

# Section 29

## Arc Mill Event

### Topics Covered in this Section:

- Introduction
- Arc Mill Event Data
- Cartesian Arc Definition
- Polar Arc Definition
- Cutter Radius Compensation
- Cam Mill Interpolation
- Arc Mill Event Example

PROGRAM MODE	N1800	<h3 style="margin: 0;">P0 - Arc Mill in XY Plane</h3> <hr/> <div style="display: flex; justify-content: space-between;"> <div style="width: 45%;"> <p><b>Cartesian Coordinates</b></p> </div> <div style="width: 45%;"> <p><b>Polar Coordinates</b></p> </div> </div> <hr/> <p> <b>P - Plane Select</b>  <b>F - Feedrate</b>  <b>C - Cutter Compensation</b>  <b>G - Wait for In Position</b>  <b>Z - Z Axis Advance (XY Plane Helix)</b>  <b>E - End Radius</b> </p>				
0-POSITION	ARC MILL					
1-LINEAR MILL						
2-ARC MILL	P0					
3-FRAME MILL	X					
4-CIRCLE MILL	Y					
5-BOLT CIRCLE	I					
6-REPEAT	J					
7-SUBROUTINE	Z					
8-DWELL						
9-M FUNCTION	A					
	B					
C-CAVITY MILL	R					
E-EIA	E					
G-GRAPHICS						
M-MACRO CALL	F					
P-PROBE	G					
R-ROTATE	C					
S-SET UP						
T-TEXT						
DEMOPART						
VIEW 1 OF 1						
FRONT END GRAPHICS		DELETE EVENT	COPY/ STORE	PROGRAM DISPLAY	RUN CALC ASSIST	

## ARC MILL EVENT - INTRODUCTION

This event mills an arc which may extend to 360°. The tool's start position locates the arc's start point. Since the control uses the start position in arc calculations, the tool must be located on the arc path at the start of the event.

You can program the arc in Cartesian coordinates (absolute or incremental) or polar coordinates. Cartesian coordinates require endpoint, arc center, direction, and feed. Absolute and incremental dimensions can be programmed in the same event.

Polar coordinates require arc radius, start angle, end angle, direction, and feed.

This event can be used to turn cutter radius compensation on and off, cut a Z advance helix and a variety of cam profiles, and specify a "wait for in position" after the event.

## ARC MILL EVENT DATA

This event is initially set to program arc motion in the XY plane. Program P1 or P2 to change the arc motion to the YZ or ZX planes. After you select the plane (P0, P1, or P2), the Arc Mill event will only allow endpoint and center coordinates that are located in that plane.

<b>Parameter</b>	<b>Description</b>	<b>Entry</b>
N	Sequence Number	Required
P	Plane Select (P0=XY, P1=YZ, P2=ZX)	Defaults to P0
<b>Cartesian Arc</b>		
X or X/	X axis endpoint	Required in P0 or P2
Y or Y/	Y axis endpoint	Required in P0 or P1
Z or Z/	Z axis endpoint (Z axis helix in P0)	Required in P1 or P2
I or I/	X axis arc center	Required in P0 or P2
J or J/	Y axis arc center	Required in P0 or P1
K or K/	Z axis arc center	Required in P1 or P2
D	Arc Direction (D0=CW, D1=CCW)	Defaults to D0
<b>Polar Arc</b>		
A	Start Angle	Required for polar
B	End Angle	Required for polar
R	Arc Radius	Required for polar
D	Arc Direction (D0=CW, D1=CCW)	Defaults to D0
E	End Radius (Cam Mill)	Optional
<b>Miscellaneous entries</b>		
F	Direct feedrate on cutting path	Modal
C	Cutter Compensation (C0=off, C1=left, C2=right)	Modal
G	Wait for In Position G not programmed=don't wait G0=wait for IP	Defaults to G blank

## **CARTESIAN or POLAR ENDPOINT DESCRIPTION**

An arc can be completely described by programming Cartesian or polar coordinates. If you run your part program through Calc-Assist, further arc descriptions can be programmed by combining Cartesian and polar coordinates (refer to the Calc-Assist part of this manual).

### **P - PLANE SELECT**

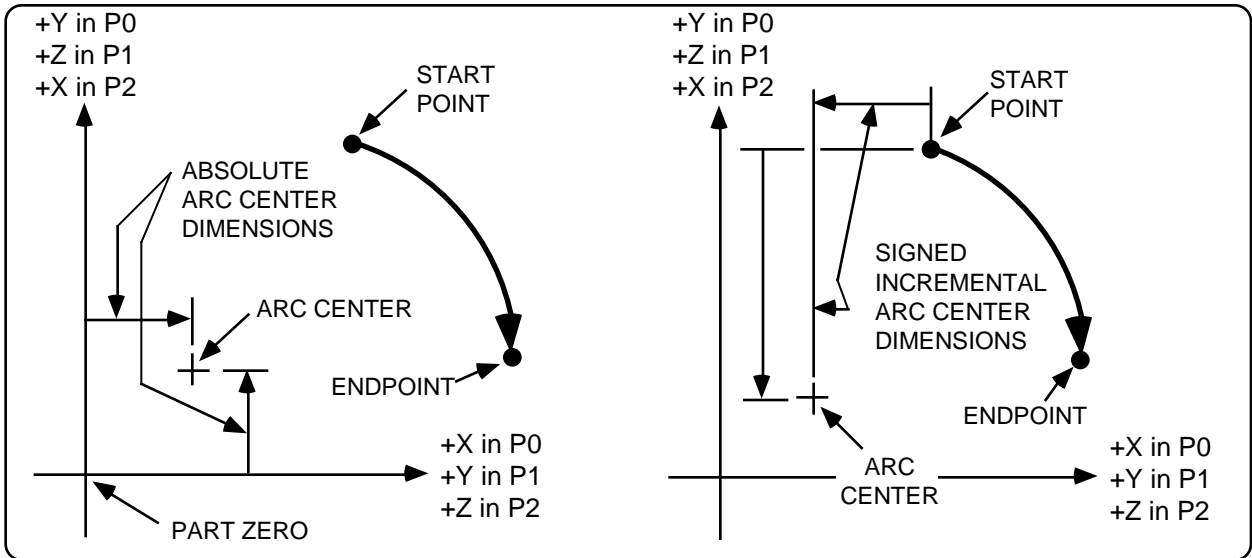
Plane Select identifies which pair of axes must move to mill the arc, and also chooses the plane for cutter offset when you are using cutter radius compensation. P0, the XY plane, is initially selected in each new event.

### **D - ARC DIRECTION**

The control initially selects D0 (clockwise) milling motion around the arc center. The cutting direction (CW or CCW) around an arc is established by looking toward the arc plane from the positive axis that is not included in the the arc's plane (e.g. an arc's direction in the XY plane is properly referenced by viewing it from the +Z axis).

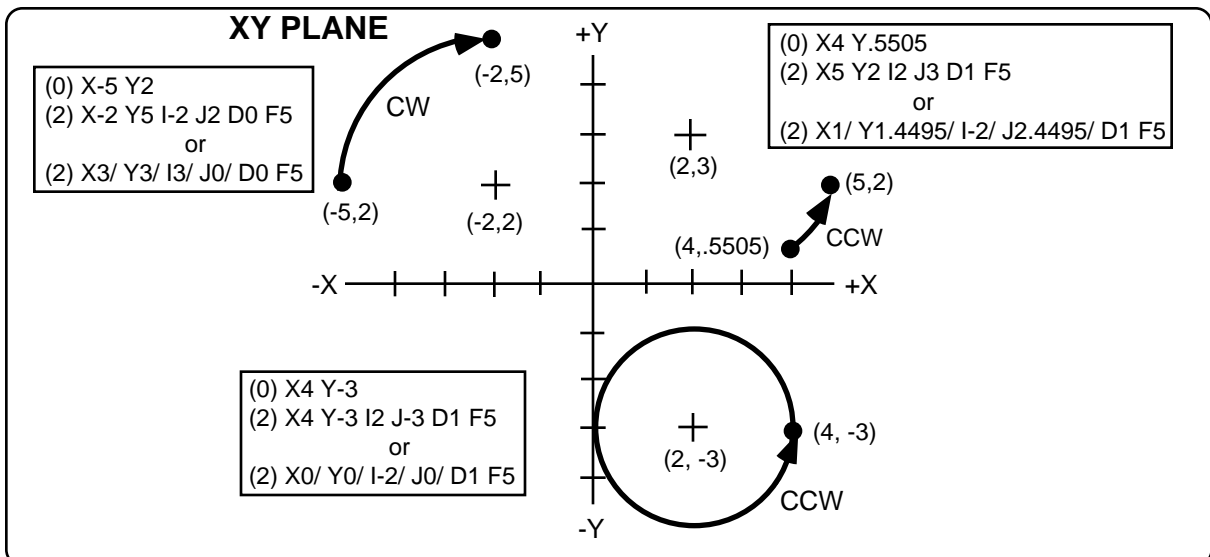
## I, J, K ARC CENTER - CARTESIAN ENTRY

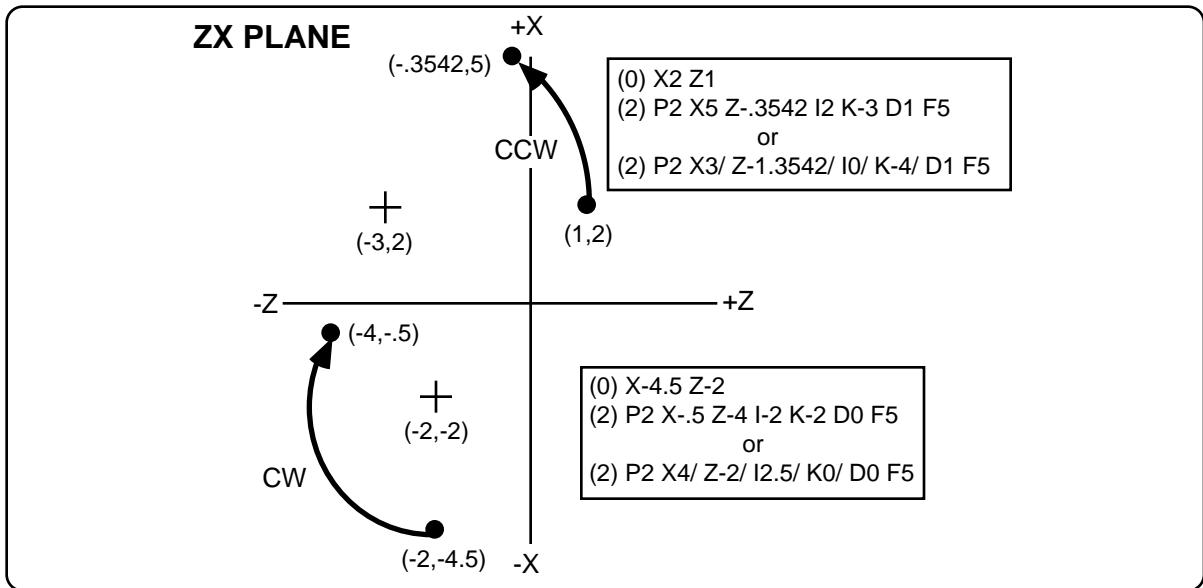
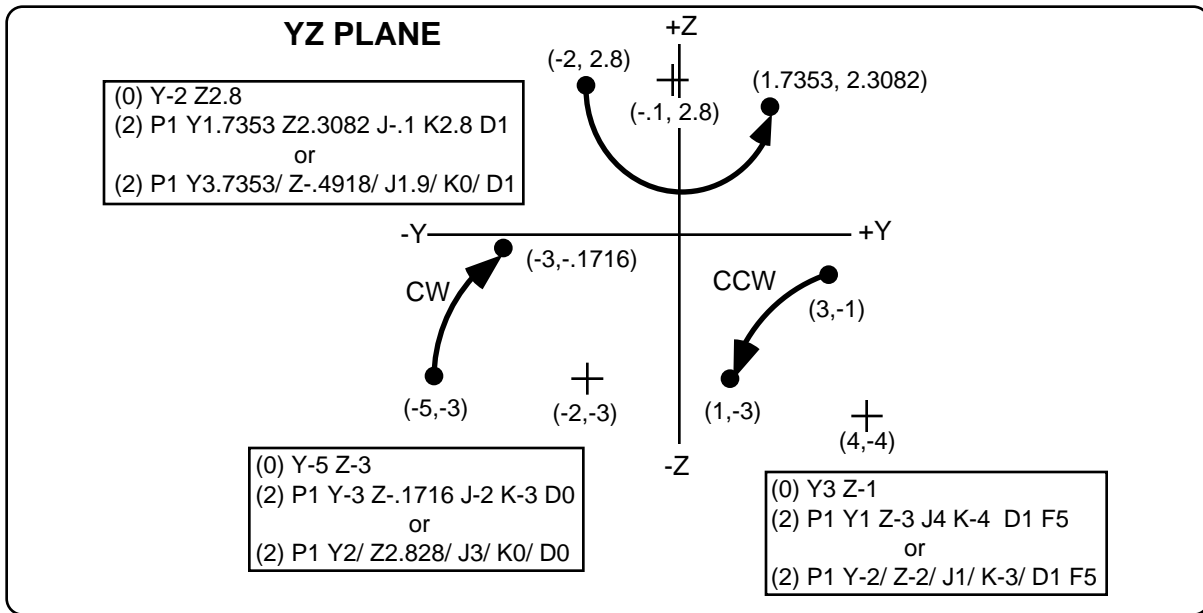
Enter both arc axis dimensions in the plane to define the arc center. An absolute or incremental entry is required for each axis. An absolute entry is the arc center's signed axis coordinate. An incremental entry is the signed distance **from** the start point **to** the arc center along the axis. Absolute and incremental entries may appear in the same event. In the plane P0, program arc center I on the X axis and arc center J on the Y axis. In plane P1, program arc center J on the Y axis and arc center K on the Z axis. In plane P2, program arc center K on the Z axis and arc center I on the X axis. Refer to illustrations **below**.



## X, Y, Z ENDPOINT - CARTESIAN ENTRY

Enter both axis dimensions in the plane to define the arc endpoint. An absolute or incremental entry is required for each axis. An absolute entry is the endpoint's signed axis coordinate. An incremental entry is the signed distance **from** the start point **to** the endpoint along the axis. Absolute and incremental entries may appear in the same event. In plane P0, program the X and Y endpoints. In P1, program Y and Z. In P2, program Z and X. Refer to illustrations, **below** and **following page**.





## R ARC RADIUS - POLAR ENTRY

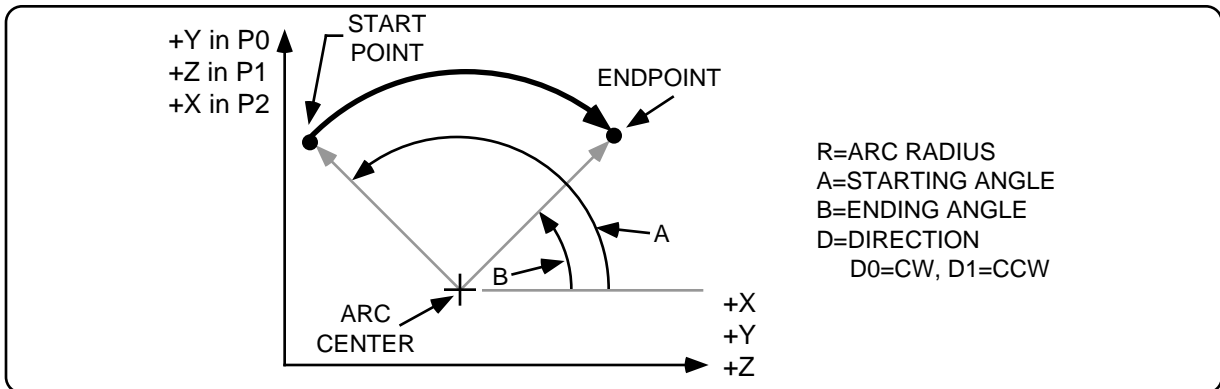
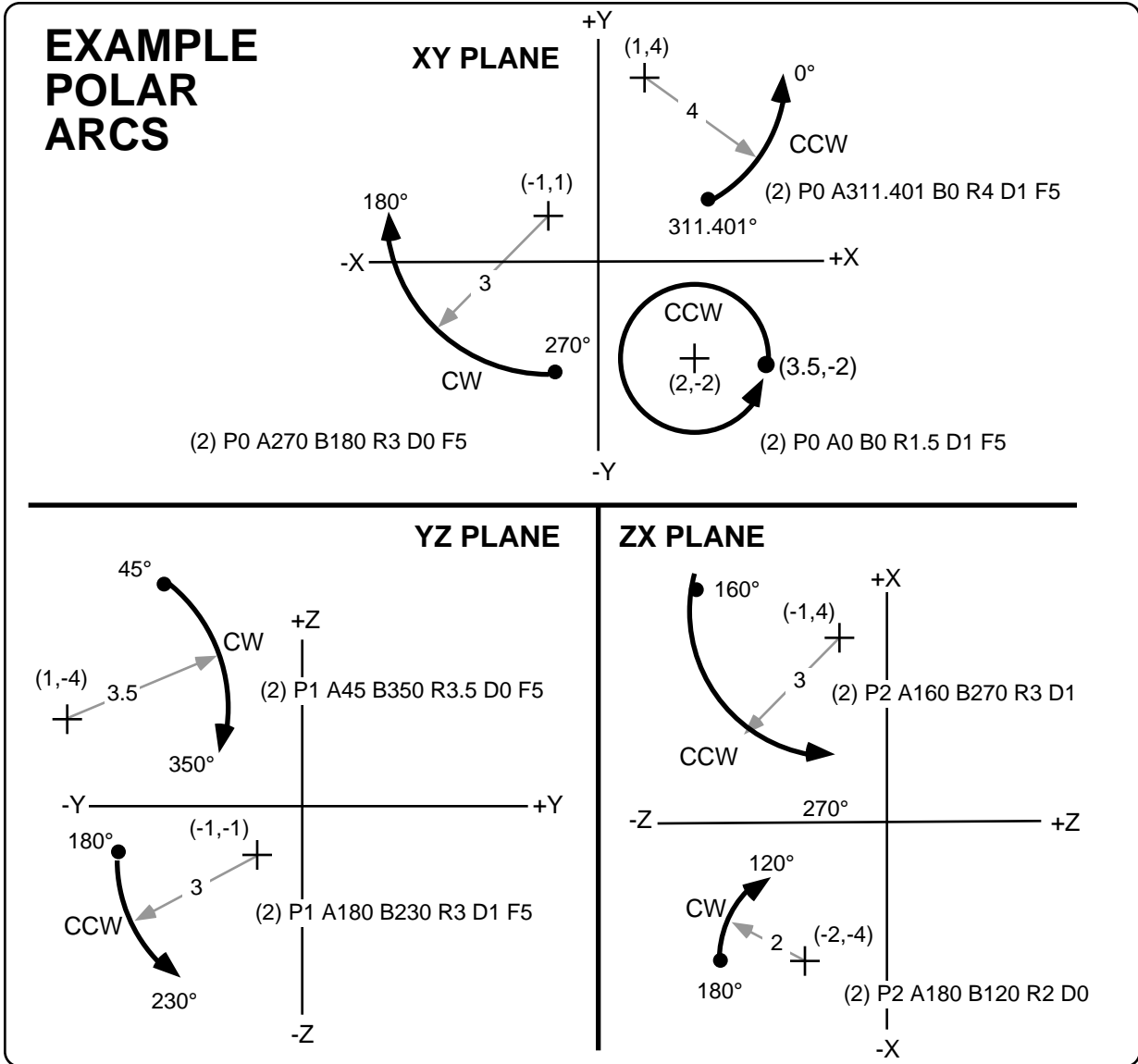
The polar arc radius is the unsigned distance from the arc center to the tool's start point.

## A, B START AND END ANGLES - POLAR ENTRY

Enter the start and end angles in the selected plane. Start angle A locates the tool's start point on the arc described by radius R. End angle B similarly defines the tool's endpoint. Both angles open counterclockwise<sup>1</sup> from a zero degrees reference line<sup>2</sup> that originates at the arc center. Refer to **illustrations, below and previous page.**

1. Counterclockwise is the direction that provides the shortest angle from the positive primary axis to the positive secondary axis in the selected plane.
2. Zero degree reference lines run parallel to, and in the same direction as, the positive primary axis in the selected plane. The primary axis in the XY plane is X, in the YZ plane is Y, and in the ZX plane is Z. The

# EXAMPLE POLAR ARCS



## F - FEEDRATE

In this event, feedrate F programs direct feed along the arc path. Feedrate is modal with all following event types which program feedrate F.

## CUTTER RADIUS COMPENSATION

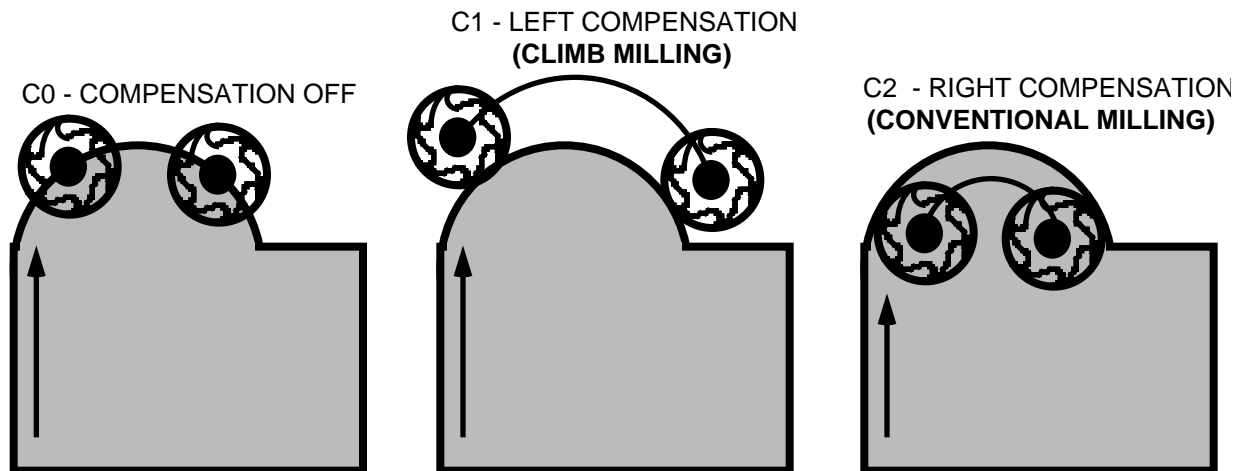
Cutter Radius Compensation (CRC) is a utility that simplifies profile programming by allowing you to program part coordinates without considering the tool's size. When you cycle a part with CRC properly programmed, the control will automatically offset the programmed path to compensate for the active tool's radius, and command the tool to move along the path that smoothly blends each event with the following Linear or Arc Mill event. CRC may only be used in an uninterrupted sequence of Linear Mill and Arc Mill events.

Note: This entry is programmed with the letter "H" if your control is equipped with an auxiliary axis that is programmed with the letter "C". Refer to Section 2.

### C - TURN CRC ON OR OFF

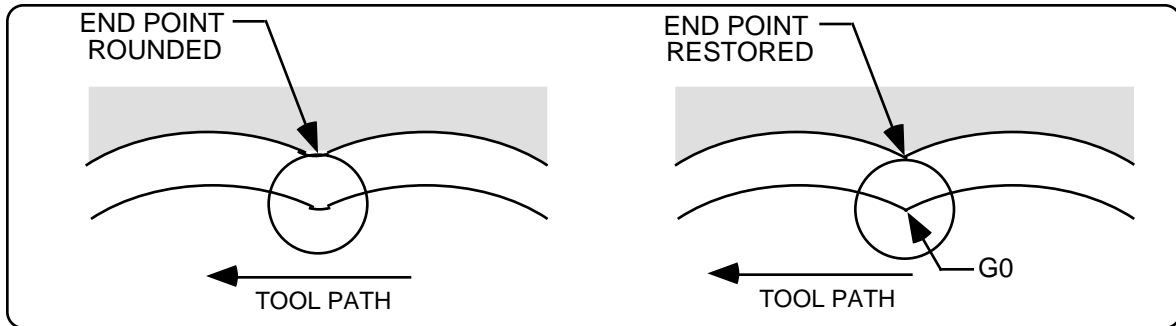
C0 cancels any active cutter compensation. C1 turns cutter compensation on to the left of the profile; C2 turns cutter compensation on to the right of the profile. Turning cutter compensation on or off will offset the tool a distance equal to the tool's radius in a direction that is perpendicular to the profile. CRC is modal with all following Linear and Arc Mill events. Refer to the illustration **below**.

Cutter compensation is described in Section 30 of this manual.



## G0 - WAIT FOR IN POSITION

You would normally program a series of linear and arc moves without using the G0 entry. However, if a high feedrate shows signs of corner rounding in a test part, program G0-Wait for In Position to restore the corner, **below**. G0 is nonmodal and operative only in the event in which it is programmed. If G is left blank (not programmed), the next event begins right after the last feed increment is output to the servos. Note that the next motion output can occur while there is still following error to be resolved. If G0 is programmed, the next event will not begin until the following error is reduced to less than the "In Position" range established by the machine supplier. A noticeable delay will usually occur during the Wait for In Position. Refer to the **lower** illustrations.



## Z - XY PLANE HELIX

When the P0 (XY) plane is selected, a helix may cut by programming the arc as described earlier with the addition of a Z axis advance.

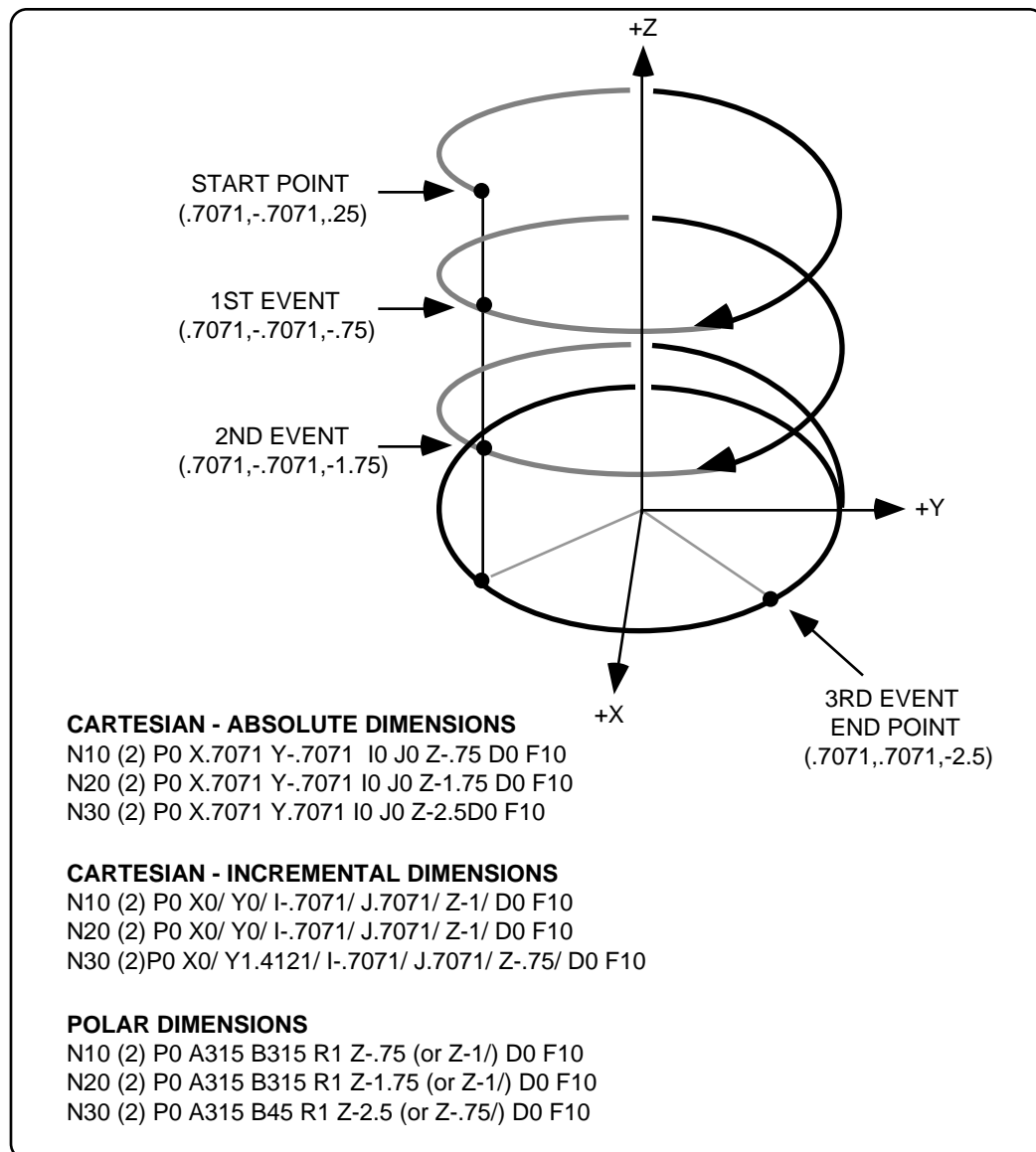
Since the Arc Mill event is limited to a 360° arc, three events will be required to mill the example program. The advance is 2.75 inches in Z over the same number of revolutions, or a lead of 1 inch per revolution.

The start point is (.7071, -.7071, 0.25), .25 inches above the surface.

The endpoint is (.7071, 0.7071, -2.5).

The tool moves in the clockwise direction.

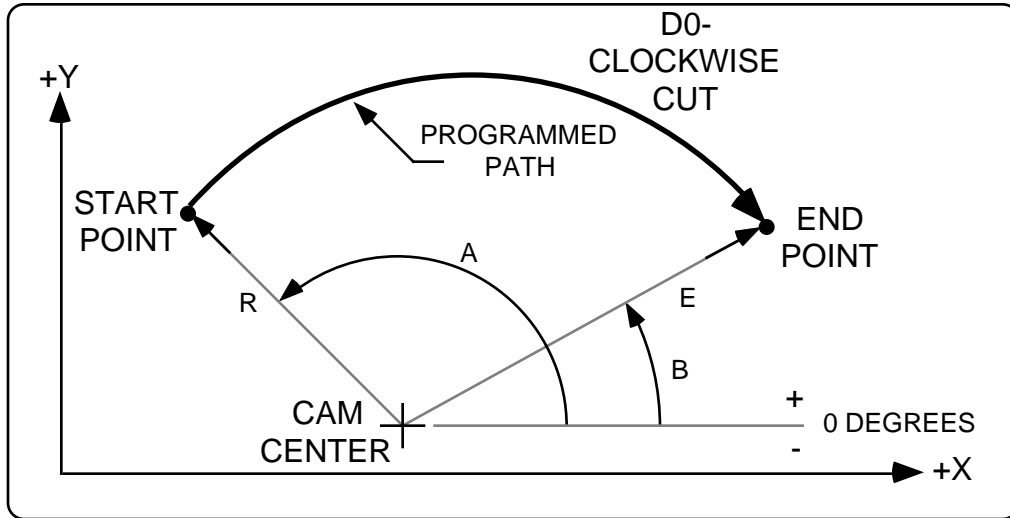
Refer to the **following** program example.



## E - CAM MILL END RADIUS - POLAR ENTRY

When end radius E is programmed in a polar Arc Mill event, a curve of uniformly changing arc radius results<sup>3</sup>. This capability is useful in programming a variety of cam profiles. The event must use A, B and R entries. End radius E is available with P0, P1 or P2 plane select. Start radius R and end radius E must each be greater than zero, and the included angle between start angle A and end angle B must be less than 360°. Cam profiles may only be programmed in the XY plane; no lead in Z may be programmed with a cam profile.

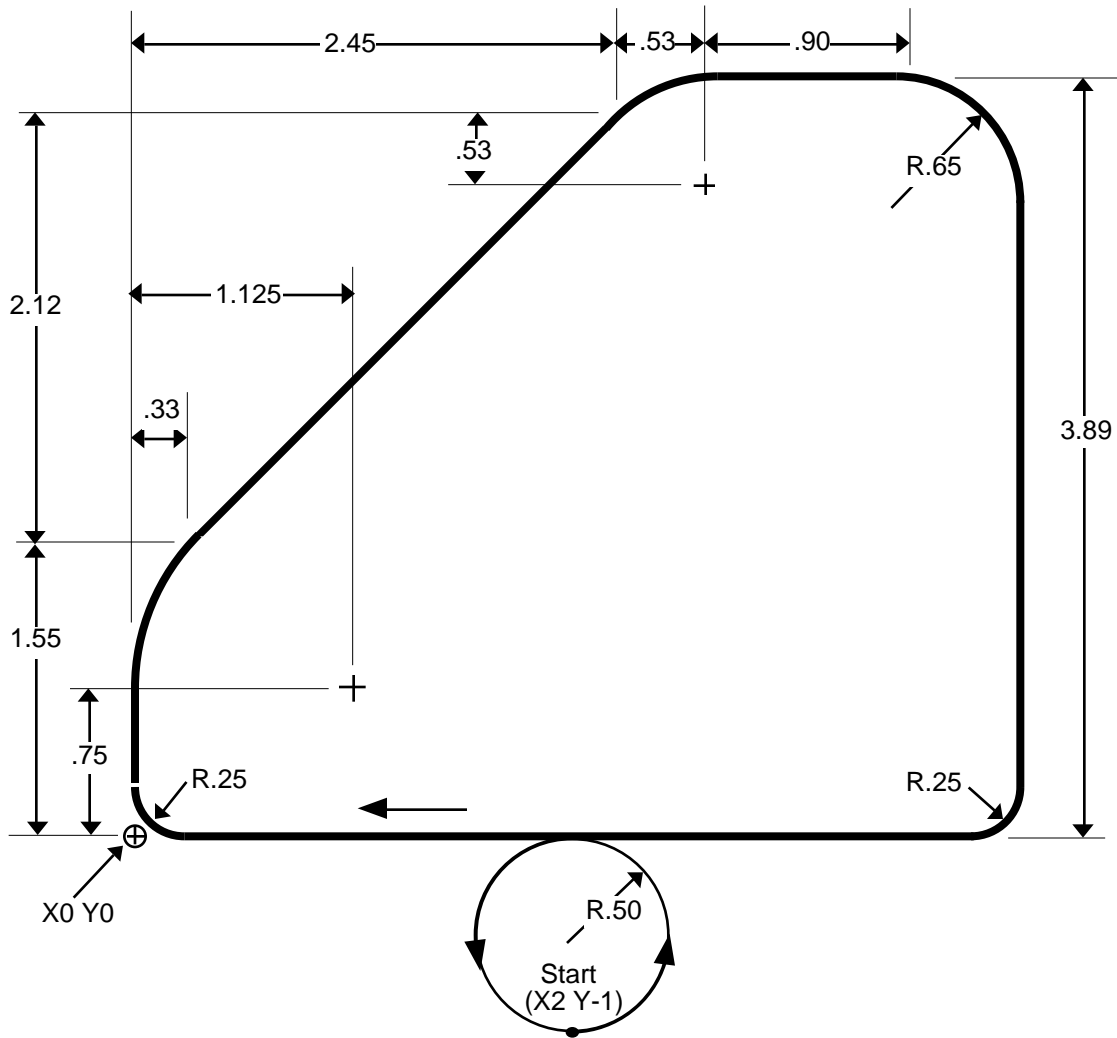
Refer to the illustration **below**.



<sup>3</sup> The change in radius is directly proportional to the change in degrees. The resulting curve is

**EXAMPLE:**

*Note that the following example is only intended to demonstrate methods of using Arc Mill events; it is not intended to be a complete part program since it does not include a Z axis depth nor does it include commands to identify a tool number or spindle speed.*



N.5	(G)	X-1 Y-1 V6	- Graphics Setup event
N01	(0)	X2 Y-1 Z.1	- convenient start position
N02	(2)	A270 B90 R.5 D1	- tangential arc to enter profile
N03	(1)	X.25	- Linear Mill to start of arc
N04	(2)	X0 Y.25 I.25 J.25 D0	- Cartesian arc
N05	(1)	Y.75	- Linear Mill event
N06	(2)	X.33 Y1.55 I.125 J.75 D0	- Cartesian arc
N07	(1)	X2.45 Y3.67	- Linear Mill event
N08	(2)	X.53/ Y3.89 I.53/ J-.53/	- Cartesian arc
N09	(1)	X.90/	- Linear Mill event
N10	(2)	A90 B0 R.65 D0	- Polar arc
N11	(1)	Y.25	- Linear Mill event
N12	(2)	A0 B270 R.25 D0	- Polar arc
N13	(1)	X2	- Linear Mill event
N14	(2)	A90 B270 R.5 D1	- Polar arc to tangentially exit profile
N99	(9)	M30	- end of program command

