CNC 8055 M

Examples manual

REF. 1010

FAGOR

FAGOR AUTOMATION

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PROGRAM STRUCTURE

1

1.1 Machining conditions

The cutting speeds and feedrates shown in this manual are for guidance only, they may vary depending on the tool and material the part is made of. To machine any of the parts of these example, use the feedrates and speeds recommended by the tool manufacturer.

The tool number will also be different depending on the machine.

1.2 Absolute and incremental coordinates

Absolute coordinates (G90):	Programming with this type of coordinates implies the use of a "part zero" as a coordinate origin.
Incremental coordinates (G91):	This type of coordinates are programmed considering the last programmed point as the origin point.

1.3 Tool penetration

Starting with any program, the tool penetrations may be distributed in that geometry until the desired total depth is reached. This is achieved using the RPT instruction that indicates the first and last block of the contour to be repeated and the number of times it must be repeated.

(RPT N1, N2) N5

N1: First block of repetitions.

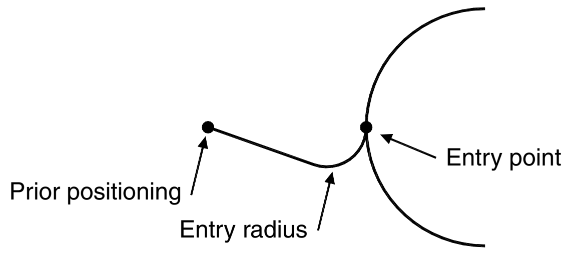
N2: Last block of repetitions.

N5: Number of times to be repeated.

When repeating downward movements, the first label must always be placed ahead of the block that indicates the depth of the pass in Z (G91 Z-5 F100). It is very important that this block contains the G91 function (incremental). The second label must be placed in the block for returning to the previous position (G40 X _ Y_).

1.4 Tangential entries and exits.

The purpose of these functions is for the tool not to enter the contour in a straight line, but describing a particular radius in order to approach the starting point tangentially. This is done to avoid possible markings on the contour. The same operation is done to exit.



- A tangential entry consists of a linear interpolation with tool radius compensation and a circular interpolation to enter the contour.
- The distance between the previous point and the entry point must never be smaller than twice the diameter of the tool.
- The entry radius must never be smaller than the tool diameter.

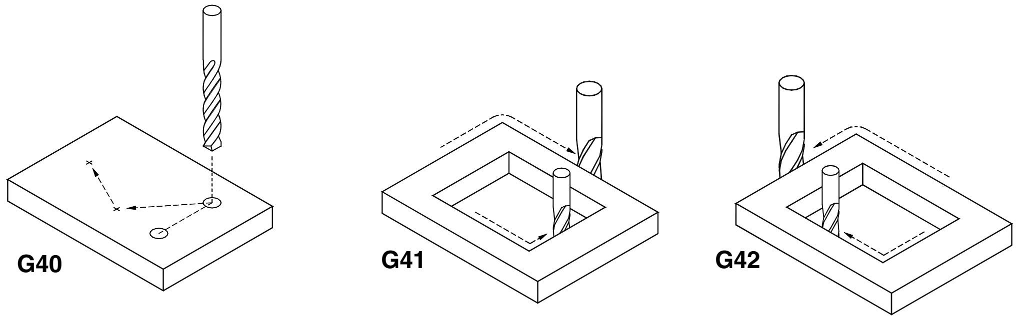
1.5 Tool radius compensation

Tool compensation may be applied in two different ways depending on the programming direction.

G40: Cancellation of tool radius compensation

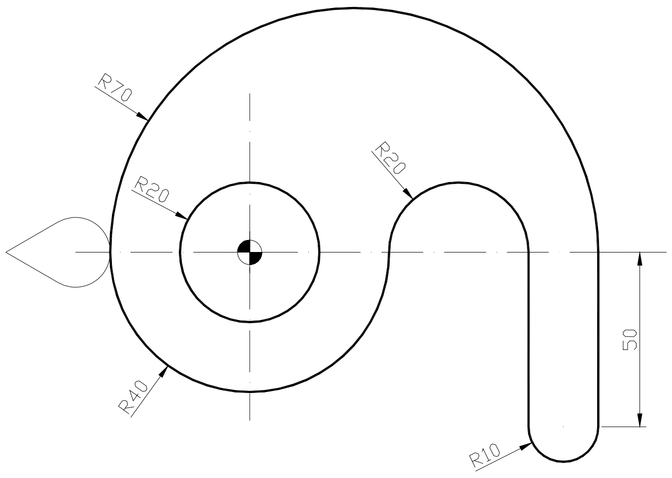
G41: Tool radius compensation to the left of the part.

G42: Tool radius compensation to the right of the part.



Function G40 cancels tool compensation.

1.6 Programming example



The structure of a program for contouring any geometry is always the following:

Header

```
G0 Z100                                  ; Safety position.
T10 D10                                  ; Call to the Ø 10 mm tool.
S10000 M3                                ; Start the spindle clockwise (M3).
```

Enter the contour

```
X-70 Y0                                  ; Position before the entry.
G43 Z0                                   ; Z down movement to the surface.
N1 G1 G91 Z-5 F100                       ; Penetration step.
G90 G37 R10 G42 X-40 Y0 F1000            ; Tangential entry and tool radius compensation.
```

Geometry

```
G3 X40 Y0 R40
G2 X80 Y0 R20
G1 X80 Y-50
G3 X100 Y-50 R10
G1 X100 Y0
G3 G38 R10 X-40 Y0 R70                   ; Tangential exit.
N2 G1 G40 X-70 Y0                        ; Return to starting point without compensation.
```

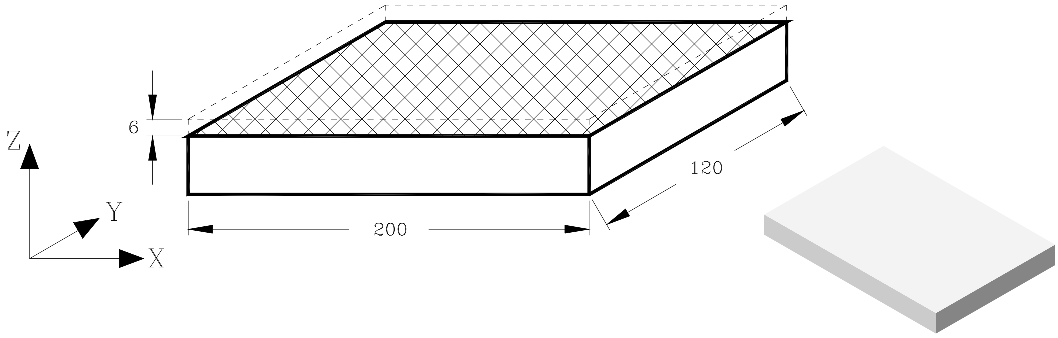
Repeat down movements.

```
(RPT N1,N2)N5                            ; Repeat down movements five times.
G0 Z100                                  ; Starting plane.
G88 G99 X0 Y0 Z2 I-30 J20 B5 D2 H500 V100 ; Circular pocket.
G0 G80 Z100                              ; Bring the tool up and cancel the cycle.
M30                                      ; End of program.
```

BASIC MACHINING OPERATIONS

2

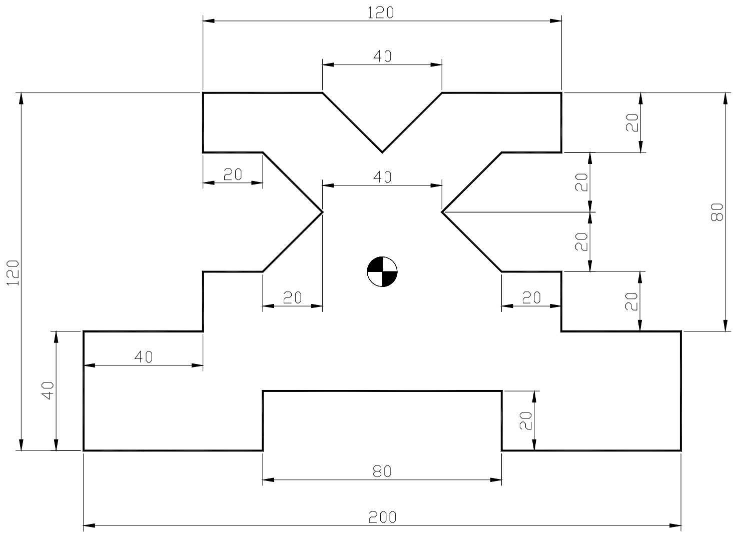
2.1 Surface milling

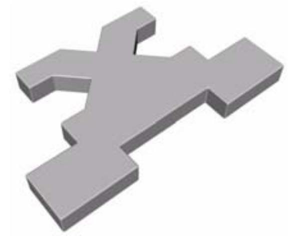


A Ø50 mm end mill is to be used to mill the XY surface 6 mm.

Absolute coordinates	Incremental coordinates
T1 D1 F200 S800 M3 M41 G0 G90 X-50 Y0 Z25 G1 Z6 F200 N10 G1 G90 X-30 Y0 F250 G91 G1 Z-2 F200 G90 G1 X230 F250 G0 Y40 G1 X-30 G0 Y80 G1 X230 G0 Y120 N20 G1 X-30 (RPT N10, N20) N2 G1 Z20 G0 X-50 M30	T1 D1 F200 S800 M3 M41 G0 G90 X-50 Y0 Z25 G1 Z6 F200 N10 G1 G90 X-30 Y0 F250 G91 G1 Z-2 F200 N20 G1 X260 F250 G0 Y40 N30 G1 X-260 G0 Y40 N40 (RPT N20, N30) (RPT N10, N40) N2 G1 G90 Z20 G0 X-50 M30

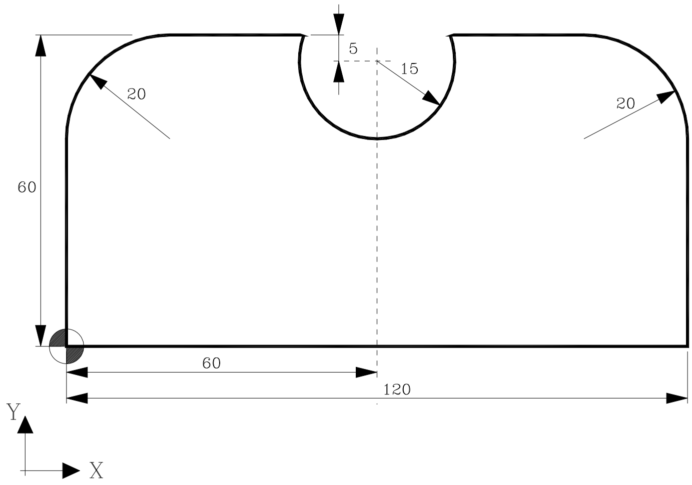
2.2 Contour programming

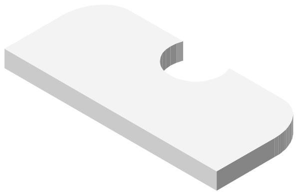


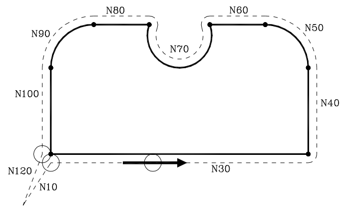


Absolute coordinates	Incremental coordinates
G0 Z100	G0 Z100
S1000 T1 D1 M3	S1000 T1 D1 M3
G90 X-100 Y-60	G90 X-100 Y-60
G1 G43 Z0	G1 G43 Z0
X-40 Y-60	G91 X60
X-40 Y-40	Y20
X40 Y-40	X80
X40 Y-60	Y-20
X100 Y-60	X60
X100 Y-20	Y40
X60 Y-20	X-40
X60 Y0	Y20
X40 Y0	X-20
X20 Y20	X-20 Y20
X40 Y40	X20 Y20
X60 Y40	X20
X60 Y60	Y20
X20 Y60	X-40
X0 Y40	X-20 Y-20
X-20 Y60	X-20 Y20
X-60 Y60	X-40
X-60 Y40	Y-20
X-40 Y40	X20
X-20 Y20	X20 Y-20
X-40 Y0	X-20 Y-20
X-60 Y0	X-20
X-60 Y-20	Y-20
X-100 Y-20	X-40
X-100 Y-60	Y-40
G0 Z100	G0 Z100
M30	M30

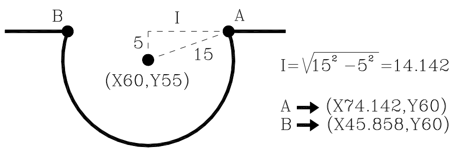
2.3 Circular interpolations







Calculating the points needed to program the part:



Programming the arc center in absolute coordinates (G90)

```
N10 G90 S1000 T2 D2 M3 M41
N20 G0 G42 X0 Y0 Z5
N30 G94 G1 Z-5 F150
N40 X120 F250
N50 Y40
N60 G3 X100 Y60 I-20 J0
N70 G1 X74.142
N80 G2 X45.858 I-14.142 J-5
N90 G1 X20
N100 G3 X0 Y40 I0 J-20
N110 G1 Y0
N120 G1 Z5
N130 G0 G40 X-30 Y-30 Z20 M30
```

Programming the arc radius in absolute coordinates (G90)

```
N10 G90 S1000 T2 D2 M3 M41
N20 G0 G42 X0 Y0 Z5
N30 G94 G1 Z-5 F150
N40 X120 F250
N50 Y40
N60 G3 X100 Y60 R20
N70 G1 X74.142
N80 G2 X45.858 R-15
N90 G1 X20
N100 G3 X0 Y40 R20
N110 G1 Y0
N120 G1 Z5
N130 G0 G40 X-30 Y-30 Z20 M30
```

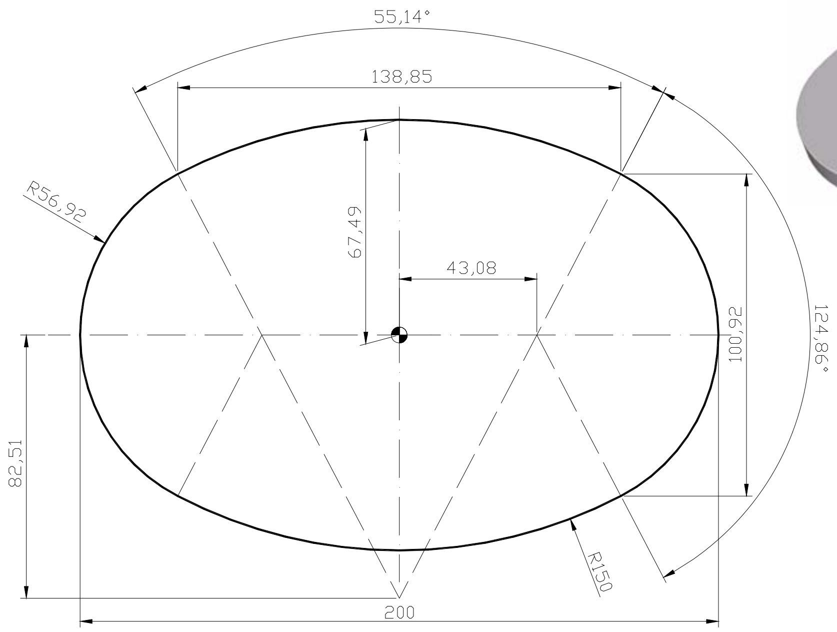
Programming the arc center in incremental coordinates (G91)

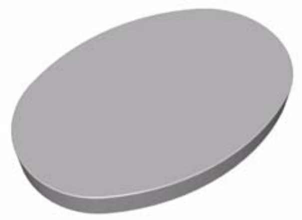
```
N10 G90 S1000 T2 D2 M3 M41
N20 G0 G42 X0 Y0 Z5
N30 G94 G1 Z-5 F150
N40 G91 X120 F250
N50 Y40
N60 G3 X-20 Y20 I-20 J0
N70 G1 X-25.858
N80 G2 X-28.284 I-14.142 J-5
N90 G1 X-25.858
N100 G3 X-20 Y-20 I0 J-20
N110 G1 Y-40
N120 G90 G1 Z5
N130 G0 G40 X-30 Y-30 Z20 M30
```

Programming the arc radius in incremental coordinates (G91)

```
N10 G90 S1000 T2 D2 M3 M41
N20 G0 G42 X0 Y0 Z5
N30 G94 G1 Z-5 F150
N40 G91 X120 F250
N50 Y40
N60 G3 X-20 Y20 R20
N70 G1 X-25.858
N80 G2 X-28.282 R-15
N90 G1 X-25.858
N100 G3 X-20 Y-20 R20
N110 G1 Y-40
N120 G90 G1 Z5
N130 G0 G40 X-30 Y-30 Z20 M30
```

2.4 Circular, Cartesian and Polar interpolations





G2/3 X Y R	G2/3 X Y I J
G0 Z100 T1 D1 S1000 M3 X-69.425 Y-80 G43 Z0 N1 G91 G1 Z-5 F100 G90 G37 R10 G42 X-69.425 Y-50.46 G3 X69.425 Y-50.46 R150 G3 X69.425 Y50.46 R56.92 G3 X-69.425 Y50.46 R150 G3 G38 R10 X-69.425 Y-50.46 R56.92 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z100 M30	G0 Z100 T1 D1 S1000 M3 X-69.425 Y-80 G43 Z0 N1 G91 G1 Z-5 F100 G90 G37 R10 G42 X-69.425 Y-50.46 G3 X69.425 Y-50.46 I69.425 J132.97 G3 X69.425 Y50.46 I-26.345 J50.46 G3 X-69.425 Y50.46 I-69.425 J-132.97 G3 G38 R10 X-69.425 Y-50.46 I26.345 J-50.46 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z100 M30

G6 G2/3 X Y I J	G8 X Y
G0 Z100 T1 D1 S1000 M3 X-69.425 Y-80 G43 Z0 N1 G91 G1 Z-5 F100 G90 G37 R10 G42 X-69.425 Y-50.46 G6 G3 X69.425 Y-50.46 I0 J82.51 G6 G3 X69.425 Y50.46 I43.08 J0 G6 G3 X-69.425 Y50.46 I0 J-82.51 G6 G3 G38 R10 X-69.425 Y-50.46 I-43.08 J0 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z100 M30	G0 G90 Z100 T1 D1 S1000 M3 X-69.425 Y-80 Z0 N1 G91 Z-5 F100 G90 G37 R10 G41 X-69.425 Y-50.46 G2 X-69.425 Y50.46 R56.92 G8 X69.425 Y50.46 G8 X69.425 Y-50.46 G8 G38 R10 X-69.425 Y-50.46 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z50 M30

G8 must be preceded by a block of the profile to be programmed.

G9 X Y I J
G0 G90 Z100 T1 D1 S1000 M3 X-69.425 Y-80 Z0 N1 G91 Z-5 F100 G90 G37 R10 G41 X-69.425 Y-50.46 G9 X-69.425 Y50.46 I-100 J0 G9 X69.425 Y50.46 I0 J67.49 G9 X69.425 Y-50.46 I100 J0 G9 G38 R10 X-69.425 Y-50.46 I0 J-67.49 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z50 M30

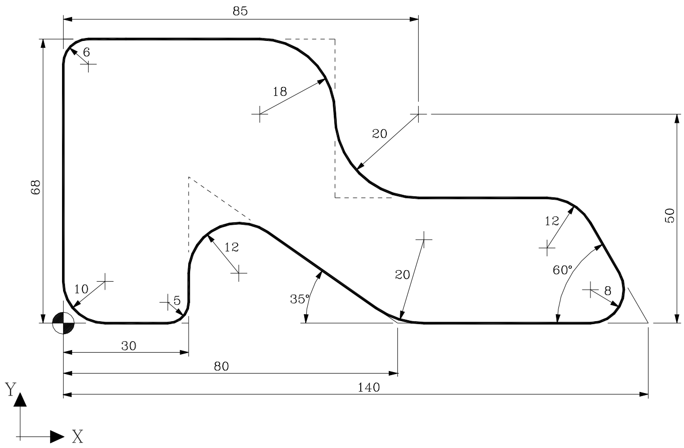
G93 I J --- G2/3 Q
G0 Z100 T1 D1 S1000 M3 X-69.425 Y-80 G43 Z0 N1 G91 G1 Z-5 F100 G90 G37 R10 G42 X-69.425 Y-50.46 G93 I0 J82.51 G3 Q297.57 G93 I43.08 J0 G3 Q62.43 G93 I0 J-82.51 G3 Q117.57 G93 I-43.08 J0 G38 R10 G3 Q242.43 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z100 M30

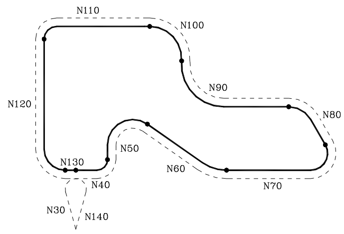
G2/3 Q I J
G0 G90 Z100 T1 D1 S1000 M3 X-69.425 Y-80 G43 Z0 N1 G91 Z-5 F100 G90 G37 R10 G41 X-69.425 Y-50.46 G2 Q117.57 I26.345 J50.46 G2 Q62.43 I69.425 J-132.97 G2 Q-62.43 I-26.345 J-50.46 G2 G38 R10 Q242.43 I-69.425 J132.97 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z100 M30

G6 G2/3 Q I J
G0 G90 Z100 T1 D1 S1000 M3 X-69.425 Y-80 G43 Z0 N1 G91 Z-5 F100 G90 G37 R10 G41 X-69.425 Y-50.46 G6 G2 Q117.57 I-43.08 J0 G6 G2 Q62.43 I0 J-82.51 G6 G2 Q-62.43 I43.08 J0 G6 G38 R10 Q242.43 I0 J82.51 N2 G1 G40 X-69.425 Y-80 (RPT N1,N2)N5 G0 Z50 M30

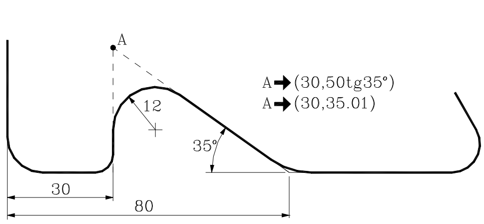
2.5 Tangential entry / exit (G37/G38) and corner rounding (G36)

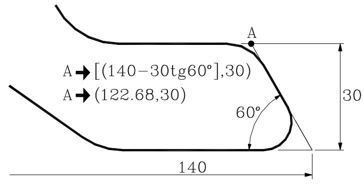
Programming a rounding or a chamfer requires programming the intersection point of the lines or arcs to be rounded or chamfered; i.e. as if there were no rounding or chamfer. Then, enter the desired function in that point (coordinate).





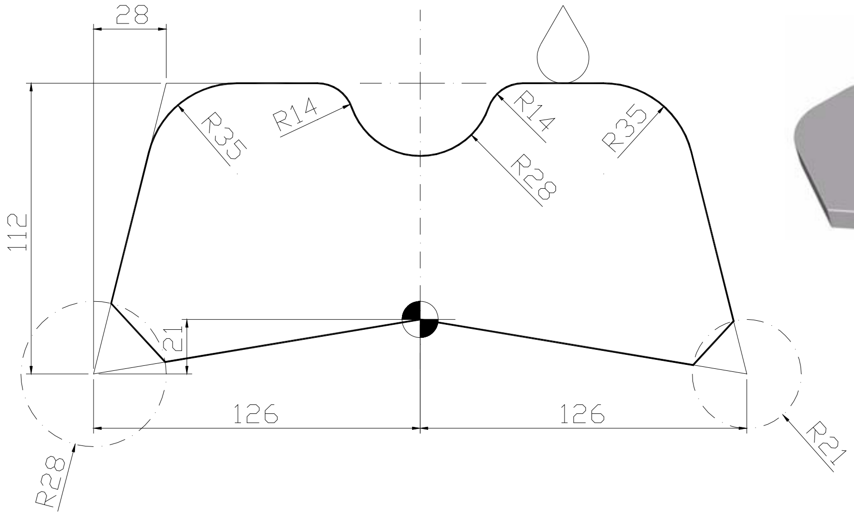
Calculating the points needed to program the part:

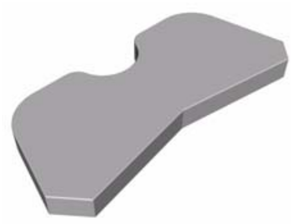




Tangential entry / exit and corner rounding
N10 G0 X15 Y-50 Z5 S1000 T2 D2 M3 M41 N20 G1 Z-5 F150 N30 G42 G37 R10 Y0 F250 N40 G36 R5 X30 N50 G36 R12 Y35.01 N60 G36 R20 X80 Y0 N70 G36 R8 X140 N80 G36 R12 X122.68 Y30 N90 G36 R20 X65 N100 G36 R18 Y68 N110 G36 R6 X0 N120 G36 R10 Y0 N130 G38 R10 X15 N140 G40 Y-50 N150 G0 X-50 Y-50 Z30 M30

2.6 Corner rounding and chamfers



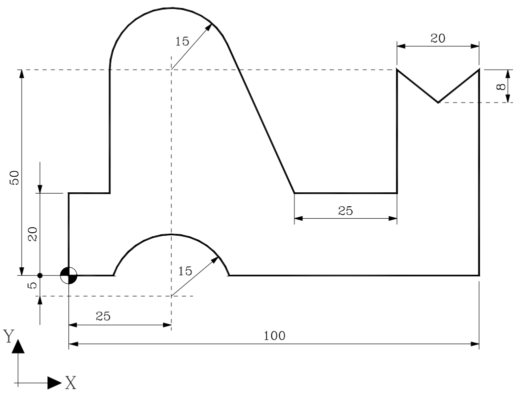


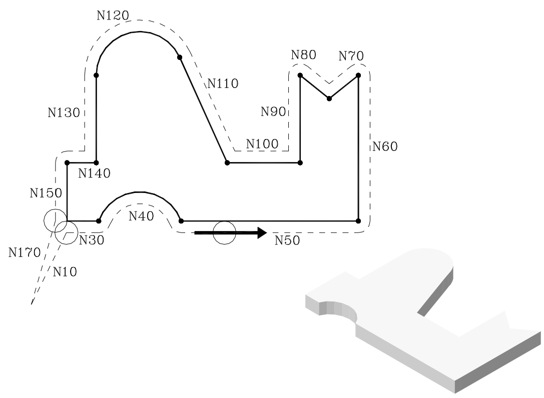
Corner rounding and chamfers

```
G0 Z100
T10 D10
S1500 M3
X52.5 Y121
G43 Z0
N1 G1 G91 Z-5 F300
G90 G37 R10 G41 X52.5 Y91
G36 R35 X98 Y91
G39 R21 X126 Y-21
X0 Y0
G39 R28 X-126 Y-21
G36 R35 X-98 Y91
G36 R14 X-28 Y91
G3 G36 R14 X28 Y91 R28
G1 G38 R10 X52.5 Y91
N2 G40 X52.5 Y121
(RPT N1,N2)N2
G0 Z100
M30
```

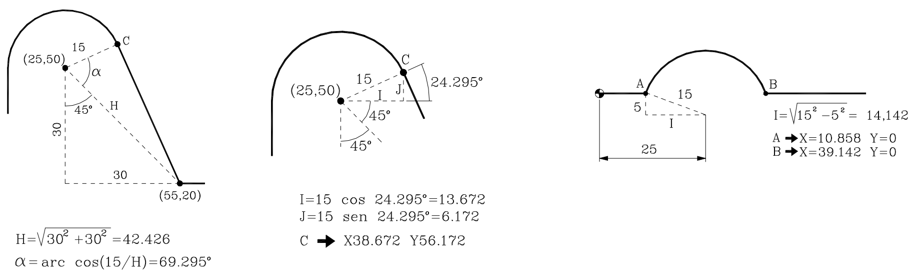
2.7 Profile definition with tool radius compensation (G40/G41/G42)

This example is carried out with right-hand tool compensation (G42):





Calculating the points needed to program the part:



Profile definition with radius compensation

```
N5 T2 D2
N10 G0 G90 G42 X0 Y0 Z5 S1000 M3 M41
N20 G94 G1 Z-5 F150
N30 X10.858 F200                          ; Beginning of the profile.
N40 G2 X39.142 I14.142 J-5
N50 G1 X100
N60 Y50
N70 X90 Y42
N80 X80 Y50
N90 Y20
N100 X55
N110 X38.672 Y56.172
N120 G3 X10 Y50 I-13.672 J-6.172
N130 G1 X10 Y20
N140 X0
N150 Y0                                   ; End of the profile.
N160 G1 Z5
N170 G0 G40 X-30 Y-30 Z20 M30
```

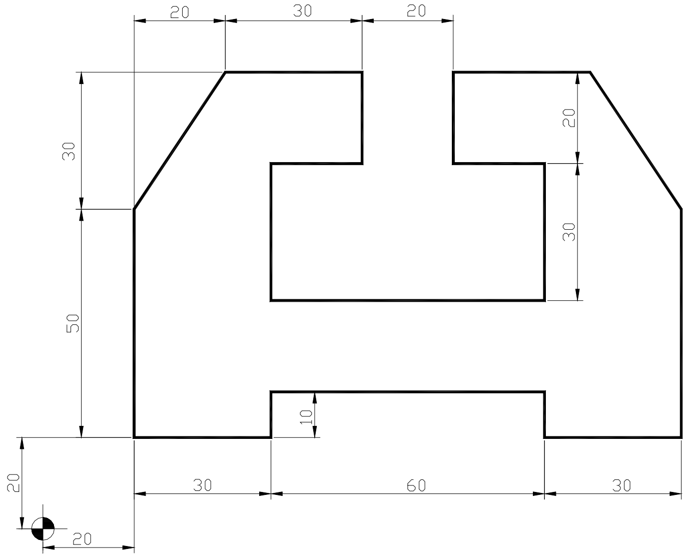
2.8 Collision detection

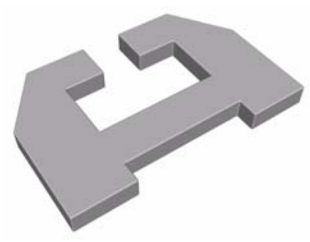
Using the collision detection option, the CNC analyzes in advance the blocks to be executed in order to detect loops or collisions of the programmed profile.

The number of blocks to be analyzed (up to 50) may be defined by the user.

When detecting a loop or a collision, the blocks that caused it will not be executed and a warning will be issued for each loop or collision eliminated.

Possible cases:	Step on a straight path, a step in a circular path and tool radius compensation too large.
Possible values:	From N3 to N50.





Collision detection

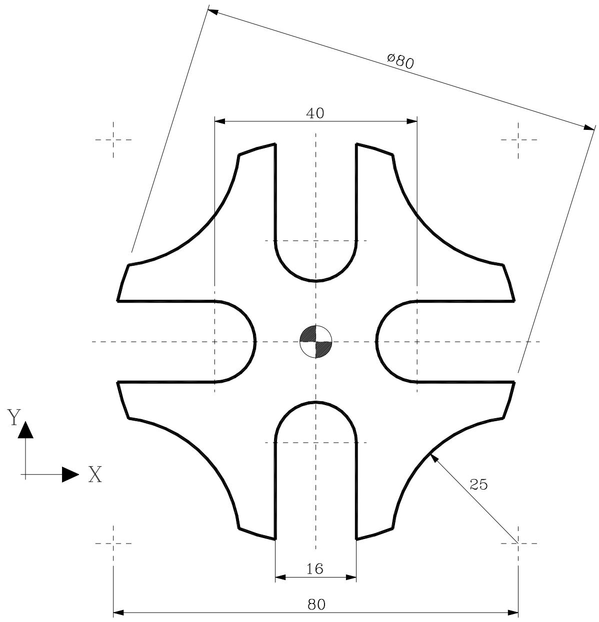
```
T22 D22
M6
G43 G0 Z30
X0 Y0 S2200 M3
N1 G91 G1 Z-5 F150
G90 G42 N20 X20 Y20 F400
X50
Y30
X110
Y20
X140
Y70
X120 Y100
X90
Y80
X110
Y50
X50
Y80
X70
Y100
X40
X20 Y70
X20 Y20
N2 G1 G40 X0 Y0
(RPT N1,N2)N3
G0 Z50
M30
```

2.9 Mirror image (G10/G11/G12/G13)

The mirror image cycle is usually generated to repeat the whole program in different areas of the part with respect to the symmetry axes.

- G10: Mirror image cycle cancellation.
- G11: Mirror on X axis.
- G12: Mirror on Y axis.

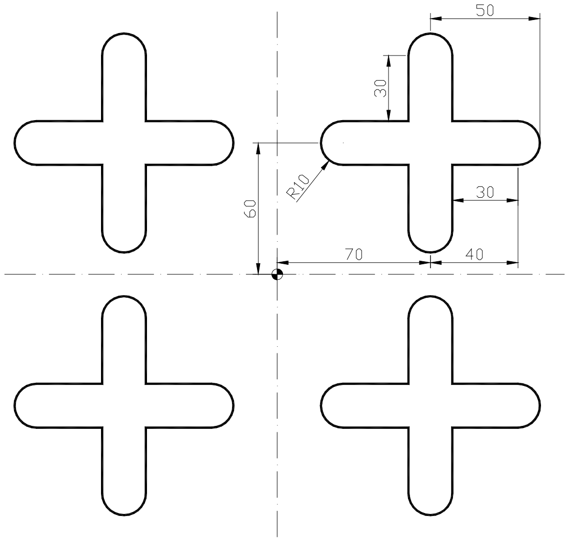
When working with "Mirror image" or "Coordinate rotation", the movement after these functions must be programmed in absolute coordinates (G90); also, if the movement is an arc, the center must be programmed in absolute coordinates (G06).

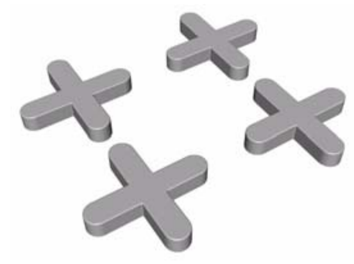


Mirror image

```
N10 G0 X50 Y0 Z10 S1000 T2 D2 M3
N20 G42 X39.192 Y8
N30 G1 Z-5 F200
N40 G90 G3 G6 X37.008 Y15.18 I0 J0 F250        ; Beginning of the profile.
N50 G2 G6 X15.18 Y37.008 I40 J40
N60 G3 G6 X8 Y39.192 I0 J0
N70 G1 Y20
N80 G2 X-8 I-8 J0
N90 G1 Y39.192
N100 G3 G6 X-15.18 Y37.008 I0 J0
N110 G2 G6 X-37.008 Y15.18 I-40 J40
N120 G3 G6 X-39.192 Y8 I0 J0
N130 G1 X-20
N140 G2 Y-8 I0 J-8
N150 G1 X-39.192                               ; End of the profile.
N200 G11 G12
N210 (RPT N40, N150)
N220 G10
N230 G1 Z10
N240 G0 G40 X50 Y0 Z30
N250 M30
```

2.10 Mirror image





Mirror image

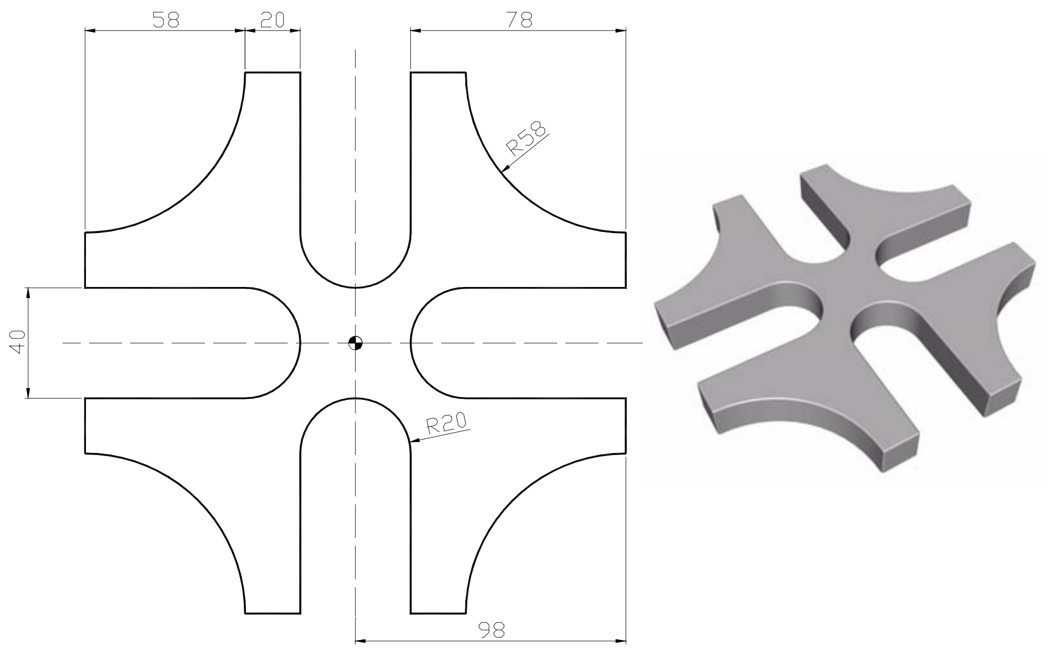
```
T10 D10
M6
G43 G0 Z100
X0 Y0 S1000 M3
N3 X30 Y30
Z0
N1 G1 G91 Z-5 F500 S1000
G90 G37 R10 G41 X60 Y30
G1 Y50
X30
G2 X30 Y70 R10
G1 X60
Y100
G2 X80 Y100 R10
G1 Y70
X110
G2 X110 Y50 R10
G1 X80
Y20
G2 X60 Y20 R10
G1 G38 R10 X60 Y30
N2 G1 G40 X30 Y30
(RPT N1,N2)N4
G0 Z100
N4 X0 Y0
G11
(RPT N3,N4)
G12
(RPT N3,N4)
G10 G12
(RPT N3,N4)
G10
M30
```

2.11 Coordinate rotation 1

The program for this part uses coordinate (pattern) rotation taking advantage of the fact that the part is symmetrical in all its quadrants. We program only a forth of the contour and then rotate the coordinate axes 90º taking the center point (part zero) as the rotation point. Since this function acts after it is defined, after programming the rotation, we repeat the programmed quadrant using the RPT instruction as often as the number of quadrants remaining. The rotation function is cancelled with another G73 but without a rotating angle.

The great advantage of coordinate (pattern) rotation vs the mirror cycle is that the rotation makes the whole part without interruption and the mirror is applied to a complete program.

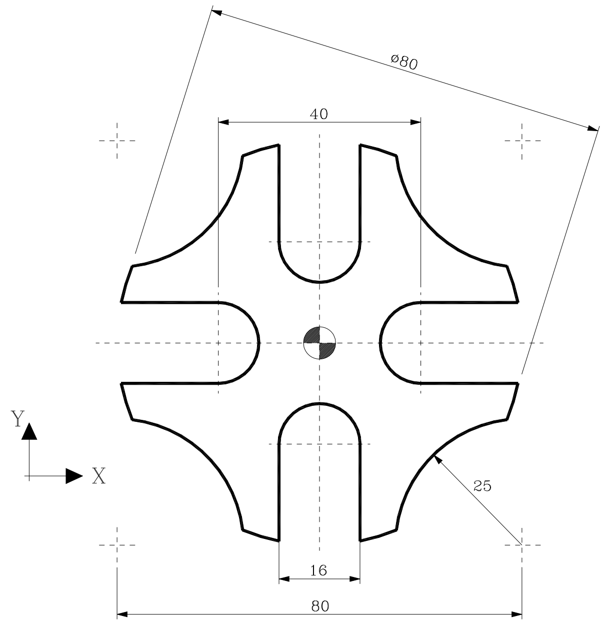
To know which rotation angle must be programmed for each part, divide by the number of quadrants of the part.



Coordinate rotation

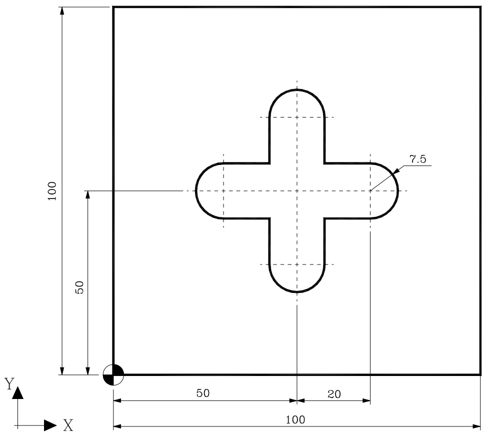
```
T10 D10
M6
G43 G0 Z100
X125 Y0 S1500 M3
Z0
N3 G1 G91 Z-5 F500 S1000
G1 G90 G42 X98 Y20 F1000
N1 X98 Y40
G2 X40 Y98 R58
G1 X20 Y98
X20 Y40
G2 X-20 Y40 R20
G1 Y98
N2 G73 Q90                                  ; Rotation ON.
(RPT N1,N2)N3
G73                                         ; Rotation OFF.
N4 G1 G40 X125 Y0
(RPT N3,N4)N5
G0 Z100
M30
```

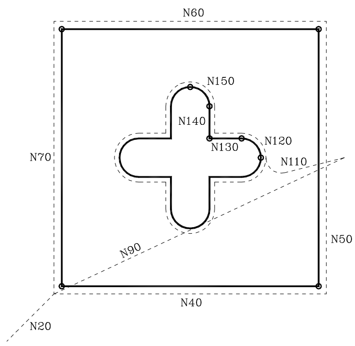
2.12 Coordinate rotation 2



Coordinate rotation
N10 G0 X50 Y0 Z10 S1000 T2 D2 M3 N20 G42 X39.192 Y8 N30 G1 Z-5 F200 N40 G90 G3 G6 X37.008 Y15.18 I0 J0 F250 N50 G2 G6 X15.18 Y37.008 I40 J40 N60 G3 G6 X8 Y39.192 I0 J0 N70 G1 Y20 N80 G2 X-8 I-8 J0 N90 G1 Y39.192 N200 G73 Q90 N210 (RPT N40, N200) N3 N220 G73 N230 G1 Z10 N240 G0 G40 X50 Y0 Z30 N250 M30

2.13 Coordinate (pattern) rotation (rotation center other than part zero)



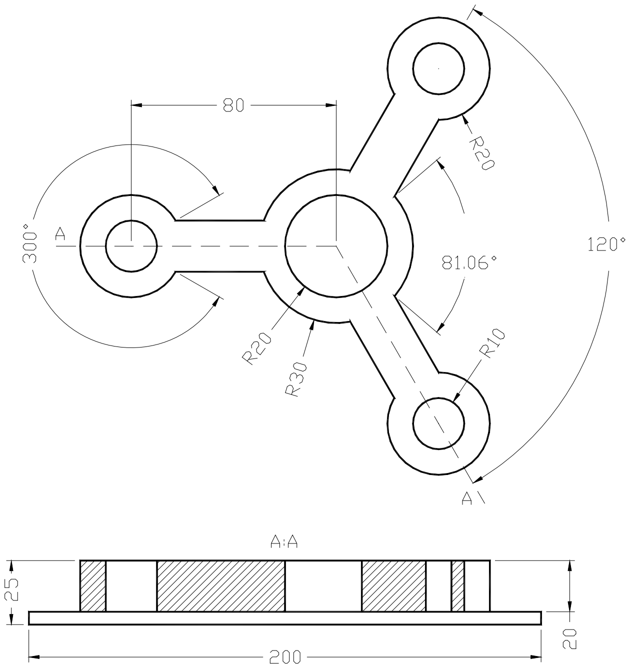


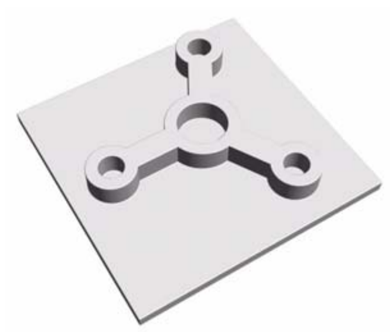
The inside is machined with tool T2 whose diameter is 10 mm. It is machined in 2 passes, the first one with a tool radius offset (D21) of 5.5 mm leaving a residual stock and the second pass with a tool radius offset (D20) of 5 mm.

Coordinate rotation	
N10 G0 G90 X-30 Y-30 Z10 S1000 T2 D21 M3 M41	
N20 G42 X0 Y0	
N30 G1 Z-5 F200	
N40 X100 F250	
N50 Y100	
N60 X0	; Beginning of the outside profile.
N70 Y0	
N80 G40 G0 Z10	
N90 X110 Y50 T2 D21	
N100 G1 Z0 F200	; End of the outside profile.
N110 G42 G5 G37 R6 X77.5 F250	
N120 G91 G3 X-7.5 Y7.5 I-7.5 J0	
N130 G1 X-12.5	; First pass of the inside profile.
N140 Y12.5	
N150 G3 X-7.5 Y7.5 I-7.5 J0	
N160 G73 Q90 I50 J50	; Coordinate (pattern) rotation (G73), where the rotation center point is (50, 50).
N170 G1 G90 X77.5 Y50	; Positioning necessary due to the next block (RPT) because the first block of the basic section (N120) is an arc that does not use function G6 and the end point (X, Y) is programmed in incremental coordinates (G91).
N180 (RPT N120, N170) N3	
N190 G73	
N200 G90 G40 G1 X110	; End of the first pass of the inside profile.
N210 D20	
N220 (RPT N110, N200)	; Second pass of the inside profile.
N230 G90 G0 Z10	
N240 X-30 Y-30	
M30	

2.14 Coordinate rotation in Polar coordinates

The following program has been carried out totally in Polar coordinates. We programmed a third of the part and applied coordinate (pattern) rotation. What's special in this kind of programming is that since there is a tangential entry, the rotation must be repeated with two RPT instructions in order to program the exit in a separate block.





Coordinate rotation in Polar coordinates

```
T10 D10
M6
G43 G0 Z100
X0 Y0 S1000 M3
R60 Q120
Z0
N4 G1 G91 Z-5 F100
G90 G37 R10 G42 R30 Q120 F1000
N1 G3 Q160.53
G93 I-80 J0
G1 R20 Q30
G3 Q-30
G93 I0 J0
N3 G1 R30 Q-160.53
G3 Q-120
N2 G73 Q120
(RPT N1,N2)
(RPT N1,N3)
G73
G38 R10 G3 Q120
N5 G1 G40 R60 Q120
(RPT N4,N5)N5
G0 Z100
```

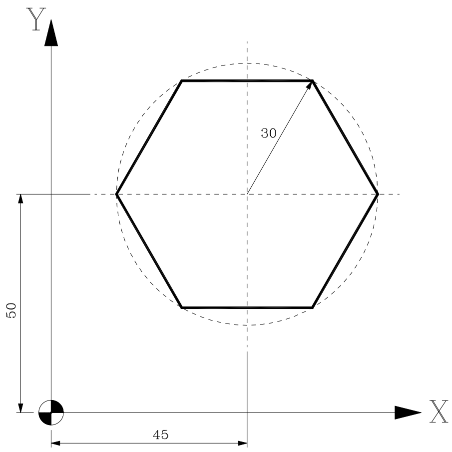
Cajeras circulares:

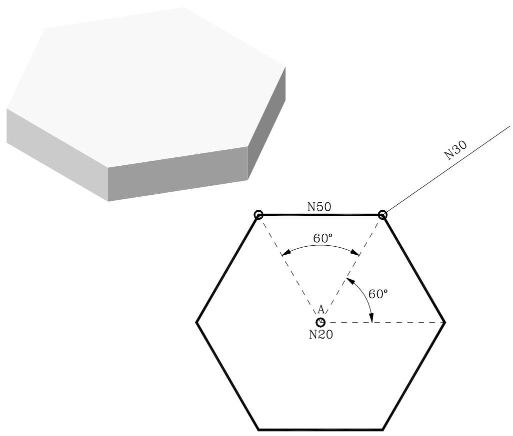
```
G93 I0 J0
G88 G99 R0 Q0 Z2 I-30 J-20 B-5 D2 H500 L0.5 V100 F1000
G79 J-10
R80 Q180
G91 Q120 N2
G90 G0 G80 Z100
M30
```

POLAR COORDINATES

3

3.1 Polar origin selection (G93)





Polar origin selection

```
N10 G0 G90 X100 Y100 Z10 S1000 T2 D2 M3 M41
N20 G93 I45 J50              ; Selecting point A as Polar origin.
N30 G42 R30 Q60
N40 G1 Z-5 F200
N50 G91 Q60                  ; Basic machining (one side).
N60 (RPT N50, N50) N5        ; Machining the rest of the sides.
N70 G0 G90 G40 Z10
N80 X100 Y100
N90 M30
```

One of the following options may be used to change the program and cancel the Polar origin:

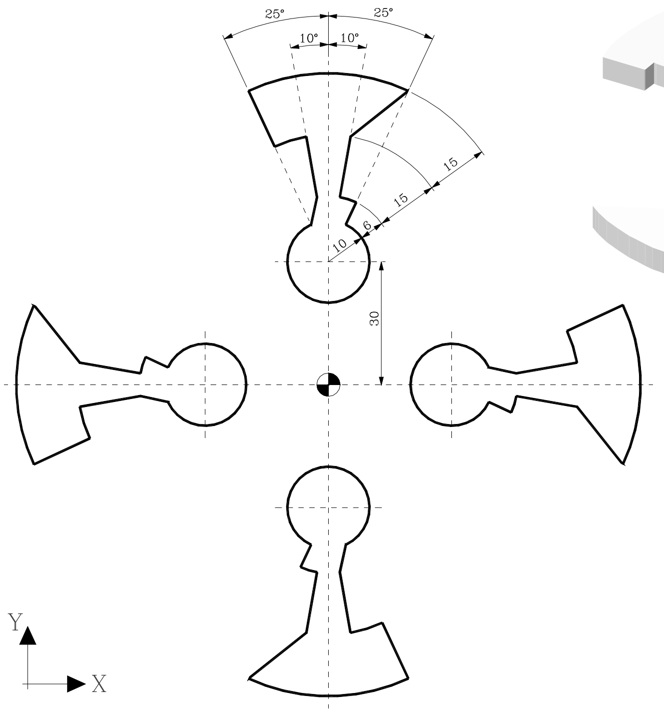
First option:

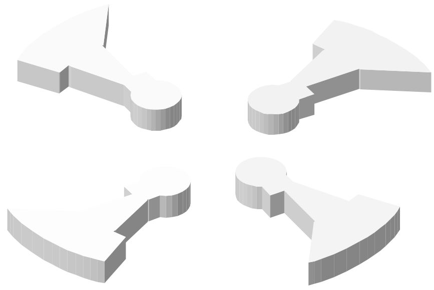
```
N80 X0 Y0             ; Positioning at the point that will be the new Polar origin.
N90 G93               ; Presetting the current point as the new Polar origin.
N100 X100 Y100
N110 M30              ; End of program.
```

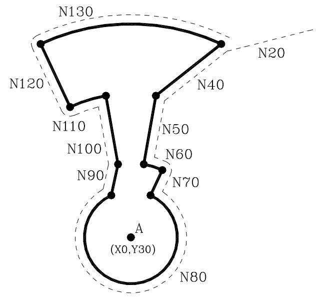
Second option:

```
N90 G93 I0 J0         ; Presetting the point X0 Y0 as the new Polar origin.
N100 X100 Y100
N110 M30              ; End of program.
```

3.2 Programming in Polar coordinates 1



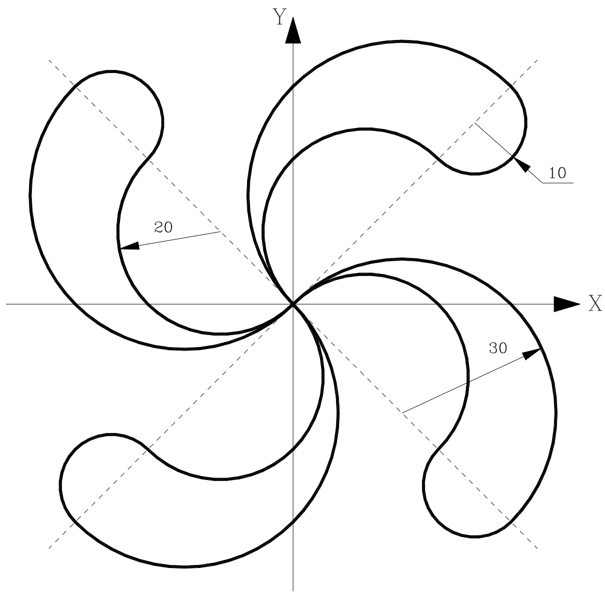


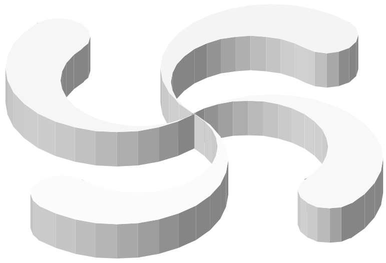


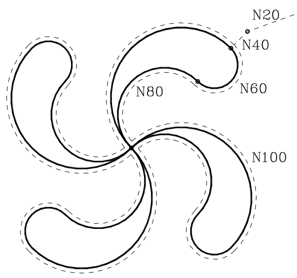
Programming in Polar coordinates

```
N10 G93 I0 J30                    ; Selects point A as Polar origin.
N20 G0 G90 G41 R46 Q65 Z10 S1000 T2 D2 M3 M41
                                  ; Beginning of a profile.
N30 G1 Z-5 F200
N40 G91 R-15 Q15
N50 R-15
N60 G2 Q-15
N70 G1 R-6
N80 G2 Q50
N90 G1 R6 Q-15
N100 R15
N110 Q15
N120 G1 R15
N130 G2 Q-50                      ; End of a profile.
N140 G40 G90 G1 Z10
N150 G73 Q-90 I0 J0               ; Coordinate (pattern) rotation.
N160 (RPT N10, N150) N3           ; Executes the other 3 profiles.
N170 G73                          ; Cancels coordinate (pattern) rotation.
N180 G90 X0 Y-30 M30
```

3.3 Programming in Polar coordinates 2



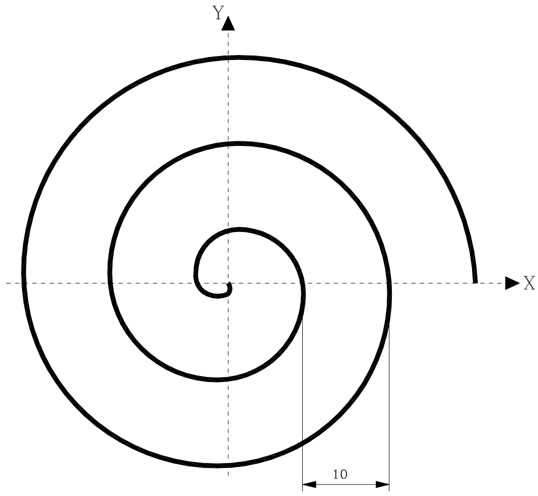




Programming in Polar coordinates

```
N10 G93 I0 J0                      ; Selects point X0 Y0 as Polar origin.
N20 G0 G90 R70 Q45 Z10 S1000 T2 D2 M3 M41
N30 G1 Z-5 F200
N40 G90 G1 G41 R60 Q45             ; Beginning of the profile.
N50 G93 I35.35534 J35.35534
N60 G2 G91 Q180
N70 G93 I14.14214 J14.14214
N80 G3 Q180
N90 G93 I21.2132 J-21.2132
N100 G2 Q180                       ; End of the profile.
N110 G93 I0 J0                     ; Cancels Polar origin.
N120 G73 Q-90                      ; Coordinate (pattern) rotation.
N130 (RPT N40, N120) N3            ; Executes the other 3 profiles.
N140 G73                           ; Cancels coordinate (pattern) rotation.
N150 G90 G40 G1 R70
N160 G0 Z10
N170 R80 Z50
M30
```

3.4 Archimedes Spiral



The spiral increases 10 mm every 360°.

- The first option assumes 0.36° increments, thus each angular increment corresponds to a radial increment of 0.01 mm.

  The number of passes needed to make the spiral is: 30 mm / 0.01 mm = 3000 increments.

- The second option assumes 0.036° increments, thus each angular increment corresponds to a radial increment of 0.001 mm.

  The number of passes needed to make the spiral is: 30 mm / 0.001 mm = 30000 increments.

  Since the CNC allows repeating the execution of a block a maximum of 9999 times, the spiral will be made in 3 blocks.

  The basic (first increment).

  Repeat the basic 9999 times (accumulated total of 10000).

  Repeat all this twice, thus completing the 30000 times.

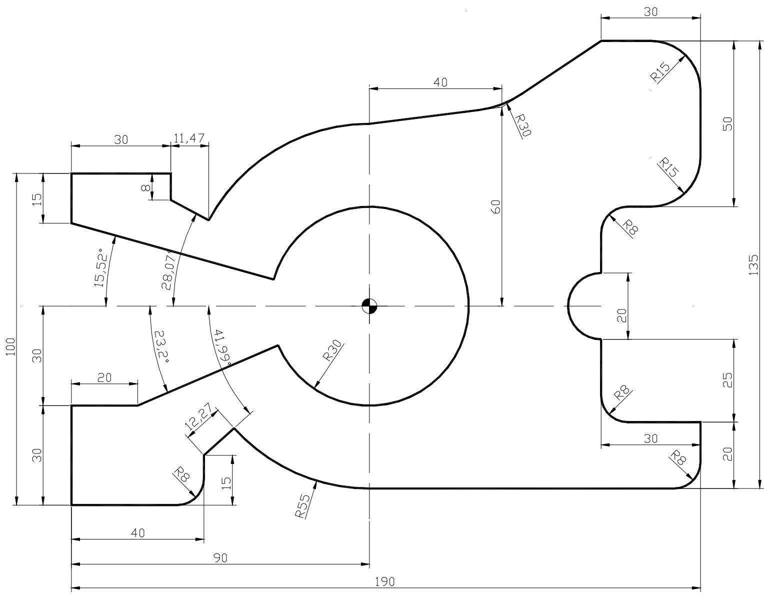
First option:

```
N10 G0 G90 X0 Y0 Z10 S1000 T5 D5 M3
N20 G1 G5 Z-5 F200
N30 G91 R0.01 Q-0.36 F100            ; First increment.
N40 (RPT N30, N30) N2999             ; Rest of the increments.
N50 G0 G90 G7 Z10 M30
```

Second option:

```
N10 G0 G90 X0 Y0 Z10 S1000 T5 D5 M3
N20 G1 G5 Z-5 F200
N30 G91 R0.001 Q-0.036 F100        ; First increment.
N40 (RPT N30, N30) N9999
N50 (RPT N30, N40) N2              ; Repeats the basic 9999 times (accumulated
                                   total of 10000 times).
N60 G0 G90 G7 Z10                  ; Repeats the previous two blocks twice, thus
                                   completing the 30000 times.
M30
```

3.5 Spacer

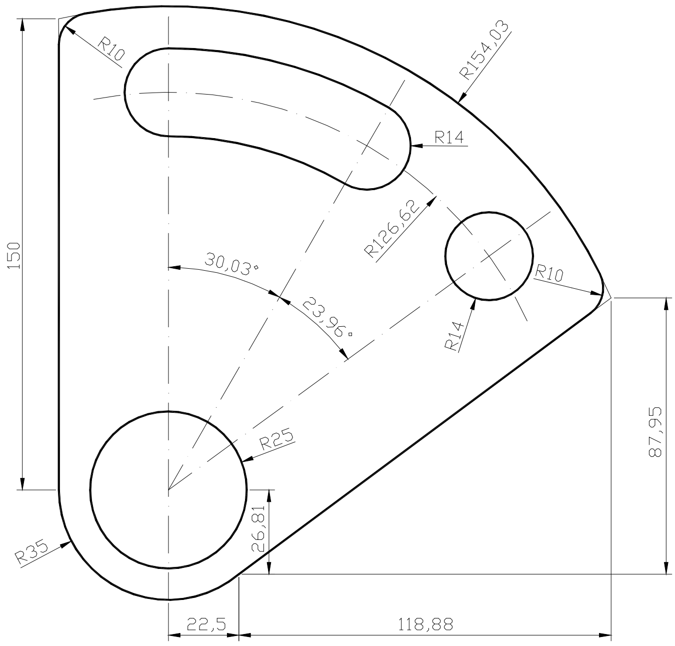


```
T8 D8
M6
G43 G0 Z100
X-30 Y-30 S1500 M3
Z0
N1 G1 G91 Z-3 F500 S1000
G90 G37 R10 G42 X0 Y0
G36 R8 X40 Y0
G1 X40 Y15
G93 I40 J15
G1 R12.268 Q48.013
G93 I90 J60
G3 Q270
G1 G36 R8 X190 Y5
X190 Y25
G36 R8 X160 Y25
X160 Y50
G2 X160 Y70 R10
G1 G36 R8 X160 Y90
G36 R15 X190 Y90
G36 R15 X190 Y140
X160 Y140
G36 R30 X130 Y120
X90 Y115
G93 I90 J60
G3 Q151.928
G1 Q-28.072 X30
X30 Y100
X0 Y100
X0 Y85
G93 I90 J60
G1 R30 Q164.476
G2 Q203.199
G1 X20 Y30
X0 Y30
G38 R10 X0 Y0
N2 G40 X-30 Y-30
(RPT N1,N2)N2
M30
```

3.6 Sliding support with helical down motion

The next example uses the two programming functions for Polar coordinates:

G93 I J	The Polar center coordinates are entered in parameters I J.
G93	When this block is read, it captures the position of the machine and the captured point will become the Polar center.



Sliding support with helical down motion	
T10 D10 M6 G0 G43 Z100 X0 Y0 S1000 M3 X-70 Y0 Z0 N1 G1 G91 Z-5 F100 G90 G37 R10 G42 X-35 Y0 F1000 G3 X22.5 Y-26.91 R35 G1 G36 R10 X141.48 Y61.04 G3 G36 R10 X-35 Y150 R154.03 G1 G38 R10 X-35 Y0 N2 G40 X-70 Y0 (RPT N1,N2)N4 G0 Z100 X0 Y0 Z0 G1 G42 X25 Y0 G2 X25 Y0 I-25 J0 Z-30 K5 G1 G40 R0 Q0 G0 Z100 G93 I0 J0 R126.62 Q36 G93	Z0 G1 G42 R14 Q0 G2 Q0 I-14 J0 Z-30 K5 G1 G40 R0 Q0 G0 Z100 G93 I0 J0 R126.62 Q60 Z0 G93 N3 G1 G91 Z-5 F100 G90 G42 R14.03 Q60 F1000 G91 G2 Q-180 G93 I0 J0 G3 Q30 G93 I0 J126.62 G2 Q-180 G93 I0 J0 G2 Q-30 G90 G1 G40 R126.62 Q60 N4 G93 (RPT N3,N4)N4 G0 Z100 M30

CANNED CYCLES

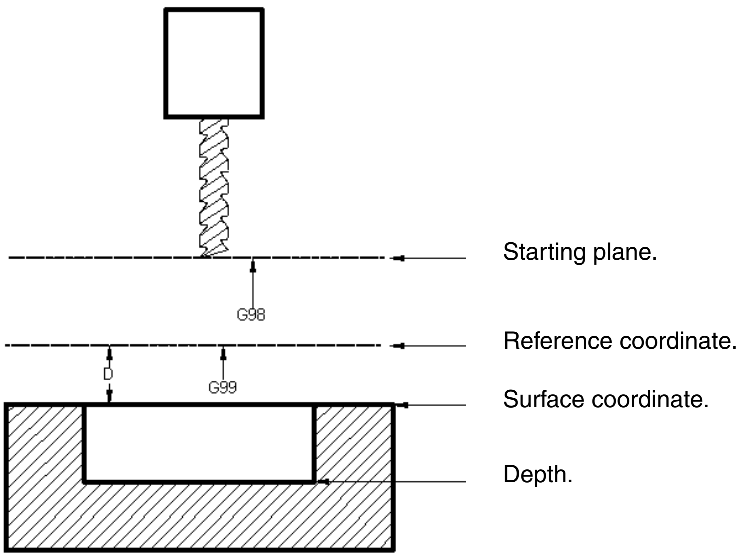
4

G69	Deep hole drilling canned cycle with variable peck.
G81	Drilling canned cycle.
G82	Drilling cycle with dwell.
G83	Deep-hole drilling canned cycle with constant peck.
G84	Tapping canned cycle.
G85	Reaming canned cycle.
G86	Boring cycle with rapid withdrawal in G00.
G87	Rectangular pocket canned cycle.
G88	Circular pocket canned cycle.
G89	Boring cycle with withdrawal at work feedrate G01.

All the cycles must be canceled with function G80. Otherwise, the cycle will be repeated in any coordinate where it is programmed. The programming sequence of any canned cycle is the following:

```
G0 Z100          ; Safety Z (stating plane).
G8x G98/99       ; Definition of the chosen cycle. Press HELP.
G0 G80 Z100      ; Cancel the cycle and withdraw the tool.
```

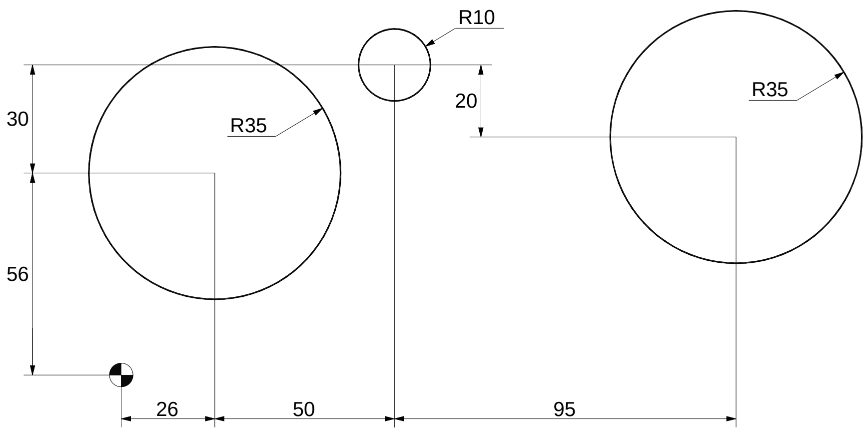
Planes to consider:



4.1 G79. Modifier of canned cycle parameters

This function is used when programming two or more cycles of the same kind, but with different machining characteristics (depth, pass, feedrate etc.). This eliminates the need to program the whole cycle again when only a few parameters are different.

EXAMPLE:



This example contains three cycles of the same kind (circular pocket G88), but they are different pockets:

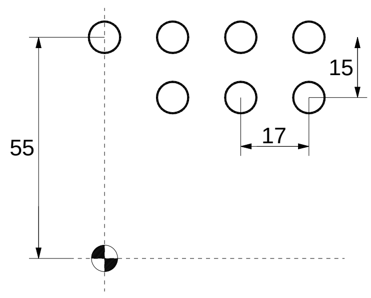
Pocket A 15 mm deep.
Pocket B 22 mm deep.
Pocket C 31 mm deep.

Modifier of canned cycle parameters	
T1 D1	
S1000 M3	
G0 Z100	; Prior positioning.
G88 G99 X26 Y56 Z2 I-15 J35 B5 D2 H500 L0.5 V100	; Pocket A.
G79 I-22 J10	; Modifier for pocket B.
X76 Y86	; Pocket B.
G79 I-31 J35	; Modifier for pocket C.
X171 Y66	; Pocket C.
G0 G80 Z100	; Cancel and withdraw.
M30	

4.2 Canned cycle repetition

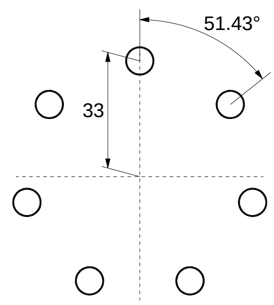
Linear repetition

```
G0 Z100
T1 D1
S1000 M3
G81 G99 X0 Y55 Z2 I-10 F150
G91 X17 N3
Y-15
X-17 N2
G90 G0 G80 Z100
M30
```

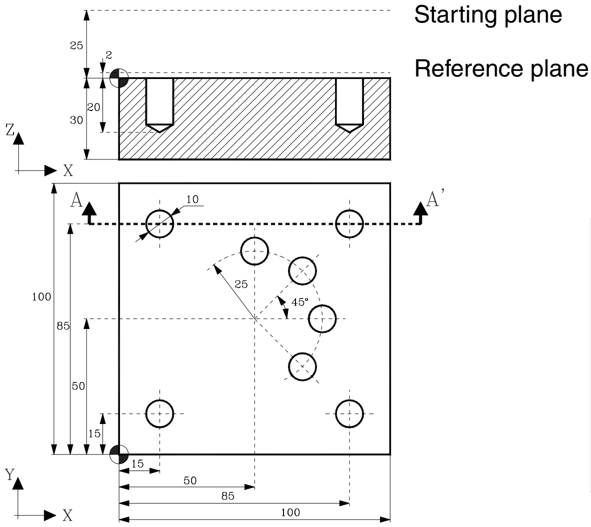


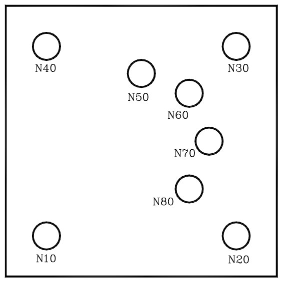
Polar repetition

```
G0 Z100
T1 D1
S1000 M3
G93 I0 J0
G81 G99 X0 Y33 Z2 I-10 F150
G91 Q51.43 N6
G90 G0 G80 Z100
M30
```



4.3 G81. Drilling canned cycle





Definition of the drilling points in:
Absolute Cartesian coordinates.
Incremental Polar coordinates with repetition.

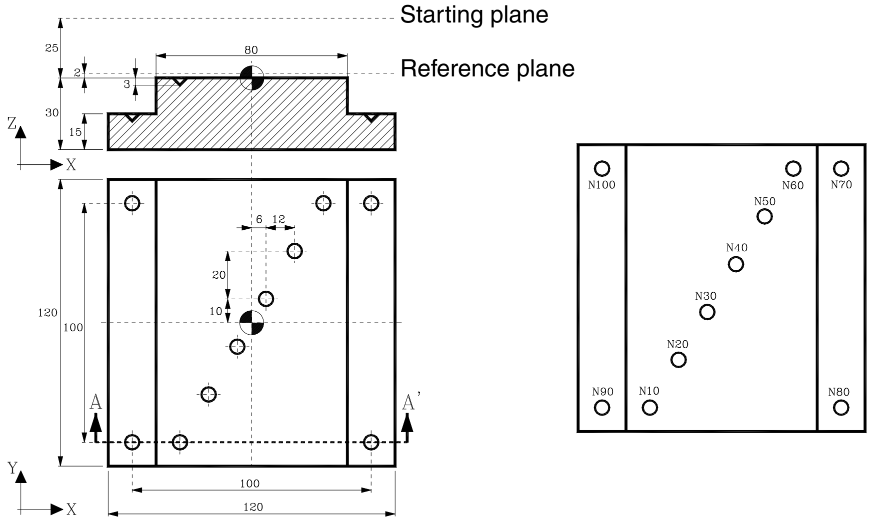
Tool:
Ø10 mm helical drill bit.

Cutting conditions:
S=1000 rpm.
F=200 mm/min.

Drilling canned cycle

```
T10 D10
G0 G90 G43 Z25 S1000 M3 M8 M41
N10 G81 G98 X15 Y15 Z2 I-20 F200
N20 X85
N30 Y85
N40 X15
N50 X50 Y75
G93 I50 J50
N60 G91 Q-45 N3
G80
G0 G90 G44 Z30
M30
```

4.4 G82. Center punching using the drilling canned cycle with dwell



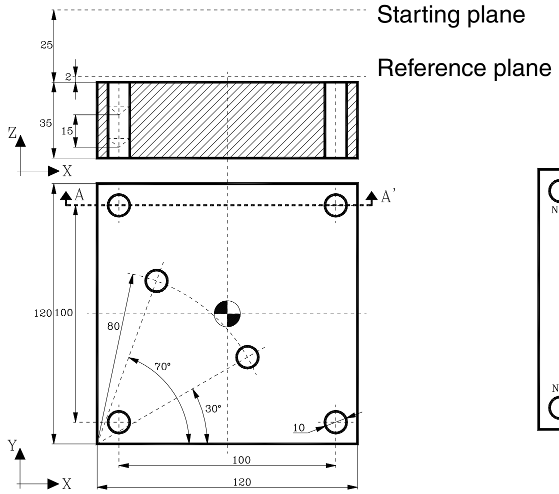
Definition of center punching in:
- Absolute Cartesian coordinates.
- Incremental Cartesian coordinates with repetition.

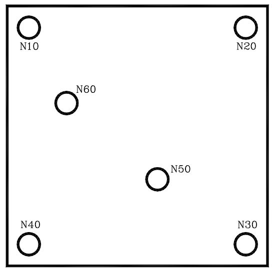
Tool:
- 45º center punching drill bit.

Cutting conditions:
- S=1800 rpm.
- F=200 mm/min.

Center punching with dwell
T6 D6 G0 G90 G43 Z25 S1800 M3 M8 M41 N10 G82 G99 X-30 Y-50 Z2 I-3 K150 F200 N20 G91 X12 Y20 N5 N70 G90 G82 G99 X50 Y50 Z-13 I-18 K150 N80 G98 Y-50 N90 G99 X-50 N100 G98 Y50 G80 G0 G90 G44 Z30 M30

4.5 G83. Deep-hole drilling canned cycle with constant peck





Definition of the drilling points:

Absolute Cartesian coordinates.
Absolute Polar coordinates.
Polar origin change.

Tool:

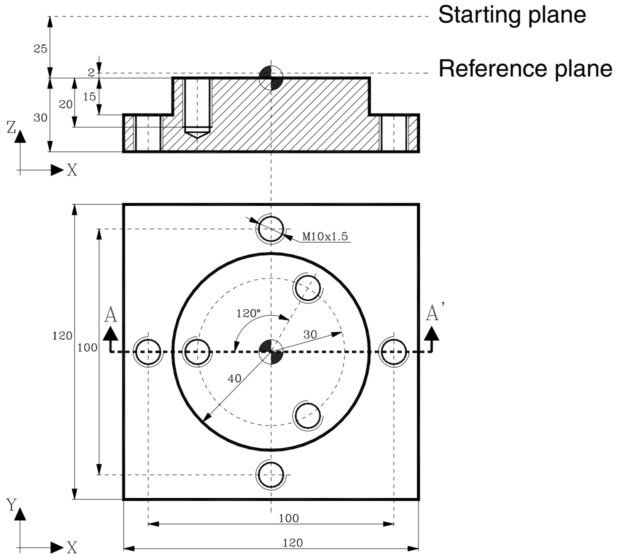
Ø10 mm helical drill bit

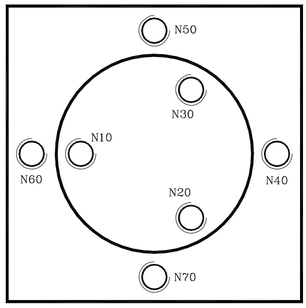
Cutting conditions:

S=1000 rpm.
F=200 mm/min.

Deep hole drilling with constant peck
T10 D10 G0 G90 G43 Z25 S1000 M3 M41 N10 G83 G99 X-50 Y50 Z2 I-15 J3 F200 N20 X50 N30 Y-50 N40 X-50 G93 I-60 J-60 N50 R80 Q30 N60 Q70 G80 G0 G90 G44 Z30 M30

4.6 G84. Tapping canned cycle





We begin with a pre-drilled part.

Definition of the tapping points:
- Absolute Cartesian coordinates.
- Incremental Polar coordinates with repetition.

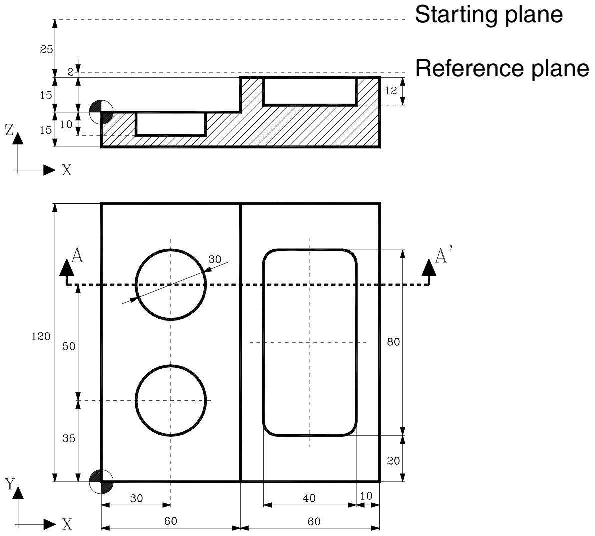
Tool:
- M-10x1.5 tap.

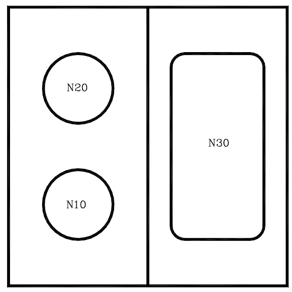
Cutting conditions:
- S=300 rpm.
- Feedrate: S x pitch = 300x1.5 = 450 mm/min.

Tapping canned cycle

```
T12 D12
G0 G90 G43 Z25 S300 M3 M8 M41
G93 I0 J0
N10 G84 G99 R30 Q180 Z10 I-20 K150 F450
N20 G91 Q120 N2
N40 G90 G98 G84 X50 Y0 Z-5 I-35 K150
N50 X0 Y50
N60 X-50 Y0
N70 X0 Y-50
G80
G0 G90 G44 Z30
M30
```

4.7 Rectangular pocket (G87) and circular pocket (G88) canned cycles





Definition of a rectangular pocket and a circular pocket.

Tool:

End mill with 2 teeth and Ø10 mm.

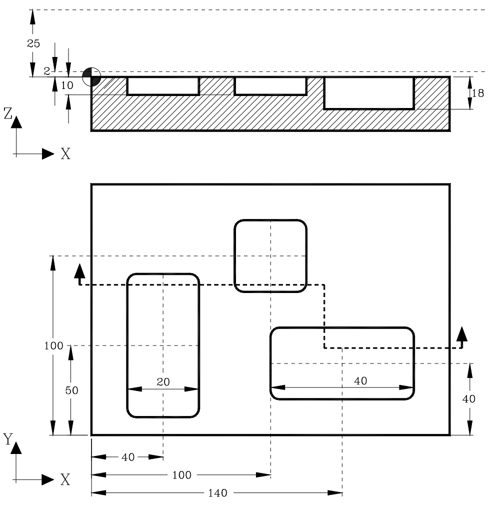
Cutting conditions:

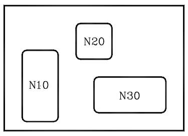
S=1600 rpm.
Roughing feedrate: 300 mm/min.
Finishing feedrate: 200 mm/min.

Rectangular and circular pocket canned cycles

```
T2 D2
G0 G90 G43 Z25 S1600 M3 M42
N10 G88 G99 X30 Y35 Z2 I-10 J-15 B5 C6 D2 H200 L1 F300
N20 G98 Y85
N30 G87 G98 X90 Y60 Z17 I3 J-20 K40 B4 C6 D2 H200 L1
G80
G0 G90 G44 Z30
M30
```

4.8 G79. Modification of the canned cycle parameters





Rectangular pocket milling cycle definition.

Modifying the dimensions and depth of the pockets.

Tool:

End mill with 2 teeth and Ø10 mm.

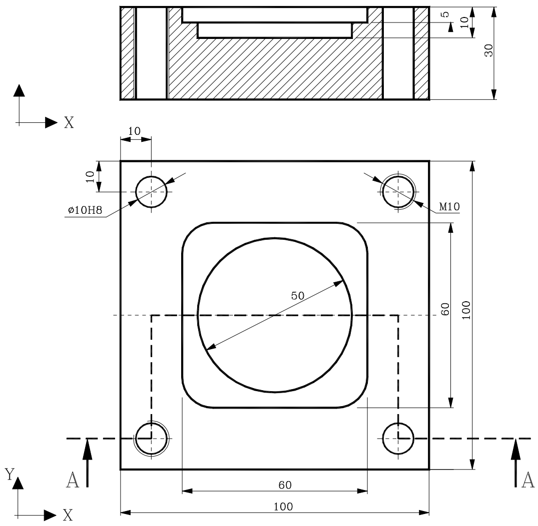
Cutting conditions:

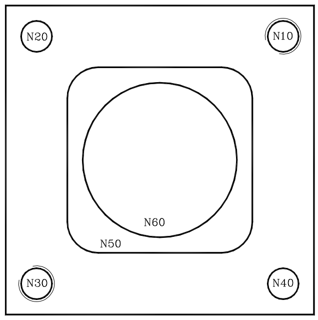
S=1600 rpm.
Roughing feedrate: 300 mm/min.
Finishing feedrate: 200 mm/min.

Modification of the canned cycle parameters

```
T2 D2
G0 G90 G43 Z25 S1600 M3 M42
N10 G87 G99 X40 Y50 Z2 I-10 J20 K40 B4 C6 D2 H200 L1 F300
G79 J20 K20
N20 X100 Y100
G79 I-18 J40 K20
N30 X140 Y40
G80
N70 G0 G90 G44 Z30
M30
```

4.9 Part 1 with canned cycles

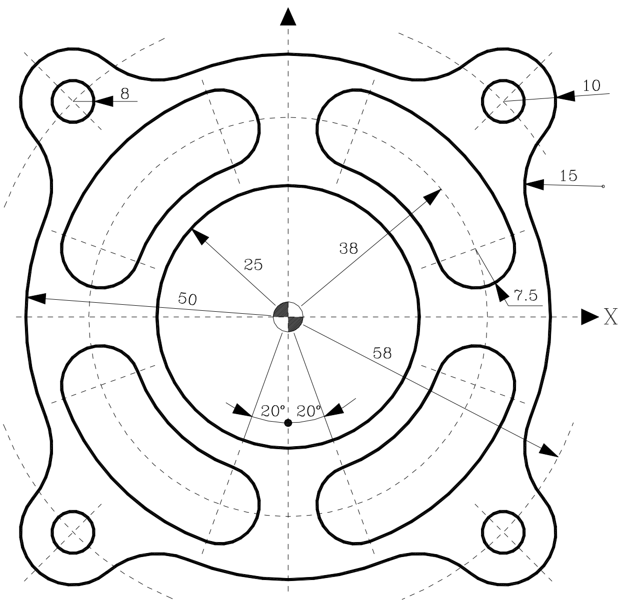




Canned cycles

```
T6 D6                                          ; Center punching drill bit.
G0 G90 G43 Z20 F200 S1800 M4 M8 M42
N10 G82 G99 X40 Y40 Z2 I-5 K300
N20 X-40
N30 Y-40
N40 X40
G80
G0 G44 Z100
T9 D9                                          ; Drill bit.
G0 G90 G43 Z20 F200 S1050 M4 M42
G81 G99 X40 Y40 Z2 I-35
X-40 Y-40
G0 G44 Z100
T8 D8                                          ; Drill bit.
G0 G90 G43 Z20 F200 S950 M4 M41
G81 G99 X-40 Y40 Z2 I-35
G0 X40 Y-40
G0 G44 Z100
T13 D13                                        ; Reamer.
G0 G90 G43 Z20 F100 S500 M4 M41
G85 G99 X-40 Y40 Z2 I-30 K200
X40 Y-40
G80
G0 G44 Z100
T12 D12                                        ; Tap.
G0 G90 G43 Z20 F450 S300 M4 M41
G84 G99 X40 Y40 Z2 I-35 K200
X-40 Y-40
G80
G0 G44 Z100
T2 D2                                          ; End mill for pockets.
G0 G90 G43 Z20 F250 S1600 M4 M42
N50 G87 G98 X0 Y0 Z2 I-5 J-30 K30 B5 D2 H200 L-1
N60 G88 G98 X0 Y0 Z-3 I-10 J-25 B5 D2 H200 L1
G80
G0 G44 Z100
M30
```

4.10 Part 2 with canned cycles



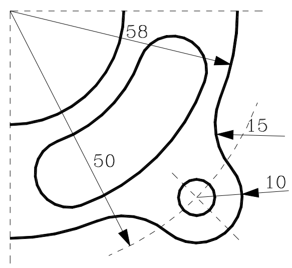
Canned cycles

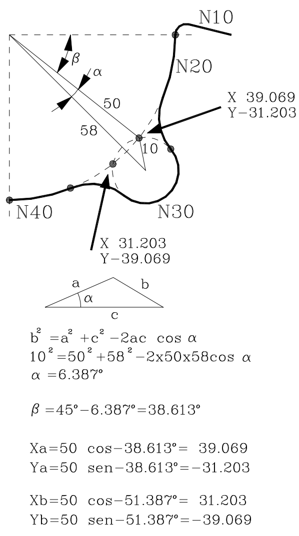
Initial positioning

```
G0 G90 G43 X60 Y0 Z5 T2 D2
G1 Z0 F250
```

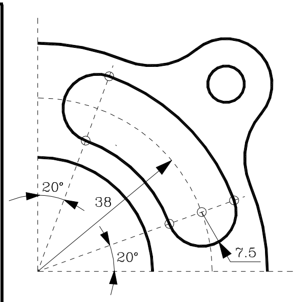
Outside profile machining

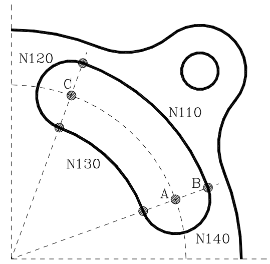
```
N0 G1 G91 Z-2 F250 S1600 M3 M8
N10 G90 G5 G1 G41 G37 R6 X50
N20 G2 G6 G36 R15 X39.069 Y-31.203 I0 J0
N30 G6 G36 R15 X31.203 Y-39.069 I41.012 J-41.012
N40 G6 X0 Y-50 I0 J0
N50 G73 Q-90
    ; -90º coordinate (pattern) rotation.
(RPT N20, N50) N2
    ; It machines quadrants 2 and 3
(RPT N20, N30)
    ; It machines quadrant 1.
G73
    ; Cancels coordinate (pattern) rotation.
G6 G38 R6 X50 Y0 I0 J0
N60 G1 G40 G7 X60
(RPT N0, N60) N4
F200 S1800 D11
    ; Tool offset and finishing conditions.
(RPT N10, N60)
G0 Z10
```





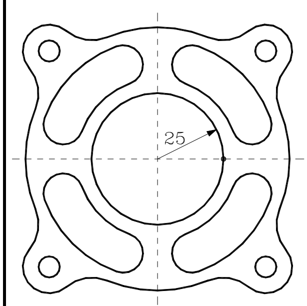
Slot milling





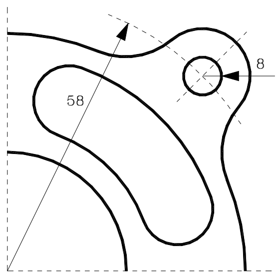

```
S1600 T2 D2 M3 M8 M42
N100 G0 G90 R38 Q20 Z5
    ; Approach to point "A"
G1 Z0 F150
N102 G91 Z-2
N105 G90 G41 G5 R45.5 F250
    ; A-B section
N110 G3 Q70
G93 I12.9967 J35.7083
    ; New Polar origin: Punto "C".
N120 G91 G3 Q180
G93 I0 J0
    ; New Polar origin: Punto X0 Y0.
N130 G2 G90 Q20
G93 I35.7083 J12.9967
    ; New Polar origin: Punto "A".
N140 G3 G91 Q180
G93 I0 J0
    ; New Polar origin: Point X0 Y0.
N150 G1 G40 G7 G90 R38 Q20
    ; B-A section.
(RPT N102, N150) N4
F200 S1800 D21
(RPT N105, N150)
    ; Finishing pass.
N160 G0 G90 Z5
G11
(RPT N100, N160)
    ; Milling of the slot of quadrant 4.
G12
(RPT N100, N160)
    ; Milling of the slot of quadrant 3.
G10 G12
(RPT N100, N160)
    ; Milling of the slot of quadrant 2.
G10
```

Milling of center hole




```
S1400 T2 D2 M3 M8 M42
G0 G90 X0 Y0 Z5
G1 Z0
N200 G1 G91 Z-2 F150
N210 G90 G37 R10 G41 G5 X25 F250
G3 G38 R10 X25 Y0 I-25 J0
N220 G1 G7 G40 X0
(RPT N200, N220) N4
F200 S1600 D21
(RPT N210, N220)
G0 G90 Z50
```

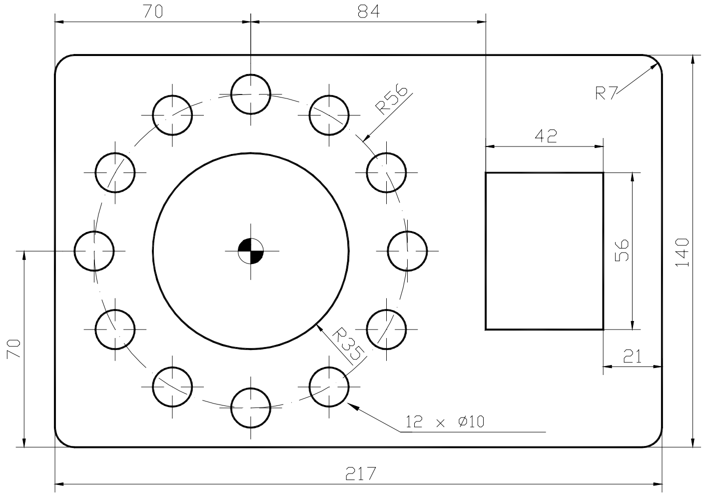
Center punching and drilling of the holes




```
G99 G81 R58 Q45 Z5 I-5 F200 S1800 T6 D6 M3 M8 M41
G0 Q135
Q225
Q315
G99 G81 R58 Q45 Z5 I-20 F200 S900 T14 D14
G91 Q90 N3
G90 G80 Z100
M30
```

4.11 Contours, pockets and drilling

To machine this part, it first makes the outside contour with 5 mm passes. It then calls the circular pocket cycle and, without canceling it, it makes the rectangular pocket. Once the two cycles are finished, it changes the tool and calls a Ø10 mm drill bit to drill the circle using Polar programming.



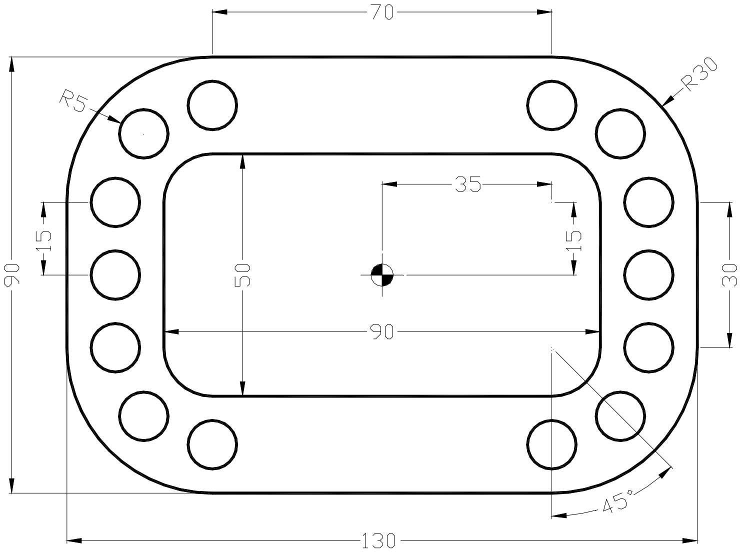
Contours, pocket and drilling

```
T12 D12                                 ; Ø12 mm tool
G43 G0 Z100
X0 Y-100
Z0
N1 G91 G1 Z-5 F100
G90 G37 R10 G42 X0 Y-70 F500
G36 R7 X147
G36 R7 Y70
G36 R7 X-70
G36 R7 Y-70
G38 R10 G1 X0 Y-70
N2 G1 G40 X0 Y-100
(RPT N1,N2)N4
G0 Z10
G88 X0 Y0 Z2 I-20 J-35 B-5 D2 H800 L0.2 V75 F1000
G87 X105 Y0 Z2 I-20 J-21 K28 B-5 D2 H800 L0.2 V75 F1000
G80 G0 Z100
T10 D10                                 ; Ø10 mm drill bit.
G43 G0 Z100
G93 I0 J0
G81 R56 Q0 Z2 I-20 K10 F120
G91 Q30 N11
G90 G0 G80 Z100
X0 Y0
M30
```

4.12 Contours and drilling in Polar coordinates

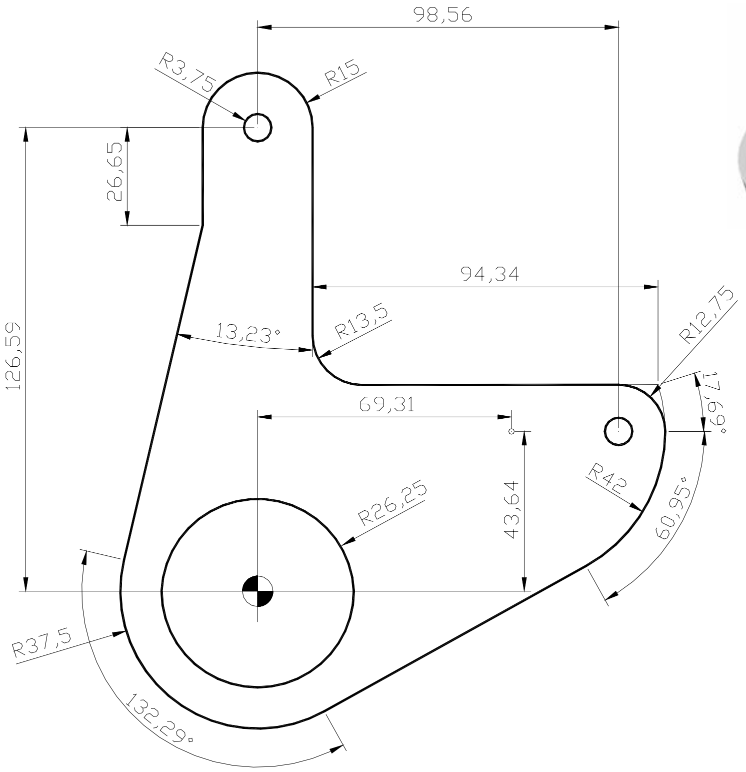
The following example makes the inside and outside contours by lowering the part. Then, the drilling is carried out in an arc by changing the Polar center just before each drilling.

The Polar center is an information character for the control and does not execute any movement when it reads this block even if it is inside a canned cycle.



Contours and drilling in Polar coordinates	
T20 D20 M6 G43 G0 Z100 X0 Y0 S1300 M3 M8 Y-80 Z0 N1 G91 G1 Z-5 F100 G90 G41 G37 R12 X0 Y-45 F800 G36 R30 X-65 G36 R30 Y45 G36 R30 X65 G36 R30 Y-45 G38 R12 X0 N2 G40 X0 Y-80 (RPT N1,N2)N3 G0 Z10 X0 Y10 Z0 N3 G91 G1 Z-5 F100 G90 G41 G37 R12 X0 Y-25 F800 G36 R10 X45 G36 R10 Y25 G36 R10 X-45 G36 R10 Y-25 G38 R12 X0 N4 G40 X0 Y10 (RPT N3,N4)N3 G0 Z100	T10 D10 M6 G43 G0 Z100 X0 Y0 S1300 M3 M8 G93 I35 J-15 G69 G99 G0 R20 Q270 Z2 I-20 B3 F150 G91 Q45 N2 Y15 N2 G93 I35 J15 Q45 N2 X-70 G93 I-35 J15 Q45 N2 Y-15 N2 G93 I-35 J-15 Q45 N2 G80 G90 G0 Z100 X0 Y0 M30

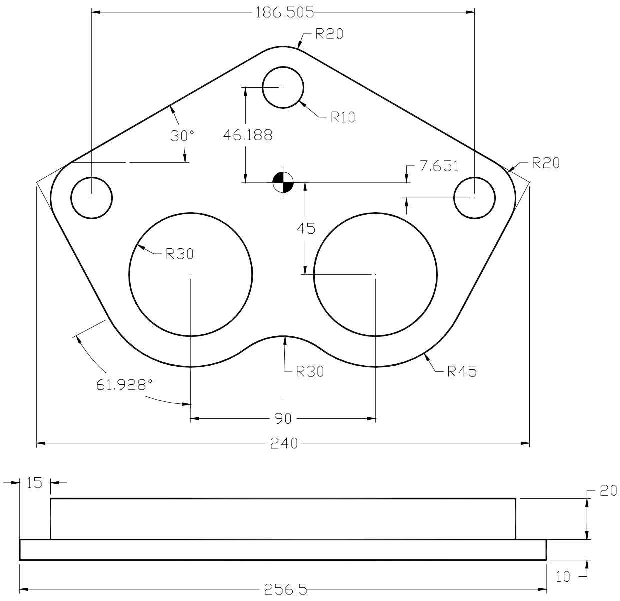
4.13 Cam



Cam

```
T12 D12                                  ; Ø12 mm tool
M6
G0 G43 Z10
X-45 Y126.59 S2000 M3 M8
Z0
N1 G91 Z-5 F100
G90 G1 G42 G37 R10 X-15 Y126.59 F500
G1 Y99.87
G93 I0 J0
G1 R37.5 Q166.76
G3 Q-60.95
G93 I69.308 J43.644
G1 R42 Q-60.95
G3 G36 R12.75 Q17.69
G1 G91 G36 R13.5 X-94.339
G90 Y126.59
G3 G38 R10 Q180 I-15 J0
N2 G1 G40 X-45 Y126.59
(RPT N1,N2) N3
G0 Z100
T2 D2                                    ; Ø7.5 mm drill bit.
M6
G0 G43 Z100
G69 G98 G90 G0 X0 Y0 Z2 I-20 B3.5 F100
X0 Y126.59
X95.558 Y43.644
G80 G0 Z100
T14 D14                                  ; Ø14 mm tool
M6
G0 G43 Z100
G88 G98 G90 G0 X0 Y0 Z3 I-20 J-26.25 B-5 D3 H300 L.2 F800
G80 G0 Z100
M30
```

4.14 Contours and pockets



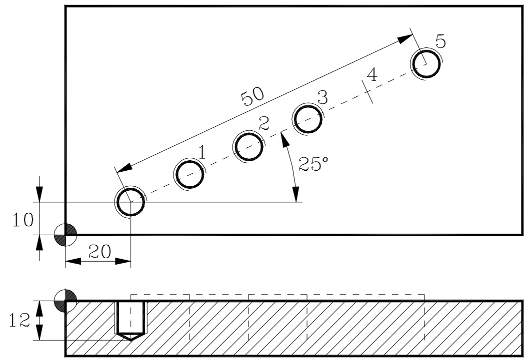
```
T12 D12                                   ; Ø12 mm tool
M6
G43 G0 Z100
X-45 Y-120 S2000 M3 M8
Z0
N1 G91 G1 Z-5 F100
G90 G1 G41 G37 R10 X-45 Y-90 F500
G93 I-45 J-45
G2 Q208.07
G1 G36 R20 Q118.07 X-120
G36 R20 Q30 X0
G36 R20 Q-30 X120
G93 I45 J-45
G1 R45 Q-28.07
G2 G36 R30 Q180
G93 I-45 J-45
G2 G38 R10 Q270
N2 G1 G40 X-45 Y-120
(RPT N1,N2) N3
G0 Z10
G88 G98 G90 G0 X-45 Y-45 Z2 I-20 J-30 B-5 D3 H300 L0.2 F800
G91 X90
G80 G90 G0 Z100
T20 D20                                   ; Ø20 mm drill bit.
M6
G43 G0 Z100
G69 G98 G90 G0 X93.2525 Y-7.651 Z2 I-25 B3 F80
X0 Y46.188
X-93.2525 Y-7.651
G80 G0 Z100
M30
```

MULTIPLE MACHINING

5

5.1 Multiple machining in a straight line (drilling and tapping)

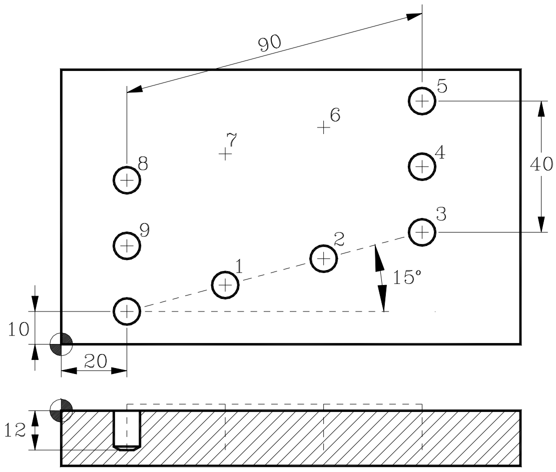
A multiple machining in a straight line may be defined in the following ways:



Multiple machining in a straight line
Option 1: Defining the length of the machining path and the number of machining operations. G0 G43 G90 X0 Y0 Z20 F200 S1500 T7 D7 M3 M41 G81 G99 X20 Y10 Z2 I-12 K50 G60 A25 X50 K6 P4 G80 G0 G90 X0 Y0 Z20 F300 S300 T11 D11 G84 G98 X20 Y10 Z2 I-12 K10 R0 G60 A25 X50 K6 P4 G80 G90 X0 Y0 M30
Option 2: Defining the length of the machining path and the step between machining operations. G0 G43 G90 X0 Y0 Z20 F200 S1500 T7 D7 M3 M41 G81 G99 X20 Y10 Z2 I-12 K50 G60 A25 X50 I10 P4 G80 G0 G90 X0 Y0 Z20 F300 S300 T11 D11 G84 G98 X20 Y10 Z2 I-12 K10 R0 G60 A25 X50 I10 P4 G80 G90 X0 Y0 M30
Option 3: Defining the number of machining operations and the step between them. G0 G43 G90 X0 Y0 Z20 F200 S1500 T7 D7 M3 M41 G81 G99 X20 Y10 Z2 I-12 K50 G60 A25 I10 K6 P4 G80 G0 G90 X0 Y0 Z20 F300 S300 T11 D11 G84 G98 X20 Y10 Z2 I-12 K10 R0 G60 A25 I10 K6 P4 G80 G90 X0 Y0 M30

5.2 Multiple machining in a rectangular pattern (drilling and reaming)

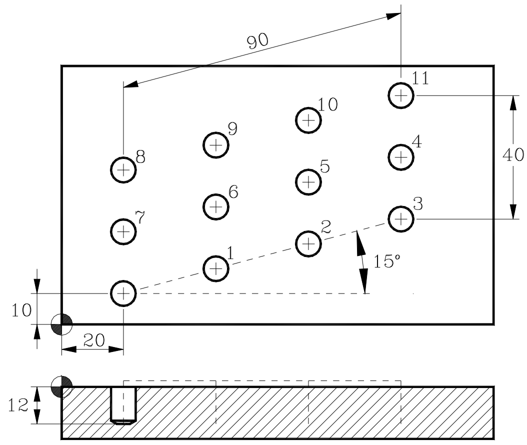
A multiple machining in a parallelogram pattern may be defined in the following ways:



Multiple machining in a rectangular pattern
Option 1: Defining the length of the machining path and the number of holes. G0 G90 X0 Y0 Z20 F200 S950 T8 D8 M3 M41 G81 G99 X20 Y10 Z2 I-12 K100 G61 A15 B75 X90 K4 Y40 D3 P6.007 G80 G0 G90 X0 Y0 Z20 F100 S500 T13 D13 M3 M41 G85 G99 X20 Y10 Z2 I-12 K50 G61 A15 B75 X90 K4 Y40 D3 P6.007 G80 G90 X0 Y0 M30 Option 2: Defining the length of the machining path and the step between machining operations. G0 G90 X0 Y0 Z20 F200 S950 T8 D8 M3 M41 G81 G99 X20 Y10 Z2 I-12 K100 G61 A15 B75 X90 I30 Y40 J20 P6.007 G80 G0 G90 X0 Y0 Z20 F100 S500 T13 D13 M3 M41 G84 G98 X20 Y10 Z2 I-12 K10 R0 G61 A15 B75 X90 I30 Y40 J20 P6.007 G80 G90 X0 Y0 M30 Option 3: Defining the number of machining operations and the step between them. G0 G90 X0 Y0 Z20 F200 S950 T8 D8 M3 M41 G81 G99 X20 Y10 Z2 I-12 K100 G61 A15 B75 I30 K4 J20 D3 P6.007 G80 G0 G90 X0 Y0 Z20 F100 S500 T13 D13 M3 M41 G84 G98 X20 Y10 Z2 I-12 K10 R0 G61 A15 B75 I30 K4 J20 D3 P6.007 G80 G90 X0 Y0 M30

5.3 Multiple machining in a grid pattern (drilling and reaming)

A multiple machining in a grid pattern may be defined in the following ways:



Multiple machining in a grid pattern.

Option 1: Define the length of the machining path and the number of holes.

```
G0 G90 X0 Y0 Z20 F200 S950 T8 D8 M3 M41
G81 G99 X20 Y10 Z2 I-12 K100
G62 A15 B75 X90 K4 Y40 D3
G80
G0 G90 X0 Y0 Z20 F100 S500 T13 D13 M3 M41
G85 G98 X20 Y10 Z2 I-12 K50
G62 A15 B75 X90 K4 Y40 D3
G80 G90 X0 Y0
M30
```

Option 2: Define the length of the machining path and the step between machining operations.

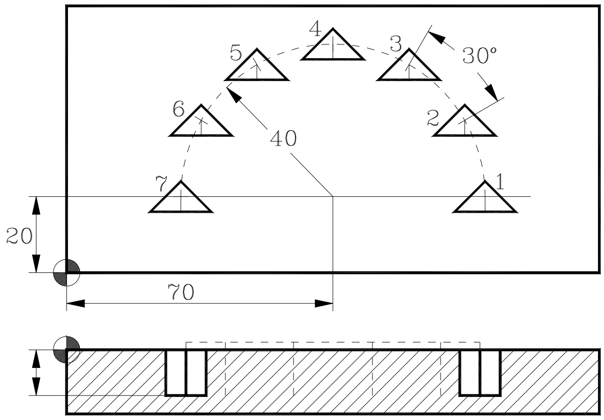
```
G0 G90 X0 Y0 Z20 F200 S950 T8 D8 M3 M41
G81 G99 X20 Y10 Z2 I-12 K100
G62 A15 B75 X90 I30 Y40 J20
G80
G0 G90 X0 Y0 Z20 F100 S500 T13 D13 M3 M41
G85 G98 X20 Y10 Z2 I-12 K50
G62 A15 B75 X90 I30 Y40 J20
G80 G90 X0 Y0
M30
```

Option 3: Define the number of machining operations and the step between them.

```
G0 G90 X0 Y0 Z20 F200 S950 T8 D8 M3 M41
G81 G99 X20 Y10 Z2 I-12 K100
G62 A15 B75 I30 K4 J20 D3
G80
G0 G90 X0 Y0 Z20 F100 S500 T13 D13 M3 M41
G85 G98 X20 Y10 Z2 I-12 K50
G62 A15 B75 I30 K4 J20 D3
G80 G90 X0 Y0
M30
```

5.4 Multiple machining in a circular pattern (drilling)

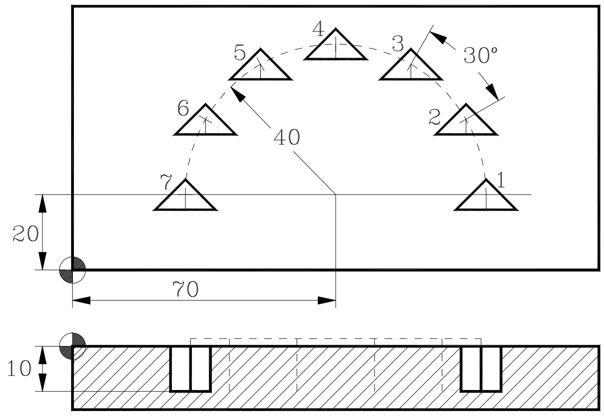
A multiple machining in a circular pattern may be defined in the following ways:



Multiple machining in a circular pattern
Option 1: Define the number of machining operations. G0 G90 X70 Y55 Z20 F200 S1500 T7 D7 M3 M41 G81 G99 X110 Y55 Z2 I-12 K50 G63 X-40 Y0 K12 C3 F300 P7.011 M30 Option 2: Define the pass between machining operations. G0 G90 X70 Y55 Z20 F200 S1500 T7 D7 M3 M41 G81 G99 X110 Y55 Z2 I-12 K50 G63 X-40 Y0 I30 C3 F300 P7.011 M30

5.5 Multiple machining in an arc

A multiple machining in an arc may be defined in the following ways:



Multiple machining in an arc

Option 1: Define the number of machining operations.

```
G0 G90 X110 Y20 Z20 F100 S1500 T5 D5 M3 M41
(MCALL 10)
G64 X-40 Y0 B180 K7 C3 F300
M30

(SUB 10)
    G90 G1 Z-10 F100
    G91 Y-4
    X8
    X-8 Y8
    X-8 Y-8
    X8
    Y4
    G90 Z20
(RET)
```

Option 2: Define the pass between machining operations.

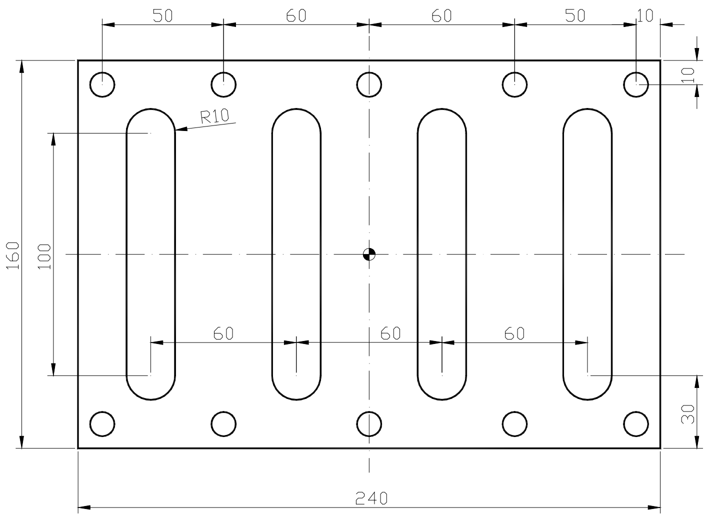
```
G0 G90 X110 Y20 Z20 F100 S1500 T5 D5 M3 M41
(MCALL 10)
G64 X-40 Y0 B180 I30 C3 F300
M30

(SUB 10)
    G90 G1 Z-10 F100
    G91 Y-4
    X8
    X-8 Y8
    X-8 Y-8
    X8
    Y4
    G90 Z20
(RET)
```

SUBROUTINES

6

6.1 CALL and MCALL subroutines



CALL SUBROUTINE

```
T1 D1
G0 Z100
S1000 M3
X-90 Y50
(CALL 1)
X-30 Y50
(CALL 1)
X30 Y50
(CALL 1)
X90 Y50
(CALL 1)
T2 D2
N1 G81 X-110 Y70 Z2 I-15 F200 S500
G91 X50
X60 N2
X50
N2 G0 G80 G90 Z100
G12
(RPT N1,N2)
M30

(SUB1)
G90 G0 Z2
G1 Z-5 F100
G91 Y-100 F500
G90 G0 Z100
(RET)
```

MCALL SUBROUTINE

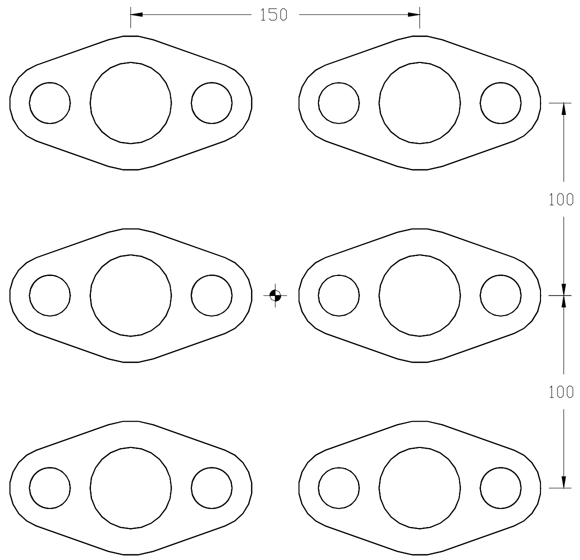
```
G0 Z100
T1 D1
S1000 M3
X-90 Y50
(MCALL 1)
G91 X60 Y100 N3
(MDOFF)
G90 G0 Z100
T2 D2
N1 G81 X-110 Y70 Z2 I-15 F200 S500
G91 X50
X60 N2
X50
N2 G0 G80 G90 Z100
G12
(RPT N1,N2)
M30

(SUB 1)
G90 G0 Z2
G1 Z-5 F100
G91 Y-100 F500
G90 G0 Z100
Y50
(RET)
```

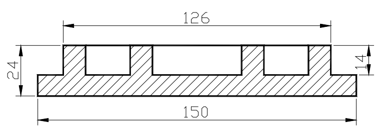
6.2 MCALL subroutine with G54

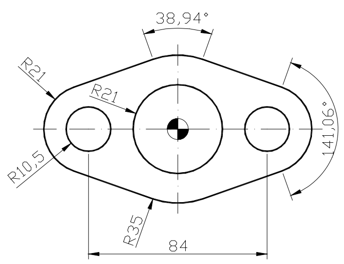
The MCALL instruction turns a subroutine into a canned cycle with all the characteristics of a canned cycle and, therefore, must be canceled with MDOFF.

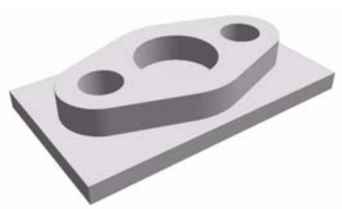
The following example takes a program already created and turns it into a subroutine applying the header and the end of subroutine to it. The header includes a coordinate preset with function G92 and the end of the subroutine includes a part zero such as G54 or any other. This part zero is the same as the one entered in the main program that calls upon the subroutine.



MCALL subroutine with G54	
G54	; Part zero.
T8 D8	; Ø16 mm flat tool.
M6	
G43 G0 Z100	
X75 Y100	
(MCALL 1)	; Call to a modal subroutine.
X75 Y0	
X75 Y-100	
X-75 Y-100	
X-75 Y0	
X-75 Y100	
(MDOFF)	; End of subroutine.
G0 Z100	
X0 Y0	
M30	







G92 X0 Y0 presets a new part zero where the tool is at the time. This turns that point into the coordinate origin. It must be borne in mind that using G92 deletes the part zero active at the time and presets the new position as the machine's new part zero.

MCALL subroutine with G54

```
( SUB 1)                          ; Subroutine to call upon the part.
G92 X0 Y0                         ; Coordinate origin preset.
T16 D16                           ; Ø16 mm flat tool.
M6
G43 G0 Z100
X0 Y0 S1000 M3 M8
Y-50
Z0
N1 G91 G1 Z-2 F100
G93 I0 J0
G90 G41 R35 Q270 F400
G2 Q250.53
G93 I-42 J0
G1 R21 Q250.53
G2 Q109.47
G93 I0 J0
G1 R35 Q109.47
G2 Q70.53
G93 I42 J0
G1 R21 Q70.53
G2 Q-70.53
G93 I0 J0
G1 R35 Q-70.53
G2 Q270
N2 G1 G40 Y-50
(RPT N1,N2)N3
G0 Z100

T10 D10                           ; Ø10 mm drill bit.
M6
G43 G0 Z100
X0 Y0 S1000 M3 M8
G69 G99 G0 X0 Y0 Z2 I-10 B3 F120
X42 Y0
X-42 Y0
G80 G0 Z100

T14 D14                           ; Ø14 mm flat tool.
M6
G43 G0 Z100
X0 Y0 S1000 M3 M8
G88 G99 X0 Y0 Z2 I-10 J-21 B3 D2 H400 L1 V100
G88 X42 Y0 Z2 I-10 J-10.5 B3 D2 H400 L1 V100
X-42 Y0
G80 G0 Z100
X0 Y0
G54                               ; Restores the initial part zero.
(RET)                             ; End of subroutine.
```

2D AND 3D POCKETS

7

7.1 2D pockets

A 2D pocket is a geometry that is emptied or in relief and has a vertical depth profile and are irregular in the XY plane The structure of a 2D pocket program is similar as calling a subroutine that is defined after the M30 from the main program.

Example:

Main program:

```
G0 Z100
G66 D.. R.. F.. S.. E...                (Subroutine calling block)
G0 Z100
M30

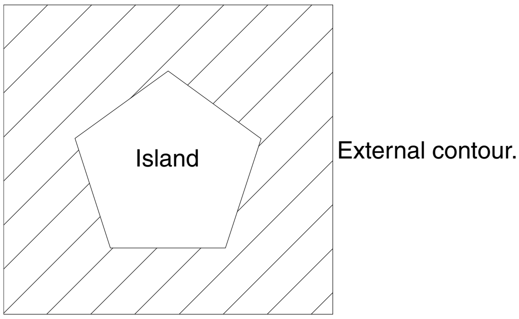
N.. G81 Z2……………….T..D..              (Pre-drilling cycle)
N..G67............................T..D..   (Roughing cycle)
N..G68.............................T..D..  (Finishing cycle)
```

Subroutine:

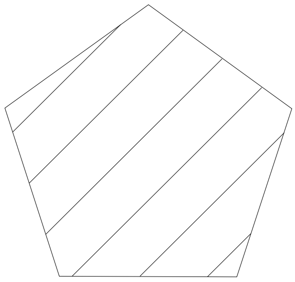
```
N G0 X Y Z
G1------------
----------------
----------------
----------------
----------------
N -------------
```

7.1.1 Geometry definition

Two geometries are defined when programming a 3D relief. An outside geometry called external contour, that defines the boundaries of the pocket and another geometry that defines the contour to be left in relief called island.



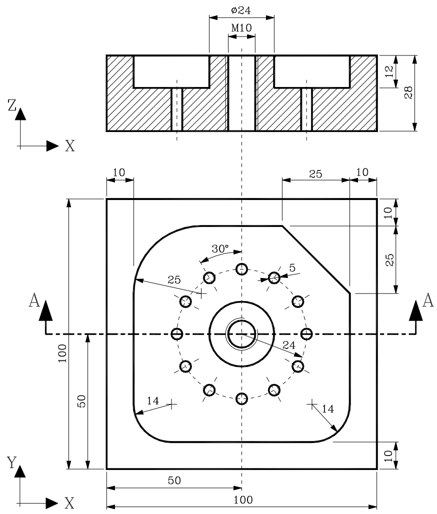
When programming 2D emptying, only the geometry of that contour is programmed.



Geometry programming rules.

- Th profile must be closed (its starting point and the end point must be the same)
- The profile cannot intersect itself.
- Function G0 cannot stay activated after defining the starting point.
- Geometrical assistance functions (mirror image, scaling factor, etc) cannot be used when defining the geometry.
- The first and last points of the geometry must be defined in the same type of coordinates (both in Cartesian or both in Polar).

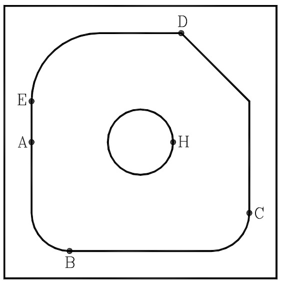
7.1.2 Pocket islands 1



Pocket islands

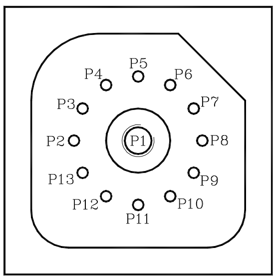
Pocket islands:

```
T2 D2
      ; Milling tool.
G0 G90 G43 X0 Y0 Z10 F250 S1600 M3 M42
G66 R100 F200 S300 E400
G0 G44 X-70 Y0 Z100
(GOTO N500)
N100 G67 A0 B6 C0 I-12 R3 T2 D2
      ; Block N100 defines the roughing operation.
N200 G68 B0 L-1 T2 D2
      ; Block N200 defines the finishing operation.
N300 G1 X-40 Y0 Z0                  ; Point "A".
G36 R14 Y-40                        ; A-B section
G36 R14 X40                         ; B-C section.
G39 R25 Y40                         ; C-D section.
G36 R25 X-40                        ; D-E section.
Y0                                  ; E-A section.
G0 X12 Y0                           ; Point "H".
N400 G2 G6 I0 J0
```

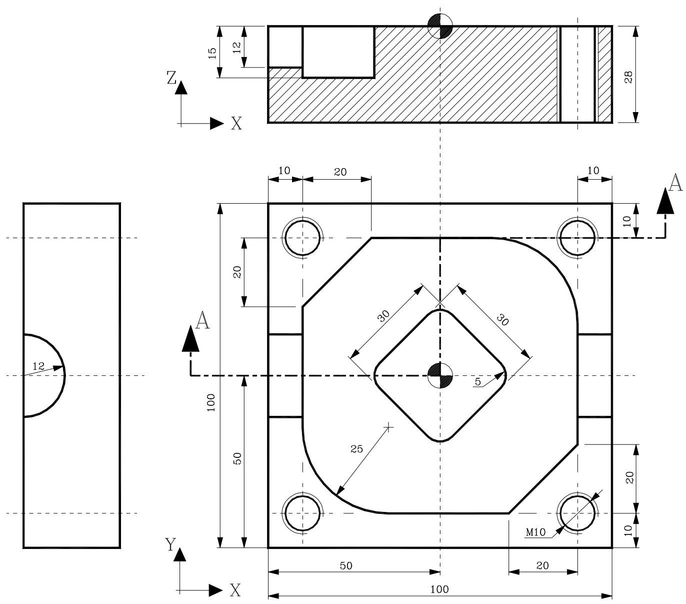


Drilling and tapping:

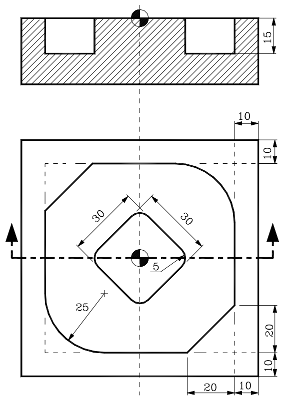
```
N500 T9 D9
      ; Ø8.5 mm drill bit.
G0 G90 G43 Z100 F200 S1050 M4 M41
G83 G98 X0 Y0 Z5 I-12 J3            ; Drilling P1.
G80
T7 D7
      ; Ø5 mm drill bit.
F200 S1500 M4 M42
G81 G99 X-24 Y0 Z-10 I-30 K0        ; Drilling P2.
G63 X24 Y0 I30 C2 F300              ; Drilling P3 to P13.
G80
G0 Z100
T12 D12
      ; Tapping tool.
G0 G90 G43 Z20 F450 S300 M4 M41
G84 G98 X0 Y0 Z5 I-30               ; Tapping P1.
G0 G44 Z50
M30
```

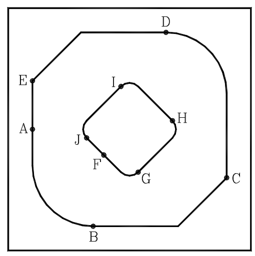


7.1.3 Pocket islands 2



Pocket islands





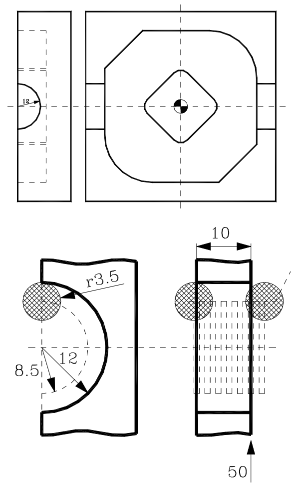

```
T2 D2
M06
G0 G90 G43 X0 Y0 Z20 F160 S1600 M3 M42
```

Pocket islands:

```
G66 D100 R110 F250 S130 E140
G0 G44 Z50
(GOTO N300)
N100 G81 Z3 I-15
N110 G67 A45 B7.5 C7 I-15 R3 T2 D2 M6
N120 G68 B0 L-1 T2 D2 M6
N130 G1 X-40 Y0 Z0             ; Point "A".
G36 R25 Y-40                   ; A-B section
G39 R20 X40                    ; B-C section.
G36 R25 Y40                    ; C-D section.
G39 R20 X-40                   ; D-E section.
Y0                             ; E-A section.
G0 X-10.606 Y-10.606           ; Point "F".
G1 G36 R5 X0 Y-21.213          ; F-G section.
G36 R5 X21.213 Y0              ; G-H section.
G36 R5 X0 Y21.213              ; H-I section.
G36 R5 X-21.213 Y0             ; I-J section
N140 X-10.606 Y-10.606         ; J-F section.
```

Slot in an arc.

```
N300 T4 D4
M6
G19                ; Selects the YZ plane as the main plane.
G1 Z5              ; Selects the Z axis as vertical axis.
F150 S1200 M3 M42
G0 G43 G90 X54.5 Y8.5 Z0
G1 X53.5
N310 G91 G1 X-1
G2 G90 Q180
G91 G1 X-1
N320 G3 G90 Q0
(RPT N310, N320) N6
G0 G90 Z10
X-36.5
Z0
(RPT N310, N320) N7
G0 G90 G17 G44 Z50
```

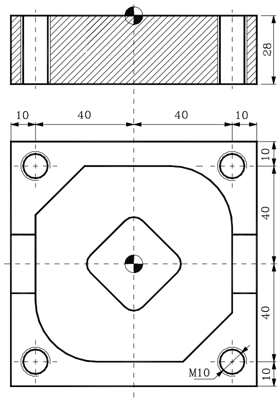


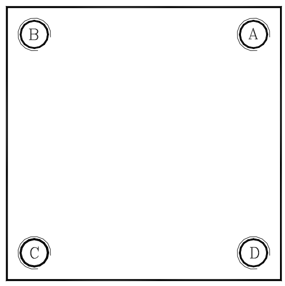
Drilling:

```
T9 D9
M6
F200 S1050 M4 M41
G0 G43 G90 X40 Y40 Z20
G83 G99 Z3 I-13 J3       ; Drilling "A".
N400 X-40                ; Drilling "B".
Y-40                     ; Drilling "C".
X40                      ; Drilling "D".
N410 G80
G0 G44 Z60
```

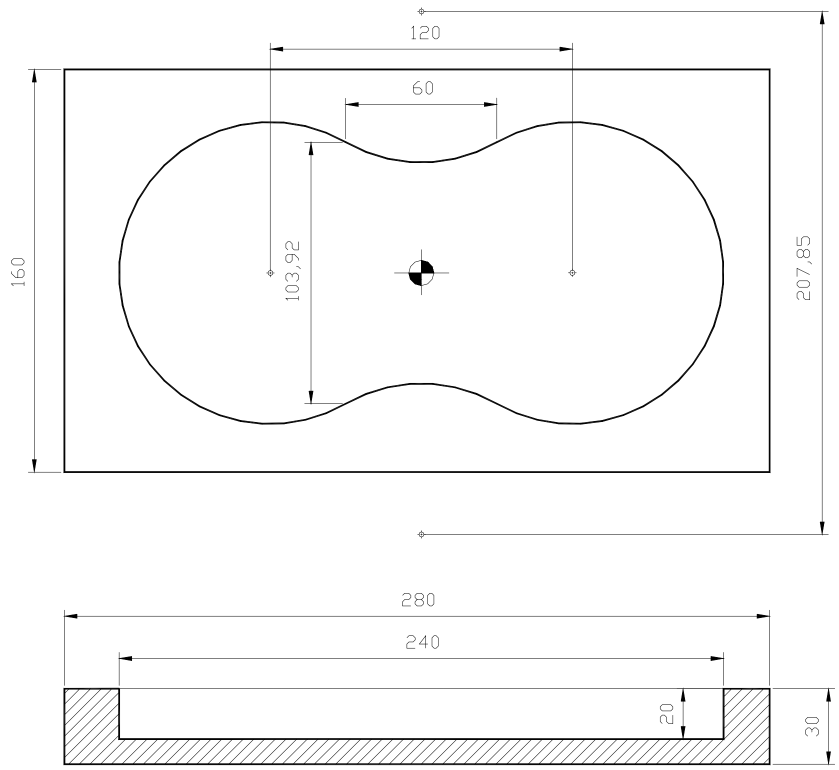
Tapping:

```
T12 D12
M6
F450 S300 M4 M41
G0 G43 G90 X40 Y40 Z20
G84 G99 Z5 I-30          ; Tapping "A".
(RPT N400, N410)         ; Tapping  "B" "C" "D".
G0 G44 Z60
M30
```

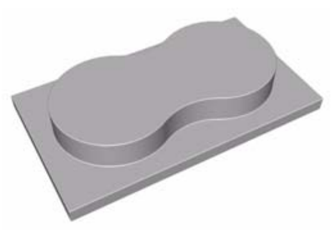




7.1.4 2D pocket (punch and die).



PUNCH



DIE

The following example machines the outside of the part. To do that, define the external contour and the part contour. This way, the machining takes place between the two defined contours.

Machining of the punch

```
G0 Z100
G66 D10 R20 F30 S40 E50
G0 Z100
M30
```

Subroutine.

```
N10 G81 Z2 I-20 F100 S600 T1 D1 M6 M3                ; Pre-drilling.
N20 G67 B5 I-20 R2 V50 F1000 S1200 T2 D2 M6 M3       ; Roughing.
N30 G68 B20 L0.5 I-20 R2 V50 F800 S2000 T3 D3 M6 M3  ; Finishing.
```

Geometry. External contour.

```
N40 G0 X-140 Y80 Z0
G1 X140
Y-80
X-140
Y80
```

Geometry. Island.

```
G0 X30 Y51.96
G6 G2 X30 Y-51.96 I60 J0
G6 G3 X-30 Y-51.96 I0 J-103.925
G6 G2 X-30 Y51.96 I-60 J0
N50 G6 G3 X30 Y51.96 I0 J103.925
```

The following example empties the inside of the geometry, thus only the contour to be machined is defined.

Machining of the die

```
G0 Z100
G66 D10 R20 F30 S40 E50
G0 Z100
M30
```

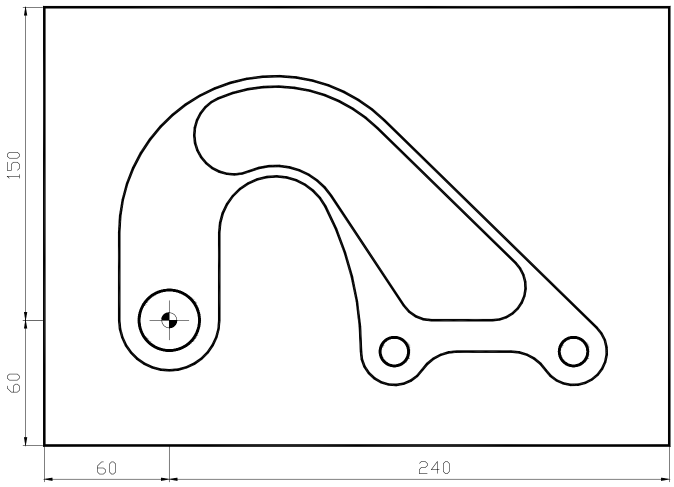
Subroutine.

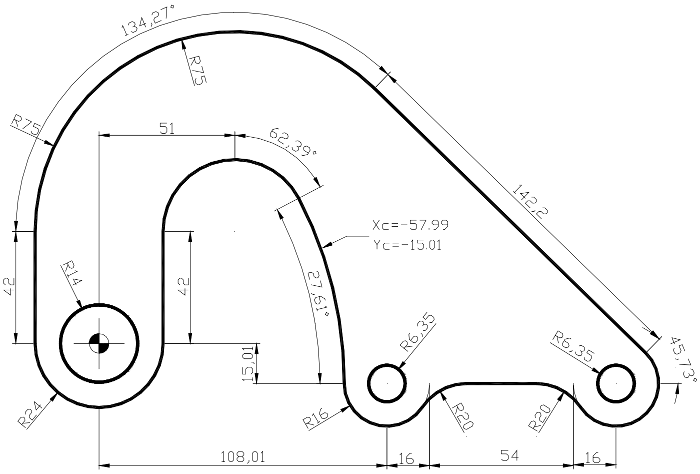
```
N10 G81 Z2 I-20 F100 S600 T1 D1 M6 M3
N20 G67 A0 B5 I-20 R2 V50 F1000 S1200 T2 D2 M6 M3
N30 G68 B20 L0.5 I-20 R2 V50 F800 S2000 T3 D3 M6 M3
```

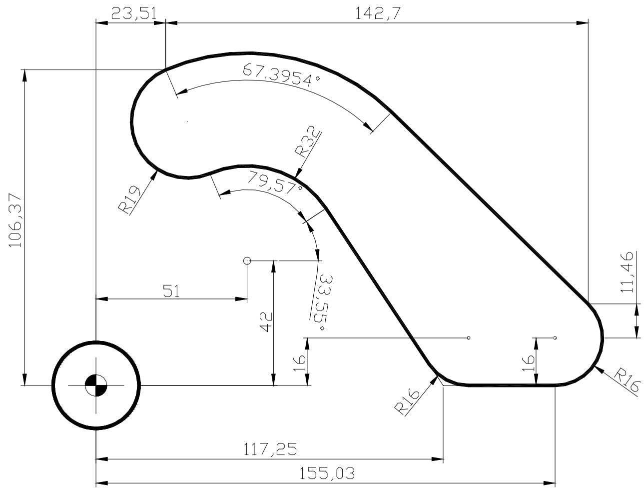
Geometry:

```
N40 G0 X30 Y51.96 Z0
G6 G2 X30 Y-51.96 I60 J0
G6 G3 X-30 Y-51.96 I0 J-103.925
G6 G2 X-30 Y51.96 I-60 J0
N50 G6 G3 X30 Y51.96 I0 J103.925
```

7.1.5 2D pocket







```
G0 Z100
G66 D10 R20 F30 S40 E50                      ; Machining of the relief.
G66 D100 R200 F300 S400 E500                 ; Emptying.
G0 Z100
G88 X0 Y0 Z2 I-20 J14 B5 D2 H500 L0.5 V100 F500 ; Pocket with a 14 mm radius
G79 J6.35
X108.01 Y-15.01
X194.01 Y-15.01
G0 G80 Z100
M30
```

; Subroutine of the relief.

```
N10 G81 Z2 I-20 F100 S600 T1 D1 M6 M3
N20 G67 B5 I-20 R2 V50 F1000 S1200 T2 D2 M6 M3
N30 G68 B20 L0.5 I-20 R2 V50 F800 S2000 T3 D3 M6 M3
```

Geometry. External contour.

```
N40 G0 X-60 Y150 Z0
G1 X240
Y-60
X-60
Y150
```

Geometry. Island.

```
G0 X-24 Y0
G3 X24 Y0 R24
G1 Y42
G6 G2 Q27.61 I51 J42
G6 G2 X92.01 Y-15.01 I-57.99 J-15.01
G36 R20 G3 X124.01 Y-15.01 R16
G1 G36 R20 X178.01
G6 G3 Q45.73 I194.01 J-15.01
G93 I51 J42
G1 R75 Q45.73
G3 X-24 Y42 R75
N50 G1 Y0
```

; Subroutine of the emptying.

```
N100 G81 Z2 I-20 F100 S600 T1 D1 M6 M3
N200 G67 B5 I-20 R2 V50 F1000 S1200 T2 D2 M6 M3
N300 G68 B20 L0.5 I-20 R2 V50 F800 S2000 T3 D3 M6 M3
```

Geometry.

```
N400 G0 X23.51 Y106.37 Z0
G93 I51 J42
G91 G2 Q-67.4
G93 I155.03 J16
G90 G1 R16 Q45.73
G2 Q270
G1 G36 R16 X117.25
G93 I51 J42
G1 R32 Q33.55
G91 G3 Q79.57
N500 G90 G2 X23.51 Y106.37 R19
```

7.2 3D pockets

3D pockets are programmed just like 2D pockets, except that each profile defined in the XY plane has its own depth profile. The relief and emptying concepts and structures of 2D and 3D pockets are similar. Their differences are:

; CALLING BLOCK:

2D						**3D**					
G66	D	R	F	S	E	G66	R	C	F	S	E

D - Pre-drilling.
R - Roughing.
F - Finishing.
C - Semi-finishing.
S - First block of geometry definition.
E - Last block of geometry definition.

As can be observed, there is no pre-drilling in 3D pockets, but there is a semi-finishing operation.

7.2.1 Structure of a 3D program

Main program:

```
G0 Z100
G66 R.. C.. F.. S.. E..                 (Subroutine calling block)
G0 Z100
M30
```

Subroutine:

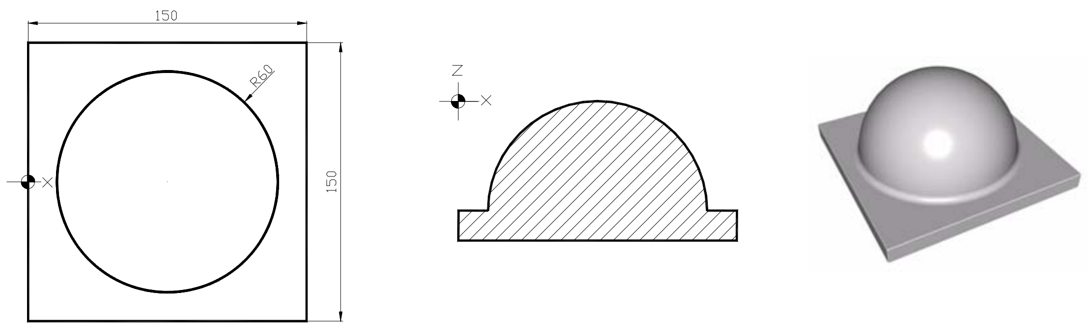
```
N.. G67 ......................... T..D..     (Roughing cycle)
N..G67 .......................... T..D..     (Semi-finishing cycle)
N..G68 .......................... T..D..     (Finishing cycle)
N G0 X Y Z
```

Geometry:

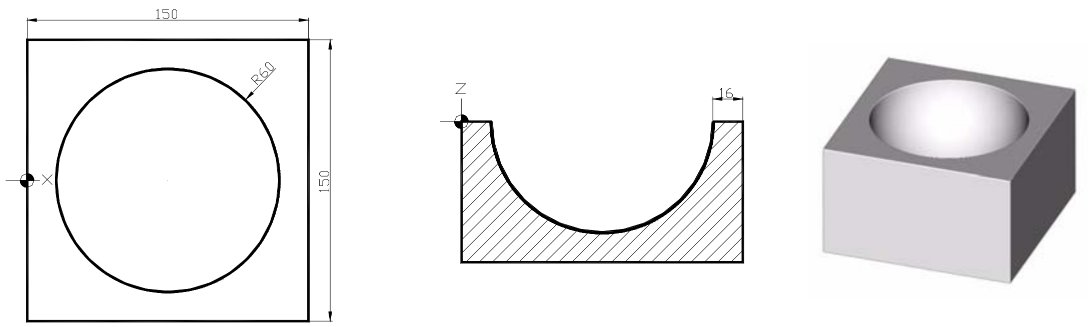
```
G1 -----------
----------------
----------------
G16 XZ                                  (Plane change)
----------------
----------------
N -------------
```

7.2.2 Semi-sphere (relief and emptying with a spherical tool).

RELIEF



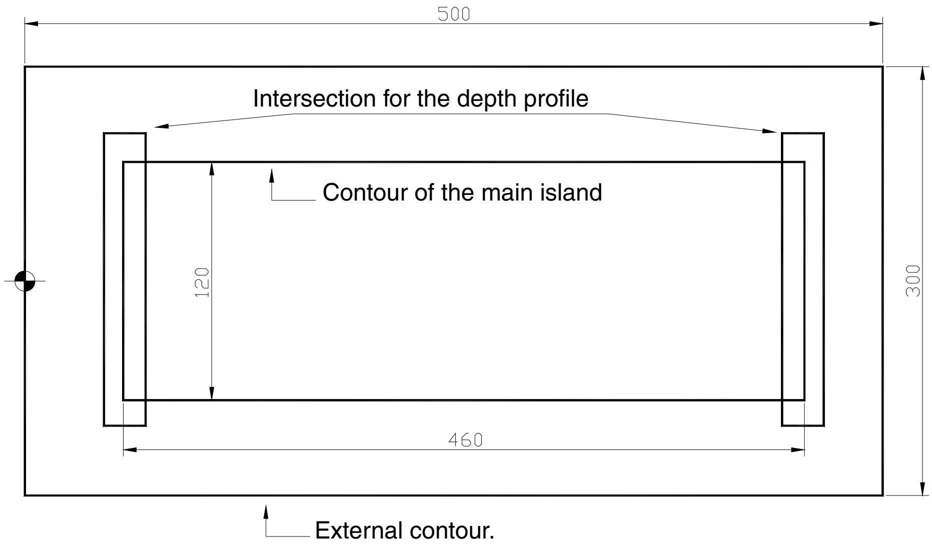
EMPTYING

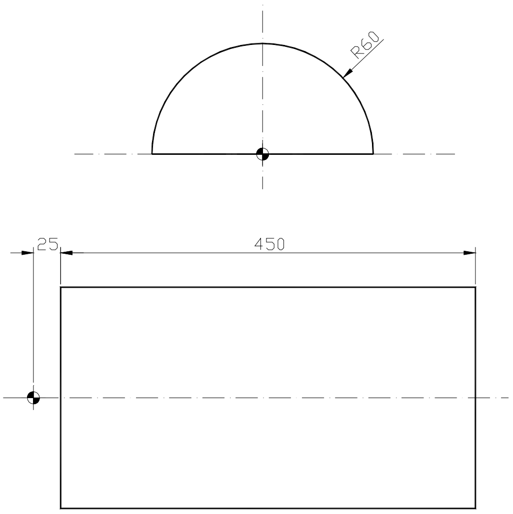


Semi-sphere in relief
G0 Z100 G66 R10 C20 F30 S40 E50 G0 Z100 M30 N10 G67 B5 I-60 R2 V100 F1000 S1000 T1 D1 M3 N20 G67 B3 I-60 R2 V100 F1000 S1000 T1 D1 M3 N30 G68 B-1 L0.5 I-60 R2 V100 F500 S2000 T1 D1 M3 N40 G0 X0 Y0 Z0 G1 Y75 X150 Y-75 X0 Y0 G16 XZ G0 X0 Z0 G1 X0 Z-60 G16 XY G0 X15 Y0 G2 X15 Y0 I60 J0 G16 XZ G0 X15 Z-60 N50 G2 X75 Z0 R60

Emptied semi-sphere
G0 Z100 G66 R10 C20 F30 S40 E50 G0 Z100 M30 N10 G67 B5 I-60 R2 V100 F1000 S1000 T1 D1 M3 N20 G67 B3 I-60 R2 V100 F1000 S1000 T1 D1 M3 N30 G68 B-1 L0.5 J6 I-60 R2 V100 F500 S2000 T1 D1 M3 N40 G0 X15 Y0 Z0 G2 X15 Y0 I60 J0 G16 XZ G0 X15 Z0 N50 G3 X75 Z-60 R60

7.2.3 Half round (relief)





Half round (relief)

```
G0 Z100
G66 R10 C20 F30 S40 E50
G0 Z100
M30

N10 G67 B5 I-60 R2 V100 F1000 S1000 T1 D1 M3
N20 G67 B3 I-60 R2 V100 F1000 S1000 T1 D1 M3
N30 G68 B-1 L0.5 I-60 R2 V100 F500 S2000 T1 D1 M3

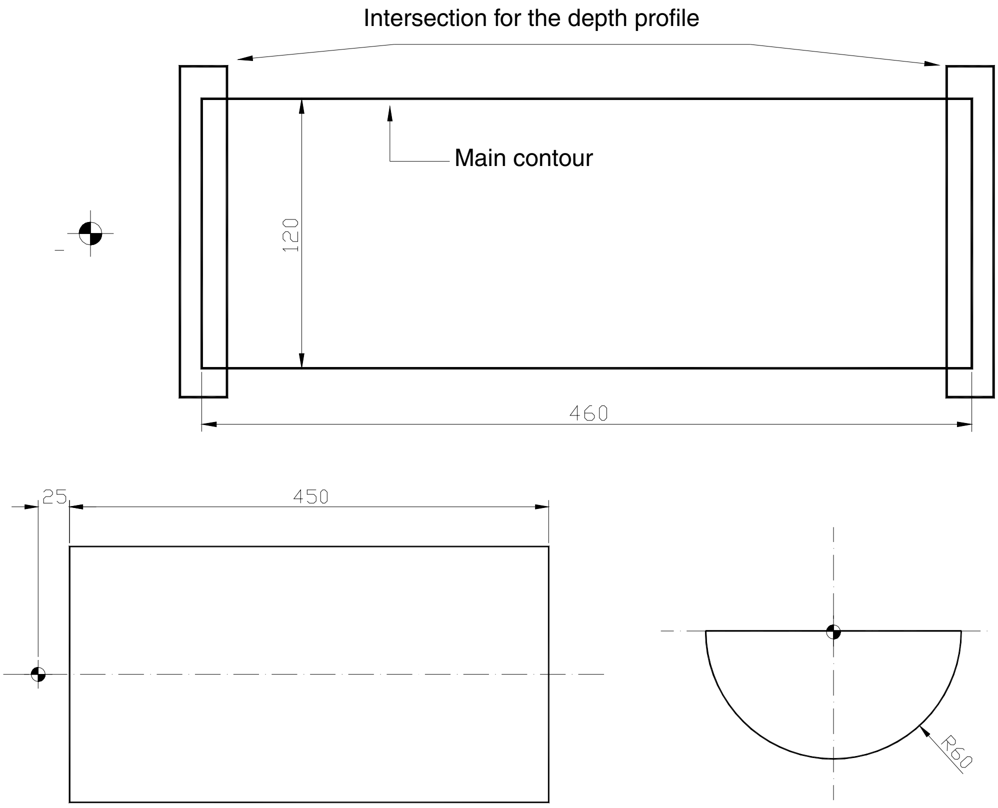
N40 G0 X0 Y0 Z0           ; External contour.
G1 Y150
X500
Y-150
X0
Y0
G16 XZ                    ; Depth plane.
G0 X0 Z0
G1 X0 Z-60

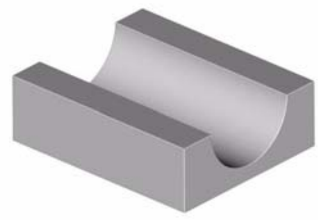
G16 XY                    ; External contour.
G0 X250 Y60
G1 X475
Y-60
X20
Y60
X250
G16 YZ                    ; Depth plane.
G0 Y60 Z-60
G3 Y0 Z0 R60

G16 XY                    ; Left intersection for the depth profile.
G0 X25 Y0
G1 Y65
X10
Y-65
X25
Y0
G16 XZ                    ; Depth plane.
G0 X25 Z0
G1 X25 Z-60

G16 XY                    ; Right intersection for the depth profile.
G0 X470 Y0
G1 Y65
X480
Y-65
X470
Y0
G16 XZ                    ; Depth plane.
G0 X470 Z0
N50 G1 X470 Z-60
```

7.2.4 Half round (emptied)





Half round (emptied)

```
G0 Z100
G66 R10 C20 F30 S40 E50
G0 Z100
M30

N10 G67 B5 I-60 R2 V100 F1000 S1000 T1 D1 M3
N20 G67 B3 I-60 R2 V100 F1000 S1000 T1 D1 M3
N30 G68 B-1 L0.5 J6 I-60 R2 V100 F500 S2000 T1 D1 M3

N40 G0 X250 Y60 Z0                          ; Main contour.
G1 X475
Y-60
X20
Y60
X250
G16 YZ
G0 Y60 Z0
G2 Y0 Z-60 R60

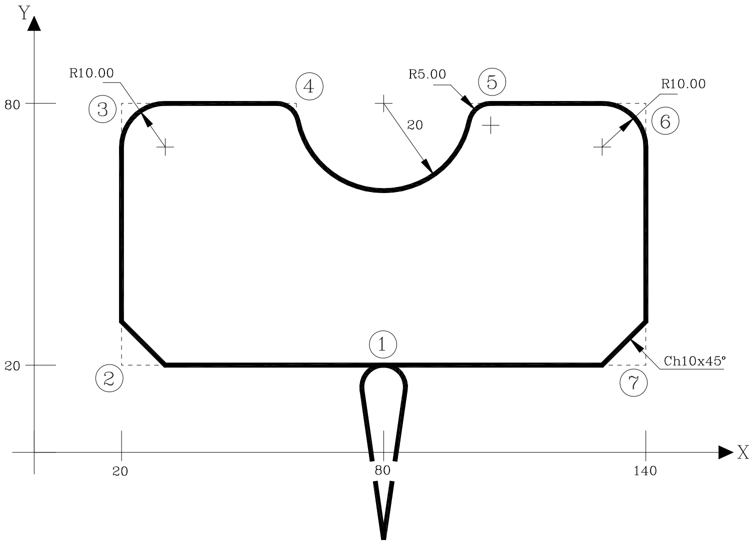
G16 XY                                      ; Intersection for the depth profile.
G0 X25 Y0
G1 Y65
X10
Y-65
X25
Y0
G16 XZ
G0 X25 Z0
G1 X25 Z-60

G16 XY                                      ; Intersection for the depth profile.
G0 X470 Y0
G1 Y65
X480
Y-65
X470
Y0
G16 XZ
G0 X470 Z0
N50 G1 X470 Z-60
```

PROFILE EDITOR

8

8.1 Profile 1



Profile definition without rounding, chamfers or tangential exit.

Starting point	X1: 80	Y1: -20			
Straight	X2: 80	Y2: 20			
Straight	X2: 20	Y2: 20			
Straight	X2: 20	Y2: 80			
Straight	X2: 60	Y2: 80			
Counterclockwise arc	X2: 100	Y2: 80	XC: 80	YC: 80	R: 20
Straight	X2: 140	Y2: 80			
Straight	X2: 140	Y2: 20			
Straight	X2: 80	Y2: 20			
Straight	X2: 80	Y2: -20			

Definition of rounding, chamfers and tangential entry and exit.

Select the CORNERS option and define:

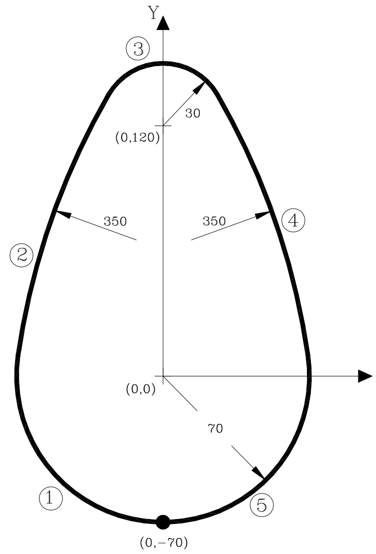
Tangential entry	Select point "1"	Press [ENTER]	Assign radius = 5
Chamfer	Select point "2"	Press [ENTER]	Assign size = 10
Rounding	Select point "3"	Press [ENTER]	Assign radius = 10
Rounding	Select point "4"	Press [ENTER]	Assign radius = 5
Rounding	Select point "5"	Press [ENTER]	Assign radius = 5
Rounding	Select point "6"	Press [ENTER]	Assign radius = 10
Chamfer	Select point "7"	Press [ENTER]	Assign size = 10
Tangential exit	Select point "1"	Press [ENTER]	Assign radius = 5

Press [ESC] to quit the CORNERS option.

End of editing

Press the softkeys FINISH + SAVE PROFILE The CNC quits the profile editing mode and the shows the ISO-coded program that has been generated.

8.2 Profile 2



Profile definition

Starting point	X1: 0	Y1: -70				
Clockwise arc (1)	XC: 0	YC: 0	R: 70			
Clockwise arc (2)	R: 350	Tang: Yes				
Clockwise arc (3)	XC: 0	YC: 120	R: 30	Tang: Yes		

The CNC shows all the possible solutions for section 2. Select the correct one.

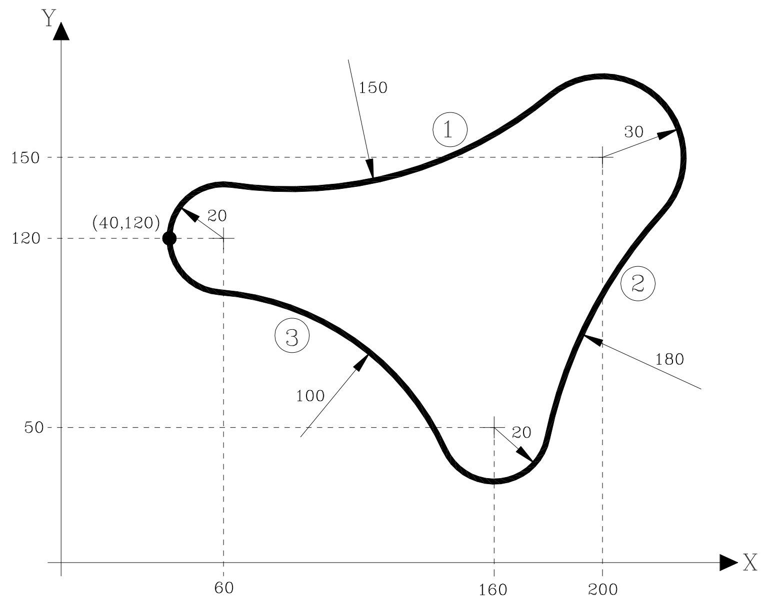
Clockwise arc (4)	R: 350	Tang: Yes				
Clockwise arc (5)	X2: 0	Y2: -70	XC: 0	YC: 0	R: 70	Tang: Yes

The CNC shows all the possible solutions for section 4. Select the correct one.

End of editing

Press the softkeys FINISH + SAVE PROFILE The CNC quits the profile editing mode and the shows the ISO-coded program that has been generated.

8.3 Profile 3



Profile definition

Starting point	X1: 40	Y1: 120			
Clockwise arc	XC: 60	YC:120	R: 20		
Counterclockwise arc (1)	R: 150	Tang: Yes			
Clockwise arc	XC: 200	YC: 150	R: 30	Tang: Yes	

The CNC shows all the possible solutions for section 1. Select the correct one.

Counterclockwise arc (2)	R: 180	Tang: Yes			
Clockwise arc	XC: 160	YC: 50	R: 20	Tang: Yes	

The CNC shows all the possible solutions for section 2. Select the correct one.

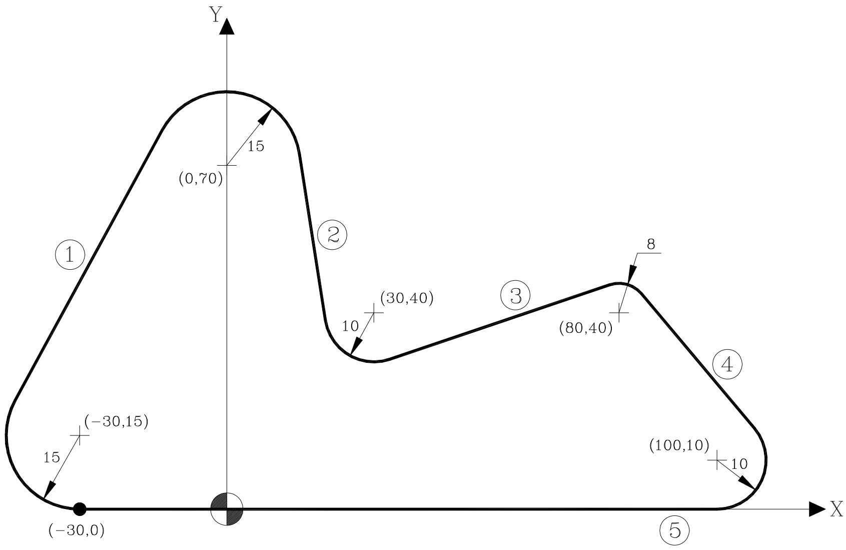
Counterclockwise arc (3)	R: 100	Tang: Yes			
Clockwise arc	X2: 40	Y2: 120	XC: 60	YC: 120	Tang: Yes

The CNC shows all the possible solutions for section 3. Select the correct one.

End of editing

Press the softkeys FINISH + SAVE PROFILE The CNC quits the profile editing mode and the shows the ISO-coded program that has been generated.

8.4 Profile 4



Profile definition

Starting point	X1: -30	Y1: 0		
Clockwise arc	XC: -30	YC: 15	R:15	
Straight (1)	Tang: Yes			
Clockwise arc	XC: 0	YC: 70	R: 15	Tang: Yes

The CNC shows all the possible solutions for section 1. Select the correct one.

Straight (2)	Tang: Yes			
Counterclockwise arc	XC: 30	YC: 40	R: 10	Tang: Yes

The CNC shows all the possible solutions for section 2. Select the correct one.

Straight (3)	Tang: Yes			
Clockwise arc	XC: 80	YC: 40	R: 8	Tang: Yes

The CNC shows all the possible solutions for section 3. Select the correct one.

Straight (4)	Tang: Yes			
Clockwise arc	XC: 100	YC: 10	R: 10	Tang: Yes

The CNC shows all the possible solutions for section 4. Select the correct one.

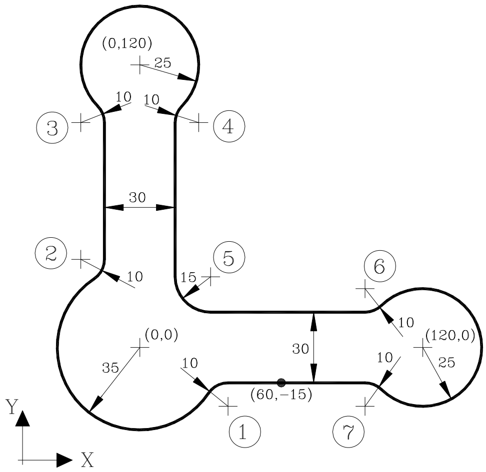
Straight (5)	X2: -30	Y2: 0	Tang: Yes

The CNC shows all the possible solutions for section 5. Select the correct one.

End of editing

Press the softkeys FINISH + SAVE PROFILE The CNC quits the profile editing mode and the shows the ISO-coded program that has been generated.

8.5 Profile 5



Profile definition

Starting point	X1: 60	Y1: -15		
Straight	Y2: -15	Ang: 180		
Counterclockwise arc (1)	R: 10	Tang: Yes		
Clockwise arc	XC: 0	YC: 0	R: 35	Tang: Yes

The CNC shows all the possible solutions for section 1. Select the correct one.

Counterclockwise arc (2)	R: 10	Tang: Yes	
Straight	X2: -15	Ang: 90	Tang: Yes

The CNC shows all the possible solutions for section 2. Select the correct one.

Counterclockwise arc (3)	R: 10	Tang: Yes		
Clockwise arc	XC: 0	YC: 120	R: 25	Tang: Yes

The CNC shows all the possible solutions for section 3. Select the correct one.

Counterclockwise arc (4)	R: 10	Tang: Yes	
Straight	X2: 15	Ang: 270	Tang: Yes

The CNC shows all the possible solutions for section 4. Select the correct one.

Counterclockwise arc (5)	XC: 30	R: 15	Tang: Yes
Straight	Y2: 15	Ang: 0	Tang: Yes

The CNC shows all the possible solutions for section 5. Select the correct one.

Counterclockwise arc (6)	R: 10	Tang: Yes		
Clockwise arc	XC: 120	YC: 0	R: 25	Tang: Yes

The CNC shows all the possible solutions for section 6. Select the correct one.

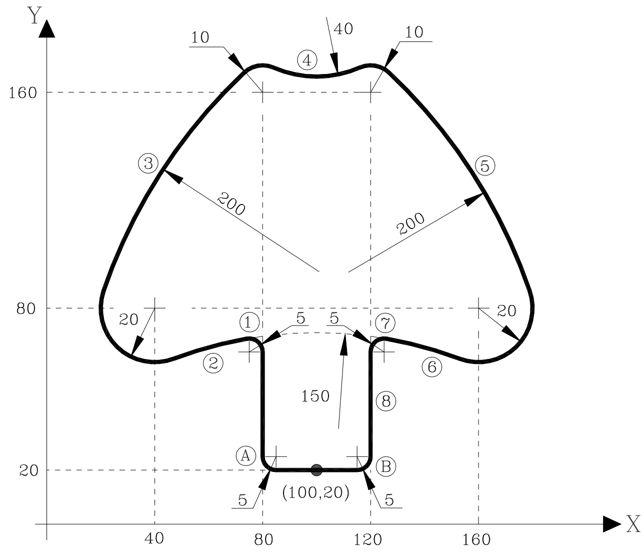
Counterclockwise arc (7)	R: 10	Tang: Yes		
Straight	X2: 60	Y2: -15	Ang: 0	Tang: Yes

The CNC shows all the possible solutions for section 7. Select the correct one.

End of editing

Press the softkeys FINISH + SAVE PROFILE The CNC quits the profile editing mode and the shows the ISO-coded program that has been generated.

8.6 Profile 6



Profile definition

Starting point	X1: 100	Y1: 20		
Straight	X2: 80	Y2: 20		
Straight	X2: 80	Ang: 90		
Counterclockwise arc (1)	XC: 75	R: 5	Tang: Yes	
Counterclockwise arc (2)	XC: 100	R: 150	Tang: Yes	
Clockwise arc	XC: 40	YC: 80	R: 20	Tang: Yes
The CNC shows all the possible solutions for section 2. Select the correct one.				
The CNC shows all the possible solutions for section 1. Select the correct one.				
Clockwise arc (3)	R: 200	Tang: Yes		
Clockwise arc	XC: 80	YC: 160	R: 10	Tang: Yes
The CNC shows all the possible solutions for section 3. Select the correct one.				
Counterclockwise arc (4)	R: 40	Tang: Yes		
Clockwise arc	XC: 120	YC: 160	R: 10	Tang: Yes
The CNC shows all the possible solutions for section 4. Select the correct one.				
Clockwise arc (5)	R: 200	Tang: Yes		
Clockwise arc	XC: 160	YC: 80	R: 20	Tang: Yes
The CNC shows all the possible solutions for section 5. Select the correct one.				
Counterclockwise arc (6)	XC: 100	R: 150	Tang: Yes	
The CNC shows all the possible solutions for section 6. Select the correct one.				
Counterclockwise arc (7)	XC: 125	R: 5	Tang: Yes	
The CNC shows all the possible solutions for section 7. Select the correct one.				
Straight (8)	X2: 120	Y2: 20	Tang: Yes	
The CNC shows all the possible solutions for section 8. Select the correct one.				
Straight	X2: 100	Y2: 20		

Definition of rounding "A" and "B".

Select the CORNERS option and define:

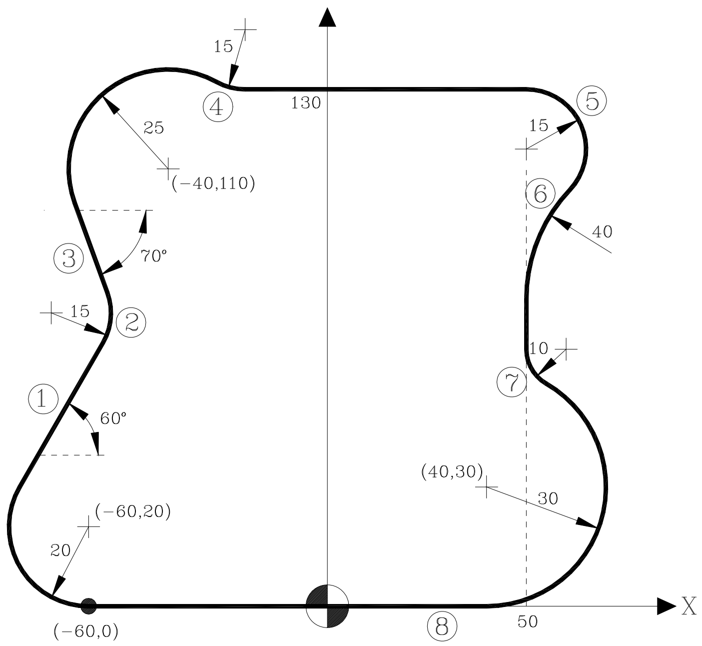
Rounding	Select point "A"	Press [ENTER]	Assign radius = 5
Rounding	Select point "B"	Press [ENTER]	Assign radius = 5

Press [ESC] to quit the CORNERS option.

End of editing

Press the softkeys FINISH + SAVE PROFILE The CNC quits the profile editing mode and the shows the ISO-coded program that has been generated.

8.7 Profile 7



Profile definition

Starting point	X1: -60	Y1: 0		
Clockwise arc	XC: -60	YC: 20	R: 20	
Straight (1)	Ang: 60	Tang: Yes		

The CNC shows all the possible solutions for section 1. Select the correct one.

Counterclockwise arc (2)	R: 15	Tang: Yes		
Straight (3)	Ang: -70	Tang: Yes		
Clockwise arc	XC: -40	YC: 110	R: 25	Tang: Yes

The CNC shows all the possible solutions for section 3. Select the correct one.

The CNC shows all the possible solutions for section 2. Select the correct one.

Counterclockwise arc (4)	R: 15	Tang: Yes	
Straight	Y2: 130	Ang: 0	Tang: Yes

The CNC shows all the possible solutions for section 4. Select the correct one.

Clockwise arc (5)	XC: 50	R: 15	Tang: Yes

The CNC shows all the possible solutions for section 5. Select the correct one.

Counterclockwise arc (6)	R: 40	Tang: Yes	
Straight	X2: 50	Ang: 270	Tang: Yes

The CNC shows all the possible solutions for section 6. Select the correct one.

Counterclockwise arc (7)	R: 10	Tang: Yes		
Clockwise arc	XC: 40	YC: 30	R: 30	Tang: Yes

The CNC shows all the possible solutions for section 7. Select the correct one.

Straight (8)	X2: -60	Y2: 0	Tang: Yes

The CNC shows all the possible solutions for section 8. Select the correct one.

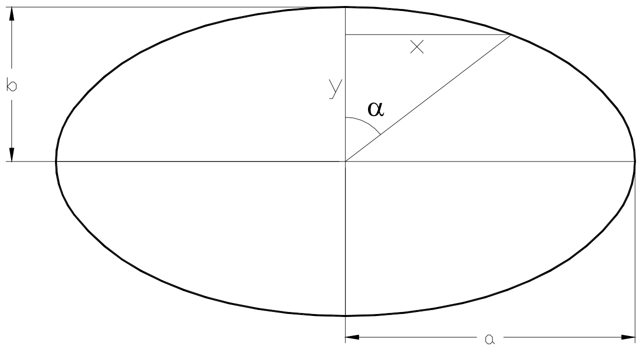
End of editing

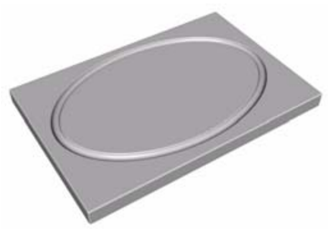
Press the softkeys FINISH + SAVE PROFILE The CNC quits the profile editing mode and the shows the ISO-coded program that has been generated.

PARAMETRIC PROGRAMMING

9

9.1 Ellipse





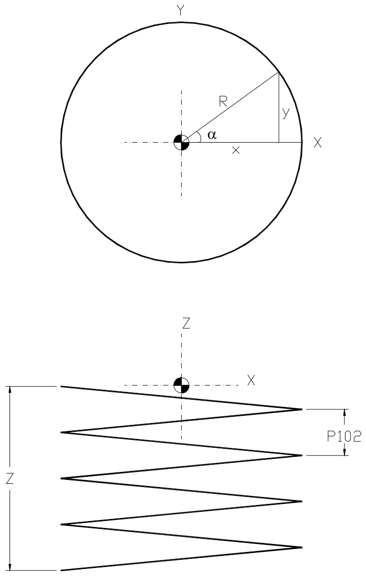
Ellipse
Formula of the ellipse X = a · sin α. Y = b · cos α. **Program** (P100 = 0) ; Starting angle. (P101 = 360) ; Final angle. (P102 = 0.5) ; Angular step. (P103 = 100) ; Semimajor axis (X). (P104 = 50) ; Semiminor axis (Y). T1 D1 G0 G43 Z100 S2000 M3 Y P104 Z5 G1 Z0 F100 G1 Z-5 F100 N1 (P120 = SIN P100 * P103, P121 = COS P100 * P104) N2 G1 X P120 Y P121 F500 (P100 = P100 + P102) (IF P100 LT P101 GOTO N1) (P100 = P101) (RPT N1, N2) G0 Z100 M30

When changing the sine by the cosine, it machines in the opposite direction.

To make circles P103 = P104. When using the angular position, use COS instead of SIN.

The ellipse program has many variations depending on the position of the ellipse and on whether it is a full ellipse or it is going to end at a particular angle. To calculate the XY positions, it uses the values of the semiminor axis and semimajor axis with the sine and cosine formulae.

9.2 Helical interpolation



Helical interpolation

Formula

X = R · cos α
Y = R · sin α

Program

```
(P100 = 0)              ; Starting angle.
(P101 = -2)             ; Angular step (- clockwise, + counterclockwise).
(P102 = 3)              ; Step in Z.
(P103 = 20)             ; final Z.
(P104 = 50)             ; Radius of the circle.
(P105 = 5)              ; Tool radius.
(P106 = 360)            ; Total rotation angle.
(P107 = 0)              ; Starting Z.
(P104 = P104 - P105)    ; For inside interpolation.
                        ; For outside interpolations (P104 = P104 + P105).

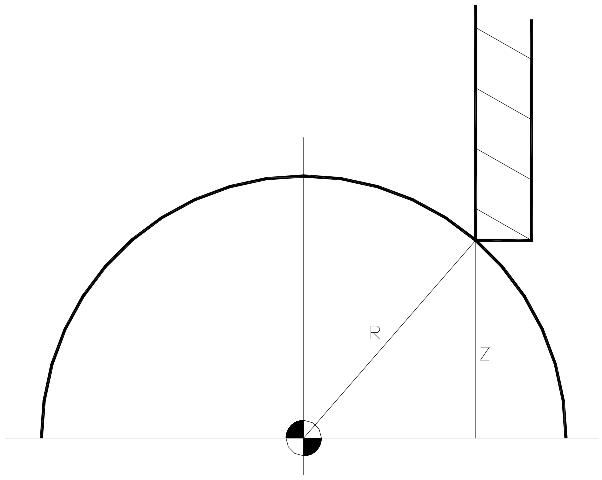

(P120 = P106 / P101, P121 = P102 / P120, P121 = ABS P121); (360 / 2 = 180, 3 / 180 = 0.016)

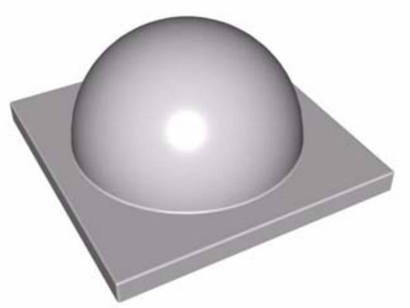
T1 D1
G0 G43 Z100 S2000 M3
X0 Y0
Z5
G1 Z P107 F100
N1 (P130 = P104 * COS P100, P131 = P104 * SIN P100)
X P130 Y P131 Z - P107 F500
(P100 = P100 + P101, P107 = P107 + P121)
(IF P107 LE P103 GOTO N1)
X0 Y0
G0 Z100
M30
```

This program does a helical interpolation combining the movement of the three axes whose values have been previously calculated in X and in Y using trigonometric formulae. The Z value is calculated dividing the desired step by the number of angular steps in a full revolution.

Once the initial movement is executed, it increments both the XY angle and the down movement in Z. Finally, it compares the starting Z with the final Z to start running the program.

9.3 Semi-sphere (flat tool)





Semi-sphere with a flat tool

Formula

X = R · cos α
Z = R · sin α

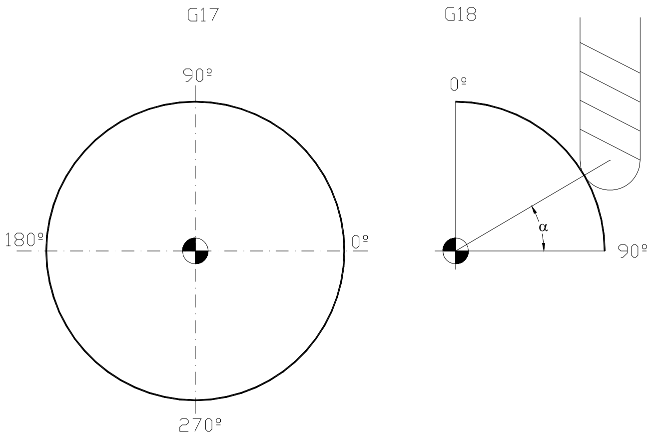
Program

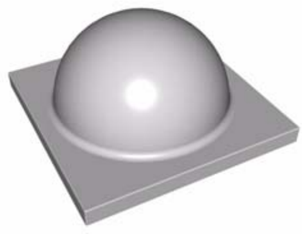
```
(P100 = 90)          ; Starting angle.
(P101 = 0)           ; Final angle.
(P102 = 2)           ; Angular step.
(P103 = 100)         ; Radius of the circle.
(P104 = 5)           ; Tool radius.

T1 D1
G0 G43 Z100 S2000 M3
X0 Y0
N1 (P120 = P103 * COS P100, P121 = P103 * SIN P100)
(P120 = P120 + P104)
G1 X P120 Y0 Z P121 F500
G93 I0 J0
N2 G2 Q360
(P100 = P100 - P102)
(IF P100 GT P101 GOTO N1)
(P100 = P101)
(RPT N1, N2)
G0 Z100
M30
```

The semi-sphere with a flat tool is carried out from top to bottom, thus going around it, it combines the XZ position that is calculated with the sine and cosine formula and the starting and final angle. Being a flat tool, its radius must be compensated for every X position.

9.4 Semi-sphere (spherical tool)





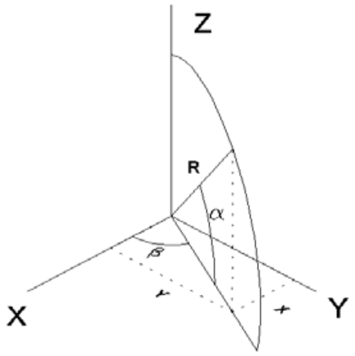
Semi-sphere with a spherical tool

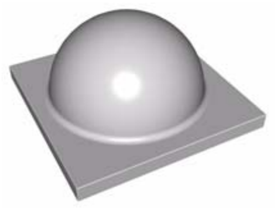
```
(P100 = 1)                  ; Starting angle.
(P101 = 3.3)                ; Angular step.
(P102 = 90)                 ; Final angle.
(P103 = 25)                 ; Sphere radius.
(P104 = 3)                  ; Tool radius.
(P105 = P103+P104)          ; Tool Compensation.

T1 D1
G0 G43 Z100
F1000 S2000 M3
X0 Y0 Z50
N1 G18
G15 Z
G93 I0 J0
G1 RP105 QP100
G17
G93 I0 J0
N2 G2 Q360
(P100 = P100 + P101)        ; Angular step.
(IF P100 LT P102 GOTO N1)
(P100 = P102)
(RPT N1,N2)
G0 Z10
M30
```

The starting angle P100 cannot be zero because a circle cannot be machined with a zero radius. The program is generated in Polar coordinates. The program makes down movements in arc in the ZX plane and, then, changes the work plane to XY to make circular movements and so on until completing the sphere. It also self-adjusts the last pass even when it is not a multiple of the angular step, because 3.3 is not a multiple of 90.

9.5 Semi-sphere (spherical coordinates)





Semi-sphere programmed in spherical coordinates

```
(P100=90)                          ; Starting angle α.
(P101=0)                           ; Final angle α.
(P102=5)                           ; Angular step α.
(P103=0)                           ; Starting angle β.
(P104=360)                         ; Final angle β.
(P105=5)                           ; Angular step β.
(P106=40)                          ; Radius of the circle.
(P107=5)                           ; Tool radius.
(P106=P106 + P107)
(P120=P120 - P106)

G0 Z100 D1
N5 (P100=90)
(P101=0)
N1 (P120=SIN P100 * P106)          ; Movement in Z.
(P120=P120 - P106)
(P130=P106 * COS P100)
(P121=P130 * COS P103)             ; Movement in Y.
(P122=P130 * SIN P103)             ; Movement in X.

N2 G1 XP122 YP121 ZP120 F800
(P100=P100 - P102)
(IF P100 GT P101 GOTO N1)
(P100=P101)

N7 (RPT N1,N2)
(P103=P103 + P105)
(IF P103 GT P104 GOTO N6)

N9 (P100=0)
(P101=90)

N3 (P120=SIN P100 * P106)          ; Movement in Z.
(P120=P120 - P106)
(P130=P106 * COS P100)
(P121=P130 * COS P103)             ; Movement in Y.
(P122=P130 * SIN P103)             ; Movement in X.

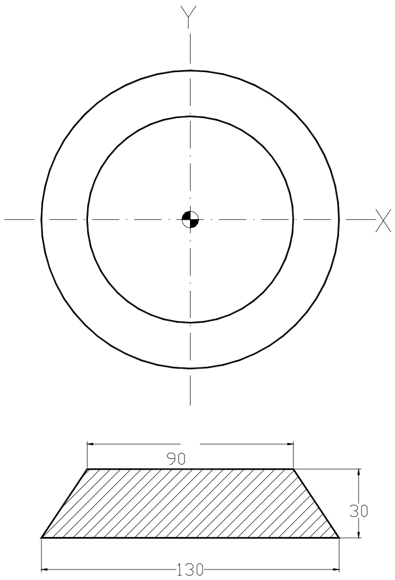
N4 G1 XP122 YP121 ZP120
(P100=P100 + P102)
(IF P100 LT P101 GOTO N3)
(P100=P101)
```

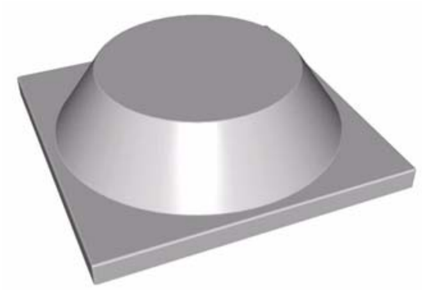
```
N10 (RPT N3,N4)
(P103=P103 + P105)
(IF P103 LT P104 GOTO N5)
(P103=P104)
(RPT N5,N7)
M30


N6 (P103=P104)                      ; Second possible ending.
(RPT N9,N10)
M30
```

This program is more complex because it uses two angular positions to achieve a semi-sphere making a vertical zig-zag movement. It has two possible endings because it can finish up or down.

9.6 Truncated cone





Truncated cone

```
(P100=65)                                      ; Movement in X.
(P101=30)                                      ; Height.
(P102=20)                                      ; X of the triangle.
(P103=5)                                       ; Tool radius.
(P104=0)                                       ; Starting radius.
(P105=1)                                       ; Radial step.
(P100=P100+P103)

(P120=P101/P102)                               ; Angle tangent.
(P130=ATAN P120)                               ; Taper angle.

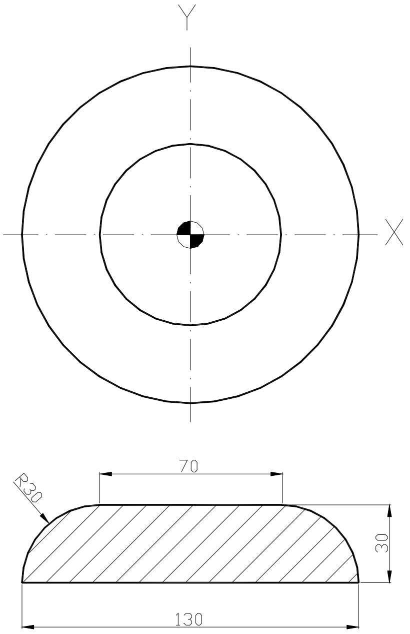
G0 Z100 S1000 D1 M3
X80 Y Z5

N1 (P131=COS P130 * P104, P132=SIN P130 * P104) ; X Z of the triangle.
(P133=P100 - ABS P131)                         ; Compensated X.
(P132=P132 - P101)                             ; Compensated Z.
(P140=P102 / COS P130)                         ; final radius.

G1 XP133 Y ZP132 F800
G93 IJ
N2 G3 Q0
(P104=P104 + P105)
(IF P104 LT P140 GOTO N1)
(P104=P140)
(RPT N1,N2)
G0 Z100
M30
```

Program carried out by increasing the taper radius, calculating the XZ position and making a full circle in XY in every positioning move. The program is executed from bottom up and it compares the starting radius with the final radius.

9.7 Solid toroid



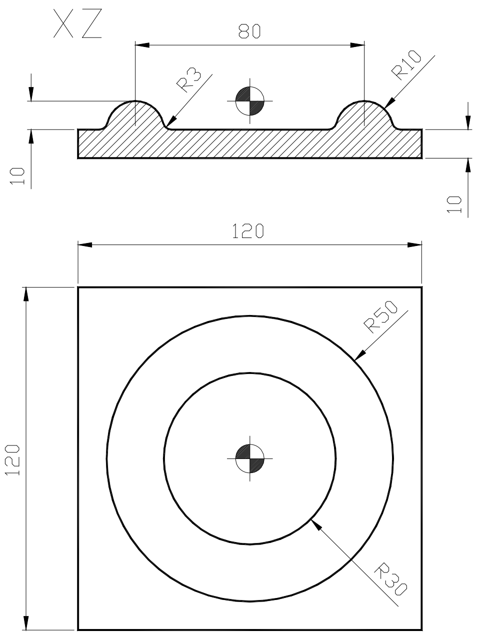
Solid toroid

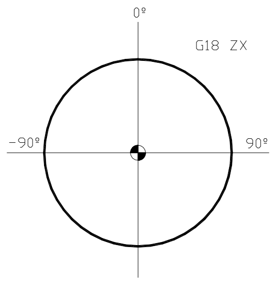
```
(P100 = 0)                    ; Starting angle.
(P101 = 90)                   ; Final angle.
(P102 = 5)                    ; Angular step.
(P103 = 30)                   ; Radius of the circle.
(P104 = 35)                   ; Movement in X.
(P105 = 5)                    ; Tool radius.
(P104 = P104 + P105)          ; Tool Compensation.

G0 Z100 D1
X50 Y
N1 (P120 = P103 * COS P100, P121 = P103 * SIN P100)
(P121 = P121 - P103)
(P120 = P120 + P104)
G1 XP120 Y0 ZP121 F800
N2 G93 I J
G3 Q0
(P100 = P100 + P102)
(IF P100 LT P101 GOTO N1)
(P100 = P101)
(RPT N1,N2)
G0 Z100
M30
```

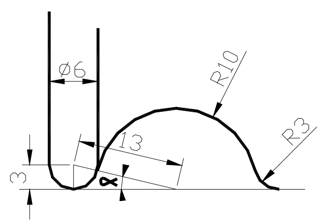
The program is carried out by calculating the X and Z positions using the sine and cosine formulae, comparing the starting angle (0º) with the final angle (90º). That's why it is machined from the outside and from the bottom up. The full circle is programmed in Polar coordinates in each position.

9.8 Circular toroid





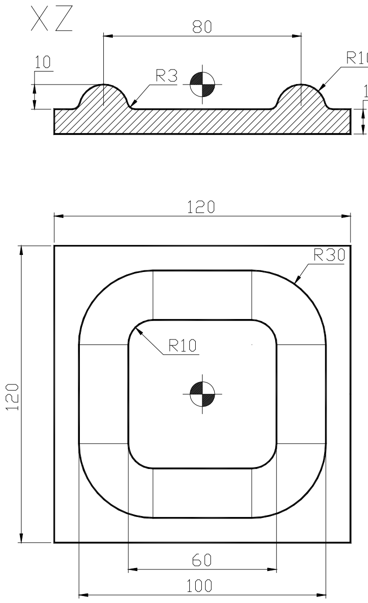
Circular toroid (male)	Circular toroid (female)	
(P130 = ASIN (3/13))		
(P100 = -90 + P130)	(P100 = 270 + P130)	; Starting angle.
(P101 = 90 - P130)	(P101 = 90 - P130)	; Final angle.
(P102 = 7)	(P102 = 7)	; Angular step.
(P103 = 10)	(P103 = 10)	; Radius of the toroid.
(P104 = 3)	(P104 = 3)	; Tool radius.
(P105 = - P103)	(P105 = - P103)	; Polar center in Z.
(P106 = 40)	(P106 = 40)	; Polar center in X.
(P120 = P103 + P104)	(P120 = P103 - P104)	
T1 D1	T1 D1	
G0 G43 Z100 S2000 M3	G0 G43 Z100 S2000 M3	
X0 Y0	X0 Y0	
N1 G18	N1 G18	
G15 Z	G15 Z	
G93 I P105 J P106	G93 I P105 J P106	
G1 R P120 Q P100	G1 R P120 Q P100	
G17	G17	
G93 I0 J0	G93 I0 J0	
N2 G3 Q360	N2 G3 Q360	
(P100 = P100 + P102)	(P100 = P100 - P102)	
(IF P100 LT P101 GOTO N1)	(IF P100 GT P101 GOTO N1)	
(P100 = P101)	(P100 = P101)	
(RPT N1, N2)	(RPT N1, N2)	
G0 Z100	G0 Z100	
M30	M30	

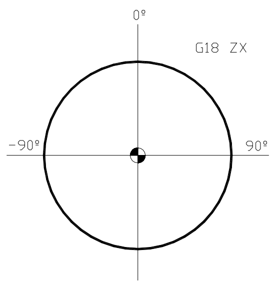


P130=ASIN 3 / 13

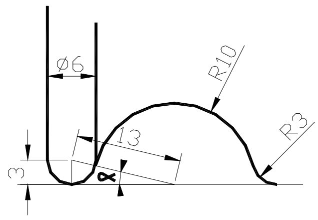
Program written in Polar coordinates with XZ plane change and without having to calculate the XZ positions. It must be pointed out that the angles are arranged differently in the G18 plane than the angles in XY.

9.9 Rectangular toroid



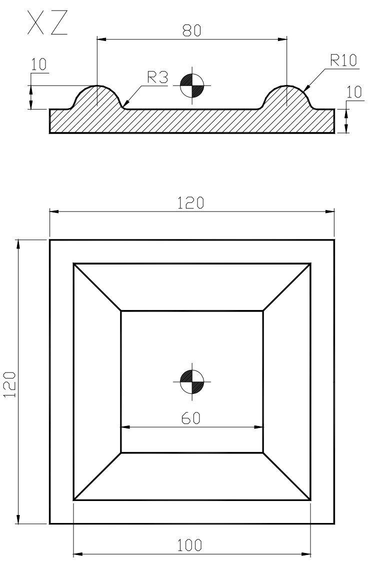


Rectangular toroid (male)	Rectangular toroid (female)	
(P130=ASIN (3 / 13))	(P130=ASIN (3 / 13))	
(P100 = -90 + P130)	(P100 = 270 + P130)	; Starting angle.
(P101 = 90 - P130)	(P101 = 90 - P130)	; Final angle.
(P102 = 7)	(P102 = 7)	; Angular step.
(P103 = 10)	(P103 = 10)	; Radius of the toroid.
(P104 = 3)	(P104 = 3)	; Tool radius.
(P105 = - P103)	(P105 = - P103)	; Polar center in Z.
(P106 = 40)	(P106 = 40)	; Polar center in X.
(P120 = P103 + P104)	(P120 = P103 - P104)	
T1 D1	T1 D1	
G0 G43 Z100 S2000 M3	G0 G43 Z100 S2000 M3	
X0 Y0	X0 Y0	
N1 G18	N1 G18	
G15 Z	G15 Z	
G93 I P105 J P106	G93 I P105 J P106	
G1 R P120 Q P100	G1 R P120 Q P100	
G17	G17	
G1 Y20	G1 Y20	
G6 G3 Q90 I20 J20	G6 G3 Q90 I20 J20	
G1 X -20	G1 X -20	
G6 G3 Q180 I -20 J20	G6 G3 Q180 I -20 J20	
G1 Y -20	G1 Y -20	
G6 G3 Q -90 I -20 J -20	G6 G3 Q -90 I -20 J -20	
G1 X20	G1 X20	
G6 G3 Q0 I20 J -20	G6 G3 Q0 I20 J -20	
N2 G1 Y0	N2 G1 Y0	
(P100 = P100 + P102)	(P100 = P100 - P102)	
(IF P100 LT P101 GOTO N1)	(IF P100 GT P101 GOTO N1)	
(P100 = P101)	(P100 = P101)	
(RPT N1, N2)	(RPT N1, N2)	
G0 Z100	G0 Z100	
M30	M30	



P130=ASIN 3 / 13

9.10 Straight rectangular toroid

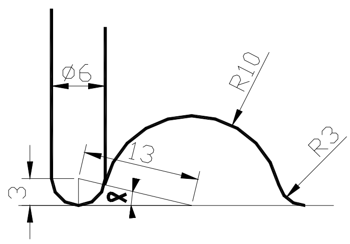


Straight rectangular toroid

```
(P120=ASIN (3 / 13))

(P100=90 - P120)          ; Starting angle.
(P101=-90 + P120)         ; Final angle.
(P102=1.7)                ; Angular step.
(P103=40)                 ; Polar center in X.
(P104=10)                 ; Polar center in Z.
(P105=30)                 ; Half movement.
(P106=3)                  ; Tool radius.
(P107=P104 + P106)        ; Compensation.

G0 Z100 S1000 M3
X50 Y
N1 G18
G15 Z
G93 I - P104 J P103
G1 R P107 Q P100
(P108=PPOSX)
G17
G1 Y P108
X - P108
Y - P108
X P108
N2 Y
(P100=P100 - P102)
(IF P100 GT P101 GOTO N1)
(P100=P101)
(RPT N1,N2)
G0 Z100
M30
```



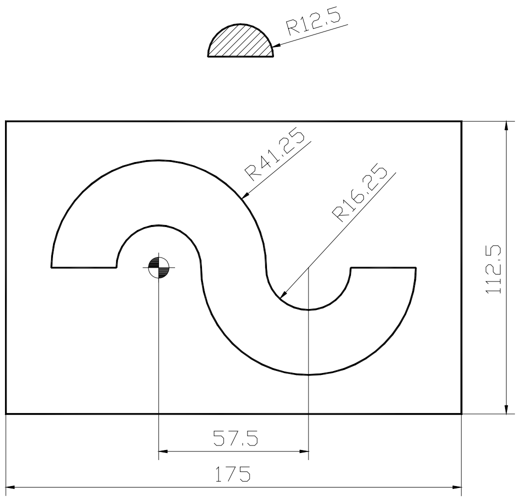
P120=ASIN 3 / 13

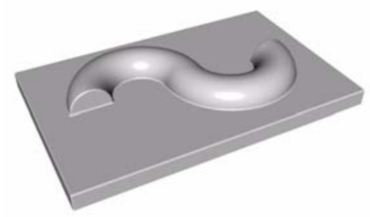
P120 is the angle that is calculated so the tool does not run into the bottom of the part and does not leave any marking on it.

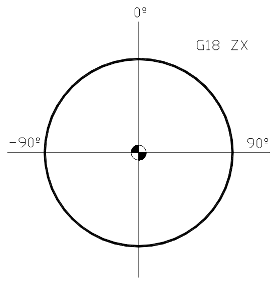
G15 Z is used to apply the tool length compensation on the Z axis even when changing the work plane.

This part is machined by going around it from the outside in. Parameter P108 is used to save the value of the X coordinate and then use this value, that will be variable, to program the square in XY. The profile of the half-round is defined by changing the work plane to G18 (ZX).

9.11 Toroid in "S"







Toroid in "S"

```
(P100 = -90)              ; Starting angle (flat tool 0).
(P101 = 0)                ; Final angle (flat tool 90).
(P102 = 7)                ; Angular step.
(P103 = 12.5)             ; "S" radius.
(P104 = 3)                ; Tool radius.
(P105 = 86.25)            ; Polar center in X.
(P120 = P103 + P104)      ; Only for spherical tool.

T1 D1
G0 G43 Z100 S2000 M3
X0 Y0
```

Spherical tool

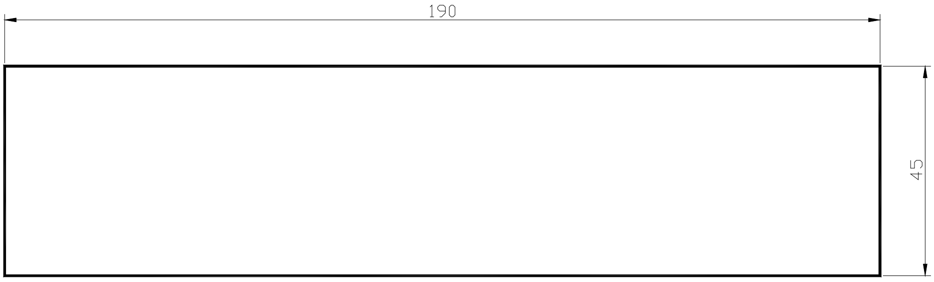
```
N1 G18
G15 Z
G93 I -12.5 J -28.75
G1 R P120 Q P100
```

Flat tool

```
(P130= P103 * COS P100, P131= P103 * SIN P100)
(P132= P130 - 28.75, P133= P132 + P104)
N1 X P133 Y 0 Z P131
```

```
G17
G93 I 0 J 0
G2 Q 0
G93 I 57.5 J 0
G3 Q 0
(P121= PPOSX, P122= P105 - P121)
(P123= P122 + P105)
G1 X P123
G2 Q 180
G93 I 0 J 0
N2 G3 Q 180
(P100 = P100 + P102)
(IF P100 LT P101 GOTO N1)
(P100 = P101)
(RPT N1, N2)
G0 Z100
M30
```

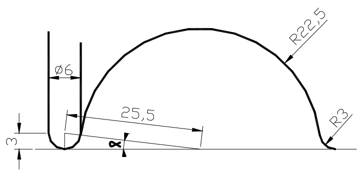
9.12 Straight cylinder



Straight cylinder

```
(P130=ASIN (3 / 25.5))
(P100 = 180)          ; Starting angle.
(P101 = 0)            ; Final angle.
(P102 = 2)            ; Angular step.
(P103 = 22.5)         ; Radius of the tube.
(P104 = 3)            ; Tool radius.
(P120 = P103+ P104)   ; Tool Compensation.

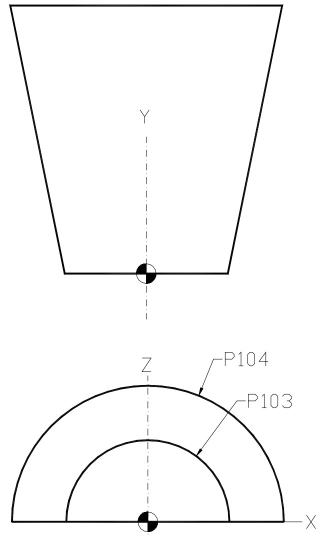

T1 D1
G0 G43 Z100 S2000 M3
X0 Y0
N1 G19
G15 Z
G93 I0 J0
G1 R P120 Q P100 F500
N2 G17
X190
(P100 = P100 - P102)
(IF P100 LT P101 GOTO N4)
N3 G19
G15 Z
G93 I0 J0
G1 R P120 Q P100
N5 G17
X0
(P100 = P100 - P102)
(IF P100 GT P101 GOTO N1)
(P100 = P101)
(RPT N1, N2)
G0 Z100
M30
N4 (P100 = P101)
(RPT N3, N5)
G0 Z100
M30
```

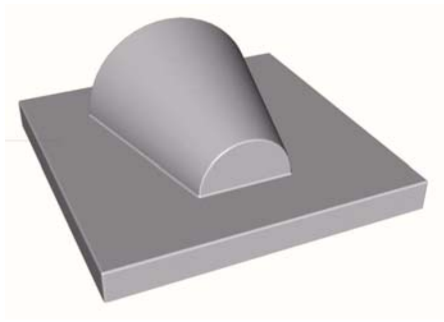


P130=ASIN 3 / 25.5

This cylinder is programmed in zig-zag with YZ plane change in Polar coordinates and with a tool having a round tip.

9.13 Taper cylinder

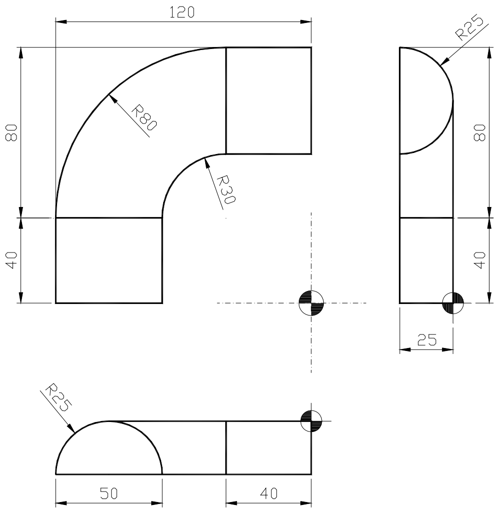


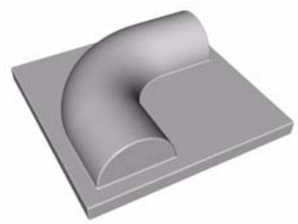


Taper cylinder
(P100 = 0) ; Starting angle. (P101 = 90) ; Final angle. (P102 = 5) ; Angular step. (P103 = 20) ; Small radius. (P104 = 60) ; Large radius. (P105 = 5) ; Tool radius. G0 Z100 D1 X50 Y N1 (P120 = P103 * COS P100, P121 = P103 * SIN P100) (P121 = P121 - P104) (P120 = P120 + P105) G1 XP120 Y-P105 ZP121 F800 Y0 (P130 = P104 * COS P100, P131 = P104 * SIN P100) (P131 = P131 - P104) (P130 = P130 + P105) XP130 Y100 ZP131 Y105 X-P130 Y100 X-P120 Y ZP121 Y-5 N2 XP120 (P100 = P100 + P102) (IF P100 LT P101 GOTO N1) (P100 = P101) (RPT N1,N2) G0 Z100 M30

This example is programmed using a double test because it has a small radius and a large radius and we have to calculate the X and Z position using the sine and cosine formula for one radius and for the other radius. Once the positions have been calculated, it goes around the part in XY from the outside up. This program is very versatile because different geometrical shapes may be obtained such as a half round or swap the large radius with the small radius or vice versa.

9.14 Angled cylinder

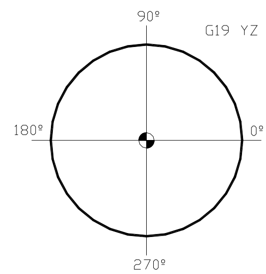


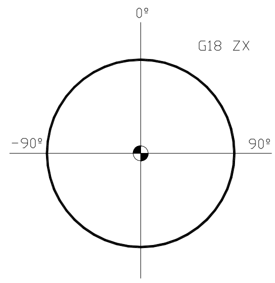


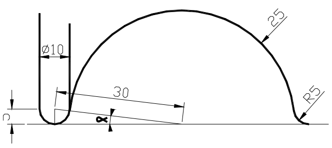
Angled cylinder

```
(P130 = ASIN (5/30))
(P100 = 90 - P130)          ; Starting angle G18.
(P101 = -90 + P130)         ; Final angle G18.
(P102 = 180 - P130)         ; Starting angle G19.
(P103 = 0 + P130)           ; Final angle G19.
(P104 = 7)                  ; Angular step.
(P105 = 25)                 ; Radius of the angle.
(P106 = 5)                  ; Tool radius.
(P120 = P105 + P106)

G0 G43 Z100 S2000 T1 D1 M3
X0 Y0
N1 G18
G15 Z
G93 I -25 J -95
G1 R P120 Q P100
G17
G1 Y 40
G93 I -40 J 40
G2 Q 90
N2 G1 X 0
(P100= P100 - P104, P102= P102 - P104)
(IF P102 LT P103 GOTO N5)
N3 G19
G15 Z
G93 I 95 J -25
G1 R P120 Q P102
G17
X -40
G93 I -40 J 40
G3 Q 180
N4 G1 Y 0
(P100=P100 - P104, P102= P102 - P104)
(IF P100 GT P101 GOTO N1)
(P100 = P101)
(RPT N1, N2)
G0 Z100
M30
N5 (P102 = P103)
(RPT N3, N4)
G0 Z100
M30
```







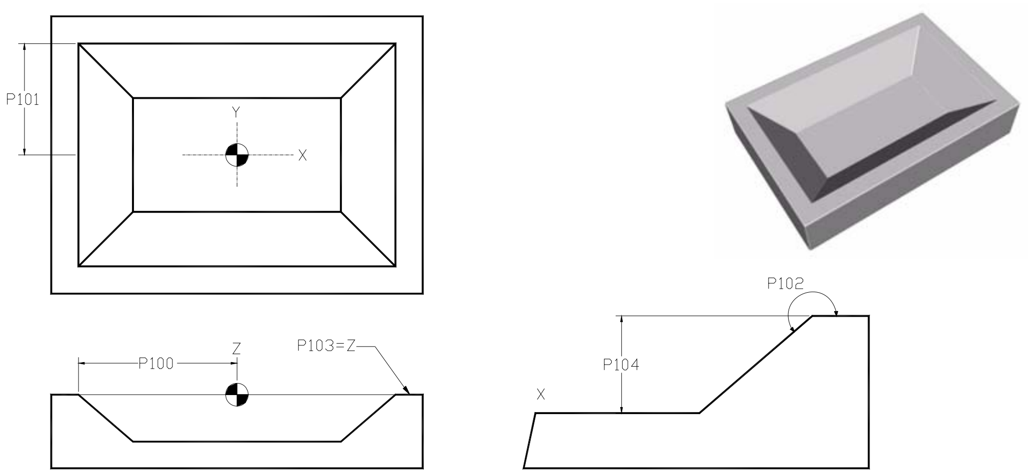
P130=ASIN 5 / 30

9. PARAMETRIC PROGRAMMING
Angled cylinder

FAGOR
·M· Model

The program is written with a plane change in XZ for the first semi-circle and in YZ for the second semi-circle. It is machined in zig-zag from the bottom up and the program has two endings. It is machined with a spherical tool.

9.15 Rectangular pocket with incline walls



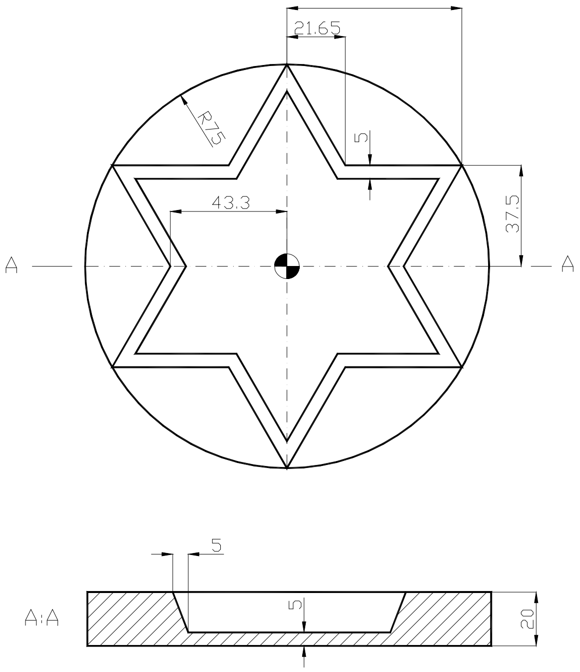
Rectangular pocket with incline walls

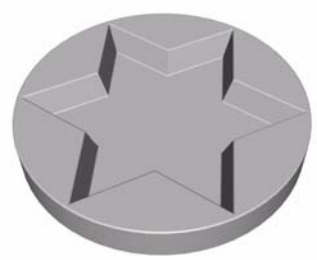
```
(P100=100)                  ; Semi axis X.
(P101=70)                   ; Semi axis Y.
(P102=250)                  ; Angle.
(P103=0)                    ; Starting Z.
(P104=-30)I.                ; final Z.
(P105=2)                    ; Step in Z.
(P106=5)                    ; Tool radius.

G0 Z100
T1 D1
X Y S1000 M3
N1 (P120=P103 / TAN P102)   ; Step in axes.
(P121=P100 + P120)          ; Movement in X.
(P121=P121 - P106)          ; Compensated X.
(P122=P101 + P120)          ; Movement in Y.
(P122=P122 - P106)          ; Compensated Y.
G1 XP121 Y ZP103
YP122
X-P121
Y-P122
XP121
N2 Y
(P103=P103 - P105)
(IF P103 GT P104 GOTO N1)
(P103=P104)
(RPT N1,N2)
G0 Z100
M30
```

The program for this pocket with an incline profile is mainly based on the inclination angle of the walls. This angle is then used in the trigonometrical formula of the tangent to calculate the step in the XY axes. The execution is carried out from Z0 to Z-30, comparing the starting Z with the final Z. The sign of the angle determines whether it is an outside or an inside pocket.

9.16 Pocket in the shape of a star





Pocket in the shape of a star

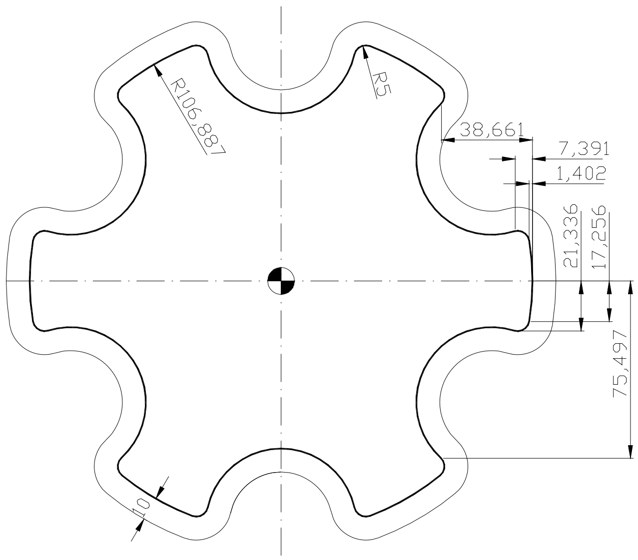
```
(P100=20)                                  ; Degrees of inclination.
(P101=15)                                  ; Depth.
(P102=8)                                   ; Number of repetitions.
(P140=TAN P100 * P101)                     ; Movement in X.
(P141=P140 / P102)                         ; Step in X.
(P142=P101 / P102)                         ; Step in Z.
(P120=COS 30 * 75, P121=SIN 30 * 75)       ; Movement in X Y.
(TOR 1=5)
(P130=P120 / 3)
(P123=P120 / 3)
(P123=P123 * 2)

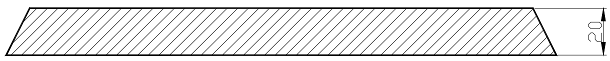
G0 Z100 S1000 T1 D1 M3
X 30 Y 10
Z0
N1 G1 G91 Z - P142 F100
G90 G41 G1 X P123 Y P121 F800 D1
X P130
X Y 75
X - P130 Y P121
X - P120
X - P123 Y
X - P120 Y - P121
X - P130
X Y - 75
X P130 Y - P121
X P120
X P123 Y
X P120 Y P121
X P123
(TOR 1=TOR 1 + P141)
G40 X 30 Y 10
N2 (P102=P102 - 1)
(RPT N1,N2) N P102
G0 Z100
M30
```

Program that combines the inclination angle with the depth and the number of repetitions with the depth. The inclination of the profile is achieved by changing the tool radius with parameter P141.

The simulation of the program in theoretical tool path shows straight down, but the simulation with "G" functions will show the inclination at each down movement getting further and further away from the part.

9.17 Profile in the shape of a star





Profile in the shape of a star

```
(P100=10)                    ; Movement in X.
(P101=20)                    ; Movement in Z.
(P104=25)                    ; Number of divisions.
(P105=P100/P104)             ; Step in X.
(P106=P101/P104)             ; Step in Z.

(TOR1=5)

G0 Z100 S1000 D1 M3
X 99.496 Y - 50
Z5
Z0
N1 G1 G91 Z - P106 F100
G1 G90 G42 Y - 21.336 F 800 D1
N4 G3 X 105.485 Y - 17.256 R5
X 105.485 Y 17.256 R 106.887
X 99.496 Y 21.336 R5
G8 X 68.226 Y 75.497
N2 G73 Q60
(RPT N4,N2) N5
(TOR1=TOR1+P105)
N3 G40 G1 X 99.496 Y - 50
(P104=P104-1)
(RPT N1,N3) N P104
G0 Z100
M30
```

This program has the peculiarity of being carried out by combining parametric programming with a pattern rotation (coordinate rotation) function (G73). The side inclination is obtained by setting the tool radius by parameter to make it larger and larger every time so the CNC separates the tool progressively from the part. The key to this exercise is the G42, because this function is the one that allows the compensation movement. Another peculiarity of this example is the setting of the number of repetitions for down movements in Z by parameter to achieve the total depth.

SCREEN CUSTOMIZING PROGRAMS

10

10.1 Machine diagnosis

This example indicates:

- How to create a user screen customizing program.
- How to create a user page (screen).
- How to create a user symbol.

In order for a screen customizing program to be executed in the user channel of the jog mode, general machine parameter "USERMAN" must be set with the program number.

For better understanding, the explanation is divided into several parts showing the program portion and the creation of the relevant pages (screens) and symbols. These parts are:

1. Request a password.
2. Show the status of inputs I1 through I40.

   (Uses user page 2 and symbols 21 and 22).
3. Show the status of outputs O1 through O18.

   (Uses user page 3 and symbols 21 and 22).
4. Show the consumption of the motors.

   (Uses user page 4 and symbols 0 through 20).

Use the [page up] and [page down] keys to scroll a page at a time.

10.1.1 Requesting the password

```
N100 (IB1= INPUT "PASSWORD = ", 6)
; Requests the password.
(IF IB1 NE (123456) GOTO N100)
; If the password is wrong (123456), it requests it again.
N200
; If it is correct, it goes on with the program on line N200 (part 2).
```

10.1.2 Shows the status of inputs I1 through I40.

Program lines (main program):

```
N200 (PAGE2)           ; Shows page 2.
(KEY=0)                ; Clears the memory of the key pressed last.
N210 (P100=PLCI1)      ; It assigns the value of inputs I1 through I32 to parameter P100.
(P199=85)              ; Row to place the symbol.
(CALL 2)               ; Call to a subroutine (it places symbols).
(P100=PLCI11)          ; It assigns the value of inputs I1 through I42 to parameter P100.
(P199=155)             ; Row to place the symbol.
(CALL 2)               ; Call to a subroutine (it places symbols).
(P100=PLCI21)          ; It assigns the value of inputs I21 through I52 to parameter P100.
(P199=225)             ; Row to place the symbol.
(CALL 2)               ; Call to a subroutine (it places symbols).
(P100=PLCI31)          ; It assigns the value of inputs I31 through I62 to parameter P100.
(P199=295)             ; Row to place the symbol.
(CALL 2)               ; Call to a subroutine (it places symbols).
(IF KEY EQ $FFAF GOTO N300)
    ; If the "page down" key has been pressed, continue in N300 (part 3).
(GOTO N210)            ; If not, it refreshes the input status.
```

Program lines (subroutine that indicates the status of a row of inputs):

This subroutine checks the 10 least significant bits of parameter P100. If the bit is set to 1, it places symbol 21 (red lamp on) and if it is set to 0, it places symbol 22 (lamp off, background color).

Call parameters:

- P100 = Value of the inputs to be displayed.
- P199 = Row to place the symbosl.

```
( SUB 2)
    (IF (P100 AND 1) EQ 0 SYMBOL 22,80,P199 ELSE SYMBOL 21,80,P199)
    (IF (P100 AND 2) EQ 0 SYMBOL 22.130,P199 ELSE SYMBOL 21.130,P199)
    (IF (P100 AND 4) EQ 0 SYMBOL 22.180,P199 ELSE SYMBOL 21.180,P199)
    (IF (P100 AND 8) EQ 0 SYMBOL 22.230,P199 ELSE SYMBOL 21.230,P199)
    (IF (P100 AND $10) EQ 0 SYMBOL 22,280,P199 ELSE SYMBOL 21,280,P199)
    (IF (P100 AND $20) EQ 0 SYMBOL 22,330,P199 ELSE SYMBOL 21,330,P199)
    (IF (P100 AND $40) EQ 0 SYMBOL 22,380,P199 ELSE SYMBOL 21,380,P199)
    (IF (P100 AND $80) EQ 0 SYMBOL 22,430,P199 ELSE SYMBOL 21,430,P199)
    (IF (P100 AND $100) EQ 0 SYMBOL 22,480,P199 ELSE SYMBOL 21,480,P199)
    (IF (P100 AND $200) EQ 0 SYMBOL 22,530,P199 ELSE SYMBOL 21,530,P199)
(RET)
```

Editing symbols 21 and 22:

Access the screen customizing mode and select: [Utilities] [Editor] [Symbol] (symbol Nr.) [Enter]

Symbol 21
Background color: Navy blue. Main color: Red. Line Solid fine. Filled circle Center: X10 Y10. Move to : X10 Y15.

Symbol 22
Background color: Navy blue. Main color: Navy blue. Line Solid fine. Filled circle Center: X10 Y10. Move to : X10 Y15.

Editing page 2:

Access the screen customizing mode and select: [Utilities] [Edit] [Page] 2 [Enter]

Select background color: Navy blue.

Edit the following texts:

Main color	Size	Text	Position
White	Large	INPUTS	X226 Y10
Red	Large	INPUTS	X224 Y8
White	Small	I1	X80 Y70
White	Small	I2	X130 Y70
White	Small	I3	X180 Y70
White	Small	I4	X230 Y70
White	Small	I5	X280 Y70
White	Small	I6	X330 Y70
White	Small	I7	X380 Y70
White	Small	I8	X430 Y70
White	Small	I9	X480 Y70
White	Small	I10	X530 Y70
White	Small	I11	X80 Y140
White	Small	I12	X130 Y140
White	Small	I13	X180 Y140
White	Small	I14	X230 Y140
White	Small	I15	X280 Y140
White	Small	I16	X330 Y140
White	Small	I17	X380 Y140
White	Small	I18	X430 Y140
White	Small	I19	X480 Y140

Main color	Size	Text	Position
White	Small	I20	X530 Y140
White	Small	I21	X80 Y210
White	Small	I22	X130 Y210
White	Small	I23	X180 Y210
White	Small	I24	X230 Y210
White	Small	I25	X280 Y210
White	Small	I26	X330 Y210
White	Small	I27	X380 Y210
White	Small	I28	X430 Y210
White	Small	I29	X480 Y210
White	Small	I30	X530 Y210
White	Small	I31	X80 Y280
White	Small	I32	X130 Y280
White	Small	I33	X180 Y280
White	Small	I34	X230 Y280
White	Small	I35	X280 Y280
White	Small	I36	X330 Y280
White	Small	I37	X380 Y280
White	Small	I38	X430 Y280
White	Small	I39	X480 Y280
White	Small	I40	X530 Y280

Edit the following circles (not filled) using white as the main color and a solid fine line:

Main color	Center	Move to :
White	X90 Y95	X90 Y102
White	X140 Y95	X140 Y102
White	X190 Y95	X190 Y102
White	X240 Y95	X240 Y102
White	X290 Y95	X290 Y102
White	X340 Y95	X340 Y102
White	X390 Y45	X390 Y102
White	X440 Y95	X440 Y102
White	X490 Y95	X490 Y102
White	X540 Y95	X540 Y102
White	X90 Y165	X90 Y172
White	X140 Y165	X140 Y172
White	X190 Y165	X190 Y172
White	X240 Y165	X240 Y172
White	X290 Y165	X290 Y172
White	X340 Y165	X340 Y172
White	X390 Y165	X390 Y172
White	X440 Y165	X440 Y172
White	X490 Y165	X490 Y172
White	X540 Y165	X540 Y172
White	Small	I19

Main color	Center	Move to :
White	X90 Y235	X90 Y242
White	X140 Y235	X140 Y242
White	X190 Y235	X190 Y242
White	X240 Y235	X240 Y242
White	X290 Y235	X290 Y242
White	X340 Y235	X340 Y242
White	X390 Y235	X390 Y242
White	X440 Y235	X440 Y242
White	X490 Y235	X490 Y242
White	X540 Y235	X540 Y242
White	X90 Y305	X90 Y312
White	X140 Y305	X140 Y312
White	X190 Y305	X190 Y312
White	X240 Y305	X240 Y312
White	X290 Y305	X290 Y312
White	X340 Y305	X340 Y312
White	X390 Y305	X390 Y312
White	X440 Y305	X440 Y312
White	X490 Y305	X490 Y312
White	X540 Y305	X540 Y312

10.1.3 Shows the status of outputs O1 through O18.

Program lines (main program):

```
N300 (PAGE3)              ; Shows page 3.
(KEY = 0 )                ; Clears the memory of the key pressed last.
N310 (P100=PLCO1)         ; It assigns the value of outputs O1 through O32 to parameter P100.
(P199=85)                 ; Row to place the symbol.
(CALL 3)                  ; Call to a subroutine (it places symbols).
(P100=PLCO10)             ; It assigns the value of outputs O10 through O41 to parameter P100.
(P199=155)                ; Row to place the symbol.
(CALL 3)                  ; Call to a subroutine (it places symbols).
(IF KEY EQ $FFA5 GOTO N200)
    ; If the "page up" key has been pressed, continue in N200 (part 2).
(IF KEY EQ $FFAF GOTO N400)
    ; If the "page down" key has been pressed, continue in N400 (part 4).
(GOTO N310)
    ; If not, it refreshes the output status.
```

Program lines (subroutine that indicates the status of a row of outputs):

This subroutine checks the 10 least significant bits of parameter P100. If the bit is set to 1, it places symbol 21 (red lamp on) and if it is set to 0, it places symbol 22 (lamp off, background color).

Call parameters:

- P100 = Value of the outputs to be displayed.
- P199 = Row to place the symbosl.

```
( SUB 3)
    (IF (P100 AND 1) EQ 0 SYMBOL 22.105,P199 ELSE SYMBOL 21.105,P199)
    (IF (P100 AND 2) EQ 0 SYMBOL 22.155,P199 ELSE SYMBOL 21.155,P199)
    (IF (P100 AND 4) EQ 0 SYMBOL 22.205,P199 ELSE SYMBOL 21.205,P199)
    (IF (P100 AND 8) EQ 0 SYMBOL 22.255,P199 ELSE SYMBOL 21.255,P199)
    (IF (P100 AND $10) EQ 0 SYMBOL 22,305,P199 ELSE SYMBOL 21,305,P199)
    (IF (P100 AND $20) EQ 0 SYMBOL 22,355,P199 ELSE SYMBOL 21,355,P199)
    (IF (P100 AND $40) EQ 0 SYMBOL 22,405,P199 ELSE SYMBOL 21,405,P199)
    (IF (P100 AND $80) EQ 0 SYMBOL 22,455,P199 ELSE SYMBOL 21,455,P199)
    (IF (P100 AND $100) EQ 0 SYMBOL 22,505,P199 ELSE SYMBOL 21,505,P199)
(RET)
```

Editing page 3

Access the screen customizing mode and select: [Utilities] [Edit] [Page] 3 [Enter]

Select background color: Navy blue.

Edit the following texts:

Main color	Size	Text	Position
White	Large	OUTPUTS	X235 Y10
Red	Large	OUTPUTS	X233 Y8
White	Small	O1	X105 Y70
White	Small	O2	X155 Y70
White	Small	O3	X205 Y70
White	Small	O4	X255 Y70
White	Small	O5	X305 Y70
White	Small	O6	X355 Y70
White	Small	O7	X405 Y70
White	Small	O8	X455 Y70

Main color	Size	Text	Position
White	Small	O9	X505 Y70
White	Small	O10	X105 Y140
White	Small	O11	X155 Y140
White	Small	O12	X205 Y140
White	Small	O13	X255 Y140
White	Small	O14	X305 Y140
White	Small	O15	X355 Y140
White	Small	O16	X405 Y140
White	Small	O17	X455 Y140
White	Small	O18	X505 Y140

Edit the following circles (not filled) using white as the main color and a solid fine line.

Main color	Center	Move to :
White	X115 Y95	X115 Y102
White	X165 Y95	X165 Y102
White	X215 Y95	X215 Y102
White	X265 Y95	X265 Y102
White	X315 Y95	X315 Y102
White	X365 Y95	X365 Y102
White	X415 Y95	X415 Y102
White	X465 Y95	X465 Y102
White	X515 Y95	X515 Y102

Main color	Center	Move to :
White	X115 Y165	X115 Y172
White	X165 Y165	X165 Y172
White	X215 Y165	X215 Y172
White	X265 Y165	X265 Y172
White	X315 Y165	X315 Y172
White	X365 Y165	X365 Y172
White	X415 Y165	X415 Y172
White	X465 Y165	X465 Y172
White	X515 Y165	X515 Y172

10.1.4 Shows the consumption of the motors

Velocity drives have an analog output (0 to 0 V) proportional to the current consumed by the motor.

The following connections have been made in this example:

- The current output of the X axis drive is connected to CNC's analog input 1.
- The current output of the Y axis drive is connected to CNC's analog input 2.
- The current output of the Z axis drive is connected to CNC's analog input 3.
- The current output of the spindle drive (S) is connected to CNC's analog input 4.

Therefore, variables "ANAI1", "ANAI2", "ANAI3" and "ANAI4" show the analog voltage for the currents of the X, Y, Z axes and spindle S.

21 symbols (0 through 20) are used to show the value of the current in 0.5V increments.

To select the right symbol each time, apply the formula "ABS ROUND (ANAI1/0.5)"; in other words, the absolute value of the rounded result of the operation "ANAI1/0.5".

Program lines:

```
N400 (PAGE 4)
     ; Shows page 4
(KEY = 0)
     ; Clears the memory of the key pressed last.
N410 (SYMBOL ABS ROUND (ANAI1/0.5), 130, 120)
(SYMBOL ABS ROUND (ANAI2/0.5), 130, 170)
(SYMBOL ABS ROUND (ANAI3/0.5), 130, 220)
(SYMBOL ABS ROUND (ANAI3/0.5), 130, 270)
(IF KEY EQ $FFA5 GOTO N300)
     ; If the "page up" key has been pressed, continue in N300 (part 3).
(GOTO N410)
     ; If not, it refreshes the consumption of the motors.
```

Editing symbols 0 and 20

Access the screen customizing mode and select: [Utilities] [Editor] [Symbol] (symbol Nr.) [Enter]

	FILLED RECTANGLE								FINE SOLID LINE					
	Green		Yellow		Red		Grey		Green		Yellow		Red	
	From	to	From	to	From	to	From	to	From	to	From	to	From	to
SYMBOL 0	---	---	---	---	---	---	X0 Y0	X400 Y30	X100 Y0	X100 Y30	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 1	X0 Y0	X20 Y30	---	---	---	---	X20 Y0	X400 Y30	X100 Y0	X100 Y30	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 2	X0 Y0	X40 Y30	---	---	---	---	X40 Y0	X400 Y30	X100 Y0	X100 Y30	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 3	X0 Y0	X60 Y30	---	---	---	---	X60 Y0	X400 Y30	X100 Y0	X100 Y30	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 4	X0 Y0	X80 Y30	---	---	---	---	X80 Y0	X400 Y30	X100 Y0	X100 Y30	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 5	X0 Y0	X100 Y30	---	---	---	---	X100 Y0	X400 Y30	---	---	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 6	X0 Y0	X120 Y30	---	---	---	---	X120 Y0	X400 Y30	---	---	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 7	X0 Y0	X140 Y30	---	---	---	---	X140 Y0	X400 Y30	---	---	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 8	X0 Y0	X160 Y30	---	---	---	---	X160 Y0	X400 Y30	---	---	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 9	X0 Y0	X180 Y30	---	---	---	---	X180 Y0	X400 Y30	---	---	X200 Y0	X200 Y30	X300 Y0	X300 Y30
SYMBOL 10	X0 Y0	X200 Y30	---	---	---	---	X200 Y0	X400 Y30	---	---	---	---	X300 Y0	X300 Y30
SYMBOL 11	X0 Y0	X200 Y30	X200 Y0	X220 Y30	---	---	X220 Y0	X400 Y30	---	---	---	---	X300 Y0	X300 Y30
SYMBOL 12	X0 Y0	X200 Y30	X200 Y0	X240 Y30	---	---	X240 Y0	X400 Y30	---	---	---	---	X300 Y0	X300 Y30
SYMBOL 13	X0 Y0	X200 Y30	X200 Y0	X260 Y30	---	---	X260 Y0	X400 Y30	---	---	---	---	X300 Y0	X300 Y30
SYMBOL 14	X0 Y0	X200 Y30	X200 Y0	X280 Y30	---	---	X280 Y0	X400 Y30	---	---	---	---	X300 Y0	X300 Y30
SYMBOL 15	X0 Y0	X200 Y30	X200 Y0	X300 Y30	---	---	X300 Y0	X400 Y30	---	---	---	---	---	---
SYMBOL 16	X0 Y0	X200 Y30	X200 Y0	X300 Y30	X300 Y0	X320 Y30	X320 Y0	X400 Y30	---	---	---	---	---	---
SYMBOL 17	X0 Y0	X200 Y30	X200 Y0	X300 Y30	X300 Y0	X340 Y30	X340 Y0	X400 Y30	---	---	---	---	---	---
SYMBOL 18	X0 Y0	X200 Y30	X200 Y0	X300 Y30	X300 Y0	X360 Y30	X360 Y0	X400 Y30	---	---	---	---	---	---
SYMBOL 19	X0 Y0	X200 Y30	X200 Y0	X300 Y30	X300 Y0	X380 Y30	X380 Y0	X400 Y30	---	---	---	---	---	---
SYMBOL 20	X0 Y0	X200 Y30	X200 Y0	X300 Y30	X300 Y0	X400 Y30	---	---	---	---	---	---	---	---

Editing page 4:

Access the screen customizing mode and select: [Utilities] [Edit] [Page] 4 [Enter]

Select background color: Navy blue.

Edit the following texts:

Main color	Size	Text	Position
White	Large	CONSUMPTION OF THE MOTORS	X64 Y10
Red	Large	CONSUMPTION OF THE MOTORS	X62 Y8
White	Medium	X	X95 Y120
White	Medium	Y	X95 Y170
White	Medium	Z	X95 Y220

Main color	Size	Text	Position
White	Medium	S	X95 Y270
White	Small	25%	X220 Y80
White	Small	50%	X320 Y80
White	Small	75%	X420 Y80

Edit the following graphic elements with a solid fine line type.

Main color	Element	1st corner	2ndt corner
White	Not filled rectangle	X129 Y119	X531 Y151
White	Not filled rectangle	X129 Y169	X531 Y201
White	Not filled rectangle	X129 Y219	X531 Y251
White	Not filled rectangle	X129 Y269	X531 Y301

Main color	Element	1st corner	2ndt corner
Green	Solid line	X230 Y100	X230 Y320
Yellow	Solid line	X330 Y100	X330 Y320
Red	Solid line	X430 Y100	X430 Y320

10.1.5 Whole program

```
; Part 1 (password)
  N100 (IB1= INPUT "PASSWORD = ", 6)
  (IF IB1 NE (123456) GOTO N100)
  ;
; Part 2 (input status)
  N200 (PAGE2)
  (KEY = 0)
  N210 (P100=PLCI1)
  (P199=85)
  (CALL 2)
  (P100=PLCI11)
  (P199=155)
  (CALL 2)
  (P100=PLCI21)
  (P199=225)
  (CALL 2)
  (P100=PLCI31)
  (P199=295)
  (CALL 2)
  (IF KEY EQ $FFAF GOTO N300)
  (GOTO N210)
  ;
  (SUB 2)
     (IF (P100 AND 1) EQ 0 SYMBOL 22,80,P199 ELSE SYMBOL 21,80,P199)
     (IF (P100 AND 2) EQ 0 SYMBOL 22,130,P199 ELSE SYMBOL 21,130,P199)
     (IF (P100 AND 4) EQ 0 SYMBOL 22,180,P199 ELSE SYMBOL 21,180,P199)
     (IF (P100 AND 8) EQ 0 SYMBOL 22,230,P199 ELSE SYMBOL 21,230,P199)
     (IF (P100 AND $10) EQ 0 SYMBOL 22,280,P199 ELSE SYMBOL 21,280,P199)
     (IF (P100 AND $20) EQ 0 SYMBOL 22,330,P199 ELSE SYMBOL 21,330,P199)
     (IF (P100 AND $40) EQ 0 SYMBOL 22,380,P199 ELSE SYMBOL 21,380,P199)
     (IF (P100 AND $80) EQ 0 SYMBOL 22,430,P199 ELSE SYMBOL 21,430,P199)
     (IF (P100 AND $100) EQ 0 SYMBOL 22,480,P199 ELSE SYMBOL 21,480,P199)
     (IF (P100 AND $200) EQ 0 SYMBOL 22,530,P199 ELSE SYMBOL 21,530,P199)
  (RET)
  ;
; Part 3 (output status)
  N300 (PAGE3)
  (KEY = 0)
  N310 (P100=PLCO1)
  (P199=85)
  (CALL 3)
  (P100=PLCO10)
  (P199=155)
  (CALL 3)
  (IF KEY EQ $FFA5 GOTO N200)
  (IF KEY EQ $FFAF GOTO N400)
  (GOTO N310)
  ;
  (SUB 3)
     (IF (P100 AND 1) EQ 0 SYMBOL 22,105,P199 ELSE SYMBOL 21,105,P199)
     (IF (P100 AND 2) EQ 0 SYMBOL 22,155,P199 ELSE SYMBOL 21,155,P199)
     (IF (P100 AND 4) EQ 0 SYMBOL 22,205,P199 ELSE SYMBOL 21,205,P199)
     (IF (P100 AND 8) EQ 0 SYMBOL 22,255,P199 ELSE SYMBOL 21,255,P199)
     (IF (P100 AND $10) EQ 0 SYMBOL 22,305,P199 ELSE SYMBOL 21,305,P199)
     (IF (P100 AND $20) EQ 0 SYMBOL 22,355,P199 ELSE SYMBOL 21,355,P199)
     (IF (P100 AND $40) EQ 0 SYMBOL 22,405,P199 ELSE SYMBOL 21,405,P199)
     (IF (P100 AND $80) EQ 0 SYMBOL 22,455,P199 ELSE SYMBOL 21,455,P199)
     (IF (P100 AND $100) EQ 0 SYMBOL 22,505,P199 ELSE SYMBOL 21,505,P199)
  (RET)
  ;
```

; Part 4 (consumption of the motors)

```
N400 (PAGE 4)
(KEY = 0)
N410 (SYMBOL ABS ROUND (ANAI1/0.5), 130, 120)
(SYMBOL ABS ROUND (ANAI2/0.5), 130, 170)
(SYMBOL ABS ROUND (ANAI3/0.5), 130, 220)
(SYMBOL ABS ROUND (ANAI4/0.5), 130, 270)
(IF KEY EQ $FFA5 GOTO N300)
(GOTO N410)
```

10.2 Slot milling

This example indicates:

- How to create a subroutine for milling the slot.

  In the example, the program contains a subroutine for milling the slot (subroutine 55).

  The user must define the dimensions of the slot before calling this subroutine.

- How to create a user screen customizing program.

  In order for this program to be executed in the user channel of the editing mode, general machine parameter "USEREDIT" must be set with the program number.

  Once all the data of the slot has been defined, this program generates, in the program being edited, the necessary blocks to mill the slot just defined.

- How to create a user page (screen).

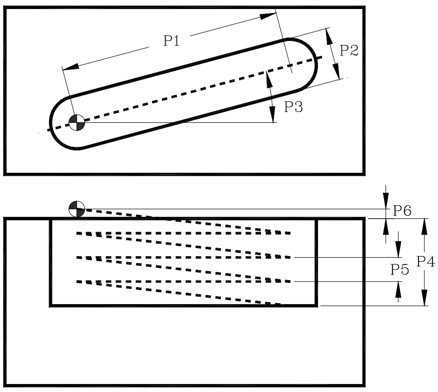
  This program uses page 50. This is the page (screen) that the CNC displays when selecting the "user editor" option in the editing mode.

Subroutine for milling the slot (Subroutine 55):

The subroutine executes the following operations:

1. It assumes the calling point as the new part zero.
2. It mills the slot.
   - Penetrate in Z all the way to the bottom running equal passes.
   - Milling of the walls while the end mill is at the bottom of the slot.
   - Withdrawal to the calling point.
3. It restores the part zero it had before milling the slot.

The subroutine calling parameters are:



P1 = Length of the slot.

P2 = Width of the slot.

P3 = Slot rotation angle.

P4 = Total depth of the slot.

P5 = Penetration step.

P6 = Approach coordinate.

Parameters used in this program, P100 through P110.

Program lines of the subroutine:

```
( SUB 55)
;
; It assumes the calling point as the new part zero.
;
(P100=PPOSX, P101=PPOSY, P102=PPOSZ)         ; Saves current position.
G92 XYZ                                      ; Presets the new part zero.
;
; Penetrate in Z all the way to the bottom of the hole. Equal passes.
;
(P5=(P4+P6)/(FUP((P4+P6)/P5)))               ; Penetrating stepequal passes.
(P103=P1*COS P3, P104=P1*SIN P3)             ; Components per axis.
N10 G01 G91 G01 XP103 YP104 Z-P5 F150        ; Basic penetration, section 1.
X-P103 Y-P104                                ; Basic penetration, section 2.
(IF (PPOSZ NE -(P4+P6)) GOTO N10)            ; If it has not reached the bottom, it
                                               repeats the basic one.
;
Milling of the walls while the end mill is at the bottom of the slot.
;
(P105=P2*SIN P3, P106=P2*COS P3, P107=P105/2, P108=P106/2)
G1 G41 XP107 Y-P108
XP103 YP104                                  ; Side milling. Inicio.
G3 X-P105 YP106 I-P107 JP108
G1 X-P103 Y-P104
G3 XP105 Y-P106 IP107 J-P108                 ; Side milling. End.
;
; Withdrawal to the calling point. Recupera el cero pieza.
;
G0 G90 G40 X Y Z
G92 XP100 YP101 ZP102
(RET)
```

Editing page 50.

Access the screen customizing mode and select: [Utilities] [Edit] [Page] 50 [Enter]

Select background color: Black.

Edit the following texts:

Main color	Size	Text	Position
White	Large	SLOT MILLING CANNED CYCLE	X72 Y10
Red	Large	SLOT MILLING CANNED CYCLE	X70 Y8
Yellow	Small	Parameters of the canned cycle	X360 Y72
Light blue	Small	Tool number	X288 Y96
Light blue	Small	(T)	X440 Y96
Light blue	Small	Tool offset number	X288 Y112
Light blue	Small	(D)	X440 Y112
Red	Small	Starting point X	X288 Y144
Red	Small	(X)	X440 Y144
Red	Small	Starting point Y	X288 Y160
Red	Small	(Y)	X440 Y160
Red	Small	Starting point Z	X288 Y176
Red	Small	(Z)	X440 Y176

Main color	Size	Text	Position
Red	Small	Approach coordinate	X288 Y192
Red	Small	(P6)	X440 Y192
Purple	Small	Length of the slot	X288 Y224
Purple	Small	(P1)	X440 Y224
Purple	Small	Width of the slot	X288 Y240
Purple	Small	(P2)	X440 Y240
Purple	Small	Rotation angle	X288 Y256
Purple	Small	(P3)	X440 Y256
Yellow	Small	Total depth	X288 Y288
Yellow	Small	(P4)	X440 Y288
Yellow	Small	Penetration step	X288 Y304
Yellow	Small	(P5)	X440 Y304

Edit the next graphic element:

Line type: Solid thick.

Main color: Yellow.

From point (X320 Y90) to (X592 Y90).

Create the figure using graphic elements.

10.2.1 User screen customizing program

```
;————————————————————————————————————————
; Initialization of variables.
;————————————————————————————————————————
(IB0=(0))
(IB1=(0))
(IB2=(0))
(IB3=(0))
(IB4=(0))
(IB5=(0))
(IB6=(0))
(IB7=(0))
(IB8=(0))
(IB9=(0))
(IB10=(0))
(IB11=(0))

;————————————————————————————————————————
; Displays page 50 and the windows on the screen.
;————————————————————————————————————————
(PAGE 50)              ; Displays page 50.
(ODW 1,6,60)           ; Displays the windows.
(ODW 2.7,60)
(ODW 3.9,60)
(ODW 4.10,60)
(ODW 5.11,60)
(ODW 6.12,60)
(ODW 7.14,60)
(ODW 8.15,60)
(ODW 9.16,60)
(ODW 10.18,60)
(ODW 11.19,60)

;————————————————————————————————————————
; It shows the initial value (0) in each window.
;————————————————————————————————————————
(DW1=IB1)
(DW2=IB2)
(DW3=IB3)
(DW4=IB4)
(DW5=IB5)
(DW6=IB6)
(DW7=IB7)
(DW8=IB8)
(DW9=IB9)
(DW10=IB10)
(DW11=IB11)

;————————————————————————————————————————
; First group of softkeys - Tool and starting point.
;————————————————————————————————————————
N1 (SK1="(T)", SK2="(D)", SK3="(X)", SK4="(Y)", SK5="(Z)", SK6="(P6)", SK7="+")
(IB0=INPUT "Press softkey to select option")
( WKEY )
(IF KEY EQ $FC00 GOTO N11) ;If option "T" continue in N11
(IF KEY EQ $FC01 GOTO N12) ;If option  "D" continue in N12
(IF KEY EQ $FC02 GOTO N13) ;If option  "X" continue in N13
(IF KEY EQ $FC03 GOTO N14) ;If option  "Y" continue in N14
(IF KEY EQ $FC04 GOTO N15)  ;If option  "Z" continue in N15
(IF KEY EQ $FC05 GOTO N16) ;If option  "P6" continue in N16
(IF KEY EQ $FC06 GOTO N2) ;If option  "+" continue in N2
(GOTO N1)
```

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;————————————————————————————————————————
; Second group of softkeys - Slot dimensions.
;————————————————————————————————————————
N2 (SK1="(P1)", SK2="(P2)", SK3="(P3)", SK4="(P4)", SK5="(P5)", SK6="FIN", SK7="+")
(IB0=INPUT "Press softkey to select option")
( WKEY )
(IF KEY EQ $FC00 GOTO N21) ;If option  "P1" continue in N21
(IF KEY EQ $FC01 GOTO N22) ;If option  "P2" continue in N22
(IF KEY EQ $FC02 GOTO N23) ;If option  "P3" continue in N23
(IF KEY EQ $FC03 GOTO N24) ;If option  "P4" continue in N24
(IF KEY EQ $FC04 GOTO N25) ;If option  "P5" continue in N25
(IF KEY EQ $FC05 GOTO N100) ;If option  "END" continue in N100
(IF KEY EQ $FC06 GOTO N1) ;If option  "+" returns to N1
(GOTO N2)

;————————————————————————————————————————
; Requests tool number.
;————————————————————————————————————————
N11 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB1=INPUT "Tool number (T):",3.0)
(DW1=IB1)
(GOTO N1)

;————————————————————————————————————————
; Requests tool offset number.
;————————————————————————————————————————
N12 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB2=INPUT "Tool offset number (D):",3.0)
(DW2=IB2)
(GOTO N1)

;————————————————————————————————————————
; Requests initial X coordinate.
;————————————————————————————————————————
N13 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB3=INPUT "Starting point (X):",-6.5)
(DW3=IB3)
(GOTO N1)

;————————————————————————————————————————
; Requests initial Y coordinate.
;————————————————————————————————————————
N14 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB4=INPUT "Starting point (Y):",-6.5)
(DW4=IB4)
(GOTO N1)

;————————————————————————————————————————
; Requests initial Z coordinate.
;————————————————————————————————————————
N15 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB5=INPUT "Starting point (Z):",-6.5)
(DW5=IB5)
(GOTO N1)

;————————————————————————————————————————
; Requests slot approach coordinate.
;————————————————————————————————————————
N16 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB6=INPUT "Slot approach coordinate (P6):", 6.5)
(DW6=IB6)
(GOTO N1)
```

```
;————————————————————————————————————————
; Requests the length of the slot.
;————————————————————————————————————————
N21 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB7=INPUT "Length of the slot (P1):", 6.5)
(DW7=IB7)
(GOTO N2)

;————————————————————————————————————————
; Requests the width of the slot.
;————————————————————————————————————————
N22 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB8=INPUT "Width of the slot (P2):", 6.5)
(DW8=IB8)
(GOTO N2)

;————————————————————————————————————————
; Requests the slot rotation angle.
;————————————————————————————————————————
N23 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB9=INPUT "Slot rotation angle (P3):", -3.5)
(DW9=IB9)
(GOTO N2)

;————————————————————————————————————————
; Requests total depth of the slot.
;————————————————————————————————————————
N24 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB10=INPUT "Total depth of the slot (P4):", 6.5)
(DW10=IB10)
(GOTO N2)

;————————————————————————————————————————
; Requests the penetration step of the slot.
;————————————————————————————————————————
N25 (SK1="", SK2="", SK3="", SK4="", SK5="", SK6="", SK7="")
(IB11=INPUT "Penetration step of the slot (P5):", 6.5)
(DW11=IB11)
(GOTO N2)

;————————————————————————————————————————
; Generates program blocks.
;————————————————————————————————————————
N100 (WBUF "T",IB1)
(WBUF "D",IB2)
(WBUF)
(WBUF "G0 G90 X",IB3)
(WBUF "Y",IB4)
(WBUF "Z",(IB5+IB6))
(WBUF)
(WBUF "(PCALL 55, P1=",IB7)
(WBUF ",P2=",IB8)
(WBUF ",P3=",IB9)
(WBUF ",P4=",IB10)
(WBUF ",P5=",IB11)
(WBUF ",P6=",IB6)
(WBUF ")")
(WBUF )
(SYSTEM )
```