SECTION V

COMPUTER-ASSISTED PART PROGRAMMING

Consider the steps involved in manually making a tape to machine the PLATE PART NO 050117 (Example No. 7 in Section IV):

1. Identify the lines and circles on the workpiece by labeling them.

2. Construct the cutter path. The cutter path is offset from the workpiece by a distance equal to the cutter radius. The tape will consist of eleven blocks of information, each defining a linear move or a quadrant of circular motion.

3. Calculate the required dimensions for each move. Note the tedious trigonometry required.

4. List these dimensions sequentially to define the cutter location path.

5. Convert these dimensions into the format required by the control system, adding instructions such as feedrates and machine functions (coolant/on, spindle/on, etc.).

6. Punch the paper tape containing the above information.

Thus, besides a knowledge of machining practice, the manual part programmer requires a high level of proficiency in basic mathematics together with the ability to solve complex trigonometric problems repetitively without making any errors.

Computer-assisted part programming shifts much of the difficult, repetitive, and exacting requirements of the job to the computer with the result that more people can become good part programmers.

Computer-assisted programming is available by using either in-house computer processing, service bureaus, or remote-access time sharing.

1. In-house processing: If computer time is readily available, an in-house computer provides the most economical method of developing program tapes. Unfortunately, few installations can support the cost of a computer facility for N/C programming alone; therefore the computer is used for payroll, accounting, inventory, engineering computations and other functions as well. Because N/C part programming has to wait its turn in the input queue line, turnaround time can become excessive. Since the generation of a useful program can take two or three debugging runs, it is very desirable that the part programmer have immediate access to the results of each run.

2. Service bureaus: Utilizing the expertise and computer facilities of a service house relieves the N/C user of the hardware and personnel costs that may only be required on a part-time basis. Many service organizations will prepare program tapes working directly from workpiece drawings. The overall job may even include fixture design and tool specification. The key to a successful user-service bureau relationship is how revisions are handled: corrections in input part specifications, program modifications required for optimum performance, etc.

3. Remote-access time sharing: Time sharing offers direct access to a computer through data terminal - telephone line hookup. The user pays only for the time that he actually uses. A part program is transmitted to a time-shared computer in which a N/C master program resides, the computer generates the required information and transmits it back to the line printer-tape punch in the user's plant. The whole process from input part program to debugged tape for a reasonably complex part may take less than an hour. Several time sharing services are available. Table 5-1 lists the parameters and specifications of several time shared systems.

TABLE 5-1. N/C TIME SHARING SERVICE COMPARISON (a). Listed by Estimated Number of NC Users

Company/NC Processor Computer	Mode	No. of Cities w.Local Phone Access	Computer Turn Around Time	NC Program Support	PTP	2 Axis CP	3 Axis CP	Documentation Training	Ease of Operation Editing	Benchmark Cost (b)
MDSI (c) COMPACT II XDS 940	Interactive, Conversational Run/Edit	125	E	E	VG	G	F	E	E	$9.25
GE-ISD ADAPT (d) GE 635	Conversational Run/Edit	80	G to VG	F	VG	G	P	VG	VG	$9.29
UNIVERSITY COMPUTING APT (e) UNIVAC 1108	Conversational Edit Remote Batch Run	30	G	VG	VG	E	E	E	G	$7.52
UNITED COMPUTING APT (f) CDC 6600	Conversational Edit Remote Batch Run	72	G to E	G	VG	VG	VG	P	G	$4.25
SCI-TEK APT UNIVAC 1108	Conversational Edit Remote Batch Run	75	E	E	VG	VG	VG	VG	VG	$3.30

NOTES:

a. All services accept 10, 15, 30 cps remote terminals (Minimum Terminal Rental is approx. $65/month).

b. See PARTNO TS BENCHMARK. Cost for pretested part - including INPUT, RUN, LIST, PUNCH TAPE. Prime time rates were used. Bridgeport Machines is not recommending,but merely listing,available sources.

c. Minimum: $10/Postprocessor Ling/month. 5-day training course, no charge. Additional features: On line plotting, data transmission verification. COMPACT II is not an APT based language.

d. Initiation fee $100. Minimum $100/mo. Additional features: Generalized post processor generator. Enhanced version of ADAPT allowing multiple statement lines. (MARK II service)

e. Initiation fee $100. No monthly minimum. 5-day training course, no charge. Additional features: Enhanced version of APT: 3D curve fitting routine (BSURF) with optional remote digitizer input, simplified lathe, mill and CAM programming language set into APT environment. Remote computer I/O available

f. Initiation fee $100. Minimum $100/mo.

5.1 FUNDAMENTAL OF APT

The most powerful, comprehensive, and universal N/C processor is APT (Automatically Programmed Tools). APT is a language consisting of about 400 words, readily understandable to designers, process engineers, mathematicians, and part programmers, that enables a series of statements to be written which converts dimensional information contained on a drawing or sketch of the part to be machined into the data necessary to enable a particular machine tool and control system to machine the part. The part programmer does this by describing surfaces and a cutting tool, and then directing the tool to move through space along the intersections described by combinations of these surfaces.

The APT system can be considered by the programmer to be simulating an ideal N/C machine, one which:

1. Always holds the workpiece stationary and moves the tool.

2. Responds to both incremental and absolute commands.

3. Has unlimited travel available in from 1 to 5 axes.

4. Will accommodate any size and configuration tool.

5. Understands all about planes, spheres, cylinders, hyperbolic paraboloids, and other geometric surfaces and the need to move the tool within tolerance at all times.

6. Can add, subtract, multiply, divide, find sines, cosines, etc.

7. Has the ability to fit smooth curves from points in space.

8. Allows the programmer to describe a plan of action, which is used several times in the program, involving a sequenced set of instructions, within which a few parameters vary, to assign a name to this plan, listing the undetermined variables, and then at some later time in the program, call for the plan to be implemented, each time supplying the specific values to be used for the parameters.

9. Can reread and modify a set of program statements many times, if desired, applying progressive transformation.

10. Can automatically clean out a POCKET defined by its boundary lines.

11. Can rotate and transform the machine tool coordinate system with respect to the part program coordinate system.

12. Can simply define point patterns such as bolt circles, rows of holes.

13. Can replace fixed APT vocabulary words with synonyms more conveniently used by the part programmer.

14. Can "talk back" to the programmer if given an irrational command or misspelled word, diagnosing the error.

15. Knows all about the punched tape formats and codes, table limits, slide dynamics, etc., of the particular machine tool controller being used.

The types of statements which can be written in APT can be categorized as follows:

1. Geometric definitions

2. Tool definition and motion statements

3. Machine tool functions

4. Computer system commands

These statements are put together in a logical sequence so as to describe the geometric surfaces which make up the desired part, direct a tool to move around these surfaces in the desired path, activate the various machine tool functions at appropriate points in the machining sequence, and call for special action on the part of the computer, such as the printing of certain information. For example, consider the programming of the PLATE, PARTNO 05117 using APT.

1. Standard APT words LINE, CIRCLE, RADIUS, GOFWD, POINT can be abbreviated as LN, CR, RA, GF and PT respectively by using a synonum statement. The synonym statements used throughout this section are:

```
00110 MACHIN / BRDGPT, 20
00120 SYN / AA,ATANGL, CA,CANØN , CN,CENTER, CR,CIRCLE, $
00130       CU,CUTTER, CY,CYLNDR, DN,DØWN  , FD,FEDRAT, $
00140       GB,GØBACK, GD,GØDLTA, GF,GØFWD , GL,GØLFT , $
00150       GR,GØRGT , GT,GØTØ  , IØ,INTØF , IP,INDIRP, $
00160       IV,INDIRV, LE,LENGTH, LN,LINE  , LT,LØADTL, $
00170       MA,MATRIX, MC,MACRØ , ØB,ØBTAIN, PL,PLANE , $
00180       PN,PØSITN, PP,PERPTØ, PR,PARLEL, PT,PØINT , $
00190       QL,QUILL , RA,RADIUS, SP,SPINDL, TC,TABCYL, $
00200       TK,THICK , TL,TLLFT , TN,TLØN  , TR,TLRGT , $
00210       TT,TANTØ , TX,TLAXIS, VE,VECTØR, XL,XLARGE, $
00220       XS,XSMALL, YL,YLARGE, YS,YSMALL, ZL,ZLARGE, $
00230       ZS,ZSMALL
00240 PX   = VE / 1, 0, 0
00250 MX   = VE /-1, 0, 0
00260 PY   = VE / 0, 1, 0
00270 MY   = VE / 0,-1, 0
00280 PZ   = VE / 0, 0, 1
00290 MZ   = VE / 0, 0,-1
00300 F1   = 100
```

2. The geometry of the part is listed first using various APT geometric definitions, examples of which are shown below.

```
L1=LN/XAXIS
L2=LN/(PT/7.2,0), AA, 120
L3=LN/(PT/0,4), AA, 30
L4=LN/YAXIS
C1=CR/YL, L1,XS,L2,RA,.75
C2=CR/XS,L2,YS,L3,RA,.75
C3=CR/YS,L3,XL,L4,RA,.75
C4=CR/XL,L4,YL,L1,RA,.75
TRAM=PT/-1,-.25
PXY=PL/0,0,1,0
```

3. The next step is to drive the tool around the part. This is done with APT motion statements:

```
CUTTER/.5$$CUTTER DIAMETER=.5
FROM/TRAM $$ INITIALIZE CUTTER LOCATION
GO/L4,PXY,L1$$ POSITION TOOL ON PART SURFACE
FD/.003
TR,GF/L1 $$ ESTABLISH RELATIONSHIP OF
         $$ TOOL TO PART AND THE DIRECTION
         $$ OF MOTION ALONG INITIAL DRIVE SURFACE
GF/C1    $$ DRIVE TOOL AROUND PART
GF/L2
GF/C2
GF/L3
GF/C3
GF/L4
GF/C4,TT,L1
FINI        $$ END OF PART PROGRAM
```

4. APT geometry and motion statements like those in the sample program enable the APT system to define the cutter path mathematically. The output of APT is the series of computed cutter locations known as the CLTAPE. The CLTAPE also contains Machine Tool Function statements that are not acted on by the APT general processor, but are passed on to a subprogram called a POSTPROCESSOR. The postprocessor contains the characteristics of a specific machine tool/controller. As such it performs all the computer operations necessary to convert the cutter path location and machine tool function instructions derived off the CLTAPE into the proper code format required by the particular machine tool/controller. The postprocessor subprogram must account for the fact that each unique machine tool/controller has its own language capabilities, and restrictions. As a result, different postprocessors may interpret the same APT machine tool function statement in a variety of ways. Examples of postprocessor words used by the BRDGPT postprocessor are:

PARTNO PLATE 050117

provides a heading for the part program and causes a man readable leader to be punched out on tape.

MACHIN/BRDGPT,20

tells the APT system which postprocessor is to be used.

TOOLNO /1001,MILL,.5,0,2

defines tool parameters that are used by the postprocessor.

LOADTL/1001

describes what tool is to be loaded in the spindle.

SPINDL/SFM,115

defines the spindle speed as 115 surface feet per minute.

FEDRAT/.003

sets the control in the milling mode with a feedrate of .003 inches/revolution/flute (chip load per tooth).

FINI

ends the part program. The tool and tape will automatically move back to the startpoint.

The process of developing an N/C tape using APT/ADAPT is as follows (see Figure 5-1):

1. The part programmer, after examining the part design, writes a set of APT/ADAPT statements called the part program. This defines all the part surfaces, the motion commands necessary to direct the tool-path and the auxiliary machine control instructions. He also writes up the setup and operating procedures for the part.

2. A typist converts the part program manuscript into the input media acceptable to the computer.

3. The program is run through the computer. The computer printout includes APT motion output data, machine control instructions for the operator and error diagnostics, if any. If errors have occurred, the part programmer modifies the part program and re-submits it to the computer. A successful run is evident when the program has passed through the four sections of APT processing defined in paragraph 5.2.

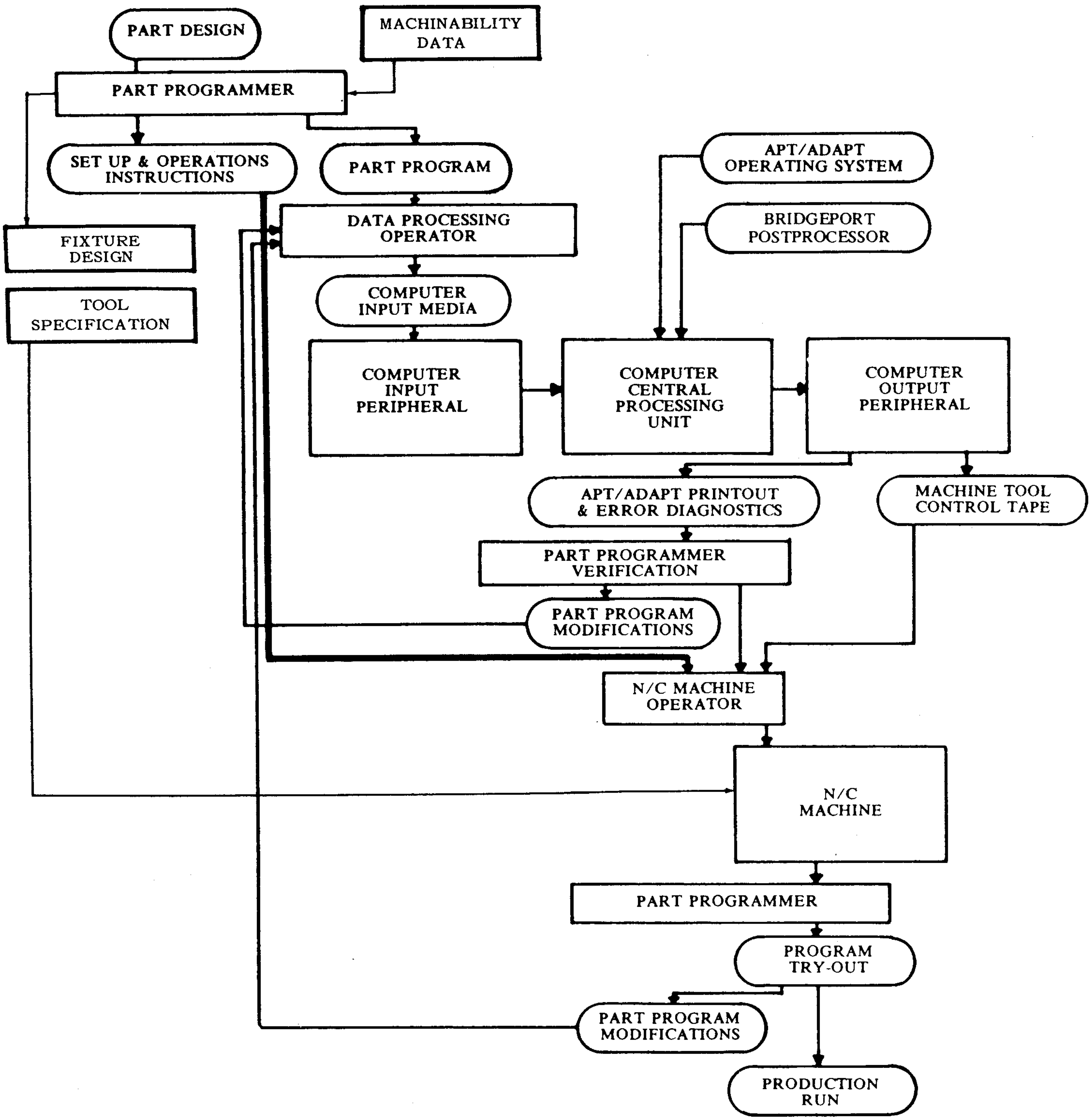


Figure 5-1. Typical N/C Operation Sequence Flow Chart

4. The program paper tape is tried out on the machine (or on a visual display device such as a cathode ray tube or a plotting machine). Additional part program modifications (such as feedrate changes, cutter path revisions) may be made.

5. The punched paper tape is now ready for the production run.

APT viewed as a computer system is very large and complex; therefore it requires large scale computers for its implementation. Implemenations of the APT system exist on the following large scale computers: Control Data 6400/6600, Univac 1108, IBM 360/50, GE 635. The major functions of the system are:

1. Language translation

2 Establishment of a geometric environment

3. Cutter position calculation

4. Postprocessing

5. Diagnostics

The language translation function reduces complex APT statements to a simple string of elementary commands according to rules of grammar and the meanings of key APT vocabulary words (there are over 400 APT vocabulary words). The elementary commands are interpreted one-by-one and control the other system functions.

A geometric environment is created through the use of a standard data base representation of the familiar curves and surfaces - lines, planes, circles, ellipsoids, etc., which a part programmer can define using the APT language. The programmer presents his information in the form most convenient to him, and the system dutifully performs the necessary geometric constructions and coordinate system transformations (for auxiliary reference frames in an engineering drawing) to reduce the data to the standard base. For example, a point defined as the intersection of two lines is represented in canonical form by its coordinates. A circle through three points is reduced by calculation to its center point, its axis vector and radius.

The geometric environment also provides a means for defining surfaces parametrically. In this type of definition, the part programmer must supply the equations for the surface and not just constants for equations already in the system. This method of surface definition is extremely powerful, since every surface can be defined parametrically.

The most complex function of the APT system is the calculation of cutter position. The system not only handles the approximations of two plane curves on a machine with contouring controls, but also can control simultaneously X, Y, Z and two rotary axes (slides). The computational methods employed are ingenious and require a high speed computer. Successive cutter positions are represented by their X-Y-Z coordinates and direction cosines of the tool axis.

Postprocessing is the last major function performed by APT. It is the function that tailors the general form of the cutter location data to the particular machine tool being used. Checks are made to ensure that machine limitations are not exceeded and that the machine will dynamically perform the requested commands. Postprocessor output is a representation of the detailed signals required by the machine controller, both readable by the operator (a listing) and readable by the machine (the punched tape).

All APT system functions have built-in diagnostic processes to detect errors made by the programmer. These may be errors in syntax, geometric errors, or attempts to move the tool in an illegal or impossible manner. As a further check on accuracy, a list of all cutter positions may be requested. The list can be scanned by the programmer for obvious errors, or automatically graphed with a digital plotter before attempting to operate the machine tool.

5.2 ORGANIZATION OF APT

APT is organized into five major sections (see Figure 5-2).

Section 0

Controls the information flow in the other sections and enters appropriate instructions into the computer as required. For example, in a point-to-point application, cutter offset calculations are not required, so the offset calculation section, Section 2, is bypassed.

Section 1

Translates the part program statements into forms more readily handled by the computer programs. Verifies that program statements are correct and prepares diagnostic comments when they are incorrect. Converts the various geometric definitions in the part program into standard (canonical) forms for efficient processing by other sections.

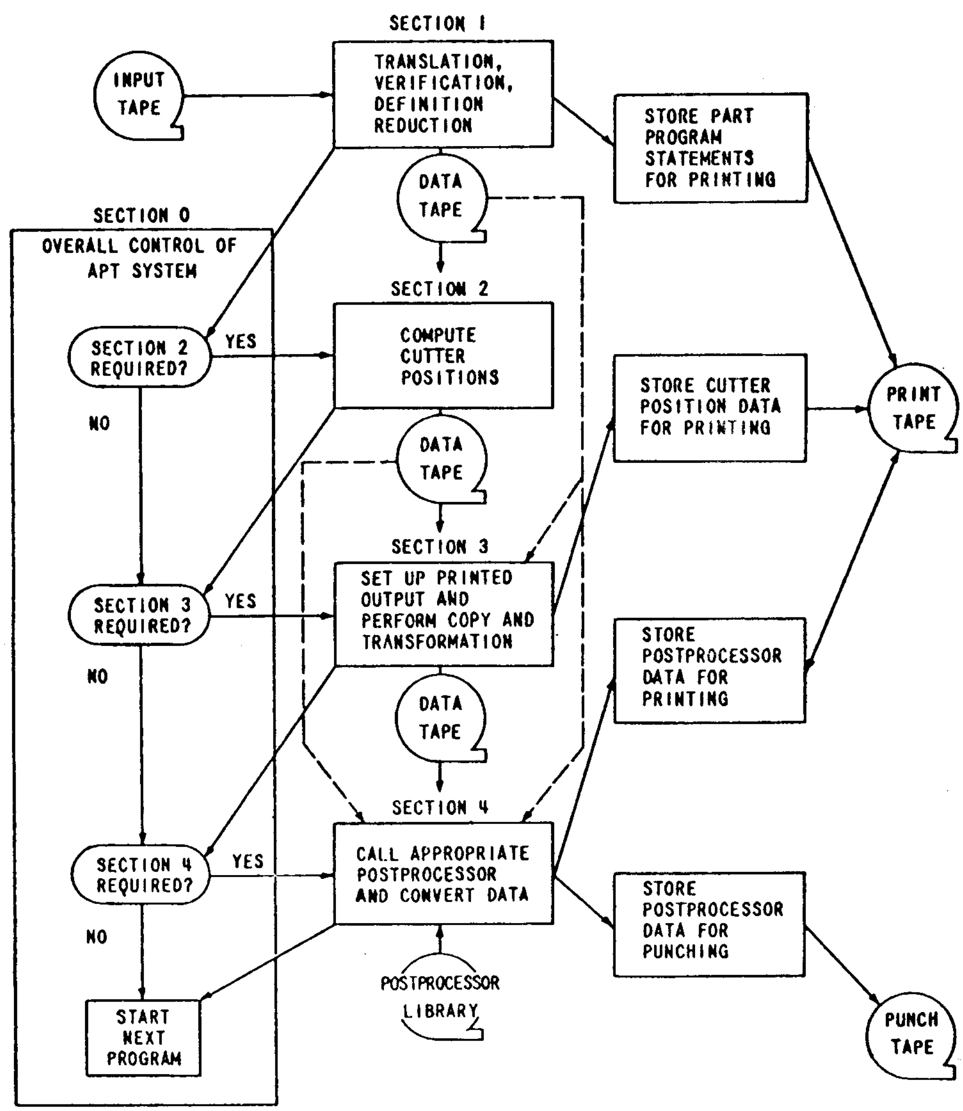


Figure 5-2. APT System Flow Diagram

Section 2

Processes the motion statements, determining the correct successive positions for the cutter based on its shape, the surfaces involved, the tolerances specified, etc.

Section 3

Prepares the printout of the calculated cutter locations and error indications. Provides the transformation and/or repetition of cutter location points.

Section 4

Calls the appropriate postprocessor.

The Completed APT input-output for PARTNO 050117 is as follows:

```
00100 PARTNØ  PLATE 05117
00110 MACHIN / BRDGPT, 20
00120 SYN / AA,ATANGL, CA,CANØN , CN,CENTER, CR,CIRCLE, $
00130       CU,CUTTER, CY,CYLNDR, DN,DØWN   , FD,FEDRAT, $
00140       GB,GØBACK, GD,GØDLTA, GF,GØFWD  , GL,GØLFT , $
00150       GR,GØRGT , GT,GØTØ   , IØ,INTØF , IP,INDIRP, $
00160       IV,INDIRV, LE,LENGTH, LN,LINE   , LT,LØADTL, $
00170       MA,MATRIX, MC,MACRØ , ØB,ØBTAIN, PL,PLANE , $
00180       PN,PØSITN, PP,PERPTØ, PR,PARLEL, PT,PØINT , $
00190       QL,QUILL , RA,RADIUS, SP,SPINDL, TC,TABCYL, $
00200       TK,THICK , TL,TLLFT , TN,TLØN   , TR,TLRGT , $
00210       TT,TANTØ , TX,TLAXIS, VE,VECTØR, XL,XLARGE, $
00220       XS,XSMALL, YL,YLARGE, YS,YSMALL, ZL,ZLARGE, $
00230       ZS,ZSMALL
00240 TØØLNØ / 1001,MILL,.5, 0, 2
00250 L1   = LN / XAXIS
00260 L2   = LN / (PT / 7, 2), AA, 120
00270 L3   = LN / (PT / 0, 4), AA, 30
00280 L4   = LN / YAXIS
00290 C1   = CR / YL, L1, XS, L2, RA, .75
00300 C2   = CR / XS, L2, YS, L3, RA, .75
00310 C3   = CR / YS, L3, XL, L4, RA, .75
00320 C4   = CR / XL, L4, YL, L1, RA, .75
00330 PXY  = PL / 0, 0, 1, 0
00340 SP1  = PT / -1, -.25
00350 CU / .5
00360 LT / 1001
00370 FRØM / SP1
00380 SP / SFM, 115
00390 PN / QL, DN
00400 FD / .003
00410 GØ / L4, PXY, L1
00420 TR, GF / L1
00430 GF / C1
00440 GF / L2
00450 GF / C2
00460 GF / L3
00470 GF / C3
00480 GF / L4
00490 GF / C4, TT,L1
00500 FINI
```

The Bridgeport postprocessor printout reads:

```
BEGIN SECTI0N       2
BEGIN SECTI0N       4
BRIDGEP0RT SERIES II NCBCCP 430/3.0 //M.KREITHEN 4/17/74
PARTN0...          PLATE 05117
..................................
BLKN0            X/H      Y/K      Z/R     AA RR CLREC  T,MIN. CARDID 0UTPUT
     SPINDL,C00LNT/0N
     ---------------------------------------
     L0ADTL 1001/  MILL,0.5000 DIA., 0.0000 LG.
     ---------------------------------------
     FR0M  / -1.0000 -0.2500  0.0000                12
     XYZ/    14.0000  7.2500  6.0000                12
     SPINDL/ 878.6 RPM
   1 C01,,57$
     QUILL/D0WN
     FEDRAT/  5.95
     G0T0  / -0.2500 -0.2500  0.0000            6   19
   2 ,.75,.0,06$
     G0T0  /  6.8557 -0.2500  0.0000            6   21
   3 ,7.1057,.0,-$
   4 ,1.0,1.0,.0,-1.0,-08$
     CIRCLE/  6.9557  0.7500  1.0000
     G0T0/    7.7217  1.2500  0.0000            6   24
   5 ,-.134,.5,1.0,.0,-08$
     G0T0  /  4.9755  6.0066  0.0000            6   26
   6 ,-2.7462,4.7566,-06$
   7 ,-.866,.5,.866,.5,-08$
     CIRCLE/  4.1095  5.5066  1.0000
     G0T0/    3.6095  6.3726  0.0000            6   29
   8 ,-.5,-.134,.0,1.0,-08$
     G0T0  /  0.2500  4.4330  0.0000            6   31
   9 ,-3.3595,-1.9396,-06$
     CIRCLE/  0.7500  3.5670  1.0000
     G0T0/   -0.2500  3.5670  0.0000            6   34
  10 ,-.5,-.866,-.5,.866,-08$
     G0T0  / -0.2500  0.7500  0.0000            6   36
  11 ,.0,-2.917,-06$
     CIRCLE/  0.7500  0.7500  1.0000
     G0T0/    0.7500 -0.2500  0.0000            6   39
  12 ,1.0,-1.0,-1.0,.0,08$
  13 002,00,50$
     G0H0ME/ -1.0000 -0.2500  0.0000            0   41
  14 003,-1.75,.0,,02$
     XYZ/    14.0000  7.2500  6.0000                41

.... MACHINING SUMMARY
   T00L/ NUM  TYPE   DIA.   LENGTH   MIN. /BLKN0

      1 1001   MILL 0.5000  0.0000   4.229     0

.... CYCLE TIME/  4.229 MIN.
.... LENGTH 0F TAPE/   2.0 FT.
.... DIAGN0STICS/    0
.... FINI
END 0F PART PR0GRAM
```

APT Training:

The following is a summary of APT Training Courses/Educational Material that is currently available:

1. Numerical Control Society (NCS, 44 Nassau Street, Princeton, New Jersey 08540)

   APT PARTPROGRAMMING COURSE. NCS correspondence course. An introduction to APT. Hardbound textbook, plus eleven worksheets. $55 members, $65 non-members.

2. University Computing Courses. (University Computing, 1949 No. Stemmons Freeway, Dallas, Texas 75207)

   APT PARTPROGRAMMING. A one-week introductory course for University Computing users.

3. General Electric ISD (GE, 7735 Old Georgetown Road, Bethesda, Maryland 20014)

   ADAPT PARTPROGRAMMING. Manual containing instructional material designed primarily for aiding novice ADAPT programmers in developing partprogramming skills.

4. UNIVAC DIV of Sperry Rand. (P.O. Box 8100, Philadelphia, Penn. 19101)

   APT DICTIONARY PROGRAMMERS REFERENCE, UP-4075. This dictionary gives a brief description of the use of each APT vocabulary word. APT ENCYCLOPEDIA, UP-4078 Rev. 2. This manual describes how to use the various APT statements.

5. Westinghouse Tele-Computer Systems Corporation (2040 Ardmore Blvd., Pittsburg, Pa. 15221)

   BASIC APT PROGRAMMING COURSE. One week course - $300. Includes instruction, materials, computer run.

5.3 POSTPROCESSOR VOCABULARY

The following vocabulary is implemented in the BRDGPT postprocessor:

AUXFUN	MACHIN	SPINDL
CLEARP	MODE	STOP
CYCLE	ORIGIN	TMARK
END	PARTNO	TOOL
FEDRAT	POSITN	TOOLNO
FINI	PPRINT	TRANS
FROM	RAPID	
LEADER	RETRCT	
LOADTL	ROTABL	
LPRINT	SEQNO	

AUXFUN/miscellaneous function(s)

This command causes the two-digit miscellaneous function code (a1...a6) to be output. The following AUXFUN codes can be used:

Miscellaneous Function	Printout		Output
0	SLIDE HOLD		NN,,0$
2	REWIND		NN,,2$
7	COOLNT/ON		NN,,7$
9	COOLNT/OFF		NN,,9$
50	CYCLE/OFF, QUILL UP		NN,,50$
52	AUXFUN/A ON		NN,,52$
53	AUXFUN/A OFF		NN,,53$
54, a	TURRET STOP/n	(Note b)	NN,,54$
56, a	INDEX TABLE/n	(Note c)	NN,,56$
57	QUILL DOWN		NN,,57$

Where NN = SEQNO

a. If a code other than those shown above is used, the following message will be output:
****ERROR ... ILLEGAL AUXFUN CODE XXX CLREC --

The code will not be output, processing will continue.

b. The number (n) following the 54 code denotes the turret stop to be used (position 1 to 12). The postprocessor assumes that initially the stop is set to position 1.

c. The number (n) following the 56 code denotes the number of table indexes to be made.

CLEARP/XYPLAN, z

This statement establishes a clearance plane, parallel to the XY plane, at a distance and direction z from the XY plane along the Z axis.

CYCLE/type parameters

Establishes cycle mode and sets up cycle sequence with parameters. Cycle vocabulary in this postprocessor is explained in the following paragraphs.

a. If the clearance parameter has not been programmed, .05 is set automatically. The minimum programmable clearance is .0002.

b. The postprocessor assumes that points following the cycle statement will be defined at the work surface. If a Z move is required along with an X and Y move, the following data blocks will be output.

   1. If the Z coordinate is greater than the current position, a rapid traverse +Z move will be output in the first data block, followed by an X, Y rapid traverse move (if programmed) in the second data block.

   2. If the Z coordinate is less than the current position, a rapid traverse X, Y move (if programmed) will be output in the first data block, followed by the rapid traverse -Z move in the second data block.

   3. The postprocessor will automatically re-establish the knee routine being used.

c. A RETRCT or RAPID GOTO, or GODLTA move can be made within the knee cycle to change Z height or to clear an obstacle. The rapid traverse move will not be followed by a knee cycle. However, a CYCLE/ .... statement must immediately follow the rapid traverse move to restart the cycle.

For example:

```
CYCLE/DRILL,3,.5,.05        CYCLE/DRILL,3,.5,.05
GOTO/1,0,0                  GOTO/1,0,0
GOTO/0,1,0                  GOTO/0,2,0
GODLTA/0,0,.5,100           RETRCT
CYCLE/DRILL,3,.5,.05        CYCLE/DRILL,3,.5,.05
```

d. The CYCLE/ .... statement can be used repetitively to change the cycle parameters without using a CYCLE/OFF statement.

For example:

```
CYCLE/DRILL,3,.5,.05
GOTO/1,0,0
CYCLE/DRILL,4,.75,.05
GOTO/2,0,0
```

e. If the delta X and delta Y values within a CYCLE/ ... are 0", but there is a Z motion, the cycle will repeat in position.

CAUTION: The Z axis feed within a CYCLE should not exceed 20 ipm.

CYCLE/BORE

This sets up the following quill actuator boring mode:

a. RAPID traverse to each CL point.

b. At the end of each move, a quill actuator bore cycle will occur.

c. Note that the Z axis will move to the z value of the CL point. No clearance value is added to the coordinate.

NOTE: The operator must manually select bore mode.

CYCLE/BORE,f,zl,c

This sets up the following knee boring cycle, similar to the drill knee cycle except that the tool is retracted to (c) above the work surface at feedrate (f) instead of at RAPID rate.

a. If the z coordinate of the next CL point is greater than the current position, a RAPID Z motion to (c) above this point is output. If the z coordinate is less than the current position, RAPID X and Y motions are output followed by a RAPID Z motion to (c) above the CL point.

b. Advance at feedrate (f) to depth (z1+c).

c. Retract at feedrate (f).

d. RAPID traverse to next CL point. Steps b. and c. above will then take place.

CYCLE/CBORE

This sets up the following quill actuator counterboring mode:

a. RAPID traverse to each CL point.

b. At the end of each move, a quill actuator bore cycle will occur.

c. Note that the Z axis will move to the z value of the CL point. No clearance value is added to the coordinate.

NOTE: The operator must manually select the counterbore mode.

CYCLE/CBORE,f,z1,c

This sets up the following quill actuator counterboring mode:

a. If the z coordinate of the next CL point is greater than the current position, a RAPID Z motion to (c) above this point is output. If the z coordinate is less than the current position, RAPID X and Y motions are output followed by a RAPID Z motion to (c) above the CL point.

b. At the end of each move, a quill actuator counterbore cycle will occur.

c. Note that the Z axis will move to the z value of the CL point. No clearance value is added to the coordinate.

CYCLE/CSINK

This sets up the following quill actuator countersinking mode:

a. RAPID traverse to each CL point.

b. At the end of each move, a quill actuator countersink cycle will occur.

c. Note that the Z axis will move the z value of the CL point. No clearance value is added to the coordinate.

CYCLE/CSINK,f,d,a,c

a. If the z coordinate of the next CL point is greater than the current position, a RAPID Z motion to (c) above this point is output. If the z coordinate is less than the current position, RAPID X and Y motions are output followed by a RAPID Z motion to (c) above the CL point.

b. Feed to depth (.2/(2*TAN(90/2))) + c.

c. RAPID traverse to (c) above CL point.

Depth is set equal to (d/(2*TAN(a/2))) where d is the spot diameter and a is given as the included tool angle.

CYCLE/CSINK,5,.2,90,.05

X 1.0, Y 1.0, Z .15, F 5, 51

CYCLE/DEEP,f,zt,z1,z2,z3,c,z4

Where zt is the total distance to be travelled, z1 is the distance to be travelled during the first down cycle, z2 is the additional distance to be travelled during the second down cycle and z3 is the distance to be travelled during succeeding down cycles. The clearance distance is c and z4 is an optional back-off distance if it is not necessary to move the tool out of the workpiece after each peck. If z2 and z3 equal 0, each successive peck will equal z1. If z4 equals 0, the tool will retract out of the workpiece each time. Note that the clearance distance (c) will be in effect, not only when initially moving the tool above the work surface, but also for each down peck depth.

a. If the z coordinate of the next CL point is greater than the current position, a RAPID Z motion to (c) above this point is output. If the z coordinate is less than the current position, RAPID X and Y motions are output followed by a RAPID Z motion to (c) above the CL point.

b. Feed in a distance (z1+c).

c. RAPID traverse to (c) above the CL point.

d. RAPID traverse for a distance (z1).

e. Feed in a distance (z2+c).

f. RAPID traverse to (c) above CL point.

g. RAPID traverse for a distance (z1+z2).

h. Feed in a distance (z3+c).

i. RAPID traverse to (c) above CL point.

j. RAPID traverse for a distance (z1+z2+z3).

k. Repeat steps h and i until total distance (zt+c) is reached.

CYCLE/DRILL

This sets up the following quill actuator drilling mode:

a. RAPID traverse to each CL point.

b. At the end of each move, a quill actuator drill cycle will occur.

c. Note that the Z axis will move to the z value of the CL point. No clearance value is added to the coordinate.

CYCLE/DRILL, f, z1, c

This sets up the following knee cycle drilling mode:

a. If the z coordinate of the next CL point is greater than the current position, a RAPID Z motion to (c) above this point is output. If the z coordinate is less than the current position, RAPID X and Y motions are output followed by a RAPID Z motion to (c) above the CL point.

b. Advance at feedrate (f) to depth (z+c).

c. Retract at RAPID to (c) above the work surface.

d. RAPID traverse to the next CL point. Steps b. and c. above will then occur.

CYCLE/OFF

This statement terminates all cycles. The following is output:

POSITN/QUILL,UP. Move to the next coordinate point in RAPID.

CYCLE/QUILL

This sets up the following quill actuator drilling mode:

a. RAPID traverse to each CL point.

b. At the end of each move, a quill actuator drill cycle will occur.

c. Note that the Z axis will move to the z value of the CL point. No clearance value is added to the coordinate.

CYCLE/QUILL,f,z1,z2

This enables the time for moving the quill up and down using the quill actuator, to be included in the machining summary cycle time. z1 is the rapid traverse distance of the quill, z2 is the feed distance at rate f. (The postprocessor will print out CYCLE/QUILL xxx M/Qc).

Where xxx is the quill cycle time in minutes. This statement is otherwise equivalent to CYCLE/DRILL.

CYCLE/QUILL,f,z1,z2,(CAM),(TS),(Z COORD),(Z)
CYCLE/QUILL,(CAM),(TS),(Z COORD),(Z)

These are alternate forms of this command, which also causes the turret stop to be repositioned prior to the initiation of the quill cycle.

NOTE: ZCOORD establishes the Z axis reference plane as set by the turret stop cam. See ROTABL.

CYCLE/REAM

a. RAPID traverse to each CL point.

b. At the end of each move, a quill actuator ream cycle will occur.

c. Note that the Z axis will move to the z value of the CL point. No clearance value is added to the coordinate.

CYCLE/TAP

This sets up the following quill actuator tapping mode:

a. RAPID traverse to each CL point.

b. At the end of each move, a quill actuator tapping cycle will occur.

c. Note that the Z axis will move to the z value of the CL point. No clearance value is added to the coordinate.

CYCLE/TAP,f,z1,c

This sets up the following knee tapping cycle, similar to the drill knee cycle except that the tool is retracted to (c) above the work surface at feedrate (f) instead of at RAPID rate.

a. If the z coordinate of the next CL point is greater than the current position, a RAPID Z motion to (c) above this point is output. If the z coordinate is less than the current position, RAPID X and Y motions are output followed by a RAPID Z motion to (c) above the CL point.

b. Advance at feedrate (f) to depth (z1+c).

c. Retract at feedrate (f).

d. RAPID traverse to next CL point. Steps b. and c. above will then take place.

END

If the rewind code is not desired at the end of the program, an END command should precede the FINI command. A tool change code will be output instead of the rewind code.

FEDRAT/f

This statement stores the feedrate in inches/minute or inches/tooth. If (f) is greater than .2, it is assumed to represent IPM: if (f) is less than .2, it is assumed to represent FPT (feed per tooth). The feedrate is modal and will stay in effect until changed by another FEDRAT statement, a feedrate "tagged on" to a motion statement or a post-processor WORD/feedrate parameter.

a. If RAPID traverse is desired, (f) should be input as 100. This RAPID traverse feedrate will be modal.

b. If (f) is in FPT and SPINDL/RPM = 0, the following message is output.

****ERROR...SPINDL/RPM,100XXXCLREC--

The SPINDL/RPM is set at 100 rpm for further processing.

c. If (f) is in FPT, and the number of flutes has not been specified in a TOOLNO statement, the following message is output:

****WARNING...2 FLUTE END MILL XXX CLREC--

The number of flutes will be set at 2 for further processing. Note that the feedrate should be given as FPT.

d. If (f) is calculated to be more than 39 IPM, the following message is output:

****WARNING...FEDRAT/--MAX.EQ.39CLREC--

The feedrate will be set at 39 ipm for further processing.

e. If (f) is calculated to be less than 1 ipm, the following message is output:

****WARNING...FEDRAT/--MIN.EQ. 1 CLREC--

The feedrate will be set at 1 ipm for further processing.

f. Deceleration will be eliminated (f-) in a block of information if the major axis in the next move segment is the same as the major axis in the current move segment and the change in minor axis velocity (as calculated by the programmed feedrate multiplied by the ratio of the minor axis to the major axis) is no greater than 5 ipm.

For example: if XD1=.5, YD1=.1, FR1=25 IPM and XD2=.5, YD2=.5, YD2=.Ø, and FR2=25 IPM, the change in velocity is 25* .1/.5 - 25* 0/.5 = 5 IPM. Thus, the first output block will be ,.5,.5,-$ or (,.5,.1,25-$).

Before the (f-) code is output, a check is made of the number of output characters in the next block of information to determine if tape reader dwell occurs. The postprocessor will assume a 150 character/second tape reader (see MACHIN/statement, parameter h) and will output a warning message for tape reader dwell.

Additionally, the radius (circular interpolation) of the major axis move at the end of a (f-) array (linear interpolation) must have the following minimum values as a function of feedrate:

IPM	INCREMENT VALUE
0-6	.0
7-10	.005
11-20	.025
21-25	.050
26-30	.075
31-35	.100
36-39	.125

(f-) will only be applied to milling with a feedrate between 5 and 39 ipm and with no programmed auxiliary functions.

CAUTION: The f-code is dependent upon the programmed input feedrate. The use of "+" feedrate override by the operator may cause the table to misposition at the f-code.

g. Feedrates for cutting circles will be modified by the ratio of the cutter path radius to the workpiece radius.

Cutting outside circles:

$$\frac{PR+CR}{PR} * PF=MF$$

$$\frac{3+.5}{3} * 12 = 14$$

Cutting inside circles:

$$\frac{PR-CR}{PR} * PF = MF$$

$$\frac{3-.5}{3} * 12 = 10$$

PR = Part Radius, CR = Cutter Radius
PF = Programmed Feedrate, MF = Modified Feedrate

NOTE: MODE/2 will inhibit the postprocessor from outputting modified feedrates.

FINI

A FINI record is the last record of the part program.

a. A go home sequence will be output automatically by the FINI statement (go home includes CYCLE/OFF). This includes any moves generated by Tool Length Compensation output.

b. If the turret stop is not at position 1, as many **54$ codes will be output as necessary to advance the turret stop to position 1, the initial TURRET STOP/ ... position.

c. A REWIND code will be automatically output by a FINI statement except when preceded by the word END.

At the end of postprocessing (FINI statement), the following MACHINING SUMMARY is output:

```
.... MACHINING SUMMARY
   TØØL/ NUM   TYPE    DIA.     LENGTH    MIN. /BLKNØ

      1 1010   DRILL  0.        0.          .741      0
      2 1017   DRILL   .4063    0.          .834     12
      3 1024   CBØRE   .5938    0.          .564     24
      4 1035   DRILL   .2969    0.          .558     36
      5 1013   DRILL   .2010    0.         1.131     46

.... CYCLE TIME/   3.827 MIN.
.... LENGTH ØF TAPE/    6.6 FT.
.... DIAGNØSTICS/    0
.... FINI
```

NOTE: The time shown in the SUMMARY output is the total time for the tool, even though it is used more than once in the program.

a. BLKNO contains the block number at which the tool was loaded into the spindle.

b. If no tool type is input, the postprocessor assumes a MILL is used.

FROM/X,Y,Z

The FROM statement initializes the spindle position with respect to the part program coordinate system. No punched output is generated by this statement. If no FROM statement is used in the program, the following message is output:

****WARNING... FROM/0,0,0 CLREC--.

The postprocessor will assume the startpoint coordinates are (0,0,0).

Note that LOADTL can return the cutter to the initial position. However, this is done within the postprocessor, not by APT. The APT motion logic retains the value of the last APT motion statement. Thus a GO/ ...(PAST,TO) statement following LOADTL should be determined from the previous last APT motion statement. An alternate method would be to use a FROM/(STARTPOINT) statement after LOADTL to reinitialize the APT motion logic.

NOTE: Either the first TOOLNO statement must define the tool initially set in the spindle or a LOADTL/ statement must be used before the initial part program FROM/ statement.

LEADER/n

This statement causes (n) inches of tape leader to be punched.

LOADTL/n
LOADTL/n,AT,x,y,z,(CAM,ts,ZCOORD,Z) (*)
LOADTL/n,CAM,ts,ZCOORD,Z
LOADTL/n,RETAIN,CAM,ts,ZCOORD,Z
LOADTL/symbolic name (**)

This statement, in conjunction with the TOOLNO data list, establishes a control tool change. The following sequence is output:

NOTE: If the x, y, z parameters are given in the LOADTL/n,AT,--- statement, the point is used as a "tool change" position.

(*) ZCOORD establishes the Z axis reference plane as set by the turret stop cam (see ROTABL).

(**) The symbolic LOADTL statement can only be used if the TOOL statement is implemented within the APT system.

If no "tool change" position is entered in the program, the "postprocessor" will assume the "home" position is the "tool change" position. (except see MODE/1).

a. Quill up ("m"50) and Z axis retract to the "tool change" Z coordinate. NOTE: The "m" 50 code will also cause CYCLE/OFF.

b. X and Y axis RAPID traverse to the "tool change" XY coordinates.

c. If a LOADTL/n, CAM, ts statement is used **54$ codes will be output until the turret stop is at the programmed position. ZCOORD, Z enables establishing the Z coordinate of the tool tip at the particular cam used.

d. If a LOADTL/n, RETAIN statement is used, the slides will maintain their existing position.

e. A **6$ code will be output. This disables power to the auxiliary control equipment (SPINDLE INHIBIT) as a safety feature while the tool is being changed.

f. The postprocessor will search the TOOLNO list for the number LOADTL/n. If the number (n) is not found, the following message is output:

****ERROR...LOADTL/XXX CLREC --

The postprocessor will assume a MILL with .0000 diameter and continue processing.

The following message will then be output LOADTL (n) / (type), (diameter), (length).

g. A **4$, **7$, output will be generated. (SPINDL, COOLNT/ON).

h. If tool lengths are programmed, a tool length compensation move will be output together with the message:

TOOL LG COMPENSATION /Z move)

NOTE: If the tool to be loaded into the spindle is shorter than the tool previously used, a Z- tool length compensation move is output after the tool change code. If the tool to be loaded is longer, a +Z tool length compensation move is output before the tool change code.

If tool lengths are not programmed, 2 inches of leader will be output together with the following message:

TOOL LG COMPENSATION /XXX

LPRINT/ (SMALL)
(LARGE)

LPRINT/SMALL will eliminate machine running time, card ID No. and the output card No. from the printer listing. Portions of this output can be examined by using LPRINT/LARGE and LPRINT/SMALL statements within the part program. If no LPRINT statement is used, the postprocessor will assume LPRINT/SMALL.

MACHIN/BRDGPT,k,m

This command called the Bridgeport Series II NCBCCP postprocessor If the programmer does not specify the postprocessor parameter (20), the following message will be output:

****WARNING...BRDGPT SERIES II NCBCCP POSTP

k = Model No. = 20 (Series II Serial Nos. 430 & Up)

m= Tape reader speed in characters/second. If m is not input, the postprocessor assumes 150 cps (standard reader).

MODE/ (N)
MODE/1

This statement flags the postprocessor to cause LOADTL/n, RETAIN to be in effect instead of LOADTL/n (return to STARTPOINT).

MODE/1, OFF

Resets the system to the original mode LOADTL/n (return to STARTPOINT).

MODE/2

This statement flags the postprocessor to suppress outputting modified feedrate when cutting circles.

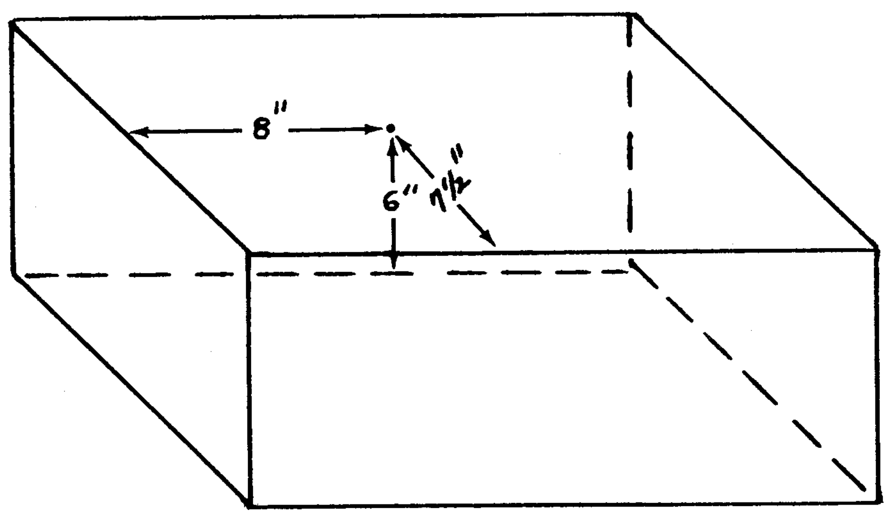
MODE/2,OFF

Resets the system to the original mode to modify feedrate when cutting circles.

ORIGIN/x,y,z,h.

This statement defines the part program reference system with respect to the X,Y,Z mechanical counters on the machine slides. When the table is in the extreme right, back, up position (as the operator faces the machine). The mechanical counters read 000. In this position the spindle is at the extreme left, front of the table. The x, y, z values input are the distances from the part program origin to this position. Since these distances are negative with respect to the tool (unless the part program origin is off the table), they should be entered as negative numbers.

For example, if the ORIGIN is 8" to the right, 7.5" to the rear and 6" down from the extreme left, front top position:



The input statement:

ORIGIN/-8,-7.5,-6

defines the distance from the machine reference origin to the part program reference origin.

a. If no ORIGIN statement is input, the postprocessor assumes ORIGIN/-15,-7.5,-6.

b. If the following statements are input:

```
ORIGIN/-15,-7.5-6
SETPT/1,-2,0
FROM/SETPT
```

when the spindle is over the SETPT, the x,y,z mechanical counters should read:

```
16000, 05500, 06000
```

c. If a CL point is such that the travel limits with respect to the ORIGIN as described below are violated, a warning message is output of the format:

```
****WARNING X (Y, Z) MOVE.GT.X (Y, Z,)LIMIT

X.LT.30, X.GT.0
Y.LT.15, Y.GT.0
Z.LT.12, Z.GT.0
```

d. The XYZ mechanical counter settings will only be printed out when FROM/ or LOADTL/ statements are used in the program. They will be printed out as:

```
XYZ/ 16.000   5.500   6.000
```

e. If 2 heads are used, the X axis distance from the center of the ram to the center of the left hand spindle can be entered as (h).

In this case, the input ORIGIN statement is:

```
ORIGIN/-(X+h), -y,-z,h
```

If the left hand spindle is to the right of the center of the ram as the operator faces the machine, use

```
ORIGIN/-X(X-h), -y,-z,h
```

PARTNO alphanumerics

This command identifies the program.

a. Print output. The part program heading will be output.

```
08/25/72.    13.31.18,
BRIDGEPØRT SERIES II NCBCCP 430/1.1
PARTNØ...          ENDCAP 050115
.................................
BLKNØ            X/H      Y/K      Z/R     AA FR CLREC  T,MIN. CARDID ØUTPUT
     SPINDL,CØØLNT/ØN
```

Each printed line containing a Block Number lists the Hollerith characters which will be packed 72 characters to an output punch card, the CL Record Number, the accumulated machining time in minutes, the input Card ID number (when used), and the Output Punch Card Number.

The PARTNO statement will output a TMARK (Rewind Stop) code and set the system in RAPID with SPINDL, COOLNT/ON.

b. Punch output. Two cards will be output. The first containing PARTNO followed by up to 66 alphanumeric characters. The second card contains 6.1 inches of leader followed by TMARK, RAPID, SPINDL/ON, COOLNT/ON.

POSITN/QUILL, (UP), (CAM), (ts), (ZCOORD), (Z)
                      (DOWN)
        /CAM, ts, (ZCOORD), (Z)
        /INDEXR, n

These statements output the following auxiliary function codes:

/QUILL, UP **50$ (also CYCLE/OFF)
/QUILL, DOWN **57$
/CAM, ts, (ZCOORD), (Z) as many **54$ codes as required to reach turret stop (ts). ZCOORD, Z enables establishing the Z coordinate of the tool tip at the particular cam used.
/INDEXR, n **56$, n times

NOTE: ZCOORD establishes the Z axis reference plane as set by the turret stop cam (see ROTABL).

PPRINT

Postprocessor Print. Characters following this word will be printed in the postprocessor output. The maximum number of characters is 66.

RAPID

Specifies maximum traverse feedrate for next motion statement and is effective for one motion only. Postprocessor will revert to previous feedrate after this motion. A RAPID statement causes the following analysis and output:

a. If the Z coordinate is greater than the current position, Z motion is output before the X and Y motion. If the Z coordinate is less than the current position, Z motion is output after the X and Y motion.

The postprocessor automatically assigns rapid rate to the following motions:

RETRCT

LOADTL

Positioning during cycle operations, unless a specific feedrate is assigned.

RETRCT

This statement will cause the Z axis to retract at RAPID rate to the plane specified in the CLEARP statement. If the motion to the CLEARP is negative, the following message will be output:

****WARNING... RETRCT /-Z XXX CARDNO --

However, the -Z move will be output. If no CLEARP has been programmed, the Z axis will move to Z = .0.

NOTE: RETRCT sets the system in RAPID traverse.

CAUTION: A RETRCT move can be made within a knee cycle to change Z height or to clear an obstacle. The RETRCT move will not be followed by a knee cycle. However, a CYCLE/.... statement must immediately follow the RETRCT statement to restart the cycle.

ROTABL/NOZ, ROTREF, x, y,z , (XY PLAN)
(YZ PLAN)

ROTABL/NOY, ROTREF, x, y,z , (XY PLAN)
(YZ PLAN)

These statements set up the ROTABL mode. NOZ, NOY indicate the axis from which power is removed to be reconnected to the rotary table. The parameters x, y, z establish the center of rotary table motion with respect to the part program coordinate system. This enables calculating the adjusted feedrate code required to maintain a specified input feedrate with respect to the distance from a CL point to the rotary table center.

a. The parameter XY PLAN defines the rotary table surface as being perpendicular to the Z axis. The parameter YZ PLAN defines the rotary table surface as being perpendicular to the X axis. (If neither is specified, the postprocessor assumes YZ PLAN.)

b. The postprocessor assumes the rotary table gear ratio is 180 to 1. Each .0005" output (with the Z axis ratio switch on the control set to 2:1) will cause the rotary table to move .01 degrees. 1 ipm input will cause a rotation rate of 20^{o}/minute.

c. ZCOORD establishes the Z axis reference plane as set by the turret stop cam.

ROTABL/ATANGL, a1

Rotates the table to the angle (a1). The direction of rotation will be determined by the shortest distance to the angle.

ROTABL/ATANGL, a1, (CLW)
(CCLW)

Rotates the table to the angle (a1). Direction of rotation of cutter about part is determined by the modifier CLW and CCLW. (CLW will cause CCLW <u>table</u> rotation)

ROTABL/ATANGL, a1, (CLW), (DRILL)
(CCLW), (MILL)

The words MILL, DRILL will cause the table rotation to be inhibited until the next CL point is read. The move to the point and the table rotation will occur together at the programmed feedrate.

ROTABL/INCR, a1

Rotates the table a delta increment (a1) from its current position. If (a1) is positive, the table will rotate CLW. (CCLW rotation of tool about part.) If (a1) is negative, the table will rotate CCLW.

ROTABL/INCR, a1, (DRILL)
(MILL)

The words MILL, DRILL will cause the table rotation to be inhibited until the next CL point is read. The move to the point and the table rotation will occur together at the programmed feedrate.

SEQNO/N, incr, k, m

This statement controls the output sequence number. Where N is the initial sequence number, k is the increment desired. If sequence numbers are only desired in front of rapid traverse moves, m equals 0. If sequence numbers are desired in all blocks, m equals 1.

Sequence numbers are output before the first tab in each tape block.

SEQNO/OFF

Causes sequence number incrementing and output to terminate.

SPINDL/RPM, r
/SFM, s

This statement enables spindle speed input for use in converting feedrate input from inches/revolution to inches/minute. If SFM is input, it is converted to RPM by using the TOOLNO diameter parameter.

a. If SFM is input and no TOOLNO diameter is input, the following message will be output:

**** ERROR...SPINDL/SFM, DIA. XX CLREC --

The postprocessor will assume 100 RPM and postprocessing will continue.

b. If RPM is greater than 3600 or less than 50, the following message is output:

****WARNING...SPINDL/(r) RPM CLREC --

The RPM value is set to either 3600 (max) or 50 (min) and postprocessing continues.

NOTE: The programmer has no control of the SPINDL/ON function. The postprocessor will automatically turn the spindle on after every programmed stop command. The Bridgeport N/C system will not operate in the AUTO mode unless the spindle is ON. (see Operating Instruction Manual.)

STOP

This command causes the code 06 to be output. The code causes CYCLE, SPINDL, COOLNT/OFF and QUILL/UP. The codes for SPINDL, COOLNT/ON will be output immediately following the 06 code. However, the quill will remain UP unless otherwise commanded.

TMARK/1

Outputs a rewind stop code. The parameter (1) serves no function, but must be programmed.

TOOL

An alternate method of identifying the desired tool is through the use of the TOOL statement:

<u>symbol</u> = TOOL/n, (type), (dia), (lg), (mod)

NOTE: The TOOL statement is not implemented in all APT systems. Consult your computer system APT reference manual.

The symbol is used to identify the tool to the LOADTL statement. For example, the above tool list could be written:

T(1) = TOOL/1,DRILL
T(2) = TOOL/2,DRILL, (7/16)
etc.

The TOOL statement is not processed until a LOADTL/T(1). Thus, to describe the first tool in the spindle, a LOADTL/ statement must be used before the initial part program FROM statement.

In the above example, the symbol T(1) is a subscripted variable. It need not be. No additional parameters may be used in a LOADTL statement if the TOOL is used. However, the parameters normally used in the LOADTL statement may be added after the fifth (modifier) parameter of the TOOL/definition: T1-TOOL/2, DRILL, (7/16), 0, 0, CAM, 3 .

NOTE: 1. No more than 24 tools may be described in a single program.

2. TOOL and TOOLNO statements may be intermixed within a program, but they must be input before a LOADTL/ statement is used.

```
TOOLNO/n, type   , dia , lg , mod
       n, MILL   , dia , lg , mod
       n, DRILL  , dia , lg
       n, BORE   , dia , lg
       n, TAP    , dia , lg
       n, CBORE, dia , lg
       n, CSINK  , dia , lg
       n, REAM   , dia , lg
```

These statements list the tools to be used in machining the part. They also describe the following tool parameters:

n, tool number
dia, tool diameter
lg, tool length
mod, number of flutes (MILL)

The TOOLNO list is used by subsequent postprocessor statements. An example of a typical TOOLNO list is as follows:

```
TOOLNO/ 1, DRILL
TOOLNO/ 2, DRILL, (7/16)
TOOLNO/ 3, MILL, .5
TOOLNO/ 4, DRILL
TOOLNO/ 5, DRILL,.375
TOOLNO/ 7, MILL, .25
TOOLNO/ 6, MILL, (3/16)
```

a. The first TOOLNO statement must define the tool initially set in the spindle, or a LOADTL/ statement must be used before the initial part program FROM/ statement. Subsequent TOOLNO statements need not be in the order they are used.

b. Fractional diameters may be input if they are enclosed within parentheses. APT will calculate the decimal equivalent.

TRANS/X, Y, Z

Cause part coordinate system to be translated (shifted) in relation to the original coordinate system. The values X, Y, Z are algebraically added to the X, Y, Z coordinate positions on the CL tape.

5.4 NOTES ON PART PROGRAMMING

a. The BRDGT, 20 postprocessor is capable of developing contouring toolpaths in the XYZ plane.

Circular interpolation is output whenever:

(1) A circle in the XY plane is used for a drive surface. (The delta Z move = 0.)

(2) The radius of the cutter center is less than 100".

(3) The programmed feedrate is less than RAPID traverse.

If a circle fails to meet criteria (1) and (2) above, each cut vector received on the CL file will be output individually as linear moves. If criteria (3) is not met, only the delta distance between the circle startpoint and endpoint will be output and the following message will be output:

**** ERROR... CIRCUT/RAPID CLREC --.

b. ROUNDOFF. The postprocessor rounds each absolute coordinate read off the CLTAPE to the nearest ten thousandths, before the incremental output moves are calculated. This eliminates the problem of accumulative round off error.

c. The FROM statement initializes the spindle position with respect to the part program coordinate system. No punched output is generated by this statement. If no FROM statement is used in the program, the following message is output:

**** WARNING... FROM/0,0,0 CLREC --.

The postprocessor will assume the startpoint coordinates are (0,0,0).

Note that LOADTL can return the cutter to the initial position. However, this is done within the postprocessor, not by APT. The APT motion logic retains the value of the last APT motion statement. Thus, a GO/ ... (PAST TO) statement following LOADTL should be determined from the previous last APT motion statement. An alternate method would be to use a FROM/(START-POINT) statement after LOADTL, to reinitialize the APT motion logic.

d. If no SEQNO statement is programmed, sequence numbers are automatically generated by the postprocessor for all output blocks except those that generate moves at less than RAPID traverse feeds.

5.5 DIAGNOSTICS

The following diagnostic messages are generated by the postprocessor:

No.

1 ERROR...ILLEGAL AUXFUN CODE

A code other than those shown in the list of AUXFUN codes was used. This code will not be output; processing will continue.

11 WARNING...TOOLNO/MILL XXX

A tool type other than those shown in the list of TOOLNO types. The postprocessor will assume a mill and continue processing.

21 ERROR...SPINDL/RPM, 100 XXX

A feedrate in Inches per Tooth was programmed with a spindle RPM of 0. Spindle RPM is set to 100 RPM for further processing.

22 WARNING...2 FLUTE END MILL XXX

A feedrate in Inches per Tooth was programmed and the number of flutes has not been specified in a TOOLNO statement. The number of flutes will be set at 2 for further processing.

23 WARNING...FEDRAT/f XXX MAX.EQ. 39

A feedrate in Inches per Tooth was programmed and the feedrate is calculated to be more than 39 inches per minute. The feedrate will be set at 39 inches per minute for further processing.

24 WARNING...FEDRAT/f XXX MIN.EQ. 1

A feedrate in Inches per Tooth was programmed and the feedrate is calculated to be less than 1 inch per minute. The feedrate will be set at 1 IPM for further processing.

31 ERROR...CYCLE/XXX PARAMETERS MISSING

Parameters are missing from the cycle statement; default values are assumed. Processing continues.

32 ERROR...CYCLE/XXX, F, ZI--ZDV MOVE

While in the knee cycle mode, a Z axis move was programmed at a feedrate less than RAPID. The feedrate in the cycle will be changed to this new value. Processing will continue.

41 ERROR...LOADTL/XXX

The tool number called for in the LOADTL statement was not found in the TOOLNO list. A mill with .0 diameter is assumed for further processing.

51 WARNING...RETRCT/-Z XXX

The motion to the CLEARP was negative. The -Z move will be output. If no CLEARF has been programmed, the Z axis will move to Z=0.

61 WARNING...SPINDL/r RPM

RPM was greater than 3600 or less than 50. The RPM value is set to either 3600 (max) or 50 (min) for further processing.

62 ERROR...SPINDL/SFM, DIA. XX

SFM was input and no TOOLNO diameter was input. 100 RPM is assumed for further processing.

71 WARNING...FROM/0, 0, 0

No FROM statement was programmed. The postprocessor assumes 0, 0, 0 for further processing.

81 WARNING...BRDGPT SERIES II NCBCCP POSTP

The parameter (20) was not called for in the MACHIN/ statement. The postprocessor assumed (20) and continues processing.

91 WARNING XMOVE. GT. XLIMIT

A CL point is such that the X travel limits, as described by the ORIGIN statement, are violated. Total X travel = 30 inches. Processing continues.

92 WARNING YMOVE. GT. YLIMIT

A CL point is such that the Y travel limits, as described by the ORIGIN statement, are violated. Total Y travel = 15 inches. Processing continues.

93 WARNING ZMOVE. GT. ZLIMIT

A CL point is such that the Z travel limits, as described by the ORIGIN statement, are violated. Total Z travel = 12 inches. Processing continues.

101 ERROR...CIRCUT/RAPID

The programmed feedrate is RAPID while making a circular move. The delta distance between the circle startpoint and endpoint will be output. Processing continues.

111 ERROR...ROTABL/FORMAT XXX

An illegal word or parameter is contained in the ROTABL statement. The ROTABL statement is ignored and processing continues.

112 ERROR...ROTABL/Z CYCLE

A Z axis knee cycle has been programmed (CYCLE/XXX,f) and the system is in the ROTABL mode. This input is ignored and processing will continue.

113 ERROR...ROTABL/Z MOVE

A Z axis move has been programmed and the system is in the ROTABL/NOZ mode (no power is connected to the Z axis). This input is ignored and processing continues.

5.6 PART PROGRAM DEVELOPMENT

Most part programs should be written in a "logical" sequence. For example, the workpiece must be defined before motion statements can be used. The sequence shown below outlines the usual order of program statements. Reference is made to part program statement line numbers in PARTNO TS BENCHMARK which follows.

HEADER. This contains the PARTNO statement, the MACHIN/call, SYN/words, PPRINT instructions to the operator and the ORIGIN statement (100-139).

TOOL DEFINITIONS. These statements list the tools to be used in the program (140-160).

GEOMETRY. The points and surfaces which control the tool motion are defined (170-290).

TOOL SET POINT. This includes the initial LOADTL statement, SPINDL/speed, CUTTER description, FROM/point (300-330).

TOOL MOTION. Describe the machining sequence using motion statements and auxiliary machine tool controller instructions.

NOTE the following features used in the program:

(560) Set the Z axis drill cycle with a Z feed of 12 ipm and a Z depth of .8".

(590) The LOADTL statement combines POSITN/QUILL, UP CYCLE/OFF RAPID GOTO/SP POSITN/CAM, 2 STOP SPINDL/ON COOLANT/ON.

(600) A dummy cutter is used, .2" greater diameter than the actual cutter diameter, to position the tool approximately in position (see GO/statement 400).

(610) Set the spindle speed at 300 SFM. Since TOOLNO/1002 = 1.0" diameter, the spindle speed = 1146 RPM.

(620) Position the tool to the pseudo DRIVE (LN4) and CHECK (LN5) surfaces, and to the actual PART SURFACE, plane PXY.

(630) Quill/Down.

(640) Describe the actual cutter size.

(650) Move to the surface (LN5) by the shortest route.

(660) TLLFT = climb mill, feedrate = .008 ipr/flute x 2 flute x 1146 RPM = 18 ipm.

(670-740)
Move cutter around part.

(750) LOADTL/1003, see (370).

(760) Set SPINDL/RPM = 800.

(770-790)
Define bolt circle patterns.

(800) CYCLE/QUILL. This will calculate machine quill cycle time. (Rapid traverse = 2", feed 10 ipm for .5") Also set turret stop in position 3.

(810) Inhibit TAPE IMAGE printout.

FINI. This ends the program, returns the tool to the setpoint and rewinds the punched tape (850).

```
00100 PARTNØ TSBENCHMARK 080172
00110 MACHIN / BRDGPT, 20
00120 SYN / AA,ATANGL, CA,CANØN , CN,CENTER, CR,CIRCLE, $
00130       CU,CUTTER, CY,CYLNDR, DN,DØWN  , FD,FEDRAT, $
00140       GB,GØBACK, GD,GØDLTA, GF,GØFWD , GL,GØLFT , $
00150       GR,GØRGT , GT,GØTØ  , IØ,INTØF , IP,INDIRP, $
00160       IV,INDIRV, LE,LENGTH, LN,LINE  , LT,LØADTL, $
00170       MA,MATRIX, MC,MACRØ , ØB,ØBTAIN, PL,PLANE , $
00180       PN,PØSITN, PP,PERPTØ, PR,PARLEL, PT,PØINT , $
00190       QL,QUILL , RA,RADIUS, SP,SPINDL, TC,TABCYL, $
00200       TK,THICK , TL,TLLFT , TN,TLØN  , TR,TLRGT , $
00210       TT,TANTØ , TX,TLAXIS, VE,VECTØR, XL,XLARGE, $
00220       XS,XSMALL, YL,YLARGE, YS,YSMALL, ZL,ZLARGE, $
00230       ZS,ZSMALL
00240 PX   = VE / 1, 0, 0
00250 MX   = VE /-1, 0, 0
00260 PY   = VE / 0, 1, 0
00270 MY   = VE / 0,-1, 0
00280 PZ   = VE / 0, 0, 1
00290 MZ   = VE / 0, 0,-1
00300 F1   = 100
00310 ØRIGIN / -8, -7.5, -6
00320 TØØLNØ / 1001, DRILL, .5
00330 TØØLNØ / 1002, MILL, 1.0, 0, 2
00340 TØØLNØ / 1003, DRILL, .5
00350 PPRINT... ØPERATØR SET STØP NØ. 3 SØ TØØL WILL RAPID DØWN
00360 PPRINT... TØ APPRX .1 ABØVE WØRK AND FEED DØWN APPRX .5
00370 PT1  = PT / 0, 0, 0
00380 PT2  = PT / 5.5, 0, 0
00390 PT3  = PT / 1, 3.25, 0
00400 CIR1 = CR / 0, 0, .875
00410 CIR2 = CR / 5.5, 0, .5
00420 LN1  = LN / RIGHT, TT, CIR1, RIGHT, TT, CIR2
00430 LN2  = LN / LEFT, TT, CIR1, LEFT, TT, CIR2
00440 LN3  = LN / PT3, RIGHT, TT, CIR1
00450 LN4  = LN / PT3, AA, 18
00460 CIR3 = CR / 1, 3.25, 1.875
00470 LN5  = LN / (PT / XL, IØ, LN4, CIR3), AA, 90, LN4
00480 CIR4 = CR / YL, LN2, XL, ØUT, CIR3, RA, 1
00490 PXY  = PL / 0, 0, 1, 0
00500 LT / 1001
00510 CU / .5
00520 SP / RPM, 800
00530 TRAM = PT / -3, 4, 3
00540 FRØM / TRAM
00550 LPRINT / LARGE
00560 CYCLE / DRILL, 12, .8
00570 GT / PT1
00580 GT / PT2
00590 LT / 1002, CAM, 2
00600 CU / 1.2
00610 SP / SFM, 300
```

```
00620 GØ / PAST, LN4, PXY, LN5
00630 PN / QL, DN
00640 CU / 1.0
00650 GØ / LN5
00660 TL, GL / LN5, .008
00670 GF /CIR3
00680 GF / CIR4
00690 GF / LN2
00700 GF / CIR2
00710 GF / LN1
00720 GF / CIR1
00730 GF / LN3
00740 GR / LN4, PAST, CIR3
00750 LT / 1003
00760 SP / RPM, 800
00770 PAT1 = PATERN / ARC, (CR/15,0,3), 0, CCLW, INCR, 10, AT, 36
00780 PAT2 = PATERN / ARC, (CR/15,0,4.5),0,CCLW,INCR,16,AT,(360/16)
00790 PAT3 = PATERN / ARC, (CR/15,0,6),0,CCLW,INCR,28,AT,(360/28)
00800 CYCLE / QUILL, 10, 2, .5, CAM, 3
00810 LPRINT / SMALL
00820 GT / PAT1
00830 GT / PAT2
00840 GT / PAT3
00850 FINI
```

```
BRIDGEPØRT SERIES II NCBCCP 430/3.0 //M.KREITHEN 4/17/74
PARTNØ...        TSBENCHMARK 080172
.................................
BLKNØ            X/H      Y/K      Z/R     AA FR CLREC  T,MIN. CARDID ØUTPUT
     SPINDL,CØØLNT/ØN
     ØRIGIN/  8.0000  7.5000  6.0000               12
....      ... ØPERATØR SET STØP NØ. 3 SØ TØØL WILL RAPID DØWN
....      ... TØ APPRX .1 ABØVE WØRK AND FEED DØWN APPRX .5
     --------------------------------------
     LØADTL 1001/ DRILL, .5000 DIA., 0.     LG.
     --------------------------------------
     SPINDL/ 800.0 RPM
     FRØM  / -3.0000  4.0000  3.0000               48
     XYZ/     5.0000 11.5000  9.0000               48
     --------------------------------------
     CYCLE/  DRILL  12.0   .800  0.
     --------------------------------------
     FEDRAT/ 12.00
   1 001,3.0,-4.0,00$                              60    0.  00570       1
   2 002,.0,.0,-2.95$                              60    .1  00570       1
   3 003,.0,.0,.85,12,51$                          60    .1  00570       1
     GØTØ  /  0.       0.       0.           12    60
   4 004,5.5,.0,$                                  64    .2  00580       1
     GØTØ  /  5.5000  0.       0.           12    64
   5 005,.0,.0,2.95,00,50$                         68    .4  00590       2
   6 006,-8.5,4.0,$                                68    .5  00590       2
     GØHØME/ -3.0000  4.0000  3.0000          0    68
   7 ,,54$                                         68    .6  00590       2
     TURRET STØP/  2
     TØØL LG CØMPENSATIØN/XXX
   8 007,,06$                                      68    .6  00590       2
   9 008,,04$                                      68    .6  00590       2
  10 ,,07$                                         68    .6  00590       2
     LEADER/   20
     --------------------------------------
     LØADTL 1002/  MILL,1.0000 DIA., 0.     LG.
     --------------------------------------
     XYZ/     5.0000 11.5000  9.0000               68
     SPINDL,CØØLNT/ØN
     SPINDL/1146.0 RPM
  11 009,6.1685,.5855,-3.0$                        80    .6  00620       3
     GØTØ  /  3.1685  4.5855  0.              0    80
  12 010,,57$                                      84    .7  00630       3
     QUILL/DØWN
  13 011,-.0952,-.031,$                            92    .7  00650       3
     GØTØ  /  3.0733  4.5545  0.              0    92
     FEDRAT/ 19.07
     GØTØ  /  3.2588  3.9839  0.             19    98
  14 ,.1855,-.5706,19$                             98    .7  00670       3
  15 ,.1162,-.7339,2.2588,.7339,24$               104    .8  00670       4
     CIRCLE/  1.0000  3.2500  2.3750
     GØTØ/    2.9721  1.9265  0.             19   104
  16 ,-.4029,-1.3235,2.375,.0,24$                104    .8  00680       4
  17 ,-.0849,-.2786,-.4151,.2786,-10$            110    .9  00680       5
     CIRCLE/  3.3872  1.6479   .5000
     GØTØ/    3.3531  1.1491  0.             19   110
```

```
18 ,.4659,-.4988,-.5,.0,10$                        110    .9 00690      5
   GØTØ  / 5.5682   .9977  0.                  19  114
19 ,2.2151,-.1514,19$                              114   1.0 00700      5
20 ,.9318,-.9977,.0682,.9977,-38$                  120   1.1 00700      6
   CIRCLE/  5.5000  0.       1.0000
   GØTØ/    5.5682  -.9977  0.                 19  120
21 ,-.9318,-.9977,1.0,.0,38$                       120   1.2 00710      6
   GØTØ  /   .0937 -1.3718  0.                 19  124
22 ,-5.4745,-.3741,19$                             124   1.2 00720      6
23 ,-.0937,-.0032,.0937,-1.3718,-30$               130   1.5 00720      7
24 ,-1.375,1.375,.0,-1.375,-30$                    130   1.5 00720      7
   CIRCLE/  0.      0.       1.3750
   GØTØ/   -1.1659   .7289  0.                 19  130
25 ,.2091,.7289,-1.375,.0,30$                      130   1.6 00730      7
   GØTØ  /   .6725  3.6693  0.                 19  134
26 ,1.8384,2.9404,19$                              134   1.6 00740      8
   GØTØ  / 3.0541  4.4432  0.                  19  138
27 ,2.3816,.7739,$                                 138   1.8 00750      8
28 012,.0,.0,3.0,00,50$                            142   2.0 00750      8
29 013,-6.0541,-.4432,$                            142   2.1 00750      9
   GØHØME/ -3.0000  4.0000  3.0000              0  142
   TURRET STØP/  2
   TØØL LG CØMPENSATIØN/XXX
30 014,,06$                                        142   2.2 00750      9
31 015,,04$                                        142   2.2 00750      9
32 ,,07$                                           142   2.2 00750      9
   LEADER/   20
   --------------------------------------
   LØADTL 1003/ DRILL, .5000 DIA., 0.     LG.
   --------------------------------------
   XYZ/      5.0000 11.5000  9.0000                142
   SPINDL,CØØLNT/ØN
   SPINDL/ 800.0 RPM
33 ,,54$                                           150   2.2 00800      9
   CYCLE/  QUILL    .095 M/QC
   TURRET STØP/  3
34 016,00,51$                                      150   2.2 00800      9
35 017,21.0,-4.0,00,50$
36 018,.0,.0,-3.0,00,51$
   GØTØ  / 18.0000  0.        0.                0  158
37 019,-.5729,1.7634,$
   GØTØ  / 17.4271  1.7634  0.                  0  160
38 020,-1.5,1.0898,$
   GØTØ  / 15.9271  2.8532  0.                  0  162
39 021,-1.8542,.0,$
   GØTØ  / 14.0729  2.8532  0.                  0  164
40 022,-1.5,-1.0898,$
   GØTØ  / 12.5729  1.7634  0.                  0  166
41 023,-.5729,-1.7634,$
   GØTØ  / 12.0000  0.        0.                0  168
42 024,.5729,-1.7634,$
   GØTØ  / 12.5729 -1.7634  0            0  170
43 025,1.5,-1.0898,$
   GØTØ  / 14.0729 -2.8532  0.                  0  172
44 026,1.8542,.0,$
   GØTØ  / 15.9271 -2.8532  0.                  0  174
45 027,1.5,1.0898,$
   GØTØ  / 17.4271 -1.7634  0.                  0  176
46 028,.5729,1.7634,$
   GØTØ  / 18.0000  0.        0.                0  178
```

```
47 029,1.5,.0,$
   GØTØ  / 19.5000  0.        0.               0  182
48 030,-.3425,1.7221,$
   GØTØ  / 19.1575  1.7221   0.               0  184
49 031,-.9755,1.4599,$
   GØTØ  / 18.1820  3.1820   0.               0  186
50 032,-1.4599,.9755,$
   GØTØ  / 16.7221  4.1575   0.               0  188
51 033,-1.7221,.3425,$
   GØTØ  / 15.0000  4.5000   0.               0  190
52 034,-1.7221,-.3425,$
   GØTØ  / 13.2779  4.1575   0.               0  192
53 035,-1.4599,-.9755,$
   GØTØ  / 11.8180  3.1820   0.               0  194
54 036,-.9755,-1.4599,$
   GØTØ  / 10.8425  1.7221   0.               0  196
55 037,-.3425,-1.7221,$
   GØTØ  / 10.5000  0.        0.               0  198
56 038,.3425,-1.7221,$
   GØTØ  / 10.8425 -1.7221   0.               0  200
57 039,.9755,-1.4599,$
   GØTØ  / 11.8180 -3.1820   0.               0  202
58 040,1.4599,-.9755,$
   GØTØ  / 13.2779 -4.1575   0.               0  204
59 041,1.7221,-.3425,$
   GØTØ  / 15.0000 -4.5000   0.               0  206
60 042,1.7221,.3425,$
   GØTØ  / 16.7221 -4.1575   0.               0  208
61 043,1.4599,.9755,$
   GØTØ  / 18.1820 -3.1820   0.               0  210
62 044,.9755,1.4599,$
   GØTØ  / 19.1575 -1.7221   0.               0  212
63 045,.3425,1.7221,$
   GØTØ  / 19.5000  0.        0.               0  214
64 046,1.5,.0,$
   GØTØ  / 21.0000  0.        0.               0  218
65 047,-.1504,1.3351,$
   GØTØ  / 20.8496  1.3351   0.               0  220
66 048,-.4438,1.2682,$
   GØTØ  / 20.4058  2.6033   0.               0  222
67 049,-.7148,1.1376,$
   GØTØ  / 19.6910  3.7409   0.               0  224
68 050,-.9501,.9501,$
   GØTØ  / 18.7409  4.6910   0.               0  226
69 051,-1.1376,.7148,$
   GØTØ  / 17.6033  5.4058   0.               0  228
70 052,-1.2682,.4438,$
   GØTØ  / 16.3351  5.8496   0.               0  230
71 053,-1.3351,.1504,$
   GØTØ  / 15.0000  6.0000   0.               0  232
72 054,-1.3351,-.1504,$
   GØTØ  / 13.6649  5.8496   0.               0  234
73 055,-1.2682,-.4438,$
   GØTØ  / 12.3967  5.4058   0.               0  236
74 056,-1.1376,-.7148,$
   GØTØ  / 11.2591  4.6910   0.               0  238
75 057,-.9501,-.9501,$
   GØTØ  / 10.3090  3.7409   0.               0  240
76 058,-.7148,-1.1376,$
   GØTØ  /  9.5942  2.6033   0.               0  242
```

```
  77 059,-.4438,-1.2682,$
     GØTØ  /  9.1504  1.3351  0.              0  244
  78 060,-.1504,-1.3351,$
     GØTØ  /  9.0000  0.      0.              0  246
  79 061,.1504,-1.3351,$
     GØTØ  /  9.1504 -1.3351  0.              0  248
  80 062,.4438,-1.2682,$
     GØTØ  /  9.5942 -2.6033  0.              0  250
  81 063,.7148,-1.1376,$
     GØTØ  / 10.3090 -3.7409  0.              0  252
  82 064,.9501,-.9501,$
     GØTØ  / 11.2591 -4.6910  0.              0  254
  83 065,1.1376,-.7148,$
     GØTØ  / 12.3967 -5.4058  0.              0  256
  84 066,1.2682,-.4438,$
     GØTØ  / 13.6649 -5.8496  0.              0  258
  85 067,1.3351,-.1504,$
     GØTØ  / 15.0000 -6.0000  0.              0  260
  86 068,1.3351,.1504,$
     GØTØ  / 16.3351 -5.8496  0.              0  262
  87 069,1.2682,.4438,$
     GØTØ  / 17.6033 -5.4058  0.              0  264
  88 070,1.1376,.7148,$
     GØTØ  / 18.7409 -4.6910  0.              0  266
  89 071,.9501,.9501,$
     GØTØ  / 19.6910 -3.7409  0.              0  268
  90 072,.7148,1.1376,$
     GØTØ  / 20.4058 -2.6033  0.              0  270
  91 073,.4438,1.2682,$
     GØTØ  / 20.8496 -1.3351  0.              0  272
  92 074,.1504,1.3351,$
     GØTØ  / 21.0000  0.      0.              0  274
  93 075,.0,.0,3.0,00,50$
     GØHØME/ -3.0000  4.0000  3.0000          0  278
  94 ,,54$
  95 ,,54$
  96 ,,54$
  97 ,,54$
  98 ,,54$
  99 ,,54$
 100 ,,54$
 101 ,,54$
 102 ,,54$
 103 ,,54$
 104 076,-24.0,4.0,,02$
     XYZ/      5.0000 11.5000  9.0000            278

 .... MACHINING SUMMARY
    TØØL/ NUM  TYPE   DIA.   LENGTH   MIN. /BLKNØ

        1 1001  DRILL  .5000  0.         .609     0
        2 1002   MILL 1.0000  0.        1.552     6
        3 1003  DRILL  .5000  0.       10.621    29

 .... CYCLE TIME/ 12.782 MIN.
 .... LENGTH ØF TAPE/  14.6 FT.
 .... DIAGNØSTICS/    0
 .... FINI
-END ØF FILE-
```