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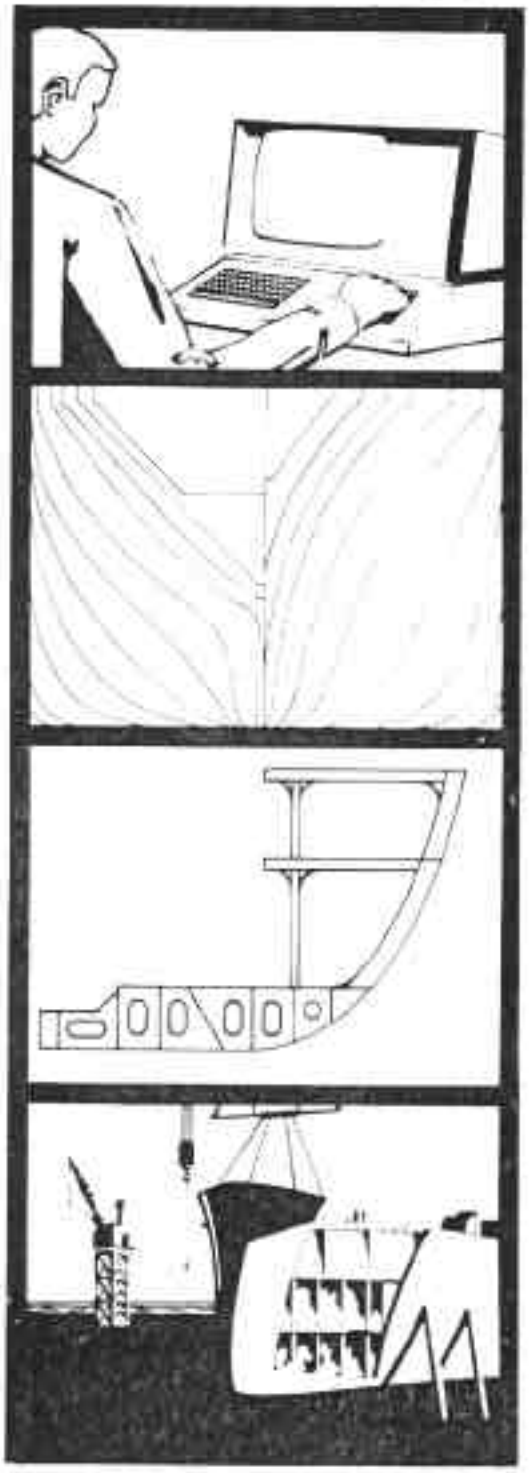

R ESEARCH
AND
E NGINEERING
FOR
A UTOMATION
AND
P RODUCTIVITY
IN
S HIPBUILDING

Proceedings of the
REAPS Technical Symposium
September 11-13, 1979
San Diego, California

INTEGRATING SHIPYARD DESIGN AND MANUFACTURING FUNCTIONS INTO AN EXISTING CAD/CAM SYSTEM

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Prior to his involvement with Manufacturing and Consulting Services Inc, Dr. Hanratty held the positions of President at Integrated Computer Systems, Manager of Automation Methods at Douglas Astronautics, Manager of Process Control at General Electric Computer Department, and Designer at General Motor Research Labs.

AD-2000 FUNCTIONS

1 MODALS AND FONTS
2 BLANK/UNBLANK
3 DELETE
4 FILE/TERMINATE
5 SPECIAL FUNCTIONS/APPLICATIONS
6 DATA BASE MANAGEMENT
7 INPUT/OUTPUT/REGENERATION
8 DISPLAY/DEPTH CONTROL
9 POINT
10 LINE
11 ARC/CIRCLE/FILLET
12 OTHER CURVES
13 ENTITY MANIPULATION
14 DATA VERIFY
15 EXTENDED GEOMETRY
16 DRAFTING
17 N/C MACHINING
18 ANALYSIS,
19 SIU/ENGLISH/RESIZE

FUNCTION CONTROL KEYS

[= REJECT
] = OPERATION COMPLETE
C = READ CROSSHAIR CURSOR
Y YES
N NO
M CHANGE MENU DISPLAY
R REPAINT THE DISPLAY
Z WINDOW (ZOOM)
D CHANGE DEPTH
F AD-2000 FUNCTIONS
CP POINT
CL LINE
CA ARC/CIRCLE
CD DELETE LAST ENTITY
P MOMENTARY POINT SELECT
LL MOMENTARY LINE SELECT
CA MOMENTARY ARC SELECT
CO MOMENTARY OTHER CURVES SELECT
S MOMENTARY SPLINE SELECT
T MOMENTARY TEXT SELECT
? "HELP" FUNCTION
! DATA CAPTURE

sl
?

1 MODALS AND FONTS

1 MENU DISPLAY
2 CONSTRUCTION MODAL
3 DISPLAY TOLERANCE
4 SYSTEM DECIMAL PLACES
5 CURVE FONT
6 MODIFY ENTITY FONT
7 MODIFY ENTITY LEVEL/PEN NO.
8 SURFACE PATHS
9 CURSOR MODE
10 VIEW VECTORS
11 SEQ.NO./POINTER SELECT
12 DISPLAY MODAL STATUS
13 DISPLAY TITLE BLOCK

1-5 CURVE FONT

1 SOLID
2 DASHED
3 PHANTOM
4 CENTERLINE

1-6 MODIFY ENTITY FONT

1 SOLID
2 DASHED
3 PHANTOM
4 CENTERLINE

2 BLANK/UNBLANK

1 BLANK ALL OF A SPECIFIC TYPE
2 BLANK ALL EXCEPT A SPECIFIC TYPE
3 BLANK ALL
4 BLANK, SELECT FROM SPECIFIC TYPE
5 BLANK, SELECT FROM ALL
6 BLANK ALL EXCEPT N1 TO N2
7 BLANK LEVELS
8 UNBLANK ALL
9 UNBLANK ALL OF A SPECIFIC TYPE
10 UNBLANK ALL EXCEPT A SPECIFIC TYPE
11 UNBLANK N1 TO N2
12 UNBLANK LEVELS

2 & 3 ENTITY TYPES

1 POINTS
2 LINES AND POINT SETS
3 ARCS AND CIRCLES
4 OTHER CURVES
5 ARRAYS AND GROUPS
6 EXTENDED GEOMETRY
7 LABELS, DIMENSIONS AND NOTES
8 CENTERLINES
9 CROSS-HATCHING
10 POINT-TO-POINT PATHS
11 N/C PATHS (NON POINT-TO-POINT)

5 SPECIAL FUNCTIONS

1 CANON
2 GRAPL-II
3 MANAGE VARIABLES
4 USER DEFINED SYMBOLS
5 LEVEL MANAGEMENT
6 ATTRIBUTE MANAGEMENT
7 DATA GRAPHS*
8 APPLICATIONS

5-2 GRAPL-II

1 VARIABLE CALCULATION
2 INPUT/EDIT GRAPL-II PROGRAMS*
3 AUTO GRAPL-II**
4 RUN GRAPL-II PROGRAM**

5-3 MANAGE VARIABLES

1 MOVE VARIABLES FROM UTF TO RTL
2 MOVE VARIABLES FROM RTL TO UTF
3 LIST TECHNOLOGY FILE VARIABLES
4 LIST RUN TIME LIBRARY VARIABLES

5-5 LEVEL MANAGEMENT

1 CHANGE LEVEL/PEN NO.
2 DEFINE LEVELS
3 LIST LEVELS
4 DELETE LEVELS
5 INITIALIZE LEVELS

5-6 ATTRIBUTE MANAGEMENT

1 CREATE
2 INTERROGATE
3 DELETE**

5-6-2 INTERROGATE

1 RETRIEVE
2 IDENTIFY MINIMUM
3 IDENTIFY MAXIMUM
4 FIND TOTAL
5 CONSTRAINED RETRIEVE
6 DISPLAY

5-6-2-5 CONSTRAINT RELATIONALS

1 LESS THAN
2 LESS THAN OR EQUAL
3 EQUAL
4 NOT EQUAL
5 GREATER THAN OR EQUAL
6 GREATER THAN

5-7-1 DATA GRAPHS*

5-7-1 DATA GRAPH TEMPLATE MODES

1 RETRIEVE
2 SELECT FROM SCREEN
3 CREATE

5-7-1 GRAPH TYPE

1 LINEAR
2 POLAR
3 PIE

5-7-1 PLOT TYPES

1 POINT PLOT
2 LINE PLOT
3 FUNCTION
4 HISTOGRAM
5 HORIZONTAL BAR GRAPH
6 VERTICAL BAR GRAPH

6 DATA BASE MANAGEMENT

1 PART MANAGEMENT
2 PATTERN MANAGEMENT
3 TEMPLATE MANAGEMENT**
4 FIGURE MANAGEMENT**
5 USER TECHNOLOGY FILE MANAGEMENT
6 DATA BASE INFORMATION
7 DUMP CURRENT PART

6-1 PART MANAGEMENT

1 SAVE PARTS ON TAPE
2 RESTORE PARTS FROM TAPE
3 LIST ON-LINE PART FILE
4 COPY PART UNDER NEW NAME
5 DELETE A PART
6 CHANGE PART STATUS
7 MERGE INTO CURRENT PART**

6-2 PATTERN MANAGEMENT

1 CREATE A PATTERN
2 RETRIEVE A PA-i-TERN
3 DELETE A PATTERN
4 LIST ON-LINE PATTERN FILE
5 INITIALIZE PATTERN LIBRARY
6 SAVE PATTERNS ON TAPE**
7 RESTORE PATTERNS FROM TAPE**

6-3 TEMPLATE MANAGEMENT**

1 CREATE A TEMPLATE
2 RETRIEVE A TEMPLATE
3 DELETE A TEMPLATE
4 LIST ON-LINE TEMPLATE FILE
5 INITIALIZE TEMPLATE LIBRARY

* NOT AVAILABLE ON 16 BIT COMPUTERS
** AVAILABLE DECEMBER, 1979

6-4 FIGURE MANAGEMENT**

1 CREATE A FIGURE
2 RETRIEVE A FIGURE
3 DELETE A FIGURE
4 LIST ON-LINE FIGURE FILE
5 INITIALIZE FIGURE LIBRARY

6-5 USER TECHNOLOGY FILE MANAGEMENT

1 LIST
2 DELETE
3 SAVE ON TAPE
4 RESTORE FROM TAPE
5 INITIALIZE

6-6 DATA BASE INFORMATION

1 ENTITY INFORMATION
2 CURRENT PART SPACE
3 PART LIBRARY SPACE
4 PATTERN LIBRARY SPACE
5 USER TECHNOLOGY FILE SPACE

6-7 CURRENT PART DUMP

1 INSPECT COMMON VALUES
2 DUMP ENTITIES BY SEQ.NO.
3 DUMP ENTITIES BY LEVEL

7 INPUT/OUTPUT/REGENERATION

1 OUTPUT CL-FILE/CLPRINT
2 PLOT
3 DISPLAY LAST SEQ. NO. USED
4 DISPLAY ENTITY SEQUENCE NUMBER
5 IDENTIFY ENTITY NUMBER N
6 IDENTIFY ENTITIES N1 TO N2
7 REGENERATE ENTITY NUMBER N
8 REGENERATE FROM N1 TO-N2
9 REGENERATE ALL
10 BULK DATA INPUT
11 USER I/O INTERFACE

8 DISPLAY/DEPTH CONTROL

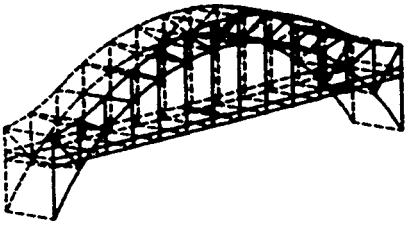
1 ZOOM
2 CHANGE DEPTH
3 CHANGE VIEW(S)
4 CHANGE WORK-VIEW
5 DEFINE AUXILIARY VIEW
6 Z-CLIP

8-1 ZOOM CONTROL

1 RETURN TO ORIGINAL SCALE
2 SELECT A NEW CENTER
3 SELECT NEW CENTER & DOUBLE SCALE
4 SELECT NEW CENTER & HALF SCALE
5 SELECT NEW CENTER & KEY-IN SCALE
6 DOUBLE SCALE
7 HALF SCALE
8 KEY-IN SCALE
9 DIAGONAL POINTS
10 KEY-IN MAX-MINS
11 AUTO MAX-MINS
12 SAVE ZODM STATUS

8-5 AUXILIARY VIEW DEFINITION

1 NORMAL AXIS CW
2 NORMAL AXIS, CCW
3 HORIZONTAL AXIS TOP OUT
4 HORIZONTAL AXIS TOP IN
5 VERTICAL AXIS RIGHT OUT
6 VERTICAL AXIS RIGHT. IN
7 ROTATE ABOUT ANY LINE
8 PARALLEL TO A PLANE
9 KEY-IN MATRIX
10 COPY AS A NEW VIEW



** AVAILABLE DECEMBER, 1979

9 POINT

1 SCREEN POSITION
2 KEY-IN COORDINATES
3 POLAR
4 DELTA
5 VECTORED
6 CIRCLE CENTER
7 ON A CIRCLE AT AN ANGLE
8 CURVE ENDPOINT
9 INTERSECTION OF TWO CURVES
10 REGENERATE SPLINE POINTS
11 ON A LINE
12 CURVE NORMAL POINT
13 BEARING/DISTANCE
14 ON A CURVE AT A PARAMETER
15 SURFACE NORMAL/PIERCE POINT
16 SPHERICAL
17 FAN POINTS
18 INCREMENTAL POINTS
19 MODIFY/REPLACE

10 LINE

1 SCREEN POSITION
2 KEY-IN COORDINATES
3 JOIN OF TWO POINTS
4 TANGENT TO TWO CURVES
5 THRU POINT AND HORIZ. OR VERTICAL
6 THRU POINT AND TANGENT TO A CURVE
7 POLAR LINE
8 THRU POINT AND PARALLEL TO A LINE
9 THRU POINT AND PERPTO A LINE
10 PARALLEL TO A LINE AT A DISTANCE
11 PARALLEL TO A LINE, TANTO A CURVE
12 PERPTO A LINE, TANGENT TO A CURVE
13 DIVIDE LINE INTO N SEGMENTS
14 JOIN TWO CURVES
15 MODIFY STATUS (INFINITE/NON-INFINITE)
16 AXIS DEFINITION
17 CHAMFER
18 MODIFY/REPLACE

11 ARC/CIRCLE/FILLET

1 SCREEN POSITION AND RADIUS
2 KEY-IN CENTER AND RADIUS
3 CENTER POINT AND RADIUS
4 CENTER POINT AND TANGENT LINE
5 CENTER POINT AND TANGENT CIRCLE
6 CENTER POINT AND POINT ON EDGE
7 THROUGH THREE POINTS
8 MODIFY ANGLES
9 FILLET
10 INSCRIBED IN THREE LINES
11 NORMAL TO VIEW
12 MODIFY/REPLACE

12 OTHER CURVES

1 SPLINE
2 OFFSET CURVE
3 CONICS
4 STRING
5 MAKE STRING FROM LINES/ARCS
6 MAKE LINES/ARCS FROM STRING
7 N-GON
8 TRIM CURVES
9 CONVERT STRING TO POINT SET CURVE

12-3 CONICS

1 ELLIPSE
2 HYPERBOLA
3 PARABOLA
4 GENERAL CONIC
5 LOFT CONIC
6 RHO CONIC
7 CYLINDER SLICE

12-4 STRING

1 SCREEN POSITION
2 KEY-IN COORDINATES
3 EXISTING POINTS
4 DELTA
5 POLAR
6 BEARING
7 CW ARC
8 CCW ARC
9 CONNECT TO CURVE
10 INDICATE ARC
11 CLOSE OPTIONS

12-7 N-GON

1 TRIANGLE
2 RECTANGLE
3 HEXAGON

12-8 TRIM MODE

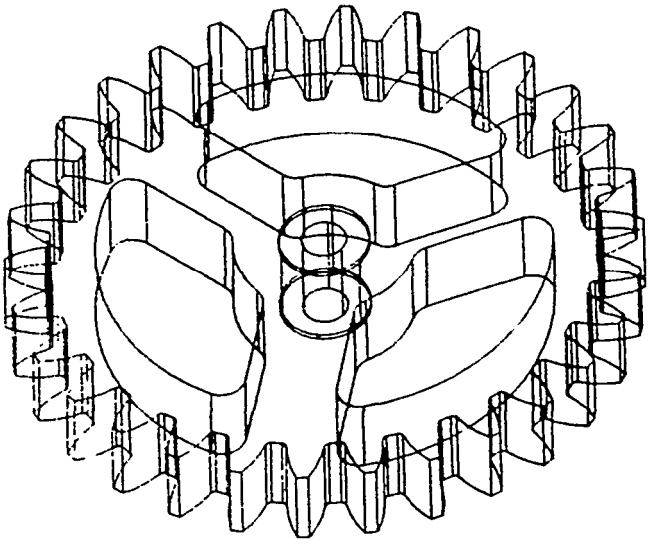
1 ONE END
2 BOTH ENDS
3 MIDDLE
4 TWO CURVES AT INTERSECTION

13 ENTITY MANIPULATION

1 RECTANGULAR ARRAY
2 CIRCULAR ARRAY
3 GROUP
4 MIRROR
5 TRANSLATE
6 ROTATE
7 DUPLICATE AND TRANSLATE
8 DUPLICATE AND ROTATE
9 ARRAY EXPLODE
10 STRETCH

14 DATA VERIFY

1 POINTS
2 LINES
3 ARCS AND CIRCLES
4 SPLINES
5 ELLIPSES
6 HYPERBOLAS
7 PARABOLAS
8 ARRAYS
9 GROUPS
10 GENERAL MEASUREMENTS
11 DRAFTING ENTITIES
12 TRIANGLES, RECTANGLES, HEXAGONS



15 EXTENDED GEOMETRY

1 3-D CURVES
2 SURFACES
3 SOLIDS
4 CROSS SECTION SLICE
5 DEVELOPABLE SURFACE LAYOUT

15-1 3-D CURVES

1 3-D SPLINE
2 SURFACE EDGE CURVE
3 SURFACE INTERSECTION CURVE
4 DRAFT OR MACHINE CURVE
5 COMPOSITE CURVE
6 VECTOR

15-2 SURFACES

1 PLANE
2 SURFACE OF REVOLUTION
3 3-D TABULATED CYLINDER
4 RULED SURFACE
5 DEVELOPABLE SURFACE
6 CURVE MESH SURFACE
7 FILLET SURFACE*
8 OFFSET SURFACE
9 SPHERE
10 CYLINDER
11 TORUS
12 CONE
13 COMPOSITE SURFACE
14 CHANGE PARAMS FOR NEW SURFACE
15 PROJECTED SURFACES
16 CURVE DRIVEN SURFACE

15-1-6 VECTOR

1 SCREEN POSITION
2 KEY-IN
3 TWO POINTS
4 PLANE UNIT NORMAL
5 SCALAR TIMES VECTOR
6 CROSS TWO VECTORS
7 NORMALIZED VECTOR
8 THRU PT AT GIVEN LENGTH & ANG
9 INTERSECTION OF TWO PLANES
10 SUM OR DIFFERENCE OF TWO VECTORS
11 THRU A PT AT ANG WITH LINE/VECTOR

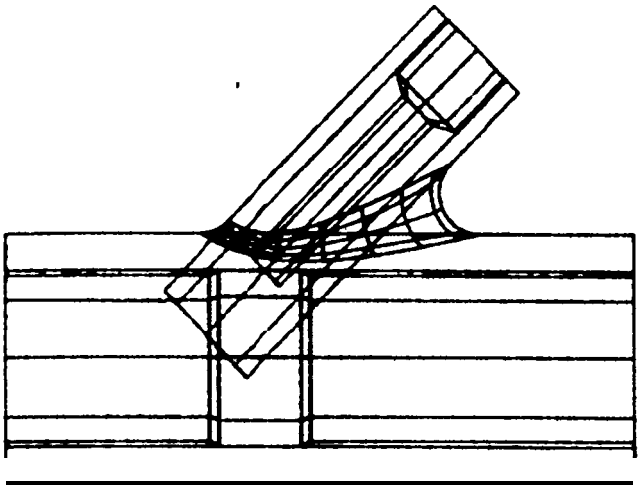
* NOT AVAILABLE ON 16 BIT COMPUTERS

15-2-1 PLANE

1 COEFFICIENTS
2 THRU THREE NON-COLLINEAR POINTS
3 THRU PT AND PARALLEL TO A PLANE
4 PARALLEL TO A PLANE AT A DISTANCE
5 THRU A PT AND PERPTO A VECTOR
6 THRU TWO PTS AND PERPTO A PLANE
7 THRU A PT AND PERPTO TWO PLANES
8 TWO LINES

15-3 SOLIDS

1 HEXAHEDRON
2 SPHEROID
3 CIRCULAR ROD
4 TOROID
5 ELLIPSOID
6 PROJECTED**
7 ROTATED**
8 FROM ORTHOGONAL VIEWS***
9 SIMULTANEOUS MULTI-VIEW CONSTRUCTION***
10 COMPOSITE***



16 DRAFTING FUNCTIONS

1 DRAFTING MODALS
2 PROJECTED ENTITY
3 CROSS-HATCHING
4 HORIZONTAL DIMENSION
5 VERTICAL DIMENSION
6 PARALLEL DIMENSION
7 ANGULAR DIMENSION
8 CIRCULAR DIMENSION
9 DIAMETER DIMENSION
10 GENERAL NOTE
11 GENERAL LABEL
12 CENTERLINE
13 MODIFY DRAFTING ENTITY
14 DETAIL MAGNIFICATION
15 BALLOON
16 TRUE POSITION SYMBOLS
17 ARROWHEAD AT END OF LINE
18 THICKNESS DIMENSION

16-1 DRAFTING MODALS

1 CHARACTER SIZE
2 WITNESS LINE CONTROL
3 TEXT-ARROW CONTROL
4 AUTOMATIC DIMENSIONS
5 KEY-IN DIMENSIONS
6 CROSS-HATCHING MATERIAL
7 DECIMAL PLACES
8 FRACTIONS
9 LABEL AND DIMENSION ORIGIN
10 ARROWHEAD ALIGNMENT
11 DRAFTING SCALE FACTOR
12 CHARACTER SET CONTROL
13 SLANT STATUS (ON/OF)
14 CHARACTER DISPLAY RATIOS
15 ARROWHEAD LENGTH
16 DIMENSION OFFSET DISTANCES
17 TEXT ANGLE CONTROL
18 DUAL DIMENSIONING
19 DISPLAY DRAFTING MODALS

16-1-2 WITNESS LINE CONTROL

1 NO SUPPRESSION
2 SUPPRESS FIRST
3 SUPPRESS SECOND
4 SUPPRESS BOTH
5 LABEL LEADER TO FIRST TEXT LINE
6 LABEL LEADER TO MIDDLE TEXT LINE

16-1-3 TEXT/ARROW CONTROL

1 TEXT IN, ARROWS IN
2 TEXT IN, ARROWS OUT
3 TEXT OUT, ARROWS OUT
4 TEXT OUT, ARROWS IN

*** AVAILABLE 1ST QUARTER, 1980

16-13 MODIFICATION TYPE

1 NEW ORIGIN
2 BASIC
3 REFERENCE
4 ADD TOLERANCE OR LIMITS
5 NEW CHAR. SIZE
6 MODIFY TEXT
7 MODIFY SLANT STATUS
8 MODIFY ANGLE
9 CHANGE TOLERANCE

16-13-6 MODIFY TEXT

1 DELETE LINE
2 INSERT LINE
3 REPLACE STRING

16-16 TRUE POSITION SYMBOL ORIGIN

1 SCREEN POSITION
2 KEY-IN
3 EXISTING POINT
4 BELOW FEATURE CONTROL BOX
5 ABOVE FEATURE CONTROL BOX

16-16 GEOMETRIC CHARACTERISTIC

1 STRAIGHTNESS
2 FLATNESS
3 ROUNDNESS (CIRCULARITY)
4 CYLINDRICITY
5 PROFILE TO A LINE
6 PROFILE TO A SURFACE
7 ANGULARITY
8 PERPENDICULARITY (SQUARENESS)
9 PARALLELISM
10 POSITION
11 CONCENTRICITY
12 SYMMETRY
13 CIRCULAR RUNOUT
14 TOTAL RUNOUT

16-16 OTHER T.P. SYMBOLS

1 MAXIMUM MATERIAL CONDITION
2 REGARDLESS OF FEATURE SIZE
3 DIAMETER
4 PROJECTED TOLERANCE ZONE

16-1-6 CROSS-HATCHING MATERIAL

1 IRON
2 STEEL
3 BRONZE, BRASS, COPPER
4 RUBBER; PLASTIC
5 REFRACTQRY MATERIAL
6 MARBLE, SLATE, GLASS
7 ZINC, LEAD, BABBITT
8 MAGNESIUM, ALUMINUM, ALUMINUM ALLOYS

16-1-9 LABEL AND DIMENSION ORIGIN

1 INDICATE POSITION
2 KEY-IN
3 DELTA
4 AUTOMATIC

16-1-12 CHARACTER SET CONTROL

F A S T
2 STANDARD
3 USER GENERATED

16-1-17 TEXT ANGLE CONTROL

1 NONE
2 ACCEPT ANGLE INPUT
3 ASK FOR PARALLEL LINE/ARC IN NOTE
4 TOTAL ANGLE CONTROL

16.12 CENTERLINE

1 POINTS
2 CIRCLE(S)
3 BOLT CIRCLE

17 N/C MACHINING

1 N/C MODALS
2 POINT-TO-POINT
3 PROFILE (PLANAR/3-AXIS/5-AXIS)
4 POCKET (PLANAR/3-AXIS/5-AXIS)
5 3-AXIS MILLING
6 5-AXIS END CUTTING
7 5-AXIS SWARF CUTTING
8 ABSOLUTE TOOL MOTION
9 LATHE
10 DEFINE CYCLE
11 DISPLAY AND EDIT
12 3 SURFACE PROFILE*
13 3-AXIS FLANGE*
14 COMPOSITE TOOL PATHS*
15 POST PROCESSORS****

17-1 N/C MODALS

1 SFM
2 TOOL PATH DISPLAY MODE
3 COOLANT
4 SPINDLE DIRECTION
5 FEED RATES
6 SPINDLE SPEED
7 CLEARANCE/RETRACT PLANES
8 TOLERANCES
9 DEEP HOLE PARAMETERS
10 RAPID FEED MODE
11 TOOL DISPLAY FOR DISPLAY & EDIT
12 DISPLAY N/C MODALS

17-1-15 TOOL DISPLAY FOR DISPLAY & EDIT

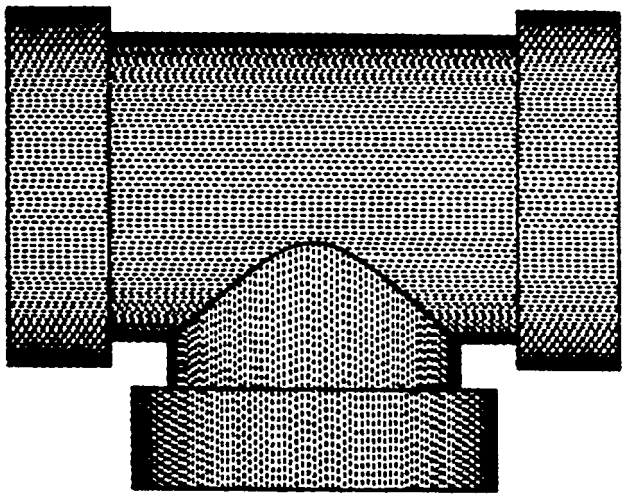
1 NONE
2 NORMAL TO VIEW
3 PARALLEL TO VIEW

17-2 POINT-TO-PQINT TOOLS

1 SPOT DRILL
2 TAP
3 DRILL
4 BORE
5 FINISH BORE
6 SPOT FACE
7 COUNTER SINK
8 REAM
9 MILL

17-10 CYCLE COMMANDS

1 CLW
2 CCLW
3 SPINDLE SPEED
4 COOLANT ON
5 COOLANT OFF
6 FLOOD COOLANT ON
7 MIST COOLANT ON
8 TAP COOLANT ON
9 PLUNGE (RAPID)
10 RETRACT (RAPID)
11 FEED TO FIXED ZT
12 FEED TO DELTA ZT FROM CURRENT DEPTH
13 FEED TO POINT + DELTA DISTANCE
14 DWELL
15 STOP
16 DEEP HOLE



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**** AVAILABLE AS SPECIAL ORDER ONLY

18 ANALYSIS

1 SPLINE ANALYSIS
2 ANALYTIC AREA/PERIMETER
3 2-D SECTION ANALYSIS
4 3-D ANALYSIS
5 WEIGHTS & VOLUMES
6 CURVE ANALYSIS

18-1 SPLINE ANALYSIS

1 SLOPE
2 CURVATURE
3 RADIUS OF CURVATURE
4 X vs. PARAMETER PLOT
5 Y vs. PARAMETER PLOT
6 EXTENDED ANALYSIS

18-2 2-D SECTION ANALYSIS

1 LENGTH OF PERIMETER
2 AREA
3 CENTER OF GRAVITY
4 FIRST MOMENT
5 MOMENT OF INERTIA
6 RADIUS OF GYRATION
7 POLAR MOMENT OF INERTIA
8 POLAR RADIUS OF GYRATION
9 MIN/MAX X,Y

18-4 3-D ANALYSIS

1 SURFACE AREA
2 VOLUME
3 WEIGHT
4 WEIGHT/UNIT LENGTH.
5 FIRST MOMENT OF MASS
6 CENTER OF MASS
7 MOMENT OF INERTIA
8 RADIUS OF GYRATION
9 SPHERICAL MOMENT OF INERTIA
10' SPHERICAL RADIUS OF GYRATION

18-5 WEIGHTS AND VOLUMES

1 SOLIDS
2 SURFACES TO A DEPTH

18-6 CURVE ANALYSIS

1 CURVE LENGTH
2 DERIVATIVES