

APPLICATION PROGRAM BULLETIN

AUTOMAP – AUTOMATIC MACHINING PROGRAM

INTRODUCTION

AUTOMAP (AUTOmatic MAchining Program) provides an effective language by which an object can be described from an engineering drawing. The general descriptive statements are translated by the AUTOMAP program into detailed instructions required to direct the actions of the machine tool.

Since AUTOMAP is a general-purpose numerical control program, the output statements produced are general. It is not necessary to alter AUTOMAP to fit the requirements of the controller used. This function is accomplished with a post-processing program.

AUTOMAP is designed for use in profiling operations where the contour is defined by a sequence of circular and straight line cuts, and simple point-to-point motions. The program is designed for use with an IBM 1620 Data Processing System with the indirect addressing and automatic divide features installed. Three phases of calculation are involved:

Language Translation – translates from English-type statements of the parts programmer into a fixed format for the second phase.

Arithmetic – produces, from the previous phase, the set of points necessary for the tool center to follow to profile the part.

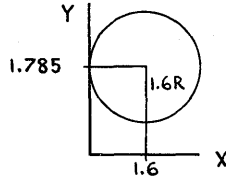
Post Processing – produces, from the results of the arithmetic phase, the feed rates and converts information into the form required for the particular controller used.

The general flow for numerical control tape preparation is shown in Figure 4.

GEOMETRIC STATEMENTS

Geometric statements define the geometric elements which comprise the cutting tool path. These definitions may be written in terms of absolute quantities or in terms of other geometric elements.

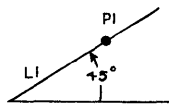
LOOP = CIRCLE / 1.60, 1.785, 1.6



defines a circle which can be specified by the name, LOOP, with its center at $x=1.60$, $y=1.785$ and a radius of 1.6.

Frequently engineering drawings do not contain explicit information. It is possible to define an element in terms of other elements.

LI = LINE / P 1, ATANGL, 45.0



specifies LI as a LINE which passes through point P 1, at an angle (ATANGL) of 45.0 degrees with the horizontal.

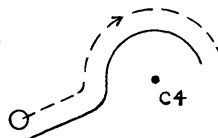
MACHINING STATEMENTS

Every movement of the machine tool must be controlled. Typical commands are:

Go left — GO LFT
Go right — GO RGT
Go forward — GO FWD

Go to — GO TO
Go past — GO PAST

GO LFT / C 4

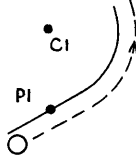


tells the cutter to progress along its present path until it encounters C 4. A left turn is made and movement will follow the curve C 4 until there is another command.

COMPOUND STATEMENTS

It may be advantageous to define a geometric element when it is needed and not in advance of its need. A compound statement accomplishes this:

```
GO LFT / LINE, P 1, RIGHT, TANTO, C 1
```



directs the cutter along a straight line which passes through point P 1, and is tangent to the circle on the right side (as viewed from the point).

A name or label may be used with a compound statement if this path is to be referred to later. The two statements:

```
L 1 = LINE / P 1, ATANGL, 45.0  
GO LFT / L 1
```

may be combined into one:

```
L 1 = GO LFT / LINE, P 1, ATANGL, 45.0
```

SAMPLE PROGRAM

To machine the part shown in Figures 1 and 2, the cutter will be moved down to the cutting level, right to the line L 1 and then move in a clockwise path around the part to the starting point. The statements shown in Figure 3 are the total AUTOMAP program for this part and are discussed in detail.

```
FROM -2.0, -3.0, 3.0
```

specifies that the starting point will be 2.0" to the left of the origin or zero, 3.0" below the origin and 3.0" above it.

```
TOLER / 0.001
```

requires that all paths generated, including non-linear cuts, will be held to a .001 tolerance.

```
TLRAD / 0.25
```

tells the system that a 0.5" diameter cutter will be used. In calculating paths, the computer will offset the specified coordinates by the tool's radius of 0.25".

```
ONKUL
```

is an instruction, that will be used by the post processor, to turn on the coolant before starting the machining.

```
FEDRAT / 10.0
```

calls for a feed rate of 10" per minute during cutting.

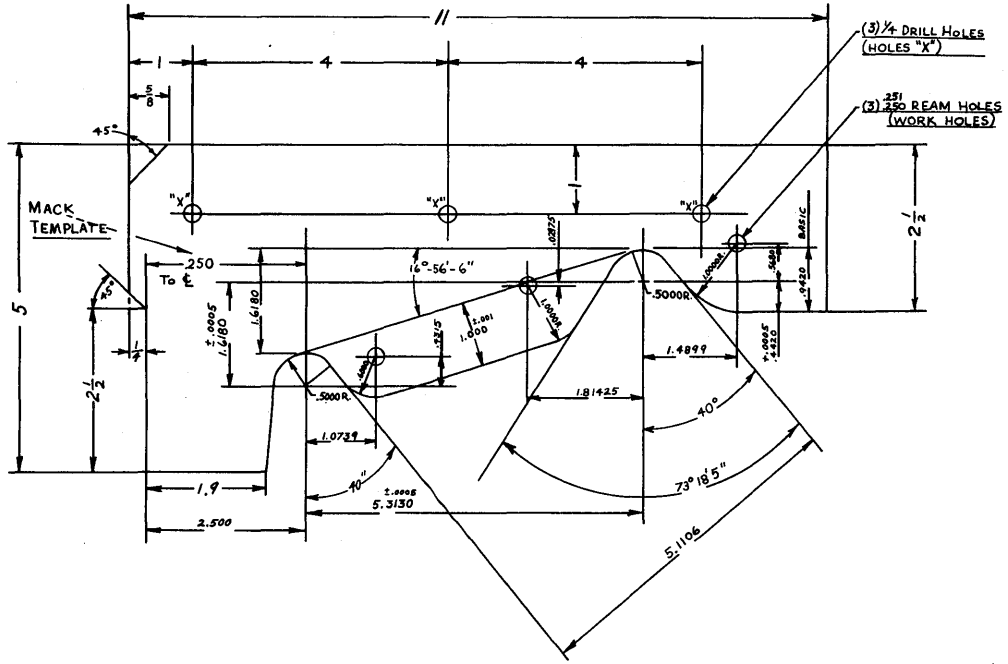
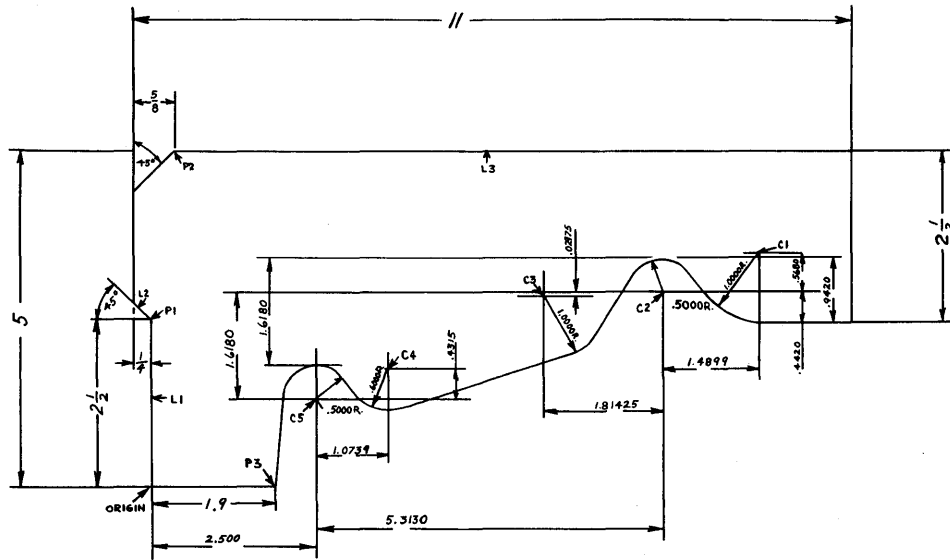


Figure 1.



(-2.0, -3.0, 3.0)
 + SET-UP POINT

Figure 2.

Program WWR AUTOMAP CODING FORM Date JULY 1962
 Coded By EJO Identification FIG 2 Page 1 of 2
 Checked By RWG 74 80

| R FOR REMARK | | AUTOMAP STATEMENT | | N, S, P |
|--------------|---|-------------------|--|-------------|
| ↓ LABEL | 6 | | | FOR CONT. ↓ |
| | | | FROM ✓ -2.0, -3.0, 3.0 | |
| | | | TOLER 10.001 | |
| | | | TLRAD ✓ 0.25 | |
| | | | ONKUL | S |
| | | | FEDRAT ✓ 10.0 | |
| | | | GO DELTA ✓ 0.0, 0.0, -3.0 | |
| | | | INDR, VECTOR ✓ 1.0, 0.0, 0.0 | |
| L1 | | | =GO TO ✓ LINE, 0.0, 0.0, 0.0, 1.0 | P |
| | | | GO LEFT ✓ L1 | |
| P1 | | | =POINT ✓ 0.0, 2.5, 0.0 | |
| L2 | | | =LINE ✓ P1, ATANGL, -45.0 | |
| | | | GO LEFT ✓ L2 | |
| | | | GO RGT ✓ LINE, PARLEL, L1, XSMALL, 0.25 | |
| P2 | | | =POINT ✓ 0.375, 5.0, 0.0 | |
| | | | GO RGT ✓ LINE, P2, ATANGL, 45.0 | |
| L3 | | | =GO RGT ✓ LINE, 0.0, 5.0, 1.0, 5.0 | |
| | | | GO RGT ✓ LINE, PARLEL, L1, XLARGE, 10.75 | |
| | | | GO RGT ✓ LINE, PARLEL, L3, YSMALL, 2.5 | |
| C1 | | | =CIRCLE ✓ 9.3029, 3.5, 1.0 | |
| C2 | | | =CIRCLE ✓ 7.813, 2.942, 0.5000 | |
| | | | GO FWD ✓ C1 | |

Program WWR AUTOMAP CODING FORM Date JULY 1962
 Coded By EJO Identification FIG 2 Page 2 of 2
 Checked By RWG 74 80

| R FOR REMARK | | AUTOMAP STATEMENT | | N, S, P |
|--------------|---|-------------------|--|-------------|
| ↓ LABEL | 6 | | | FOR CONT. ↓ |
| | | | GO FWD ✓ LINE, LEFT, TANTO, C1, RIGHT, TANTO, C2 | |
| | | | GO FWD ✓ C2 | |
| C3 | | | =CIRCLE ✓ 5.99875, 2.91225, 1.0 | |
| | | | GO FWD ✓ LINE, RIGHT, TANTO, C2, LEFT, TANTO, C3 | |
| | | | GO FWD ✓ C3 | |
| C4 | | | =CIRCLE ✓ 3.5739, 1.7555, 0.6 | |
| | | | GO FWD ✓ LINE, LEFT, TANTO, C3, LEFT, TANTO, C4 | |
| | | | GO FWD ✓ C4 | |
| C5 | | | =CIRCLE ✓ 2.5, 1.324, 0.5 | |
| | | | GO FWD ✓ LINE, LEFT, TANTO, C4, RIGHT, TANTO, C5 | |
| | | | GO FWD ✓ C5 | |
| P3 | | | =POINT ✓ 1.9, 0.0, 0.0 | |
| | | | GO FWD ✓ LINE, P3, LEFT, TANTO, C5 | |
| | | | GO RGT ✓ LINE, PARLEL, L3, YSMALL, 5.0 | |
| | | | GO PAST ✓ L1 | |
| | | | GO DELTA ✓ 0.0, 0.0, +3.0 | |
| | | | OKUL | S |
| | | | GO TO ✓ -2.0, -3.0, 3.0 | |
| | | | FINI | |

Figure 3.

GO DLTA / 0.0, 0.0, -3.0

specifies the cutter depth by moving the cutting tool down 3.0".

INDR, VECTOR / 1.0, 0.0, 0.0

specifies a direction parallel to the x axis.

L 1 = GO TO / LINE, 0.0, 0.0, 0.0, 1.0

instructs the cutter to follow the preceding line until line L 1 is encountered.

L 1 is defined as a line passing through points (0.0, 0.0) and (0.0, 1.0).

Position the cutter tangent to line L 1 on the outside of the part.

GO LFT / L 1

specifies that a left turn is to be made at L 1. The combination of the last two statements also specifies that the cutter will be on the outside of the workpiece.

P 1 = POINT / 0.0, 2.5, 0.0

states that the point P 1 is at x=0.0, y=2.5 and z=0.0.

L 2 = LINE / P .1, ATANGL, -45.0

another line (L 2) passes through point (P 1) making an angle of -45.0 degrees with the horizontal.

GO LFT / L 2

causes the cutter to turn left and proceed along L 2.

GO RGT / LINE, PARLEL, L 1, XSMALL, 0.25

continues movement along L 2 until an unlabeled line is reached which is parallel to L 1 at a distance of 0.25". Two lines satisfy this condition. The one with the smaller x value is wanted, i. e., x=-0.25.

P 2 = POINT / 0.375, 5.0, 0.0

defines a point where x=0.375, y=5.0, z=0.0.

GO RGT / LINE, P 2, ATANGL, 45.0

specifies movement right on a line (not defined by a name). This line passes through P 2 and forms an angle of 45.0 degrees with the horizon.

L 3 = GO RGT / LINE, 0.0, 5.0, 1.0, 5.0

defines L 3 as a line passing through the points (0.0, 5.0) and (1.0, 5.0).

GO RGT specifies a right turn when this line is reached.

GO RGT / LINE, PARLEL, L 1, XLARGE, 10.75

instructs a right turn on a line parallel to L 1 at a distance 10.75" away with the largest value of x.

GO RGT / LINE, PARLEL, L 3, YSMALL, 2.5

instructs a right turn on a line parallel to L 3 at a distance 2.5" away with the smallest y value.

C 1 = CIRCLE / 9.3029, 3.5, 1.0

specifies a circle with a radius of 1" whose center is at x=9.3029, y= 3.5.

C 2 = CIRCLE / 7.813, 2.942, 0.5

specifies a circle with a radius of 0.5" whose center is at (7.813, 2.942).

GO FWD / C 1

Forward (FWD) states that there will be no turn. The cutter will move in the same general direction after it intersects the curve (C 1) which it will then follow.

GO FWD / LINE, LEFT, TANTO, C 1, RIGHT, TANTO C 2

specifies another tangency condition by the use of FWD. The unnamed line has a left tangency to circle C 1 and right tangency to circle C 2, when viewed from circle C 1.

GO FWD / C 2

causes the cutter to continue from the previously described line and in the same general direction along circle C 2.

C 3 = CIRCLE / 5.99875, 2.91225, 1.0

defines a circle with a radius of 1.0" and a center at (5.99875, 2.91225).

Generally the accuracy implied by the decimal positions cannot be justified but the values are recorded as such to agree with the engineering drawing.

GO FWD / LINE, RIGHT, TANTO C 2, LEFT, TANTO, C 3

instructs forward movement along the line which is right tangent to C 2 and left tangent to C 3.

GO FWD / C 3

instructs forward movement along C 3.

C 4 = CIRCLE / 3.5739, 1.7555, 0.6

defines a circle C 4 of a 0.6" radius with a center at (3.5739, 1.7555).

GO FWD / LINE, LEFT, TANTO, C 3, LEFT, TANTO, C 4

instructs forward movement along a line that is left tangent to circles C 3 and C 4.

GO FWD / C 4

causes movement on the circle C 4.

C 5 = CIRCLE / 2.5, 1.324, 0.5

defines the circle C 5 as having a 0.5" radius and a center at (2.5, 1.324).

GO FWD / LINE, LEFT, TANTO, C 4, RIGHT TANTO, C 5

produces forward movement along the line that is left tangent to C 4 and right tangent to C 5.

GO FWD / C 5

instructs movement along circle C 5.

P 3 = POINT / 1.9, 0.0, 0.0

defines a point (P 3) with coordinates of (1.9, 0.0, 0.0).

GO FWD / LINE, P 3, LEFT, TANTO, C 5
tells the cutter to continue its present path until it encounters a line that passes through point P 3 and is left tangent to circle C 5.

GO RGT / LINE, PARLEL, L 3, Y SMALL, 5.0
produces movement on a line that is parallel to line L 3 with the smaller y value.

GO PAST / L 1
insures a clean corner cut at the lower left of the part.

GO DELTA / 0.0, 0.0, 3.0
retracts the cutter 3.0" to its home position.

OFKUL
is an instruction, that will be used by the post processor, to turn the coolant off after machining is completed on each workpiece.

GO TO / -2.0, -3.0, 3.0
causes positioning at the starting point for the next workpiece.

FINI
tells the machine that all parts are completed.

NOTE

This bulletin discusses AUTOMAP generally and is not intended to be a complete programming reference guide. Many of the systems capabilities have not been included.

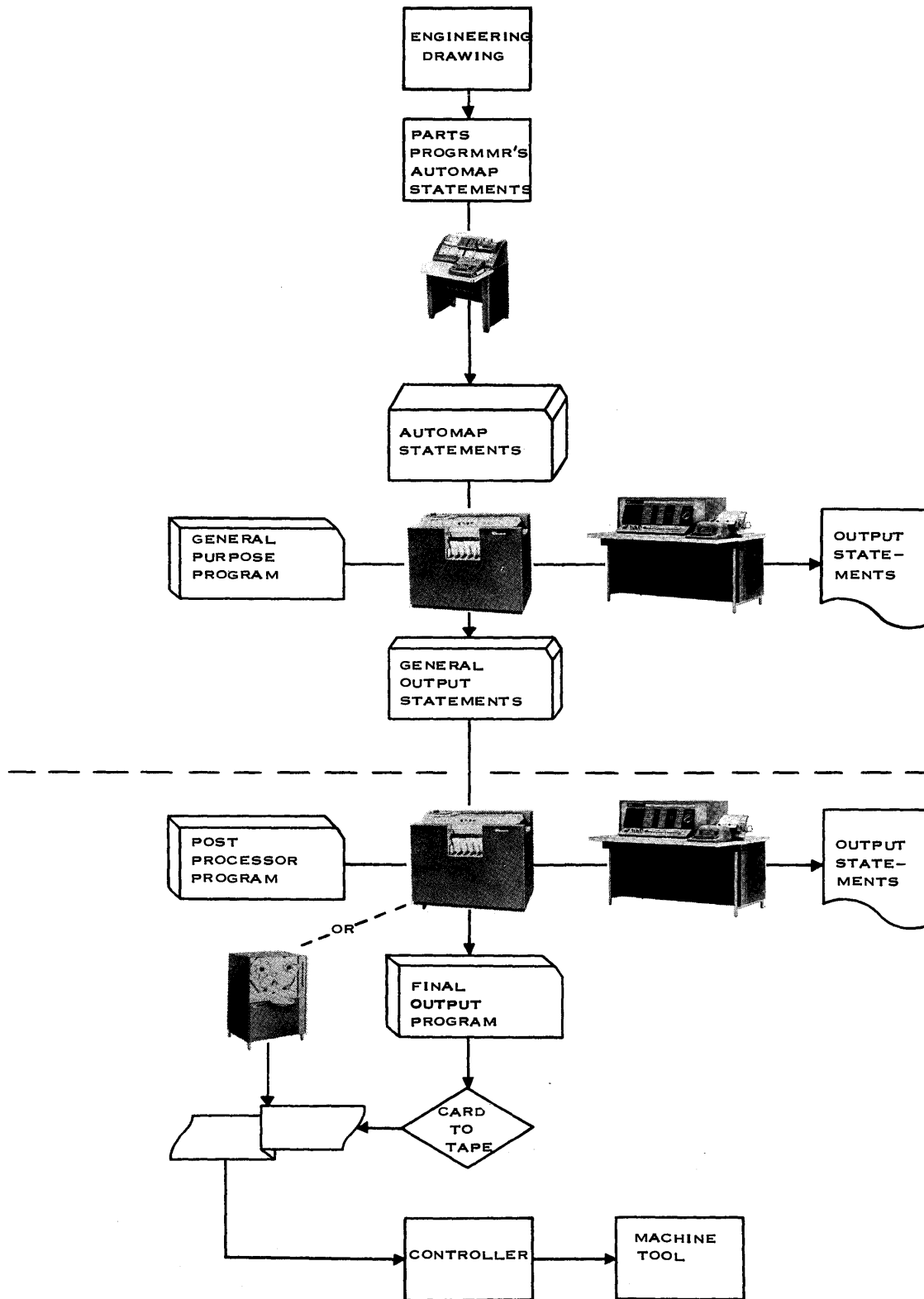


Figure 4.

IBM

International Business Machines Corporation
Data Processing Division, 112 East Post Road, White Plains, N. Y.