THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the REAPS Technical Symposium

Paper No. 4: Computer-Aided Engineering and Drafting in Shipbuilding

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Dr. Cowan has a B.S. degree from Brown University and M.S. and Ph.D. degrees from Case Institute of Technology.
PROBLEMS COMPANIES FACE TODAY

- HIGH COST OF CREATING DESIGN DOCUMENTATION
- RISING COST OF MANPOWER
- TIME WASTED ON TEDIOS REPETITIVE TASKS
- LACK OF STANDARDIZATION
- PEAK WORK LOAD SITUATIONS
- REJECTED FINISHED PARTS
- TRIAL AND ERROR APPROACH TO PARTS PROGRAMMING
- LONG PRODUCT LEAD TIMES

RESULT OF THESE PROBLEMS
- WASTED COMPANY RESOURCES

RESULTING IN
- INCREASED PRODUCT COST
- REDUCED PRODUCTION
- REDUCED COMPETITIVE POSITION

BOTTOM LINE.
- LOST $$'s
<table>
<thead>
<tr>
<th>HARDWARE</th>
<th>SOFTWARE</th>
</tr>
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<tbody>
<tr>
<td>PLOTTER/DIGITIZERS</td>
<td>100% FORTRAN BASED</td>
</tr>
<tr>
<td>CRT's</td>
<td>SIMULTANEOUS, COMPATIBLE 3D AND 2D DATA BASES</td>
</tr>
<tr>
<td>DIGITIZERS</td>
<td>SIMULTANEOUS, MULTI-APPLICATION</td>
</tr>
<tr>
<td>PHOTOPLottERS</td>
<td>PEP</td>
</tr>
<tr>
<td>AUTOMATIC SCANNER</td>
<td>DATA BASE MANAGEMENT</td>
</tr>
<tr>
<td>PLOTTERS</td>
<td>MULTI-TERMINAL OPERATING SYSTEM AND FILE MANAGER</td>
</tr>
<tr>
<td>FULL RANGE OF COMPUTER</td>
<td>OPTIMIZED MAN-MACHINE INTERFACE</td>
</tr>
<tr>
<td>PERIPHERALS</td>
<td>SELF-TUTORING</td>
</tr>
<tr>
<td></td>
<td>FORTRAN COMPILER</td>
</tr>
<tr>
<td></td>
<td>NC POST PROCESSORS</td>
</tr>
<tr>
<td></td>
<td>ACCOUNTING FEATURES</td>
</tr>
</tbody>
</table>
3D MD/NC SYSTEM OVERVIEW

INPUT DESIGN INTERACTION

EDIT (CHANGE-UPDATE)

INTERROGATE

NC TAPES FOR MANUFACTURING
CL FILES
APT SOURCE

ENGINEERING DRAWINGS

GRAPHICS FOR TECHNICAL PUBLICATIONS

DATA FORMATTED FOR ENGINEERING ANALYSIS

BILL OF MATERIALS

APT LABELED PLOTS
CENTRAL DATA BASE CONCEPT

- **DESIGN DRAFTING**
  - **DESIGN DOCUMENTATION**
  - **COMMON CENTRAL DATA BASE (DIGITAL)**
    - **ENGINEERING**
    - **TECHNICAL PUBLICATIONS**
      - **PRODUCT DESCRIPTION**
    - **MANUFACTURING**
      - **FINISHED PRODUCT**
    - **DESIGN ANALYSIS**
DESIGN ON INTERACTIVE GRAPHIC SYSTEMS

- AREA, PERIMETER, LENGTH, VOLUME, DENSITY, WEIGHT
- 3D DISTANCE
- MINIMUM DISTANCE
- INTERSECTING LINES
- INTERSECTING LINES AND PLANES
- INTERFERENCE AND CLEARANCE
- TOLERANCE STACKING
- STRESS, STRAIN, THERMAL EXPANSION
- FIT PARTS TOGETHER
- CROSS-SECTION
- INTERSECTION OF SURFACES

+ ALL THE GEOMETRIC CONSTRUCTIONS
DRAFTING ON INTERACTIVE GRAPHIC SYSTEMS

- ISOMETRIC VIEWS
- CROSS-SECTIONS
- DIMENSIONING (ENGLISH & METRIC)
- CROSS-HATCHING
- FILLETS
- FEATURE CONTROL SYMBOLS
- SCALE, COPY, ROTATE, MIRROR, DELETE ETC.

Once design is completed the draftsman can easily create finished drawings of parts and assemblies

- Higher quality drawings
- In a shorter period of time
- At a reduced cost
BASIC GEOMETRY

POINT
LINE
STRING
CIRCLE
ARC

GROUPS
FILLET
SPLINE (CUBIC)

CONICS
(ELLIPSE)
(HYPERBOLA)
(PARABOLA)

ARRAYS
(RECTANGULAR)
(CIRCULAR)
EXTENDED GEOMETRY

- TABULATED CYLINDERS
- Ruled Surfaces
- Surfaces of Revolution
- B-Surfaces
- Mesh Surfaces
- Surface Intersections
AUTOMATIC DIMENSIONING

- ENGLISH/METRIC
- HORIZONTAL
- VERTICAL
- RADIAL
- DIAMETER
- ANGULAR
- PARALLEL POINTS (DIMENSIONS AT AN ANGLE)
- AUTOMATIC TOLERANCING
- ANSI Y14.5
GENERAL NOTES

1—DIM SPECIFIED MUST BE MAINTAINED.
2—DIM SHOWN IN ENGLISH AND METRIC FORM.
PEP PROGRAM (WEDGE)

PEP' JRIIS. WEDGE
SOURCE VERSION # 137 7-11-75
OBJECT VERSION **NONE**

11 PARTNO/WEDGE
21 $PARAMETERS
31 A=2.5 $LENGTH
41 B=A*COS (75) $THICK
51 C=2.5 $CONSTANT
61 D=.2 $DENSITY
71 $PART DEFINED

81 L1=LINE/0,0,A,0
91 L2=LINE/A,0,O,B
101 L3=LINE/0,B,0,o
111 L4=LINE/o,o,o,o,c
121 L5=LINE/o,o,c,A,o,c
131 L6=LINE/A,0,C,A,0,0
141 L7=LINE/A,0,C,O,B,C
151 L8=LINE/0,B,C,O,B,O
161 L9=LINE/0,B,C,0,0,C

171 AREA=A*B/2
181 VOLU-AREA*D
191 WGT=VOLU*D
201 PRINT/AREA, VOLU, WGT
211 FILE
221 FINI
THE FOUR VIEWS OF A WEDGE, RESULTED FROM EXECUTING THIS PROGRAM
NUMERICAL CONTROL

- GRAPHIC TOOL PATH DERIVATION
- UP TO 5-AXIS CAPABILITY
- POCKETING
- PROFILING
- POINT TO POINT
- ABSOLUTE AND SURFACE MACHINING
- APT SOURCE, APT GEOMETRIC SOURCE, APT LABEL PLOT
  (AUTOMATIC TAGGING), CL FILES, NC TAPES
- POST PROCESSORS
- MAGNETIC OR PAPER TAPE OUTPUT
HOW DO PEOPLE INTERFACE WITH THE SYSTEM?

- NO COMPUTER KNOWLEDGE REQUIRED
- EASY TO LEARN ENGLISH LANGUAGE COMMANDS
- SELF-TUTORING
COMMAND LANGUAGE

VERB NOUN: DIGITIZE

EXAMPLE: INSERT A SERIES OF CONNECTED LINES

INS LIN: DIG, DIG₂, DIG₃, DIG₄
TYPICAL NORMS ENTERED USING PEP AND A COMBINATION OF PARAMETERS AND DIGITIZED DATA
PARTS NESTED ON CRT