21 The Polygon Group

Introduction

All of the commands in this group use the *polygon buffer*, a temporary data storage area in your printer. Using the polygon buffer is an integral part of drawing wedges, rectangles, and other types of polygons. Some of the commands in this chapter define and draw complete shapes while others act only on the contents of the polygon buffer. The information in this chapter enables you to achieve the following results in your programs:

- Draw circles, wedges, and rectangles.
- Use polygon mode for drawing polygons, subpolygons, and circles.

The following commands are described in this chapter:

Table 21-1 The Polygon Group Commands

Command	Summary
EA, Edge Rectangle Absolute	Outlines a rectangle defined with absolute coordinates.
EP, Edge Polygon	Outlines the contents of the polygon buffer.
ER, Edge Rectangle Relative	Outlines a rectangle defined with relative coordinates.
EW, Edge Wedge	Defines and outlines a wedge-shaped polygon.
FP, Fill Polygon	Fills the polygon shape specified in the polygon buffer.
PM, Polygon Mode	Allows you to create user-defined polygons in the polygon buffer.

Table 21-1 The Polygon Group Commands (continued)

RA, Fill Rectangle Absolute	Fills a rectangle specified with absolute coordinates.
RR, Fill Rectangle Relative	Fills a rectangle specified with relative coordinates.
WG, Fill Wedge	Defines and fills a wedge-shaped polygon.

Using the Polygon Buffer

As mentioned, a buffer is a temporary storage area for information. The *polygon buffer* collects the commands and coordinates that define a polygon you want to print. This polygon remains in the buffer until replaced by another polygon, or until the buffer is cleared by initializing the printer. Some commands use the polygon buffer automatically, while other commands require that you enter the polygon mode. The following commands use the polygon buffer, but do not allow you to enter polygon mode first.

Table 21-2

Mnemonic	Command Name
EA,	Edge Rectangle Absolute
ER,	Edge Rectangle Relative
EW,	Edge Wedge
RA,	Fill Rectangle Absolute
RR,	Fill Rectangle Relative
WG,	Fill Wedge

Drawing Rectangles

You can draw a rectangle by outlining (edging) the defined area using the Edge Rectangle Absolute (EA) or Edge Rectangle Relative (ER) commands.

To draw a rectangle, the printer uses the current pen location for one corner; you give the coordinates for the diagonally opposite corner. The printer draws the rectangle defined by these two points. The following simple command sequence uses EA to draw a rectangle.

Table 21-3

Example: Drawing Rectangles	
?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1 (black). You must select a pen to print HP-GL/2 images.
PA10,10;	Specify absolute plotting and move to (10,10).
EA2500,1500;	Draw the outline of a rectangle, with the lower left corner being the current pen location (10,10) and the upper right corner being (2500,1500).
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

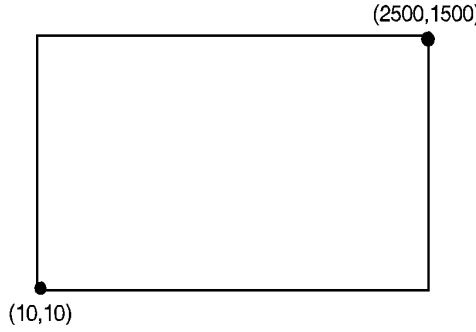

Figure 21-1

The Fill Rectangle Absolute (RA) and Fill Rectangle Relative (RR) commands, both discussed later in this chapter, fill their rectangles with the default or current fill pattern. You may also want to edge (or outline) the rectangle for better image definition with some fill types. The following command sequence draws two filled rectangles: one edged and one not.

Table 21-4 Example: Filled Rectangles

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
PA0,0;	Specify absolute plotting and move to location (0,0).
FT3;	Specify fill type 3 (hatching—parallel lines).
RR1500,1000;	Fill a rectangular shape with the currently active fill pattern. The lower left corner of the rectangle should be the current location (0,0), and the upper right corner should be 1500 plu in the X direction and 1000 plu in the Y direction from the starting location.

Table 21-4 Example: Filled Rectangles (continued)

EP;	Draw an edge around the rectangle that was just drawn. Since the previous RR command leaves its definition in the polygon buffer (1500,1000), you do not need to specify the coordinates again.
PR2000,0;	Specify relative plotting and move the cursor 2000 plu in the X direction from the current pen location.
FT4,100,45;	Specify fill type number 4 (cross-hatching), set the spacing to 100 plu between fill lines, and set the fill line angle to 45°.
RR1500,1000;	Fill a rectangle with the currently specified fill type. Use the current pen location (0,0) as the lower left corner of the rectangle and a point (1500,1000) relative plu away for the upper right corner.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

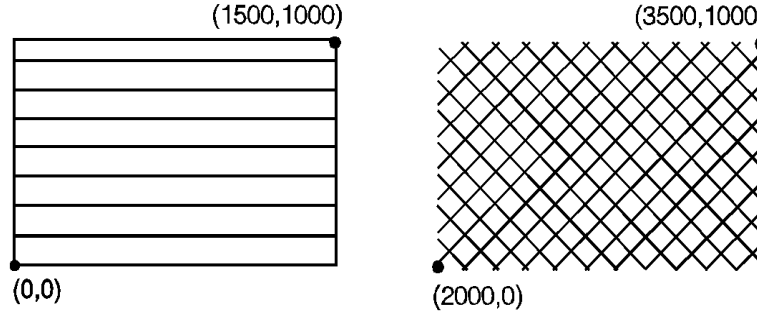

Figure 21-2

Drawing Wedges

A wedge is a section of a circle. Wedges are commonly used to draw pie charts. You can draw a wedge by outlining (edging) the defined area using the Edge Wedge (EW) command, or you can create filled wedges using the Fill Wedge (WG) command.

The wedge commands use your current pen location as the center point; you specify the radius, the start angle, and the sweep angle. The *radius* determines the length of the two sides of the wedge. The sign (positive or negative) of the radius determines the location of a 'zero-degree' reference point. The *start angle* is the number of degrees from the zero reference point at which you want to draw the first radius. The *sweep angle* is the number of degrees through which you want to draw the arc. To draw or fill a circle, simply specify a 360-degree sweep angle. Figure 21-4 shows the different parameters of a wedge with a positive radius.

Note

A *positive angle* of rotation is in the direction of the +X-axis to the +Y-axis as shown below. A *negative angle* of rotation is in the direction of the +X-axis to the –Y-axis.

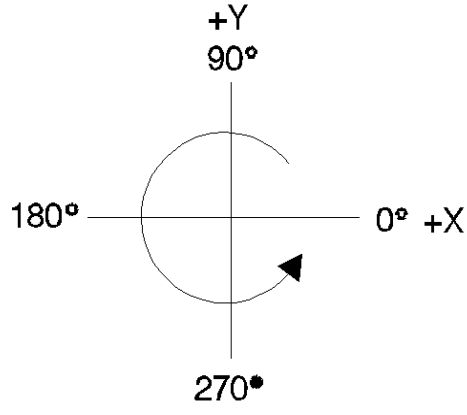

Figure 21-3

Note

The relationship of the +X-axis to +Y-axis (and –Y-axis) can change as a result of the scaling point or scaling factor changes, thus, changing the direction of a positive (or negative) angle of rotation.

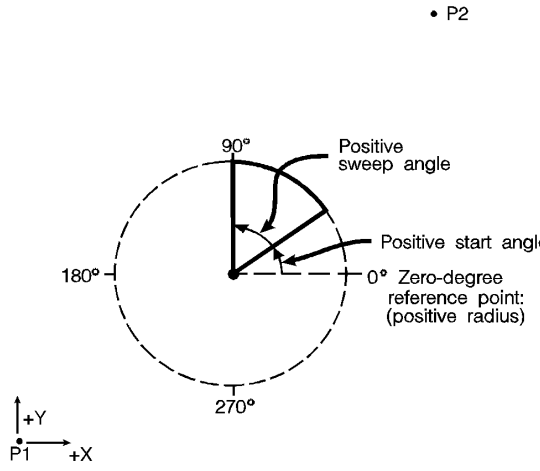

Figure 21-4 Drawing Wedges

The following example draws a wedge using the EW command. The radius of the wedge is 600 plotter units, the wedge begins 90° from the zero-degree reference point, and the wedge “sweeps” for 60°.

Note

In the example plots, some reference points are added which are not part of the example plot. These reference points are added for clarification.

Table 21-5 Example: Drawing Wedges

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
PA2500,3500;	Specify absolute plotting and move to location (2500,3500).

Table 21-5 Example: Drawing Wedges (continued)

EW600,90,60;	Draw the outline of a wedge, using the current pen location (2500,3500) as the point of the wedge. The wedge has a radius of 600 plotter units, begins at 90° from the default zero-degree reference point, and “sweeps” for 60°.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

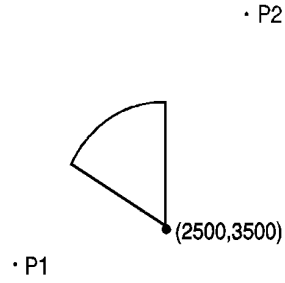

Figure 21-5

The following example uses different fill types with wedges and circles.

Table 21-6 Example: Filling Wedges and Circles

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1 (black).
PA1400,2500;	Select absolute plotting mode and move to (1400,2500).
WG600,150,120;	Fill a wedge with radius 600 plu, a start angle of 150°, and a sweep angle of 120°. Since no fill type was specified, the wedge is black (solid black is the default fill type).

Table 21-6 Example: Filling Wedges and Circles (continued)

PA2300,2500;FT3, 75,45;	Specify absolute plotting and move to (2300,2500). Select fill type number 3 (hatching--parallel lines), with 75 plu between hatching lines, and hatching lines tilted at 45°.
WG600,90,180;	Fill a wedge with the current fill type; use a radius of 600 plu, a start angle of 90°, and a sweep angle of 180°.
FT1,0,0;WG600, 270,60;	Specify a fill type of solid black and fill a wedge using the same center and radius as the previous wedge. Start the wedge at 270° with a sweep of 60°.
FT4,60,45;WG600, 330,120;	Specify fill type number 4 (cross-hatching) with 60 plu between lines and the lines tilted at 45°. Fill a wedge using the same center and radius as the previous two wedges. Start the wedge at 330° with a sweep of 120°.
PA3500,2500; WG400,0,360;	Select absolute plotting and move to (3500,2500). Create a filled circle using the current fill type (cross-hatching), specifying a start angle of 0° and a 360° sweep.
PA4500,2500;FT; WG400,0,360;	Move to (4500,2500), select a solid fill, and fill a 360° wedge (circle).
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

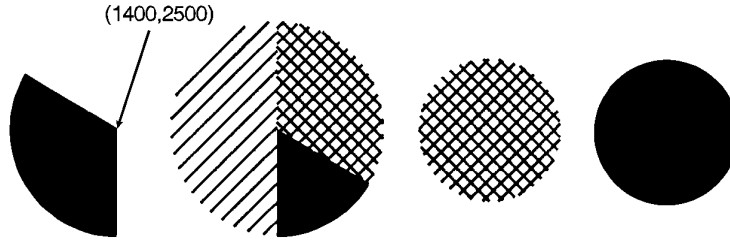

Figure 21-6

Drawing Polygons

A polygon consists of one or more closed sequences of connected line segments (which may cross each other). Drawing polygons requires the use of the polygon mode. The Polygon Mode (PM) command tells the printer to store subsequent commands and coordinates in the polygon buffer before printing the shape. (Rectangles and wedges are polygons which have their own drawing commands; the printer automatically generates and stores the coordinates in the polygon buffer.)

You can use the following commands in polygon mode to create polygons. These commands are stored in the polygon buffer until they are replaced with another polygon or the printer is initialized.

Table 21-7

Polygon Definition Commands	**Group**
AA, Arc Absolute	*The Vector Group*
AR, Arc Relative	
AT, Absolute Arc Three Point	
BR, Bezier Relative	
BZ, Bezier Absolute	
CI, Circle	
PA, Plot Absolute	
PD, Pen Down	
PE, Polyline Encoded	

Table 21-7 (continued)

PR, Plot Relative PU, Pen Up RT, Relative Arc Three Point	
PM1/PM2, Polygon Mode	*The Polygon Group*

Drawing Subpolygons

While in polygon mode, you can define either one polygon or a series of subpolygons. Like a polygon, a subpolygon is a closed sequence of connected line segments. For example, the block letter C is one complete polygon. However, the block letter D is actually two subpolygons: the outline and the 'hole.'

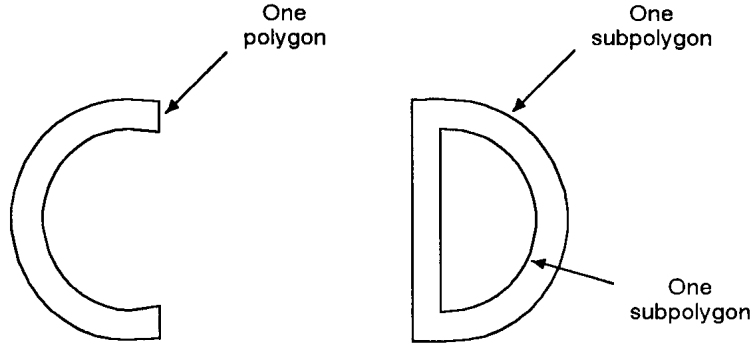

Figure 21-7 Drawing Subpolygons

To create one polygon, for example, the letter C, move the pen to the starting location for the polygon, then use the Polygon Mode (PM) command to enter polygon mode. Define the shape of the C using the appropriate commands and coordinates, then exit polygon mode. Now draw the polygon using either the Edge Polygon (EP) or Fill Polygon (FP) command.

To create a series of subpolygons, for example, the letter D, move the pen to the starting location of the first subpolygon, then enter polygon mode. Define the outer shape of the letter D using the appropriate commands and coordinates, then close the subpolygon, staying in polygon mode. Define the inner shape of the D, then exit polygon mode. Now draw the subpolygons using either the Edge Polygon (EP) or Fill Polygon (FP) command. For more information on entering and exiting polygon mode, refer to the Polygon Mode (PM) command discussed in this chapter.

In polygon mode, you can define points with the pen up or down. However, the Edge Polygon (EP) command only draws between points defined when the pen was down. In contrast, the Fill Polygon (FP) command fills between all points, regardless of whether they were defined when the pen was up or down. (Exception: the line connecting two subpolygons is never drawn, and is not a fill boundary.)

Filling Polygons

There are two methods which can be selected for filling polygons: the **even/odd** fill method and the **non-zero winding** fill method.

Even/Odd Fill Method

There is a simple way to determine which portions of a single polygon or series of subpolygons is filled when you send a Fill Polygon (FP) command using the default method 0, (fill using even/odd rule):

Draw a straight line extending from any point within an enclosed area of the polygon to a point outside the polygon. FP fills the enclosed area in question only if the line you have drawn intersects the edges of the polygon an odd number of times. Figure 21-8 illustrates this ‘odd-even’ rule.

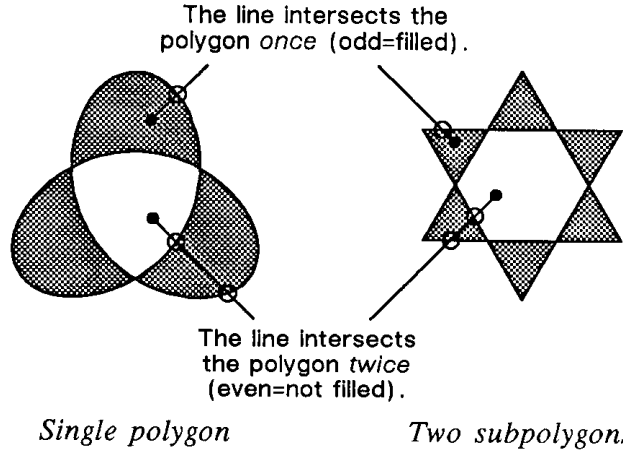

Figure 21-8 Filling Polygons: Even/Odd Fill Method

Non-Zero Winding Fill Method

The *non-zero* winding fill algorithm (fill method 1) determines whether a point is inside a region enclosed by a line path using the following steps:

1 Draw a ray from the point across the path segment.

2 Add 1 every time the line segment crosses the ray from left to right or bottom to top.

3 Subtract 1 every time the segment crosses the ray from right to left or top to bottom.

4 FP fills the enclosed area in question if the sum of steps 2 and 3 is non-zero. Figure 21-9 illustrates the non-zero winding fill concept.

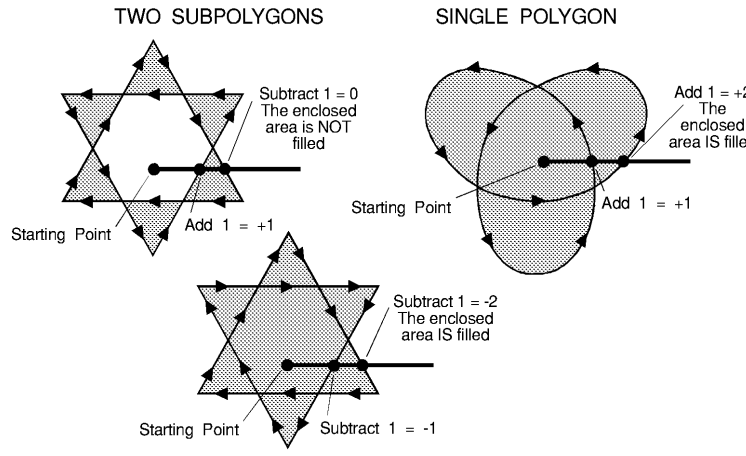

Figure 21-9 Filling Polygons: Non-Zero Winding Fill Method

Drawing Circles in Polygon Mode

Polygon mode interprets the Circle (CI) command differently than the other HP-GL/2 commands. The printer treats a circle as a complete subpolygon. The printer automatically closes the first polygon (if any) before starting the circle, and uses the first coordinates (if any) after the circle is drawn to start a new subpolygon.

If you did not close your first polygon completely before sending the CI command, the printer automatically closes the polygon by adding a point (at the starting point of the previous subpolygon). This can change your current pen location and the placement of the circle in your polygon, resulting in an inaccurate polygon.

`Approximating Polygon Buffer Use

You can use the following formula to estimate how much buffer space a polygon consumes. Each point in a polygon uses 8 bytes. For example, the minimum number of points the printer will hold is 512.

If you multiply 512 points by 8 bytes per point, the result is 4096 bytes (4 Kbytes). That means the minimum your printer can store in the polygon buffer is 4 Kbytes. That is the worst case, however. Unless the printer has a substantial amount of fonts, macros, or graphics already downloaded into user memory, you can put much more into the polygon buffer. As we just calculated, for every 4 Kbytes of extra unused user memory, the polygon buffer can store 512 more points. You can see how in most cases there is little chance of a polygon buffer overflow, especially with the addition of optional printer memory.

The following formula explains how to calculate the buffer space used by a polygon:

number of points in polygon × 8 = buffer space consumed by polygon''

Counting the Points in a Polygon

The starting pen location and each subsequent point define a polygon. As shown in the following illustration, a rectangle is defined by five points, not four. This is because the starting location is counted again as the ending location.

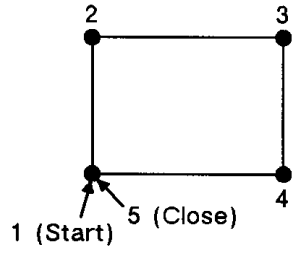

Figure 21-10

The following shape has seven points.

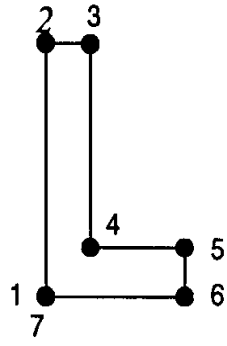

Figure 21-11

Counting the Points in a Circle or Arc

When a circle or arc defines a polygon, the number of points depends on the number of chords in the arc. There is always one more point than the number of chords, because the starting location is counted again as the ending location. Use the following formula to determine the number of points used to draw a circle or arc:

$$\#\ \text{of Points} = \frac{\text{Arc Angle (degrees)}}{\text{Chord Angle (degrees)}} + 1$$

Using this formula, a full circle with the default chord angle of 5° consists of 73 points (360/5 + 1 = 73), and a 45° arc with a chord angle of 3° consists of 16 points (45/3 + 1 = 16).

Notes

If the chord angle does not divide evenly into the arc, round up to the next integer before adding one: 45/2 + 1 = 23 + 1 = 24.

In polygon mode, the smaller a circle's chord angle, the more chords will be stored in the polygon buffer to draw it.

EA, Edge Rectangle Absolute

This command defines and outlines a rectangle using absolute coordinates. Use EA when drawing charts or schematic diagrams that require rectangles.

EA *X,Y[;]*

Parameter	Format	Functional Range	Default
X,Y coordinates	current units	-2^{30} to $2^{30} - 1$	no default

The EA command defines and edges a rectangle using absolute coordinates and the current pen, line type and line attributes. The EA command performs an automatic pen down. When the command execution is complete, the original pen location and up/down status are restored.

- **X,Y Coordinates** — Specify the opposite corner of the rectangle from the current pen location. The current pen location is the starting point of the rectangle. Coordinates are interpreted in current units: as user-units when scaling is on; as plotter units when scaling is off.

Note

The following illustration shows the current pen location in the lower left corner and the command's X,Y coordinates in the upper-right corner. Depending on the coordinate values, the points can be in any two diagonally opposite corners.

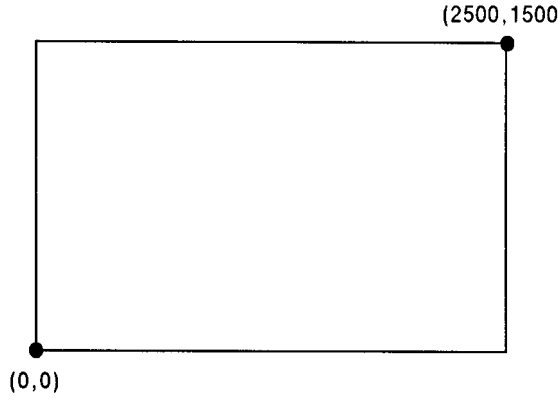

Figure 21-12

Note

Any line drawn along the border of the effective window causes the line to be clipped, producing a line width one-half of the defined pen width. For example, all the lines drawn in the above example are half the width of the other lines since they are clipped at the window borders.

The only difference between the EA command and the RA (Fill Rectangle Absolute) command is that the EA command produces an outlined rectangle, and RA, a filled one.

The EA command clears the polygon buffer and then uses it to define the rectangle before drawing. Refer to *Drawing Polygons* at the beginning of this chapter for more information.

The following example uses absolute coordinates to draw some rectangles. The same image is drawn later using the ER command instead. Compare this example with the ER example to understand the differences between the coordinates used (relative vs. absolute).

Table 21-8 Example: Using EA to Draw Rectangles

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.

Table 21-8 Example: Using EA to Draw Rectangles (continued)

SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
SC0,150,0,150,1;	Set up user scaling, with P1 being (0,0) user-units and P2 being (150,150) user-units. (Isotropic scaling is specified.)
PA75,105; EA115,130;	Specify absolute plotting mode and move to (75,105). Use EA to outline the shape of a rectangle that begins at (75,105) and has an upper right corner of (115,130) user-units.
PA95,105;PD95,95;	Draw a line from (95,105) to (95,95).
PD65,95,65,90;	Draw a line from the current pen location (95,95) to (65,95), and another line from there to (65,90).
PU45,90;EA85,65;	Lift the pen and move to (45,90). Draw the outline of a rectangle with an upper left corner of (45,90) and a lower right corner of (85,65).
PU95,95;PD125, 95,125,90;	Lift the pen and move to (95,95). Lower the pen and draw a line to (125,95), then to (125,90).
PU145,90;EA105,65;	Lift the pen and move to (145,90). Draw the outline of a rectangle, with the upper right corner at (145,90) and the lower left corner at (105,65).
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

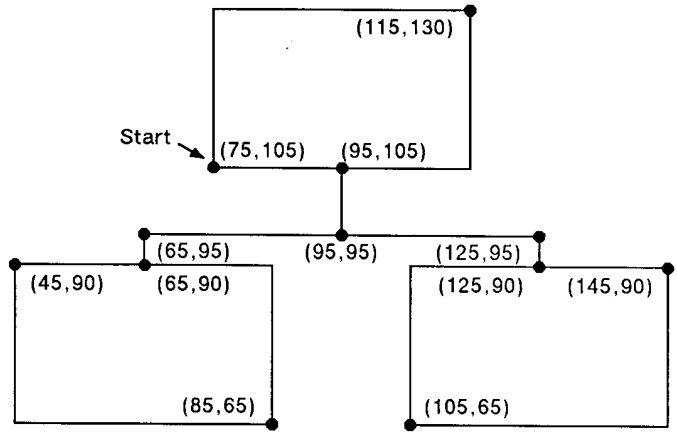

Figure 21-13

Table 21-9

Related Commands	Group
EP, Edge Polygon ER, Edge Rectangle Relative FP, Fill Polygon RA, Fill Rectangle Absolute RR, Fill Rectangle Relative	*The Polygon Group*
LA, Line Attributes LT, Line Type PW, Pen Width	*The Line and Fill Attributes Group*

EP, Edge Polygon

This command outlines the polygon currently stored in the polygon buffer. Use EP to edge polygons that you defined in polygon mode and with the Fill Rectangle and Wedge Commands (RA, RR, and WG).

EP *[;]*

The EP command outlines any polygon that is currently in the polygon buffer. This includes wedges and rectangles defined using the EA, ER, EW, RA, RR, and WG commands. EP accesses the data in the polygon buffer, but does not clear the buffer or change the data in any way.

The EP command only edges between points that were defined with the pen down, using the current pen, line type and attributes. When the command execution is complete, the original pen location and up/down status are restored.

The following example creates a shape in polygon mode, then uses EP to outline it.

Table 21-10 Example: Using the EP Command

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1 (black).
PA2000,10;	Specify absolute plotting and move to position (2000,10).
PM0;PD10,2000,10,10, 2000,10;PM1;	Enter polygon mode, store a pen down command, and then store points (10,2000), (10,10), and (2000,10). Close the polygon.
PU610,610; CI500;PM2;	While still in polygon mode, lift the pen and move to (610,610). Draw a circle with a diameter of 500 plu, then close the current subpolygon and exit polygon mode.

Table 21-10 Example: Using the EP Command (continued)

EP;	Outline the polygon that was just stored in the polygon buffer.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

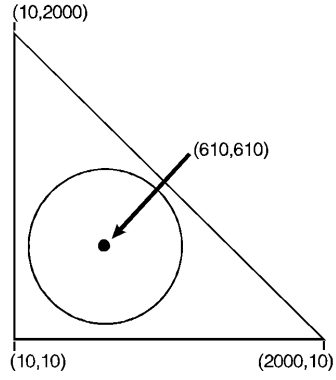

Figure 21-14

Table 21-11

Related Commands	**Group**
EA, Edge Rectangle Absolute ER, Edge Rectangle Relative EW, Edge Wedge PM, Polygon Mode RA, Fill Rectangle Absolute RR, Fill Rectangle Relative WG, Fill Wedge	*The Polygon Group*
LA, Line Attributes LT, Line Type PW, Pen Width	*The Line and Fill Attributes Group*

ER, Edge Rectangle Relative

This command defines and outlines a rectangle using relative coordinates. Use ER when drawing charts or schematic diagrams that require rectangles.

ER *X,Y[;]*

Parameter	Format	Functional Range	Default
X,Y increments	current units	-2^{30} to $2^{30} - 1$	no default

The ER command defines and edges a rectangle using relative coordinates and the current pen, line type, and line attributes. The ER command includes an automatic pen down. When the command operation is complete, the original pen location and up/down status are restored.

- **X,Y Increments** — Specify the opposite corner of the rectangle from the current pen location. The current pen location is the starting point of the rectangle. Increments are interpreted in current units: as user-units when scaling is on; as plotter units when scaling is off.

Note

The following illustration shows the current pen location in the lower left corner and the command's X,Y increment location in the upper right corner. When drawing a rectangle, these points can be in any two diagonally opposite corners.

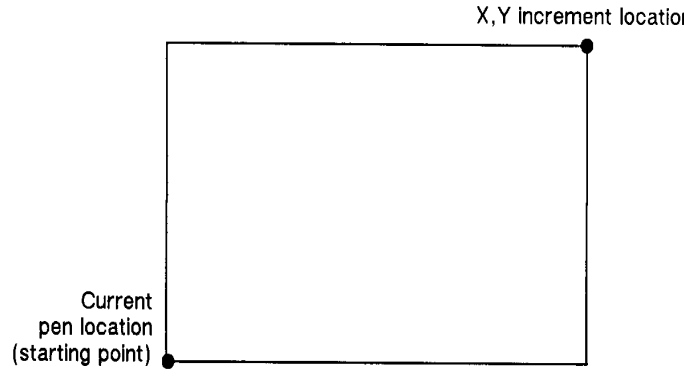

Figure 21-15 Edge Relative Rectangle Command

The only difference between the ER command and the RR (Fill Relative Rectangle) command is that the ER command produces an outlined rectangle, and RR, a filled one.

The ER command clears the polygon buffer and then uses it to define the rectangle before drawing. Refer to “Drawing Polygons” earlier in this chapter for more information.

The following example uses relative coordinates to draw the same image shown in the EA command example. Compare this example with the EA example to understand the differences between the coordinates used.

Table 21-12 Example: Using ER to Draw Rectangles

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. The SP command must be used to enable printing.
SC0,150,0,150,1;	Specify user scaling, with P1 being (0,0) and P2 (150,150); the “1” indicates isotropic scaling.

Table 21-12 Example: Using ER to Draw Rectangles (continued)

PA75,105;ER40,25;	Enter absolute plotting mode and move to (75,105). Draw a rectangle using the current pen location as the lower left corner and a point (40,25) user-units away as the upper right corner.
PR20,0;PD0,-10;	Specify relative plotting and move the pen 20 user-units to the right. Place the pen down and draw a line to a point 10 user-units down.
PD-30,0,0,-5;	With the pen down, move 30 user-units to the left and 5 units down.
PU-20,0;ER40,-25;	Lift the pen and move 20 user-units to the left, then draw the outline of a rectangle with the current pen location as one corner and a point (40,-25) user-units away as the opposite corner.
PU50,5;PD30,0, 0,-5;	Lift the pen and move 50 user-units to the right and 5 units up. Place the pen down and draw a line 30 user-units to the right, then 5 units down.
PU20,0;ER-40,-25;	Lift the pen and move 20 user-units to the right. Draw a rectangle from that point, with the current pen location being one corner and the opposite corner being 40 user-units to the left and 25 units down.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

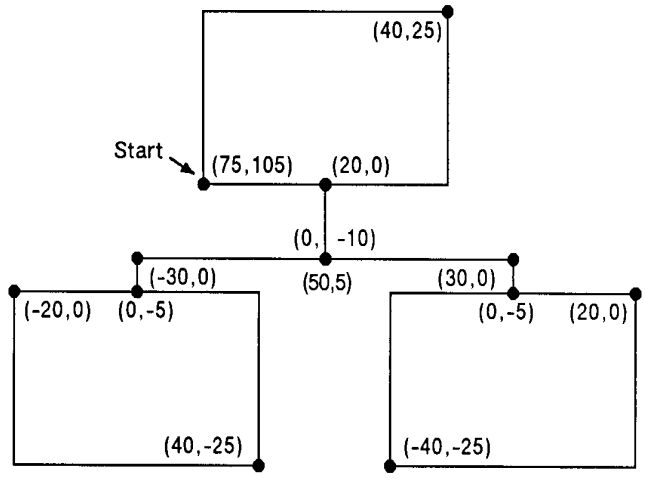

Figure 21-16

Table 21-13

Related Commands	Group
EA, Edge Rectangle Absolute EP, Edge Polygon FP, Fill Polygon RA, Fill Rectangle Absolute RR, Fill Rectangle Relative	*The Polygon Group*
LA, Line Attributes LT, Line Type PW, Pen Width	*The Line and Fill Attributes Group*

EW, Edge Wedge

This command outlines any wedge. Use EW to draw sections of pie charts.

EW *radius,start angle,sweep angle,[,chord angle;]*

Parameter	Format	Functional Range	Default
radius	current units	-2^{30} to $2^{30} - 1$	no default
start angle	clamped real	-32768 to 32767	no default
		modulo 360	
sweep angle	clamped real	±360°	no default
chord angle	clamped real	0.5° to 180°	5°

The EW command defines and edges a wedge using the current pen, line type and attributes. The EW command includes an automatic pen down. When the command execution is complete, the original pen location and up/down status are restored.

The only difference between the EW command and the WG (Fill Wedge) command is that the EW command produces an outlined wedge, and the WG command, a filled one.

Always use isotropic scaling in drawings that contain wedges unless you wish the wedges to “stretch” with changes in the aspect ratio of the drawing (causing elliptical wedges). For more information, refer to the discussion of scaling and the Scale (SC) command description in Chapter 19.

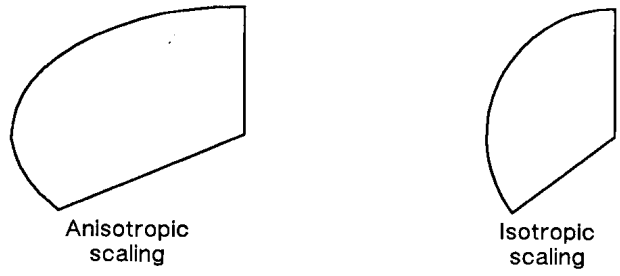

Figure 21-17 Anisotropic and Isotropic Scaling

- **Radius** — Specifies the distance from the current pen location to the start of the wedge's arc. Since the wedge is a portion of a circle, this parameter is the radius of the circle. It specifies the distance from the current pen location (which becomes the center of the circle), to any point on the circumference of the circle.

  The radius is interpreted in current units: as user-units when scaling is on; as plotter units when scaling is off. The sign (positive or negative) of the radius determines the location of the zero-degree reference point. The illustration following the parameter descriptions shows the location of the zero-degree reference point for a positive and a negative radius.
- **Sweep Angle** — Specifies the number of degrees through which the arc is drawn. A positive sweep angle is in the direction of the +X-axis to the +Y-axis; a negative sweep angle is in the direction of the +X-axis to the –Y-axis. However, the relative position of the +X-axis to the +Y-axis can change as a result of scaling point or scaling factor changes, thus, changing the direction of the sweep angle. Also, if you specify a start angle greater than 360°, a start angle equal to the remainder of the start angle/360° is used.
- **Chord Angle** — Specifies the chord angle used to draw the arc. The default is a chord angle of 5 degrees. Refer to the Arc Absolute (AA) command discussion in Chapter 20 for further information on chords and chord angles.

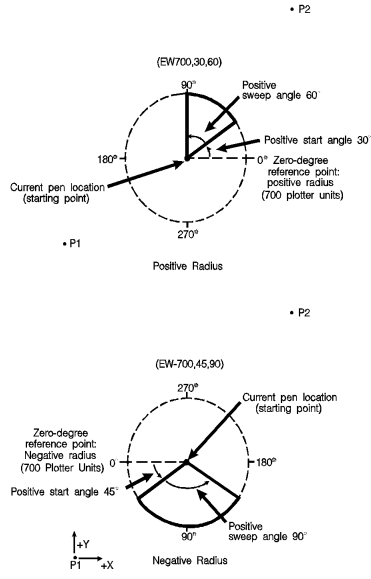

Figure 21-18

Table 21-14 Example: Using EW to Draw a Pie Chart

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
SC-3000,3000, -2000,2000,1;	Enter the scaling mode, specifying P1 as (-3000,-2000) and P2 as (3000,2000). Use isotropic scaling.
PA0,0;	Specify absolute plotting and move to user-unit location (0,0).
EW-1000,90,180;	Draw a wedge section with a radius of 1000 user-units, a start angle of 90°, and a sweep angle of 180°. The minus sign before the radius (-1000) sets the zero-degree reference point to the left side of the drawing.

Table 21-14 Example: Using EW to Draw a Pie Chart

EW-1000, 330,120;	Using the same center point and zero-degree reference point, draw a wedge section outline starting at 330° and sweeping 120°.
PR-60,110;	Move the cursor 60 user-units to the left and 110 user-units up.
EW-1000,270,60;	From the new center point location, draw a wedge using a negative zero-reference point, starting at 270° and sweeping for 60°.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

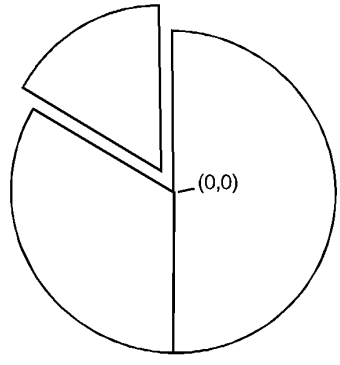

Figure 21-19

Table 21-15

Related Commands	**Group**
EP, Edge Polygon FP, Fill Polygon WG, Fill Wedge	*The Polygon Group*
SC, Scale	*The Configuration/Status Group*
CI, Circle	*The Vector Group*
LA, Line Attributes	*The Line and Fill Attributes Group*

Table 21-15 (continued)

LT, Line Type PW, Pen Width	

Table 21-16 Possible Error Conditions

Condition	Printer Response
polygon buffer overflow	edges contents of buffer

FP, Fill Polygon

This command fills the polygon currently in the polygon buffer. Use FP to fill polygons defined in polygon mode or with the Edge Rectangle or Edge Wedge commands (EA, ER, EW, RA, RR, or WG).

FP *fill method [;]*

or

FP *[;]*

Parameter	Format	Functional Range	Default
fill method	clamped integer	0 or 1	0 (odd-even fill)

- **Fill Method** — Specifies the algorithm used to determine which portions of the polygon are “inside” the polygon and therefore are to be filled:
  - 0 -- Even/odd fill algorithm (default)
  - 1 -- Non-zero winding fill algorithm

Note

Even/odd (method 0) and **Non-zero** (method 1) winding fill methods are described in detail under “Filling Polygons,” earlier in this chapter.

The FP command fills any polygon that is currently in the polygon buffer. FP accesses the data in the polygon buffer, but does *not* clear the buffer or change the data in any way.

The FP command fills between points defined with either the pen down or the pen up. The polygon is filled using the current pen, fill type, line type and attributes (if the fill type is not raster). The FP command includes an automatic pen down. When the command execution is complete, the original pen location and up/down status are restored.

The example on the next page creates a polygon composed of two subpolygons. In this case, the FP command fills alternating areas, beginning with the outside area.

Table 21-17 Example

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
PA1500,1500;	Specify absolute plotting and move to (1500,1500).
PM0;CI1000,60; PA1500,1500; CI500;PM2;	Enter the polygon mode, store a circle with radius of 1000 plu and a 60° chord angle, store a pen move to (1500,1500), and another circle with a 500 plu radius and a 5° (default) chord angle. Close the current polygon and exit polygon mode.
LT4;FT3,50,45;	Select line type 4 and fill type 3. Specify a 50 plu distance between the fill lines, and slant the lines at a 45° angle.
FP;	Using even-odd fill method, fill the polygon currently in the polygon buffer with the line and fill types just specified.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

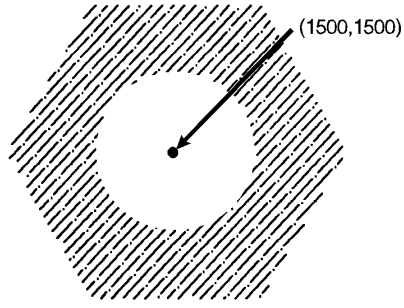

Figure 21-20

Table 21-18

Related Commands	Group
EA, Edge Rectangle Absolute ER, Edge Rectangle Relative EW, Edge Wedge PM, Polygon Mode RA, Fill Rectangle Absolute RR, Fill Rectangle Relative WG, Fill Wedge	*The Polygon Group*
FT, Fill Type LA, Line Attributes LT, Line Type PW, Pen Width	*The Line and Fill Attributes Group*

PM, Polygon Mode Command

This command enters polygon mode for defining shapes, such as block letters or any unique area, and exits for subsequent filling and/or edging. Fill polygons using the Fill Polygon (FP) command and/or outline them using the Edge Polygon (EP) command.

PM *polygon definition [;]*

or

PM *[;]*

Parameter	Format	Functional Range	Default
polygon definition	clamped integer	0, 1, and 2	0

In polygon mode, you define the area of the polygon(s) using graphics commands. These commands (and associated X,Y coordinates) are stored in the polygon buffer. The polygon is not printed until you exit polygon mode and fill and/or outline the area.

- **No Parameters** — Clears the polygon buffer and enters polygon mode. Equivalent to (PM0).
- **Polygon Definition** — Defines polygon mode status as follows.
  - **0** — Clears the polygon buffer and enters polygon mode.
  - **1** — Closes the current polygon (or subpolygon) and remains in polygon mode; all commands sent following PM1 but before a PM2 (or the next PM1) are stored as one subpolygon.
  - **2** — Closes current polygon (or subpolygon) and exits polygon mode.

The following paragraphs explain how to use each parameter. The order in which you use these commands is very important.

(PM0) or (PM)

Use (*PM0*) to clear the polygon buffer and enter polygon mode. While in polygon mode, only certain commands are allowed. The following list contains these commands:

Table 21-19

Polygon Mode Allowable Commands	**Group**
DF, Default Values IN, Initialize	*The Configuration/Status Group*
AA, Arc Absolute AR, Arc Relative AT, Absolute Arc Three Point BR, Bezier Relative BZ, Bezier Absolute CI, Circle PA, Plot Absolute PD, Pen Down PE, Polyline Encoded PR, Plot Relative PU, Pen Up RT, Relative Arc Three Point	*The Vector Group*
PM1/PM2, Polygon Mode	*The Polygon Group*

The polygon buffer stores the lines (vectors) that define your polygon. These vectors are accessed later when you exit polygon mode and fill and/or edge the polygon.

Note

While in polygon mode, the CI command is interpreted differently than other graphics commands. Refer to “Drawing Circles in Polygon Mode,” earlier in this chapter for more details.

When you define a polygon, the pen location before the *PM0* command is the first point (vertex) of the polygon, and the first point stored in the polygon buffer. For example, if you execute the

commands (*PA0,1750;PM0*), the absolute coordinates (0,1750) specify the first point of your polygon. Each subsequent pair of coordinates defines a point, or vertex, of the polygon.

You can define points with the pen up or down. However, the EP command only draws between points that are defined when the pen is down. On the other hand, the FP command fills the area(s) between all vertices, regardless of whether the pen is up or down when defined.

It is good programming practice to ‘close’ the polygon before exiting polygon mode. Closing a polygon means adding the final vertex that defines a continuous shape; the last coordinates or increments represent the same location as the

first. If you have not closed the polygon, executing (*PM1*) or (*PM2*) forces closure by adding a point to close the polygon.

You can also use the Initialize (IN) or Default Values (DF) commands while in polygon mode. Both commands exit polygon mode, clear the polygon buffer, and begin executing subsequent commands immediately. You must exit polygon mode to execute other HP-GL/2 graphics commands.

Note

Sending an ?E while in polygon mode causes the printer to exit polygon mode, clear the polygon buffer, exit HP-GL/2 mode, and eject a page. Sending an ?E while in polygon mode is not recommended, but it performs an important function (allowing you to recover from a previous job that left the printer in polygon mode).

(PM1)

Use (*PM1*) to close the current polygon (or subpolygon) and remain in polygon mode; the printer adds a closure point if necessary. When you use (*PM1*), the point after (*PM1*) becomes the first point of the next subpolygon. This move is not used as a boundary when filling a polygon with FP. When drawing the polygon, the pen always moves to this point in the up position, regardless of the current pen status. Each subsequent coordinate pair after (*PM1*) defines a point of the subpolygon.

(PM2)

Use (*PM2*) to close the current polygon (or subpolygon) and exit polygon mode. Remember, if you have not closed your polygon, executing (*PM2*) adds a point to close the polygon. Refer to “Pen Status and Location” in Chapter 17, *Introduction to HP-GL/2 Graphics.*

The following example draws the surface area of a 3-prong electrical receptacle as a series of subpolygons, then fills and edges it using the FP and EP commands, respectively.

Table 21-20 Example: Using the PM Command

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
PA2000,2000;	Specify absolute plotting and move to (2000,2000).
PM0;PD3000,2000, 3000,3000;	Enter polygon mode, store a Pen Down command, and store locations (3000,2000) and (3000,3000).
PD2000,3000, 2000,2000;	Store two more pen-down locations, (2000,3000) and (2000,2000).
PM1;	Close the first polygon.
PD2080,2160,2480, 2160, 2480,2340, 2080,2340,2080, 2160;	Store 5 pen-down locations for a subpolygon.
PM1;	Close the subpolygon.
PD2080,2660,2480, 2660,2480,2840, 2080,2840,2080, 2660;	Store pen-down locations for another subpolygon.
PM1;	Close the second subpolygon.

Table 21-20 Example: Using the PM Command (continued)

PD2920,2340,2920, 2660,2720,2660;	Begin a third subpolygon that draws the ground plug portion of the receptacle.
AA2720,2500,180; PD2920,2340;	Store a 180° arc that goes from (2720,2660) to (2720,2500).
PM2;FP;EP;	Close the subpolygon and exit polygon mode. Fill (even/odd), then edge the polygon and subpolygons currently stored in the buffer.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

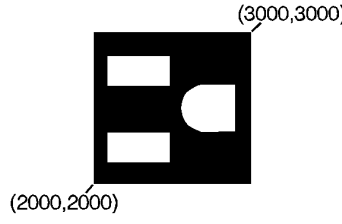

Figure 21-21

Table 21-21

Related Commands	**Group**
EP, Edge Polygon FP, Fill Polygon	*The Polygon Group*

RA, Fill Rectangle Absolute

This command defines and fills a rectangle using absolute coordinates. Use RA to fill rectangular shapes in drawings. (To outline a rectangle using absolute coordinates, use the EA command.)

RA *X,Y[;]*

Parameter	Format	Functional Range	Default
X,Y coordinates	current units	-2^{30} to $2^{30} - 1$	no default

The RA command defines and fills a rectangle using the current pen, the current line and fill types, and absolute X,Y coordinates. The RA command includes an automatic pen down. When the command operation is complete, the original pen location and up/down status are restored.

- **X,Y Coordinates** — Specify the corner of the rectangle that is diagonally opposite from the current pen location (the starting point of the rectangle). Coordinates are interpreted in current units: as user-units when scaling is on; as plotter units when scaling is off.

Note

The following illustration shows the current pen location in the lower-left corner and the command's X,Y coordinates in the upper-right corner. Depending on the X,Y coordinates used, these points can be in any two diagonally opposite corners.

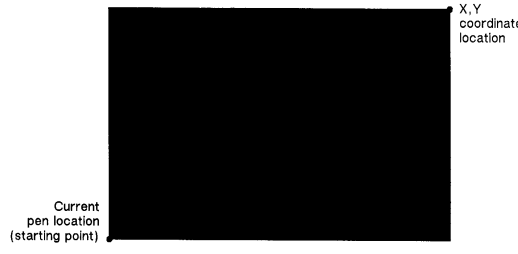

Figure 21-22 Fill Rectangle Absolute

The only difference between the RA command and the EA (Edge Rectangle Absolute) command is that the RA command produces a filled rectangle, and EA, an outlined one.

The RA command clears the polygon buffer and then uses it to define the rectangle before drawing. Refer to “Using the Polygon Buffer” earlier in this chapter.

The following example uses RA with three different fill types to create rectangles such as those you might use in a bar chart. The rectangles in the right bar are edged using the EA command. (For more information about fill types, refer to the FT command description in Chapter 22.)

Table 21-22 Example: Using the RA Command with Different Fill Types

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
PA400,400; RA800,1200;	Enter absolute plotting mode and move to (400,400). Draw a rectangle with (400,400) as the lower left corner and (800,1200) as the upper right corner.
PA400,1200;FT3, 50;RA800,1600;	Move the pen to (400,1200), select fill type 3 (parallel lines) with a 50 plu space between lines, and draw a rectangle with (400,1200) as the lower left corner and (800,1600) as the upper right corner.
PA400,1600;FT4; RA800,2000;	Move to (400,1600) and specify fill type 4 (cross-hatching). Draw a rectangle with a lower left corner of (400,1600) and an upper right corner of (800,2000).
PA1200,400;FT; RA1600,1200; EA1600,1200;	Move to location (1200,400) and select the default fill type (solid black). Fill and edge a rectangle using (1200,400) as the lower left corner and (1600,1200) as the upper right corner.

Table 21-22 Example: Using the RA Command with Different Fill Types (continued)

PA1200,1200;FT3, 50;RA1600,1600; EA1600,1600;	Move to absolute position (1200,1200) and select fill type 3, with a 50 plu distance between each line. Draw a rectangle with (1200,1200) as the lower left corner and (1600,1600) as the upper right. Using the default line type, edge the rectangle just drawn.
PA1200,1600;FT4 ; RA1600,2000; EA1600,2000;	Move to (1200,1600) and select the cross-hatch pattern fill type. Draw a rectangle with the current pen location as one corner and (1600,2000) as the opposite corner.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

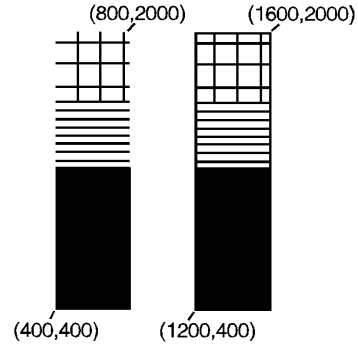

Figure 21-23

Table 21-23

Related Commands	**Group**
EA, Edge Rectangle Absolute EP, Edge Polygon ER, Edge Rectangle Relative FP, Fill Polygon RR, Fill Rectangle Relative	*The Polygon Group*

Table 21-23 (continued)

FT, Fill Type LT, Line Type RF, Raster Fill Definition	*The Line and Fill Attributes Group*

RR, Fill Rectangle Relative

This command defines and fills a rectangle using relative coordinates. Use RR to fill rectangular shapes in drawings. (To outline a rectangle using relative coordinates, use the ER command.)

RR *X,Y[;]*

Parameter	Format	Functional Range	Default
X,Y increments	current units	-2^{30} to $2^{30} - 1$	no default

The RR command defines and fills a rectangle using the current pen, the current line and fill types, and relative coordinates. The RR command includes an automatic pen down. After the command is executed, the original pen location and up/down status are restored.

- **X,Y Increments** — Specify the corner of the rectangle that is diagonally opposite from the current pen location, which is the starting point of the rectangle. Coordinates are interpreted in current units: as user-units when scaling is on; as plotter units when scaling is off.

Note

The following illustration shows the current pen location in the lower-left corner and the command's X,Y increments in the upper-right corner. However, these points can be in any two opposite corners depending on the coordinates used.

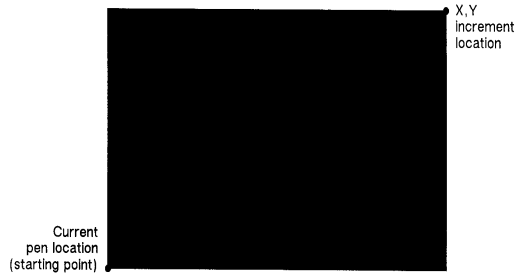

Figure 21-24 Fill Rectangle Relative

The only difference between the RR command and the ER (Edge Relative Rectangle) command is that the RR command produces a filled rectangle, and ER, an outlined one.

The RR command clears the polygon buffer and then uses it to define the rectangle before drawing. A rectangle requires enough buffer space to hold five points.

The following example uses RR with three different fill types (refer to the FT command description) to create rectangles such as those you might use in a bar chart. The rectangles in the right bar are edged using the ER command.

Table 21-24 Example: Using the RR Command with Different Fill Types

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
PA400,400; RR400,800;	Specify absolute plotting and move to location (400,400). Fill a rectangle with the default fill (black), with (400,400) as the lower left corner and the upper right corner 400 plu to the right and 800 plu up from there.

Table 21-24 Example: Using the RR Command with Different Fill Types (continued)

PR0,800;FT3,50; RR400,400;	Enter the relative plotting mode and move 800 plu in the Y direction and select fill type 3 (parallel lines). Draw a rectangle using the current pen location as the lower left corner; the upper right corner is 400 plu to the right and 400 plu up from the lower left corner.
PR0,400;FT4; RR400,400;	Move 400 plu up and select fill type 4 (cross-hatching). Draw a rectangle using the current pen position as the lower left corner and a point 400 plu to the right and 400 plu up as the upper right corner.
PA1200,400;FT; RR400,800; ER400,800;	Move to absolute location (1200,400) and select the default fill type (solid black). Draw and edge a rectangle that begins at the current pen position and extends 400 plu to the right, then 800 plu up from there.
PR0,800;FT3,50; RR400,400; ER400,400;	Move 800 plu up from the current position and select fill type 3 (parallel lines), with 50 plu between each line. Draw a rectangle using the current pen location as the lower left corner and a point 400 plu up and 400 plu to the right as the upper right corner. Edge the rectangle.
PR0,400;FT4; RR400,400; ER400,400;	Move 400 plu up from the current pen position. Select fill type 4 (cross-hatching). Draw a rectangle using the current pen location as the lower left corner, the right corner being (400,400) relative plotter units away.
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

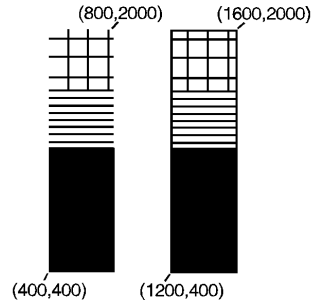

Figure 21-25

Table 21-25

Related Commands	Group
EA, Edge Rectangle Absolute EP, Edge Polygon ER, Edge Rectangle Relative FP, Fill Polygon RA, Fill Rectangle Absolute	*The Polygon Group*

WG, Fill Wedge

This command defines and fills any wedge. Use WG to draw filled sections of a pie chart.

WG *radius,start angle,sweep angle[,chord angle;]*

Parameter	Format	Functional Range	Default
radius	current unit	-2^{30} to $2^{30} - 1$	—
start angle	clamped real	-32768 to 32767	—
sweep angle	clamped real	±360°	—
chord angle	clamped real	0.5° to 180°	5°

The WG command defines and fills a wedge using the current pen, fill type, and line types. The WG command includes an automatic pen down. When the command operation is complete, the original pen location and up/down status are restored.

The only difference between the WG command and the EW (Edge Wedge) command is that the WG command produces a filled wedge, and the EW, an outlined one.

Always use isotropic scaling in any drawing that contains wedges (to avoid drawing an elliptical wedge). (Refer to the discussion of scaling in Chapter 17 for more information.)

Figure 21-26 Fill Wedge with Scaling

- **Radius** — Specifies the distance from the current pen location to the start of the wedge's arc. Since the wedge is a portion of a circle, this parameter is the radius of the circle. It specifies the distance from the current pen location (which becomes the center of the circle), to any point on the circumference of the circle.
  - The radius is interpreted in current units: as user-units when scaling is on; as plotter units when scaling is off. The sign of the radius (+ or -) determines the location of the zero-degree reference point. The illustration following the parameter descriptions shows the location of the zero-degree reference point for a positive and negative radius.
- **Start Angle** — Specifies the beginning point of the arc as the number of degrees from the zero-degree reference point. A positive start angle positions the radius in the positive direction (the direction from the +X-axis toward the +Y-axis) from the zero-degree reference point; a negative start angle positions the radius in a negative direction from the zero-degree reference point. If you specify a start angle greater than 360°, a start angle equal to the remainder of the start angle/360° is used.

- **Sweep Angle** — Specifies in degrees the angle through which the arc is drawn. A positive angle draws the angle in the positive direction (angle of rotation - +X-axis to the +Y-axis); a negative angle draws the angle in the negative direction (+X-axis to the –Y-axis). (Note, the relation of the +X-axis to the +Y-axis/–Y-axis can change as a result of scaling point or scaling factor changes.) If a sweep angle greater than 360 degrees is specified, a 360-degree angle is used.
- **Chord Angle** — Specifies the chord angle used to define the arc. The default is 5 degrees. Refer to the “Chord Angle” discussion in the Arc Absolute (AA) command discussion (Chapter 20) for information on setting the chord angle.

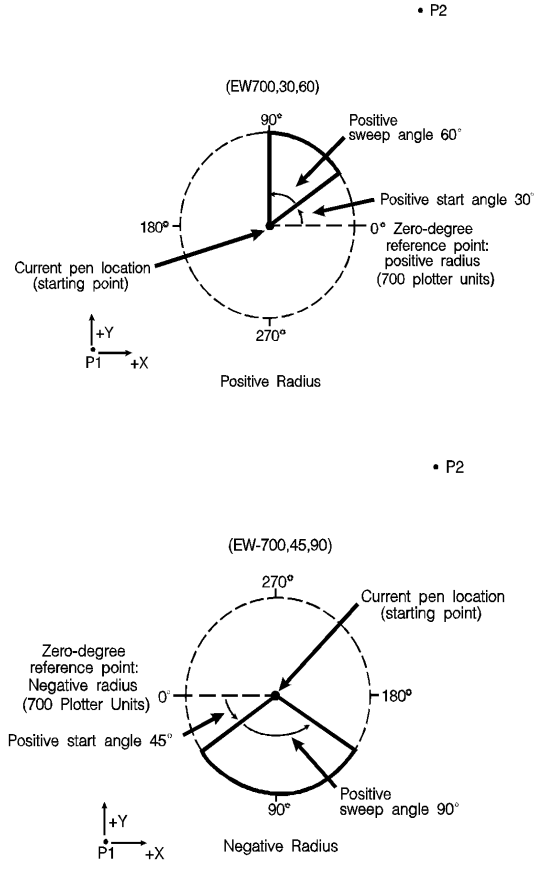

Figure 21-27

Table 21-26 Example: Filling then Edging vs. Edging then Filling Chart

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select pen number 1. Even though there is no physical pen, the SP command must be used to enable printing.
SC-3000,3000, -2000,2000,1;	Set up user scaling, with P1 being (-3000,-2000) and P2 being (3000,2000). Specify isotropic scaling.
PA0,0;FT3,75,45; WG-1000,90,180;	Enter absolute plotting mode and move to user-unit position (0,0). Select fill type 3 (parallel lines), with 75 user-units between lines and the lines slanted 45°. Fill a wedge with the current fill pattern; use a radius of 1000 user-units, a starting angle of 90° and a sweep angle of 180°. The zero-degree reference point is on the left side of the circle (indicated by the negative radius parameter [-1000]).
EW-1000,90,180;	Draw an outline (edge) around the same wedge.
FT4,60,45; WG-1000,330,120;	Select fill type 4 (cross-hatching), specifying 60 user-units between lines and with the lines tilted at 45°. Fill a wedge that has the same radius and center point, but with a starting angle of 330° and a sweep angle of 120°.
EW-1000,330,120;	Edge the same wedge.
PR-60,110;FT1;	Specify relative plotting and move the pen 60 user-units to the left and 110 units up. Select fill type 1 (solid black).
WG-1000,270,60;	Fill a wedge with a radius of 1000 user-units, a start angle of 270°, and a sweep angle of 60°.
EW-1000,270,60;	Edge the outline of the wedge that was just filled.

Table 21-26 Example: Filling then Edging vs. Edging then Filling Chart (continued)

?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

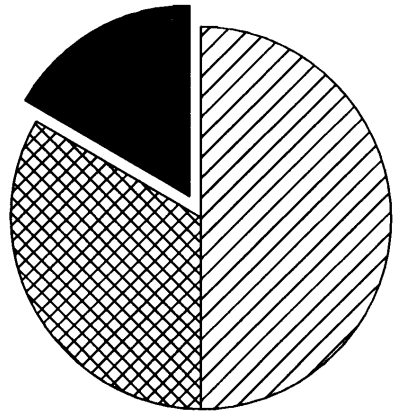

Figure 21-28

The center point of the above circle is located at (0,0).

Note

When transparency mode (TR command) is opaque, filling then edging an object may produce different results from edging and then filling. This is especially true when large pen widths are used. The following example illustrates this.

Table 21-27 Example:

?E	Reset the printer.
?%0B	Enter HP-GL/2 mode.
IN;	Initialize HP-GL/2 mode.
SP1;	Select printer logical pen number 1.
TR0;	Set transparency mode OFF (opaque)
PU4000,6000;	Position pen.

Table 21-27 Example: (continued)

PW5;	Select pen width of 5 units.
PM0;	Enter polygon mode.
CI1000;	Draw a circle with a radius of 1000 units.
PM2;	Close polygon and exit polygon mode.
FT10,30;	Select 30% shading fill type.
FP;EP;	Fill then Edge polygon.
PU4000,3000;	Select pen position (4000, 3000) for second circle.
PM0;	Enter polygon mode.
CI1000;	Draw another circle with a radius of 1000 units.
PM2;	Close polygon and exit polygon mode.
EP;FP;	Edge then fill polygon (circle).
?%0A	Enter the PCL mode.
?E	Send a reset to end the job and eject the page.

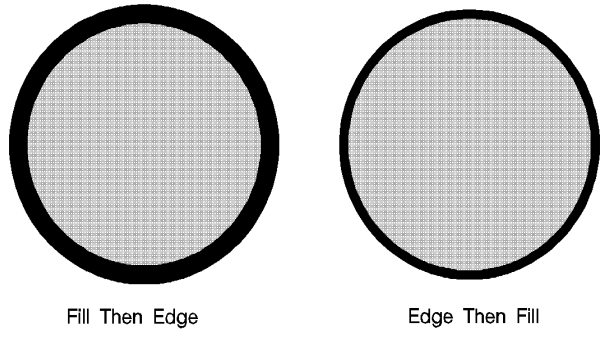

Figure 21-29

The center of the left circle is located at (4000,3000). The center of the right circle is located at (4000,6000).

Table 21-28

Related Commands	Group
EP, Edge Polygon EW,Edge Wedge	*The Polygon Group*
SC, Scale	*The Configuration/Status Group*
CI, Circle	*The Vector Group*
FP, Fill Polygon	*The Polygon Group*
FT, Fill Type	*The Line and Fill Attributes Group*