software package being developed for freshmen engineering design at Texas A&M. The system software and hardware will be discussed. The problems discovered and solved during the development will be explained briefly along with the apparent limitations of the hardware configuration.

I. INTRODUCTION

The Engineering Design Graphics Department at Texas A&M University is developing a computer-aided design software package for use in freshment engineering design projects. This work is being funded by the National Science Foundation, by Houston Instrument and by the Texas Engineering Experiment Station.A previous paper[1] described the background for the work including the software plan and a hardware development sytem. Since that paper was presented, the development system has undergone considerable change and modifications have been made to the software plan. This paper will describe the hardware configuration now being used and the progress in software development. Some of the experience in using the system in class will be described along with the things the authors have learned during the development.

* The software development is being supported by the National Science Foundation under a Local Course Improvement grant SER 78-00370, by Houston Instrument through loan of equipment, and by the Texas Engineering Experiment Station.

II. SYSTEM HARDWARE

In a previous paper[1] the development system for CREATOR was described as being a North Star Microcomputer (32K bytes of RAM Memory and one disk drive) and a Tektronix terminal. The current configuration is a similar microcomputer and graphics CRT with plotter, digitizer and printer. See Figure 1.

The system microcomputer is a North Star Horizon ™ with 48K bytes of RAM Memory, two minifloppy disk drives, two serial input/output (I/O) ports, one parallel input port and one parallel output port. The graphics CRT is a Lear Siegler ADM-3A™ modified with the addition of Digital Engineering's Retrographic™ RG-512 PC board. The graphics resolution is 512H x 250V for a screen area of 10 inches by 7 inches. The RG-512 board permits the use of Tektronix software although that feature is not used in this system. The HIPLØT™ 7 in. by 10 in. plotter and HIPAD™ 11 in. x 11 in. digitizer board are manufactured by Houston Instrument and have selectable resolutions of either .01 in. or .005 in. The CRT, digitizer and plotter have similar resolutions and sizes and this allows the user to see on the CRT what will be plotted on the plotter after the figure has been input from the digitizer board, without the need for scaling. The printer is a Heath Data Systems WH-14 and provides 10 characters/inch (80 column), 12 characters/inch (96 column) or 16.5 characters/inch (132 column) on 8.5 inch wide paper. The total system cost is approximately $8500.00.

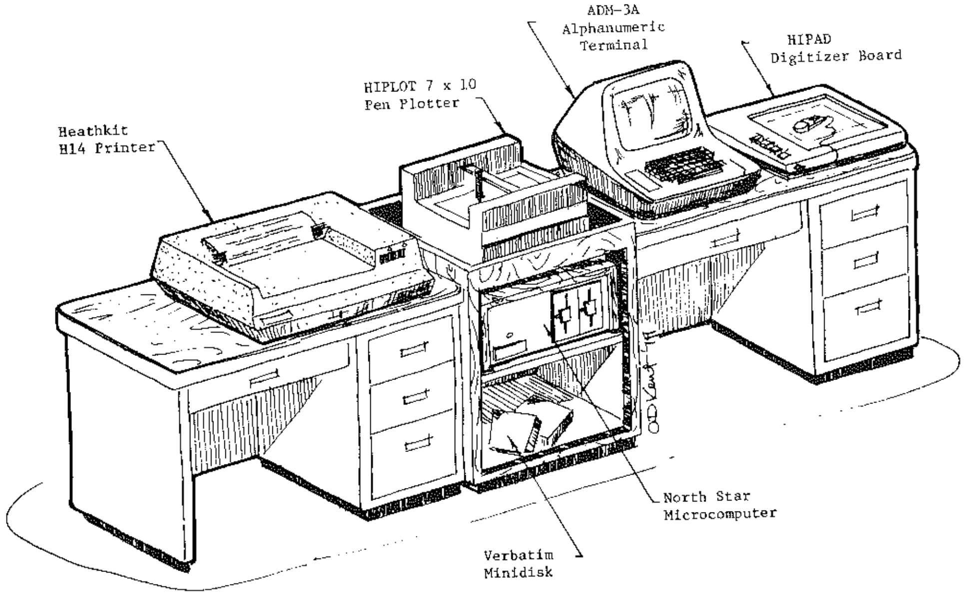


Figure 1. CREATOR Hardware Configuration.

The modified CRT is interfaced to the North Star microcomputer through an RS-232-C serial I/O port at 9600 baud. The printer is interfaced at 4800 baud using the second North Star serial output port and an asynchronous 'clear to send' line. The plotter is connected to the parallel output port and utilizes the first six of the eight parallel lines provided. The digitizer is physically connected to the parallel input port but uses only the first of these eight input lines for optional digitizer control along with the last two parallel output lines. Actual communication is via the second RS-232-C serial input port by internal jumper. The digitizer communications rate is 4800 baud.

III SOFTWARE

The discussion of software will be divided into two parts, system software and applications software. The system software covers the operating system, the programming language used and the subroutines or functions used to drive the peripherals. The applications software is comprised of the programs that the students use.

The programming language chosen for the development was North Star's BASIC. It is a 16K interpreter BASIC (occupies 16K bytes of memory) and provides for user defined functions. BASIC was chosen because it is available on most microprocessor-based systems.

The System Software

The CREATOR system is being developed for freshmen. The software is written so that the student can answer questions while using the system and not have to know about programming. A system monitor has been written that allows the student to choose which program he wishes to execute from a list or 'menu'. See figure 2. This is keyboard input and if the student makes a mistake the terminal 'beeps' at him and allows him to try again. Interrupts are disabled so that the student cannot inadvertently stop execution.

All programs are written with these features so that the student is prevented from making most errors that would cause the system to stop running. It is impossible to think of all the ways the system might be stopped and if the student does stop the system he can press the RESET button and the software will begin execution with the menu.

Handouts on the software (user's manuals) are provided for the student using the system. In addition there is a summary of instructions at the system desk. Each student is given a demonstration of each type of software (graphing, text editing, sketching, etc.) before he has to use it. For most students the demonstration and user's manuals are sufficient to use the system effectively.

```
** CREATOR SYSTEM MONITOR ** TAMU  VER. 2.0 4/3/79

************  CREATOR DEMO DISK  ************

THESE ARE YOUR PROGRAM CHOICES FOR THIS DISK.

CATEGORY          PROGRAM NAME
--------          ------------
GENERAL           FILES
                  TEXT
GRAPHS            BARGRAPH
                  BRLGRAPH
                  PIEGRAPH
DEVELOPMENT       SKETCH2D
                  PLOT 3D
ANALYSIS          LATHE
                  MILL
INPUT WHICH YOU WOULD LIKE TO RUN.  ?
```

Figure 2. CREATOR Menu.

In order to have the system perform as described above minor modifications had to be made to the disk operating system (DOS) and to BASIC. One of those modifications was the addition of the machine code plotting routine for the HIPLØT plotter to BASIC. Such routines are called 'drivers' and each peripheral (digitizer, plotter, printer and the graphics board in the CRT) requires one. The other drivers were all written in BASIC. Originally the plotter driver was written in BASIC for a serial port but when the decision was made to use the NORTH STAR I/O ports (only 2 serial I/O ports) the machine code routine was written. This allowed the use of the North Star parallel output port. It also allows the use of other plotters that require a parallel output port such as a CalComp 563 drum plotter.

All software is documented by identifying variables and by describing the routine functions. Some routines require that the documenting statements be removed before execution due to memory size. Figure 3 shows part of a typical documented routine.

Applications Software

At Texas A&M University the freshman engineering design graphics courses, EDG 105 and 106, are organized with a team design project requiring one third of the class time. The design activities follow a six-step design process which includes Problem Identification, Preliminary Ideas, Refinement, Analysis, Decision and Implementation. The CREATOR software is being written for the students to use in the design process. This is not to replace the current program but, instead is to supplement the students' activities and let them see the advantages and disadvantages of such systems. See Figure 4 - CREATOR Software Organization.

In the following paragraphs a brief description of the programs currently available will be provided and also the software yet to be written will be noted. Many times as programs are written hardware features are discovered that prevent programs from being written that had been planned or allow for ones that had not been planned.

a. Problem Identification

The programs available for Problem Identification are TEXT and the graphing routines for bar graphs, pie graphs, and broken line graphs. The TEXT program is a subset of the North Star text editing functions

```
10    REM PROCEDURE - LATHE
20    REM
30    REM FUNCTION - ESTIMATES THE MACHINING TIME FOR A LATHE
40    REM             TURNING OPERATION
50    REM
60    REM INPUTS - 1)DIAMETER OF THE STOCK TO BE MACHINED
70    REM          2)THE NUMBER OF DIAMETERS TO BE MACHINED
80    REM          3)DIAMETER OF EACH CUT
90    REM          4)LENGTH OF EACH CUT
100   REM          5)THE TYPE OF MATERIAL TO BE USED
110   REM          6)THE NUMBER OF PARTS TO BE MADE
120   REM
130   REM PROCESS - 1)GET THE DIAMETER OF THE STOCK
140   REM           2)GET THE NUMBER OF DIAMETERS TO BE MACHINED
150   REM           3)GET EACH DIAMETER
160   REM           4)GET EACH LENGTH
170   REM           5)GET THE TYPE OF MATERIAL
180   REM           6)GET THE NUMBER OF PARTS TO BE MADE
190   REM           7)CALCULATE THE ESTIMATED TIME TO MACHINE THE LOT
200   REM           8)CALCULATE THE ESTIMATED TIME TO MACHINE ONE PART
210   REM
220   REM OUTPUT - 1)THE TIME TO MACHINE THE LOT
230   REM          2)THE TIME TO MAKE ONE PART
240   REM
250   REM EXTERNAL REFERENCES - NONE
260   REM
270   REM EXIT CONDITIONS - NORMAL COMPLETION
280   REM
290   REM ERROR MESSAGES - 1)ERROR,LLLLL,NN
300   REM                    WHERE LLLLL IS THE LINE NUMBER IN WHICH THE
310   REM                    ERROR OCCURRED AND NN IS THE ERROR CODE.
320   REM                  2)*** ERROR *** THE STOCK SIZE MUST BE GREATER
330   REM                        THAN ZERO!
340   REM                    THIS IS DISPLAYED WHENEVER ZERO IS INPUT FOR
350   REM                    THE STOCK SIZE.
```

Figure 3. Lathe Routjne - Partial Documented Listing.

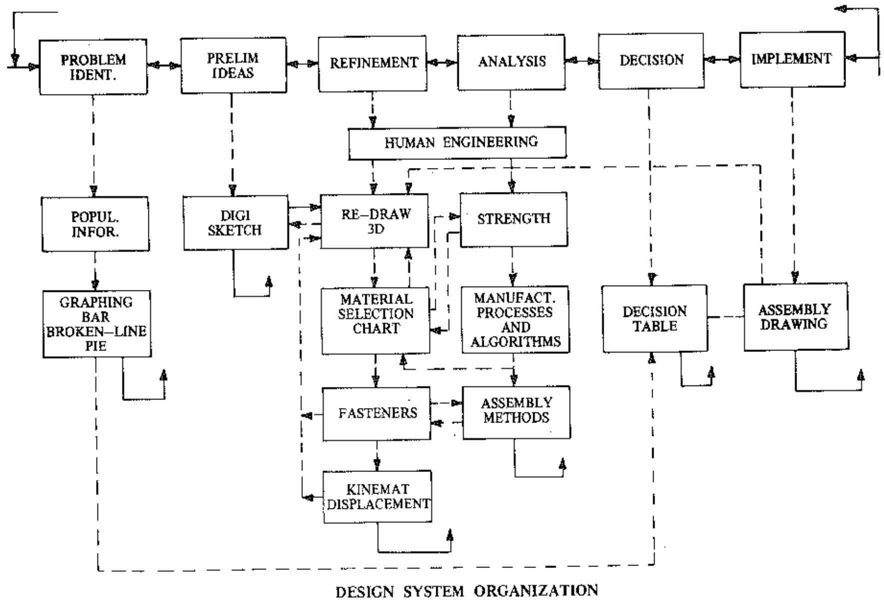


Figure 4. CREATOR Software Organization.

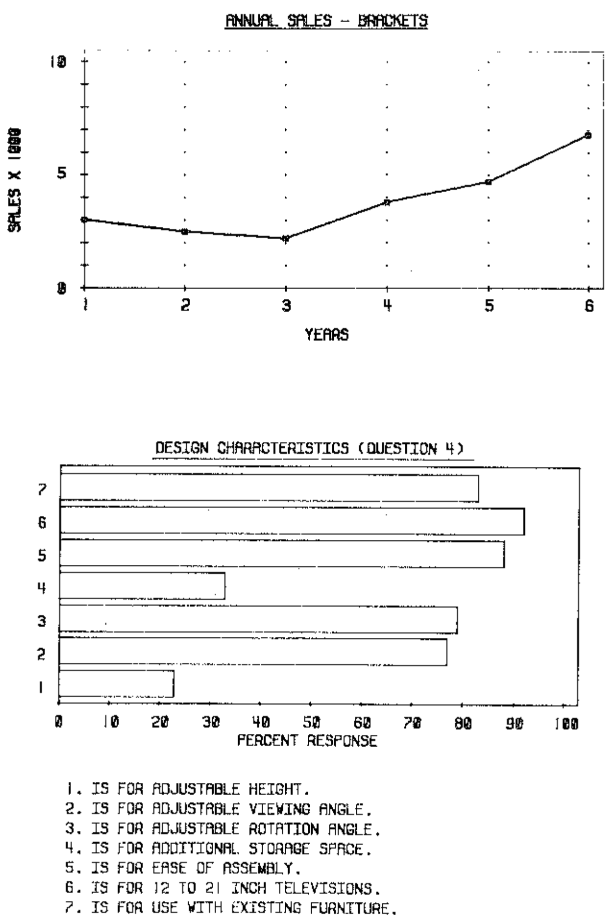


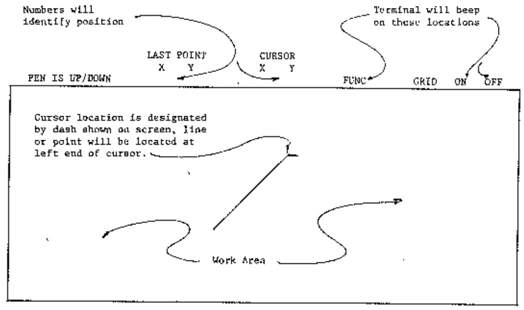
Figure 5. Typical Bar and Broken-line Graphs.

that allow students to prepare, edit and print out problem statements and questionnaires. Each team of students have a user disk and a program called FILES is available to create disk space for a copy of any text generated. The graphing routines are used to display questionnaire results. Figure 5 shows typical bar and broken line graphs.

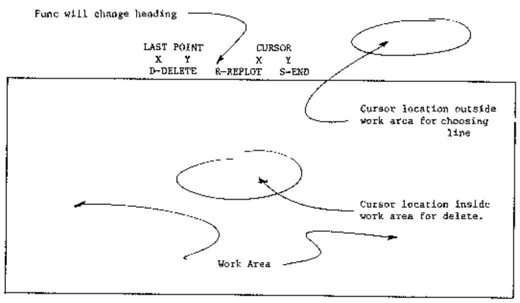
b. Preliminary Ideas

In this part of the design process the students sketch pictorial views of ideas generated in a brainstorming session. SKETCH 2D can be used for two dimensional objects. The student uses FILES to create disk space for X,Y coordinates and pen values. Then he can trace his figure using the digitizer and see the results on the CRT. If a line is incorrect he can edit the picture and get a plot from the plotter. Figure 6a shows the items the user sees on the screen as he is digitizing his figure and Figure 6b shows the screen when the function option is chosen in Figure 6a.

INPUT3D is a program that requires the student to establish the X,Y,Z coordinates of the features of an object and the path that a pen plotter would take connecting those points. If an isometric grid is used for the pictorial sketch this is relatively easy to do. As the student puts in his points the figure or part is plotted on the CRT screen as an isometric drawing and the X,Y,Z coordinates and pen values are printed on the screen. If a point is input incorrectly the student can take the last point out by striking 'CONTROL' 'C' on the keyboard. This erases the last point or line from the CRT screen as well. Figure 7a shows the screen dring input and Figure 7b shows the finished part. The FILES program is required to



a.

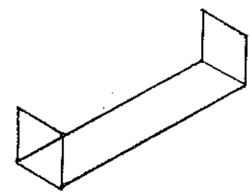


b.

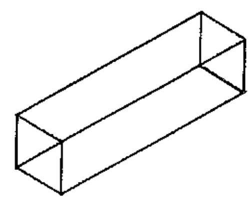
Delete will allow any one line to be removed from the sketch file. The current delete line is blinked at about 1HZ. Lines are selected in reverse order by pressing the cursor button with the digitizer puck located above the work area. The blinking line is deleted if the puck is within the work area.

Figure 6. SKETCH2D CRT Display.

```
POINT (1)   0 0 0
INPUT P  3
POINT (2)   1 0 0
INPUT P  2
POINT (3)   1 1 0
INPUT P  2
POINT (4)   0 1 0
INPUT P  2
POINT (5)   0 0 0
INPUT P  2
POINT (6)   0 0 4
INPUT P  2
POINT (7)   1 0 4
INPUT P  2
POINT (8)   1 1 4
INPUT P  2
POINT (9)   0 1 4
INPUT P  2
POINT (10)  0 0 4
INPUT P  2
POINT (11)  1 0 4
INPUT P  3
POINT (12)  1 0 0
INPUT P  2
```



a.



b.

```
POINT (1)   0 0 0 3
POINT (2)   1 0 0 2
POINT (3)   1 1 0 2
POINT (4)   0 1 0 2
POINT (5)   0 0 0 2
POINT (6)   0 0 4 2
POINT (7)   1 0 4 2
POINT (8)   1 1 4 2
POINT (9)   0 1 4 2
POINT (10)  0 0 4 2
POINT (11)  1 0 4 3
POINT (12)  1 0 0 1
POINT (13)  1 1 0 3
POINT (14)  1 1 4 2
POINT (15)  0 1 4 3
POINT (16)  0 1 0 2
```

Figure 7. INPUT3D CRT Display.

create disk storage space for 3-D data as it was for 2-D data. A separate file for each part of an assembly can be created. These part files can then be put together to form an assembly drawing using a program called ASSEMBLY. Figure 8 shows two parts in an isometric assembly.

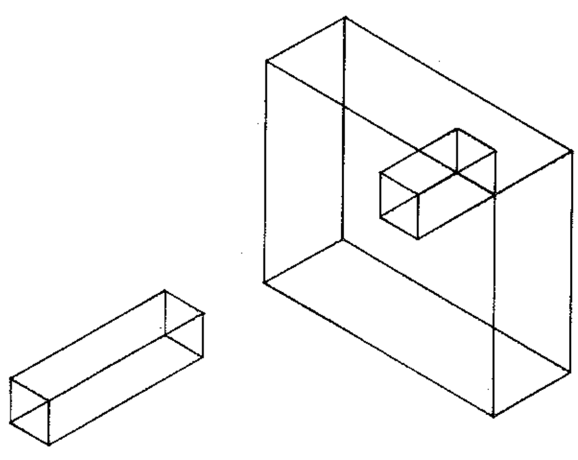


Figure 8. Isometric Assembly.

Once a file of 3-D data is established on the disk a program called PLOT3D allows the data to be plotted as an orthographic, oblique isometric, axonometric or perspective drawing. Figure 9 shows these drawing of a simple object.

All figures are dealt with as 'wire frame' drawings. Most students can work with these effectively and eliminate hidden lines as needed.

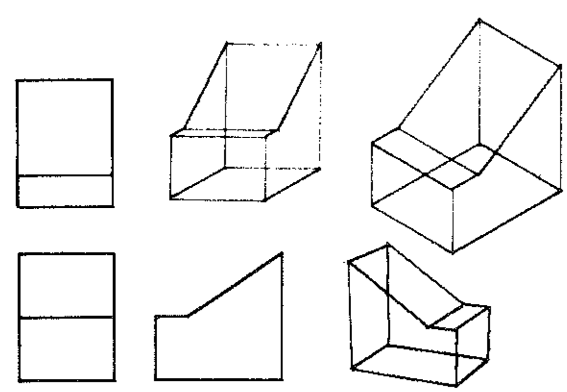


Figure 9. PLOT3D Output Options - Orthographic, Oblique, Isometric, Axonometric Drawings.

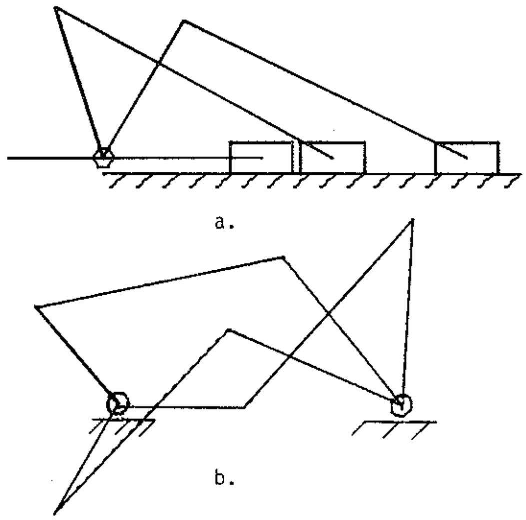


Figure 10. Crank-rocker and Crank-slider Linkages.

c. Refinement and Analysis

Although much remains to be done in these areas INPUT3D and PLOT3D can do scale drawings for refinement. In addition programs for some kinematic linkages have been developed to help the student determine clearances for moving parts. Crank-slider and crank-rocker linkages have been developed and are the most common 4-bar linkages. In many cases this level of sophistication is not needed but these programs will provide insight into the best way to display rotating and translating parts. Figures 10a and 10b show these linkages. The programs also provide velocities and accelerations as well as displacements.

Going further in kinematic analysis requires that the path of a point on a two-dimensional connecting link be produced. This provides information for more complicated linkages. The programs for calculating velocity and accelerations for the point have not been written yet. Figure 11 shows a typical linkage in two positions and the path of a point on the coupler link.

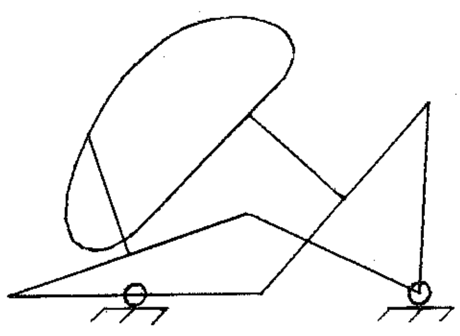


Figure 11. Path of a point on a 2-D Connecting Link for a Crank-rocker Linkage.

Another aspect of analysis is the time required to manufacture a part. Freshmen rarely have a good concept of manufacturing details. In order to attack with this problem a series of manufacturing time estimation programs have been developed that will allow the student to determine how long it will take to manufacture one or several parts. The formulas used are based on metal removal rates and carbide tools. The student need only know the material, and volume to be removed. Four programs have been developed. They include LATHE, MILL, DRILL and WELD. Other programs for casting and molding processes have been partially written. Several additional programs will be required to adequately cover processes that the freshmen might use.

As the programs for manufacturing were being developed considerable time was spent finding a limited list of materials for the design projects. The list included metals plastics, ceramics, rubber and woods and their costs, properties and typical applications. Both the manufacturing processes and the materials list will be covered in more detail in a future article. It should be noted that the programs give reasonable estimates, not exact answers. One of the most difficult things was to remember that the users are freshmen and not get bogged down with details that only juniors, seniors or manufacturing engineers might understand. The two people involved in this part of the project were Scot Carpenter, now of the University of Houston, and Helen Fitz, a Texas A&M graduate student.

A set of routines for strength analysis has been started but is not ready at this time. Such programs that are available require input data that most freshmen are not ready to provide.

d. Decision and Implementation

Little work has been done on the last two steps of the process. Analysis provides information for making decisions but no system of files has been developed to store the analytical information. Implementation for the freshmen design projects is a set of working drawings. The INPUT3D and PLOT3D program should make this relatively easy.

IV. SOME PROBLEMS

Hardware

The authors had assumed that 32K of memory and one disk drive would be sufficient. 48K and two disk drives proved to be necessary for implementing software. It was assumed that two people could time share one microcomputer. At the current state of hardware only one person using graphics can use one microcomputer and maintain reasonable response time. A printer or plotter might be shared, but a microcomputer, graphics CRT and digitizer board are essential for each user. For freshmen and many other students the resolution of .01 inch is sufficient as long as all components match.

Software

Much of the initial software was written with a deadline for a particular program rather than meeting certain specifications. This is not the correct approach. It is better to lay out each step and program required. The original software was not documented because it was not possible to do it in the time allotted. Now a second programmer has been hired to standardize program features and document programs. He will become the chief programmer. User orientation requires that the student-user not be overwhelmed by the system. All programs should be liberally supplemented with handouts and demonstrations.

Personnel

One person should have a concept of the system function. One person should understand electronics and programming to stretch the system to its capacity. One person should be willing to keep the documentation up, make sure programs have a standard form and keep track of programs. Other people are required for special applications. This project could not be carried out without each of the individuals mentioned above.

The understanding of electronics can be partially replaced by good dealers, salesmen and repairmen. Programming techniques can be learned. The essential element for all personnel is that they enjoy the challenge. With computer graphics it is rather easy to find people, particularly students, who can't wait to get their hands on hardware. It is a more difficult task to find which students want to play and which ones want to work. The EDG 408 class (Computer Graphics) has been a good source of students to work on the system.

V. RESULTS AND CONCLUSIONS

The CREATOR system has provided much information on hardware configurations and software features for the authors. The development system has been used in a pilot project with satisfying results, even though the software was not complete. The students were interested in using the system and, where software development was complete, used it to try more design alternatives. The students enjoyed using the system and when the class was over they left with the impression that computer graphics can be used to advantage in the design process.

The hardware configuration appears to be a good one for this educational design application and the resolution of the digitizer, CRT and plotter are satisfactory. The student gets to use many of the components found in graphics systems and loses his fear of the computer. The BASIC language provides enough features to utilize the capabilities of the hardware components.

Now that the drivers for the hardware peripherals have been written and the format for writing and documenting software established it is relatively easy to involve other personnel who have expertise in the design process or in manufacturing operations. Software development will continue in areas concerned with inputting and displaying three dimensional data and in manufacturing operations, including cost. More faculty members are getting involved with the system and the hardware configuration has been an excellent one of teaching beginning computer graphics programming.

The small microcomputer-based system is a superb one for starting a computer graphics program and the low cost makes systems such as this one very attractive for individuals and educational institutions.

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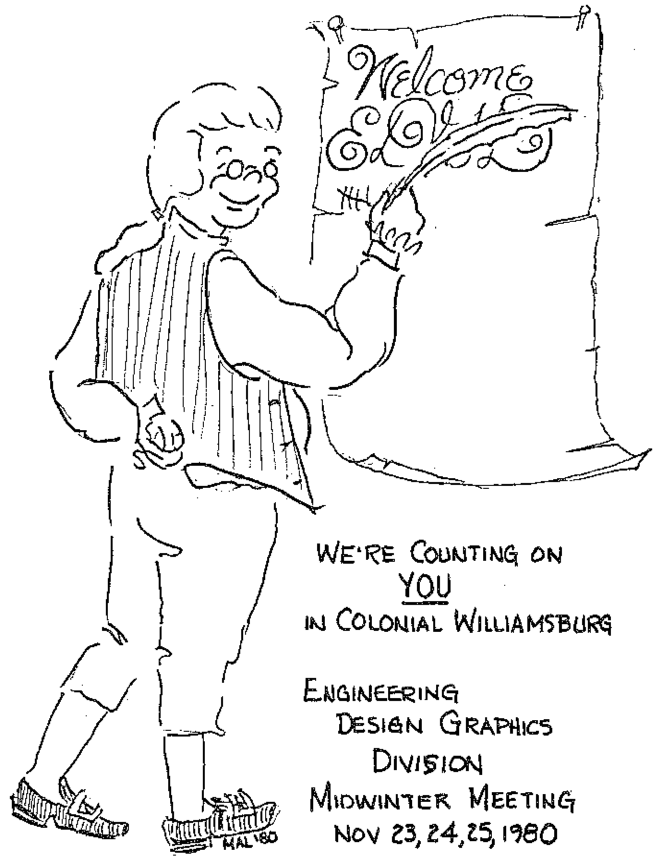


MID-YEAR MEETING
COGSWELL COLLEGE/SAN FRANCISCO
November 14-16, 1979

There are not enough pages in this entire issue of the Journal to report to the EDGD membership the complete value of the midyear meeting to those of us who attended. The technical program (printed in the Fall, 1979 Journal) was outstanding. Pete Miller really did an outstanding job in arranging for speakers and topics. Subjects on industrial use of graphics and modelling, faculty evaluation/motivation, computer graphics, teaching techniques, graphic techniques for presentation -- all of these filled our minds to the brim. But, San Francisco -- ah! -- the city filled our spirits. Ron Pare' knows his environs, and presented us with the best the city had to offer. From the facilities at the hotel, to the tours arranged for the participants and spouses, Ron and "company" left us with great memories.

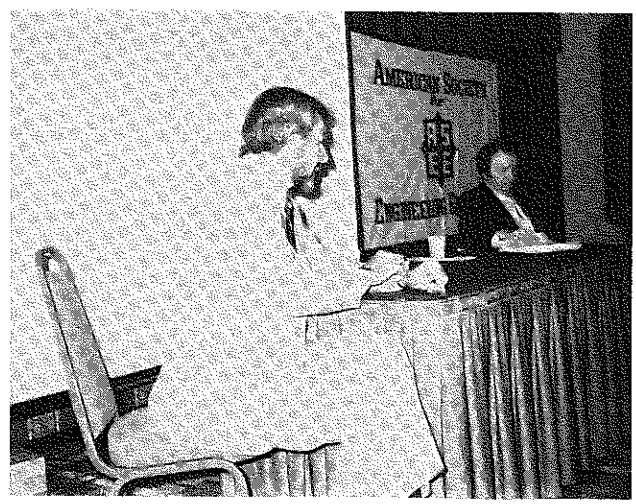
This was the first conference at which the "Certificates for participation" were awarded to the speakers and session chairmen. Of course, no report on the conference would be complete without mentioning the Oppenheimer Award. Frank Oppenheimer, the founder and donor of the award was able to be with us this year and we all count that as good fortune -- for us. The winners of the award were Sanders and Eide, who gave a memorable performance as "indian" and "chief", respectively.

But, next year -- on the other side of the continent -- Colonial Williamsburg, and another show by V.P.I.&S.U.

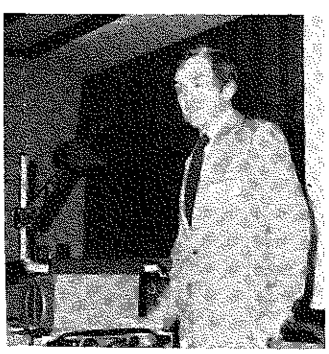
Thanks to Margaret Eller, whose snapshots appear on these pages, and to Larry Goss who also took photographs for the Journal. Y'all are good!!

Mary Copeland, WestArk Community College

John Demel, TAMU



Arvid Eide, Gordon Sanders
Iowa State University



Carlton Staples, WPI

Discussion at the Business Luncheon

Presentation of the Oppenheimer Award.
(Frank Oppenheimer, Arvid Eide)

AN UNAVAILABLE PROOF - AID FOR TEACHERS OF DESCRIPTIVE GEOMETRY

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ABSTRACT: Two proofs are suggested for the lemma: The horizontal projection of the major diameter of an elliptical section of the cone of rotation is always the major diameter of the horizontal projection of the section.

As it is known, the intersection line between a circular cone and a plane cutting two diametrically-opposite generating lines, is an ellipse (see fig. 1), with major diameter KL, and minor diameter MN. (Fig. 1 and fig. 2).

The projection of the ellipse on the horizontal plane will also be, generally speaking, an ellipse. But, while the size of the minor diamter MN when projected on the horizontal plane remains unchanged (i.e., "true size"), the major diameter is sometimes reduced very significantly. Very often the question arises whether the projection of the diameter KL on the horizontal plane may become shorter than that of MN.

fig. 1

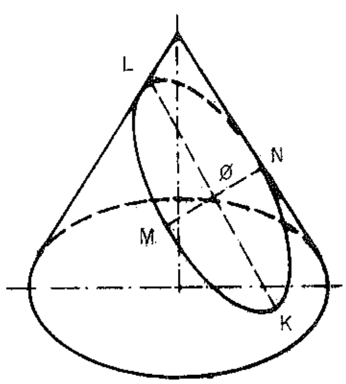
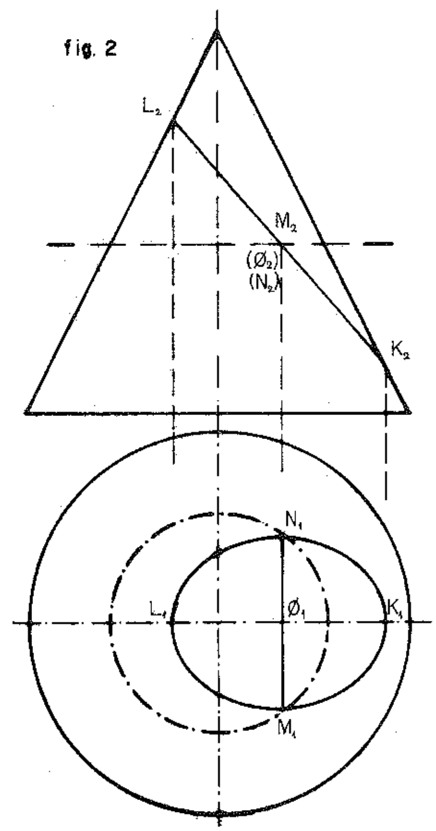


fig. 2



The writer checked a considerable number of the newer textbooks, and to his astonishment failed to find any hint of a proof that the major diameter remains longer in the horizontal projection of the intersection line ellipse.

Two simple proofs are suggested below.

For what follows it seems useful to recall the most commonly-used construction for obtaining the size of both main diameters of the ellipse in the two main projections (see fig. 2).

I. Proof Number 1.

Let us put the elevation of the cone in a cartesian system of coordinates.

1. VK $\therefore \quad \frac{x}{R} + \frac{y}{h} = 1$

VJ $\therefore \quad \frac{x}{R} + \frac{y}{h} = 1$

LK $\therefore \quad \frac{x}{R} + \frac{y}{m} = 1$

2. The coordinates of L (Point of intersection of $\overline{KL}$ and $\overline{JV}$):

$$y_L = \frac{2\ h \cdot m}{h + m}$$

$$x_L = R(1 - \frac{2h}{h + m}) = - R\,\frac{h - m}{h + m}$$

3. The coordinates of $\emptyset$ (Midpoint of $\overline{LK}$):

$$y_\emptyset = \frac{h - m}{h + m} = n$$

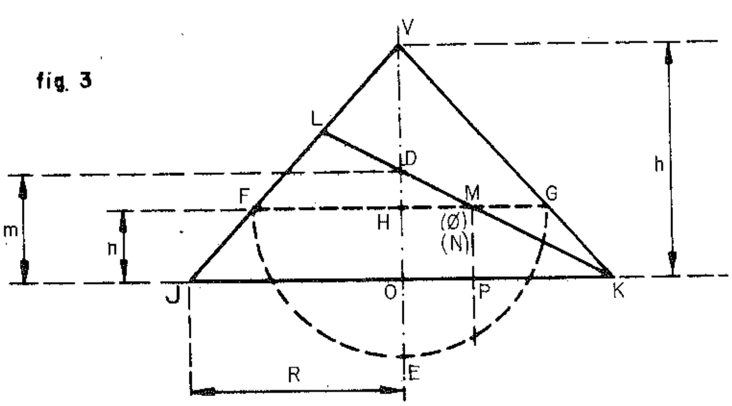
$$x = \tfrac{1}{2}\,(R - R\frac{h - m}{h + m}) = R\,\frac{m}{h + m}$$

4. $\overline{FH} = \overline{HE} = \overline{HG}$:

$$\frac{\overline{HG}}{R} = \frac{h - n}{h}$$

$$\overline{HG} = R(1 - \frac{n}{h}) = R(1 - \frac{m}{h + m}) = R\,\frac{h}{h + m}$$

fig. 3



Now, $\overline{PK}$ (the projection of the major half-diameter of the ellipse on the horizontal plane) equals:

$$\overline{PK} = R - x_\emptyset = R - R\,\frac{m}{h + m}$$

$$= R\,\frac{h}{h + m} = \overline{HG} = \overline{HE}$$

but, obviously

$$\overline{\emptyset N} < \overline{HE}$$

hence

$$\overline{\emptyset N} < \overline{PK}$$

Q.E.D.

II. Proof Number 2.

A still simpler proof is based on the theorem stating that a line passing through the midpoint of one of the sides of a triangle parallel to its base <u>equals half the base</u>.

Thus: $\overline{F\emptyset}$, passing through the midpoint of the side $\overline{LK}$ of the triangle J K L equals ½ JK, i.e. R: $\overline{F\emptyset} = R$

Now,

$$\overline{PK} = R - \overline{OP} = R - \overline{H\emptyset}$$

But,

$$\overline{FH} = \overline{F\emptyset} - \overline{H\emptyset} = R - \overline{H\emptyset}$$

Hence

$$\overline{PK} = \overline{FH}$$

Since

$$\overline{FH} = \overline{HE}$$
$$\overline{PK} = \overline{HE}$$

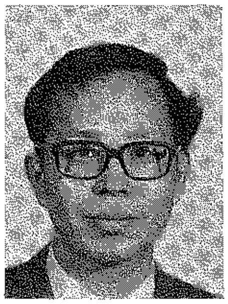
and obviously

$$\overline{HE} > \overline{N\emptyset}$$

Finally,

$$\overline{PK} > \overline{N\emptyset}$$

Bearing in mind that $\overline{PK}$ is the projection of the major half-diamter of the ellipse on the horizontal plane, the statement is proved.



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A REVIEW OF SOME MATHEMATICAL TECHNIQUES FOR PRODUCING AXONOMETRIC PROJECTION

Introduction

Among the various types of three-dimensional projections which find applications in engineering illustration, axonometric projection is used most extensively in catalogs, in general sales literature, and in engineering and technical manuals. To produce an axonometric projection it is necessary to rotate the object a certain angle about an imaginary vertical axis, and then tilt it forward about an imaginary horizontal axis. The front view obtained through orthographic projection is an axonometric projection. To graphically represent an axonometric projection, a Cartesian coordinate system, with arbitrary scales for the three axonometric axes, is used. A 4 X 4 transformation matrix is used to produce an affine transformation on a set of points which are then projected onto a plane from a center of projection at infinity. In order to develop the mathematical forms for axonometric projection, let's consider a rotation about the Y-axis (vertical axis), then followed by a rotation about the X-axis (horizontal axis). For a rotation of angle about the Y-axis, the transformation matrix is given by Rogers and Adams (1976, p. 50) as follows:

$$T = \begin{bmatrix} \cos\phi & 0 & -\sin\phi & 0 \\ 0 & 1 & 0 & 0 \\ \sin\phi & 0 & \cos\phi & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

In similar manner, the transformation matrix for a rotation of angle about the X-axis is given by Rogers and Adams (p. 49):

$$T' = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & \sin\theta & 0 \\ 0 & -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

It must be noted that in the previous rotations the conventional right-handed angles of rotation are assumed (Mochel, 1973, p. 20) in which rotations are considered positive in a right-hand sense as one looks from the origin outward along the axis of rotation. See Figure 1.

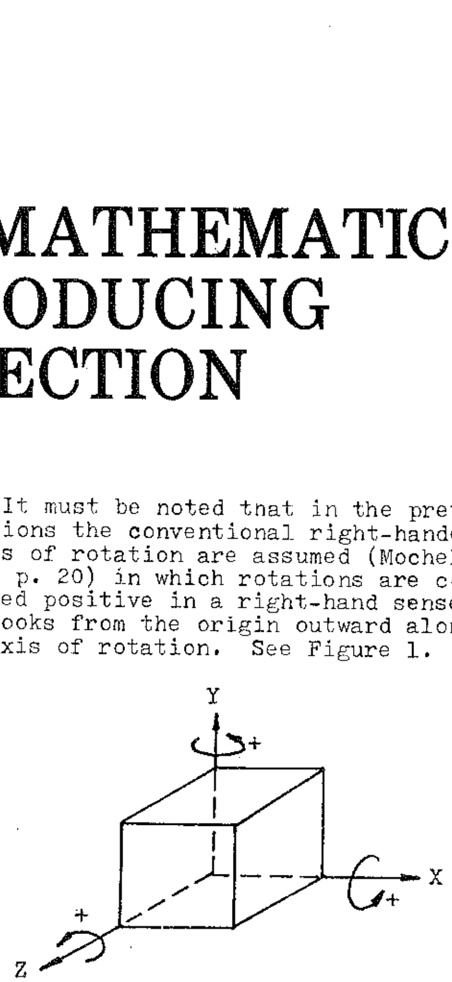

Figure 1

The concatenation of T and T' will yield the transformation matrix for the axonometric projection as follows:

$$[X\ Y\ Z\ H] = [x\ y\ z\ 1]$$
$$\begin{bmatrix} \cos\phi & 0 & -\sin\phi & 0 \\ 0 & 1 & 0 & 0 \\ \sin\phi & 0 & \cos\phi & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos\theta & \sin\theta & 0 \\ 0 & -\sin\theta & \cos\theta & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$[X\ Y\ Z\ H] = [x\ y\ z\ 1] \begin{bmatrix} \cos\phi & \sin\phi\cdot\sin\theta & -\sin\phi\cdot\cos\theta & 0 \\ 0 & \cos\theta & \sin\theta & 0 \\ \sin\phi & -\cos\phi\cdot\sin\theta & \cos\phi\ \cos\theta & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \ldots (1)$$

Equation (1) is the fundamental trans-formation matrix for producing axonometric projection upon which the computer graphics programming is structured. The three general calculation formulas for axonometric projection (Niayesh, 1977, p. 27) are also proved by this equation. Together these formulas can be applied to solving scales and angles problems in axonometric projection.

Proofs of the Three General Calculation Formulas

By use of the transformation matrix, the unit vector on the x'-axis transforms to

$$[X\ Y\ Z\ H] = [\cos\phi \quad \sin\phi\ \sin\theta \quad -\sin\phi\cos\theta \quad 1]$$

As a result of this transformation, the foreshortened scale of the x'-axis is

$$x' = \sqrt{\cos^2\phi + (\sin\theta\ \sin\phi)^2} \ldots\ldots (2)$$

Similarly, the unit vector on the y'-axis transforms to

$$[X\ Y\ Z\ H] = [0 \quad \cos\theta \quad \sin\theta \quad 1]$$

and the foreshortened scale of the y'-axis is

$$y' = \sqrt{\cos^2\theta} = \cos\theta \ldots\ldots\ldots (3)$$

Similarly, the foreshortened scale of the z'-axis is

$$z' = \sqrt{\sin^2\phi + (\cos\phi\ \sin\theta)^2} \ldots\ldots (4)$$

From Equations (2), (3), and (4), we obtain

$$\begin{aligned}
&(x')^2 + (y')^2 + (z')^2 \\
&= \cos^2\phi + \sin^2\phi\ \sin^2\theta + \cos^2\theta \\
&\quad + \sin^2\phi + \cos^2\phi\ \sin^2\theta \\
&= \sin^2\theta\ (\sin^2\phi + \cos^2\phi) \\
&\quad + (\cos^2\phi + \sin^2\phi) + \cos^2\theta \\
&= \sin^2\theta + 1 + \cos^2\theta \\
&= 1 + 1 \\
&= 2
\end{aligned}$$

Thus, we have

$$(x')^2 + (y')^2 + (z')^2 = 2 \ldots\ldots (5)$$

which is the Equation (VII) in Niayesh's article (1977).

We now consider the angles which the projected x'-axis and z'-axis make with the horizontal (Figure 2). Let these two angles be α and β, respectively, and from the transformation matrix, they are given by

$$\tan\alpha = \frac{\sin\phi\ \sin\theta}{\cos\phi} \ldots\ldots\ldots (6)$$

$$\tan\beta = \frac{\cos\phi\ \sin\theta}{\sin\phi} \ldots\ldots\ldots (7)$$

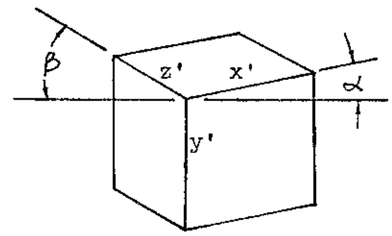

Figure 2

$$\text{Since } \tan\alpha = \frac{\sin\alpha}{\cos\alpha} = \frac{\sin\alpha}{\sqrt{1-\sin^2\alpha}},$$

and from Eq. (6) we obtain

$$\frac{\sin\alpha}{\sqrt{1-\sin^2\alpha}} = \frac{\sin\phi\ \sin\theta}{\cos\phi}.$$

Square both sides and by use of cross-multiplication, we have

$$\sin^2\alpha\ \cos^2\phi = (1-\sin^2\alpha)(\sin^2\phi\ \sin^2\theta),$$

$$\sin^2\alpha\ (\cos^2\phi + \sin^2\phi\ \sin^2\theta) = \sin^2\phi\ \sin^2\theta,$$

$$\sin^2\alpha = \frac{\sin^2\phi\ \sin^2\theta}{\cos^2\phi + \sin^2\phi\ \sin^2\theta}.$$

Multiply both the numerator and the denominator by $\cos^2\theta$, we have

$$\begin{aligned}
&\sin^2\alpha \\
&= \frac{\cos^2\theta\cdot(\sin^2\phi\ \sin^2\theta)}{\cos^2\theta\cdot(\cos^2\phi + \sin^2\phi\ \sin^2\theta)} \\
&= \frac{(1-\sin^2\theta)(\sin^2\phi\ \sin^2\theta)}{\cos^2\theta\ \cos^2\phi + \cos^2\theta\ \sin^2\phi\ \sin^2\theta} \\
&= \frac{\sin^2\phi\ \sin^2\theta - \sin^2\phi\ \sin^4\theta}{\cos^2\theta\ \cos^2\phi + \cos^2\theta\ \sin^2\phi\ \sin^2\theta} \\
&= \frac{\sin^2\theta\cdot(\sin^2\phi - \sin^2\phi\ \sin^2\theta)}{\cos^2\theta\ \cos^2\phi + \cos^2\theta\ \sin^2\phi\ \sin^2\theta}
\end{aligned}$$

$$= \frac{\sin^2\theta \cdot (1 - \cos^2\phi - \sin^2\phi \ \sin^2\theta)}{\cos^2\theta \ \cos^2\phi + \cos^2\theta \ \sin^2\phi \ \sin^2\theta}$$

$$= \frac{1 - (\cos^2\phi + \sin^2\phi \ \sin^2\theta) \ (1 - \cos^2\theta)}{(\cos^2\phi + \sin^2\phi \ \sin^2\theta) \cos^2\theta}$$

$$= \frac{1 - (x')^2 \quad 1 - (y')^2}{(x')^2 \ (y')^2}.$$

or $\sin\alpha$

$$= \frac{1 - (x')^2 \quad 1 - (y)^2.}{(x') \ (y')} \quad \ldots\ldots\ldots(8)$$

Equation (8) is the Equation VIII in Niayesh's article.

Similarly, we obtain

$$\sin\beta = \frac{1 - (y')^2 \quad 1 - (z')^2}{(y') \ (z')}. \quad \ldots \quad (9)$$

which is the Equation IX in Niayesh's article.

Practical Applications

We now consider some practical applications of the equations described previously in solving scales and angles problems in axonometric projection.

First, let's consider the isometric projection. To form an isometric projection, all three isometric axes are equally foreshortened. This requires that both

$$(x')^2 = (y')^2$$

and

$$(z')^2 = (y')^2$$

From equations (2) and (3), we obtain

$$\left.\begin{aligned} \cos^2\phi + \sin^2\phi \ \sin^2\theta &= \cos^2\theta \text{ -----(1)} \\ \sin^2\phi + \cos^2\phi \ \sin^2\theta &= \cos^2\theta \text{ -----(2)} \end{aligned}\right\}$$

The first condition gives

$$\sin^2\phi = \frac{\sin^2\theta}{1 - \sin^2\theta}$$

The second condition gives

$$\sin^2\phi = \frac{1 - 2\sin^2\theta}{1 - \sin^2\theta}$$

Thus, we have

$$\frac{\sin^2\theta}{1 - \sin^2\theta} = \frac{1 - 2\sin^2\theta}{1 - \sin^2\theta}$$

It follows that $\sin^2\theta = \frac{1}{3}$, or $\sin\theta = \sqrt{\frac{1}{3}}$ and $\theta = 35.264^\circ$. Then $\sin^2\phi = \frac{1}{2}$ or $\phi = 45^\circ$.

The angle which the x'-axis makes with the horizontal is given by Equation (6) as

$$\tan\alpha = \frac{\sin\phi \ \sin\theta}{\cos\phi} = \frac{\sqrt{3}}{3}, \text{ and } \alpha = 30^\circ.$$

Similarly, $\tan\beta = \frac{\sqrt{3}}{3}$, and $\beta = 30^\circ$.

Using the values of ϕ and θ for an isometric projection, the transformation matrix in Equation (1) becomes

$$[X \ Y \ Z \ H] = [x \ y \ z \ 1] \begin{bmatrix} 0.707107 & 0.408248 & -0.577353 & 0 \\ 0 & 0.816597 & 0.577353 & 0 \\ 0.707107 & -0.408248 & 0.577353 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

An algorithm which implements this specific isometric transformation matrix and using a BASIC language subprogram is given by Rogers and Adams (1976, p. 210).

In another approach to isometric projection by use of Eq. (5), we obtain

$$(x')^2 + (y')^2 + (z')^2 = 2$$

since $x' = y' = z'$

thus $3\,(x')^2 = 2$

$$(x')^2 = \frac{2}{3}$$

or $x' = \frac{2}{3} = 0.8165$, $y' = 0.8165$, $z' = 0.8165$

From Eq. (8), we obtain

$$\sin\alpha = \frac{\sqrt{(1 - \frac{2}{3})^2}}{\frac{2}{3}} = \frac{1}{2}$$

and $\alpha = 30^\circ$, and $\beta = 30^\circ$, resulting in the same angular value for α and β as presented previously.

Next we consider a specific example for a dimetric projection in which

$$x' : y' : z' = 1 : 1 : \frac{3}{4}.$$

From Eq. (5), we obtain

$$(x')^2 + (y')^2 + (z')^2 = 2$$

$$2\,(x') + \frac{9}{16}\,(x')^2 = 2$$

$$(x')^2 = \frac{32}{41}, \text{ and}$$

$x' = 0.8835$

$y' = 0.8835$

$z' = 0.6626$

Using the values of x', y', and z' in Equations (2), (3), and (4), we obtain

$$\left.\begin{aligned} \cos^2\phi + \sin^2\phi \ \sin^2\theta &= (0.8835)^2 \ . \ .(1) \\ \cos^2\theta &= (0.8835)^2 \ . \ .(2) \\ \sin^2\phi + \cos^2\phi \ \sin^2\theta &= (0.6626)^2 \ . \ .(3) \end{aligned}\right\}$$

The second condition gives

$$\cos\theta = 0.8835, \text{ or } \theta = 27.94^\circ$$

Substituting the value of θ in the third condition yields

$$\sin\phi = 0.5303, \text{ or } \phi = 32.03^\circ$$

From Eq. (6) and (7), we obtain

$$\tan\alpha = \frac{(0.5303)\ (0.4685)}{0.8478} = 0.2932, \quad \alpha = 16.34^\circ$$

$$\tan\beta = \frac{(0.8478)\ (0.4685)}{0.5303} = 0.7485, \quad \beta = 36.81^\circ$$

Using the values of ϕ and θ given here for a dimetric projection, the transformation matrix (Eq. 1) is given by:

$$\begin{bmatrix} X & Y & Z & H \end{bmatrix} = \begin{bmatrix} x & y & z & 1 \end{bmatrix} \begin{bmatrix} 0.847802 & 0.248461 & -0.468504 & 0 \\ 0 & 0.883452 & 0.468530 & 0 \\ 0.530311 & -0.397212 & 0.748992 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

We should note that if we choose $\phi = 45^\circ$ and $\theta \neq 35.36^\circ$ we will have a dimetric projection. The relationship between ϕ and θ is given as follows:

$$\sin^2\phi = \frac{\sin^2\theta}{1 - \sin^2\theta} \ . \ . \ . \ . \ . \ . \ . \ .(10)$$

$$\sin^2\theta = \frac{\sin^2\phi}{1 + \sin^2\phi} \ . \ . \ . \ . \ . \ . \ . \ .(11)$$

Thus we are able to choose initially either ϕ or θ for a dimetric projection. However, it must be noted that if we choose θ first it must be less than 45° or $\sin\phi$ will be greater than 1. If we choose ϕ first, any value of θ is possible (Peckham, 1974, p. 18).

If we make two rotations, ϕ and θ as described previously, but do not choose angular values leading to the isometric or trimetric projections, we will obtain a trimetric projection. As an example, we can rotate 30° (ϕ) about the y-axis, followed by 20° (θ) about the x-axis, we will obtain a trimetric projection. The transformation matrix can be obtained by use of Eq. (1) with $\phi = 30^\circ$ and $\theta = 20^\circ$.

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Rogers, D. F., & Adams, J. A. Mathematical Elements for Computer Graphics. New York: McGraw-Hill, 1976.

Jobs

The Engineering Design Graphics Department of Texas A&M University is seeking applicants for an assistant or associate professorship. Duties will include the teaching of engineering graphics and descriptive geometry to freshman engineering students. Applicants should be competent in and able to teach specialty courses such as computer graphics, electronic drafting, pipe and vessel drafting, nomography, etc.

It is preferred that applicants have a doctor's degree with at least one degree in a field of engineering. Salary is open based upon the qualifications of the applicant. Texas A&M is an equal opportunity, affirmative action employer.

Graduate Assistantships and part-time teaching positions are also available in the Engineering Design Graphics Department.

Contact James H. Earle, Engineering Design Graphics Department, Texas A&M University, College Station, Texas. Phone (713) 845-1633.

PROF. CLAIRE HULLEY
DEPT OF ENGINEERING SCIENCE
UNIVERSITY OF CINCINNATI
CINCINNATI, OH

TANGENT CIRCLES

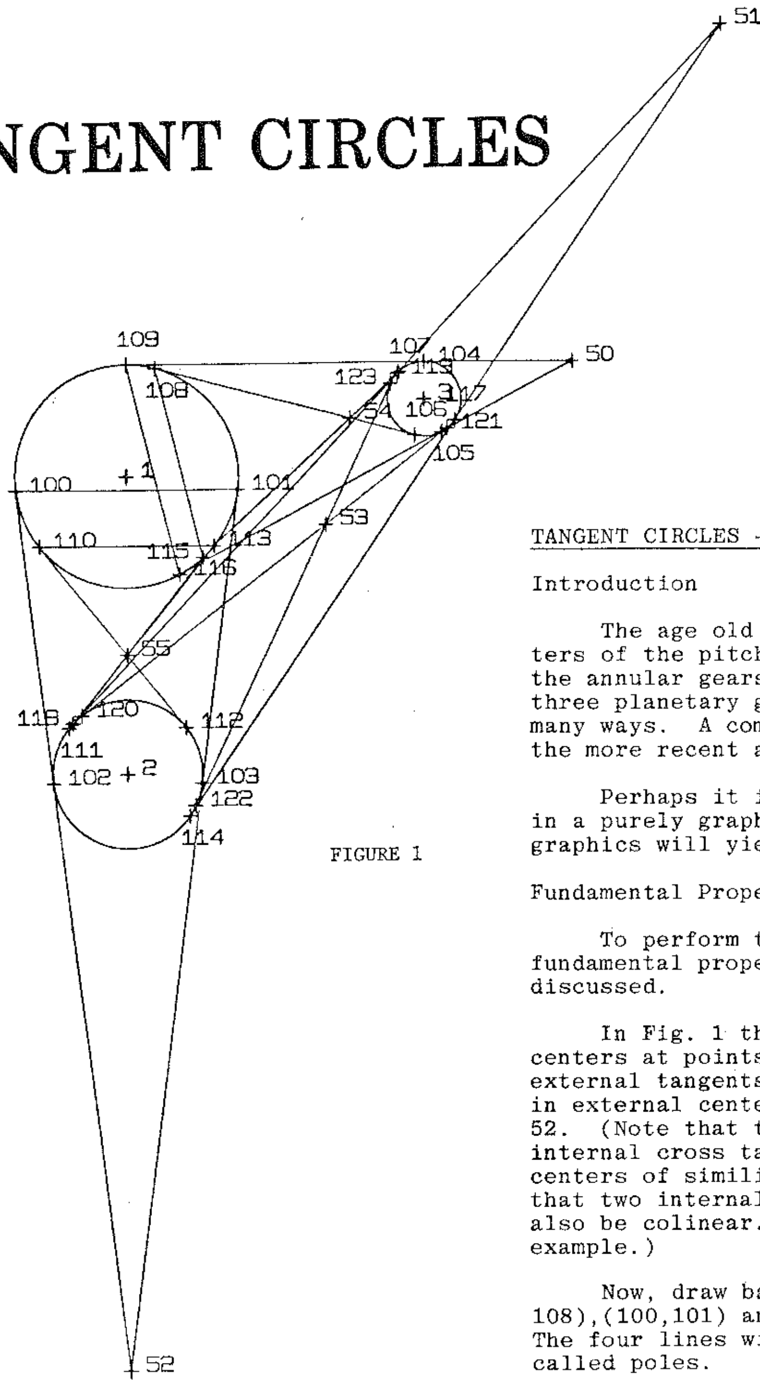


FIGURE 1

TANGENT CIRCLES - THE CLASSICAL APPROACH

Introduction

The age old problem of finding the centers of the pitch circles of the external and the annular gears which mesh with a set of three planetary gears has been handled in many ways. A computer grid search is one of the more recent attempts.

Perhaps it is time to review the problems in a purely graphical form and to realize graphics will yield all eight possible answers!

Fundamental Properties

To perform the desired geometry certain fundamental properties of circles should be discussed.

In Fig. 1 three circles are given with centers at points 1, 2, and 3. Construct external tangents for each pair intersecting in external centers of similitude 50, 51, and 52. (Note that they are colinear.) Construct internal cross tangents locating internal centers of similitude 53, 54, and 55. Note that two internal and one external center will also be colinear. (Points 52, 53, and 54, for example.)

Now, draw base lines (115,109),(116, 108),(100,101) and (110,113) for each circle. The four lines will intersect in four points called poles.

A second concept is also needed. If a line is drawn through the midpoints of tangents (100,102),(101,103) it will determine the radical axis for circles 1 and 2 and any point on this axis will have all four tangents to these circles equal in length. The intersection of the two radical axes will locate the radical center where all six tangents to the three circles are equal in length.

GENERAL CASE

Problem: Draw a circle tangent to three circles. (Eight possible solutions)
Given: Three circles with centers at points 1, 2 and 3 and different radii.

Solution: Construct all possible external and internal cross tangents for all cirlce pairs. <u>Selected</u> tangency points are marked with small triangles.
Next, construct base lines connecting corresponding tangency points.

The intersection of the four base lines with each other determines four poles for each of the circles.
Poles 40,41,42 and 43 for circle 1.
Poles 60,61,62 and 63 for circle 2.
Poles 80,81,82 and 83 for circle 3.

The radical axis is drawn through the midpoints of tangents to each circle pair. In Fig. 2 these lines intersect in the radical center, point 70.

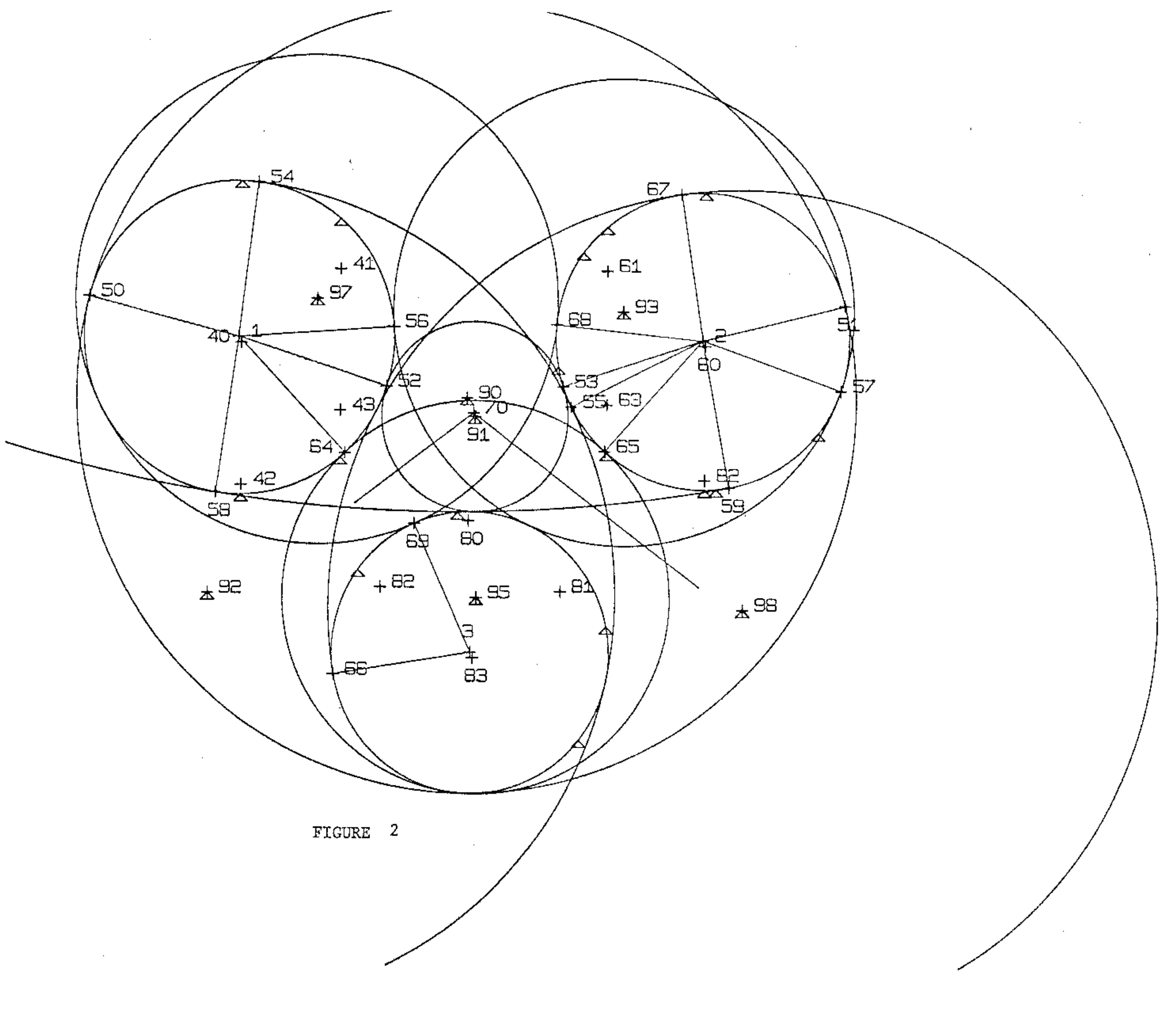


FIGURE 2

Next connect the radical center 70 with each of the poles 60, 61, 62 and 63 and where these lines intersect the circle determines the tangency points (50,53),(68,67), (65,69) and (55,57). The numbers in the parentheses are placed with the point nearest the radical center first. Points 53, 68,65 and 55 are then external tangency points and 51,67,59 and 57 are the internal tangency points. The centers for the eight circles must lie along lines drawn through each of these points passing through center 2. This is repeated for one of the other circles. (Centers noted with a cross and a triangle).

As an example take a circle pair with their centers (to be determined) 92 and 93.
- Where line 70,41 crosses circle 1 are the tangecy points 54 and 56.
- Where line 70,63 crosses circle 2 are the tangency points 55 and 57.
- Where line 1,54 and 2,55 cross locates center 92.
- Where line 1,56 and 2,57 cross locates center 93.

SPECIAL CASES FOLLOW:

Problem: Draw a circle tangent to two circles passing through a point.
(Four solutions possible)

Given: Point 1 and circles with centers at points 2 and 3.
Solution: In Fig. 3 point 1 is treated as a circle of zero radius. Therefore, only one base line (10,13) exists for circles 1 and 2; also, only one base line (16,19) exists for circles 1 and 3.

Base lines (four in number) are constructed for circles 2 and 3 in the usual manner.

Base line intersection points (poles) are then determined. (Points 26,27,28 and 29).

Bisect tangents and locate the radical axis (11,14) and (20,17) intersecting in the radical center 21.

The intersection of lines through the radical center 21 and the poles 26 and 27 and circle 1 determine tangency points 30, 31, 32 and 33. Repeat for circle two. The tangency points being 37, 36, 22 and 34. The intersection of lines (2,30) and (3,37) locates center 103. The intersection of lines (2,31) and (3,36) locates center 40. Similarly centers 43 and 104 are determined.

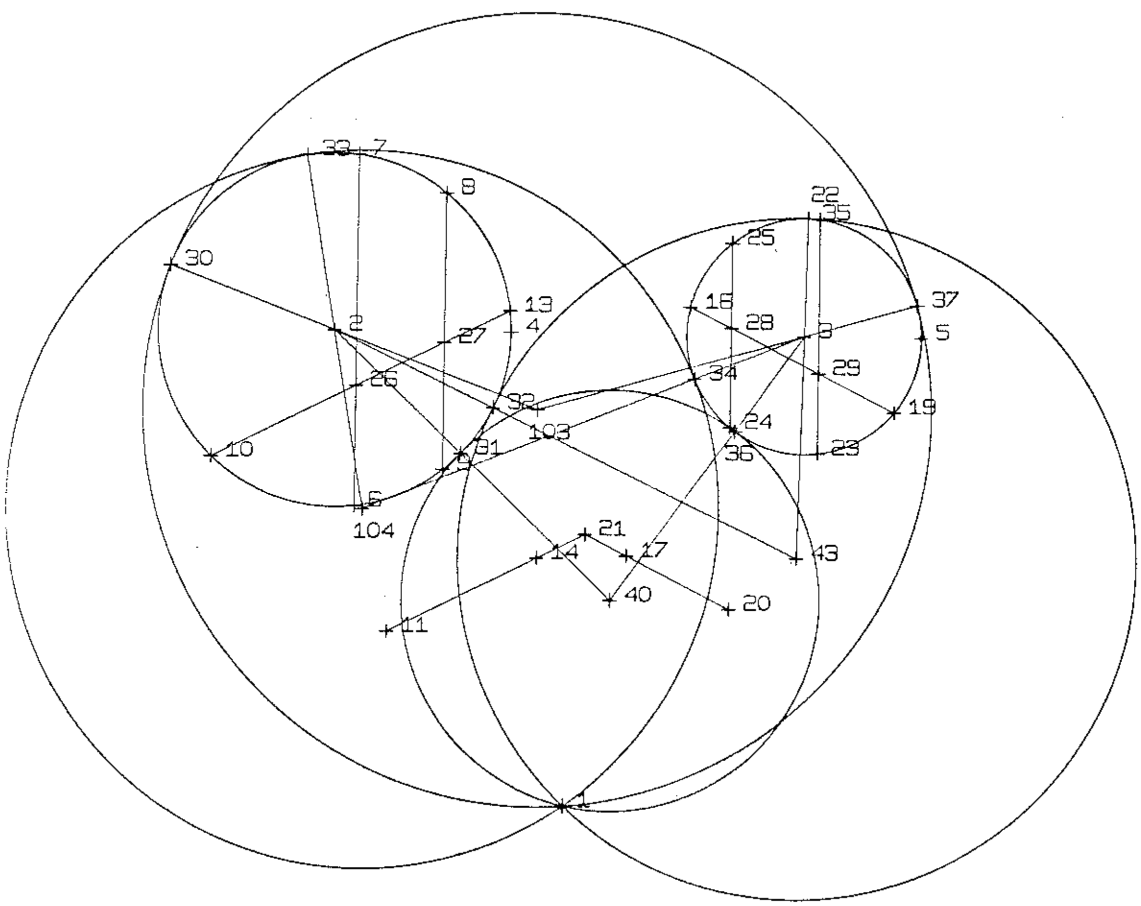


FIGURE 3

Problem: Draw a circle passing through two points and tangent to two circles. (Two circles are possible. Refer to Fig. 4.)

Given: Circle center at point 1 and points 2 and 3.
Solution: Points 2 and 3 will be treated as circles of zero radii.

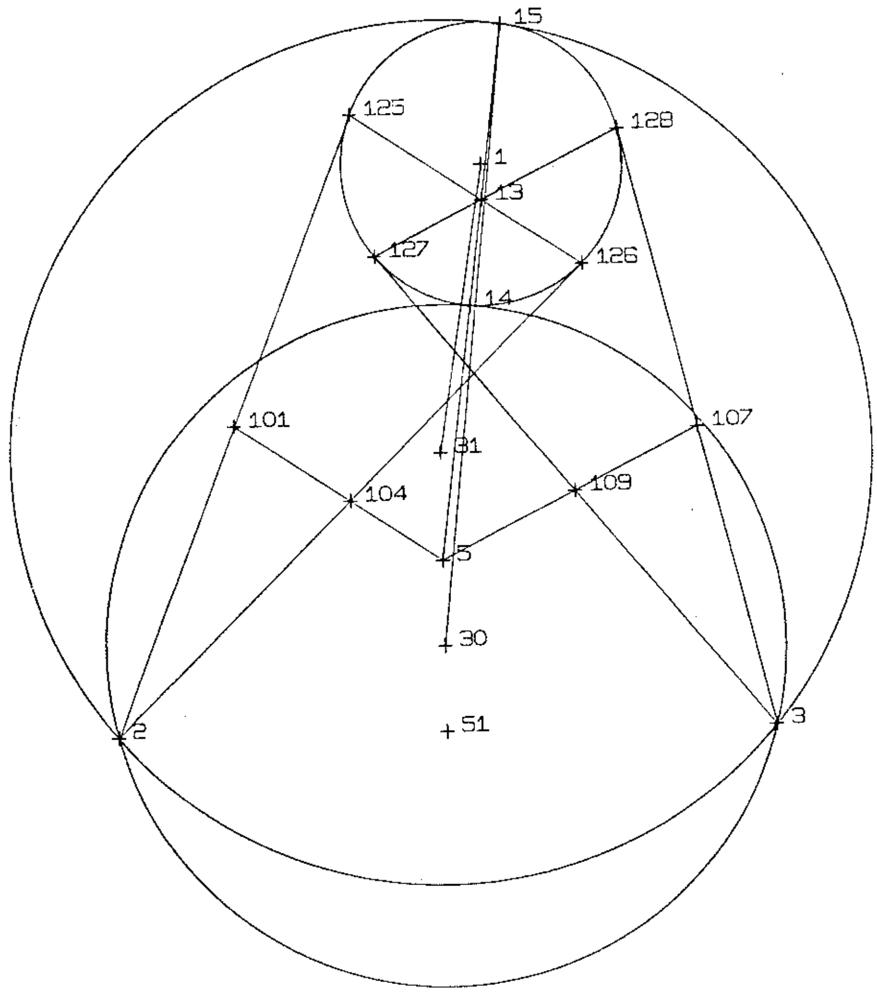


FIGURE 4

Draw tangents and connect bisectors (101,104) and (107,109). These intersect in the radical center 5. Base lines (125, 126) and (127,128) intersect in pole 13.

Connect pole 13 with center 5 and locate the intersection with circle 1 in tangency points 14 and 15.

Find the intersections of lines (1,14) and (1,15) with the radical axis (5,51) locating centers 30 and 31. Draw the circles.

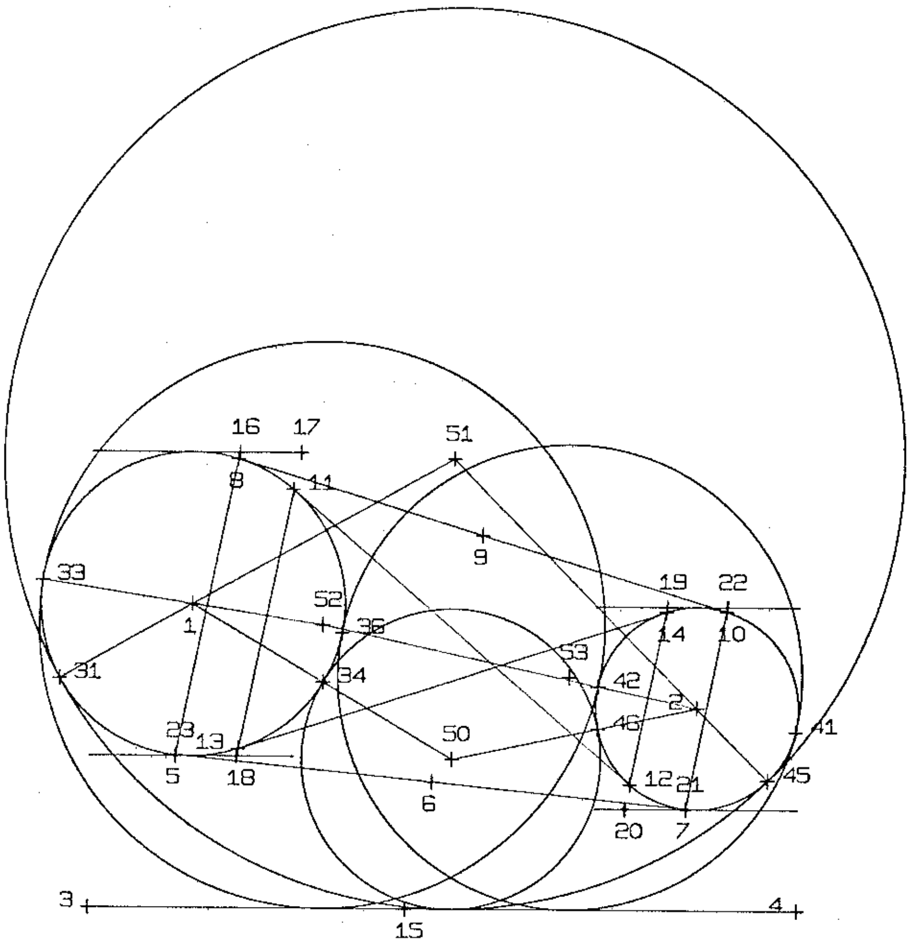


FIGURE 5

Problem: Draw a circle tangent to two circles and tangent to a line.
(Four Solutions)
Given: Circles with centers at points 1 and 2 and a line (3,4). See Fig. 5.
Solution: The line (3,4) will be treated as a circle of infinite radius and center at infinity.

(Comment: The radical axis between a circle 1 and infinite circle (3,4) is line (3,4). The radical center must then lie along (3,4). Also, line (16,17), parallel to line (3,4) on the far side of circle 1, represents the external tangents and the base line for circle 1 and the line (3,4). Similarly line (5,18), parallel to (3,4) on the near side of circle 1, represents the internal tangents and the second base line for circle 1 and line (3,4). These facts may be verified by drawing circle (3,4) with a very large radius and allowing it to increase without bound.)

Construct tangents (8,10) and (5,7). Draw a line through midpoints 6 and 9 intersecting (3,4) in point 15, the radical center.

Draw base lines (8,5) and (11,13) crossing the base lines on the near and the far side of circle 1 parallel to line (3,4) in four poles (16,23,17 and 18).

Lines are now drawn through the radical center 15 and poles (16,23,17 and 18) intersecting circle 1 in tangency points (34,31, 36 and 33). Repeating this construction for circle 2 determines tangency points (41, 41,45 and 46). From these tangency points the centers are determined as before.

Problem: Draw a circle tangent to a circle and two straight lines.
(Two solutions.)
Given: Circle with center 5 and lines (1,2) and (3,4)
Solution: The two lines (1,2) and (3,4) will be treated as circles with infinite radii and centers at infinity.

From Fig. 5 the radical axis must lie along lines (1,2) and (3,4). The radical center must then lie at the intersection, Point 11 in Fig. 6.

External and internal tangents are drawn for circle 5 and the two infinite circles.

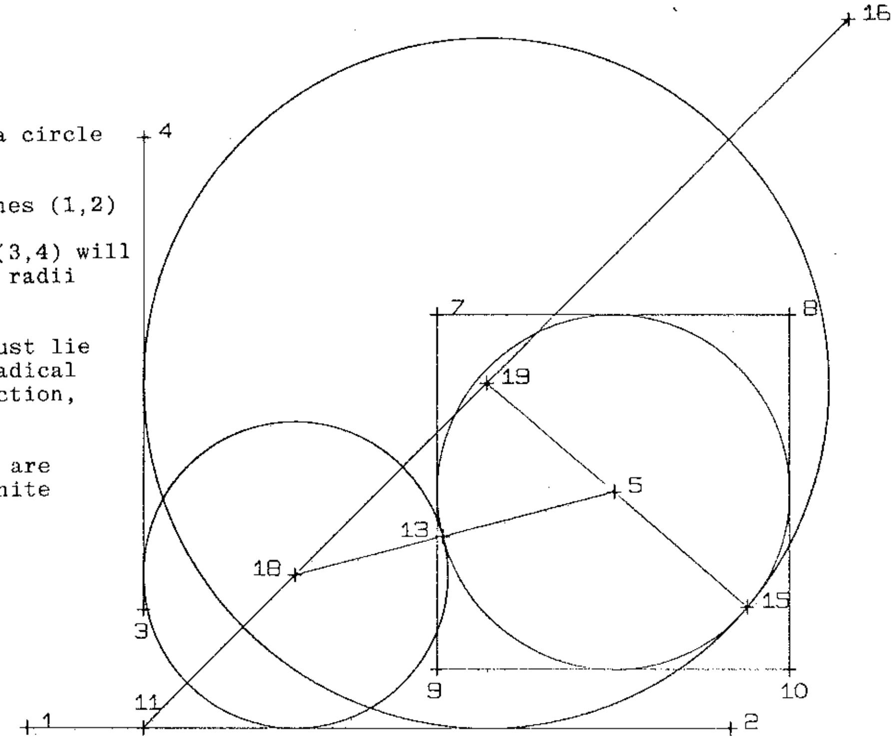


FIGURE 6

Draw lies (7,8) and (8,10) parallel to (1,2) and (3,4) on the far side of the circle. Draw (7,9) and (9,10) parallel to (3,4) and (1,2) on the near side of the circle. The intersection of these indefinite line segments determines poles (7,8,9 and 10).

Find the intersection of a line through the radical center 11 and pole 9 and a line through center 11 and pole 8 with circle 5 in tangency points 13 and 15. Now knowing the tangency points and that the center must lie along the bisector of angle (4,11, 2) center 18 and 19 are determined. The circles are then drawn.

The solution of a circle tangent to a circle, passing through a point and tangent to a line is handled in a similar manner.

It is interesting to note that the problem of drawing a circle through three points (zero radii circles) is a very special case. All poles, base lines and tangency points collapse on each of the three given points leaving the perpendicular bisector of the three center lines to intersect in the radical center with becomes the single remaining center of the circle passing through these three points.

AUTHOR'S NOTE: All illustrations in this article have been computer-plotter generated using a package of COGO with direct plotter output written by the author.

COMMENT:
PROF. DONALD PIERCE
UNIVERSITY OF NEBRASKA - LINCOLN

. . . (This thesis) could possibly have a use in multiple friction drive. . . He errs in stating the problem is ". . . passing through two points and tangent to two circles." He means ". . .passing through one point and tanget to two circles." - which is what his figure depicts.

I believe that a more readable notation of letters with subscripts would make it much easier to follow.

The basic material is available in books on Advanced Euclidean Geometry (e.g., Roger A. Johnson).

He covered CCC, LLC, LCC, PPC, and PPP. He might as well have covered PPL, PLL, LLL, PLC, and PCC to make it more complete. . .

COMMENT:
PROF. JAMES WOLFORD
UNIVERSITY OF NEBRASKA - LINCOLN

This appears to be more a geometric exercise than a practical kinematics problem. The problem apparently seldom arises in design. I have never seen it discussed in any kinematics or machine elements book. In gear design, one cannot use ust any theoretical pitch circle. I must be of such a size that the gear will have a whole number of teath on it, and the mating gears must all have the same diametral pitch -- that is: the same number of teath per inch of diameter. Such things are not considered in (this) solution. The method does not appear to be new but simply reviews classical solutions.

As for publication, it depends on whether such review articles are acceptable. I don't believe that it is of major importance in kinematics, but might be an interesting article for geometry buffs. . .

COMMENT:
PROF. B. LEIGHTON WELLMAN
PROF. EMERITUS OF MECH. ENGRG.
WORCESTER POLYTECHNIC INSTITUTE

. . . I think this material should be presented again for the benefit of our younger instructors, but in its present form it is too difficult for easy comprehension. I would therefore like to make the follwoing suggestions to Prof. Hulley: 1) the basic concepts of centers of similitude and radical axis would be clearer if illustrated first with only two circles; 2) add the lines that locate centers and illustrate alignment; 3) distinguish given and constructed lines by using heavy, light, dash, etc.; 4) use letters with distinctive primes or subscripts rather than numerals (a concession to traditional geometry). . .

Finally, the last sentence only piques my curiosity! Did the computer analyze and solve the problems beginning with only the given data, or did it only plot the results of the graphical solution? A little more explanation here seems desirable. . .

(HULLEY'S REBUTTAL)

. . . .Let me begin by saying that the best descriptive geometry text ever written was B. L. Wellman's text and I, too, regret that his Introduction to Graphical Analysis and Design is no longer in print. . . I am delighted with the sugestion that:

(a) basic concepts would be clearer if additional examples were included, and (b) cover also PPL, PLL, PLC, and PCC to make more complete.

However, this would make for a <u>very</u> lengthy article and I am sure would present the editor with a problem. My objective was precisely to present the material to younger instructors and hopefully have them attempt to apply the concepts in the other cases.

In answer to the suggestions concerning alphamerics for notation and different line types and weights:

There is a COGO (Coordinate Geometry for Civil Engineers) package available for many years to perform the computation for surveying problems. A consulting firm expanded it so it could be used to output on a drum plotter. I modified and extended the package to run with a flatbed small increment plotter and added more documentation.

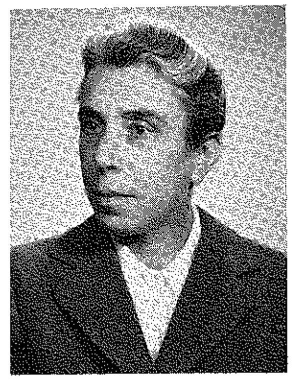
The software is rather large and was written for a system having only one pen and only solid line support which is considered adequate for civil engineering.

I, too, would have preferred line weight variations (multipen support) and dotted line techniques. However the logic already fills all available core on my machine and try as I may, I cannot get funds to expand. Other software I have written does allow for this option.

In answer to Prof. Wellman's question. .

Yes, the computer did the entire project with some assistance. The help consisted in asking that some geometric output be punched and later entered into the cardreader. This is again the result of using a package designed for one purpose to do something quite different. Also, I must admit that in some cases straight lines were treated as circles of infinite radii with centers at infinity (realizing that infinity to a computer is the largest number it can store. In this machine the error in a 12" line is a deviation of plus or minus 1.0×10^{-12}in.)

COMPUTER GRAPHICS FOR CURVED SURFACES



Prof. Dr. Luisa Bonfiglioli
5 Kinnereth Str.
KIRIATH BIALIK 27000
(Israel)

In his paper "Representation of curved surfaces by computer graphics "Prof. A. Rotenberg explains the analytical steps required for solving problems of computer drafting of outlines of curved surfaces. At the end of section VII he wrote: the programs were then corrected to erase the hidden outlines and arcs of the envelopes which do not belong to the outlines.

I should like to complete his paper by adding the description of a very simple method that enables us to draw the outline of the curved surface by means of the plotter which, itself and automatically, selects the visible portions of the outline. My method is based on the three-dimensional molding method (See section II) and gives a fair approximate outline of the curved surface so that, only by superimposing the approximate drawing upon the true drawing, we can perceive the difference between the two drawings.

According to the three-dimensional molding method a set of planar and parallel sections is drawn on the surface Σ (Fig. 1) and the resulting drawing is the line tangent to the projections of these sections one by one. According to my method the outline of Σ is <u>the line which connects the points of intersection between two successive projected sections</u>.

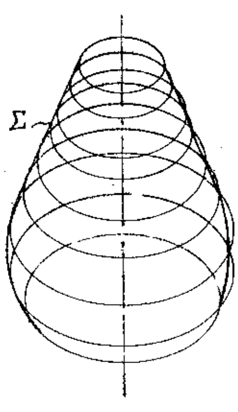


Figure 1.

It is obvious that the equations of the sections are supposed to be known. The interval between successive sections must fit the shape of Σ therefore it is not uniform; but it is always very small. Let us suppose that the sections of Σ are circles and we project them (Fig. 2) onto the plane Π by means of rays k orthogonal to Π (Orthogonal Axonometry).

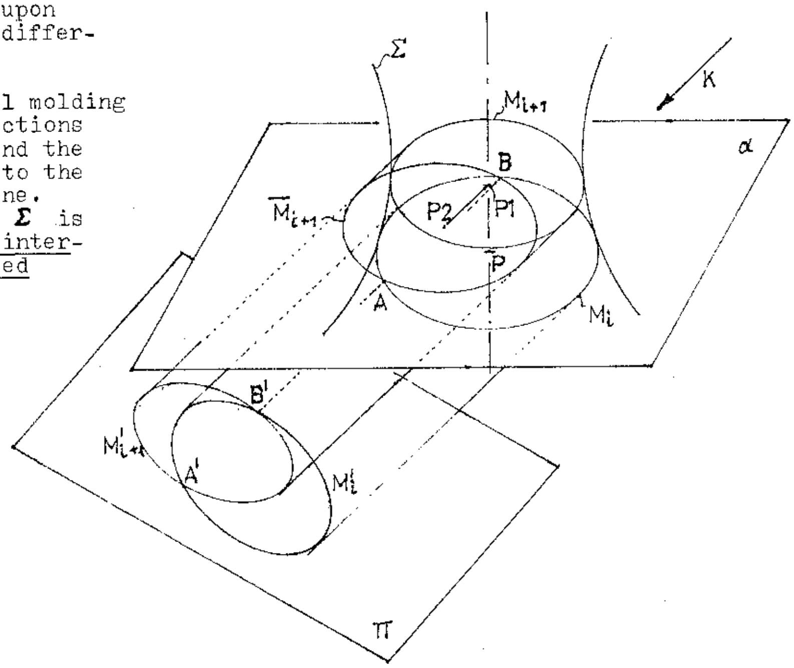


Figure 2.

Let M_i , M_{i+1} be two circular parallel sections of Σ and α the plane of M_i . Project them onto Π as ellipses M'_i , M'_{i+1} which intersect at the points A', B'. These points are the projections of the points of intersection A, B between M_i and the projection $\overline{M}_{i+1}$ of M_{i+1} on α in direction k. Because M_{i+1} is parallel to α , $\overline{M}_{i+1}$ is a circle identical to M_{i+1} and the determination of A and B depends on the solution of the system:

$$(1) \quad \begin{cases} x^2 + y^2 = RP^2 \\ (x-xP2)^2 + (y-yP2)^2 = RP2^2 \end{cases}$$

where RP is the radius of the circle M_i and RP2 is the one of $\overline{M}_{i+1}$. By iterating the process from the lowest section, giving real points of intersection, to the highest one we obtain all the points of the approximate outline.

As for the visibility of the points of the outline remember (Fig. 3) that if a point A belongs to Σ whose known equation is (2) $f(x,y,z) = 0$ its coordinates xA, yA, zA must satisfy (2) i.e. the numerical value of f(xA, yA, zA) is zero.

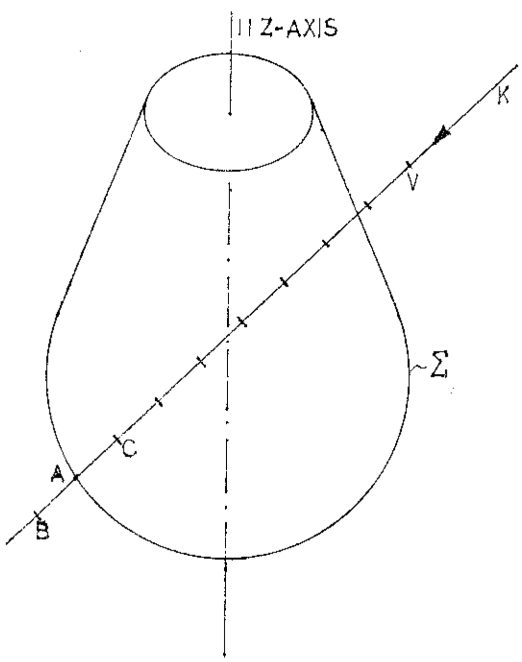


Figure 3.

But if we substitute in (2) the coordinates of two points B, C (B, C belong to the ray k passing through A and lay at opposite sides in respect to A) the values of (2) are numbers $\neq 0$ whose signes are opposite. Hence: suppose (Fig. 3) that the ray k is at the same time ray of visibility directed from above Σ towards it. Choose on k an arbitrary point V, far enough from A to be external to Σ and above it.

Divide the segment AV into N equal intervals and substitute the coordinates of the successive points of division (From A towards V) in (2) If after the substitutions the signs of the numerical values of (2) are the same, the point A is visible, otherwise it is invisible. The related program can be adapted to perspective projection and any other system of projection; to the case that the axis of Σ is not parallel to the coordinate axes X, Y,Z, or a twisted curve.

For the sake of simplicity in the following examples Σ (Fig. 4) is a TORUS whose center is S. The locus of the centers of the spheres that generate Σ is a circle M whose radius is R. The radii of the spheres is RS.

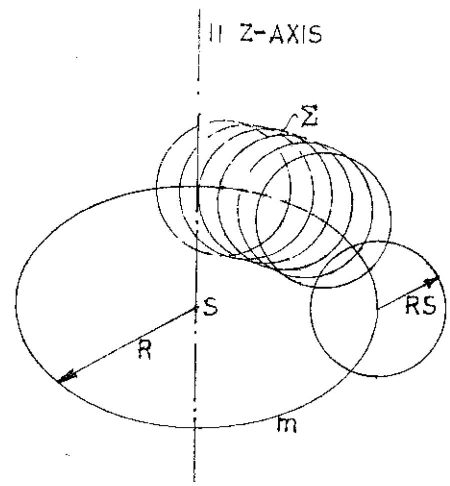


Figure 4.

Fig. 5 : The axis of Σ is parallel to the Z-Axis therefore m is parallel to the coordinate plane XY; R-5 in, RS=2.5 in.

Fig. 6 : The same conditions as in Fig 5 but RS = 1 in.

Fig. 7 : The same conditions as Fig. 5, but RS = 3.5 in.

Fig. 8 : The drawing represents the Torus Σ of the Fig. 5 in perspective projection.

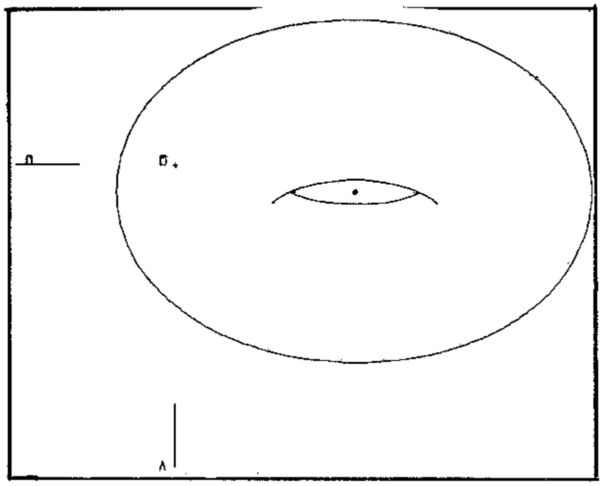


Figure 5.

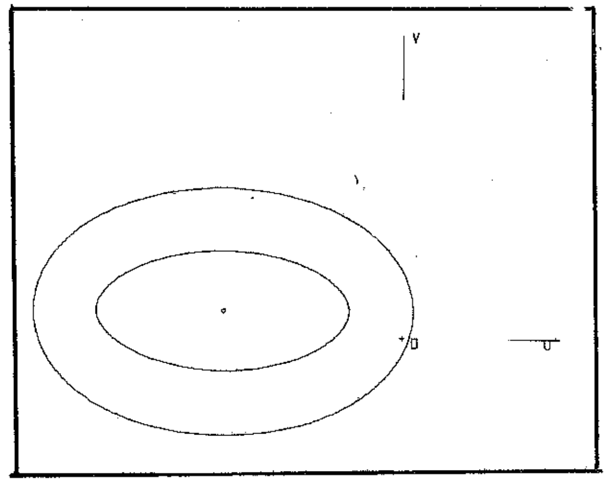


Figure 6.

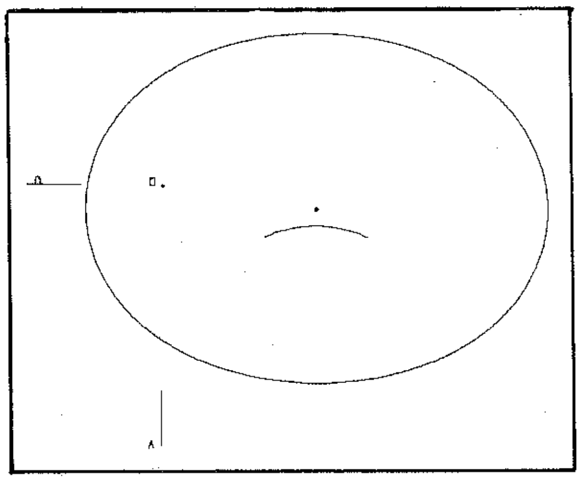


Figure 7.

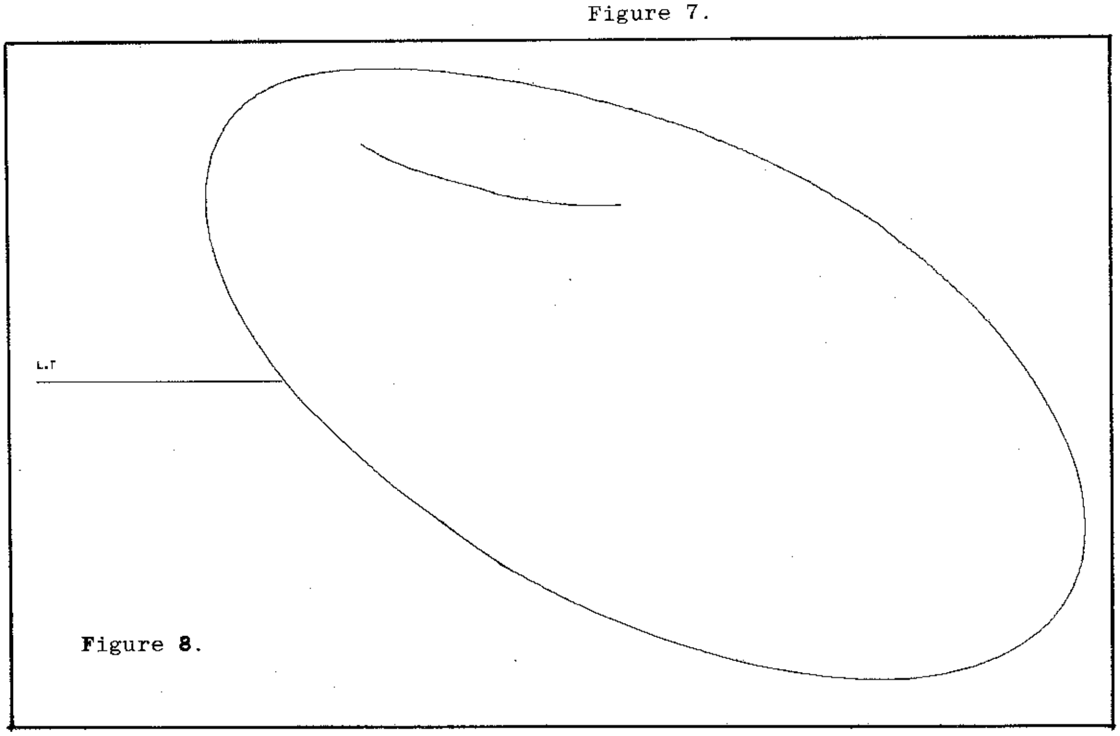


Figure 8.

THE INNER WORLD OF THE SQUARE -- GEOMETRICAL FORM-BASES FOR PICTURES AND FILMS, ESPECIALLY FOR A "VISUAL MUSIC"

Reinhard Lehnert
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Federal Republic of Germany

> "The primitive plant becomes the strangest creature in the world, which Nature herself should envy me. With this modulus and the key to it, can ever more plants be devised ad infinitum, which must be consistent, for even they do not exist, yet could exist, and are not memrely picturesque shadows and apparitions, but have an inner truth and needfulness."
> Goethe: Italienische Reise II
> 17.5.1787

The present article continues two articles published in this Journal (Winter 1975, pp. 7-18, and Fall 1979, pp. 42-54) but is also comprehensible without reference to any of these articles. Like its predecessors it deals with a totally novel, elementary and voluminous class of geometrical figures (discovered by me) which I call the "inner-stars". These inner-stars form bases for drawing non-representational pictures and films, and others showing letters and objects which I call "inner-pictures" and "inner-games". In this way it is possible to create two totally novel kins of art, a "static" one and a "dynamic" "visual music". It is apparent the "dynamic visual music" will present to the eye something corresponding to what music presents to the ear. The inner-stars will take the same part in dynamic visual music as the scales take in music. Like its predecessors the present article only deals with such inner-stars, based on a square "universe-star" which belong to the number of extension 3 and to the number of division 2 for the "field-lines", and the resulting line segments which only possess the simplest gradients, 0, 1 and -1 (the gradient angles 90°, 0°, 45° and -45°).

1. The Three Form-Sources of Pictorial Arts.

The works of pictorial arts present static and dynamic partial forms and attributes of forms optically perceptible which we may associate with the following three "form-sources". The first of these "sources" comprises static-geometrical and dynamic-geometrical forms and form-attributes (eg., a quadrangle, a uniform-circular movement, parallel arrangement of several partial forms). The second of these "sources" comprises static-objective and dynamic-objective forms and attributes of forms (eg., the outline of a horse's head, the architecture of a dwelling-house, the optic outward shape of human laughter). By "object" we understand a (non-geometrical) thing or similar event of our world (of "nature" or of the "human world") which we have stored up in its individual property or the one characteristic of the species in our memory of perception (as precursor of a notion). The third of the sources comprises "occasional forms" and "attributes of occasional forms". These are forms and attributes of forms which we have not stored up in our optical memory of forms neither as entities nor with regard to single parts, and neither with regard to their equality nor their similarity.

The world of static geometrical forms comprises two- or three-dimensional forms; forms that are limited by straight lines or even planes, and others limited by curved lines or curved planes (and that algebraically or transcendentally limited); forms that are non-ornamental, others that are in a wider sense ornamental (i.e., those showing unsystematic repetitions); furthermore, one-layered (traditional) ornamental forms and poly-layered ones (inner-pictures and inner-stars). The world of the static objective forms that are optically perceptible comprises the optically perceptible forms of 1. stones, 2. plants, 3. animals, 4. man, 5. articles of clothing and adornments, 6. implements, tools and machines, 7. buildings viewed from the inside, 8. buildings viewed from the outside, and 9. landscapes.

2. Essence and Meaning of These Three Form-Sources.

These three form-sources are different in their essence. The central geometrical forms such as (1) plane and straight line, (2) sphere and circle, (3) cube and square, are mathematically exactly and unchangeably determined in all their parts and attributes. They have their fixed places in the order of all geometrical forms and consequently in the order of the universe. A central geometrical form cannot get lost forever. If necessary, it will be rediscovered again and again. Every such form is a "natural centre" for many infinitely deviating forms. An objective form such as the outline of the head of a horse can scarecely get lost as a type (thereto the horse would have to become extinct and all pictures of the horse be destroyed), but well as an exact singular form existing now and here. An occasional form such as the form of an ink stain cannot be found again if it ever becomes lost.

There is an important connection between geometric, objective, and occasional forms: again and again we unconsciously or consciously try to describe occasional forms by objective ones, as well as occasional and objective forms by geometrical ones, and so to conceive them, never vice-versa. The works of the pictorial arts present forms composed of geometrical, objective, and occasional forms, and that composed again according to geometrical, objective, and occasional arrangements. The choice, deformation, and composition as to space and time of all these forms is a performance (or possibly a blunder) of the esthetic, and, over and above, of the artistic sense. For the aforesaid relation between geometrical and objective forms cf. Kurt Badt: Raumphantasien und Raumillusionen, Wesen der Plastik, Köln 1063, pp. 131-173, especially pp. 141-142.

3. The Three Form-Sources and the Genres of the Pictorial Arts.

The great genres in modern pictorial arts differ essentially in the manner in which they make use of the three form-sources mentioned above. Rougly speaking, we may say Idealism, Realism, and Naturalism, in different ways Impressionism and Expresionism, too, use the second form-source first of all; Constructivism uses the first and the third; Surrealism uses the second, and concerning the composition and arrangement of the partial forms, the third; Tachism uses the third. The "art of the inner-pictures" and the "dynamic visual music" will use the first form-source first of all, and that in an essentially different "more radical" way than outstanding geometric, or geometric-dynamic figure. (Notice for mathematicians: The set of all inner-pictures and inner-games on finitely many colours is mathematically enumerable, that means: it may be delineated one-to-one on the set of natural figures 1, 2, 3, 4. . .

4. Further Information about the Genres of Pictorial Arts.

Without my own comment, I cite some interesting points of view in this context about the genres and about the pathology of the pictorial arts:

> "In every painted work of art of the ancient art of painting, intellectual (noetic), sensual,

> "In every painted work of art of the ancient art of painting, intellectual (noetic), sensual, emotional and imaginative elements are blended together in different degrees and in different 'alloys'. What happens now when the striving for purity seizes them, too -- when each of these components claim an absolute position?

> "The sensual element, barring an absolute position, produces the different varieties of the pure paintings of perception -- scientific impressionism, photographic 'realism' -- as an extreme case, photography. The noetic element, in absolute position, produces the constructivistic 'picture', in the extreme case the pure construction as in the works of Malevitch or Mondrian. The imaginative element in absolute position produces dreamy paintings, in an extreme case, the pure reproduction of the fantastic products of trauma or of madness. The emotional element in the absolute position produces . . . 'pure' sob-stuff blooming not accidentally as late as in the 19th century. Mateiralistic naturalism, constructivism, the art of fantastic products and the sob-stuff reveal each time the revolt of one limb - eye, head, desire, heart - against the whole." (Hans Sedlmayr; Die Revolution der modernen Kunst, Hamburg 1955, rde 1, pp. 42-43)

> "In this way result typical blunders of the work of art. I am going to mention only some. If the technical side becomes independent, the product is technical perfection; if the purely formal element becomes independent, the product is the formalistic artificial work of art; if the significant element becomes independent, the product is the literary one, etc.

From this point of view a 'pathology' of the work of art could already be developed." (Hans Sedlmayr: Kunst und Wahrheit, Hamburg 1958, rde 71, pp. 101-102)

5. About the Geometrical Form-Sources of the "Plane-Art".

We confine ourselves to the "plane-arts" -- the genres of art covering plane-pictures with colours and forms. As a rule, the plane-peice itself is of geometrical nature, namely as a fragment of a plane. As a rule, the border-line and the frame of the picture are of geometrical nature, viz as quadrangles. As mentioned before, we frequently use geometrical forms to describe accidental and objective forms, and to comprehend them by that. But geometrical forms and attributes of forms can also appear exactly in the picture. That is the case with pictures of Kandinsky, Mondrian and Malevitch, but also on ornaments and on pictures designed on ornamental form-bases.

We speak of a one-layered ornament, when a figure comes about by a partial-figure, a "base-figure", which need not be geometrical itself, repeating itself in geometrical regular arrangements showing symmetries of rotation of or parallel motion or of grids. Accordingly we discern one-dimensional (rotation-ornaments -- figures representing stars, rosettes), one-dimensional (band-ornaments -- decorations in arts and crafts and architecture), and two-dimensional (plane-ornaments -- parqueting of the plane, Islamic mural decorations). We speak of a one-layered ornament-picture when a picture was designed in a perceptible way on a one-layered ornament as a form-base; for example, by base-figures repeating each other being coloured in different ways. We find such pictures in the works of Victor Vasarely and M. C. Escher.

We speak of a many-layered ornament when a figure comes about by at least two one-layered ornaments with different "cell" dimensions visible overlapping each other. The most perfect figures of that kind are the inner stars. We speak of a many-layered ornament-picture when a picture was designed in a perceptible way on a many-layered ornament as a form-base. The most perfect figures of this kind are the inner-pictures.

6. Ornament and "Visual-Music".

One-layered ornaments are not suited as form-bases for pictorial or filmic art. The reason for this is that these figures are lacking a hierarchical structure and therefore the ability of imparting a hierarchical structure to the pictures and films designed on them. The inner-stars, and only the inner-stars, possess this attribute in perfection.

In the preface we compared the inner stars with the scales in music. This comparison seems to be justified only if the inner-stars make "sharply form-based", characteristic, transposable "form-sounds" possible corresponding to the characteristic two-tone chords, triads, etc., of music. That is the case, indeed. A proof of this assertion based on the notions of "strong-points", "strong-lines' and "field-lines" must remain undone for lack of space.

7. The Three-Dimensional Ornaments.

The following can be said about the existance and importance for art of the three-dimensional ornaments. (1) Nature has produced one-layered three-dimensional ornaments in crystals. But, nature knows no many-layered ornaments. The reason is that its "rigid bodies" cannot penetrate each other. (As everybody knows, nature has not produced the technical form of the wheel, for other reasons.) (2) Without difficulties we can produce "three-dimensional inner-pictures" and this with plastiline of different colours, but we cannot look into them, just as we cannot see pieces of bacon in a sausage without cutting the sausage. (3) Without difficulties we can describe and imagine "three-dimensional inner-games", but for technical reasons we cannot produce them. Of course, we would not be able to look into them.

In summary: up to now, the plane-arts have made use of the first of its three form-sources only very imperfectly, but the use of the inner-stars as form-bases for pictures and films will make full use of the geometric form-source and by this expand the plane-arts by two quite novel genres of art.

8. Liberty of Choice and Liberty of Shaping.

The works of the plane-arts known up to now -- on the one hand -- and the inner-pictures and -games -- on the other hand -- differ, by the way, in the methods of their composition. Let us first of all explain the terms "liberty of choice" and "liberty of shaping". The poet and the composer have a --- limited --- liberty of choice in their works, but they have no liberty of shaping. The poet can choose from the words of his language, but he cannot omit the "-se" from the word "house" because of the rhyme. The composer can choose among the notes of the scale, but he can by no means raise one note by a quarter of one whole-step.

The art of the pictorial artist -- aside from architecture -- cannot dispense with the liberty of shaping. This is still valid for the art of Mondrian. The painter can paint a tree a little higher, a little tighter, a little greener; he can place a little bit to the right, etc. The art of the inner-pictures and the dynamic visual music still to be founded, offer exclusively the liberty of choice to the creating artist. That impedes the access to shaping and experiencing inner-pictures and -games for the pictorial artist enormously. The painter is afraid of the "compulsion of the geometric system".

9. Information about the Pictures 1-4.

Picture 2 presents the "square cell-star of the number of extension 3", in shorthand, sC3. Strictly speaking, it only shows the central cell of layer 0 (the largest square), 3 x 3 = 9 cells of layer 1 (the second largest squares), 9 x 9 = 81 of layer 2, and 27 x 27 = 729 of layer 3. To get the whole sC3 we must: (1) add in our thoughts all finer layers, 4, 5, 6 . . . (by that we get the "reduced sC3"; (2) continue the figure thus obtained over the whole plane of the picture; (3) add all the coarser layers. -1, -2, -3, . . .

Picture 1 presents the "square point-star of the number of extension 3", the sP3. Strictly speaking, it only shows the central cell of layer 0, and in it the "strong points" of layers o, 1, 2,3, and 4. The strong-points of sP3 are the centres of the cells of sC3. We call a strong-point which coincides with a strong-point of the next higher layer a "bound", every other one "free". It is recognized at once that Picture 1 shows one bound and (9-1)=8 free strong-points of layer 1; 9 bound and (81-9)=72 free ones of layer 2; 81 bound and (729-81)=648 free ones of layer 3; 729 bound and (6561-729)=5832 free ones for layer 4. In the center of the picture lies one bound strong point each from every layer . . . , -3, -2, -1, 0, 1, 2, 3 . . .

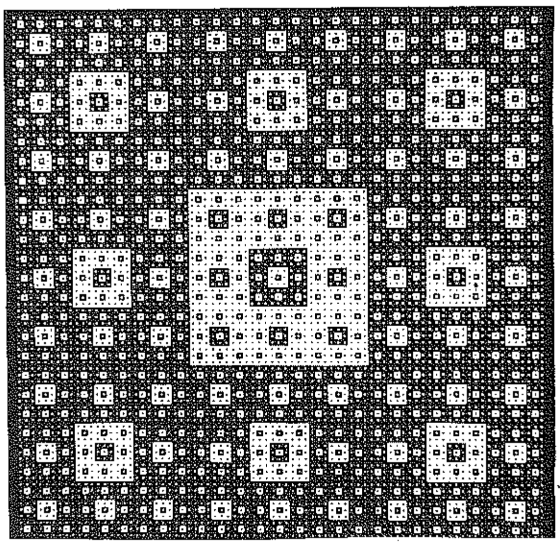


Figure 1.

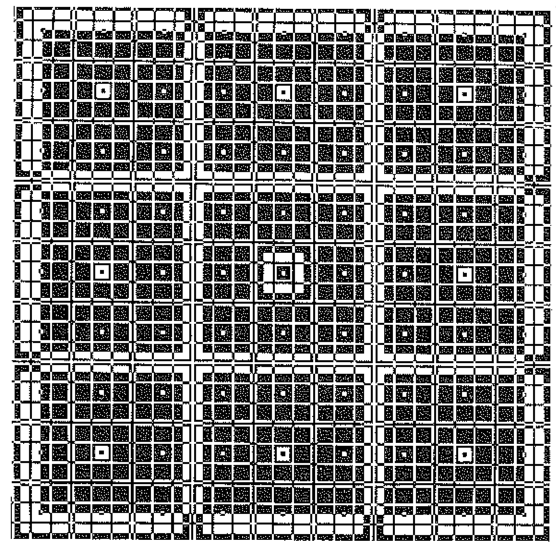


Figure 2.

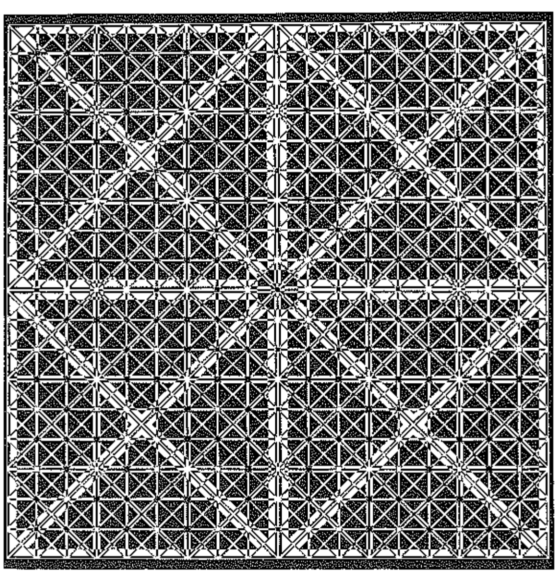


Figure 3.

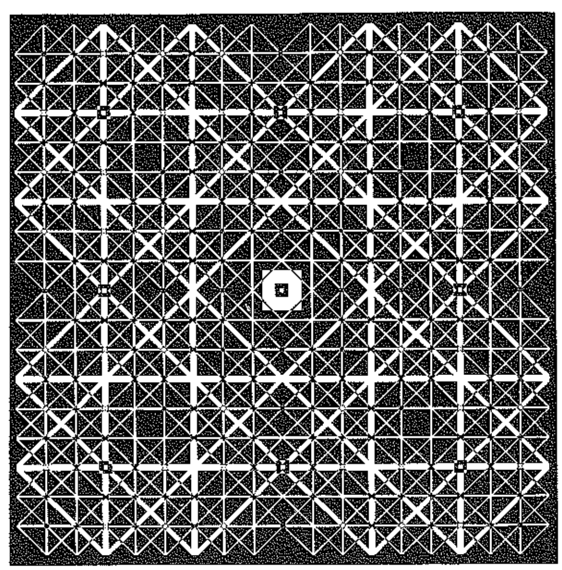


Figure 4.

Picture 3 presents a "universal-star" of sP3 (and of sC3). More exactly it shows the central cell of layer 0, and in it, for the layers 0, 1, and 2 all the "strong-lines" and all the "field-lines of the number of division 2" in so far as they have the gradients , 0, 1, or -1, that is, they have the gradient angles 90^{o}, 0^{o}, 45^{o}, or -45^{o}. We call a straight line a "strong-line of layer n" when it lies together with at least two (and then necessarily with infinitely many) strong-points of layer n. We call a strong-line with coincides with a strong-line of the next coarser layer "bound", every other one "free". We call a line segment which is part of a "strong-line" a "strong-segment" We call a straight line which bisects the field between two neighbouring strong-lines of a layer n a "field-line of layer n and the field number 2." We call a field-line which coincides with a field-line of the next coarser layer "bound", every other "free". We call a line segment which is part of a field-line a "field-segment"

Picture 4 presents a "complete-star" of sP3. More exactly, it shows all free strong- and field-lines of picture 3. It serves for designing the appertaining inner-stars.

10. Information about the Pictures 5 and 6.

Picture 5 presents an "inner-star" (ISt), namely an "overlapping-star" (OSt). More exactly, it only shows the central cell of layer 0, and in it the border lines of the "base-figures" (BF) of layers 0, 1, and 2. The BFs are square rhombs overlapping their four neighbours (upwards, downwards, right and left) in one smaller rhomb each.

But we can also interpret Picture 5 as the representation of two further ISts, namely of an "adjacent-star" (ASt) and a "linked-star" (LSt). The BFs of the ASt are dodecagons touching their four neighbours in two vertices. The BFs of this LSt are "rings" consisting of four larger and four smaller rhombs each. Each of these BFs has two larger and one smaller rhomb in common with each of its four neighbours. It is "linked" with this neighbour by these common plane-pieces.

Finally, we can also interpret Picture 5 as the representation of numerous (i.e., infinitely many) further LSts. We obtain them, for example, by enlarging the BF of the LSt mentioned above by further plane-pieces of its neighbours. Of course, we can also omit one or more plane-pieces of the original ring.

So Picture 5 represents several ISts (also several ASts). Primarily it only represents a "border-line-star", or "border-star" (BSt), to which the described ISts are coordinated. We obtain a BSt if we only look at the border-lines of the BFs of an ISt and consider the totality of these border-lines in every layer as a "one-and only" line-grid. Each complete-star is a BSt, but not vice-versa. A BSt is no ISt.

Picture 6 represents another BSt. To it, among others, are coordinated: an OSt whose BFs are hexagons, an ASt whose BFs are dodecagons, and a LSt whose BFs are "rings" consisting of four parallelograms and two rhombs, each.

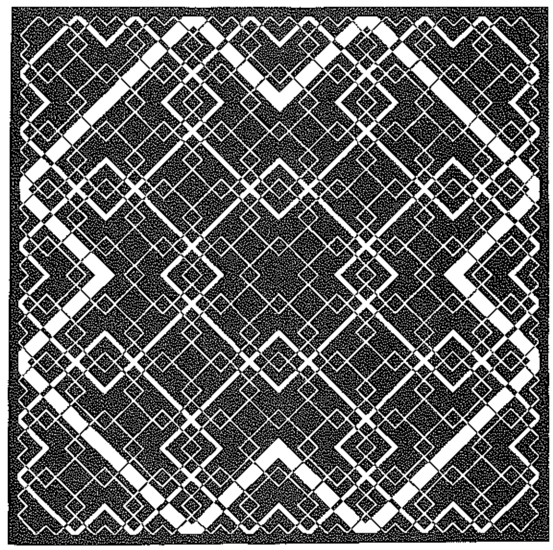


Figure 5.

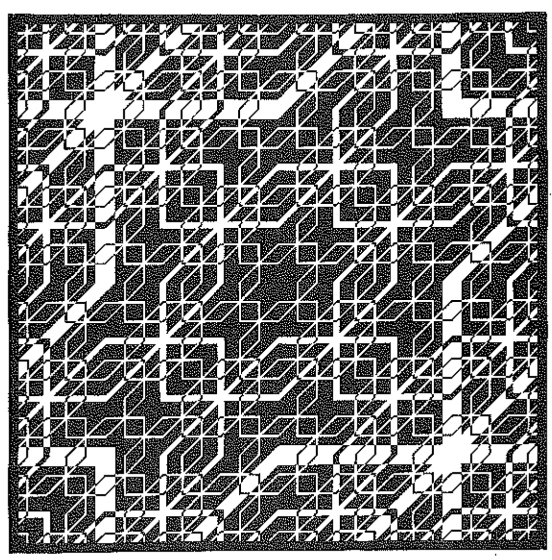


Figure 6.

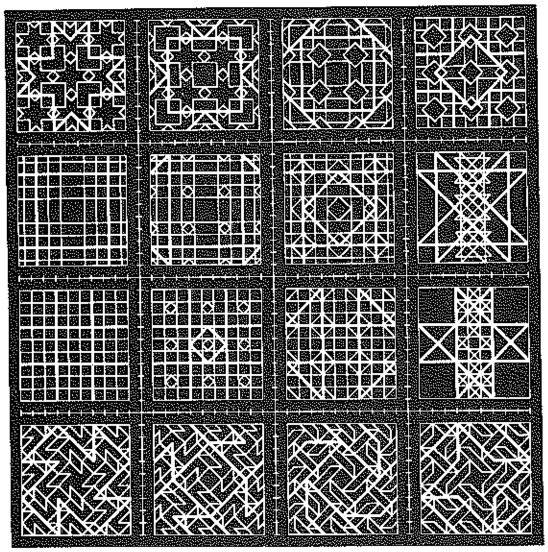


Figure 7.

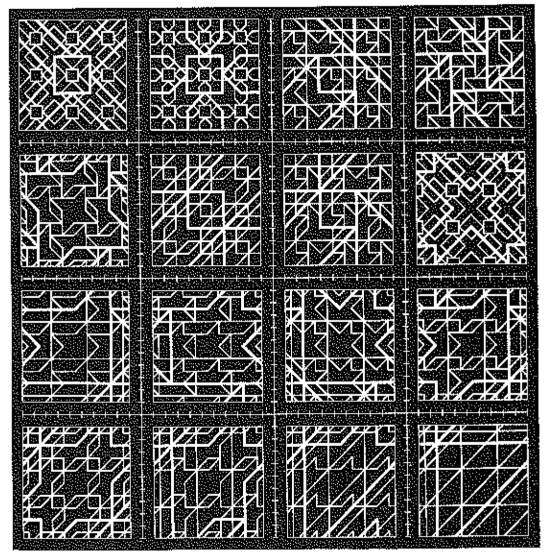


Figure 8.

11. Information about the Pictures 7-10.

Pictures 7-10 show 16 partial pictures each which we characterize by the numbers, (7;1;1;) - (7;4;4), . . . , (10;1;1) - (10;4;4); the first number meaning the number of the picture, the second number is that of the line, and the third number is that of the column. These 4x16=64 partial pictures represent one BSt each. More exactly, they only show the central cell of layer 0, respectively, and in it the line-grids of layers 0 and 1, the line-grids of layer 0 consisting of strong-lines and field-lines of layer 1, the line-grids of layer 1 consisting of strong-lines and field-lines of layer 2.

The partial picture (7;1;1) shows among others an ASt whose BFs are stars with 8 indentations and a LSt whose BFs are "rings" consisting of four squares and four much smaller rhombs. (7;1;2) shows, among others, a LSt whose BFs are "rings" consisting of four stars with eight indentations. Between the BSts of the partial pictures (7;1;1) and (7;1;2) there exists a relationship of forms. The layers of the first and those of the second blend by parallel motion in directions of 45°. (7;1;3) shows among others a LSt whose BFs are squares in whose four angles rhombs are attached. (7;1;4) shows among others a LSt whose BFs are rhombs in the middle of whose four sides

Figure 9.

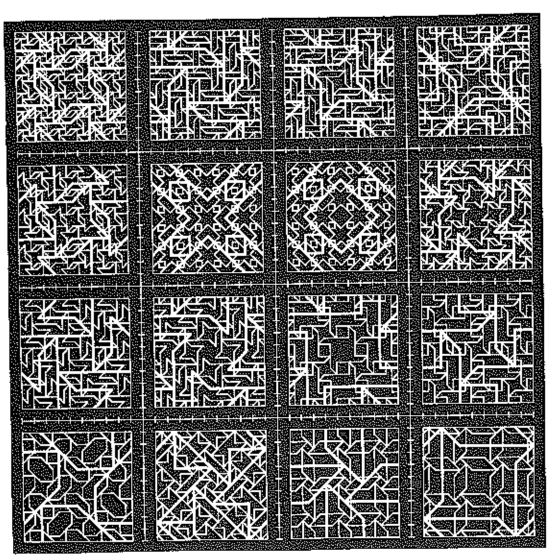
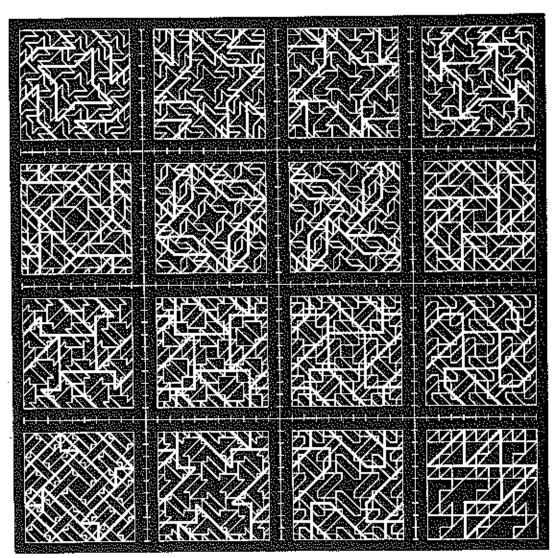


Figure 10.



squares are attached. Between the BSts of the partial pictures (7;1;3) and (7;1;4) there exists again the relationship of forms described above.

(7;2;1) shows among others a LSt whose BFs are squares in whose four angles smaller squares are attached, and a LSt whose BFs are "rings" consisting of four quadrangles the lengths of whose sides are to each other as 1 to 2, respectively 2 to 1. (7;2;2) shows among others an OSt whose BFs are octagons overlapping their nieghbors in an oblong hexagon each. (7;3;3), (7;2;4) and (7;3;4) show among others a similar OSt each. (7;2;4) and (7;3;4) are incompletely designed. The reader may copy them and look for the octagons and hexagons mentioned above.

(7;4;1) shows among others an ASt whose BFs are dodecagons, an OSt whose BFs are rotations stars, and a LSt whose BFs are "rings" consisting of four square rhombs and four parallelograms. (7;4;2) shows among others an OSt whose BFs are "rings" consisting of four rotation stars over lapping each other. (7;4;3) and (7;4;4) show two especially excellent LSts each.

(8;4;1) shows the BSt of Picture 6. (8;4;4) shows among others an ASt whose BFs are triangles, and several LSts whose BFs are "rings" consisting of three triangles and "stars" consisting of three triangles. The reader may view the rest of the partial figures and determine the components by referring to the examples given above.

Figure 11.

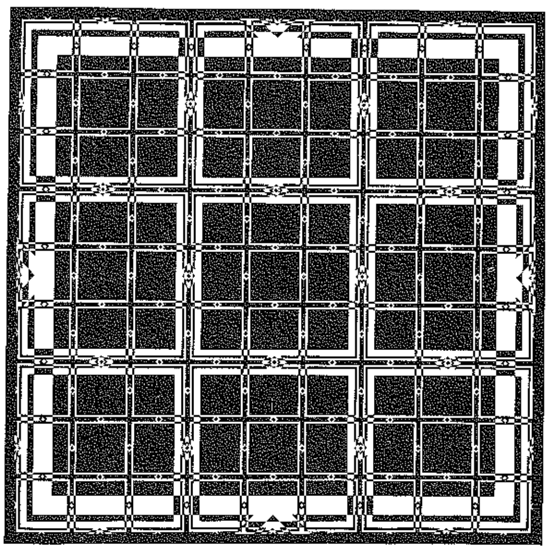


Figure 12.

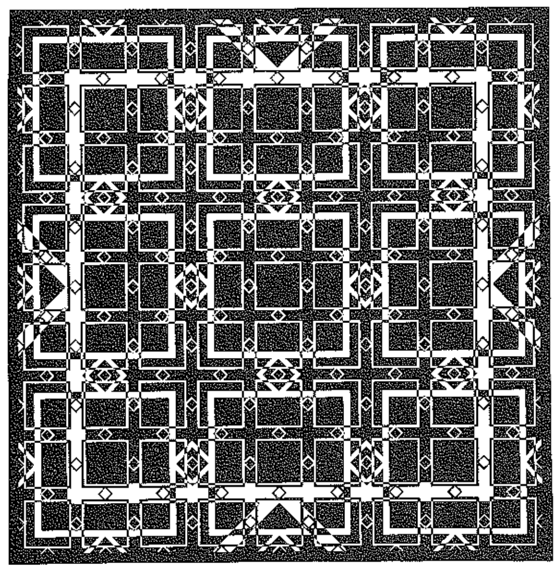


Figure 13.

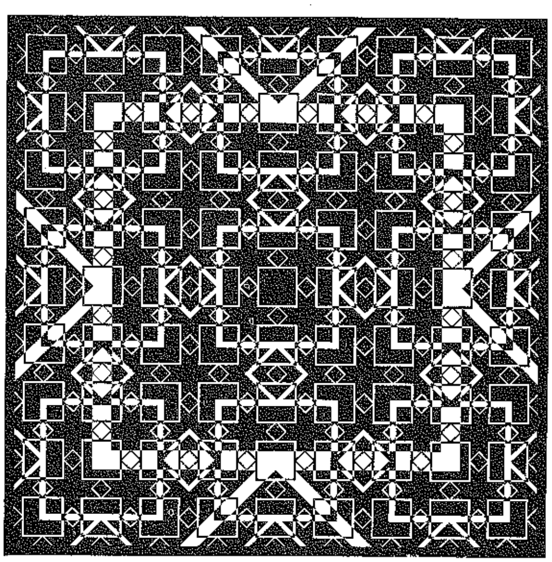
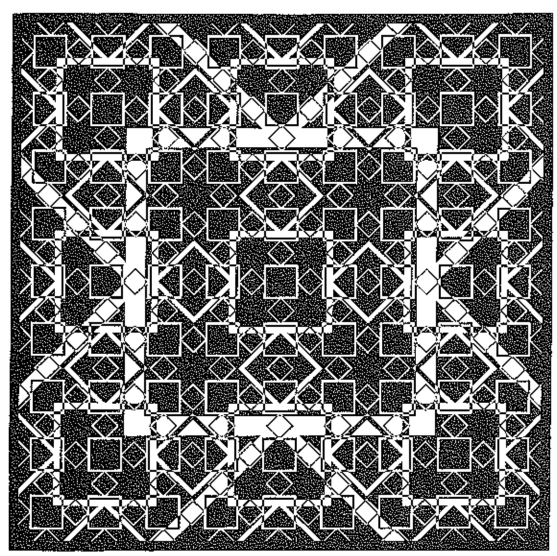


Figure 14.



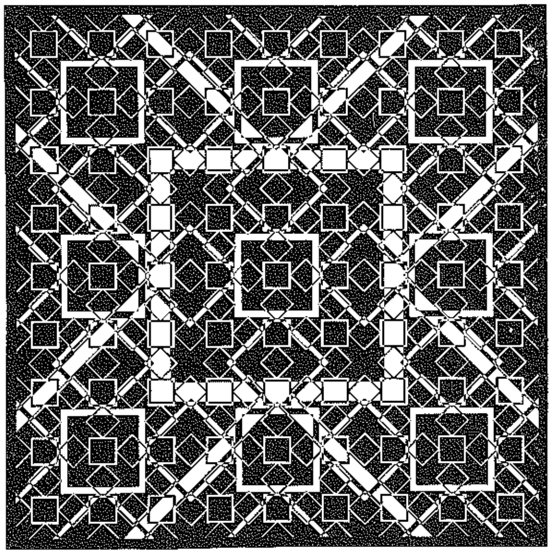


Figure 15.

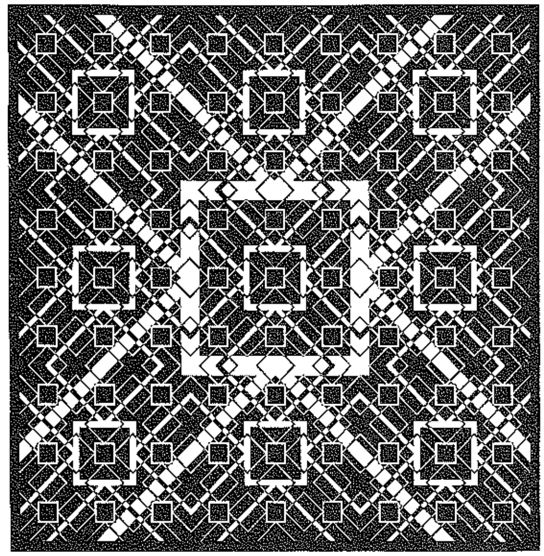


Figure 16.

12. Information about Pictures 11-22.

Pictures 11-22 are again three-layered of the kind of the Pictures 5 and 6. The BSts of the Pictures 11-18 belong to a form-class characterized by the following attribute: each of these BSts shows among others a LSt whose BFs are squares in the middle of whose four sides rhombs are attached. In Picture 11 this square is largest, and these rhombs are smallest. From 11 to 18 the size of this square decreases and size of the rhombs increases. We recognize at once: the BSts and consequently also the ISts of Pictures 13 and 16 form a first quality-class, those of the remaining pictures of the series 11-18 a second quality-class and that for the reason given in the paragraph below.

In the BSts of Pictures 13 and 16 the line-grid of layer 0 consists of strong- and field-segments of layer 1, that of layer 1 consists of strong- and field-segments of layer 2; in general, the line-grid n consists of strong- and field-segments of layer (n+1). These two BSts are the only ones with this attribute in the above-mentioned form-class. In the BSts of the remaining pictures of the series 11-18, on the contrary, the line-grid of layer n consists of strong- and field-segments of layer (n+2). These BSts are the only ones with this attribute in the above-mentioned form class.

We can complete the series of the BSts of the Pictures 11-18 by adding all further BSts of the aforesaid form-class. The we get in all 2x1 = 2 BSts of quality-class 1;

Figure 17.

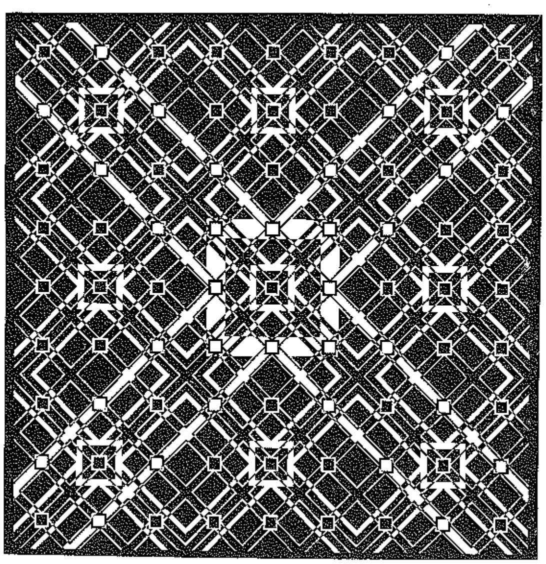
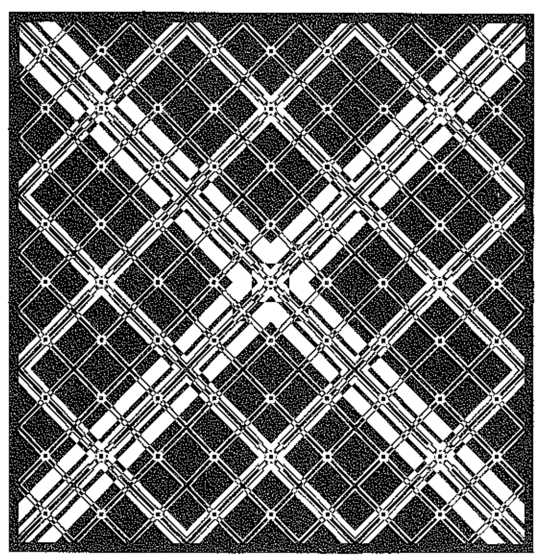


Figure 18.



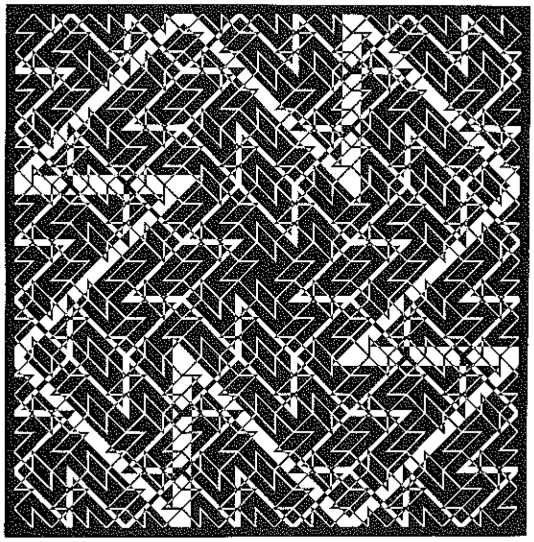


Figure 19.

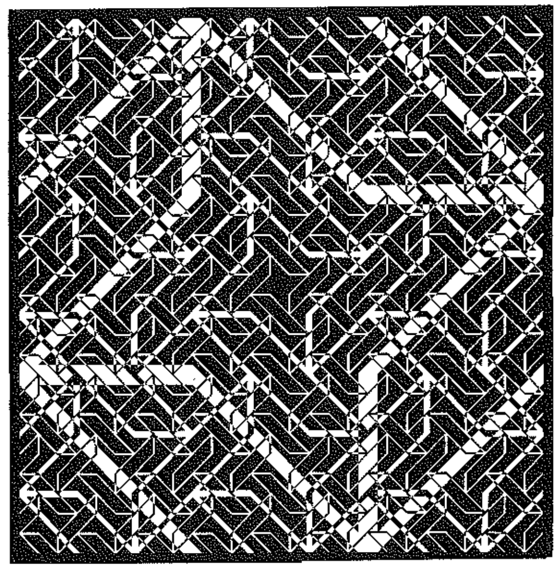


Figure 20.

Figure 21.

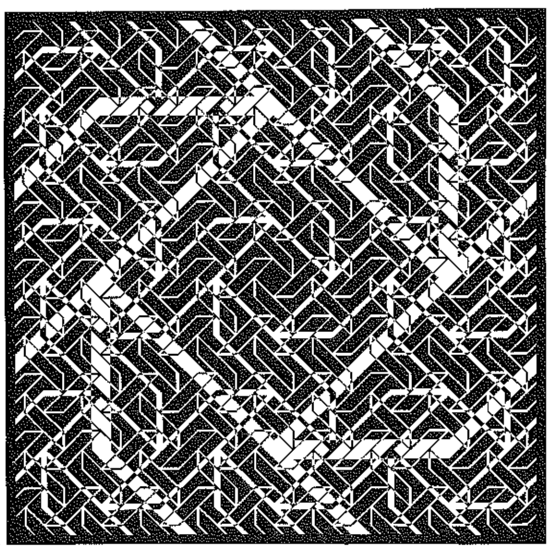
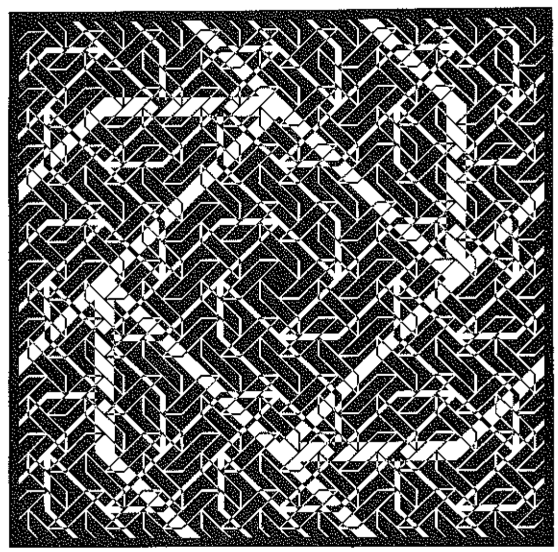


Figure 22.



2x3=6 of quality-class 2; 2x9=18 of quality class 3; 2x27-54 of quality class 4, etc. In quality-class n (n=1,2,3 . . .) we get as many BSts as there exist free vertical strong- and field-lines of layer n lying in the central cell of layer 0 between the center and right border, namely $2 \times 3^{n-1}$. (See Picture 4).

The ISts of sP3 belonging to the complete-star of Picture 4 and the aforesaid form-class, form therefore an infinite series with strict layering with regard to their quality. The "quality" itself concerns the manner of how the BFs are intersected by the border-lines of the BFs of the respectively coarser layers. We also obtain corresponding transformation-series for numerous other form-classes.

Corresponding transformation-series can also be obtained if instead of field-lines of the number of division f = 2, we use such ones of the number of division f = 4 or 5, 7, 8, 10, 11, 13, 14, etc. The symbol "f" can be every natural number which is relatively prime to the number of extension 3 of the underlying point-star sP3. Of course, we must then take as a basis the respectively corresponding complete-star instead of the complete-star of Picture 4.

Corresponding transformation-series are also obtained by admitting strong- and field-lines of other gradients, e.g., gradients of gr = 1, -2, (1/2), -(1/2), 3, -3, (1/3), -(1/3), (3/2), -(3/2), (2/3), -(2/3); here the gradient "gr" can be any rational number.

Corresponding transformation-series can also be obtained if, instead of the point-star sP3, we take as a basis other point-stars from the series of the square point-stars sP2, sP3, sP4, sP5, . . . or from the series of the hexagonal point-stars hP2, hP3, hP4, hP5, . . .

Pictures 19-22 represent the same BSt as the partial pictures (7;4;1) - (7;4;4), but show three instead of 4 layers.

13. Information about the Pictures 23-26.

Pictures 23-26 are "inner-pictures", i.e., they originate from one ISt each by a covering; i.e., by selecting finitely many BFs according to any point of view, or by chance decisions, deletion of all (infinitely many) remaining BFs and subsequent colouring of the figure thus originated -- according, again, to any point of view or by chance decisions. This coloring ought to meet the following conditions: (1) every plane-piece shall be coloured homogeneously; (2) plane-pieces having a common borderline-segment shall be coloured with different colours, except the case that certain BFs (of the same layer) shall "fuse" into one another. (We call such pictures "fusion pictures".)

Pictures 23-26 are "linked-pictures", i.e., they are based on one LSt each. The LSts of Pictures 23 and 24 are coordinated to the BSt of the partial picture (7;3;1). The LSts of Pictures 25 and 26 are coordinated to the BSt of the partial picture (7;2;1). These two BSts are especially elementary; the first consists exclusively of vertical and horizontal field-lines and the second consists exclusively of vertical and horizontal strong-lines.

Pictures 23-26 all show the same covering. In them appear: (1) the central BF of layer 0; (2) the three left BFs of layer 1; (3) 22 BFs of layer 2 forming an "M"; (4) 139 of layer 3 forming the stylized letters "Licht-Musik"; (5) 241 of layer 4 forming 5 ornamental rows.

Pictures 23-26 all show the same colouring, namely the simplest possible: the border-stripe and the grounding are black. Where BFs in odd numbers lie upon it the color is white; where they are in even numbers, the colour is black. We see easily; if only two "colours" are available, and if it shall be made safe that no segment of a borderline of an appearing BF becomes invisible, the described method of colouring is essentially the only possible one. "Essentially" would mean: except a simple change of "colours" in the interior of the picture with the exception of the border-stripes.

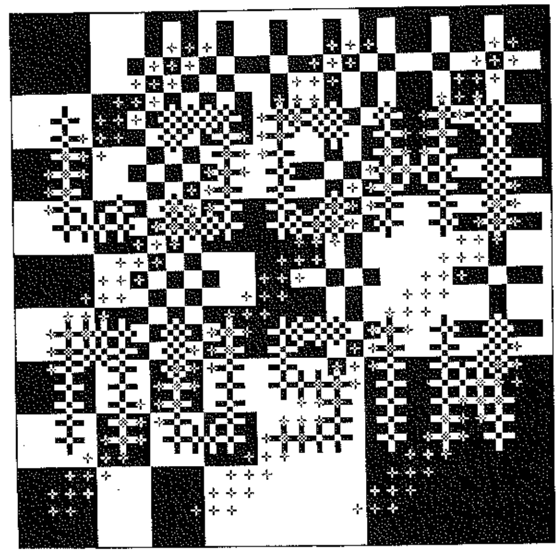


Figure 23.

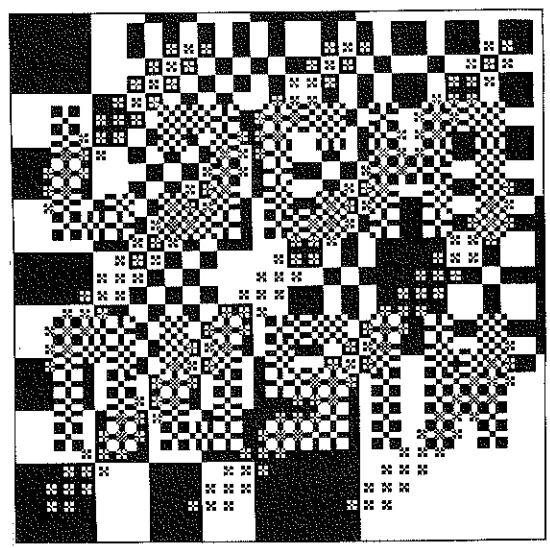


Figure 24.

14. Information about Pictures 27-40.

Picture 27 presents the "auxiliary-star" sAu3. We obtain it from sC3 by reducing all cells centrically in teh (linear) scale of 1 to (2/3). It possesses all the attributes of the ISt except the "connection" The BFs have no points in common with their neighbours. The sAu3 serves for designing ISts and inner-pictures. Picture 27 more exactly shows a square plane-piece that is concentric to the central cell of layer 0 and is a little larger than this one. In

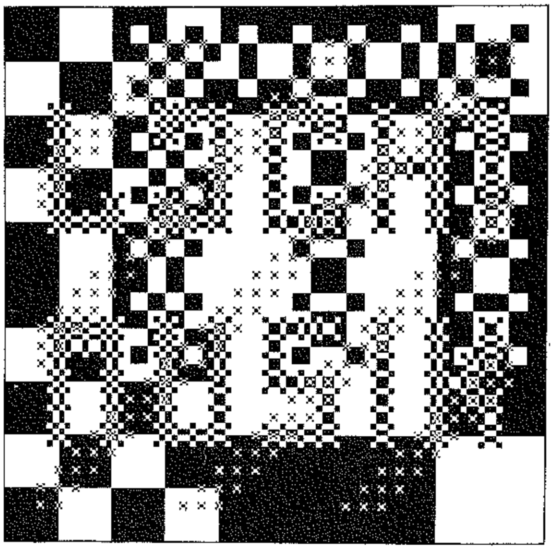


Figure 25.

this plane-piece it shows BFs of layer 0, 1, 2, and 3. The original figure, on which all the pictures shown in this article were designed, shows the BFs of layer 4 in addition, and this with the side-length of 8 cm.

First of all this original figure was designed on transparent paper with India ink. Of this design two photostatic copies of the same size were made. On the white reverse side of these photostats, the pictures were designed and colored with India ink. This designing and colouring was done with the help of a special device prepared by the author. It consists of a table, a neon tube between the legs of this small table, and a glass plate on the legs. This glas plate has the dimensions 1400mm by 500mm by 5 mm.

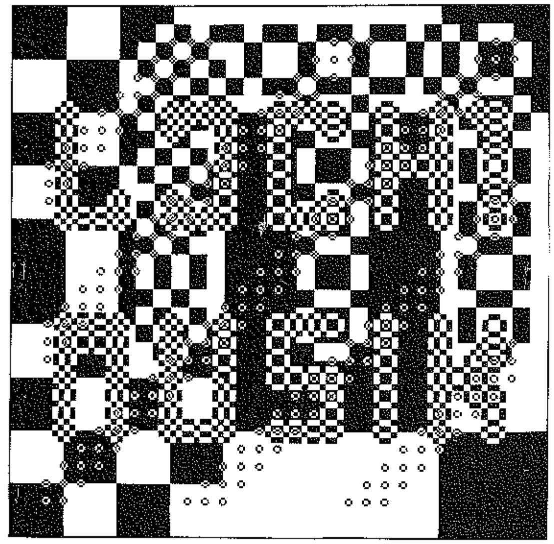


Figure 26.

Picture 27 shows a larger number of octagons. These are the BFs and form the sketch in lines of an inner-picture, namely the overlapping-picture shown in Picture 28. Picture 27 shows the construction of these octagons on the sAu3. We look at the respectively appertaining BF of sAu3 as well as its four neighbors upwards, downwards, to the right, and to the left. We connect the angles pointing outward and obtain the octagon we wanted. The appertaining OSt is identical with that of the partial picture (7;2;4). Picture 27 shows 4 BFs of layer 2, 43 of layer 3, and 330 of layer 4. Picture 28 shows the appertaining inner-picture in black and white colouring described above. It represents a donkey.

Figure 27

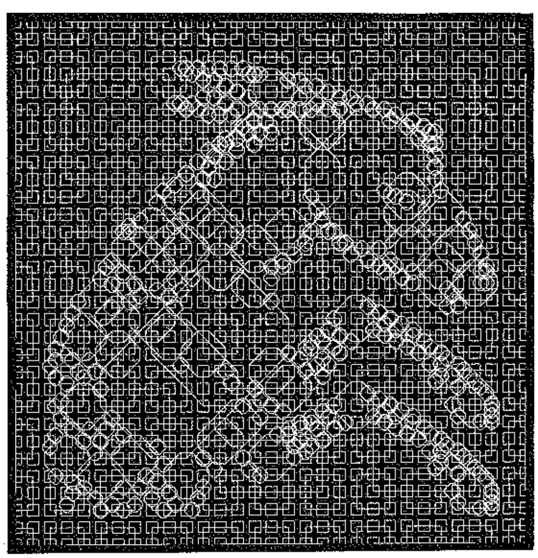
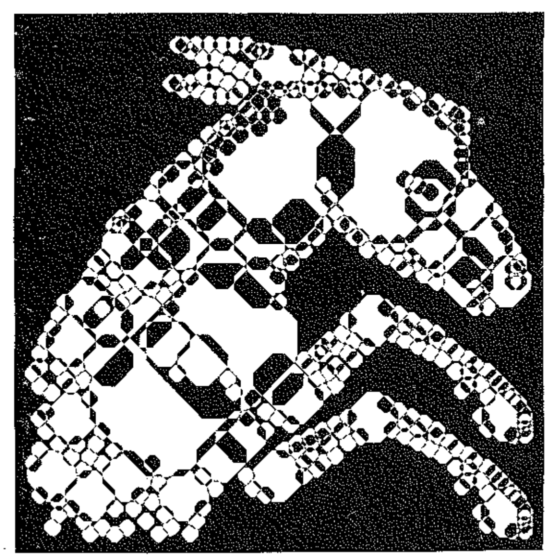


Figure 28



Pictures 29-32 are inner-pictures of the same ISt as Picture 28. They represent the four periods of life of man in female figures; a girl, a virgin, a woman and an aged woman. Pictures 33-36 are the plans of the Pictures 29-32; i.e., they represent their coverings with BFs. The white coloured squares indicate which BFs appear.

Pictures 37-40 are likewise inner-pictures of the same ISt as Picture 28. In these pictures, however, appear fusions of BFs. Which BFs shall fuse is up to the "composer" of the picture. But only BFs of the same layer are allowed to fuse. We call such pictures "fusion-pictures". Pictures 37-40 represent: a marabou (the large white plane-piece in the middle represents the beak), an owl, a chicken, and three little birds on a twig in a cage.

Pictures 29-32 were designed by Mr. Walter Schmeer in Saarbücken at my suggestions, and Pictures 37-40 were designed, also at my suggestion, by Mrs. Anneliese Brandel in Dudweiler/Saar.

Figure 29.

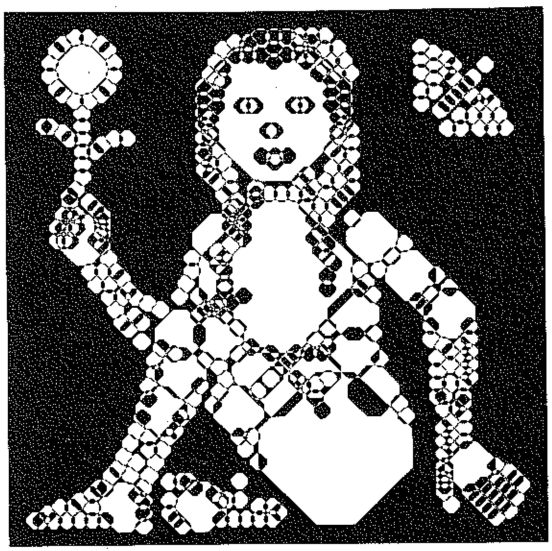


Figure 30.

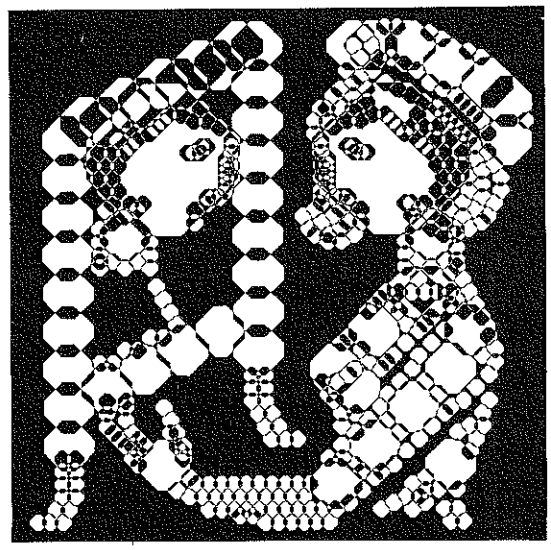


Figure 31.

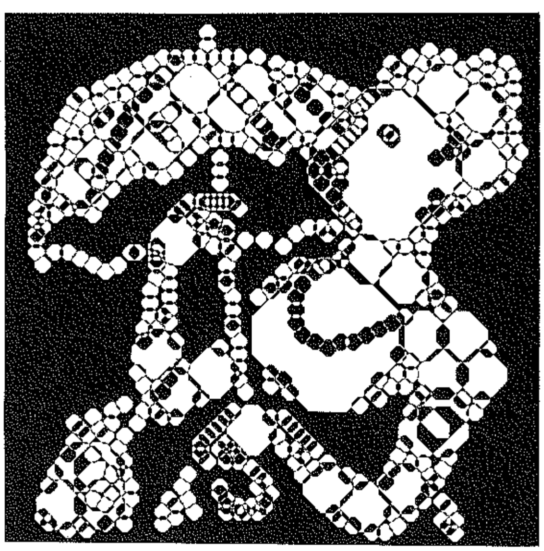
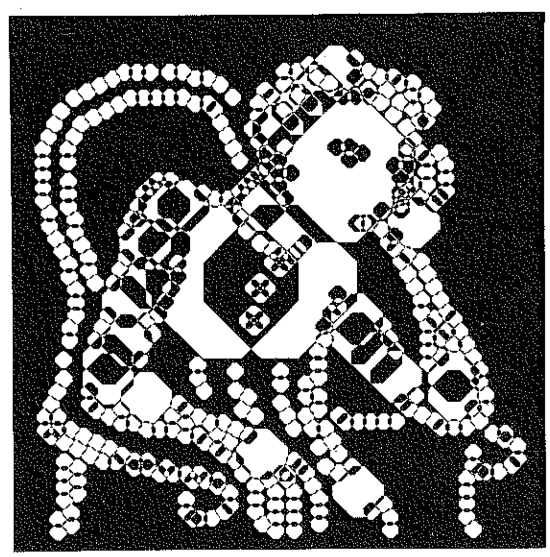


Figure 32.



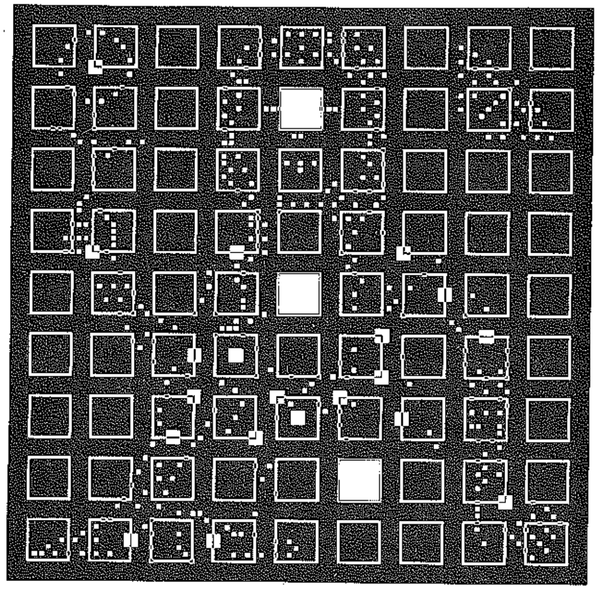


Figure 33.

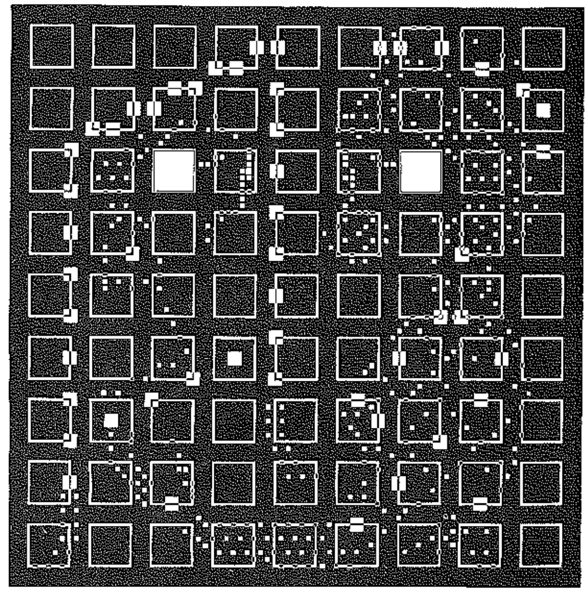


Figure 34.

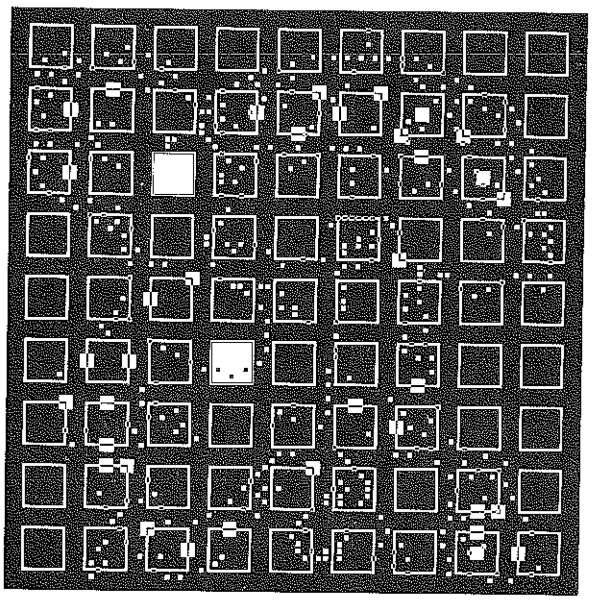


Figure 35.

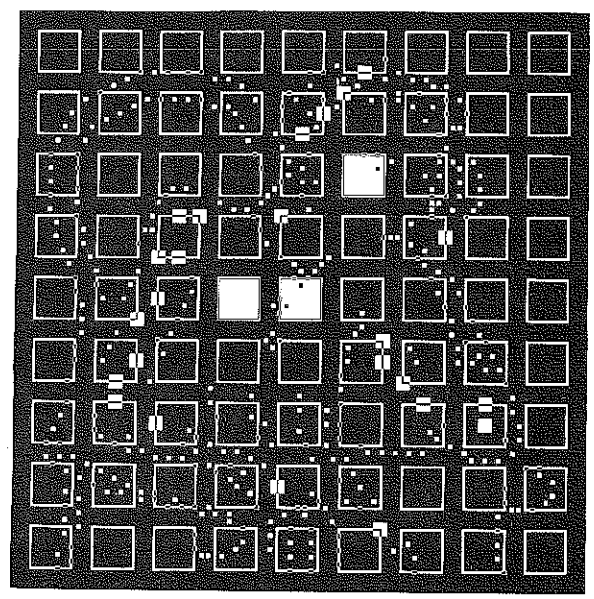


Figure 36.

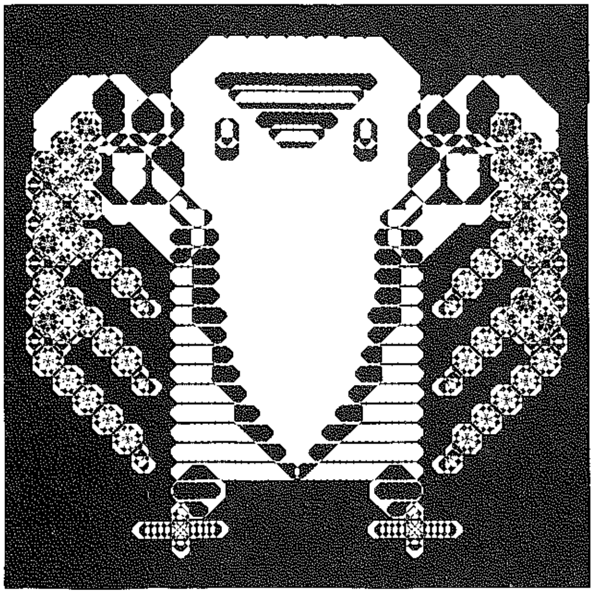


Figure 37.

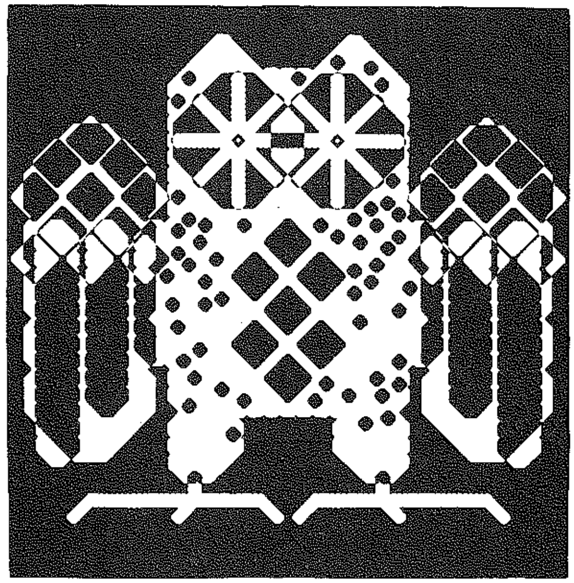


Figure 38.

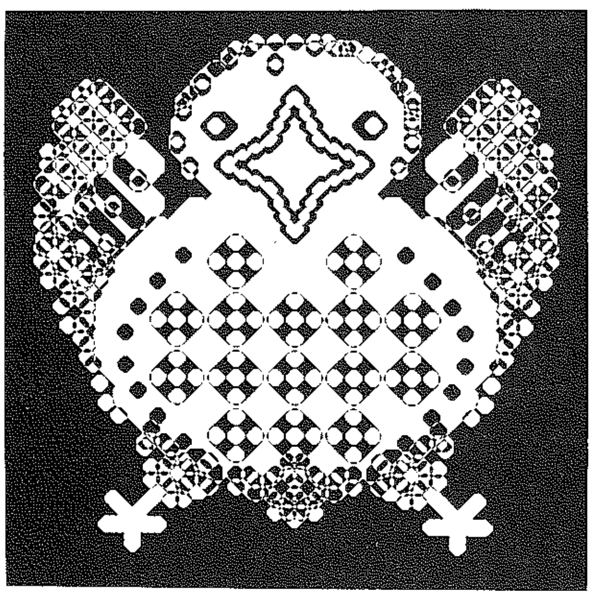


Figure 39.

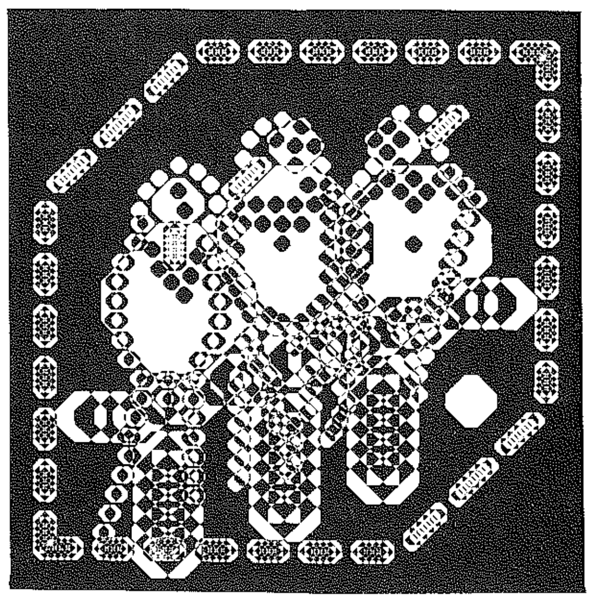


Figure 40.

PUZZLE CORNER

ROBERT P. KELSO
LOUISIANA TECH UNIVERSITY

"PERPLEXAHEDRON" (Paraphrased)
Winter '79 Puzzle

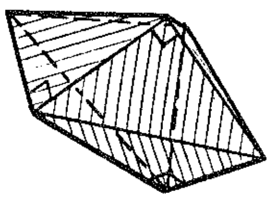


FIG. 2

Given: A "Perplexing" Octahedron with all surfaces formed by right isosceles triangles of equal size.

Required: Construct two adjacent orthographic views using conventional drawing techniques. (No calculations)

Send your solutions to:

Robert P. Kelso
Assistant Editor EDGJ
Dept, of Ind. Engrg.
& Comp. Science
Louisiana Tech University
Ruston, LA 71272

Solutions received before March 15, 1980 will be included in the Spring Issue.

The time difference between the Fall Isslue release date and the Winter Issue deadline (November 15) is insufficient to allow for responses so in the future we are going to make the Puzzle Corner a Fall and Spring column only and will hold over the Fall '79 puzzle.

It is an interesting one. We trust you have not made the same mistake that we have of telling students that the only view in which the true-angle-between-two-lines will be seen is the view which shows both TL!!!!

engineering design graphics journal

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

July 31, 1979

Mr. Abe Rotenberg
Department of Mechanical Engineering
University of Melbourne
Parkville, Victoria 3052
Australia

Dear Abe:

Thank you for yours of 18 July.

Re: Your "perplexolution"

It is my view that if a solver has resorted to an algebraic calculation at any stage of the problem solving process then he has violated the spirit of the "no calculations" condition. I see no difference in "legitumacy" between using the calculation to scale the dimensions directly on the drawing and in using them as a goal for a geometrically derived dimension as in the case of the perplexolution.

I suggest that a greater difficulty would have been posed if the conditions specified "using Descriptive Geometry exclusively". Would these conditions have ruled out the perplexolution? I believe this goes to the heart of your question: What are the definitive differences among Mathematics, Plane Geometry, Mechanical Drawing and Descriptive Geometry? I have given this considerable thought and have torn up two long letters because both ended in circular arguments. It is with much regret that, at this writing, I can not invest more time to it but I am keenly interested in receiving your (or anyone's) analysis.

A point that should be borne during this analysis is the fact that all first degree algebraic equations of not more than three variables and also all third degree equations of one variable (and those equations which lie between these two) are peculiarly amenable to geometric (as opposed to mathematical curve plotting) solutions which means that the algebraic calculations of the perplexolution could, theoretically, have been accomplished by geometric methods.

Best,
Pat

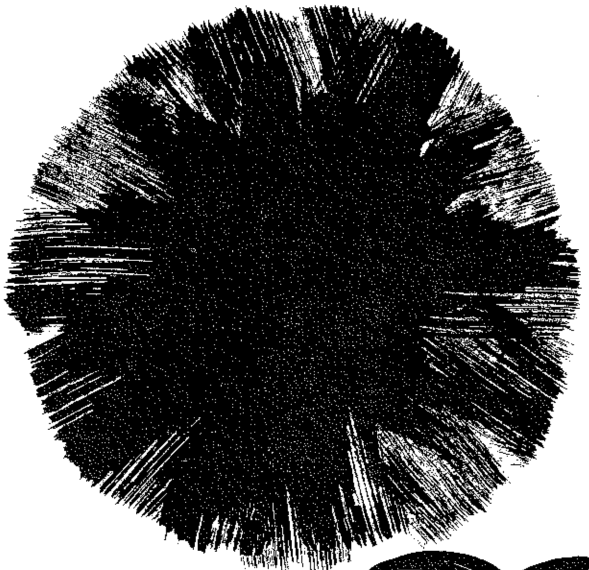
Robert P. Kelso
Assistant Editor

The 'Corner's indispensible correspondent and friend, Abe Rotenberg of the University of Melbourne, took some issue ("to provoke a public discussion") with our contention that his geometric solution to the Perplexahedron (Fall '79) did not satisfy the "no calculations" condition. He called his solution the "Perplexolution". Recall that he apparently made a calculation to determine the mathematical solution, then submitted the geometry which would yield that solution. Below is our reply. What would be yours?

Do you have an opinion on this which can be defended?

Perhaps this is hairsplitting, but it seems we "Descript Nuts" should be able to definitively distinguish from other disciplines that which we teach. In the meantime, break out your T-squares and square off with the Fall/Winter puzzle. See ya next issue

Robert P. Kelso



eclipse

THE NORTH DAKOTA WINTER WAS KIND TO US.
THE FINGER & PILLOW DRIFTS OF SNOW ACROSS THE HIGHWAY
COULD NOT KEEP US FROM OUR MEETING
WITH THE UMBRA OF THE MOON'S SHADOW.
THE SUN BEGAN TO GROW THINNER.
OFF THE SIDE OF THE HIGHWAY, A GRAVEL ROAD
LED US TO THE TOP OF A WIND SWEPT HILL OVERLOOKING
THE TOWN OF DONNYBROOK. THIS WAS THE PLACE OF OUR VIGIL.

THE BITE OUT OF THE SUN GREW,
REDUCING IT TO THE THINNEST OF CRESCENTS. SOON
SHADOW BANDS DANCED ACROSS THE SNOW AT OUR FEET,
FOREWARNING OF THE DARKNESS THAT WE SAW
RAPIDLY APPROACHING US.
THEN WE LOOKED UP TO SEE A FIERY CIRCLE
WITH A BRILLIANT SPOT OF LIGHT FROM THE LAST BIT OF THE SUN
TO BE COVERED. THE SPOT QUICKLY FADED AND THE FIERY
BEADS ON THE CIRCLE WENT OUT IN RAPID SUCCESSION
AS THE VALLEYS OF THE MOON FELL INTO DARKNESS.
THE CIRCLE WITHIN WAS EMPTY,
AND WITHOUT WERE TONGUES OF RED. THE PEARLY WHITE
CORONA STRETCHED UNEVENLY IN ALL DIRECTIONS
INTO THE INDIGO SKY. THE CIRCLE OF THE HORIZON
GLOWED WITH YELLOW & ORANGE. SUNSET WAS EVERYWHERE.

SUDDENLY, ON THE CIRCLE ABOVE, A BRIGHT SPOT OF LIGHT
APPEARED. WE TURNED AWAY.

T. A. WEBER

METRIC

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