11

QUICKDRAW PRELIMINARIES

Includes Demonstration Program PreQuickDraw

QuickDraw and Imaging

QuickDraw is a collection of system software routines that your application uses to perform most **imaging** operations on Macintosh computers. Imaging entails the construction and display of graphical information, including shapes, pictures, and text, which can be displayed on such output devices as screens and printers.

This chapter serves as a prelude to Chapter 12 — Drawing With QuickDraw, and introduces certain matters which need to be discussed before the matter of actually drawing with QuickDraw is addressed. These matters include the history of QuickDraw, RGB colours, colour and the video device, the colour graphics port, translation of RGB values, and graphics devices.

History of QuickDraw

As the system software has developed, QuickDraw has progressed through the following three main evolutionary stages:

- **Basic QuickDraw**, which was designed for the early black-and-white Macintoshes. System 7 added new capabilities to basic QuickDraw, including support for offscreen graphics worlds.
- The **original version of Color QuickDraw**, which was introduced with the first Macintosh II systems, and which could support up to 256 colours.
- The **current version of Color QuickDraw**, which was originally introduced as **32-bit Color QuickDraw**. This version has been expanded to support millions of colours.

The Appearance Manager requires that Color QuickDraw be present. Accordingly, this edition of Macintosh C assumes Color QuickDraw in all circumstances. Where the word "QuickDraw" is used, Color QuickDraw is invariably implied.

RGB Colours and Pixels

When using QuickDraw, you specify colours as **RGB colours**. An RGB (red-green-blue) colour is defined by its red, green and blue components. For example, when each of the red, green and blue components of a colour are at their maximum intensity (0xFFFF), the result is the colour white. When each of the components has zero intensity (0x0000), the result is the colour black.

You specify a colour to QuickDraw by creating an RGBColor structure in which you use three 16-bit unsigned integers to assign intensity values for the three additive[1] primary colours. The RGBColor data type is defined as follows:

```
RGBColor = record
   red : UInt16;                    { Magnitude of red component. }
   green : UInt16;                  { Magnitude of green component. }
   blue : UInt16;                   { Magnitude of blue component. }
   end;
```

A **pixel** (picture element) is the smallest dot that QuickDraw can draw. Each colour pixel represents up to 48 bits in memory.

Colour and the Video Device

QuickDraw supports a variety of screens of differing sizes and colour capabilities. It is thus device-independent. Accordingly, you do not have to concern yourself with the capabilities of individual screens. For example, when your application uses an RGBColor structure to specify a colour by its red, green and blue components, with each component defined in a 16-bit integer, QuickDraw compares the resulting 48-bit value with the colours actually available on a video device (such as a plug-in video card or a built-in video interface) at execution time and then chooses the closest match. What the user finally sees depends on the characteristics of the actual video device and screen.

The video device that controls a screen may have either:

- **Indexed colours**, which support pixels of 1-bit, 2-bit, 4-bit, or 8-bit pixel depths[2]. The indexed colour system was introduced with the Macintosh II, that is, at a time when memory was scarce and moving megabyte images around was impractical.

- **Direct colours**, which support pixels of 16-bit and 32-bit depths. Most video devices in the current day are direct colour devices. (However, as will be seen, there are circumstances in which a direct colour device will act like an indexed colour device.)

QuickDraw automatically determines which method is used by the video device and matches your requested 48-bit colour with the closest available colour.

Indexed Colour Devices

Video devices using indexed colours support a maximum of 256 colours at any one time, that is, with indexed colour, the maximum value of a pixel is limited to a single byte, with each pixel's byte specifying one of 256 (2^8) different values.

Video devices implementing indexed colour contain a data structure called a **colour lookup table** (or, more commonly, a **CLUT**). The CLUT, in turn, contains entries for all possible colour values.

256 colours is, for many images, sufficient for near-photographic quality. The problem is that the colours needed for one photographic image may not be appropriate for another. Because most indexed video devices use a **variable CLUT**, however, you can display one

[1] On a video device, the primary colours are referred to as additive because, when each of the three colour components is at maximum intensity, the result is the colour white. On a printer, the primary colours are referred to as subtractive because the colour black results when the three colour components are at maximum intensity.

[2] Pixel depth means the number of bits assigned to each pixel, and thus determines the maximum number of colours that can be displayed at the one time. A 4-bit pixel depth, for example, means that an individual pixel can be displayed in any one of 16 separate colours. An 8-bit pixel depth means that an individual pixel can be displayed in any one of 256 separate colours.

image using one set of 256 colours and then use system software to reload the CLUT with a second set of 256 colours that are appropriate for the next image.[3] If your application needs this sort of control on indexed video devices, you can use the Palette Manager to arrange palettes (that is, sets of colours) for particular images and for video devices with differing colour capabilities.

If your application uses a 48-bit RGBColor structure to specify a colour, the Color Manager examines the colours available in the CLUT on the video device. Comparing the CLUT entries to the RGBColor structure you specify, the Color Manager determines which colour in the CLUT is closest, and gives QuickDraw the index to this colour. QuickDraw then draws with this colour.

Fig 1 illustrates this process. In Fig 1, the user selects a colour for some object in an application (1). Using a 48-bit RGBColor structure to specify the colour, the application calls a QuickDraw routine to draw the object in that colour (2). QuickDraw uses the Color Manager to determine what colour in the video devices's CLUT comes closest to the requested colour (3).

At startup, the video device's declaration ROM supplies information for the creation of a GDevice structure (see below) that describes the characteristics of the device. The resulting structure contains a ColorTable structure that is kept synchronised with the card's CLUT.

The Color Manager examines the GDevice structure to find what colours are currently available (4) and to decide which colour comes closest to the one requested by the application. The Color Manager gets the index value for the best match and returns the value to QuickDraw (5), which puts the index value into those places in video RAM which store the object.

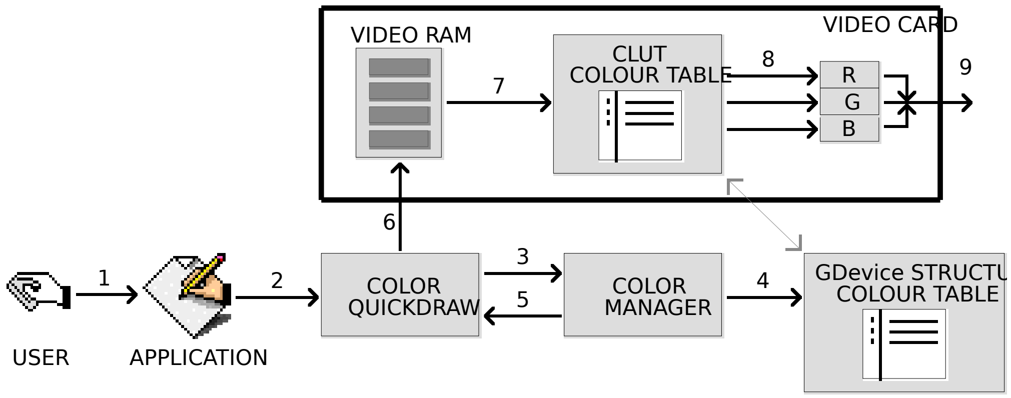


FIG 1 - INDEXED COLOUR SYSTEM

The video device continually displays video RAM by taking the index values, converting them to colours according to CLUT entries at those indexes (7), and sending them to the digital-to-analog converters (8) which produce a signal for the screen (9).

Direct Colour Devices

Video devices which implement direct colour eliminate the competition for limited colour lookup table spaces and remove the need for colour table matching. By using direct colour, video devices can support thousands or millions of colours.

When you specify a colour using a 48-bit RGBColor structure on a direct colour system, QuickDraw truncates the least significant bits of its red, green and blue components to either 16 bits (five bits each for red, green and blue, with one bit unused) or 32 bits (eight bits for red, green and blue, with eight bits unused). (See Translation of RGB Colours to Pixel Values, below.) Using 16 bits, direct video devices can display 32,768 different colours. Using 32 bits, the device can display 16,777,215 different colours

[3] Some Macintosh computers, such as grayscale PowerBook computers, have a fixed CLUT, which your application cannot change.

Fig 2 illustrates the direct colour system. A user chooses a colour for some object (1) and, using a 48-bit RGBColor structure to specify the colour, the application uses a QuickDraw routine to draw the object in that colour (2).

QuickDraw knows from the GDevice structure (3) that the screen is controlled by a direct device in which pixels are, say, 32 bits deep, which means that eight bits are used for each of the red, green and blue components of the requested colour. Accordingly, QuickDraw passes the high eight bits from each 16-bit component of the 48-bit RGBColor structure to the video device (4), which stores the resulting 24-bit value in video RAM for the object. The video device continually displays video RAM by sending the 8-bit red, green and blue values for the colour to digital-to-analog converters (5) which produce a signal for the screen (6).

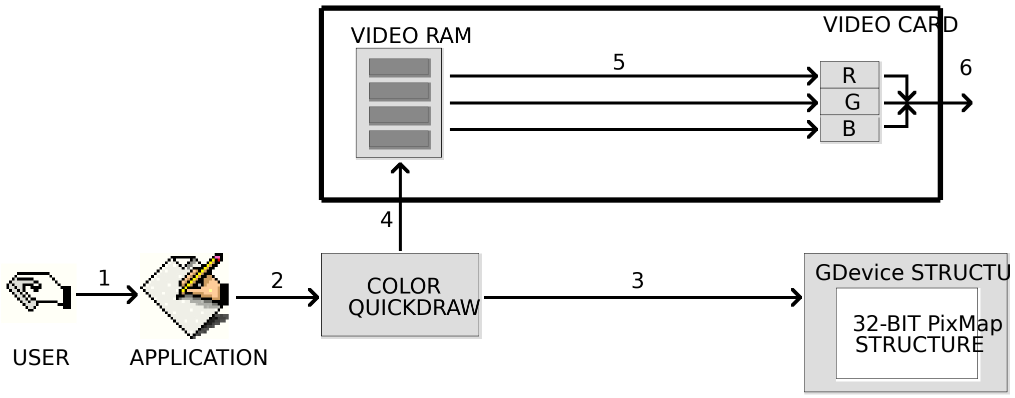


FIG 2 - DIRECT COLOUR SYSTEM

Direct colour not only removes much of the complexity of the CLUT mechanism for video device developers, but it also allows the display of thousands or millions of colours simultaneously, resulting in near-photographic resolution.

Direct Devices Operating Like Indexed Devices

Note that, when a user uses the Monitors and Sound control panel to set a direct colour device to use 256 colours (or less) as either a grayscale or colour device, the direct device creates a CLUT and operates like an indexed device.

Colour Graphics Port

QuickDraw performs its operations in a **colour graphics port**, a data structure of type CGrafPort.

> ***Historical Note***
>
> There is a related type of graphics port called the **basic graphics port,** which was originally the drawing environment provided by basic QuickDraw. A basic graphics port is defined in a GrafPort structure. It contains the information basic QuickDraw needed to create and manipulate onscreen black-and-white images, or colour images that employed basic QuickDraw's eight-colour system.
>
> Since the Appearance Manager requires that Color QuickDraw be present, the basic graphics port is now redundant.

A colour graphics port defines a complete drawing environment that determines where and how colour graphics operations take place. Amongst other things, a colour graphics port:

- Contains a handle to a **pixel map** which, in turn, contains a pointer to the area of memory in which your drawing operations take place.

- Contains a metaphorical graphics **pen** with which to perform drawing operations. (You can set this pen to different sizes, patterns and colours.)

- Holds information about text, which is styled and sized according to information in the graphics port.

The fields of a colour graphics port are maintained by QuickDraw. QuickDraw provides routines for changing and reading those fields. For example, routines are available to reshape and resize the pen, change the pen's pattern and colour, switch fonts, etc.

You can open many colour graphics ports at the same time. Each has its own local coordinate system, drawing pattern, background pattern, pen size and location, foreground colour, background colour, pixel map, etc. You can instantly switch from one graphics port to another using the function SetPort.

When you use Window Manager and Dialog Manager functions to create windows, dialog boxes, and alert boxes, those managers automatically create colour graphics ports for you

The CGrafPort structure is as follows:

```
CGrafPort = RECORD
    device:         INTEGER;          { Device-specific information. }
    portPixMap:     PixMapHandle;     { Handle to pixel map. }
    portVersion:    INTEGER;          { Flags and version number. }
    grafVars:       Handle;           { Handle to additional colour fields. }
    chExtra:        INTEGER;          { Extra width added to non-space characters. }
    pnLocHFrac:     INTEGER;          { Fractional horizontal pen position. }
    portRect:       Rect;             { Port rectangle. }
    visRgn:         RgnHandle;        { Visible region. }
    clipRgn:        RgnHandle;        { Clipping region. }
    bkPixPat:       PixPatHandle;     { Background pattern. }
    rgbFgColor:     RGBColor;         { Requested foreground colour. }
    rgbBkColor:     RGBColor;         { Requested background colour. }
    pnLoc:          Point;            { Pen location. }
    pnSize:         Point;            { Pen size. }
    pnMode:         INTEGER;          { Pattern mode. }
    pnPixPat:       PixPatHandle;     { Pen pattern. }
    fillPixPat:     PixPatHandle;     { Fill pattern. }
    pnVis:          INTEGER;          { Pen visibility. }
    txFont:         INTEGER;          { Font number for text. }
    txFace:         StyleField;       { Text font style. }
    txMode:         INTEGER;          { Text source mode. }
    txSize:         INTEGER;          { Font size for text. }
    spExtra:        Fixed;            { Extra width added to space characters. }
    fgColor:        LONGINT;          { Actual foreground colour. }
    bkColor:        LONGINT;          { Actual background colour. }
    colrBit:        INTEGER;          { Colour bit (reserved). }
    patStretch:     INTEGER;          { (Used internally.) }
    picSave:        Handle;           { Picture being saved. (Used internally.) }
    rgnSave:        Handle;           { Region being saved. (Used internally.) }
    polySave:       Handle;           { Polygon being saved. (Used internally.) }
    grafProcs:      CQDProcsPtr;      { Pointer to low-level drawing routines. }
    END;

CGrafPtr = ^CGrafPort;
CWindowPtr = CGrafPtr;
```

Main Field Descriptions

portPixMap A handle to a PixMap structure (see below) which describes the pixels in this colour graphics port.

portVersion In the highest two bits, flags set to indicate that this is a CGrafPort structure and, in the remainder of the field, the version number of QuickDraw that created this structure.

grafVars

A handle to a GrafVars structure, which contains colour information additional to that contained in the CGrafPort structure itself, and which is used by QuickDraw and the Palette Manager. For example, one field contains the RGB colour for highlighting.

portRect

The port rectangle that defines a subset of the pixel map to be used for drawing. All drawing done by your application occurs inside the port rectangle. (In a window's graphics port, the port rectangle is also called the **content region**.)

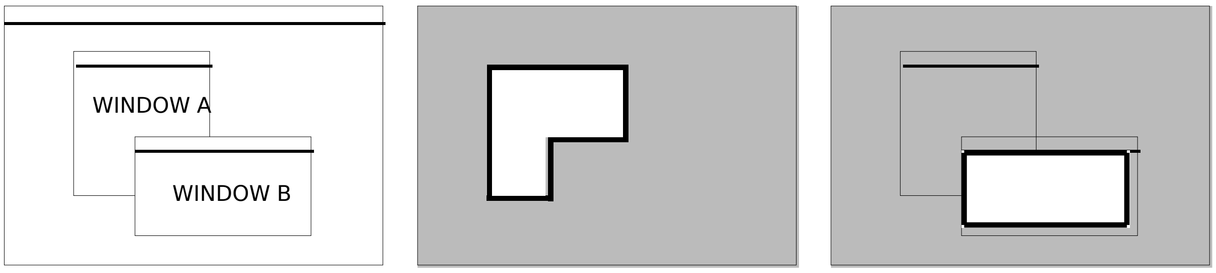
The port rectangle uses the local coordinate system defined by the **boundary rectangle** in the portPixMap field of the PixMap structure (see below). The upper-left corner (which, for a window, is called the window origin) of the port rectangle has a vertical coordinate of 0 and a horizontal coordinate of 0. The port rectangle usually falls within the boundary rectangle, but it is not required to do so.

visRgn

The region of the graphics port that is actually visible on screen, that is, the part of the window not covered by other windows (see Fig 3). By default, the visible region is equivalent to the port rectangle.

clipRgn

The graphics port's **clipping region**, an arbitrary region that you can use to limit drawing to any region within the port rectangle. The default clipping region is set arbitrarily large; however, you can change the clipping region using the function ClipRect. At Fig 3, for example, Window B's clipping region has been set by the application to prevent the scroll bar areas being over-drawn.



TWO COLOUR GRAPHICS PORTS

VISIBLE REGION OF WINDOW

MODIFIED CLIPPING REGION OF WINI

FIG 3 - VISIBLE REGION AND CLIPPING REGION

bkPixPat

A handle to a PixPat structure that describes the background **pixel pattern**. Various QuickDraw functions use this pattern for filling scrolled or erased areas.

rgbFgColor

An RGBColor structure that contains the *requested* **foreground colour**. By default, the foreground colour is black.

rgbBkColor

An RGBColor structure that contains the *requested* **background colour**. By default, the background colour is white.

pnLoc

The point where QuickDraw will begin drawing the next line, shape, or character. It can be anywhere on the coordinate plane.

pnSize

The vertical height and horizontal width of the graphics pen. The default size is a 1-by-1 pixel square. If either the pen width or height is 0, the pen does not draw.

pnMode

The pen **transfer mode**, that is, a Boolean or arithmetic operation that determines how QuickDraw transfers the pen pattern to the pixel map during drawing operations. When the graphics pen draws into a pixel map, QuickDraw first determines what pixels in the pixel image are affected and finds their corresponding pixels in the pen pattern. QuickDraw then does a pixel-by-pixel comparison based on the transfer mode. QuickDraw stores the resulting pixel in its proper place in the image.

pnPixPat A handle to a PixPat structure (see below) that describes the **pixel pattern** used by the graphics pen for drawing lines and framed shapes, and for painting shapes.

fillPixpat A handle to a PixPat structure (see below) that describes the **pixel pattern** that is used when you call QuickDraw shape filling functions.

pnVis The graphics pen's **visibility**, that is, whether it draws on the screen.

txFont A **font family ID** number that identifies the font to be used in the graphics port.

txFace The **style** of the text, for example, bold, italic, and/or underlined.

txMode The transfer **mode** for text drawing, which functions much like the transfer mode specified in the pnMode field (see above).

txSize The text size in pixels. The Font Manager uses this information to provide the bitmaps for text drawing. The value in this field can be represented by

point size x device resolution / 72 dpi

where *point* is a typographical term meaning approximately 1/72 inch.

fgColor The **pixel value** of the foreground colour supplied by the Color Manager. (See Colour and the Video Device, above, and Translation of RGB Colours to Pixel Values, below.) This is the colour actually displayed on the device, that is, it is the the best available approximation to the requested color in the rgbFgColor field.

bkColor The **pixel value** of the background colour supplied by the Color Manager. (See Colour and the Video Device, above, and Translation of RGB Colours to Pixel Values, below.) This is the colour actually displayed on the device, that is, it is the the best available approximation to the requested color in the rgbBkColor field.

Pixel Maps

QuickDraw draws in a **pixel map**. The portPixMap field of the CGrafPort structure contains a handle to a pixel map, which is a data structure of type PixMap. A PixMap structure contains a pointer to a **pixel image**, as well as information on the image's storage format, depth, resolution, and colour usage. The PixMap structure is as follows:

```
PixMap = RECORD
    baseAddr:     Ptr;            { Pointer to image data. }
    rowBytes:     INTEGER;        { Flags, and bytes in a row. }
    bounds:       Rect;           { Boundary rectangle. }
    pmVersion:    INTEGER;        { Pixel Map version number. }
    packType:     INTEGER;        { Packing format. }
    packSize:     LONGINT;        { Size of data in packed state. }
    hRes:         Fixed;          { Horizontal resolution in dots per inch. }
    vRes:         Fixed;          { Vertical resolution in dots per inch. }
    pixelType:    INTEGER;        { Format of pixel image. }
    pixelSize:    INTEGER;        { Physical bits per pixel. }
    cmpCount:     INTEGER;        { Number of components in each pixel. }
    cmpSize:      INTEGER;        { Number of bits in each component. }
    planeBytes:   LONGINT;        { Offset to next plane. }
    pmTable:      CTabHandle;     { Handle to a colour table for this image. }
    pmReserved:   LONGINT;        { (Reserved.) }
    END;

    PixMapHandle = ^PixMapPtr;
    PixPatPtr = ^PixPat;
```

Field Descriptions

baseAddr For an onscreen pixel image, a pointer to the first byte of the image. The pixel image that appears on the screen is normally stored on a graphics card rather than in main memory. Note that there can be several pixel maps pointing to the same pixel image, each imposing its own coordinate system on it.

A pixel image is analogous to the **bit image** used by basic QuickDraw. A bit image is a collection of bits in memory that form a grid. Fig 4 illustrates a bit image, which can be visualised as a matrix of rows and columns of bits with each row containing the same number of bytes. Each bit corresponds to one screen pixel. If a bit's value is 0, its screen pixel is white; if the bit's value is 1, the screen pixel is black. A bit image can be any length that is a multiple of the row's width in bytes. On black-and-white Macintoshes, the screen itself is one large visible bit image.

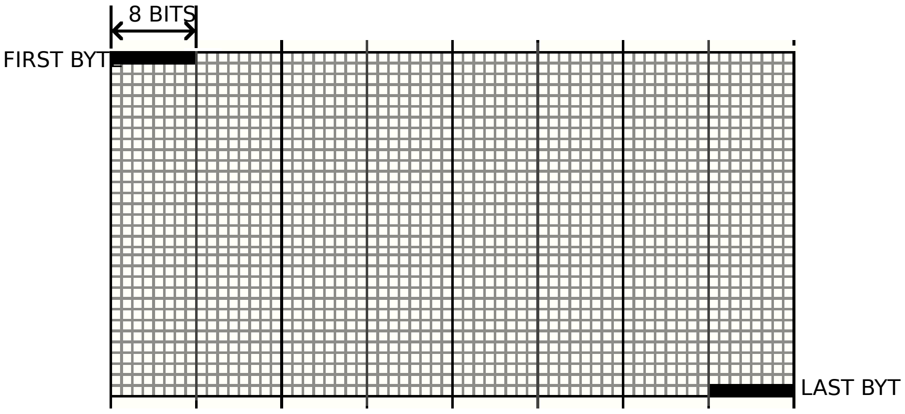


FIG 4 - A BIT IMAGE

A pixel image is essentially the same as a bit image, except that a number of bits, not just one bit, are assigned to each pixel. The number of bits per pixel in a pixel image is called the pixel depth.

rowBytes The offset in bytes from one row of the image to the next. The value must be even and less than $4000. For best performance it should be a multiple of 4. Bit 15 is used as a flag. If bit 15 = 1, the data structure is a PixMap structure, otherwise it is a BitMap structure. (The rowbytes bytes in a PixMap structure occupy the same bytes (fifth and sixth) as they do is a BitMap.)

bounds The boundary rectangle, which links the local coordinate system of a graphics port to QuickDraw's global coordinate system and defines the area of the pixel image into which QuickDraw can draw. All drawing in a colour graphics port occurs in the intersection of the boundary rectangle and the port rectangle (and, within that intersection, all drawing is cropped to the colour graphics port's visible region and its clipping region.)

As shown at Fig 5, QuickDraw assigns the entire screen as the boundary rectangle. The boundary rectangle shares the same local coordinate system as the port rectangle of the window.

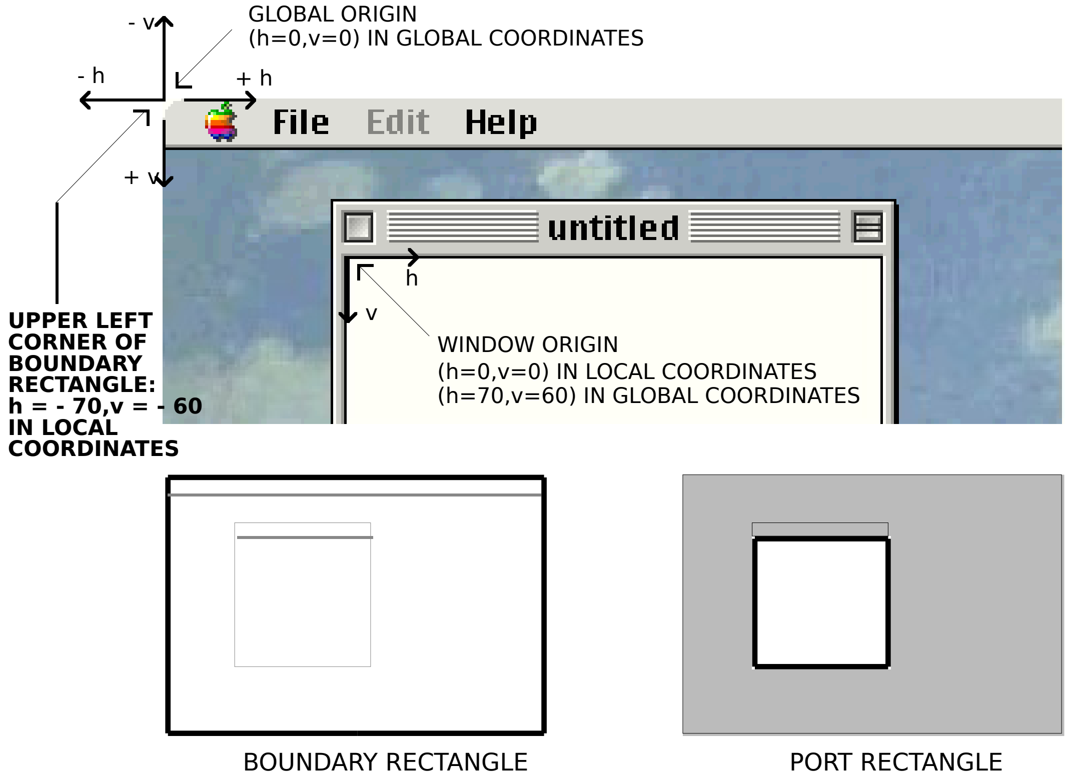

- v
GLOBAL ORIGIN
(h=0,v=0) IN GLOBAL COORDINATES
- h
+ h
File
Edit
Help
+ v
untitled
h
v
WINDOW ORIGIN
(h=0,v=0) IN LOCAL COORDINATES
(h=70,v=60) IN GLOBAL COORDINATES
UPPER LEFT CORNER OF BOUNDARY RECTANGLE: h = - 70,v = - 60 IN LOCAL COORDINATES
BOUNDARY RECTANGLE
PORT RECTANGLE

FIG 5 - LOCAL AND GLOBAL COORDINATE SYSTEMS, THE BOUNDARY RECTANGLE AN

Do not use the bounds field to determine the size of the screen; instead, use the gdRect field of the GDevice structure (see below) for the screen.

pmVersion The version number of QuickDraw that created this PixMap structure.

packType The packing algorithm used to compress image data.

packSize The size of the packed image in bytes.

hRes The horizontal resolution of the image in pixels per inch, abbreviated as dpi (dots per inch). By default, the value here is $00480000 (for 72 dpi), but QuickDraw supports PixMap structures of other resolutions. For example, PixMap structures for scanners can have dpi resolutions of 150, 200, 300, or greater.

vRes Describes the vertical resolution. (See hRes).

pixelType The storage format for a pixel image. Indexed pixels are indicated by a value of 0. Direct pixels are specified by a value of RGBDirect, or 16. In the PixMap structure of the GDevice structure (see below) for a direct device, this field is set to the constant RGBDirect when the screen depth is set.

pixelSize The pixel depth, that is, the number of bits used to represent a pixel. Indexed pixels can have sizes of 1, 2, 4, or 8 bits. Direct pixel sizes are 16 or 32 bits.

cmpCount The number of components used to represent a colour for a pixel. With indexed pixels, each pixel is a single value representing an index in a colour table, so this field contains the value 1. With direct pixels, each pixel contains three components (one integer each for the intensities of red, green, and blue), so this field contains the value 3.

cmpSize Specifies how large each colour component is. For indexed devices, it is the same value as that in the pixelSize field. For direct devices, each of the three colour components can be either 5 bits for a 16-bit pixel (one of these 16 bits is unused), or 8 bits for a 32 bit pixel (8 of these 32 bits are unused). (See Translation of RGB Colours to Pixel Values, below.)

planeBytes QuickDraw does not support multiple-plane images, so the value of this field is always 0.

pmTable Contains a handle to the ColorTable structure. ColorTable structures define the colours available for pixel images on indexed devices. (The Color Manager stores a colour table for the currently available colours in the graphic's device's CLUT. You use the Palette Manager to assign different colour tables to your different windows.)

You can create colour tables using either ColorTable structures or 'clut' resources. Pixel images on direct devices do not need a colour table because the colours are stored right in the pixel values. In such cases, pmTable points to a dummy colour table.

Pixel Patterns and Bit Patterns

Pixel Patterns

Three fields in the colour graphics port structure (pnPixPat, fillPixPat, and bkPixPat,) hold handles to a pixel pattern , a structure of type PixPat.

Pixel patterns, which define a repeating design, can use colours at any pixel depth, and can be of any width and height that is a power of 2. You can create your own pixel patterns in your program code, but it is usually simpler and more convenient to store them in resources of type 'ppat'. Fig 6 shows an 8-by-8 pixel 'ppat' resource being created using Resorcerer.

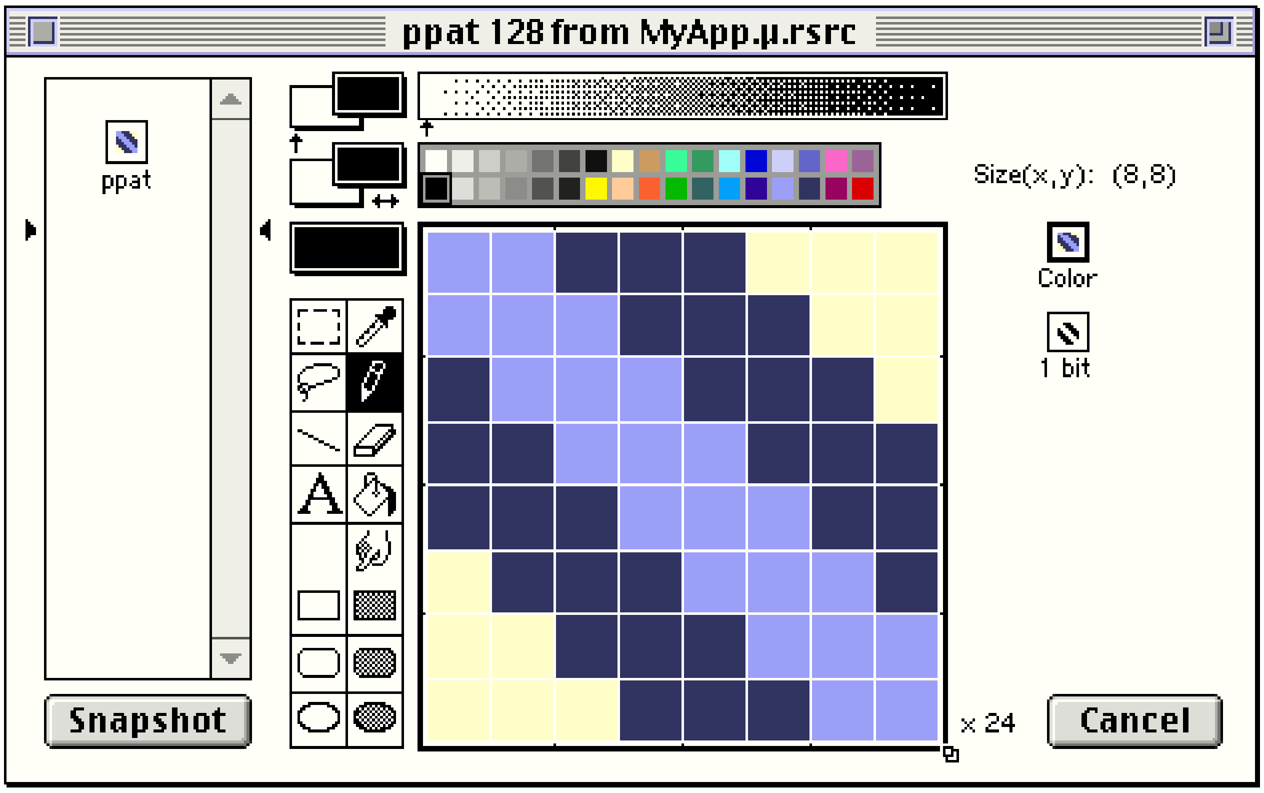
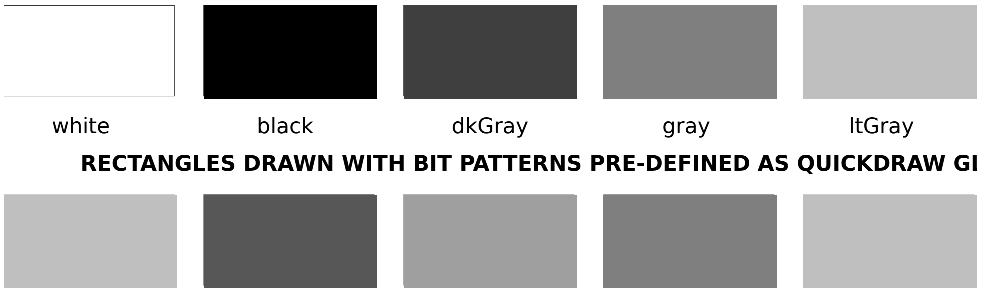


FIG 6 - CREATING A 'ppat' RESOURCE USING RESORCERER

Bit Patterns

Bit patterns date from the era of the black-and-white Macintosh, but may be assigned to the pnPixPat , fillPixPat, and bkPixPat fields of a colour graphics port. (PixPat structures can contain bit patterns as well as pixel patterns.) Bit patterns are defined in data structures of type Pattern, a 64-pixel image of a repeating design organised as an 8-by-8 pixel square.

Five bit patterns are pre-defined as QuickDraw global variables. The five pre-defined patterns are available not only through the QuickDraw globals but also as system resources stored in the System resource file. Fig 7 shows images drawn using some some of the 38 available system-supplied bit patterns.

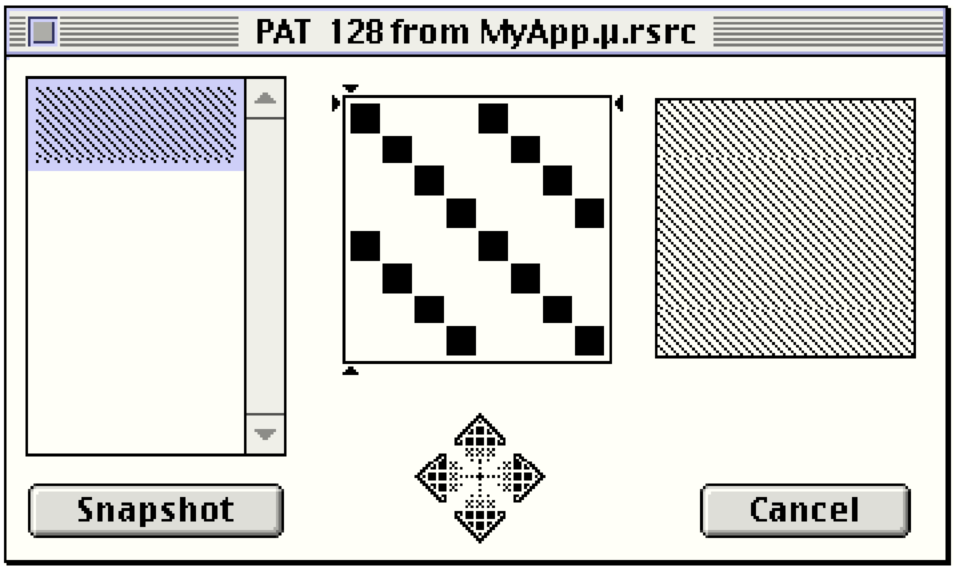


RECTANGLES DRAWN WITH BIT PATTERNS PRE-DEFINED AS QUICKDRAW GI

RECTANGLES DRAWN WITH OTHER BIT PATTERNS IN THE SYTEM RESOU

FIG 7 - RECTANGLES DRAWN USING BIT PATTERNS IN THE SYSTEM F

You can create your own bit patterns in your program code, but it is usually simpler and more convenient to store them in resources of type 'PAT ' or 'PAT#'. Fig 8 shows a 'PAT ' resource being created using Resorcerer, together with the contents of the pat field of the structure of type Pattern that is created when the resource is loaded.



```
pat[0] = 10001000 = 0x88
pat[1] = 01000100 = 0x44
pat[2] = 00100010 = 0x22
pat[3] = 00010001 = 0x11
pat[4] = 10001000 = 0x88
pat[5] = 01000100 = 0x44
pat[6] = 00100010 = 0x22
pat[7] = 00010001 = 0x11
```

FIG 8 - CREATING A 'PAT ' RESOURCE USING RESORCERER

Creating Colour Graphics Ports

Your application creates a colour graphics port using either the GetNewCWindow, NewCWindow, or NewGWorld function. These functions automatically call OpenCPort (which opens the port) and InitCPort (which and initialises the port).

Translation of RGB Colours to Pixel Values

As previously stated, the baseAddr field of the CGrafPort structure contains a pointer to the beginning of the onscreen pixel image. When your application specifies an RGB colour for a pixel in the pixel image, QuickDraw translates that colour into a value appropriate for display on the user's screen. QuickDraw stores this value in the pixel. The **pixel value** is a number used by system software and a graphics device to represent a colour. The translation from the colour you specify in an RGBColor structure to a pixel value is performed at the time you draw the colour. The process differs for direct and indexed devices as follows:

- When drawing on indexed devices, QuickDraw calls the Color Manager to supply the index to the colour that most closely matches the requested colour in the current device's CLUT. This index becomes the pixel value for that colour.

- When drawing on direct devices, QuickDraw truncates the least significant bits from the red, green and blue fields of the RGBColor structure. The result becomes the pixel value that QuickDraw sends to the graphics device.

Your application never needs to handle pixel values. However, to clarify the relationship between RGBColor structures and the pixels that are actually displayed, the following presents some examples of the derivation of pixel values from RGBColor structures.

Derivation of Pixel Values on Indexed Devices

Fig 9 shows the translation of an RGBColor structure to an 8-bit pixel value on an indexed device.

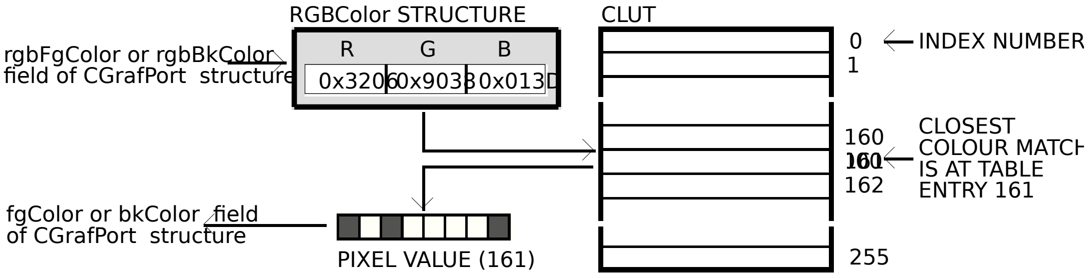

RGBColor STRUCTURE
CLUT
rgbFgColor or rgbBkColor field of CGrafPort structure
R
G
B
0x3206
0x9038
0x013D
0
1
INDEX NUMBER
160
161
162
CLOSEST COLOUR MATCH IS AT TABLE ENTRY 161
fgColor or bkColor field of CGrafPort structure
PIXEL VALUE (161)
255

FIG 9 - TRANSLATING AN RGBColor STRUCTURE TO AN 8-BIT PIXEL VALUE ON

The application might later use GetCPixel to determine the colour of a particular pixel. As shown at Fig 10, the Color Manager uses the index number stored as the pixel value to find the RGBColor structure stored in the CLUT for that pixel's colour. Also as shown at Fig 10, this is not necessarily the exact colour first specified.

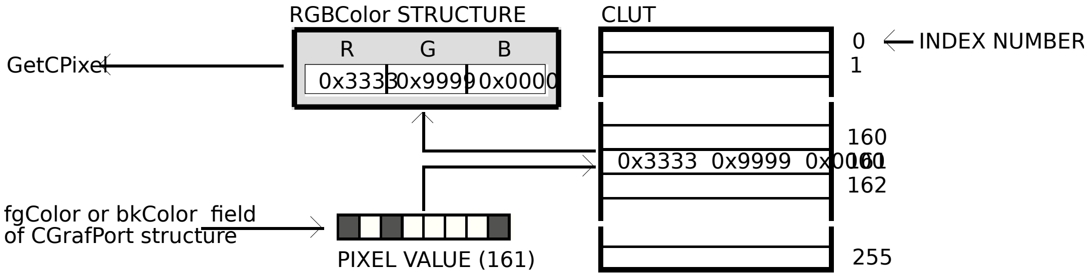


FIG 10 - TRANSLATING AN 8-BIT PIXEL VALUE ON AN IDEXED DEVICE TO AN R

Derivation of Pixel Values on Direct Devices

Fig 11 shows how QuickDraw converts an RBGColor structure into a 16-bit pixel value on a direct device by storing the most significant 5 bits of each 16-bit field of the 48-bit RGBColor structure in the lower 15 bits of the pixel value, leaving an unused high bit. Fig 11 also shows how QuickDraw expands a 16-bit pixel value to a 48-bit RGBColor structure by dropping the unused high bit of the pixel value and inserting three copies of each 5-bit component and a copy of the most significant bit into each 16-bit field of the RGBColor structure. Note that the result differs, in the least significant 11 bits, from the original 48-bit value.

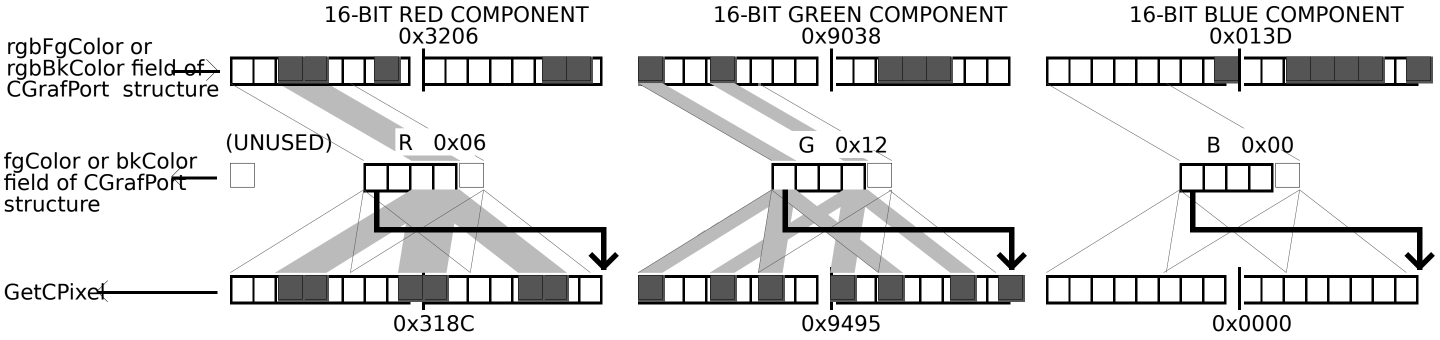


FIG 11 - TRANSLATING AN RGBColor STRUCTURE TO A 16 BIT PIXEL VALUE, AND FROM A 16-BIT PIXEL VAI ON A DIRECT DEVICE

Fig 12 shows how QuickDraw converts an RBGColor structure into a 32-bit pixel value on a direct device by storing the most significant 8 bits of each 16-bit field of the structure into the lower 3 bytes of the pixel value, leaving 8 unused bits in the high byte of the pixel value. Fig 12 also shows how QuickDraw expands a 32-bit pixel value to an RBGColor structure by dropping the unused high byte of the pixel value and doubling each of its 8-bit components. Note that the resulting 48-bit value differs in the least significant 8 bits of each component from the original RBGColor structure.

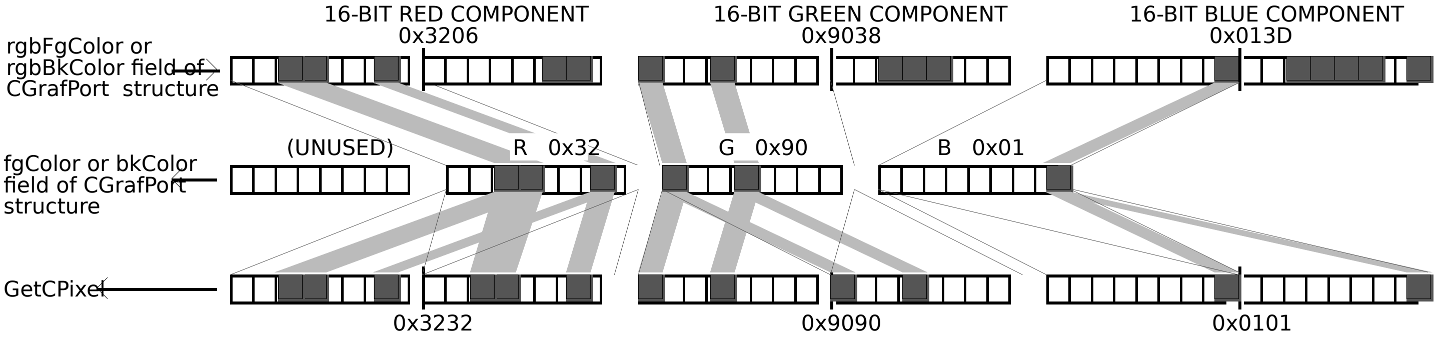


FIG 12 - TRANSLATING AN RGBColor STRUCTURE TO A 32 BIT PIXEL VALUE, AND FROM A 32-BIT PIXEL VAI ON A DIRECT DEVICE

Colours on Grayscale Screens

When QuickDraw displays a colour on a grayscale screen, it computes the luminance, or intensity of light, of the desired colour and uses that value to determine the appropriate gray value to draw.

A grayscale device can be a colour graphics device that the user sets to grayscale by using the Monitors and Sound control panel. For such a graphics device, Colour QuickDraw places an evenly spaced set of grays in the graphics device's CLUT.

By using the GetCTable function, your application can obtain the default colour tables for various graphics devices, including grayscale devices.

Graphics Devices and GDevice Structures

As previously stated, QuickDraw provides a device-independent interface. Your application can draw images in the graphics port for a window and QuickDraw automatically manages the path to the screen — even if the user is using multiple screens. QuickDraw communicates with a video device, such as a plug-in video card or a built-in video interface, by automatically creating and managing a structure of data type GDevice.

Types of Graphics Device

A **graphics device** is anything into which QuickDraw can draw. There are three types of graphics device:

- **Video devices**, such as video cards and built-in video interfaces, that control screens.
- **Offscreen graphics worlds**, which allow your application to build complex images offscreen before displaying them.[4]
- **Printing graphics ports** for printers.[5]

GDevice Structure

For a video device or an offscreen graphics world, QuickDraw automatically creates, and stores state information in, a GDevice structure. Note that printers do not have GDevice structures.

When the system starts up, QuickDraw uses information supplied by the Slot Manager to create and initialise a GDevice structure for each video device found during startup. When you use the NewGWorld function to create an offscreen graphics world, QuickDraw automatically creates a GDevice structure.

All existing GDevice structures are linked together in a list called a **device list**. The global variable DeviceList holds a handle to the first structure in the list. At any given time, exactly one graphics device is the **current device** (also called the **active device**), that is, the one in which drawing is actually taking place. A handle to its GDevice structure is stored in the global variable TheGDevice. By default, the GDevice structure corresponding to the first video device found is marked as the current device.

Your application generally never needs to create GDevice structures; however, in may need to examine GDevice structures to determine the capabilities of the user's screens. The GDevice structure is as follows:

```
GDevicePtr = ^GDevice;
GDevice = RECORD
    gdRefNum:       INTEGER;          { Reference Number of Driver. }
    gdID:           INTEGER;          { Client ID for search procedures. }
    gdType:         INTEGER;          { Type of device (indexed or direct). }
    gdITable:       ITabHandle;       { Handle to inverse lookup table for Color Manager. }
    gdResPref:      INTEGER;          { Preferred resolution. }
    gdSearchProc:   SProcHndl;        { Handle to list of search functions. }
    gdCompProc:     CProcHndl;        { Handle to list of complement functions. }
    gdFlags:        INTEGER;          { Graphics device flags. }
    gdPMap:         PixMapHandle;     { Handle to pixel map for displayed image. }
    gdRefCon:       LONGINT;          { Reference value. }
    gdNextGD:       Handle;           { Handle to next GDevice structure. }
    gdRect:         Rect;             { Device's global boundaries. }
    gdMode:         LONGINT;          { Device's current mode. }
    gdCCBytes:      INTEGER;          { Width of expanded cursor data. }
    gdCCDepth:      INTEGER;          { Depth of expanded cursor data. }
    gdCCXData:      Handle;           { Handle to cursor's expanded data. }
    gdCCXMask:      Handle;           { Handle to cursor's expanded mask. }
    gdReserved:     LONGINT;          { (Reserved.  Must be 0.) }
    END;

    GDPtr = ^GDevice;
    GDHandle = ^GDPtr;
```

Main Field Descriptions

gdType The general type of graphics device. See Flag Bits of gdType Field, below.

[4] See Chapter 13 — Offscreen Graphics Worlds, Pictures, Cursors, and Icons.

[5] See Chapter 15 — Printing.

gdITable Points to an **inverse table**. An inverse table is a special Color Manager data structure arranged in such a manner that, given an arbitrary RGB colour, its pixel value (that is, its index number in the CLUT) can be found quickly.

gdFlags Device attributes (that is, whether the device is a screen, whether it is the main screen, whether it is set to black-and-white or colour, whether it is the active device, etc.) See Flag Bits of gdType Field, below.

gdPMap Contains a handle to the pixel map (PixMap) structure, which contains the dimensions of the image buffer, along with the characteristics of the graphics device (resolution, storage format, pixel depth, and colour table. QuickDraw automatically synchronises the pixel map's colour table (ColorTable) structure with the CLUT on the video device.

gdNextGD A handle to the next graphics device in the device list. If this is the last graphics device in the device list, this field contains 0.

gdRect The boundary rectangle of the graphics device represented by the GDevice structure. The main screen has the upper-left corner of the rectangle set to (0,0). All other graphics devices are relative to this point.

Flag Bits of gdType Field

Constant	Bit	Meaning
clutType	0	CLUT device.
fixedType	1	Fixed CLUT device.
directType	2	Direct device.

Flag Bits of gdFlags Field

Constant	Bit	Meaning
gdDevType	0	0 = black-and-white. 1 = colour.
burstDevice	7	Device supports block transfer.
ext32Device	8	Device must be used in 32-bit mode.
ramInit	10	Device was initialised from RAM.
mainScreen	11	Device is the main screen.
allInit	12	All devices were initialised from 'scrn' resource.
screenDevice	13	Device is a screen device.
noDriver	14	GDevice structure has no driver.
screenActive	15	Device is current device.

Setting a Device's Pixel Depth

The gdPMap field of the GDevice structure contains a handle to a PixMap structure which, in turn, contains the PixelSize field to which is assigned the pixel depth of the device.

The Monitors and Sound control panel is the user interface for changing the pixel depth of video devices. Since the user can control the capabilities of the video device, your application should be flexible, that is, although it may have a preferred pixel depth, it should do its best to accommodate less than ideal conditions. Your application can use the SetDepth function to change the pixel depth, but it should not do so without the consent of the user. Before calling SetDepth, you should use the HasDepth function to determine whether the available hardware can support the pixel depth you require.

Other Graphics Managers

In addition to the QuickDraw functions, several other collections of system software functions are available to assist you in drawing images.

Palette Manager

To provide more sophisticated colour support on indexed graphics devices, your application can use the Palette Manager. The Palette Manager allows your application to specify sets of colours that it needs on a window-by-window basis. On a video device that uses a variable CLUT, your application can use the Palette Manager to display any number of palettes (that is, sets of colours) consisting of 256 colours each. Remember, though, that only one set of colours (palette) can be displayed at any one time.

Color Picker Utilities

To solicit colour choices from users, your application can use the Color Picker Utilities. The Color Picker Utilities also provide functions that allow your application to convert between colours specified in RGBColor structures and colours specified for other colour models, such as the CMYK (cyan, magenta, yellow, black) model used for many colour printers. (See Chapter 23 — Miscellany.)

Coping With Multiple Monitors

Image optimisation and window dragging in a multiple monitors environment is addressed at Chapter 23 — Miscellany.

Relevant QuickDraw Constants, Data Types, and Functions

Constants

Flag Bits of gdType Field of GDevice Structure

clutType	= 0
fixedType	= 1
directType	= 2

Flag Bits of gdFlags Field of GDevice Structure

gdDevType	= 0
burstDevice	= 7
ext32Device	= 8
ramInit	= 10
mainScreen	= 11
allInit	= 12
screenDevice	= 13
noDriver	= 14
screenActive	= 15

Pixel Type

RGBDirect	= 16	16 and 32 bits-per-pixel pixelType value.

Data Types

Colour Graphics Port

```
CGrafPort = RECORD
    device:          INTEGER;             { Device-specific information. }
    portPixMap:      PixMapHandle;        { Handle to pixel map. }
    portVersion:     INTEGER;             { Flags and version number. }
    grafVars:       Handle;             { Handle to additional colour fields. }
    chExtra:        INTEGER;            { Extra width added to non-space characters. }
    pnLocHFrac:     INTEGER;            { Fractional horizontal pen position. }
    portRect:       Rect;               { Port rectangle. }
    visRgn:         RgnHandle;          { Visible region. }
    clipRgn:        RgnHandle;          { Clipping region. }
    bkPixPat:       PixPatHandle;       { Background pattern. }
    rgbFgColor:     RGBColor;           { Requested foreground colour. }
    rgbBkColor:     RGBColor;           { Requested background colour. }
    pnLoc:          Point;              { Pen location. }
    pnSize:         Point;              { Pen size. }
    pnMode:         INTEGER;            { Pattern mode. }
    pnPixPat:       PixPatHandle;       { Pen pattern. }
    fillPixPat:     PixPatHandle;       { Fill pattern. }
    pnVis:          INTEGER;            { Pen visibility. }
    txFont:         INTEGER;            { Font number for text. }
    txFace:         StyleField;         { Text font style. }
    txMode:         INTEGER;            { Text source mode. }
    txSize:         INTEGER;            { Font size for text. }
    spExtra:        Fixed;              { Extra width added to space characters. }
    fgColor:        LONGINT;            { Actual foreground colour. }
    bkColor:        LONGINT;            { Actual background colour. }
    colrBit:        INTEGER;            { Colour bit (reserved). }
    patStretch:     INTEGER;            { (Used internally.) }
    picSave:        Handle;             { Picture being saved. (Used internally.) }
    rgnSave:        Handle;             { Region being saved. (Used internally.) }
    polySave:       Handle;             { Polygon being saved. (Used internally.) }
    grafProcs:      CQDProcsPtr;        { Pointer to low-level drawing routines. }
    END;

CGrafPtr = ^CGrafPort;
CWindowPtr = CGrafPtr;
```

GrafVars

```
GrafVars = RECORD
    rgbOpColor:     RGBColor;           { Colour for addPin  subPin and average. }
    rgbHiliteColor:RGBColor;            { Colour for hiliting. }
    pmFgColor:      Handle;             { Palette Handle for foreground colour. }
    pmFgIndex:      INTEGER;            { Index value for foreground. }
    pmBkColor:      Handle;             { Palette Handle for background colour. }
    pmBkIndex:      INTEGER;            { Index value for background. }
    pmFlags:        INTEGER;            { Flags for Palette Manager. }
    END;

GVarPtr = ^GrafVars;
GVarHandle = ^GVarPtr;
```

Pixel Map

```
PixMap = RECORD
    baseAddr:       Ptr;                { Pointer to image data. }
    rowBytes:       INTEGER;            { Flags, and bytes in a row. }
    bounds:         Rect;               { Boundary rectangle. }
    pmVersion:      INTEGER;            { Pixel Map version number. }
    packType:       INTEGER;            { Packing format. }
    packSize:       LONGINT;            { Size of data in packed state. }
    hRes:           Fixed;              { Horizontal resolution in dots per inch. }
    vRes:           Fixed;              { Vertical resolution in dots per inch. }
    pixelType:      INTEGER;            { Format of pixel image. }
    pixelSize:      INTEGER;            { Physical bits per pixel. }
    cmpCount:       INTEGER;            { Number of components in each pixel. }
    cmpSize:        INTEGER;            { Number of bits in each component. }
    planeBytes:     LONGINT;            { Offset to next plane. }
    pmTable:        CTabHandle;         { Handle to a colour table for this image. }
    pmReserved:     LONGINT;            { (Reserved.) }
    END;

    PixMapHandle = ^PixMapPtr;
    PixPatPtr = ^PixPat;
```

Color Table

```
ColorTable = RECORD
    ctSeed:         LONGINT;            { Unique identifier for table. }
    ctFlags:        INTEGER;            { High bit: 0 = PixMap; 1 = device. }
    ctSize:         INTEGER;            { Number of entries in CTTable minus 1. }
    ctTable:        CSpecArray;         { Array [0..0] of ColorSpec. }
    END;

ColorTablePtr = ^ColorTable;
CTabPtr = ^ColorTable;
CTabHandle = ^CTabPtr;
```

ColorSpec

```
ColorSpec = RECORD
    value:            INTEGER;                  { Index or other value. }
    rgb:              RGBColor;                 { True colour. }
    END;

ColorSpecPtr = ^ColorSpec;
CSpecArray = ARRAY [0..0] OF ColorSpec;
```

BitMap

```
BitMap = RECORD
    baseAddr:         Ptr;
    rowBytes:         INTEGER;
    bounds:           Rect;
    END;

BitMapPtr = ^BitMap;
BitMapHandle = ^BitMapPtr;
```

Pixel Pattern

```
    PixPat = RECORD
    patType:          INTEGER;                  { Type of pattern. }
    patMap:           PixMapHandle;             { The pattern's pixMap. }
    patData:          Handle;                   { Pixmap's data. }
    patXData:         Handle;                   { Expanded Pattern data (internal use). }
    patXValid:        INTEGER;                  { Flags whether expanded Pattern valid. }
    patXMap:          Handle;                   { Handle to expanded Pattern data (reserved). }
    pat1Data:         Pattern;                  { Bit map's data. }
    END;

PixPatPtr = ^PixPat;
PixPatHandle = ^PixPatPtr;
```

Pattern

```
Pattern = RECORD
    pat:              PACKED ARRAY [0..7] OF UInt8;
    END;

PatternPtr = ^Pattern;
PatPtr = ^Pattern;
PatHandle = ^PatPtr;
```

> **Note:** Patterns were originally defined as:
>
> ```
>             Pattern = PACKED ARRAY [0..7] OF 0..255;
> ```
>
> The new struct definition was introduced with the Universal Headers. The old array definition of Pattern would cause 68000-based CPUs to crash in certain circumstances.

GDevice

```
GDevicePtr = ^GDevice;
GDevice = RECORD
    gdRefNum:         INTEGER;                  { Reference Number of Driver. }
    gdID:             INTEGER;                  { Client ID for search procedures. }
    gdType:           INTEGER;                  { Type of device (indexed or direct). }
    gdITable:         ITabHandle;               { Handle to inverse lookup table for Color Manager. }
    gdResPref:        INTEGER;                  { Preferred resolution. }
    gdSearchProc:     SProcHndl;                { Handle to list of search functions. }
    gdCompProc:       CProcHndl;                { Handle to list of complement functions. }
    gdFlags:          INTEGER;                  { Graphics device flags. }
    gdPMap:           PixMapHandle;             { Handle to pixel map for displayed image. }
    gdRefCon:         LONGINT;                  { Reference value. }
```

```
    gdNextGD:       Handle;              { Handle to next GDevice structure. }
    gdRect:         Rect;                { Device's global boundaries. }
    gdMode:         LONGINT;             { Device's current mode. }
    gdCCBytes:      INTEGER;             { Width of expanded cursor data. }
    gdCCDepth:      INTEGER;             { Depth of expanded cursor data. }
    gdCCXData:      Handle;              { Handle to cursor's expanded data. }
    gdCCXMask:      Handle;              { Handle to cursor's expanded mask. }
    gdReserved:     LONGINT;             { (Reserved.  Must be 0.) }
    END;

    GDPtr = ^GDevice;
    GDHandle = ^GDPtr;
```

Functions

Opening and Closing Colour Graphics Ports

```
PROCEDURE OpenCPort(port: CGrafPtr);
PROCEDURE InitCPort(port: CGrafPtr);
PROCEDURE CloseCPort(port: CGrafPtr);
```

Saving and Restoring Colour Graphics Ports

```
PROCEDURE SetPort(port: GrafPtr);
PROCEDURE GetPort(VAR port: GrafPtr);
```

Creating, Setting and Disposing of Pixel Maps

```
FUNCTION  NewPixMap: PixMapHandle;
PROCEDURE DisposePixMap(pm: PixMapHandle);
PROCEDURE CopyPixMap(srcPM: PixMapHandle; dstPM: PixMapHandle);
PROCEDURE SetPortPix(pm: PixMapHandle);
```

Creating, Setting and Disposing of Graphics Device Structures

```
FUNCTION  NewGDevice(refNum: INTEGER; mode: LONGINT): GDHandle;
PROCEDURE SetGDevice(gd: GDHandle);
PROCEDURE DisposeGDevice(gdh: GDHandle);
PROCEDURE InitGDevice(qdRefNum: INTEGER; mode: LONGINT; gdh: GDHandle);
PROCEDURE SetDeviceAttribute(gdh: GDHandle; attribute: INTEGER; value: BOOLEAN);
```

Getting the Available Graphics Devices

```
FUNCTION  GetGDevice: GDHandle;
FUNCTION LMGetMainDevice: GDHandle;
FUNCTION LMGetDeviceList: GDHandle;
FUNCTION GetNextDevice(curDevice: GDHandle): GDHandle;
```

Determining the Characteristics of a Video Device

```
FUNCTION  TestDeviceAttribute(gdh: GDHandle; attribute: INTEGER): BOOLEAN;
PROCEDURE ScreenRes(VAR scrnHRes: INTEGER; VAR scrnVRes: INTEGER);
```

Changing the Pixel Depth of a Video Device

```
FUNCTION SetDepth(gd: GDHandle; depth: INTEGER; whichFlags: INTEGER; flags: INTEGER): OSErr;
FUNCTION HasDepth(gd: GDHandle; depth: INTEGER; whichFlags: INTEGER; flags: INTEGER): INTEGER;
```

Demonstration Program

```
{  ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊
// PreQuickDraw.p
// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊
//
// This program opens a window in which is displayed some information extracted from
// the GDevice structure for the main video device and some colour information extracted
// from the window's colour graphics port structure.  When the monitor is set to 256
// colours or less, the colours in the colour table in the GDevice structure's pixel map
// structure are also displayed.
//
// A Demonstration menu, which is enabled if the monitor is a direct device set to 256
// colours or less at program start, allows the user to set the monitor to 16-bit colour,
// and restore the original pixel depth, using application-defined functions.
//
// The program utilises 'MBAR', 'MENU', 'WIND', and 'STR#' resources, and a 'SIZE'
// resource with the is32BitCompatible flag set.
//
// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ }

program PreQuickDraw;

//
..............................................................................................................................................................................
...................................... interfaces

uses

    { Universal Interfaces. }
    Appearance, Devices, Dialogs, Palettes, Processes, Sound, TextUtils, ToolUtils,
    LowMem, NumberFormatting;

//
..............................................................................................................................................................................
......................................... constants

const

rMenubar = 128;
rWindow = 128;
mApple = 128;
 iAbout = 1;
mFile = 129;
 iQuit = 11;
mDemonstration = 131;
 iSetDepth = 1;
 iRestoreDepth = 2;
rIndexedStrings = 128;
sMonitorInadequate = 1;
sSettingPixelDepth16 = 2;
sMonitorIsDepth16 = 3;
sMonitorIsDepthStart = 4;
sRestoringMonitor = 5;
MAXLONG = $7FFFFFFF;

//
..............................................................................................................................................................................
..................... global variables

var

gDone : boolean;
gStartupPixelDepth : SInt16;

// ........................................................................................................................................................... main
program block variables

mainMenubarHdl : Handle;
mainMenuHdl : MenuHandle;
mainWindow : WindowPtr;
mainString : Str255;
mainEvent : EventRecord;
mainErr : OSErr;

//
..............................................................................................................................................................................
.............. routine prototypes

procedure DoInitManagers; forward;
procedure DoEvents({const} var theEvent : EventRecord); forward;
procedure DoDisplayInformation(theWindow : WindowPtr); forward;
function  DoCheckMonitor : boolean; forward;
procedure DoSetMonitorPixelDepth; forward;
procedure DoRestoreMonitorPixelDepth; forward;
procedure DoMonitorAlert(labelText : Str255); forward;

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ DoInitManagers

procedure DoInitManagers;
    var
    osError : OSErr;
    begin
    MaxApplZone;
    MoreMasters;

    InitGraf(@qd.thePort);
    InitFonts;
    InitWindows;
    InitMenus;
    TEInit;
    InitDialogs(nil);

    InitCursor;
    FlushEvents(everyEvent, 0);

    osError := RegisterAppearanceClient;

    end;
        { of procedure DoInitManagers }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ DoEvents

procedure DoEvents({const} var theEvent : EventRecord);
    var
    charCode : SInt8;
    menuChoice : SInt32;
    menuID, menuItem : SInt16;
    partCode : SInt16;
    theWindow : WindowPtr;
    itemName : Str255;
    daDriverRefNum : SInt16;
    theRect : Rect;

    begin
    case theEvent.what of

        keyDown, autoKey: begin
            charCode := SInt8(BAnd(theEvent.message, charCodeMask));
            if (BAnd(theEvent.modifiers, cmdKey) <> 0) then
                begin
                menuChoice := MenuEvent(theEvent);
                menuID := HiWord(menuChoice);
                menuItem := LoWord(menuChoice);
                if ((menuID = mFile) and (menuItem  = iQuit)) then
                    begin
                    gDone := true;
                    end;
                end;
            end;
                { of keyDown, autoKey }

        mouseDown: begin
            partCode := FindWindow(theEvent.where, theWindow);
            if (partCode <> 0) then
                begin
                case partCode of

                    inMenuBar: begin
                        menuChoice := MenuSelect(theEvent.where);
                        menuID := HiWord(menuChoice);
                        menuItem := LoWord(menuChoice);

                        if (menuID = 0) then
                            begin
                            Exit(DoEvents);
                            end;

                        case menuID of

                            mApple: begin
                                if (menuItem = iAbout) then
                                    begin
                                    SysBeep(10);
                                    end
                                else begin
                                    GetMenuItemText(GetMenuHandle(mApple), menuItem, itemName);
                                    daDriverRefNum := OpenDeskAcc(itemName);
                                    end;
                                end;

                            mFile: begin
```

```
                                if (menuItem = iQuit) then
                                    begin
                                    gDone := true;
                                    end;
                                end;

                            mDemonstration: begin
                                if (menuItem = iSetDepth) then
                                    begin
                                    DoSetMonitorPixelDepth;
                                    end
                                else if (menuItem = iRestoreDepth) then
                                    begin
                                    DoRestoreMonitorPixelDepth;
                                    end;
                                end;

                            otherwise begin
                                end;

                            end;
                                { of case statement }

                        HiliteMenu(0);
                        end;

                    inDrag: begin
                        DragWindow(theWindow, theEvent.where, qd.screenBits.bounds);
                        theRect := theWindow^.portRect;
                        theRect.right := theWindow^.portRect.left + 250;
                        InvalRect(theRect);
                        end;

                    otherwise begin
                        end;

                    end;
                        { of case statement }
                end;
            end;
                { of mouseDown }

        updateEvt: begin
            theWindow := WindowPtr(theEvent.message);
            BeginUpdate(theWindow);
            SetPort(theWindow);
            EraseRect(theWindow^.portRect);
            DoDisplayInformation(theWindow);
            EndUpdate(theWindow);
            end;
                { of updateEvt }

        otherwise begin
            end;

        end;
            { of case statement }
    end;
        { of procedure DoEvents }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ DoDisplayInformation

procedure DoDisplayInformation(theWindow : WindowPtr);
    var
    whiteColour : RGBColor;
    blueColour : RGBColor;
    deviceHdl : GDHandle;
    videoDeviceCount : SInt16;
    theString : Str255;
    deviceType, pixelDepth : SInt32;
    bytesPerRow : SInt32;
    theRect : Rect;
    pixMapHdl : PixMapHandle;
    cgrafPtr : CGrafPtr;
    pixelValue : SInt32;
    redComponent, greenComponent, blueComponent : SInt32;
    colorTableHdl : CTabHandle;
    entries, a, b, c : SInt16;
    theColour : RGBColor;
    begin
    whiteColour.red := $FFFF;
    whiteColour.green := $FFFF;
    whiteColour.blue := $FFFF;
    blueColour.red := $4444;
    blueColour.green := $4444;
    blueColour.blue := $9999;
    videoDeviceCount := 0;

    RGBForeColor(whiteColour);
    RGBBackColor(blueColour);
    EraseRect(theWindow^.portRect);

    //
..........................................................................................................................................................................
................. Get Device List

    deviceHdl := LMGetDeviceList;

    // ............................................................................................................................................. count video devices
in device list

    while (deviceHdl <> nil) do
        begin
        if TestDeviceAttribute(deviceHdl, screenDevice) then
            begin
            videoDeviceCount := videoDeviceCount + 1;
            end;

        deviceHdl := GetNextDevice(deviceHdl);
        end;

    NumToString(SInt32(videoDeviceCount), theString);
    MoveTo(10, 20);
    DrawString(theString);
    if (videoDeviceCount = 1) then
        begin
        DrawString(' video device in the device list.');
        end
    else begin
        DrawString(' video devices in the device list.');
        end;

    //
..........................................................................................................................................................................
................. Get Main Device

    deviceHdl := LMGetMainDevice;

    //
..........................................................................................................................................................................
determine device type

    MoveTo(10, 35);
    if BitTst(Ptr(@deviceHdl^^.gdFlags), 15 - gdDevType) then
        begin
        DrawString('The main video device is a colour device.');
        end
    else begin
        DrawString('The main video device is a monochrome device.');
        end;

    MoveTo(10, 50);
    deviceType := deviceHdl^^.gdType;

    case deviceType of

        clutType: begin
            DrawString('It is an indexed device with variable CLUT.');
            end;

        fixedType: begin
            DrawString('It is is an indexed device with fixed CLUT.');
            end;

        directType: begin
            DrawString('It is a direct device.');
            end;

        otherwise begin
```

```
      end;

    end;
      { of case statement }

  //
................................................................................................................................................................ Get
Handle to Pixel Map

  pixMapHdl := deviceHdl^^.gdPMap;

  //
.................................................................................................................................................................
determine pixel depth

  MoveTo(10, 70);
  DrawString('Pixel depth = ');
  pixelDepth := pixMapHdl^^.pixelSize;
  NumToString(pixelDepth, theString);
  DrawString(theString);

  // ....................................................................................................................................... Get Device's
Global Boundaries

  theRect := deviceHdl^^.gdRect;

  // ................................................................................................ determine bytes per row and total pixel image bytes

  MoveTo(10, 90);
  bytesPerRow := BAnd(pixMapHdl^^.rowBytes, $7FFF);
  DrawString('Bytes per row = ');
  NumToString(bytesPerRow, theString);
  DrawString(theString);

  MoveTo(10, 105);
  DrawString('Total pixel image bytes = ');
  NumToString(bytesPerRow * theRect.bottom, theString);
  DrawString(theString);

  // .................................................. convert device's global boundaries to coordinates of graphics port

  GlobalToLocal(theRect.topLeft);
  GlobalToLocal(theRect.botRight);

  MoveTo(10, 125);
  DrawString('Boundary rectangle top = ');
  NumToString(theRect.top, theString);
  DrawString(theString);

  MoveTo(10, 140);
  DrawString('Boundary rectangle left = ');
  NumToString(theRect.left, theString);
  DrawString(theString);

  MoveTo(10, 155);
  DrawString('Boundary rectangle bottom = ');
  NumToString(theRect.bottom, theString);
  DrawString(theString);

  MoveTo(10, 170);
  DrawString('Boundary rectangle right = ');
  NumToString(theRect.right, theString);
  DrawString(theString);

  // ......................................................................................................................... Get Pointer to Colour
Graphics Port

  cgrafPtr := CGrafPtr(theWindow);

  // ..................................................................................................................... determine requested
background colour

  MoveTo(10, 190);
  GetBackColor(blueColour);
  DrawString('Requested background colour (rgb) = ');
  MoveTo(10, 205);
  NumToString(UInt16(blueColour.red), theString);
  DrawString(theString);
  DrawString('  ');
  NumToString(UInt16(blueColour.green), theString);
```

```
    DrawString(theString);
    DrawString('  ');
    NumToString(UInt16(blueColour.blue), theString);
    DrawString(theString);

    // .......................................................................................................................................... get actual
colour (pixel value)

    pixelValue := cgrafPtr^.bkColor;

    // ................. if direct device, extract colour components, else begin retrieve colour table index

    MoveTo(10, 220);

    if (deviceType = directType) then
        begin
        if (pixelDepth = 16) then
            begin
            redComponent := BAnd(BSR(pixelValue, 10), $0000001F);
            greenComponent := BAnd(BSR(pixelValue, 5), $0000001F);
            blueComponent := BAnd(pixelValue, $0000001F);
            end
        else if (pixelDepth = 32) then
            begin
            redComponent := BAnd(BSR(pixelValue, 16), $000000FF);
            greenComponent := BAnd(BSR(pixelValue, 8), $000000FF);
            blueComponent := BAnd(pixelValue, $000000FF);
            end;

        DrawString('Background colour used (rgb) = ');
        MoveTo(10, 235);

        NumToString(redComponent, theString);
        DrawString(theString);
        DrawString('  ');

        NumToString(greenComponent, theString);
        DrawString(theString);
        DrawString('  ');

        NumToString(blueComponent, theString);
        DrawString(theString);
        end
    else if ((deviceType = clutType) or (deviceType = fixedType)) then
        begin
        DrawString(' Background colour used (color table index) = ');
        MoveTo(10, 235);
        NumToString(pixelValue, theString);
        DrawString(theString);
        end;

    // ................................................................................................................................................ Get
Handle to Colour Table

    colorTableHdl := pixMapHdl^^.pmTable;
    entries := colorTableHdl^^.ctSize;

    // ........................................................................................... if any entries in colour table, draw the colours

    MoveTo(250, 20);
    DrawString('Colour table in GDevice''s PixMap:');

    if (entries < 2) then
        begin
        MoveTo(260, 105);
        DrawString('Dummy (one entry) colour table only.');
        MoveTo(260, 120);
        DrawString('To get some entries, set the monitor to');
        MoveTo(260, 135);
        DrawString(' 256 colours, causing it to act like an');
        MoveTo(260, 150);
        DrawString('                    indexed device.');
        SetRect(theRect, 250, 28, 458, 236);
        FrameRect(theRect);
        end;

    c := 0;
    for a := 28 to 223 by 13 do
        begin
        for b := 250 to 445 by 13 do
```

```
            begin
            if (c <= entries) then
                begin
                SetRect(theRect, b, a, b + 12, a + 12);
                theColour := colorTableHdl^^.ctTable[c].rgb;
                c := c + 1;
                RGBForeColor(theColour);
                PaintRect(theRect);
                if (((deviceType = clutType) or (deviceType = fixedType)) and (c - 1 = pixelValue)) then
                    begin
                    RGBForeColor(whiteColour);
                    InsetRect(theRect, -1, -1);
                    FrameRect(theRect);
                    end;
                end;
            end;
        end;
    end;
        { of procedure DoDisplayInformation }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ DoCheckMonitor

function DoCheckMonitor : boolean;
    var
    mainDeviceHdl : GDHandle;

    begin
    mainDeviceHdl := LMGetMainDevice;

    if (HasDepth(mainDeviceHdl, 16, 0, 0) = 0) then
        begin
        DoCheckMonitor := false;
        end
    else begin
        gStartupPixelDepth := mainDeviceHdl^^.gdPMap^^.pixelSize;
        DoCheckMonitor := true;
        end;
    end;
        { of procedure DoCheckMonitor }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ DoSetMonitorPixelDepth

procedure DoSetMonitorPixelDepth;
    var
    mainDeviceHdl : GDHandle;
    ignoredErr : OSErr;
    alertString : Str255;
    pixelDepth : SInt16;

    begin
    mainDeviceHdl := LMGetMainDevice;
    pixelDepth := mainDeviceHdl^^.gdPMap^^.pixelSize;

    if (pixelDepth <> 16) then
        begin
        GetIndString(alertString, rIndexedStrings, sSettingPixelDepth16);
        DoMonitorAlert(alertString);
        ignoredErr := SetDepth(mainDeviceHdl, 16, 0, 0);
        end
    else begin
        GetIndString(alertString, rIndexedStrings, sMonitorIsDepth16);
        DoMonitorAlert(alertString);
        end;
    end;
        { of procedure DoSetMonitorPixelDepth }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ DoRestoreMonitorPixelDepth

procedure DoRestoreMonitorPixelDepth;
    var
    mainDeviceHdl : GDHandle;
    ignoredErr : OSErr;
    alertString : Str255;
    pixelDepth : SInt16;

    begin
    mainDeviceHdl := LMGetMainDevice;
    pixelDepth := mainDeviceHdl^^.gdPMap^^.pixelSize;

    if (pixelDepth <> gStartupPixelDepth) then
```

```
        begin
        GetIndString(alertString, rIndexedStrings, sRestoringMonitor);
        DoMonitorAlert(alertString);
        ignoredErr := SetDepth(mainDeviceHdl, gStartupPixelDepth, 0, 0);
        end
    else begin
        GetIndString(alertString, rIndexedStrings, sMonitorIsDepthStart);
        DoMonitorAlert(alertString);
        end;
    end;
        { of procedure DoRestoreMonitorPixelDepth }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ DoMonitorAlert

procedure DoMonitorAlert(labelText : Str255);
    var
    paramRec : AlertStdAlertParamRec;
    itemHit : SInt16;
    ignoredErr : OSErr;

    begin
    paramRec.movable := true;
    paramRec.helpButton := false;
    paramRec.filterProc := nil;
    paramRec.defaultText := StringPtr(kAlertDefaultOKText);
    paramRec.cancelText := nil;
    paramRec.otherText := nil;
    paramRec.defaultButton := kAlertStdAlertOKButton;
    paramRec.cancelButton := 0;
    paramRec.position := kWindowDefaultPosition;

    ignoredErr := StandardAlert(kAlertNoteAlert, @labelText, nil, @paramRec, itemHit);
    end;
        { of procedure DoMonitorAlert }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊ main program block

begin

    //
.......................................................................................................................................................................................................
...... initialise managers

    DoInitManagers;

    // ........................................................................................................................................................................................... set
up menu bar and menus

    mainMenubarHdl := GetNewMBar(rMenubar);
    if (mainMenubarHdl = nil) then
        begin
        ExitToShell;
        end;
    SetMenuBar(mainMenubarHdl);

    mainMenuHdl := GetMenuHandle(mApple);
    if (mainMenuHdl = nil) then
        begin
        ExitToShell;
        end
    else begin
        AppendResMenu(mainMenuHdl, 'DRVR');
        end;

    if not DoCheckMonitor then
        begin
        GetIndString(mainString, rIndexedStrings, sMonitorInadequate);
        DoMonitorAlert(mainString);
        mainMenuHdl := GetMenuHandle(mDemonstration);
        DisableItem(mainMenuHdl, 0);
        end
    else begin
        if (gStartupPixelDepth > 8) then
            begin
            mainMenuHdl := GetMenuHandle(mDemonstration);
            DisableItem(mainMenuHdl, 0);
            end;
        end;

    DrawMenuBar;
```

```
  // ............................................................................. open windows, set font size, show windows, move windows

  mainWindow := GetNewCWindow(rWindow, nil, WindowPtr(-1));
  if (mainWindow = nil) then
    begin
    ExitToShell;
    end;

  SetPort(mainWindow);
  TextSize(10);

  //
.................................................................................................................................................................
................. enter eventLoop

  gDone := false;

  while not gDone do
    begin
    if WaitNextEvent(everyEvent, mainEvent, MAXLONG, nil) then
      begin
      DoEvents(mainEvent);
      end;
    end;

end.
  { of main program block }

// ◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊◊
```

Demonstration Program Comments

When this program is first run, the user should:

- Drag the window to various position on the main screen, noting the changes to the coordinates of the boundary rectangle.
- Open the Monitors and Sound control panel and, depending on the characteristics of the user's system:
  - Change between the available resolutions, noting the changes in the bytes per row and total pixel image bytes figures displayed in the window.
  - Change between the available colour depths, noting the changes to the pixel depth and total pixel image bytes figures, and the background colour used figures, displayed in the window.
- Note that, when 256 or less colours are displayed on a direct device (in colours and grays), the device creates a CLUT and operates like a direct device. In this case, the background colour used figure is the colour table entry (index), and the relevant colour in the colour table display is framed in white.

Assuming the user's monitor is a direct colour device, the user should then run the program again with the monitor set to display 256 colours prior to program start. The Demonstration menu and its items will be enabled. The user should then choose the items in the Demonstration menu to set the monitor to a pixel depth of 16 and back to the startup pixel depth.

DoEvents

In the case of a mouse-down event, in the inDrag case, when the user releases the mouse button, the left half of the window is invalidated, causing the left half to be redrawn with the new boundary rectangle coordinates.

DoDisplayInformation

In the first ten lines, RGB colours are assigned to the window's colour graphics port's rgbFgColor and rgbBkColor fields. The call to EraseRect causes the content region to be filled with the background colour.

Get Device List

The call to LMGetDeviceList gets a handle to the first GDevice structure in the device list. The device list is then "walked" in the while loop. For every video device found in the list, the variable videoDeviceCount is incremented. GetNextDevice gets a handle to the next device in the device list.

Get Main Device

LMGetMainDevice gets a handle to the startup device, that is, the device on which the menu bar appears.

The call to BitTest with the gdDevType flag determines whether the main (startup) device is a colour or black-and-white device. In the next block, the gdType field of the GDevice structure is examined to determine whether the device is an indexed device with a variable CLUT, an indexed device with a fixed CLUT, or a direct device (or a direct device set to display 256 colours or less and, as a consequence, acting like an indexed device).

Get Handle to Pixel Map

At the first line of this block, a handle to the GDevice structure's pixel map is retrieved from the gdPMap field.

In the next block, the pixel depth is extracted from the PixMap structure's pixelSize field.

Get Device's Global Boundaries

At the first line of this block, the device's global boundaries are extracted from the GDevice structure's gdRect field.

At the next block, the number of bytes in each row in the pixel map is determined. (The high bit in the rowBytes field of the PixMap structure is a flag which indicates whether the data structure is a PixMap structure or a BitMap structure.)

At the next block, the bytes per row value is multiplied by the height of the boundary rectangle to arrive at the total number of bytes in the pixel image.

The two calls to GlobalToLocal convert the boundary rectangle coordinates to coordinates local to the colour graphics port.

Get Pointer To Colour Graphics Port

The first line simply casts theWindow to a pointer to a colour graphics port so that, later on, the bkColor field can be accessed.

The next block gets the current (requested) background colour using the function GetBackColor, and then extracts the red, green, and blue components.

At the next line, the pixel value in the bkColor field of the colour graphics port is retrieved. This is an SInt32 value holding either the red, green, and blue components of the background colour actually used for drawing (direct device) or the colour table entry used for drawing (indexed devices).

For direct devices with a pixel depth of 16, the first 15 bits hold the three RGB components. For direct devices with a pixel depth of 32, the first 24 bits hold the RGB components. These are extracted in the "if (deviceType = directType) then" block. For indexed devices the value is simply the colour table entry (index) determined by the Color Manager to represent the nearest match to the requested colour.

Get Handle To Colour Table

The first two lines get a handle to the colour table in the GDevice structure's pixel map and the number of entries in that table.

The final block paints small coloured rectangles for each entry in the colour table. If the main device is an indexed device (or if it is a direct device set to display 256 colours or less), the colour table entry being used as the best match for the requested background colour is outlined in white.

DoCheckMonitor

DoCheckMonitor is called at program start to determine whether the main device supports 16-bit colour and, if it does, to assign the main device's pixel depth at startup to the global variable gStartupPixelDepth.

The call to LMGetMainDevice gets a handle to the main device's GDevice structure. The function HasDepth is used to determine whether the device supports 16-bit colour. The pixel depth is extracted from the pixelSize field of the PixMap structure in the GDevice structure.

DoSetMonitorPixelDepth

DoSetMonitorPixelDepth is called when the first item in the Demonstration menu is chosen to set the main device's pixel depth to 16.

If the current pixel depth determined at the first two lines is not 16, a string is retrieved from a 'STR#' resource and passed to the application-defined routine DoMonitorAlert, which displays a movable modal alert box advising the user that the monitor's bit depth is about to be changed to 16. When the user dismisses the alert box, SetDepth sets the main device's pixel depth to 16.

If the current pixel depth is 16, the last two lines display an alert box advising the user that the device is currently set to that pixel depth.

DoRestoreMonitorPixelDepth

DoRestoreMonitorPixelDepth is called when the second item in the Demonstration menu is chosen to reset the main device's pixel depth to the startup pixel depth.

If the current pixel depth determined at the first two lines is not equal to the startup pixel depth, a string is retrieved from a 'STR#' resource and passed to the application-defined routine DoMonitorAlert, which displays a movable modal alert box advising the user that the monitor's bit depth is about to be changed to the startup pixel depth. When the user dismisses the alert box, SetDepth sets the main device's pixel depth to the startup pixel depth.

If the current pixel depth is the startup pixel depth, the last two lines display an alert box advising the user that the device is currently set to that pixel depth.

main program block

Before DrawMenuBar is called, a call to the application-defined routine DoCheckMonitor assigns the startup pixel depth to a global variable and determines whether the main device supports 16-bit colour. If the main device does not support 16-bit colour, the Demonstration menu is disabled. If the main device does support support 16-bit colour, the Demonstration menu is disabled only if the current pixel depth is not 8 (256 colours) or less.