
5

In this chapter:

- *Colors*
- *Patterns*
- *The Drawing Pen*
- *Shapes*

Drawing

When a Be application draws, it always draws in a view. That's why the chapter that deals with views precedes this chapter. In Chapter 4, *Windows, Views, and Messages*, you saw that a `BView`-derived class overrides its inherited hook member function `Draw()` so that it can define exactly what view objects should draw in when they get updated. The example projects in this chapter contain classes and member functions that remain unchanged, or changed very little, from previous example projects. What will be different is the content of the `Draw()` function. The code that demonstrates the concepts of each drawing topic can usually be added to the `Draw()` routine.

In Be programming, the colors and patterns that fill a shape aren't defined explicitly for that shape. Instead, traits of the graphics environment of the view that receives the drawing are first altered. In other words, many drawing characteristics, such as color and font, are defined at the view level, so all subsequent drawing can use the view settings. In this chapter, you'll see how to define a color, then set a view to draw in that color. You'll see how the same is done for patterns—whether using Be-defined patterns or your own application-defined ones.

After you learn how to manipulate the graphic characteristics of a view, it's on to the drawing of specific shapes. The point (represented by `BPoint` objects) is used on its own, to define the end points of a line, and to define the vertices of more sophisticated shapes (such as triangles or polygons). The rectangle (represented by `BRect` objects) is used on its own and as the basis of more sophisticated shapes. These shapes include round rectangles, ellipses, and regions. Round rectangles and ellipses are closely related to `BRect` objects, and aren't defined by their own classes. Polygons and regions are more sophisticated shapes that make use of points and rectangles, but are represented by their own class types (`BPolygon` and `BRegion`). In this chapter, you'll see how to outline and fill each of these different

shapes. Finally, I show how to combine any type and number of these various shapes into a picture represented by a `BPicture` object.

Colors

The BeOS is capable of defining colors using any of a number of *color spaces*. A color space is a scheme, or system, for representing colors as numbers. There are several color space Be-defined constants, each containing a number that reflects the number of bits used to represent a single color in a single pixel. For instance, the `B_COLOR_8_BIT` color space devotes 8 bits to defining the color of a single pixel. The more memory devoted to defining the color of a single pixel, the more possible colors a pixel can display.

`B_GRAY1`

Each pixel in a drawing is either black (bit is on, or 1) or white (bit is off, or 0).

`B_GRAY8`

Each pixel in a drawing can be one of 256 shades of gray—from black (bit is set to a value of 255) to white (bit is set to a value of 0).

`B_CMAP8`

Each pixel in a drawing can be one of 256 colors. A pixel value in the range of 0 to 255 is used as an index into a color map. This system color map is identical for all applications. That means that when two programs use the same value to color a pixel, the same color will be displayed.

`B_RGB15`

Each pixel in a drawing is created from three separate color components: red, green, and blue. Five out of a total of sixteen bits are devoted to defining each color component. The sixteenth bit is ignored.

`B_RGB32`

Like the `B_RGB15` color space, each pixel in a drawing is created from three separate color components: red, green, and blue. In `B_RGB32` space, however, eight bits are devoted to defining each color component. The remaining eight bits are ignored.

`B_RGBA32`

Like the `B_RGB32` color space, each pixel in a drawing is created from three separate color components: red, green, and blue. Like `B_RGB`, eight bits are used to define each of the three color components. In `B_RGBA32` space, however, the remaining eight bits aren't ignored—they're devoted to defining an alpha byte, which is used to specify a transparency level for a color.

RGB Color System

As listed above, the BeOS supports a number of color spaces. The RGB color space is popular because it provides over sixteen million unique colors (the number of combinations using values in the range of 0 to 255 for each of the three color components), and because it is a color system with which many programmers and end users are familiar with (it's common to several operating systems).

The BeOS defines `rgb_color` as a `struct` with four fields:

```
typedef struct {
    uint8 red;
    uint8 green;
    uint8 blue;
    uint8 alpha;
} rgb_color
```

A variable of type `rgb_color` can be initialized at the time of declaration. The order of the supplied values corresponds to the ordering of the `struct` definition. The following declares an `rgb_color` variable named `redColor` and assigns the `red` and `alpha` fields a value of 255 and the other two fields a value of 0:

```
rgb_color redColor = {255, 0, 0, 255};
```

To add a hint of blue to the color defined by `redColor`, the third value could be changed from 0 to, say, 50. Because the `alpha` component of a color isn't supported at the time of this writing, the last value should be 255. Once supported, an `alpha` value of 255 will represent a color that is completely opaque; an object of that color will completely cover anything underneath it. An `alpha` field value of 0 will result in a color that is completely transparent—an effect you probably don't want. An `rgb_color` variable can be set to represent a new color at any time by specifying new values for some or all of the three color components. Here an `rgb_color` variable named `blueColor` is first declared, then assigned values:

```
rgb_color blueColor;

blueColor.red = 0;
blueColor.green = 0;
blueColor.blue = 255;
blueColor.alpha = 255;
```



While choosing values for the red, green, and blue components of a color is easy if you want a primary color, the process isn't completely intuitive for other colors. Quickly now, what values should you use to generate chartreuse? To experiment with colors and their RGB components, run the `ColorControl` program that's discussed a little later in this chapter. By the way, to create the pale, yellowish green color that's chartreuse, try values of about 200, 230, and 100 for the red, green, and blue components, respectively.

High and Low Colors

Like all graphics objects, an `rgb_color` variable doesn't display any color in a window on its own—it only sets up a color for later use. A view always keeps track of two colors, dubbed the *high* and *low* colors. When you draw in the view, you specify whether the current high color, the current low color, or a mix of the two colors should be used.

Views and default colors

When a new view comes into existence, it sets a number of drawing characteristics to default values. Included among these are:

- A high color of black
- A low color of white
- A background color of white

Additionally, when a `BView` drawing function is invoked, by default it uses the view's high color for the drawing. Together, these facts tell you that unless you explicitly specify otherwise, drawing will be in black on a white background.

Setting the high and low colors

The `BView` member functions `SetHighColor()` and `SetLowColor()` alter the current high and low colors of a view. Pass `SetHighColor()` an `rgb_color` and that color becomes the new high color—and remains as such until the next call to `SetHighColor()`. The `SetLowColor()` routine works the same way. This next snippet sets a view's high color to red and its low color to blue:

```
rgb_color redColor = {255, 0, 0, 255};
rgb_color blueColor = {0, 0, 255, 255};

SetHighColor(redColor);
SetLowColor(blueColor);
```

Drawing with the high and low colors

Passing an `rgb_color` structure to `SetHighColor()` or `SetLowColor()` establishes that color as the one to be used by a view when drawing. Now let's see how the high color is used to draw in color:

```
rgb_color redColor = {255, 0, 0, 255};
BRect      aRect(10, 10, 110, 110);

SetHighColor(redColor);

FillRect(aRect, B_SOLID_HIGH);
```

The previous snippet declares `redColor` to be a variable of type `rgb_color` and defines that variable to represent red. The snippet also declares a `BRect` variable named `aRect`, and sets that variable to represent a rectangle with a width and height of 100 pixels. The call to `SetHighColor()` sets the high color to red. Finally, a call to the `BView` member function `FillRect()` fills the rectangle `aRect` with the current high color (as specified by the Be-defined constant `B_SOLID_HIGH`)—the color red.

Shape-drawing routines such as `FillRect()` are described in detail later in this chapter. For now, a brief introduction will suffice. A shape is typically drawn by first creating a shape object to define the shape, then invoking a `BView` member function to draw it. That's what the previous snippet does: it creates a rectangle shape based on a `BRect` object, then calls the `BView` member function `FillRect()` to draw the rectangle.

One of the parameters to a `BView` shape-drawing routine is a pattern. As you'll see ahead in the "Patterns" section of this chapter, a pattern is an 8-pixel-by-8-pixel template that defines some combination of the current high color and low color. This small template can be repeatedly "stamped" into an area of any size to fill that area with the pattern. Patterns are everywhere these days: desktop backgrounds, web page backgrounds, and so on. You can create your own patterns, or use one of the three Be-defined patterns. Each of the Be-defined patterns is represented by a constant:

- `B_SOLID_HIGH` is a solid fill of the current high color.
- `B_SOLID_LOW` is a solid fill of the current low color.
- `B_MIXED_COLORS` is a checkerboard pattern of alternating current high color and low color pixels (providing a dithered effect—what looks like a single color blended from the two colors).

A view's default high color is black. So before a view calls `SetHighColor()`, the use of `B_SOLID_HIGH` results in a solid black pattern being used. The above snippet invokes `SetHighColor()` to set the current high color to red, so subsequent uses of `B_SOLID_HIGH` for this one view result in a solid red pattern being used.

Determining the current high and low colors

You can find out the current high or low color for a view at any time by invoking the `BView` member functions `HighColor()` or `LowColor()`. Each routine returns a value of type `rgb_color`. This snippet demonstrates the calls:

```
rgb_color  currentHighColor;
rgb_color  currentLowColor;

currentHighColor = HighColor();
currentLowColor  = LowColor();
```

The default high color is black, so if you invoke `HighColor()` before using `SetHighColor()`, an `rgb_color` with red, green, and blue field values of 0 will be returned to the program. The default low color is white, so a call to `LowColor()` before a call to `SetLowColor()` will result in the return of an `rgb_color` with red, green, and blue field values of 255. Because the `alpha` field of the high and low colors is ignored at the time of this writing, the `alpha` field will be 255 in both cases.

RGB, low, and high color example project

The `RGBColor` project is used to build a program that displays a window like the one shown in Figure 5-1. Given the nature of this topic, you can well imagine that the window isn't just as it appears in this figure. Instead a shade of each being a shade of gray, the three rectangles in the window are, from left to right, red, blue, and a red-blue checkerboard. Because of the high resolution typical of today's monitors, the contents of the rightmost rectangle dither to a solid purple rather than appearing to the eye as alternating red and blue pixels.



Figure 5-1. The window that results from running the `RGBColor` program

Chapter 4 included the `TwoViewClasses` project—a project that introduced a new view class named `MyDrawView`. That class definition was almost identical to the original `MyHelloView`. This chapter's `RGBColor` project and all remaining projects in this chapter display a single window that holds a single `MyDrawView` view, and no `MyHelloView`. So the `MyHelloView.cpp` file is omitted from these projects, and the data member meant to keep track of a `MyHelloView` in the `MyHelloWindow` class (reproduced below) is also omitted:

```
class MyHelloWindow : public BWindow {  
  
public:  
    MyHelloWindow(BRect frame);  
    virtual bool  QuitRequested();  
  
private:  
    MyDrawView    *fMyDrawView;  
};
```

Creating a new `MyHelloWindow` object now entails creating just a single `MyDrawView` view that fills the window, then attaching the view to the window:

```
MyHelloWindow::MyHelloWindow(BRect frame)
    : BWindow(frame, "My Hello", B_TITLED_WINDOW, B_NOT_RESIZABLE)
{
    frame.OffsetTo(B_ORIGIN);
    fMyDrawView = new MyDrawView(frame, "MyDrawView");
    AddChild(fMyDrawView);

    Show();
}
```

Drawing in a view takes place automatically when the system calls the view's `Draw()` routine. That function is the code I play with in order to try out drawing ideas. Here's how the `RGBColor` project implements the `MyDrawView` version of `Draw()`:

```
void MyDrawView::Draw(BRect)
{
    BRect    aRect;
    rgb_color redColor = {255, 0, 0, 255};
    rgb_color blueColor;

    blueColor.red = 0;
    blueColor.green = 0;
    blueColor.blue = 255;
    blueColor.alpha = 255;

    SetHighColor(redColor);
    SetLowColor(blueColor);

    aRect.Set(10, 10, 110, 110);
    FillRect(aRect, B_SOLID_HIGH);

    aRect.Set(120, 10, 220, 110);
    FillRect(aRect, B_SOLID_LOW);

    aRect.Set(230, 10, 330, 110);
    FillRect(aRect, B_MIXED_COLORS);
}
```

The previous routine demonstrates two methods of assigning an `rgb_color` variable a color value. After that, the `SetHighColor()` and `SetLowColor()` functions set the `MyDrawView` high color and low color to red and blue, respectively. Then in turn each of the three rectangles is set up, then filled.

The View Color (Background)

To color a shape, the program often refers to the `B_SOLID_HIGH` constant. As you just saw in the previous example project, the `B_SOLID_LOW` and `B_MIXED_COLORS`

constants can also be used to include the view's current low color in the drawing. By now it should be apparent that neither the high nor low color implicitly has anything to do with a view's background color.

Setting a view's background color

By default, a new view has a background color of white. This background color can be set to any RGB color by invoking the `BView` member function `SetViewColor()`. Here a view's background color is being set to purple:

```
rgb_color purpleColor = {255, 0, 255, 255};
SetViewColor(purpleColor);
```

Calling `SetViewColor()` changes the background color of a view without affecting either the high color or the low color. Consider a view with a current high color of blue, a current low color of yellow, and a background color set to purple. Calling a `BView` fill routine with a pattern argument of `B_SOLID_HIGH` draws a blue shape. An argument of `B_SOLID_LOW` draws a yellow shape. Finally, an argument of `B_MIXED_COLORS` draws a green shape. All shapes are drawn against the view's purple background.

View color example project

The `ViewColor` program displays a window that looks identical to that displayed by the `RGBColor` example, except for one feature. Both programs display a window with a red, blue, and purple rectangle in it, but the `ViewColor` window background is pink rather than white. This trick is performed by adding just a few lines of code to the `AttachedToWindow()` routine defined in the `MyDrawView.cpp` file in the `RGBColor` project. Here an `rgb_color` variable is set up to define the color pink, and that variable is used as the argument to a call to `SetViewColor()`. Here's the new version of the `MyDrawView` member function `AttachedToWindow()`:

```
void MyDrawView::AttachedToWindow()
{
    SetFont(be_bold_font);
    SetFontSize(24);

    rgb_color pinkColor = {255, 160, 220, 255};
    SetViewColor(pinkColor);
}
```

Color Control View

The RGB components of any given color won't be known by a program's user. There are exceptions, of course—graphics artists involved in electronic media or

electronic publications may have a working knowledge of how RGB values correspond to colors. Those exceptions aside, if your program allows users to select their own colors, your program should provide a very user-friendly means for them to accomplish this task. The `BColorControl` class does just that.

Color levels and the `BColorControl` object

The `BColorControl` class is derived from the `BControl` class, which itself is derived from the `BView` class. So a `BColorControl` object is a type of view. Your program creates a `BColorControl` object in order to allow a user to select an RGB color without the user knowing anything about the RGB color system or RGB values.

What the `BColorControl` object displays to the user depends on the number of colors the user's monitor is currently displaying. The user can set that parameter by choosing Screen from the preferences menu in the Deskbar. Coincidentally, the Screen preferences window (which has been revamped and turned into the Background preferences application) itself holds a `BColorControl` object. So you can see how the monitor's color depth is set and take a look at a `BColorControl` object by selecting the Screen preferences or by simply looking at Figure 5-2.

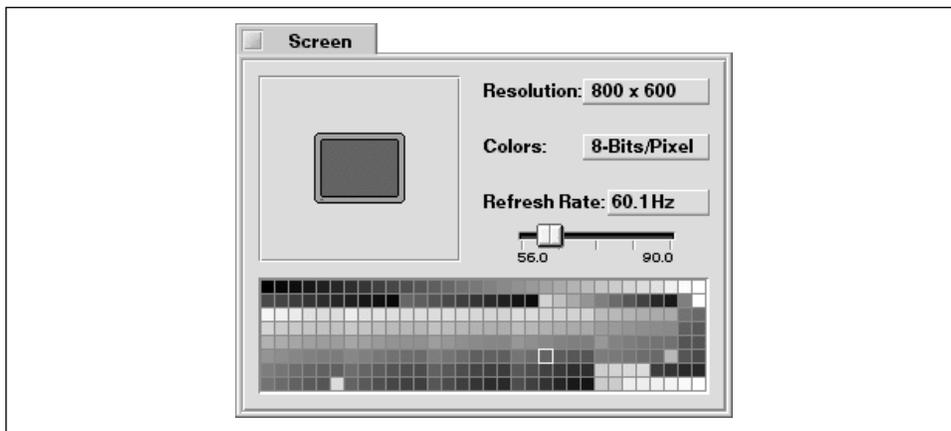


Figure 5-2. The Screen preferences program set to display 8-bit color

The Screen preferences window holds a number of objects representing `BView`-derived classes. Among them is a pop-up menu titled Colors. In Figure 5-2, you see that I have my monitor set to devote 8 bits of graphics memory to each pixel, so my monitor can display up to 256 colors. The Screen preferences window lets me choose one of the 256 system colors to be used as my desktop color. This is done by clicking on one of the 256 small colored squares. This matrix, or block of squares, is a `BColorControl` object.

Choosing 32-Bits/Pixel from the Colors pop-up menu in the Screen preferences window sets a monitor to display any of millions of colors. As shown in Figure 5-3, doing so also changes the look of the `BColorControl` object. Now a color is selected by clicking on the red, green, and blue ramps, or bands, of color along the bottom of the Screen preferences window. Unbeknownst to the user, doing this sets up an RGB color. The Screen preferences program combines the user's three color choices and uses the resulting RGB value as the desktop color.

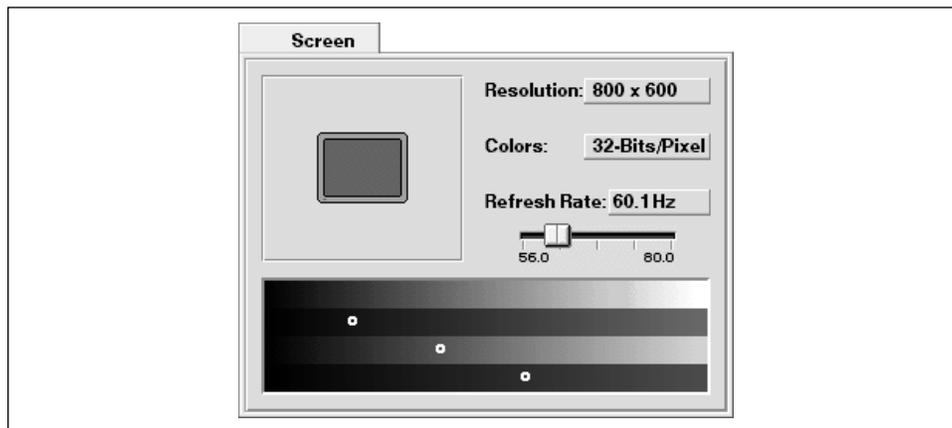


Figure 5-3. The Screen preferences program set to display 32-bit color

Creating a `BColorControl` object

The Screen preferences window serves as a good example of how a `BColorControl` object can help the user. To use the class in your own program, declare a `BColorControl` object and the variables that will be used as parameters to the `BColorControl` constructor. Then create the new object using `new` and the `BColorControl` constructor:

```
BColorControl      *aColorControl;
BPoint             leftTop(20.0, 50.0);
color_control_layout matrix = B_CELLS_16x16;
long               cellSide = 16;

aColorControl = new BColorControl(leftTop, matrix, cellSide, "ColorControl");

AddChild(aColorControl);
```

The first `BColorControl` constructor parameter, `leftTop`, indicates where the top left corner of the color control should appear. The color control will be placed in a view (by calling the `AddChild()` function of the host view, as shown above), so you should set `BPoint`'s coordinates relative to the view's borders.

The second parameter, `matrix`, is of the Be-defined datatype `color_control_layout`. When the user has the monitor set to 8 bits per pixel, the 256 system colors are displayed in a matrix. This parameter specifies how these squares should

be arranged. Use one of five Be-defined constants here: `B_CELLS_4x64`, `B_CELLS_8x32`, `B_CELLS_16x16`, `B_CELLS_32x8`, or `B_CELLS_64x4`. The two numbers in each constant name represent the number of columns and rows, respectively, that the colored squares are placed in. For example, `B_CELLS_32x8` displays the 256 colors in eight rows with 32 colored squares in each row.

The third `BColorControl` constructor parameter, `cellSide`, determines the pixel size of each colored square in the matrix. A value of 10, for instance, results in 256 squares that are each 10 pixels by 10 pixels in size.

The fourth parameter provides a name for the `BColorControl` object. Like any view, a `BColorControl` object has a name that can be used to find the view. The name can be supplied using a string (as shown in the previous snippet) or by passing in a constant variable that was defined as a `const char *` (as in `const char *name = "ColorControl";`).

Note that the overall size of the `BColorControl` object isn't directly specified in the constructor. The size is calculated by the constructor, and depends on the values supplied in the second and third parameters. The matrix parameter specifies the shape of the block of colors, while the `cellSide` value indirectly determines the overall size. A matrix with 8 rows of cells that are each 10 pixels high will have a height of 80 pixels, for instance.

I've discussed the `BColorControl` constructor parameters as if they will be used with 8-bit pixels. For the values used in the previous example, the resulting color control looks like the one displayed in the window in Figure 5-4. If the user instead has the monitor set to 32 bits for each pixel, the same arguments are used in the display of four bands, three of which the user clicks on in order to create a single color. The top gray band represents the `alpha`, or color transparency level, component. As of this writing, the `alpha` component is unimplemented, but it should be implemented by the time you read this. Instead of creating a matrix of color squares, the arguments are now used to determine the shape and overall size the four bands occupy. Figure 5-5 shows the color control that results from executing the previous snippet when the monitor is set to 32 bits per pixel.



The user can set the monitor to the desired bits-per-pixel level, so your program can't count on being used for a matrix or bands. In Figure 5-5, you see that the color bands are very broad—that's the result of specifying a 16-by-16 matrix (`B_CELLS_16x16`). To display longer, narrower color bands, choose a different Be-defined constant for the `BColorControl` constructor `matrix` argument (such as `B_CELLS_64x4`). Regardless of the values you choose for the `matrix` and `cellSize` parameters, test the resulting color control under both monitor settings to verify that the displayed control fits well in the window that displays it.

Using a color control

When a window displays a color control, the user selects a color by clicking on its cell (if the user's monitor is set to 8 bits per pixel) or by clicking on a color intensity in each of the three color component bands (if the user's monitor is set to 32 bits per pixel). In either case, the `BColorControl` object always keeps track of the currently selected color. Your program can obtain this color at any time via a call to the `BColorControl` member function `ValueAsColor()`. Obviously enough, a call to this routine returns the value of the color control object in the form of an RGB color. In this next snippet, the user's current color choice is returned and stored in an `rgb_color` variable named `userColorChoice`:

```
rgb_color userColorChoice;

userColorChoice = aColorControl->ValueAsColor();
```

What your program does with the returned color is application-specific. Just bear in mind that this value can be used the same way any `rgb_color` is used. You know about the `SetHighColor()` routine that sets a view's high color, and you've seen how to fill a rectangle with the current high color by calling the `BView` member function `FillRect()`, so an example that carries on with the previous snippet's `userColorChoice` RGB color will be easily understandable:

```
BRect aRect(40.0, 50.0, 400.0, 55.0);

SetHighColor(userColorChoice);

FillRect(aRect, B_SOLID_HIGH);
```

The previous snippet creates a rectangle in the shape of a long horizontal bar, sets the high color to whatever color the user has the color control currently set at, then fills the rectangle with that color.

ColorControl example project

If you set your monitor to use 8 bits per pixel (using the Screen preferences utility), running this chapter's `ColorControl` example program results in a window like the one shown in Figure 5-4. If you instead have your monitor set to use 32 bits per pixel, running the same program displays a window like that shown in Figure 5-5.

Regardless of your monitor's pixel setting, the `ColorControl` program displays three text boxes to the right of the color matrix or color bands. These text boxes are displayed automatically by the `BColorControl` object, and the area they occupy constitutes a part of the total area occupied by the control. If you click on a color cell or a color band, the numbers in these boxes will change to reflect the appropriate RGB values for the color you've selected. If you click in a text box (or use the Tab key to move to a text box) and type in a value between 0 and 255, the

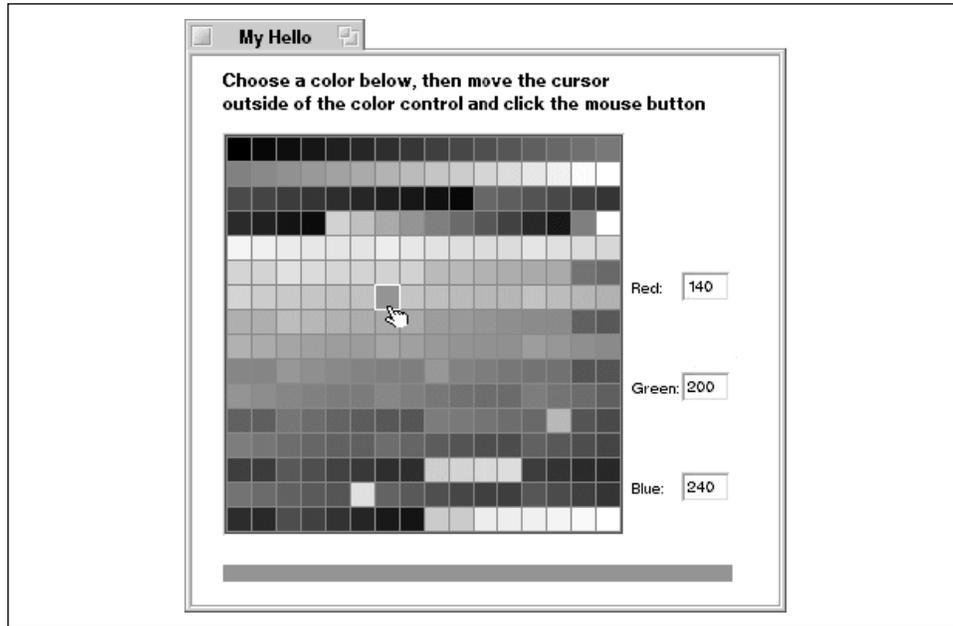


Figure 5-4. The ColorControl program's window that results from running at 8-bit color

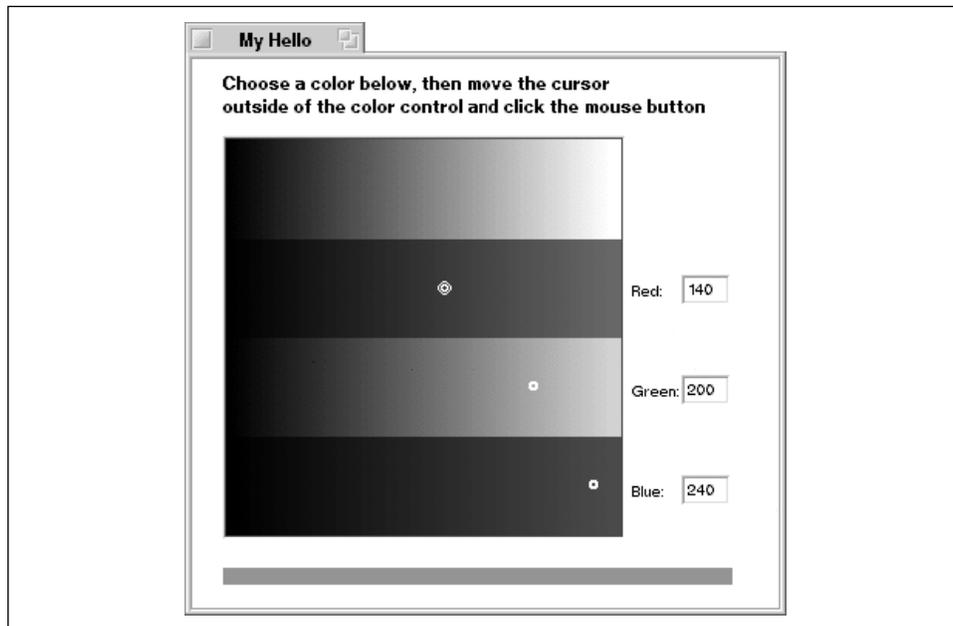


Figure 5-5. The ColorControl program's window that results from running at 32-bit color

color display will update itself to display the color that best matches the value you've entered. These actions are all automatic, and require no coding effort on your part. The reason this handy feature works is that the `BControl` class overrides the `BView` class member function `KeyDown()`, and in turn the `BColorControl` class overrides the `BControl` version of `KeyDown()`. The `BColorControl` version of the routine sees to it that the text box values reflect the displayed color.

If you move the cursor out of the color control area (keep in mind that this area includes the text boxes), then click the mouse button, a long, narrow bar is drawn along the bottom of the window—as shown in Figures 5-4 and 5-5. The color of this bar will match whatever color you have currently selected in the color control. The selection of this color and the drawing of the bar are handled by the `MyDrawView` version of the `MouseDown()` routine. Besides overriding the `BView` hook function `MouseDown()`, this project's version of the `MyDrawView` class adds a `BColorControl` data member. The color control data member will be used to keep track of the control. Here's how the `ColorControl` project declares the `MyDrawView` class:

```
class MyDrawView : public BView {
public:
    MyDrawView(BRect frame, char *name);
    virtual void AttachedToWindow();
    virtual void Draw(BRect updateRect);
    virtual void MouseDown(BPoint point);

private:
    BColorControl *fColorControl;
};
```

The `MyHelloApplication` class and `MyHelloWindow` class are almost identical to versions found in previous examples. The `MyHelloApplication` constructor defines the size of a window and creates a single `MyHelloWindow`, and the `MyHelloWindow` defines a single `MyDrawView` whose size is the same as the window it resides in.

The `MyDrawView` constructor, which in other projects has been empty, sets up and creates a color control. The control object is added to the newly created `MyDrawView` object as a child:

```
MyDrawView::MyDrawView(BRect rect, char *name)
    : BView(rect, name, B_FOLLOW_ALL, B_WILL_DRAW)
{
    BPoint leftTop(20.0, 50.0);
    color_control_layout matrix = B_CELLS_16x16;
    long cellSide = 16;

    fColorControl = new BColorControl(leftTop, matrix, cellSide,
```

```

        "ColorControl");
    AddChild(fColorControl);
}

```

In the `MyDrawView` constructor, you see that the control will have its top left corner start 20 pixels from the left and 50 pixels from the top of the `MyDrawView` view that the control appears in. Starting down 50 pixels from the top of the view leaves room for the two lines of instructional text that are displayed in the window (refer back to Figure 5-4 or 5-5). Those lines are drawn each time the system has to update the view they appear in:

```

void MyDrawView::Draw(BRect)
{
    MovePenTo(BPoint(20.0, 20.0));
    DrawString("Choose a color below, then move the cursor");
    MovePenTo(BPoint(20.0, 35.0));
    DrawString("outside of the color control and click the mouse button");
}

```

When the user clicks in the `MyDrawView` view, the `MouseDown()` routine that the `MyDrawView` class overrides is automatically invoked:

```

void MyDrawView::MouseDown(BPoint point)
{
    BRect    aRect(20.0, 330.0, 350.0, 340.0);
    rgb_color userColorChoice;

    userColorChoice = fColorControl->ValueAsColor();

    SetHighColor(userColorChoice);

    FillRect(aRect, B_SOLID_HIGH);
}

```

`MouseDown()` creates the long, thin rectangle that appears along the bottom of the view when the user clicks the mouse button. Before this function draws the rectangle with a call to `FillRect()`, a `ValueAsColor()` call obtains the color currently selected in the view's color control. A call to `SetHighColor()` makes the user-selected color the one used in function calls that include `B_SOLID_HIGH` as a parameter.

Improving the ColorControl example project

For brevity, the `ColorControl` example sets the high color and fills in the colored rectangle in the `MouseDown()` routine. Typically, drawing takes place only in a view's `Draw()` function. One way to accomplish that would be to move the code currently in `MouseDown()` to `Draw()`:

```

void MyDrawView::Draw(BRect)
{
    BRect    aRect(20.0, 330.0, 350.0, 340.0);

```

```

    rgb_color  userColorChoice;

    MovePenTo(BPoint(20.0, 20.0));
    DrawString("Choose a color below, then move the cursor");
    MovePenTo(BPoint(20.0, 35.0));
    DrawString("outside of the color control and click the mouse button");

    userColorChoice = fColorControl->ValueAsColor();
    SetHighColor(userColorChoice);
    FillRect(aRect, B_SOLID_HIGH);
}

```

The body of `MouseDown()` could then consist of a single line of code: a call to the `BView` function `Invalidate()`. Then, when the user clicks the mouse in the `MyDrawView` view, `MouseDown()` makes the system aware of the fact that the view needs updating, and the system invokes `Draw()`:

```

void MyDrawView::MouseDown(BPoint point)
{
    Invalidate();
}

```

One further improvement to the `ColorControl` example program would be to preserve the current state of the view before changing its high color. As implemented (here and in the previous section), the text the program draws is drawn in black the first time the `Draw()` function executes. Subsequent calls will update any previously obscured text (as in the case when an overlapping window is moved off the `ColorControl` program's window) in whatever color was selected by the user. That is, the program's call to `SetHighColor()` affects not only the long, narrow color rectangle at the bottom of the program's window, but also text drawn with calls to `DrawString()`. To remedy this, preserve the state of the high color by invoking the `BView` function `HighColor()` to get the current high color before changing it. After calling `SetHighColor()` and `FillRect()`, use the `rgb_color` value returned by `HighColor()` to reset the high color to its state prior to the use of the user-selected color. Here's how `Draw()` now looks:

```

void MyDrawView::Draw(BRect)
{
    BRect      aRect(20.0, 330.0, 350.0, 340.0);
    rgb_color  userColorChoice;
    rgb_color  origHighColor;

    MovePenTo(BPoint(20.0, 20.0));
    DrawString("Choose a color below, then move the cursor");
    MovePenTo(BPoint(20.0, 35.0));
    DrawString("outside of the color control and click the mouse button");

    origHighColor = HighColor();

    userColorChoice = fColorControl->ValueAsColor();
    SetHighColor(userColorChoice);
}

```

```
FillRect(aRect, B_SOLID_HIGH);  
  
SetHighColor(origHighColor);  
}
```

Patterns

A pattern is an 8-pixel-by-8-pixel area. Each of the 64 pixels in this area has the color of either the current high or current low color. A pattern can be one solid color (by designating that all pixels in the pattern be only the current high color or only the current low color), or it can be any arrangement of the two colors, as in a checkerboard, stripes, and so forth. Regardless of the arrangement of the pixels that make up the pattern, it can be used to fill an area of any size. And regardless of the size or shape of an area, once a pattern is defined it can be easily “poured” into this area to give the entire area the look of the pattern.

Be-Defined Patterns

You’ve already encountered three patterns—the Be-defined constants `B_SOLID_HIGH`, `B_SOLID_LOW`, `B_MIXED_COLORS` each specify a specific arrangement of colors in an 8-pixel-by-8-pixel area. Here the `B_MIXED_COLORS` pattern is used to fill a rectangle with a checkerboard pattern made up of alternating current high and current low colors:

```
BRect aRect(20.0, 20.0, 300.0, 300.0);  
  
FillRect(aRect, B_MIXED_COLORS);
```

The `BView` class defines a number of stroke and fill member functions. Each stroke function (such as `StrokeRect()` and `StrokePolygon()`) outlines a shape using a specified pattern. Patterns have the greatest effect on the look of a shape outline when the outline has a thickness greater than one pixel (setting the thickness at which lines are drawn is covered ahead in the “The Drawing Pen” section). Each fill function (such as `FillRect()` and `FillPolygon()`) fills a shape using a specified pattern. This may not be entirely obvious when looking at some source code snippets because these drawing routines make the pattern parameter optional. When the pattern parameter is skipped, the function uses the `B_SOLID_HIGH` pattern by default. So both of the following calls to `FillRect()` produce a rectangle filled with a solid pattern in the current high color:

```
BRect rect1(100.0, 100.0, 150.0, 150.0);  
BRect rect2(150.0, 150.0, 200.0, 200.0);  
  
FillRect(rect1, B_SOLID_HIGH);  
FillRect(rect2);
```

Earlier in this chapter, the example project `RGBColor` demonstrated the use of the `B_SOLID_HIGH`, `B_SOLID_LOW`, and `B_MIXED_COLORS` constants by using these constants in the filling of three rectangles (see Figure 5-1). After setting the high color to red and the low color to blue, the rectangle that was filled using the `B_MIXED_COLORS` constant appeared to be purple. I say “appeared to be purple” because, in fact, none of the pixels in the rectangle are purple. Instead, each is either red or blue. Because the pixels alternate between these two colors, and because pixel density is high on a typical monitor, the resulting rectangle appears to the eye to be solid purple. Figure 5-6 illustrates this by showing the `RGBColor` program’s window and the window of the pixel-viewing utility program `Magnify`. The `Magnify` program (which is a Be-supplied application that was placed on your machine during installation of the BeOS) shows an enlarged view of the pixels surrounding the cursor. In Figure 5-6, the cursor is over a part of the purple rectangle in the `RGBColor` window, and the pixels are displayed in the `Magnify` window.

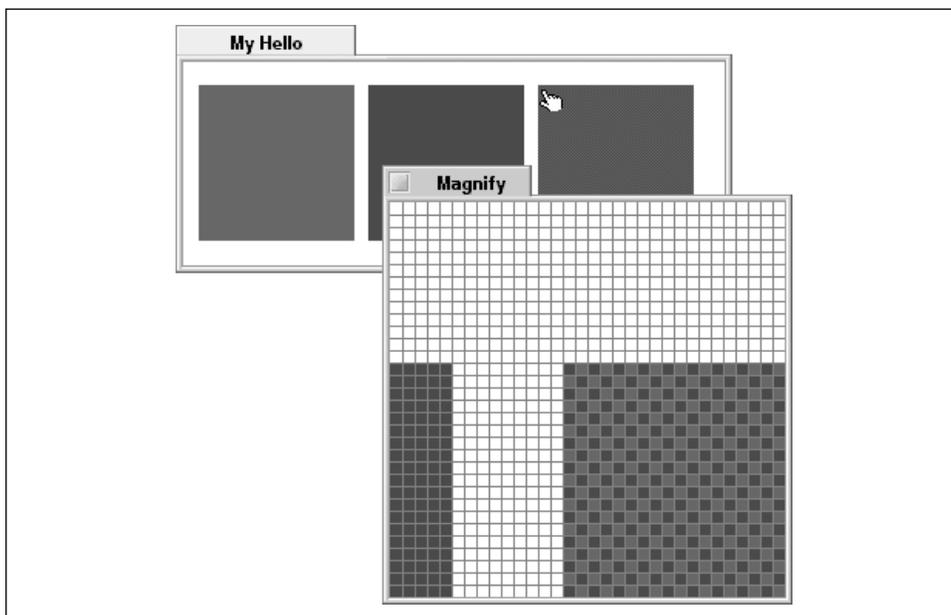


Figure 5-6. Using the `Magnify` program to view the `B_MIXED_COLORS` pattern

Application-Defined Patterns

The three Be-defined patterns come in handy, but they don’t exploit the real power of patterns. Your project can define a pattern that carries out precisely your idea of what a shape should be filled with.

Bit definition of a pattern

A pattern designates which of the 64 bits (8 rows of 8 bits) in an 8-pixel-by-8-pixel area display the current high color and which display the current low color. Thus the specific colors displayed by the pattern aren't designated by the pattern. Instead, a pattern definition marks each of its 64 bits as either a 1 to display the high color or a 0 to display the low color. The colors themselves come from the high and low colors at the time the pattern is used in drawing.

A pattern is specified by listing the hexadecimal values of the eight bits that make up each row of the pattern. Consider the pattern shown in Figure 5-7. Here I show the 8-by-8 grid for a pattern that produces a diagonal stripe. You can do the same using a pencil and graph paper. Each cell represents one pixel, with a filled-in cell considered on, or 1, and an untouched cell considered off, or 0. Since a pattern defines only on and off, not color, this technique works fine regardless of the colors to be used when drawing with the pattern.

1100	1100		cc
0110	0110		66
0011	0011		33
1001	1001		99
1100	1100		cc
0110	0110		66
0011	0011		33
1001	1001		99

Figure 5-7. The binary and hexadecimal representations of a pattern

The left side of Figure 5-7 shows the binary representation of each row in the pattern, with a row chunked into groups of four bits. The right side of the figure shows the corresponding hexadecimal values for each row. Looking at the top row, from left to right, the pixels are on/on/off/off, or binary 1100. The second set of four pixels in the top row has the same value. A binary value of 1100 is hexadecimal c, so the binary pair translates to the hexadecimal pair cc. The hexadecimal values for each remaining row are determined in the same manner. If you're proficient at working with hexadecimal values, you can skip the intermediate binary step and write the hexadecimal value for each row by simply looking at the pixels in groups of four.

Row by row, the hexadecimal values for the pattern in Figure 5-7 are: cc, 66, 33, 99, cc, 66, 33, 99. Using the convention of preceding a hexadecimal value with 0x, the pattern specification becomes: 0xcc, 0x66, 0x33, 0x99, 0xcc, 0x66, 0x33, 0x99.

The pattern datatype

Using the previous method to define a pattern isn't just an exercise in your knowledge of hexadecimal numbers, of course! Instead, you'll use a pattern's eight hexadecimal pairs in assigning a `pattern` variable. Here's how Be defines the `pattern` datatype:

```
typedef struct {
    uchar data[8];
} pattern;
```

Each of the eight elements in the `pattern` array is one byte in size, so each can hold a single unsigned value in the range of 0 to 255. Each of the hexadecimal pairs in each of the eight rows in a pattern falls into this range (0x00 = 0, 0xff = 255). To create a `pattern` variable, determine the hexadecimal pairs for the pattern (as shown above) and assign the variable those values. Here I'm doing that for the pattern I designed back in Figure 5-7:

```
pattern stripePattern = {0xcc, 0x66, 0x33, 0x99, 0xcc, 0x66, 0x33, 0x99};
```

This is also how Be defines its three built-in patterns. The `B_SOLID_HIGH` pattern is one that has all its bits set to 1, or on; the `B_SOLID_LOW` pattern has all its bits set to 0, or off; and the `B_MIXED_COLORS` pattern has its bits set to alternate between 1 and 0:

```
const pattern B_SOLID_HIGH = {0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff, 0xff}
const pattern B_SOLID_LOW  = {0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00, 0x00}
const pattern B_MIXED_COLORS = {0xaa, 0x55, 0xaa, 0x55, 0xaa, 0x55, 0xaa, 0x55}
```

Using a pattern variable

Once initialized, a variable of type `pattern` is used just as one of the Be-defined pattern constants—pass the variable as an argument to any routine that requires a pattern as a parameter. The following snippet defines a pattern variable and two rectangle variables. The code then fills one rectangle with a solid color and the other with diagonal stripes:

```
pattern stripePattern = {0xcc, 0x66, 0x33, 0x99, 0xcc, 0x66, 0x33, 0x99};
BRect    solidRect(10.0, 10.0, 110.0, 110.0);
BRect    stripedRect(200.0, 10.0, 210.0, 110.0);

FillRect(solidRect, B_SOLID_HIGH);
FillRect(stripedRect, stripePattern);
```

Because the previous snippet doesn't include any code that hints at the current state of the high and low colors, you can't infer what colors will be in the resulting rectangles—you know only that one will have a solid fill while the other will have diagonal stripes running through it.

Pattern example project

The Pattern project builds a program that displays a window with a single rectangle drawn in it. The rectangle is filled with the diagonal stripe pattern that was introduced on the preceding pages. Figure 5-8 shows the Pattern program's window. Also shown is the Magnify program's window as it displays an enlarged view of some of the pixels in the Pattern program's filled rectangle.

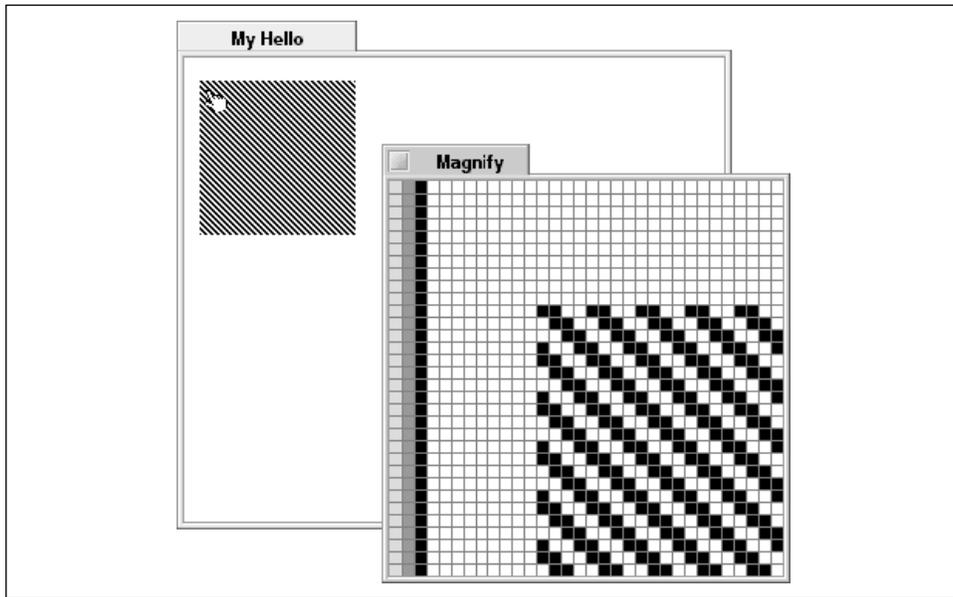


Figure 5-8. Using the Magnify program to view the application-defined pattern

As is the case for many of this chapter's remaining examples, the Pattern project was created by starting with a recent project (such as the RGBColor project) and altering the code in just one of the routines—the `Draw()` member function of the `MyDrawView` class. Here's how the new version of that routine looks:

```
void MyDrawView::Draw(BRect)
{
    BRect    aRect;
    pattern  stripePattern = {0xcc, 0x66, 0x33, 0x99, 0xcc, 0x66, 0x33, 0x99};

    aRect.Set(10.0, 10.0, 110.0, 110.0);
    FillRect(aRect, stripePattern);
}
```

You can experiment with the Pattern project by adding color to the rectangle. Precede the call to `FillRect()` with a call to `SetHighColor()`, `SetLowColor()`, or both. Changing the current high color will change the color of what are presently

the black stripes, while changing the current low color will change the color of what are presently the white stripes.

The Drawing Pen

Whenever drawing takes place, the pen is at work. The pen is a way to summarize and express two properties of a view's drawing environment. When drawing starts, it starts at some specific location in a view. When line drawing takes place, the line has some specific thickness to it. These traits are stored in a view and can be altered by invoking `BView` member functions. In keeping with the analogy of drawing with a pen, the names of these routines include the word "pen."

Pen Location

The location of the rectangle drawn by `FillRect()` has been previously established during the setting up of the rectangle:

```
BRect  aRect(10.0, 10.0, 110.0, 110.0);  
  
FillRect(aRect, B_SOLID_HIGH);
```

For the drawing of text and lines, this isn't the case. Typically, you'll move the pen to the location where drawing is to start, then draw.

Moving the pen

When it's said that the pen is moved, what's actually taking place is that a call sets the starting location for subsequent drawing. Moving the pen doesn't have any visible effect—nothing gets drawn. To move the pen, invoke the view's `MovePenTo()` or `MovePenBy()` function.

The `MovePenTo()` function accepts either a single `BPoint` argument or a pair of floating-point arguments. In either case, the result is that the arguments specify the coordinate at which the next act of drawing starts. The first argument to `MovePenTo()` is the horizontal coordinate to move to, while the second argument is the vertical coordinate. The movement is relative to the view's origin. Each of the following four calls to `MovePenTo()` has the same result—drawing will be set to start at pixel (30.0, 40.0) in the view's system coordinate:

```
BPoint  aPoint(30.0, 40.0);  
float   x = 30.0;  
float   y = 40.0;  
  
MovePenTo(aPoint);  
MovePenTo(BPoint(30.0, 40.0));  
MovePenTo(30.0, 40.0);  
MovePenTo(x, y);
```

Like `MovePenTo()`, the `MovePenBy()` function moves the starting location for drawing. `MovePenTo()` moves the pen relative to the view's origin. `MovePenBy()` moves the pen relative to its current location in the view. Consider this snippet:

```
MovePenTo(30.0, 40.0);
MovePenBy(70.0, 10.0);
```

The call to `MovePenTo()` moves the pen to the location 30 pixels from the left of the view and 40 pixels from the top of the view. That places the pen at the point (30.0, 40.0). The call to `MovePenBy()` uses this current location as the reference and moves the pen 70 pixels to the left and 10 pixels down. The result is that, relative to the view's origin, the pen is at the point (100.0, 50.0).

Negative values for `MovePenBy()` move the pen “backwards” in the view. A negative horizontal argument moves the pen to the left, while a negative vertical argument moves the pen up. Because `MovePenTo()` specifies a particular coordinate to end up at rather than a direction to move in, negative values shouldn't be passed as the arguments of this routine.

MovePen example project

As shown in Figure 5-9, the `MovePen` project results in a program that displays a window with three characters written to it. I've added coordinate information to the figure—the arrows and values aren't actually displayed in the window.

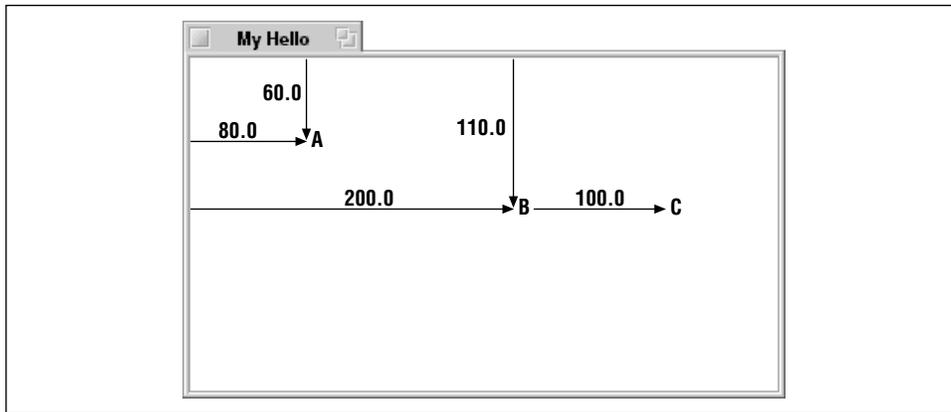


Figure 5-9. The window that results from running the `MovePen` program

Where the characters “A,” “B,” and “C” get drawn in the window depends on calls to the `MovePenTo()` and `MovePenBy()` functions. To get a good feel for working with a view's coordinate system, edit the arguments to the existing function calls in the `Draw()` routine, or add additional calls to `MovePenTo()` and `MovePenBy()`:

```
void MyDrawView::Draw(BRect)
{
```

```
MovePenTo(BPoint(80.0, 60.0));
DrawString("A");

MovePenTo(200.0, 110.0);
DrawString("B");

MovePenBy(100.0, 0.0);
DrawString("C");
}
```

Pen Size

The pen is used to draw shape outlines. Chapter 4 introduced the `BView` member function `StrokeRect()`, which draws the outline of a rectangle. Here a 100-pixel-by-100-pixel rectangle is framed in a view:

```
BRect aRect(10.0, 10.0, 110.0, 110.0);

StrokeRect(aRect);
```

As you'll see later in this chapter, there are a number of `BView StrokeXxx()` member functions, each of which outlines a particular shape. All of these functions are affected by the current size of the pen.

Setting the pen size

By default, the pen can be thought of as having a tip that is the size of a single pixel. Thus, drawing with the pen produces a line with a thickness of one pixel. You can change the size or thickness of the pen at any time by invoking the `BView` member function `SetPenSize()`. This routine accepts a single argument, the new pixel thickness for the pen. In this next snippet, the same rectangle that was outlined in the previous snippet is given a frame, or border, three pixels thick. The lines you specify to be drawn are in the center of the pixels in a thick pen.

```
BRect aRect(10.0, 10.0, 110.0, 110.0);

SetPenSize(3.0);
StrokeRect(aRect);
```

Setting the pen size for a view affects all subsequent calls to `StrokeXxx()` functions. After changing the pen size and invoking a `StrokeXxx()` function, you may want to reset the pen size to a thickness of a single pixel:

```
SetPenSize(3.0);
StrokeRect(aRect);
SetPenSize(1.0);
```

Getting the pen size

The best process to use when altering the pen size is to obtain and save the current pen size, change it, perform the desired drawing using the new pen size, then

restore the pen to the saved size. The `BView` member function `PenSize()` allows you to do that. When invoked, `PenSize()` returns a float that holds the current thickness of the pen. This next snippet provides an example of the use of `PenSize()`:

```
float savedPenSize;

savedPenSize = PenSize();
SetPenSize(3.0);
StrokeRect(aRect);
SetPenSize(savedPenSize);
```

PenSize example project

The `PenSize` project displays a window that holds six rectangles. As shown in Figure 5-10, the thickness of the outline of each rectangle differs.

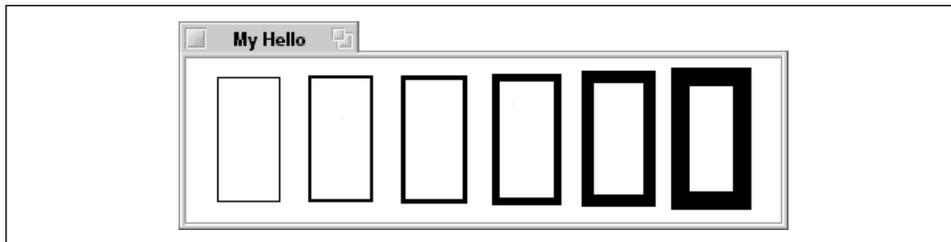


Figure 5-10. The window that results from running the `PenSize` program

As is becoming a habit, the `Draw()` function of the `MyDrawView` class does the example's work. The function begins by defining and setting six rectangles. Each rectangle has a width of 40 pixels and a height of 80 pixels. The outline thickness of each rectangle differs due to the call to `SetPenSize()` that precedes each call to `StrokeRect()`:

```
void MyDrawView::Draw(BRect)
{
    BRect rect1(20.0, 20.0, 60.0, 100.0);
    BRect rect2(80.0, 20.0, 120.0, 100.0);
    BRect rect3(140.0, 20.0, 180.0, 100.0);
    BRect rect5(200.0, 20.0, 240.0, 100.0);
    BRect rect8(260.0, 20.0, 300.0, 100.0);
    BRect rect12(320.0, 20.0, 360.0, 100.0);

    SetPenSize(1.0);
    StrokeRect(rect1);

    SetPenSize(2.0);
    StrokeRect(rect2);

    SetPenSize(3.0);
    StrokeRect(rect3);
```

```
SetPenSize(5.0);  
StrokeRect(rect5);  
  
SetPenSize(8.0);  
StrokeRect(rect8);  
  
SetPenSize(12.0);  
StrokeRect(rect12);
```

Shapes

Be claims that the BeOS is an operating system for the graphics community. So it's hoped that the BeOS makes it easy for programmers to support the drawing of both simple and complex shapes. And, of course, it does.

Points and Lines

Drawing a line or lines is drawing at its most basic level. Points are used in specifying where a line should be drawn within a view.

The BPoint class

A point is represented by a `BPoint` object. The `BPoint` object consists of two floating point values, one denoting an `x` or horizontal coordinate and the other defining a `y` or vertical coordinate. On a monitor, this coordinate pair matches one particular pixel.

A `BPoint` object can have values assigned to its coordinate pair members either at the time of declaration or anytime thereafter. At declaration, one of the `BPoint` constructors can be used to take care of the task of assigning values to the `BPoint` members:

```
BPoint aPoint(40.0, 70.0);
```

To assign coordinates after the object's declaration, either use the `BPoint` member function `Set()` or assign values directly to the `x` and `y` data members:

```
BPoint point1;  
BPoint point2;  
  
point1.Set(100.0, 200.0);  
point2.x = 100.0;  
point2.y = 200.0;
```

Note the lack of the use of `new` in the previous line of code, and the direct assignment of values to an object's data members. The point is basic to drawing operations, so Be has defined the `BPoint` to act like a basic datatype rather than a class. The declaration of a `BPoint` is all that's needed to actually create a `BPoint` object.

Because the `BPoint` data members are declared public, direct access is allowed. You've seen a similar situation with the `BRect` class as well.

Line drawing

Unlike `BPoint`, the BeOS defines no `BLine` class to represent lines. Instead, line drawing takes place using the `BView` member function `StrokeLine()`. When invoking this function, you can use a pair of `BPoint` objects to specify the start and end points of a line, or a single `BPoint` object to specify just the line's end point. If only the end point is specified, the current pen location in the view is used as the start point. Both types of call to `StrokeLine()` are demonstrated here:

```
BPoint start1(50.0, 50.0);
BPoint end1(150.0, 50.0);
BPoint start2(20.0, 200.0);
BPoint end2(20.0, 250.0);

StrokeLine(start1, end1);

MovePenTo(start2);
StrokeLine(end2);
```

In the previous snippet, two lines are drawn. The first is a horizontal line 100 pixels in length that is drawn from the point (50.0, 50.0) to the point (150.0, 50). The second is a vertical line 50 pixels in length that is drawn from the point (20.0, 200.0) to the point (20.0, 250.0).

Both versions of `StrokeLine()` offer a final optional parameter that specifies a pattern in which the line is drawn. The following snippet draws lines of the same length and location as the previous snippet (assume the same `BPoint` variables are declared). Here, however, the horizontal line is red and the vertical line is green:

```
rgb_color redColor = {255, 0, 0, 255};
rgb_color greenColor = {0, 255, 0, 255};

SetHighColor(redColor);
SetLowColor(greenColor);

StrokeLine(start1, end1, B_SOLID_HIGH);

MovePenTo(start2);
StrokeLine(end2, B_SOLID_LOW);
```

You aren't limited to the Be-defined patterns—any pattern can be used as an argument to `StrokeLine()`. In this next snippet, the diagonal stripe pattern discussed earlier in this chapter is used. The high color is set to red, and the low color is left in its default state of white. Additionally, the pen size is set to 10.0. The result is a

line 10 pixels in thickness with diagonal red stripes running through it. Figure 5-11 shows the line that is drawn from this snippet:

```

pattern    stripePattern = {0xcc, 0x66, 0x33, 0x99, 0xcc, 0x66, 0x33, 0x99};
rgb_color  redColor      = {255, 0, 0, 255};
BPoint     start1(50.0, 50.0);
BPoint     end1(150.0, 50.0);

SetHighColor(redColor);

SetPenSize(10.0);

StrokeLine(start1, end1, stripePattern);

```

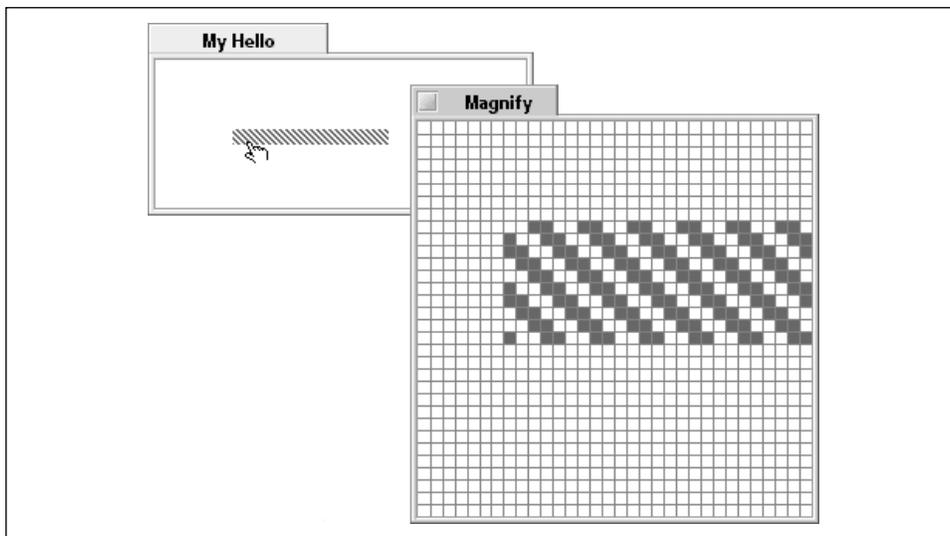


Figure 5-11. Using the Magnify program to view a thick, patterned line

PointAndLine example project

The PointAndLine project is a simple exercise in moving the pen and drawing lines. The resulting program draws the two lines pictured in Figure 5-12.

The `MyDrawView` member function `Draw()` has been written to define two `BPoint` objects that specify the start and end of a horizontal line. After drawing the line, the pen is first moved to the line's start point, and then moved down a number of pixels. `StrokeLine()` is called again, this time to draw a diagonal line that ends at the same point where the first line ended.

```

void MyDrawView::Draw(BRect)
{
    BPoint  point1;
    BPoint  point2;

```

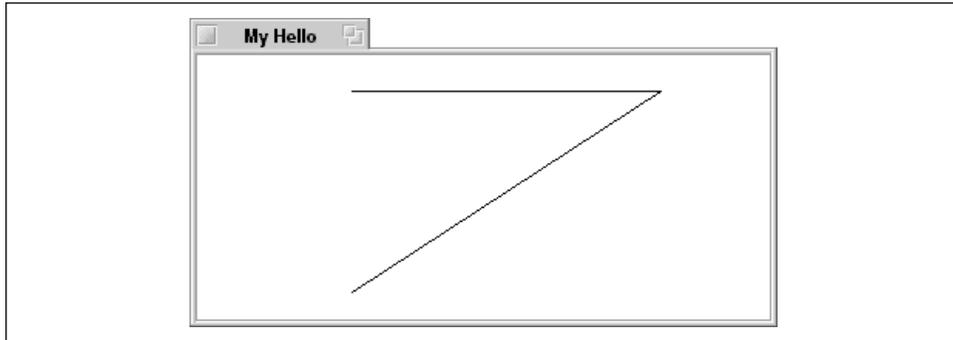


Figure 5-12. The window that results from running the *PointAndLine* program

```
point1.Set(100.0, 80.0);
point2.Set(300.0, 80.0);

StrokeLine(point1, point2);

MovePenTo(point1);
MovePenBy(0.0, 130.0);
StrokeLine(point2);
}
```

Rectangles

The `BRect` class is used to create objects that represent rectangles. Rectangles are important in their own right, as they're the basis for defining the boundaries of interface elements such as windows and controls. But they are also instrumental in the definition of other shapes, including round rectangles, ellipses, and regions—as you'll see ahead.

Setting a rectangle

A `BRect` object has four data members of type `float`: `left`, `top`, `right`, and `bottom`. Each data member specifies a pixel location that defines one of the four edges of a rectangle. The values of the `left` and `right` members are relative to the left edge of the view that is to hold the rectangle, while the values of the `top` and `bottom` members are relative to the top edge of the view.

Upon declaration, the boundaries of a `BRect` object can be set by specifying values for each of the four data members or by listing two points—one of which specifies the rectangle's top left corner while the other specifies the rectangle's bottom right corner. In this next snippet, both of the `BRect` objects would have the same boundaries:

```
BRect  rect1(10.0, 30.0, 110.0, 130.0);

BPoint leftTopPt(10.0, 30.0);
```

```
BPoint  rightBottomPt(110.0, 130.0);
BRect   rect2(leftTopPt, rightBottomPt);
```

A rectangle's data members can also be set after the `BRect` object's declaration. Again, the following rectangle shares the same coordinates as the previous two:

```
BRect  aRect;

aRect.left   = 10.0;
aRect.top    = 30.0;
aRect.right  = 110.0;
aRect.bottom = 130.0;
```

A more efficient means of achieving the above result is to use the `BRect` member function `Set()`. The order of the values passed to `Set()` is `left`, `top`, `right`, `bottom`:

```
BRect  aRect;

aRect.Set(10.0, 30.0, 110.0, 130.0);
```

Like a point, which is represented by a `BPoint` object, a rectangle is considered basic to drawing. The `BRect` class is set up so that a `BRect` object is created upon declaration of a `BRect`. Additionally, the `BRect` data members are public, so they can be accessed either directly or via member functions such as `Set()`. In short, `BRect` objects and `BPoint` objects can and should be created on the stack (declared locally).

Drawing a rectangle

In Chapter 4, you saw that shape drawing is achieved by invoking a `BView` member function. There, `StrokeRect()` was called to draw a framing rectangle around a view. In this chapter, you've already seen that a rectangle is filled by calling `FillRect()`. Both routines accept as an argument a previously set up rectangle. This snippet calls `StrokeRect()` to frame one rectangle, then calls `FillRect()` to fill a smaller rectangle centered within the first:

```
BRect  outerRect(10.0, 10.0, 160.0, 160.0);
BRect  innerRect(30.0, 30.0, 140.0, 140.0);

StrokeRect(outerRect);
FillRect(innerRect);
```

Both `StrokeRect()` and `FillRect()` accept an optional `pattern` parameter. Here the rectangles just defined are drawn with a black and white checkerboard pattern:

```
StrokeRect(outerRect, B_MIXED_COLORS);
FillRect(innerRect, B_MIXED_COLORS);
```

Rectangles example project

The Rectangles project displays a window consisting of the rectangles shown in Figure 5-13.

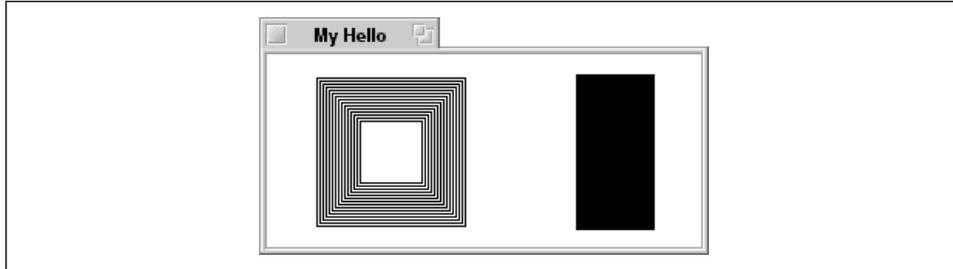


Figure 5-13. The window that results from running the Rectangles program

The left rectangle consists of many nested, or inset, rectangles. The `MyDrawView` member function `Draw()` sets up what will be the outermost rectangle shown. After the `BRect` object's boundaries are set, a `for` loop insets and draws each rectangle. The `BRect` member function `InsetBy()` creates the desired inset effect by adjusting the values of the data members of the calling `BRect` object. After fifteen rectangles are framed one inside the other, a solid black rectangle is drawn to the right of the window:

```
void MyDrawView::Draw(BRect)
{
    int32 i;
    BRect aRect;

    aRect.Set(30.0, 30.0, 130.0, 130.0);

    for (i = 0; i < 15; i++) {
        aRect.InsetBy(2.0, 2.0);
        StrokeRect(aRect);
    }

    aRect.Set(200.0, 30.0, 250.0, 130.0);
    FillRect(aRect);
}
```

Round rectangles

A rectangle with rounded corners is a shape that appears in both user-interface elements (most buttons are round rectangles) and everyday objects (picture some of the boxes in a flow chart). You can use the `BView` member function `StrokeRoundRect()` to take an “ordinary” rectangle—a `BRect` object—and provide a degree of rounding to each of its corners.

In `StrokeRoundRect()`, the first argument is a previously set up rectangle. The second and third `StrokeRoundRect()` parameters specify the amount of rounding to be applied to each corner. Together these two parameters specify the shape of an ellipse; the second parameter establishes the ellipse radius along the x-axis, while the third parameter establishes the ellipse radius along the y-axis. Think of setting an ellipse in each corner of the rectangle and drawing only one quarter of the ellipse in order to form a rounded corner. The following snippet demonstrates a call to `StrokeRoundRect()`:

```
BRect  aRect;

aRect.Set(30.0, 30.0, 130.0, 130.0);

StrokeRoundRect(aRect, 20.0, 20.0);

FillRoundRect(aRect, 30.0, 30.0);
```

To fill a round rectangle, call the `BView` member function `FillRoundRect()`. The parameters to this function match those used in `StrokeRoundRect()`:

```
BRect  aRect;

aRect.Set(30.0, 30.0, 130.0, 130.0);

FillRoundRect(aRect, 20.0, 20.0);
```

Like other `BView` drawing routines, both `StrokeRoundRect()` and `FillRoundRect()` accept an optional `pattern` argument. Omitting this argument tells the view to use `B_SOLID_HIGH`.

Ellipses

You've seen that a line isn't represented by a class, but is instead drawn using a `BView` member function. A similar situation exists for an ellipse. And like a round rectangle, an ellipse is specified using a rectangle.

Drawing an ellipse

After defining a rectangle, an ellipse is drawn by inscribing an oval within the boundaries of the rectangle. The rectangle itself isn't drawn—it simply serves to specify the size of the ellipse. A circle, of course, is an ellipse whose height and width are equal.

The `BView` member function `StrokeEllipse()` does the drawing:

```
BRect  aRect;

aRect.Set(30.0, 30.0, 130.0, 130.0);

StrokeEllipse(aRect);
```

An ellipse can be filled by the `BView` member function `FillEllipse()`:

```
BRect  aRect;

aRect.Set(200.0, 30.0, 250.0, 130.0);
FillEllipse(aRect);
```

By default, an ellipse is outlined or filled using a solid pattern and the current high color. As with other `BView` drawing routines, a call to either `StrokeEllipse()` or `FillEllipse()` can include an optional second parameter that specifies a different pattern.

An alternate method of specifying the boundaries of an ellipse is to supply `StrokeEllipse()` or `FillEllipse()` with a center point and an x-axis and y-axis radius. The next snippet draws a single ellipse that is both outlined and filled. A call to `SetLowColor()` sets the low color to blue. The subsequent call to `FillEllipse()` draws an ellipse that is filled with a black and blue checkerboard pattern. Specifying the `B_MIXED_COLORS` pattern in the call to `FillEllipse()` tells the routine to fill the ellipse with a checkerboard pattern that alternates the current high color (by default, black) with the current low color (which was just set to blue). The call to `StrokeEllipse()` relies on the current high color (black) to outline the ellipse in a solid pattern (`B_SOLID_HIGH`, since no pattern was specified). Note that when both filling and outlining a single ellipse it's important to call the `StrokeEllipse()` routine after calling `FillEllipse()`. If the calling order is reversed, the call to `FillEllipse()` will obscure whatever outline was drawn by the call to `StrokeEllipse()`:

```
rgb_color  blueColor = {0, 0, 255, 255};
BPoint     center(100.0, 100.0);
float      xRadius = 40.0;
float      yRadius = 60.0;

SetLowColor(blueColor);
FillEllipse(center, xRadius, yRadius, B_MIXED_COLORS);

StrokeEllipse(center, xRadius, yRadius);
```

Polygons

A polygon is a closed shape with straight sides. Unlike a rectangle, which consists of sides that must be vertical and horizontal, a polygon can include sides that run diagonally.

Setting up a polygon

The `BPolygon` class is used to create objects that represent polygons. When creating a new `BPolygon` object, pass the `BPolygon` constructor an array of `BPoints` that specify the points that make up the vertices of the polygon, along with an

`int32` value that specifies how many points are in the array. Here's how a `BPolygon` object representing a three-sided polygon might be defined:

```
BPoint    pointArray[3];
int32     numPoints = 3;
BPolygon  *aPolygon;

pointArray[0].Set(50.0, 100.0);
pointArray[1].Set(150.0, 20.0);
pointArray[2].Set(250.0, 100.0);

aPolygon = new BPolygon(pointArray, numPoints);
```

The previous snippet creates an array of three `BPoint` objects. The coordinates of each `BPoint` object are then assigned by calling the `BPoint` member function `Set()`. Next, `new` is used to create a new `BPolygon` object whose vertices are defined by the `BPoints` in the `pointArray` array.

Alternatively, a `BPolygon` can be created without immediately defining its vertices. In this case, the polygon can be defined later by calling the `BPolygon` member function `AddPoints()`, which adds an array of `BPoint` objects to the `BPolygon` object. Here, the same polygon that was defined in the previous snippet is again defined—this time using a call to `AddPoints()`:

```
BPoint    pointArray[3];
int32     numPoints = 3;
BPolygon  *aPolygon;

aPolygon = new BPolygon();

pointArray[0].Set(50.0, 100.0);
pointArray[1].Set(150.0, 20.0);
pointArray[2].Set(250.0, 100.0);

aPolygon->AddPoints(pointArray, numPoints);
```

Drawing a polygon

Once a `BPolygon` object is defined, its outline can be drawn by calling the `BView` member function `StrokePolygon()`, or it can be filled in with the `BView` member function `FillPolygon()`. If the following call to `StrokePolygon()` is made after either of the previous two snippets execute, the result is an outlined triangle.

```
StrokePolygon(aPolygon);
```

Note that `StrokePolygon()` draws the lines of the polygon's edges starting at the first point in the array, and finishes by closing the polygon with a line from the last point back to the first point. Thus, the previous call to `StrokePolygon()` draws the following three lines.

- From point (50.0, 100.0) to point (150.0, 20.0)
- From point (150.0, 20.0) to point (250.0, 100.0)
- From point (250.0, 100.0) back to point (50.0, 100.0)

A call to `FillPolygon()` fills the previously defined polygon with a pattern. Here the triangle polygon is filled with the default pattern of `B_SOLID_HIGH`:

```
FillPolygon(aPolygon);
```

As you've come to expect from the `BView StrokeXxx()` and `FillXxx()` routines, both `StrokePolygon()` and `FillPolygon()` may include an optional pattern polygon that specifies a pattern to use for the outline or fill of the polygon.

Finally, you can include yet one more optional parameter in the polygon drawing routines—a `bool` value that indicates whether the final shape-closing line should or shouldn't be drawn. By default, this line is drawn to finish up the polygon. If `false` is passed, a series of connected lines rather than a polygon will be drawn.

Drawing a triangle

On the previous pages you saw how to define and draw a triangle using a `BPolygon` object. The BeOS also provides a shortcut for working with this special case of a polygon. It's useful because so many 3D objects are built from dozens of tiny triangles. Instead of defining an array of points and adding those points to a `BPolygon` object, you can forego the both these steps and simply call one of two `BView` member functions: `StrokeTriangle()` or `FillTriangle()`. Pass the three `BPoint` objects that define the triangle's vertices. Here, the same triangle that was drawn using a `BPolygon` object is drawn using a call to `StrokeTriangle()`:

```
BPoint point1;
BPoint point2;
BPoint point3;

point1.Set(50.0, 100.0);
point2.Set(150.0, 20.0);
point3.Set(250.0, 100.0);
StrokeTriangle(point1, point2, point3);
```

As expected, `FillTriangle()` is invoked in the same manner as `StrokeTriangle()`. Again as expected, both functions accept an optional pattern parameter.

Regions

A region groups a number of rectangles together into a single `BRegion` object. This object can then be manipulated as a unit—rotated, colored, and so forth. The rectangles that make up a region can vary in size, and can be defined such that

they form one continuous shape or any number of seemingly unrelated shapes. In Figure 5-14, a window has been divided into four areas. Each area holds a single region. That last point is worthy of repeating: the window holds four regions. The rectangles in the area at the bottom left of the window don't form a single, solid area, but because they've been marked to all be a part of a single `BRegion` object, they collectively make up a single region. The same applies to the rectangles in the lower right area of the window.

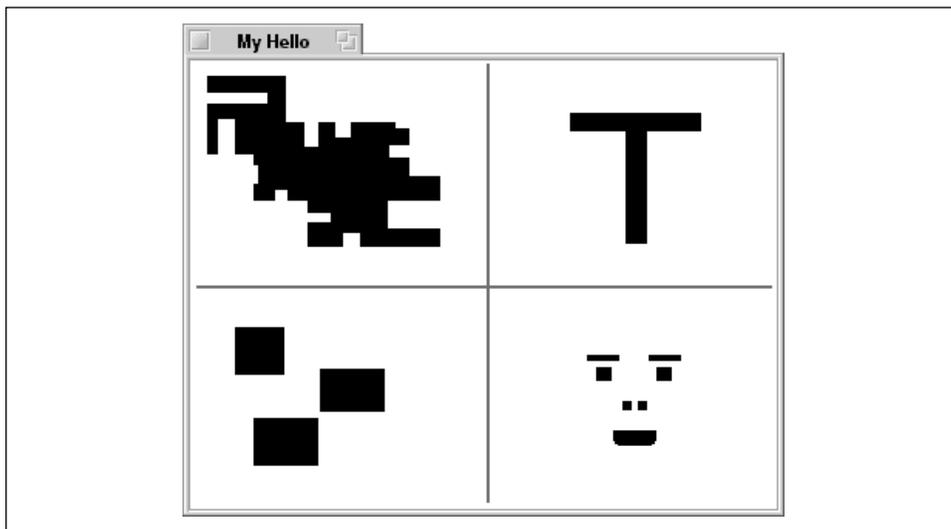


Figure 5-14. A window displaying four regions

Setting up a region

To set up a region, first create a new `BRegion` object. Then define a rectangle and add that rectangle to the `BRegion`. In the following snippet, two rectangles are defined and added to a `BRegion` object named `aRegion`:

```
BRect    aRect;
BRegion  *aRegion;

aRegion = new BRegion();

aRect.Set(20.0, 20.0, 70.0, 70.0);
aRegion->Include(aRect);

aRect.Set(50.0, 50.0, 150.0, 100.0);
aRegion->Include(aRect);
```

Drawing a region

Creating a region and adding rectangles to it defines the area (or areas) the region occupies. It doesn't, however, display the region in a view. To do that, invoke the

`BView` member function `FillRegion()`. Here, the region that was created in the previous snippet is filled with the default `B_SOLID_HIGH` pattern:

```
FillRegion(aRegion);
```

The `BRegion` object keeps track of all of the constituent rectangles and is responsible for filling each. Like other `FillXxx()` functions `FillRegion()` allows you to specify an optional pattern.



There is no `StrokeRegion()` member function in the `BView` class. Because a region can consist of any number of overlapping rectangles, outlining each individual rectangle would result in lines running through the contents of the region.

Testing for inclusion in a region

One important use of a region is to test where a point lies within an area. If a point lies in any one of the rectangles that defines a region, that point is considered a part of, or belonging to, the region. To test a point for inclusion in a region, call the `BRegion` member function `Contains()`. Pass this routine the `BPoint` object to test, and `Contains()` will return a `bool` value that indicates whether or not the tested point lies within the region. In this next snippet, a region consisting of just a single rectangle is defined. A point is then defined and tested for inclusion in this region:

```
BRect    aRect(20.0, 20.0, 70.0, 70.0);
BRegion  *aRegion;
BPoint   aPoint(60.0, 90.0);

aRegion = new BRegion();
aRegion->Include(aRect);
FillRegion(aRegion);

if (aRegion->Contains(aPoint))
    // do something
else
    // do something else
```

Region example project

The Region project results in a program that displays a window like the one shown in Figure 5-15.

The dark area in Figure 5-15 represents a single region composed of three rectangles. The `MyDrawView` member function `Draw()` defines and adds each rectangle in turn to the `BRegion` object. After all of the rectangles have been

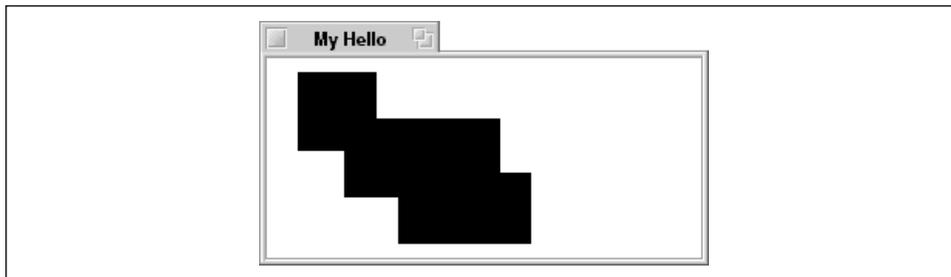


Figure 5-15. The window that results from running the Region program

added, `FillRegion()` is called to fill the entire region with the default pattern of `B_SOLID_HIGH`:

```
void MyDrawView::Draw(BRect)
{
    BRect    aRect;
    BRegion  *aRegion;

    aRegion = new BRegion();

    aRect.Set(20.0, 20.0, 70.0, 70.0);
    aRegion->Include(aRect);

    aRect.Set(50.0, 50.0, 150.0, 100.0);
    aRegion->Include(aRect);

    aRect.Set(85.0, 85.0, 170.0, 130.0);
    aRegion->Include(aRect);
    FillRegion(aRegion);
}
```

Region point testing example project

While the region shown in Figure 5-15 is filled, it doesn't have to be. By omitting a call to `FillRegion()`, it's possible to define a region without making it visible. One practical reason for doing this is for testing mouse button hits. If your program needs to find out whether the user clicked in a particular area of a window—even a very irregularly shaped area—a region that includes the entire area to test can be set up. The `BRegion` class includes a routine that tests for the inclusion of a `BPoint`. The `BView` member function `MouseDown()` provides your application with a `BPoint` object that holds the pixel location of the cursor at the time of a mouse button click. By overriding a view's `MouseDown()` function and implementing it such that it compares the cursor location with the area of the region, your program can easily respond to mouse button clicks in an area of any shape.

The `RegionTest` project creates a program that draws a region to a window—the same region created by the `Region` example project and pictured in Figure 5-15.

What's been added is the ability to test for a mouse button click in the region. If the user clicks anywhere in the dark area, the system beep is played. Clicking in the window but outside of the region produces no effect.

To let the `MyDrawView` view (which occupies the entire area of the window it resides in) respond to mouse button clicks, the program overrides `MouseDown()`. To enable a `MyDrawView` object to keep track of its region, a `BRegion` object has been added as a private data member in the `MyDrawView` class. Here's the new declaration of the `MyDrawView` class:

```
class MyDrawView : public BView {
public:
    MyDrawView(BRect frame, char *name);
    virtual void AttachedToWindow();
    virtual void Draw(BRect updateRect);
    virtual void MouseDown(BPoint point);

private:
    BRegion      *fThreeRectRegion;
};
```

In the previous example (the `Region` project), the region was set up in the `Draw()` function. Because in that project the `MyDrawView` class didn't retain the information about the region (it didn't define a `BRegion` object as a data member), it was necessary to recalculate the region's area each time the view it resided in needed updating. Now that the view retains this information, the `BRegion` needs to be set up only once. The `MyDrawView` constructor is used for that purpose:

```
MyDrawView::MyDrawView(BRect rect, char *name)
    : BView(rect, name, B_FOLLOW_ALL, B_WILL_DRAW)
{
    BRect    aRect;

    fThreeRectRegion = new BRegion();

    aRect.Set(20.0, 20.0, 70.0, 70.0);
    fThreeRectRegion->Include(aRect);

    aRect.Set(50.0, 50.0, 150.0, 100.0);
    fThreeRectRegion->Include(aRect);

    aRect.Set(85.0, 85.0, 170.0, 130.0);
    fThreeRectRegion->Include(aRect);
}
```

With the `BRegion` construction moved to the `MyDrawView` constructor, the implementation of the `MyDrawView` member function `Draw()` is reduced to nothing more than a call to `FillRegion()`:

```
void MyDrawView::Draw(BRect)
{
```

```
        FillRegion(fThreeRectRegion);
    }
```

Implementing the `MouseDown()` routine for the `MyDrawView` class is as easy as comparing the cursor location (supplied by the system when it automatically invokes `MouseDown()`) to the area of the region. The `BRegion` member function `Contains()` handles that task:

```
void MyDrawView::MouseDown(BPoint point)
{
    if (fThreeRectRegion->Contains(point))
        beep();
}
```

If the cursor is over any part of the region when the mouse button is clicked, the computer beeps. Your more sophisticated program will of course find something more interesting to do in response to the user clicking the mouse button in a region!

Pictures

Now that you know about the myriad shapes the BeOS allows you to draw, you'll appreciate the `BPicture` class. A `BPicture` object consists of any number of shapes of any type. Once defined, this combination of one, two, or hundreds of shapes can be quickly drawn and redrawn with a single function call.

Setting up a picture

A picture object is created by using `new` to allocate memory for an empty, temporary `BPicture`. The creation of the new object takes place within a call to the `BView` member function `BeginPicture()`. Doing so instructs the view to store the results of subsequent calls to `BView` drawing functions in the picture object, as opposed to drawing the results of the calls to the view (as is normally the case). When the picture is considered complete, the `BView` member function `EndPicture()` is called. This routine returns the completed temporary picture object. This temporary object should be assigned to an application-defined `BPicture` object. The following snippet provides an example:

```
BPicture *aPicture;

BeginPicture(new BPicture);
    BRect aRect;

    aRect.Set(10.0, 10.0, 30.0, 30.0);
    FillRect(aRect);
    MovePenTo(40.0, 10.0);
    StrokeLine(BPoint(60.0, 10.0));
aPicture = EndPicture();
```

For simplicity, the previous snippet defines a picture that consists of a small filled-in rectangle and a short, horizontal line. Your own pictures may prove to be far more complex. In particular, you'll want to include calls such as `SetFont()`, `SetPenSize()`, and so forth in order to set up the drawing environment appropriate to your drawing. If such calls aren't made, the state of the view's drawing environment at the time the picture is created will be used when the picture is later drawn.



The previous snippet indents the code between the `BeginPicture()` and `EndPicture()` calls for purely aesthetic reasons. Doing so isn't necessary, but it does make it obvious just what code the picture object consists of.

Completing a picture by calling `EndPicture()` doesn't prohibit you from adding to that same picture at a later time. To add to an existing `BPicture` object, pass that object to `BeginPicture()` and start drawing. After calling `EndPicture()`, the new drawing code will be a part of the existing picture. Here the previous picture-creating snippet is repeated. After the picture is completed, it is reopened and a vertical line is added to it:

```

BPicture *aPicture;

BeginPicture(new BPicture);
    BRect aRect;

    aRect.Set(10.0, 10.0, 30.0, 30.0);
    FillRect(aRect);_
    MovePenTo(40.0, 10.0);
    StrokeLine(BPoint(60.0, 10.0));
aPicture = EndPicture();
...
...
BeginPicture(aPicture);
    MovePENto(10.0, 40.0);
    StrokeLine(BPoint(10.0, 60.0));
aPicture = EndPicture();

```

Drawing a picture

Once defined, a picture is drawn by invoking the `BView` member function `DrawPicture()`. Just pass the picture as the argument:

```

DrawPicture(aPicture);

```

Before calling `DrawPicture()`, specify the starting position of the picture by moving the pen to where the upper left corner should be. Alternately, a `BPoint` object can be passed to `DrawPicture()` to denote where drawing should start. Both

techniques are shown here. The result of executing the code will be two identical pictures, one beneath the other.

```
BPicture *aPicture;

BeginPicture(new BPicture);
    // line and shape-drawing code here
aPicture = EndPicture();

MovePenTo(100.0, 20.0);
DrawPicture(aPicture);

DrawPicture(aPicture, BPoint(100.0, 250.0));
```

Keep in mind that if a picture hasn't set up its drawing environment, the state of the view at the time the picture was created is used when the picture is drawn. If the view's graphic state happened to be in its default state (a high color of black, a pen size of 1.0, and so forth), the drawing will be made as expected. However, if any of the view's graphic settings were altered at some point before the picture was created, the drawing of the picture may occur with unpredictable and undesirable effects. Consider the previous snippet. If a call to `SetPenSize(10.0)` had been made somewhere before the call to `BeginPicture()`, any line drawing done by the `aPicture` picture would include lines with a thickness of 10 pixels. That most likely won't be the desired effect. If the picture is to draw lines with a thickness of 1 pixel, then a call to `SetPenSize(1.0)` should be made in the picture-defining code, like this:

```
BPicture *aPicture;

BeginPicture(new BPicture);
    SetPenSize(1.0);
    // line and shape-drawing code here
aPicture = EndPicture();
```

You don't have to keep track and reverse changes that are made to the drawing environment by a picture. That is, after a call to `EndPicture()`, your code doesn't need to restore the view's environment to its pre-`BeginPicture()` state. That's because all environmental changes that are made between calls to `BeginPicture()` and `EndPicture()` apply only to the picture, not to the view.

Picture example project

The Picture project draws a number of cascading rectangles, as shown in Figure 5-16.

For this project I've added a private data member `BPicture` object named `fPicture` to the `MyDrawView` class. In the `MyDrawView` member function `AttachedToWindow()`, this picture is created and defined. A `for` loop is used to set up the numerous offset rectangles that make up the picture.

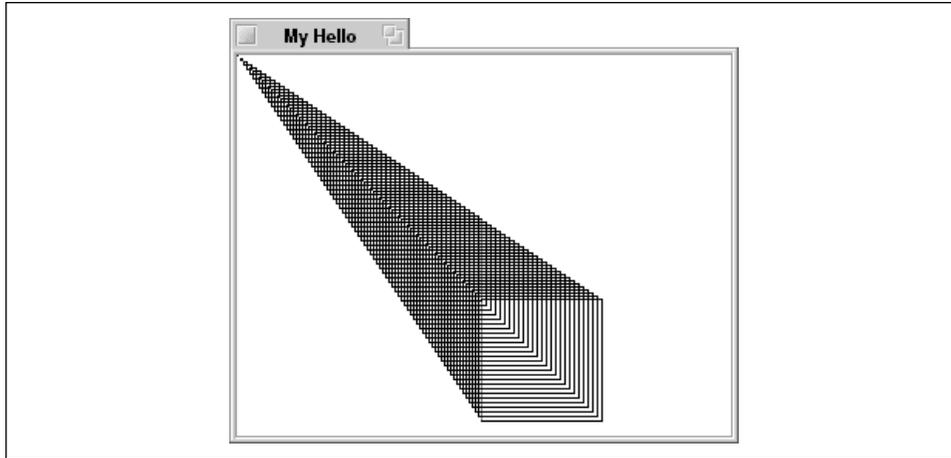


Figure 5-16. The window that results from running the *Picture* program

```
void MyDrawView::AttachedToWindow()
{
    SetFont(be_bold_font);
    SetFontSize(24);

    BeginPicture(new BPicture);
    BRect aRect;
    int32 i;

    for (i=0; i<80; i++) {
        aRect.Set(i*2, i*2, i*3, i*3);
        StrokeRect(aRect);
    }
    fPicture = EndPicture();
}
```

While the temptation is to define the picture in the `MyDrawView` constructor (it is, after all, an initialization act), the code must instead appear in the `AttachedToWindow()` routine. The `BPicture` definition relies on the current state of the view the picture belongs to, and the view's state isn't completely set up until `AttachedToWindow()` executes.

Once the picture is set up and saved in the `fPicture` data member, a `MyDrawView` object can make use of it. That's done in the `Draw()` function, where a call to `MovePenTo()` ensures that the drawing will start in the top left corner of the view (and, because the view is the same size as the window, the top left corner of the window). A call to `DrawPicture()` performs the drawing:

```
void MyDrawView::Draw(BRect)
{
    MovePenTo(0.0, 0.0);
    DrawPicture(fPicture);
}
```